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TRADITIONAL AGROFORESTRY SYSTEMS AND SOCIOECONOMIC STATUS OF FARMERS IN KANGRA VALLEY OF NORTH WESTERN HIMALAYA, INDIA

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Abstract: The study was conducted to evaluate the existing agroforestry systems and socio-economic status of the farmers in Kangra district of Himachal Pradesh, India. A total number of 220 farmers were selected randomly from four group's viz., marginal, small, medium and large based on landholding capacity by dividing the district into three altitudinal zones namely zone-I (<500 m amsl), zone-II (500-1000 m amsl) and zone –III (>1000 m amsl) for survey and data collection. The main forms of traditional agroforestry systems found in the study area are the agrisilvicultural (AS), agrisilvihorticultural (ASH), agrihorticulture (AH), agrisilvipastoral (ASP), pastoralsilviculture (PS) and silvipastoral (SP) systems. The survey data were collected with a pre-structured questionnaire in personal interviews with household heads and data for family structure, education status of heads of households, literacy rate of family, status of off farm employment, land use statistics was recorded.

Keywords: Agroforestry, Socioeconomic, Farmers, Kangra, Western Himalaya

INTRODUCTION

Forests are cleared mainly into agricultural land as a result of population growth, high dependability of population to agriculture sector and low awareness of forest functions on the environment. The decrease in land area for conserving forest resources and increasing land pressure due to population growth is the major problem faced around the world. Degradation of fertile land puts even more pressure on forests, as additional land needs to be cleared because existing agricultural land is not sufficiently productive anymore due to exhausted soils and water scarcity. These conditions lead into a poverty increase which affects many farmers and damage the natural resources (deforestation, watershed degradation etc.) (Ducoirtieux *et al.,* 2006). Agroforestry serves as multiple functions and able to mitigate these problems through several mechanisms. In turn, practitioners have seen these ecological benefits turn into economic benefits through the increase of agricultural output (Hildreth, 2008). Moreover, in rural areas, agroforestry improves socio-economic conditions by creating job opportunities and provides income, thereby reducing the scarcity of food production and improving financial state (Goudarzian and Yazdani, 2015).

Agroforestry practices in India is old, traditional and practised in various forms (Solanki, 1998 and Sharma, 1996) and is based on the socio-economic, cultural, communication and demographic factors of the population, experiences of farmers and other related factors. Existing agroforestry systems in any area is the result of farmers innovation and experimentation over centuries (Rafiq *et al.,* 2000). Adoption of innovations in agroforestry technology is a complicated process determined by both environmental and socioeconomic factors (Malla, 2000 and Neupane *et al.,* 2002). In most developing countries, the level of participation in any production activity can be linked to the socioeconomic status of households (Agarwal, 1986).

There are different types of agroforestry mixed farming systems are practiced in western Himalayas but, now-a-days few are being replaced and are in danger of disappearing due to socio-economic and demographic conditions. The awakened rural farmer in the hills of district Kangra have witnessed many changes in farming, livestock rearing, traditional agroforestry and in plantations of horticultural crops. Keeping this in mind, the present study was to investigate the existing agroforestry systems in relation to socioeconomic status of the farmers in study area.

MATERIAL AND METHOD

The present study was carried out in the 12 panchayats of Kangra district of Himachal Pradesh, India that lies between 31°41'to 32°28'N latitude and 75°35' to 77°04' E longitude having altitude ranges from 248 to 5861 m amsl (Figure 1). The climate of the district varies from sub-tropical in low hills and valleys to sub-humid in the mid hills and getting temperate in high hills. The average annual rainfall in the district varies from 1500 to 1800 mm. Snowfall is also received in upper ridges of the district. Average minimum and maximum temperature of the district are 3°C and 45°C, respectively.

The entire district was divided into three altitudinal zones viz. Zone I (< 500 m amsl), Zone II (500-1000 m amsl) and Zone III (> 1000 m amsl); in each zone four panchayats were selected and from each selected panchayat as per classification of government of Himachal Pradesh, farmers were divided on the basis of their land holding into four different farmers

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categories: Marginal (<1 ha), Small (1-2 ha), Medium (2-5 ha) and 4 Large (>5 ha) and a random sample of five farmers from each category were taken as ultimate unit of the study. Twenty farmers were falling in each category in each altitudinal zone except large category in altitudinal zone III as there was no farmer found in large category in selected panchayats. In total, 220 farmers were surveyed to know about socioeconomic status, livelihood methods and agroforestry systems practised in the area. The relevant information about the study was collected through pre-tested schedule for the purpose through personal interviews with each head of the household. A multistage sampling technique was used to generate the information regarding various variables. Group discussions and direct observations were also considered wherever possible to generate information on general farming and vegetation patterns. Gram pradhans (Heads of the village legislative councils), patwaris (village revenue officers) and block officials were also interviewed to collect precise quantitative data and validated it. The trees and agricultural crops found in the studied area are shown in the Table 1. Agroforestry systems existing in the study area were also identified on the basis of structure (nature and arrangement) and function (role of output) of components.

RESULT AND DISCUSSION

Socioeconomic

a) Family structure

Family structure represented the total number of individuals in a household comprising of adults, children and their male- female population in each group. The family structure and sex ratio of the sampled households given in (Table 2, 3) showed that the average family size of marginal, small, medium and large farmer category in altitudinal zone I was 5.35, 5.25, 8.05 and 6.65 individuals; respectively. However, the overall family size was 6.33. The average family size was reported maximum in medium farmer category followed by large, marginal and small farmer categories. The sex ratio of adults were found maximum in small (953) farmer category, followed by medium (836), large (836) and marginal (804) farmer categories. The overall sex ratio of adults was found 857. The sex ratio of children were found maximum in small (1100) farmer category, followed by marginal (846), medium (810) and large (750) farmer categories. The overall sex ratio of children was found 857. The total sex ratio of adults and children were found highest in small farmer (981) followed by medium (830) and large (822) farmer categories, whereas the lowest total sex ratio of adults and children were found in marginal (814) farmer category. The overall sex ratio was found 853.

The average family size in marginal, small, medium and large farmer category in altitudinal zone II was 5.30, 5.35, 7.25 and 6.35 individuals; respectively. However, the overall family size was 6.06. The average family size was found maximum in medium farmer category followed by large, small and marginal farmer categories. The sex ratio of adults were found to be maximum (849) in large farmer category, followed by medium (841), marginal (778) and small (773) farmer categories. The overall sex ratio of adults was found 815. The sex ratio of children were found maximum in medium (1071) farmer category followed by small (933), large (933) and marginal (857) farmer categories. The overall sex ratio of children was found 948 which were higher than the overall sex ratio of adults 815. Generally, the total sex ratio of adults and children were found maximum in medium (883) farmer category which is followed by large (868), small (814) farmer categories and on the otherhand it was recorded minimum in marginal (797) farmer category. The overall sex ratio was found 844.

The average family size range between 6.10 - 6.30 individuals in marginal, small and medium farmer category, respectively in altitudinal zone III. However, the overall family size was 6.22. The average family size was found maximum in medium farmer category followed by small and marginal farmer categories. The large farmer category was not reported in this zone. The sex ratio of adults were found highest in medium (960) farmer category followed by small (957) and marginal (933) farmer categories. The overall sex ratio of adults was found 950. The sex ratio of children were found maximum in marginal (1056) farmer category, followed by small (737) and medium (647) farmer categories. The overall sex ratio of children was found 815 which were lower than the overall sex ratio of adults (950). The total sex ratio of adults and children were found maximum in marginal (968) farmer category followed by small (894) and medium (881) farmer categories. The overall sex ratio was found 913 which were found highest among all the selected altitudinal zones. Yadav *et al.*, (2016) also found that the average family size lies between 4.3-5.0 at different elevation zones of Kumaon Himalaya, Uttarakhand, India. The overall sex ratio of three altitudinal zone found to be in line with the sex ratio of state and national averages of 968 and 933 respectively (Census, 2011).

b) Educational status of head of families

Educational status of head of family in each category of farmers in different altitudinal zones were having varying levels viz. primary, middle, matric, senior secondary, graduation and post graduation (Table 4). Head of the family having minimum education level even up to primary standard was considered literate. A cursory glance of data of altitudinal I showed that literacy rate was maximum (90.00%) in marginal farmer category which was followed by small (85.00%), medium (80.00%) and large (75.00%) farmer categories. However, the overall literacy rate in altitudinal zone- I was 82.50 percent.

The literacy rate was maximum (85.00%) in medium farmer category which was followed by marginal (80.00%), large (80.00%) and small (75.00%) farmer categories in altitudinal zone II. However, the overall literacy rate (80.00%) was found in altitudinal zone-II which was lower than the literacy rate of heads (82.50%) in altitudinal zone- I.

The literacy rate was found highest in marginal (90.00%) farmer category followed by small (85.00%) and medium (80.00%) farmer categories in altitudinal zone III. The overall literacy rate (85.00%) was found in altitudinal zone- III which was higher than the literacy of heads in altitudinal zone- I (82.50%) and altitudinal zone- II (80.00%). In the study area, irrespective of altitudinal zones and categories, the percentage of literate head of family was found more than illiterate. It is observed that most of the household heads were governed by men in the study area which were found in consistent with the findings of Chen *et al.,* (2006), Demurger and Fournier (2010); Sharma *et al.,* (2012).

c) Sex-wise literacy of family

The role of education is to equip people with the knowledge and to encourage them in their own decision making mechanism. Education imparts confidence and competitiveness in the individual which plays a significant role in transforming his/her society. At the same time, education helps to secure off-farm employment by which it eases the capital constraints. Thus, the analysis of the educational status of households becomes important (Table 5). In altitudinal zone I, the sex-wise educational status of both males and females showed that the literacy rate of males were found maximum in large (98.63%) farmer category, followed by medium (97.70%), small (92.59%) and marginal (86.21%) farmer categories whereas literacy rate of females were found maximum in medium (85.14 %) farmer category, followed by small (82.14%), marginal (79.59%) and large (75.00%) farmer categories. The data also revealed that the literacy rate of males (94.49%) were higher than the literacy rate of females (80.75%) in all the farmer categories. On an average, the highest family literacy rate was observed among the medium (91.93%) farmers category, followed by large (87.97%), small (87.27%) and marginal (83.18%) farmer categories. The overall family literacy in altitudinal zone- I was 87.59 per cent.

The literacy rate of males were found maximum in large (95.59%) farmer category, followed by marginal (88.14%), medium (87.01%) and small (86.44%) farmer categories whereas literacy rate of females were found maximum in large (93.22%) farmer category, followed by medium (79.41%), small (75.00%) and marginal (70.21%) farmer categories in altitudinal zone II. The data also revealed that the literacy rate of males (89.35%) were higher than the literacy rate of females (80.18%) in all the farmer categories. On an average, the highest family literacy rate was observed among the large (94.49%) farmer category, followed by medium (83.45%), small (81.31%) and marginal (80.19%) farmer categories. The overall family literacy in altitudinal zone- II was 84.86 per cent and it was lower than the average family literacy of altitudinal zone- I.

In altitudinal zone- III, the literacy rate of males were found 98.39, 93.94 and 90.91 per cent in marginal, small and medium farmer categories, respectively. Whereas, the literacy rate of females were 78.33, 81.36 and 90.00 percent in marginal, small and medium farmer categories, respectively. Thus, maximum literacy of males (98.39%) and females (90.00%) were found in marginal and medium farmer categories, respectively. The literacy rate of males (94.33%) were found higher than the literacy rate of females (83.24%) in all farmer categories. On an average, the highest family literacy rate was observed among the medium (90.48%) farmer category, followed by marginal (88.52%) and small (88.00%) farmer categories. The overall family literacy in altitudinal zone- III was 89.00 per cent which was found higher than the literacy rate in altitudinal zone- I (87.59%) and II (84.86%). It is evident from the results that the percentages of illiterate females were found higher than that of males in all the altitudinal zones, irrespective of the farmer categories. The results also conclude that overall family literacy rate was found maximum in altitudinal zone- III, followed by I and II. Our present findings, exhibited that overall literacy rate of different altitudinal zones of study area were found higher than the literacy rate (82.80%) of H.P. (Census, 2011). Yadav *et al.,* (2016) also founded the overall literacy rate as 83.0% in Kumaon Himalaya, Uttarakhand, India.

d) Status of off-farm employment

Off-farm employment is not only an additional source of income to the farmers but also an alternative medium of economic gain during crop failure. In the present study (Table 6), the sampled farmers met their livelihood through government employment/pension, grocery shop-keeping, carpentry, family trade, tailoring, vegetable vendor, private transport, industries, etc. were the sources of off-farm income. Males were found dominating in employment in government as well as private services in all the altitudinal zones. Similar studies on off farm employment were done by Sharma *et al.,* (2009) and Yadav *et al.,* (2016). Among different farmer categories, in altitudinal zone- I, the income of individuals from government services were found maximum in small (70.88%) farmer category followed by medium (55.97%) and large (55.39%) farmer categories, whereas minimum income of individuals from government services was recorded in marginal (41.58%) farmer category. The income of individuals from private services were found highest in marginal (58.42%) farmer category,

followed by large (44.61%) and medium (44.03%) farmer categories, while the lowest income of individuals from private services was observed in small (29.12%) farmer category. Moreover in the total population of altitudinal zone- I, the income of individuals from private services (53.81%) were found maximum than the income of individuals from government services (46.19%).

The income of individuals from government services were found highest in large (68.33%) farmer category followed by marginal (61.54%) and small (56.24%) farmer categories, whereas lowest income of individuals from government services was recorded in medium (53.83%) farmer category in altitudinal zone II. The income of individuals from private services were found maximum in medium (46.17%) farmer category, followed by small (43.76%) and marginal (38.46%) farmer categories, while the lowest income of individuals from private services was observed in large (31.67%) farmer category. However in the total population of altitudinal zone- II, the income of individuals from government services (66.83%) were found maximum than the income of individuals from private services (33.17%).

The income of individuals from government services were found maximum in medium (63.66%) farmer category followed by marginal (56.00%) farmer category, whereas minimum income of individuals from government services was observed in small (55.61%) farmer category in altitudinal zone III. The income of individuals from private services were found highest in small (44.39%) farmer category, followed by marginal (44.00%) farmer category, while lowest income of individuals from private services was recorded in medium (36.34%) farmer category. In the total population of altitudinal zone-III, the income of individuals from government services (64.45%) were found higher than the income of individuals from private services (35.55%).

e) Land use statistics

Land is a basic requirement for farming. The size of the land holding is directly related to household income, consumption and savings. Land use statistics presented in table 7 revealed that agriculture was the major land use system prevalent in the study area. In altitudinal zone I, the irrigated and unirrigated lands under all the farmer categories were found 13.52 and 69.82 per cent. Data further showed that maximum land area under agriculture was recorded in marginal (88.24%) farmer category, followed by medium (86.82%) and small (84.05%) farmer categories, whereas minimum land area under agriculture was observed in large (79.65%) farmer category. Further in case of land area under pasture, the maximum area was found under small (15.23%) farmer category followed by large (14.52%) and medium (11.05%) farmer categories, while minimum area was recorded under marginal (10.12%) farmer categories. Average land holding was found maximum in large (5.99 ha) farmer category, followed by medium (2.99 ha), small (1.38 ha) and marginal (0.70 ha) farmer categories. The overall land holding per household for this zone was found 2.76 ha.

The total irrigated and unirrigated land under all the farmer categories were found 2.17 and 78.33 per cent, respectively in altitudinal zone II. The maximum proportion of total agriculture land was found in large (81.64%) farmer category, followed by marginal (81.37%) and small (79.76%) farmer categories, while minimum proportion of total agriculture land was found in medium (78.58%) farmer category. Maximum land area under pasture was found in medium (18.81%) farmer category followed by small (17.51%), large (15.84%) and marginal (15.11%) farmer categories. Average land holding was found in the following order: large (5.49 ha) > medium (3.03 ha) > small (1.37 ha) > marginal (0.63 ha) farmer category. Data also reflect that average land holding per household for this zone was 2.63 ha.

In altitudinal zone III, the irrigated and unirrigated lands under all the farmer categories were found 1.67 and 73.34 per cent. The marginal category of farmers had 76.51 per cent land area under agriculture and 20.32 per cent under pasture. Small category of farmers had 70.65 per cent of land area under agriculture and 27.55 per cent under pasture. Likewise, 77.23 per cent land area among medium category of farmers was under agriculture and 21.25 per cent of area under pasture. Data further reflect that the average land-holding per household was maximum in medium (2.59 ha) farmer category followed by small (1.52 ha) and marginal (0.60 ha) farmer categories. The average land holding per household for this altitudinal zone was 1.57 ha.

Identification and comparison status of agroforestry systems

Irrespective of different categories of farmers and altitudinal zones, a total of six agroforestry systems types existed in the studied area. The agroforestry systems predominant in Kangra district were Agrisilviculture (AS), Agrisilvihorticulture (ASH), Agrihorticulture (AH), Agrisilvipastoral (ASP), Pastoralsilviculture (PS) and Silvipastoral (SP) and there comparative status among different categories were shown in table 8. These systems may be attributed to agroclimatic conditions of the area and need of the farmers i.e. food, fodder, fuel wood and timber etc. Anita *et al.*, (2008) also reported that the traditional agroforestry practices helped the peoples to fulfil their basic needs i.e. food, fodder, fuel wood and timber and identified prevalent agroforestry systems viz. AH, AS, ASP, PS, PH in Lahaul and Kinnaur District (H.P.).

CONCLUSION

From the present study it was found that the overall sex ratio of three altitudinal zones found to be in line with the sex ratio of state and national averages of 968 and 933 respectively which shows that there was no gender biasness in the study area. Adult population constituted 79.45, 76.70 and 73.73 per cent of the total population among three altitudinal zones suggesting, thereby, greater availability of the family labour. The average family size was 6.33, 6.06 and 6.22 in three altitudinal zones, respectively. The majority of the family heads were found literate among three altitudinal zones. In terms of educational status, males were found to be more literate in comparison to females in all farmers categories of three altitudinal zones. Among various identified agroforestry systems agrisilviculture (AS) and pastoralsilviculture (PS) systems were most prevalent agroforestry systems in Kangra District. Hence, the study represents the clear picture of socioeconomic status of farmers and existing agroforestry systems which will help the researchers to understand the agroforestry system of study area in order to make improvement and develop technologies that will help local people/farmers to fulfil basic needs and overcome the existing constraints.

Figure 1. Location map of the study area

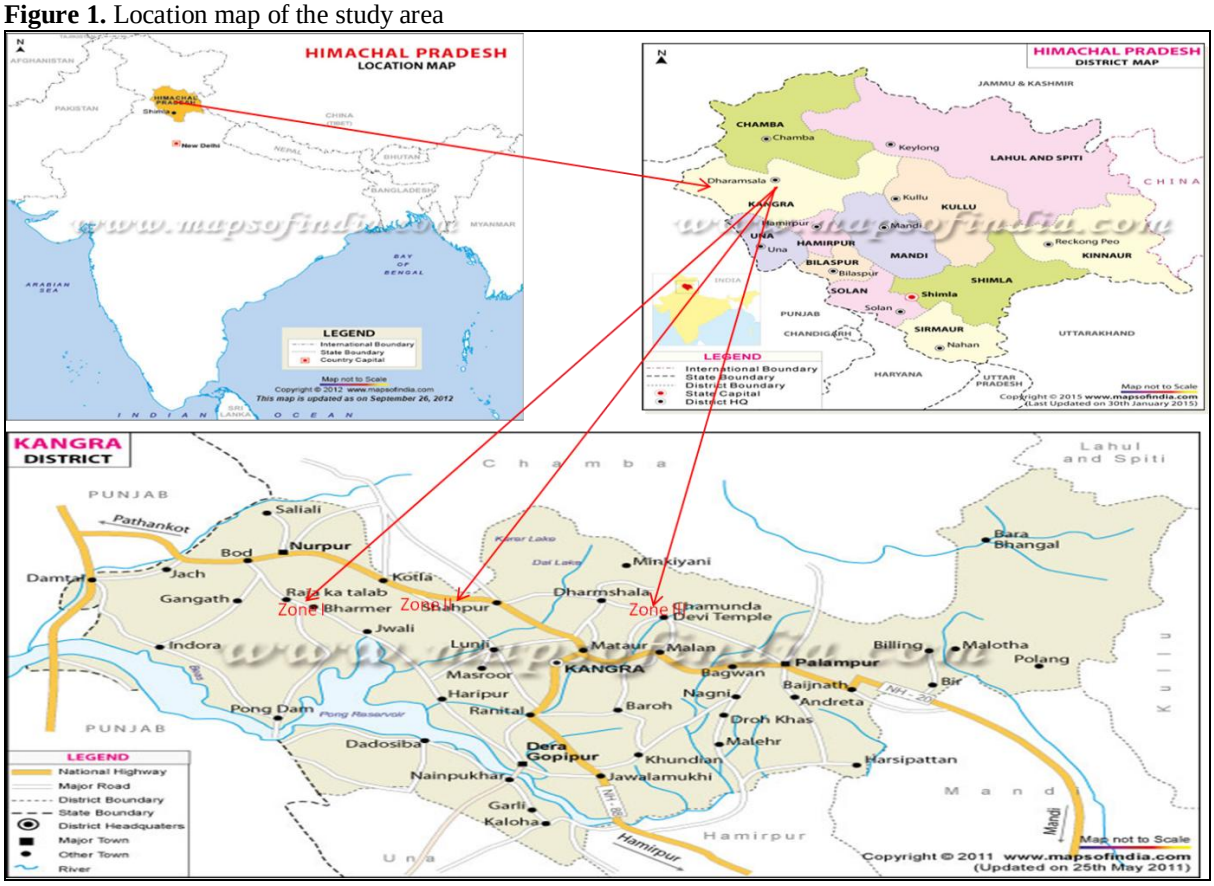

Table 1. Trees and agricultural crops present in the existing agroforestry systems of study area

Forest trees
Morus alba, Acacia catechu, Dalbergia sissoo, Toona ciliata, Albizia chinensis Populus deltiodes, Celtis australis, Bombax ceiba, Melia azedarach, Terminalia bellerica, Cassia fistula, Ficus palmata, Bauhinia variegata Grewia optiva, Leucaena leucocephala, Salix alba, Syzygium cumini and Zizyphus mauritiana
Fruit trees
Mangifera indica, *Psidium guajava*, *Litchi chinensis*, Prunus persica, Prunus domestica, *Citrus limon*, *Citrus aurantifolia* and *Citrus sinensis*
Agricultural Crops
Cereals
Triticum astivum (Wheat), *Zea mays* (Maize), *Oryza sativa* (Paddy) and *Hordeum vulgare* (Barley)
Oilseed crops and Pulses
Brassica nigra (Mustard), *Sesamum indicum* (Till), *Vigna mungo* (Maash) and *Phaseolus vulgaris* (Rajmash)
Vegetables

Curcuma longa (Turmeric), *Solanum lycopersicum* (Tomato), *Brassica oleracea* (Cabbage), *Brassica oleracea* (Cauliflower), *Solanum melongena* (Brinjal), *Capsicum annuum* (Capsicum), *Abelmoschus esculentus* (Ladies finger), *Momordica charantia* (Karela), *Cucurbita maxima* (Pumpkin), *Raphanus sativus* (Radish), *Allium cepa* (Onion), *Allium sativum* (Garlic) and *Capsicum frutescens* (Chilli)

Table 2. Family structure of four farmers category in three altitudinal zones of Kangra District

Category	Adult (A)			Children (C)			Grand Total (A+C)	Average Family Size
	Male	Female	Total	Male	Female	Total		
Altitudinal zone- I								
Marginal	46 (42.99)	37 (34.58)	83 (77.57)	13 (12.15)	11 (10.28)	24 (22.43)	107 (100)	5.35
Small	43 (40.95)	41 (39.05)	84 (80.00)	10 (9.52)	11 (10.48)	21 (20.00)	105 (100)	5.25
Medium	67 (41.61)	56 (34.78)	123 (76.40)	21 (13.04)	17 (10.56)	38 (23.60)	161 (100)	8.05
Large	61 (45.86)	51 (38.35)	112 (84.21)	12 (9.02)	9 (6.77)	21 (15.79)	133 (100)	6.65
Total	217 (42.89)	185 (36.56)	402 (79.45)	56 (11.07)	48 (9.49)	104 (20.55)	506 (100)	6.33
Altitudinal zone- II								
Marginal	45 (42.45)	35 (33.02)	80 (75.47)	14 (13.21)	12 (11.32)	26 (24.53)	106 (100)	5.30
Small	44 (41.12)	34 (31.78)	78 (72.90)	15 (14.02)	14 (13.08)	29 (27.10)	107 (100)	5.35
Medium	63 (43.45)	53 (36.55)	116 (80.00)	14 (9.66)	15 (10.34)	29 (20.00)	145 (100)	7.25
Large	53 (41.73)	45 (35.43)	98 (77.17)	15 (11.81)	14 (11.02)	29 (22.83)	127 (100)	6.35
Total	205 (42.27)	167 (34.43)	372 (76.70)	58 (11.96)	55 (11.34)	113 (23.30)	485 (100)	6.06
Altitudinal zone- III								
Marginal	44 (36.07)	41 (33.61)	85 (69.67)	18 (14.75)	19 (15.57)	37 (30.33)	122 (100)	6.10
Small	47 (37.60)	45 (36.00)	92 (73.60)	19 (15.20)	14 (11.20)	33 (26.40)	125 (100)	6.25
Medium	50 (39.68)	48 (38.10)	98 (77.78)	17 (13.49)	11 (8.73)	28 (22.22)	126 (100)	6.30
Large	-	-	-	-	-	-	-	-
Total	141 (37.80)	134 (35.92)	275 (73.73)	54 (14.48)	44 (11.80)	98 (26.27)	373 (100)	6.22

(Values in parenthesis are the percentages)

Table 3. Sex ratio of adults and children of four farmers category in three altitudinal zones of Kangra District

Category	Adult (A)			Children (C)			Grand Total Sex ratio (A+C) (Per 1000 male)
	Male	Female	Sex ratio (Per 1000 male)	Male	Female	Sex ratio (Per 1000 male)	
Altitudinal zone- I							
Marginal	2.30 (42.99)	1.85 (34.58)	804	0.65 (12.15)	0.55 (10.28)	846	814
Small	2.15 (40.95)	2.05 (39.05)	953	0.50 (9.52)	0.55 (10.48)	1100	981
Medium	3.35 (41.61)	2.80 (34.78)	836	1.05 (13.04)	0.85 (10.56)	810	830
Large	3.05 (45.86)	2.55 (38.35)	836	0.60 (9.02)	0.45 (6.77)	750	822
Total	2.71 (42.89)	2.31 (36.56)	857	0.70 (11.07)	0.60 (9.49)	857	853

Altitudinal zone- II							
Marginal	2.25 (42.45)	1.75 (33.02)	778	0.70 (13.21)	0.60 (11.32)	857	797
Small	2.20 (41.12)	1.70 (31.78)	773	0.75 (14.02)	0.70 (13.08)	933	814
Medium	3.15 (43.45)	2.65 (36.55)	841	0.70 (9.66)	0.75 (10.34)	1071	883
Large	2.65 (41.73)	2.25 (35.43)	849	0.75 (11.81)	0.70 (11.02)	933	868
Total	2.56 (42.27)	2.09 (34.43)	815	0.73 (11.96)	0.69 (11.34)	948	844
Altitudinal zone- III							
Marginal	2.20 (36.07)	2.05 (33.61)	933	0.90 (14.75)	0.95 (15.57)	1056	968
Small	2.35 (37.60)	2.25 (36.00)	957	0.95 (15.20)	0.70 (11.20)	737	894
Medium	2.50 (39.68)	2.40 (38.10)	960	0.85 (13.49)	0.55 (8.73)	647	881
Large	-	-	-	-	-	-	-
Total	2.35 (37.80)	2.23 (35.92)	950	0.90 (14.48)	0.73 (11.80)	815	913

(Values in parenthesis are the percentages)

Table 4. Educational status of head of family of four farmers category in three altitudinal zones of Kangra District

	Education Level									
Category	**Primary**	**Middle**	**Matric**	**Secondary**	**Graduate**	**PG**	**Literate**	**Illiterate**	**Total**	**Literacy (%)**
Altitudinal zone- I										
Marginal	3 (15.00)	2 (10.00)	4 (20.00)	2 (10.00)	7 (35.00)	-	18 (90.00)	2 (10.00)	20(100)	90.00
Small	2 (10.00)	1 (5.00)	7 (35.00)	4 (20.00)	3 (15.00)	-	17 (85.00)	3 (15.00)	20 (100)	85.00
Medium	4 (20.00)	2 (10.00)	5 (25.00)	2 (10.00)	3 (15.00)	-	16 (80.0)	4 (20.00)	20 (100)	80.00
Large	1 (5.00)	2 (10.00)	6 (30.00)	4 (20.00)	2 (10.00)	-	15 (75.00)	5 (25.00)	20 (100)	75.00
Total	10 (12.50)	7 (8.75)	22 (27.50)	12 (15.00)	15 (18.75)	-	66 (82.50)	14 (17.50)	80 (100)	82.50
Altitudinal zone- II										
Marginal	4 (20.00)	5 (25.00)	5 (25.00)	2 (10.00)	-	-	16 (80.00)	4 (20.00)	20 (100)	80.00
Small	3 (15.00)	2 (10.00)	7 (35.00)	2 (10.00)	1 (5.00)	-	15 (75.00)	5 (25.00)	20 (100)	75.00
Medium	1 (5.00)	6 (30.00)	6 (30.00)	4 (20.00)	-	-	17 (85.00)	3 (15.00)	20 (100)	85.00
Large	3 (15.00)	6 (30.00)	3 (15.00)	4 (20.00)	-	-	16 (80.00)	4 (20.00)	20 (100)	80.00
Total	11 (13.75)	19 (23.75)	21 (26.25)	12 (15.00)	1 (1.25)	-	64 (80.00)	16 (20.00)	80 (100)	80.00
Altitudinal zone- III										
Marginal	1 (5.00)	3 (15.00)	9 (45.00)	4 (20.00)	1 (5.00)	-	18 (90.00)	2 (10.00)	20 (100)	90.00
Small	-	3 (15.00)	9 (45.00)	3 (15.00)	1 (5.00)	1 (5.00)	17 (85.00)	3 (15.00)	20 (100)	85.00
Medium	1 (5.00)	2 (10.00)	6 (30.00)	2 (10.00)	5 (25.00)	-	16 (80.00)	4 (20.00)	20 (100)	80.00
Large	-	-	-	-	-	-	-	-	-	-
Total	2 (3.33)	8 (13.00)	24 (40.00)	9 (15.00)	7 (11.67)	1 (1.67)	51 (85.00)	9 (15.00)	60 (100)	85.00

(Values in parenthesis are the percentages)

Table 5. Sex-wise literacy of family of four farmers category in three altitudinal zones of Kangra District

Category	Literate		Illiterate		Total		Total (Literate + Illiterate)	Family literacy (%)
	Male	Female	Male	Female	Literate	Illiterate		
Altitudinal zone- I								
Marginal	50 (86.21)	39 (79.59)	8 (13.79)	10 (20.41)	89 (83.18)	18 (16.82)	107	83.18
Small	50 (92.59)	46 (82.14)	4 (7.41)	10 (17.86)	96 (87.27)	14 (12.73)	110	87.27
Medium	85 (97.70)	63 (85.14)	2 (2.30)	11 (14.86)	148 (91.93)	13 (8.07)	161	91.93
Large	72 (98.63)	45 (75.00)	1 (1.37)	15 (25.00)	117 (87.97)	16 (12.03)	133	87.97
Total	257 (94.49)	193 (80.75)	15 (5.51)	46 (19.25)	450 (88.06)	61 (11.94)	511	87.59
Altitudinal zone- II								
Marginal	52 (88.14)	33 (70.21)	7 (11.86)	14 (29.79)	85 (80.19)	21 (19.81)	106	80.19
Small	51 (86.44)	36 (75.00)	8 (13.56)	12 (25.00)	87 (81.31)	20 (18.69)	107	81.31
Medium	67 (87.01)	54 (79.41)	10(12.99)	14 (20.59)	121 (83.45)	24 (16.55)	145	83.45
Large	65 (95.59)	55 (93.22)	3 (4.41)	4 (6.78)	120 (94.49)	7 (5.51)	127	94.49
Total	235 (89.35)	178 (80.18)	28 (10.65)	44 (19.82)	413 (85.15)	72 (14.85)	485	84.86
Altitudinal zone- III								
Marginal	61 (98.39)	47 (78.33)	1 (1.61)	13 (21.67)	108 (88.52)	14 (11.48)	122	88.52
Small	62 (93.94)	48 (81.36)	4 (6.06)	11 (18.64)	110 (88.00)	15 (12.00)	125	88.00
Medium	60 (90.91)	54 (90.00)	6 (9.09)	6 (10.00)	114 (90.48)	12 (9.52)	126	90.48
Large	-	-	-	-	-	-	-	-
Total	183 (94.33)	149 (83.24)	11 (5.67)	30 (16.76)	332 (89.01)	41 (10.99)	373	89.00

(Values in parenthesis are the percentages)

Table 6. Status of off-farm employment of four farmers category in three altitudinal zones of Kangra District

Category	Government services					Private Services					Grand Total
	Male	Income/month (Rs)	Female	Income/month (Rs)	Total	Male	Income/month (Rs)	Female	Income/month (Rs)	Total	
Altitude- I											
Marginal	10	19300.00 (28.69)	3	8666.67 (12.88)	27966.67 (41.58)	10	15300.00 (22.75)	2	24000.00 (35.68)	39300.00 (58.42)	67266.67 (100)
Small	10	20200.00 (33.93)	1	22000.00 (36.95)	42200.00 (70.88)	3	17333.33 (29.12)	-	-	17333.33 (29.12)	59533.33 (100)
Medium	12	19166.67 (42.62)	1	6000.00 (13.34)	25166.67 (55.97)	15	19800.00 (44.03)	-	-	19800.00 (44.03)	44966.67 (100)
Large	16	24187.50 (24.73)	1	30000.00 (30.67)	54187.50 (55.39)	11	23636.36 (24.16)	4	20000.00 (20.44)	43636.36 (44.61)	97823.86 (100)
Total	48	21083.33 (27.76)	6	14000.00 (18.43)	35083.33(46.19)	39	19538.46 (25.72)	6	21333.33 (28.09)	40871.79 (53.81)	75955.13 (100)
Altitude- II											
Marginal	15	19800.00 (61.54)	-	-	19800.00 (61.54)	8	12375.00 (38.46)	-	-	12375.00 (38.46)	32175.00 (100)
Small	12	18916.67 (41.05)	2	7000.00 (15.19)	25916.67 (56.24)	6	20166.67 (43.76)	-	-	20166.67 (43.76)	46083.33 (100)
Medium	19	21684.21 (53.83)	-	-	21684.21 (53.83)	15	18600.00 (46.17)	-	-	18600.00 (46.17)	40284.21 (100)
Large	14	19500.00 (29.94)	2	25000.00 (38.39)	44500.00 (68.33)	8	20625.00 (31.67)	-	-	20625.00 (31.67)	65125.00 (100)
Total	60	20150.00 (37.25)	4	16000.00 (29.58)	36150.00 (66.83)	37	17945.95 (33.17)	-	-	17945.95 (33.17)	54095.95 (100)
Altitude- III											
Marginal	17	21000 (56.00)	-	-	21000.00 (56.00)	12	16500.00 (44.00)	-	-	16500.00 (44.00)	37500.00 (100)
Small	16	20562.5 (43.05)	1	6000.00 (12.56)	26562.50 (55.61)	15	21200.00 (44.39)	-	-	21200.00 (44.39)	47762.5 (100)
Medium	21	22428.58 (34.75)	3	18666.67 (28.92)	41095.24 (63.66)	11	23454.55 (36.34)	-	-	23454.55 (36.34)	64549.78 (100)
Large	-	-	-	-	-	-	-	-	-	-	-
Total	54	21425.92 (37.40)	4	15500.00 (27.05)	36925.93 (64.45)	38	20368.42 (35.55)	-	-	20368.42 (35.55)	57294.34 (100)

(Values in parenthesis are the percentages)

Table 7. Farmers category wise land use statistics (per ha) in three altitudinal zones of Kangra District

Category	Agriculture			Pasture	Orchard	Average land holding
	Irrigated	Unirrigated	Sub total			
Altitudinal Zone I						
Marginal	0.09 (13.41)	0.53 (74.83)	0.62 (88.24)	0.07 (10.12)	0.01 (1.64)	0.70 (100)
Small	0.24 (17.06)	0.92 (66.99)	1.16 (84.05)	0.21 (15.23)	0.01 (0.70)	1.38 (100)
Medium	0.43 (14.28)	2.24 (74.98)	2.59 (86.82)	0.33 (11.05)	0.07 (2.19)	2.99 (100)
Large	0.74 (12.34)	4.03 (67.31)	4.77 (79.65)	0.87 (14.52)	0.35 (5.87)	5.99 (100)
Total	0.37 (13.52)	1.93 (69.82)	2.29 (82.68)	0.37 (13.39)	0.11 (3.96)	2.76
Altitudinal Zone II						
Marginal	0.004 (0.61)	0.51 (80.76)	0.51 (81.37)	0.10 (15.11)	0.02 (3.51)	0.63 (100)
Small	0.03 (2.10)	1.06 (77.66)	1.09 (79.76)	0.24 (17.51)	0.04 (2.80)	1.37 (100)
Medium	0.06 (2.03)	2.32 (76.55)	2.38 (78.58)	0.57 (18.81)	0.08 (2.60)	3.03 (100)
Large	0.13 (2.45)	4.35 (79.20)	4.48 (81.64)	0.87 (15.84)	0.14 (2.59)	5.49 (100)
Total	0.06 (2.17)	2.06 (78.33)	2.12 (80.50)	0.44 (16.87)	0.07 (2.67)	2.63
Altitudinal Zone III						
Marginal	0.01 (2.22)	0.45 (74.29)	0.46 (76.51)	0.12 (20.32)	0.02 (3.17)	0.60 (100)
Small	0.04 (2.39)	1.04 (68.26)	1.08 (70.65)	0.42 (27.55)	0.03 (1.89)	1.52 (100)
Medium	0.03 (1.11)	1.97 (76.11)	2.00 (77.23)	0.55 (21.25)	0.04 (1.48)	2.59 (100)
Large	-	-	-	-	-	-
Total	0.03 (1.67)	1.15 (73.34)	1.18 (75.01)	0.36 (23.17)	0.03 (1.83)	1.57

(Values in parenthesis are the percentages)

Table 8. Comparative status of various agroforestry system types in different altitudinal zones and farmers category of Kangra District

AFS types	Altitudinal Zone- I				Altitudinal Zone- II				Altitudinal Zone- III			
	Marginal	Small	Medium	Large	Marginal	Small	Medium	Large	Marginal	Small	Medium	Large
AS	5	7	9	5	6	5	8	5	6	7	5	-
ASH	3	4	5	3	4	3	-	3	4	5	3	-
AH	-	-	-	3	-	-	3	4	-	-	-	-
ASP	-	5	6	-	4	6	4	-	5	4	6	-
PS	4	6	5	6	5	5	6	4	4	6	5	-
SP	-	-	3	4	-	2	4	3	-	3	4	-

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RESEARCH ARTICLE

DEVELOPMENT OF CENTRIFUGAL ASPIRATOR OF PNEUMATIC METERING MECHANISM PLANTER OF RAINFED SEEDS

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Abstract: A pneumatic metering mechanism for planting of different seed was developed forprecise planting for groundnut, cotton, okra, sesameseeds. Centrifugal aspirator with radial blade was designed for creating the required vacuum pressure that pressure is required to pick the single seed. The optimum vaccume pressure was found to be 5, 2, 2 and 0.3 kPa for groundnut, cotton, okra, and sunflower. The airflow velocity 3.3 m/s gave the best results, with minimum lateral displacement of the seed. Effect of the different shapes of the seed plate orifice, upon the pneumatic planting of different shaped was analyzed which showed that the proper orifice shape was circular for spherical seed and elliptical for longer and flatter seed. The dimension of the seed plate orifice was 3mm diameter circular plate for okra seed, where as for groundnut, cotton and sesame seed, the elliptical shaped orifice with dimension (5,4.5), (3,3.5),(2.24,0.80) mm longer and shorter axis gave best result. The sizes of the different shaped orifices were analyzed to the effect of seed box exposed area upon the seed picked per orifices. The result for all shaped orifices clearly indicated that the meeting rate increases with the increase in the seed exposed area.

Keywords: Pneumatic metering mechanism, Orifice plate,Centrifugal aspirator, Vacuum pressure

INTRODUCTION

Crop sowing and establishment of the proper crop stand in the field is an important farm operation in any crop production programme. Crops like cotton, groundnut, sunflower and vegetables require precise placement of the seeds for proper growth and development. For sowing of the above crops, farmers in the country are still adopting the traditional methods of sowing, which are not only time and labour consuming, but also give the nonuniform seed spacing. Further, in these methods, farmers use higher seed rate and perform additional thinning operations to obtain optimum plant density in the field. The practice results in higher cost of the seeds and results in lower crop yield of the crops, which are susceptible to proper plant population. Pneumatic metering mechanism is a relatively newer concept of planting of the seeds. These machines use vacuum seed metering principle. The principle offers several advantages, especially the single seed picking, no mechanical damage to the seed and their capability to deal with both bolder and lighter seeds. Several researchers in India and abroad have developed tractor operated pneumatic planters. Adoption of these machines has been quite limited, due to their higher initial cost. Still considering the high accuracy and precision of the machinery, these machines have great potential for adoption for production of high value cash crops; especially requiring highly viable seeds.

Kumaran and Kumar (2004) designed a vacuum precision planter for planting okra and cotton seed and found that the quality of feed index for the seed tested was 76 to 86 percent, with the precision ranging from 23-25 percent.Ozmerzi *et al.* (2002)researched on Effect of sowing depth on precision seederuniformity to determine the effects of different depths of sowing maize with reference to the precision sowing technique. Karayel *et al.(*2004) observed optimum vacuum pressure 40 kPa for maize I and II; 30 kPa for cotton, soya bean and watermelon I; 25kPa for watermelon II, melon and cucumber; 20kPa for sugarbeet; and 15kPa for onion seeds. Singh*et al.* (2005) found that the metering system with a speed of 0.42 m/s, and a vacuum pressure of 2 kPa produced superior results with a quality of feed index of 94.7% and a coefficient of variation in spacing of 8.6%.Gaikwad and Sirohi (2008) found satisfactorily suction pressures of 4.91 and 3.92 kPa and nozzle diameters of 0.46 and 0.49 mm to achieve more than 90% single seed sowing in the case of capsicum and tomatoin low-cost pneumatic seeder for nursery plug trays for manual indenting and small vegetable seeds.Yazgi and Degirmencioglu (2007) on seed spacing uniformity performance of a precision metering unit when vacuum plates with different number of holes were used for the cotton and corn seeds. The forward speed values were as selected as 1.0, 1.5 and 2.0 m/swhile vacuum plates with hole diameter of 3.5 mm for cotton and 4.5 mm for corn seeds were used.. In the experiments, vacuum pressure was applied at 6.3 kPa.

MATERIAL AND METHOD

Development of pneumatic metering mechanism planter of lighter and bolder seed for groundnut, cotton, sesame and okra seeds. Study on physical

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parameter of seed and Factors affecting the performance of pneumatic metering mechanism and design of aspirator blower, optimization of suction pressure, different shapes of orifice openings of seed plate.the study was carried out at CIAE Bhopal.

Concept of pneumatic planting

The pneumatic planting concept is based on the suction pressure. An aspirator is used, to develop the suction pressure in the suction chamber, inside the pneumatic disc. The seeds are held against the orifice, made on the seed metering plate, due to the suction pressure, as the plate passes through the seed hopper. The seeds are held on the orifices, till it reaches the chamber open to the atmosphere. In the chamber open to the atmosphere, the seed is exposed to the atmospheric pressure. Thus, the suction pressure is cut off and the seeds are dropped on the grease belt or on the soil surface, under gravity**.**

Factors affecting the performance of pneumatic metering mechanism planter

The size, shape and weight of the individual seed have predominant effect upon the performance of the pneumatic seed metering mechanism. Variation of sizes and weight of the seeds would require variation in size of orifice on the seed plates and range of suction pressures for effective single seed pick up without misses. The leakage of the suction pressure from the vacuum chamber into the chamber open to the atmosphere, in the pneumatic disc would result in improper release of the lighter seeds. Similarly, the different shapes of the different seeds would also have some effect upon the planting accuracy. These aspects need suitable solution for development of an effective pneumatic planter for adoption. The leakage of the suction pressure from the vacuum chamber intothe chamber open to the atmosphere, in the pneumatic disc would result in improper release of the lighter seeds.

Physical dimensions of the seeds

From the design point of view of the pneumatic planting system, it was necessary to determine the various physical dimensions of the seeds. The average length, width & thickness of the different seeds were determined by randomly selecting the 100 kernels of each seed from the seed lot.

Different shapes of orifice openings on the seed plate.

Seed plate orifices of different shape viz, circular, elliptical and triangular were selected. The sizes of all the shapes were determined, with the consideration that the exposed area to the seed is same for all the three shaped orifices.

Sphericity of the seeds was calculated by the Following formula,

sphericity, $$\phi = \frac{[lbt]^{\frac{1}{3}}}{l}100 \qquad \ldots.1$$

Where Φ is Sphericity in %, l,b,t is Average length, width, and thickness of the seeds.

Circular shaped orifice

The size of metering orifice was determined from the following relationship

$$d_0 = 0.6b_{av} \qquad ....2$$

Where, d_o is the size of metering orifice in mm, b_{av} is Average width of seed to be held in mm.

Then, the seed exposed area was determined from the following equation;

$$A = \frac{\pi}{4}d^2 \qquad \ldots.3$$

Where, A is Seed exposed area in mm^2, d_o is Size of metering orifice (mm)

Triangular shaped orifice

The dimension of the triangular shaped orifice was calculated from the following equation;

$$A = \frac{\sqrt{3}}{4}s^2 \qquad \ldots.4$$

Where, A is Seed exposed area in mm^2, s is Side of the equilateral triangular orifice in mm.

Elliptical shaped orifice

For finding the dimension of the elliptical shaped orifice, the ratio of the average thickness and average width was taken and the length of the longer axis of elliptical shaped hole was taken equal to the multiplication of the ratio to the shorter axis. Mathematically,

$$A = \pi\gamma a^2 \qquad \ldots.5$$

Where, A is Seed exposed area in mm^2,a is longer axis of the elliptical shaped hole in mm, b is Shorter axis of the elliptical shaped hole in mm equal to γ. a, γ is ratio of the average thickness to the average width of the seed.

Theoretical design consideration of pneumatic metering mechanism planter

During operation of the centrifugal aspirator, energy from the shaft is transferred to the air flowing through impeller blades. The air is rotated about the center of the impeller at an angular velocity. The resulting centrifugal force moves the air towards the periphery and through it into the passage, surrounding the impeller. As the air is moved, from the center to the periphery of the impeller, the work done by the centrifugal force in the impeller channel, changes the flow energy and the kinetic energy of the air is converted into the pressure energy.

Air flow and static pressure requirement

The airflow rate required for the aspirator was decided on the basis of the terminal velocity required to pick single seed and the total cross sectional area of the suction chamber in the pneumatic disc. As groundnut was the heaviest of the seeds, its terminal velocity 10.87; for variety JL-24 was considered (Kachru *et al*., 1994). For creating the suction pressure inside the pneumatic disc, the total cross sectional area of the suction chamber was calculated. Slot was made between the PCD 220mm and 200 mm on the vacuum baffle for creating the suction. The suction chamber was over 330^0 portion of the

disc. Thus, the cross sectional area was calculated from the given formula,

$$A = \frac{\pi}{4} \times \frac{\theta}{360} \times \left(d_2^2 - d_1^2\right)n \qquad \ldots.6$$

Where, A is Cross sectional area of the vacuum chamber in m^2, θ is Angle of slot of the vacuum chamber on the pneumatic disc in degree, d_1, d_2 is Outer and inner diameter of the vacuum chamber in m n is Number of suction chambers in pneumatic metering unit.

$$A = \frac{\pi}{4} \times \frac{330}{360} \times \left(0.22^2 - 0.20^2\right) \times 4$$

$$A = 0.024m^2$$

Therefore, the actual quantity of the airflow required, Q was calculated as,

$$Q = A \times V \qquad \ldots..7$$

$$Q = 0.024 \times 10.87$$

$$Q = 0.26m^3/s$$

The static head is the difference of the outlet and the inlet pressure. The design pressure at the inlet was chosen as suction requirement of groundnut seed (Singh *et al.*, 2001), and pressure at the outlet was decided such that the suction pressure of 5.4 kPa is maintained at the inlet. Thus, static pressure 'H' worked out as,

H= Outlet pressure – inlet pressure

=(Atmospheric pressure + inlet pressure) – inlet pressure

=(10.33 + 0.54) – 0.54

=10.33 m of water column.

Thus, the aspirator was to be designed for airflow of 0.26 m^3/s and total head of 10.33 m of water column.

Design of the impeller

Impeller inlet diameter was calculated from the equation,

$$d_1 = 3.65 \times (Q/N)^{\frac{1}{3}} + 0.02 \qquad \ldots..8$$

Where,d1 isimpeller inlet diameter in m, N is rpm of the impeller; taken as 6000 rpm,

Therefore, $d_1$for the design parameters worked out as,

$$d_1 = 3.65 \times \left(\frac{0.26}{6000}\right)^{\frac{1}{3}} + 0.02$$

$$d_1 = 0.15m$$

The ratio of the impeller outlet to the inlet diameter generally varies from 1.6 to 2.7. Taking the ratio as 2.7,

$$d_2 = 2.7 \times d_1 \qquad ...9$$

$$d_2 = 2.7 \times 0.15$$

$$d_2 = 0.4m$$

Where, d2 isOuter diameter of the impeller in m.

Diameter of the shaft

The diameter of the shaft was decided from the torque requirement, which in turn, was determined from the power requirement at a given speed. The power requirement of the aspirator was calculated as,

$$P_{mot} = m\frac{Q'H'g}{1000\eta\eta_{tr}} \qquad \ldots..10$$

Where, Pmot **is** Power required for running the motor in hp, Q' is Actual air flow required; taken as 1.2 times theoretical airflow required, m^3/s H' is Actual static head, taken as 1.05 time theoretical head in m, η is Efficiency of the motor, assumed to be 75%, ηtrisTransmission efficiency, taken as 92% for V-belt transmission.

$$P_{mot} = 1.2\frac{1.20 \times 0.26 \times 1.05 \times 10.33 \times 9.81}{1000 \times 0.75 \times 0.92}$$

$$P_{mot} = 0.06kW$$

$$P_{mot} = 0.08hp$$

Torque transmitted was calculated from the formula,

$$P_{mot} = \frac{2\pi NT}{4500} \qquad ...11$$

Where, P is Power required in hp, N is Impeller speed in rpm, T is Torque transmitted in kg-m

$$0.08 = \frac{2\pi \times 6000 \times T}{4500}$$

$$T = 0.01kg - m$$

$$T = 1kg - cm$$

Diameter of the shaft was calculated from the given equation,

$$T = \frac{\pi}{16} f_s d^3 \qquad \ldots..12$$

Where, T is Torque transmitted by the shaft in kg-cm, f**s** **is** Torsional strength of the material, taken as 600kg/cm^2 for mild steel

d = Diameter of the shaft, cm

$$d^3 = \frac{16 \times 1}{\pi \times 600}$$

$$d = 0.2cm$$

As the calculated diameter of the shaft was very small, a shaft of standard diameter 2.5 cm was selected for the study (Pandya and Shah, 1983).

Design of Impeller hub

Impeller hub diameter is taken as 1.2 to 1.4 d.

$$d_{hub} = 1.2 \times d \qquad \ldots.13$$

$$d_{hub} = 1.2 \times 2.5$$

$$d_{hub} = 3cm$$

The length of the hub is taken as 1 to 1.5 times the hub diameter.

$$l_{hub} = 1.4 \times d_{hub} \qquad ...14$$

$$l_{hub} = 1.4 \times 3$$

$$l_{hub} = 4.2cm$$

Design of the blades

The inlet blade width is determined from the discharge equation,

$$b_1 = \frac{Q}{\pi d_1 c_1 \mu_1} \qquad \text{....15}$$

Where, Q is Air flow rate in m^3/s d1 is Impeller vane inlet diameter in m, c1 is velocity at the impeller eye in m/s, μ_1 is Factor against the blockage of air by the blades; taken as 0.85.

The velocity at the impeller inlet is calculated from the equation,

$$c_1 = \frac{4Q}{\eta_v \pi \left(d_2^2 - d_{hub}2\right)} \qquad \text{...16}$$

Where, $\eta_v$isVolumetric efficiency; taken as 0.98

$$c_1 = \frac{4 \times 0.26}{0.98 \times \pi \times \left(0.15^2 - 0.03^2\right)}$$

$$c_1 = 15.65 m/s$$

Putting the value of $c_1$in equation15,

$$b_1 = \frac{0.26}{0.85 \times \pi \times 0.15 \times 15.65}$$

$$b_1 = 0.041m$$

$$b_1 = 4cm$$

For the uniform thickness of blades, the width of the blade at the outer end is taken equal to the width of the blade at inlet i.e. 4 cm.

As in the Fig.1 *i* is the inclination of the blade with the disc plain; assumed to be 4^0.

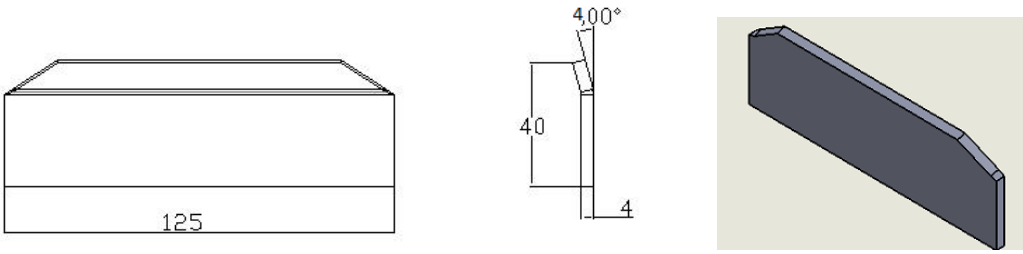

Fig.1. Impeller blade profile

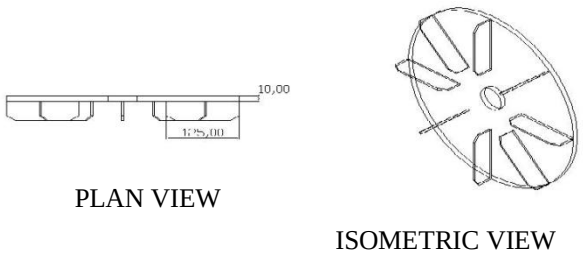

Fig.2. Side view of impeller blade.

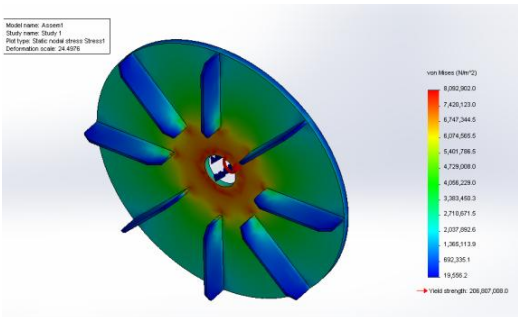

Fig. 3. static stress analysis.

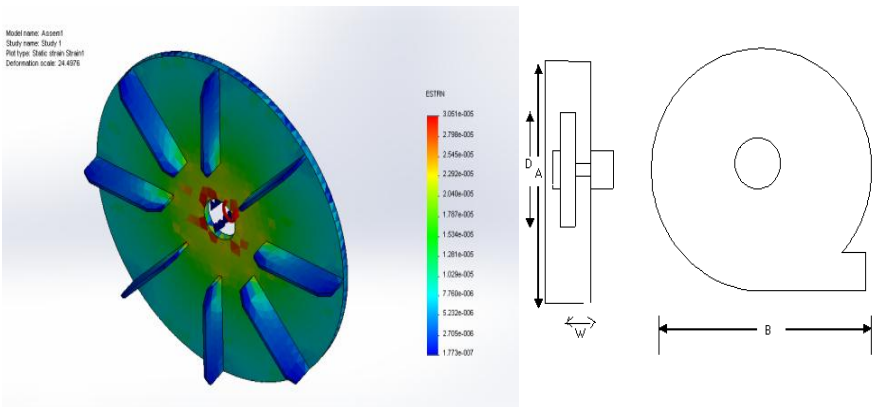

Fig.4. static strain analysisand Impeller casing

The value of $\beta_1$is calculated from the equation,

$$\tan\beta_1 = \frac{c_1}{u_1} \quad \text{....17}$$

Where, u1 is Peripheral component of the velocity at the impeller inlet, in m/s and was calculated as follow

$$u_1 = \frac{\pi d_1 N}{60} \quad \text{....18}$$

$$u_1 = \frac{\pi \times 0.15 \times 6000}{60}$$

$$u_1 = 45.65 m/s$$

Putting the values of c1 and u1 in equation 3.17,

$$\tan\beta_1 = \frac{15.65}{45.65}$$

$$\beta_1 = 19^0$$

Thus, β_{1v} can be calculated as

$$\beta_{1v} = \beta_1 + i \quad \text{....19}$$

$$\beta_{1v} = 19 + 4$$

$$\beta_{1v} = 23^0$$

β**2v** is the blade angle at the outlet and is taken as twiceβ_{1v}, thus its value was 46^0.

Therefore, number of blades was calculated from the Pliederer empirical formula,

$$Z = 6.5\frac{m+1}{m-1} Sin\frac{\beta_1 + \beta_2}{2} \quad \text{....20}$$

Putting the values of m, $\beta_{1v}$and β_{2v}in the above equation,

$$Z = 6.5\frac{2.7+1}{2.7-1} Sin\frac{23_1 + 46}{2}$$

$$Z = 8.01$$

Thus, the number of blades was selected to be 8.

Design of aspirator housing

The configuration of aspirator housing considerably affects the performance of a centrifugal aspirator and thus, it is as important as aspirator impeller. The size of housing should be decided, based on the space availability. The purpose of the housing is to control the airflow, from the inlet to the discharge, and in the process, to convert the velocity head into the static pressure head. Pressure conversion is accomplished, as the cross-section of the air stream increases, in the increasing annular space. The dimensions of the different section of the aspirator housing were determined by following formula:

$$A = 1.7 d_2 \quad \text{.....21}$$

$$A = 1.7 \times 40$$

$$A = 68 cm$$

$$B = 1.5 d_2 \quad \text{.....22}$$

$$B = 1.5 \times 40$$

$$B = 60 cm$$

$$C = 1.25 b + 0.1 d_2 \quad \text{....23}$$

$$C = 1.25 \times 4 + 0.1 \times 40$$

$$C = 9 cm$$

Table1. Design values of Aspirator.

S.NO.	Centrifugal Aspirator	Values
1	Impeller outside diameter, cm	40
2	Impeller inlet diameter, cm	14.50
3	Impeller thickness, cm	4
4	Type of blade	Radial
5	Number of blades	8
6	Inlet blade angle	23^0
7	Outlet blade angle	46^0
8	Diameter of the shaft, cm	2.50
9	Diameter of the hub, cm	3.0
10	Hub length, cm	4.2
11	Type of casing	Volute type
12	Height of the casing, cm	68
13	Width of the casing, cm	60

Table2. Physical properties of different seed.

Particulars	Ground Nut	Cotton	Sunflower	Okra
Variety	Vaishali	Jk-4	MSH-17	Anamika
Average length, mm	11.51	7.78	9.52	5.80`
Average width, mm	7.49	4.35	5.12	5.03
Average thickness mm	6.76	3.50	3.27	4.70
Weight of 1000 grain g	460	59	49	56
Sphericity, %	72	63	57	89
Designed size of seed plate orifice, mm	4.5	2.6	3.07	3.0

RESULT AND DISCUSSION

Physical properties of different seed

In view of the objective of the study a laboratory pneumatic planting system consisting of aspirator and seed metering assembly was designed and developed.Physiscal properties of different seeds were measured for deciding the shape and size of the seed plate orifice for single seed pickup. Physical properties such as length, width, thikness, sphericity and thousand of weight was measured for groundnut, cotton, sesame and okra as shown in Table 2.

From Table 2 it was observed that groundnut was the largest of the seeds where the average length,width,thickness of seed were 11.51,7.49,and 6.76mm respectively, where as sesame seed was the shortest of the seeds where the average length,width,thickness were 3.19,2.24,and 0.80mm respectively. Groundnut was the heaviest seed in thousand grain weights of 460g while sesame, cotton, and okra of thousand grain weight were of 2.37,59 and 56g respectively.

From the table it was observed that sphericity of okra seed was found 89% which was largest of the seed selected for the all seeds. Being a flat seeds the sphericity of sesame seed was 56% which was least while cotton and groundnut of 63 and 735 respectively in elliptical shape. Seed plate orifice for the groundnut and sesame was longest 4.5mm and 1.35mm respectively. The orifice diameter of okra and cotton were found to be 2.6 and 3mm respectively.

Performance of the circular orifice seed plate under varying suction pressure for different seeds

The study for groundnut, sesame, cotton and okra were carried out with sees plate with circular shaped orifice with 4 number of orifices .the diameter of seed plate orifice for groundnut,cotton,sesame and okra seeds was 4.5,3,1.5, and 3mm respectively.

The Table 3, 4, 5 and 6 shown the placement behavior of the seeds in terms of the number of seeds dropped (skip, single, multiple) for the different seeds. As shown in Table 3 for groundnut seed test conducted at pressure from 3.5to 5.4 kPa and observed that with the increase in the suction pressure, the number of seeds, picked by each orifice increased. The percent of missing and multiple was highest at the suction pressure of 3.5kPa with 32 and 5.4 kPa with 13%.at the suction pressure of 5.0kPa the seed plate gave the highest single seed pickup 93% with no misses and minimum multiple of 7% which was the best performance under the different suction pressure.For cotton seeds test conducted at pressure from 1 to 2.5kPa and observed that the percent missing was highest at suction pressure 1kPa whereas percent of multiples was highest at suction pressure of 2.5kPa.The highest percent of single seed were picked at a suction pressure of 2.0kPa with 92% with no missing and 8% multiples shown in Table 4.

For sesame seed test conducted at pressure from 0.1 to 0.35kPa and observed that percent missing was highest at suction pressure 0.1kPa whereas percent of multiples was highest at suction pressure of 0.35kPa. The highest percent of single seed were picked at a suction pressure of 0.30kPa with 92% with no missing and 8% multiples shown in Table 5. For okra seed test conducted at pressure from 1 to 2.5kPa and observed that percent missing was highest at suction pressure1kPa whereas percent of multiples was highest at suction pressure of 2.5kPa. The highest percent of single seed were picked at a suction pressure of 2kPa with 91% with no missing and 9% multiples shown in Table 6.It was observed that suction pressure required to pick the individual seed dependent upon the weight of the seeds. Due to heavier weight of Groundnut it requires high suction pressure while in sesame require low pressure due to lighter weight.This result resemble the work done by Short and Hubber (1970) and Karayel(2004).

Table 3. Performance of the 4.5 mm circular orifice seed plate under varying suction pressure for groundnut seed

S.No	Suction pressure inside pneumatic disc kPa	Particulars of seed per orifice	% picking
1	3.5	Skip (0)	32
		Single (1)	68
		Multiple (>1)	0
2	4.5	Skip (0)	14
		Single (1)	84
		Multiple (>1)	2
3	5.0	Skip (0)	0
		Single (1)	93
		Multiple (>1)	7
4	5.4	Skip (0)	0
		Single (1)	87
		Multiple (>1)	13

Table 4. Performance of the 3.0 mm circular orifice seed plate under varying suction pressure for cotton seed

S. No	Suction pressure inside pneumatic disc kPa	Particulars of seed per orifice	% picking
1	1.0	Skip (0)	26
		Single (1)	73
		Multiple (>1)	1
2	1.5	Skip (0)	10
		Single (1)	85
		Multiple (>1)	5
3	2.0	Skip (0)	0
		Single (1)	92
		Multiple (>1)	8
4	2.5	Skip (0)	0
		Single (1)	84
		Multiple (>1)	16

Table 5. Performance of the 1.5 mm circular orifice seed plate under varying suction pressure for sesame seed

S.No	Suction pressure inside pneumatic disc kPa	Particulars of seed per orifice	% picking
1	0.1	Skip (0)	32
		Single (1)	68
		Multiple (>1)	0
2	0.25	Skip (0)	11
		Single (1)	85
		Multiple (>1)	4
3	0.3	Skip (0)	0
		Single (1)	92
		Multiple (>1)	8
4	0.35	Skip (0)	0
		Single (1)	84
		Multiple (>1)	16

Table 6. Performance of the 3.0 mm circular orifice seed plate under varying suction pressure for okra seed

S.No	Suction pressure inside pneumatic disc kPa	Particulars of seed per orifice	% picking
1	1.0	Skip (0)	23
		Single (1)	74
		Multiple (>1)	3
2	1.5	Skip (0)	12
		Single (1)	83
		Multiple (>1)	5
3	2.0	Skip (0)	0
		Single (1)	91
		Multiple (>1)	9
4	2.5	Skip (0)	0
		Single (1)	81
		Multiple (>1)	19

Table 7. Effect of size of the seed plate orifice upon pneumatic planting

S No	**seed**	**Shape of the orifice**	**Dimension (mm)**	**Miss**	**Single**	**Multiple**
1	Groundnut	Elliptical	(5.5 x 5)	0	89	11
			(5 x 4.5)	0	93	7
2	Cotton	Elliptical	(3.5 x 3)	0	86	14
			(3 x 2.5)	0	92	8
3	Okra	Circular	(3.50)	0	87	13
			(3.0)	0	91	9
4	Sesame	Circular	(2.4 x 0.8)	0	93	7
			(1.5 x 0.8)	10	90	0

Effect of size of the seed plate orifice upon pneumatic panting

For the studying of effect of sizes of the seed plate orifice upon pneumatic panting of the single seeds, tests were connected to optimized suction pressure of the different seeds using the seed plates of different shape.

Test were conducted at optimized suction pressure o 5kPa using elliptical shaped orifice of longer and shorter axis (5,4.5) and (5.5,5) mm respectively for groundnut. Elliptical shaped orifices with longer and shorter axis 5 and 4.5 mm gave best results with 93% single seed picking with no misses and minimum multiple 7%. As showin Table 7For cotton elliptical shape orifice of longer and shorter orifice axis 3 and 2.5 mm gave the best results with 92% and no misses while in sesame (2.24,0.80) and (1.50,0.80) mm respectively with air flow velocity of 3.3 m/s of positive pressure chamber of the pneumatic disc. In sesame, elliptical orifices with longer and shorter axis 2.24 and 0.80 mm gave best results with 93% single seed picking and 7% multiple. In cotton test results showed that seed plate with 3mm diameter orifice gave the best results with 91% single seed picking. It was observed that with the increase in the dimensions of the orifice there was simultaneous increase in the number of multiples whereas decrease in the orifice dimension resulted in increase in the no of misses it is due to the reason that with the increase in the orifice opening more number of seeds are exposed to the suction pressure.

SUMMARY AND CONCLUSION

It was concluded that in this study that the centrifugal type radial blade aspirator with the impeller outer diameter 40cm and 8 numbers of blades on the impeller was sufficient to create the required suction pressure. For groundnut, cotton, okra and sesame seed the optimum suction pressure for single seed pickup through circular orifice were 5.0, 2.0,2.0 and 0.3 kPa respectively. It was also concluded that increase in suction pressure increased in the number of seed selected per orifice. The shape of the seed plate orifice has considerable effect upon the pneumatic planting of the different seeds.

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RESEARCH ARTICLE

INTEGRATED PEST AND DISEASE MANAGEMENT THROUGH ORGANIC FARMING APPROACHES IN MUSTARD

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Abstract: Field experiment was conducted to study the effect of the different organic modules for management of *Alternaria blight* and *Powdery mildew* diseases of Indian Mustard (Brassica juneca)(L.) Czern &Coss) Efficacy of different organic modules were also tested against aphid management in successful growing of organic mustard.Treatment module comprising of seed treatment with *Trichoderma viride*@8g/kg seed +foliar spray of Azadirachtin @3ml/lit.at 5-10DAS+Neem oil spray@2% at 10-20DAS+NSKE spray@5% at 30-40 DAS+cow urine spray@10% at 50-60DAS+milk whey spray @10% at 60-75 DAS was found significantly superior over control and gave maximum seed yield of mustard 13.65q/ha. in comparison to control which gave only 10.16q/ha. mustard seed yield.This organic module was found superior in respect to disease control also,and effectively controlled both the diseases and record minimum disease intensity of *Alternaria blight(*15.94%) and *Powdery mildew* 17.67%. Where as in control 38.32% and 48.15% disease intensity was observed respectively. This module gave the highest net return of Rs.23294/over control with maximum B:C ratio of 1.88,1.83 and 1.84 in year 2012-13 & 2013-14 &2014-15respectively.

Keywords: Mustard, *Alternaria blight*, *Powdery mildew*, Aphids *Trichoderma viride*, Milk whey, *Azedirachtin*

INTRODUCTION

Mustard is one of the most important oil seed crops of India and state of Rajasthan dominates in production of mustard in India. Being a cash crop, there is a great demand of organic mustard (Sahota, 13) Organic mustard in Rajasthan represent a very negligible part of our total oil production. The one of the constraints in increasing the area under organic mustard production is look of suitable organic production practices for different agro climate regions. The present investigation was aimed to study the influence of certain bioagent, organic manures bio pesticides on diseases control and yield of mustard in southern Rajasthan

Organic farming is gaining gradual momentum across the world. In India about 528171 hectare area is under organic farming with 44926 numbers of certified organic farms (willer, 2011)

Among various annual oil seeds crop cultivated in India, the rapeseed mustard is accounted for 25 percent total area and 1/3 of total oil production in the country after groundnut.India ranked third after Canada and China in Area (19.3%) and production (11.1%).In India rapeseed mustard is being cultivated in seven ststes viz Rajasthan, Madhya Pradesh, Utter Pradesh, Haryana, West Bengal, Assam and Gujarat, which contributes maximum to its production and productivity. Among the states, Rajasthan owns the share of almost 50 to total production and acreage in the country with productivity of 1046 Kg/ha. during 2014-15.

Alternaria blight and *Powdery mildew* disease are most important diseases of mustard in India.The diseases causes heavy lossess depending upon the stage of infection. Chemical management of both diseases and sucking pest aphids by fungicides and insectisides is un economical and environmentally hazardous. Therefore, there is a need to look for non hazardous and eco friendly control measures for plant diseases and pest management. In this context an investigation was planned to evaluate the efficacy of organic module against *Alternaria brassicae* and *Erysiphae poligoni* pathogens causing *Alternaria blight* and *Powdery mildew* diseases in mustard respectively.

MATERIAL AND METHOD

The efficacy of eight different modules were tested against Alternaria blight&Powdery mildew diseases and sucking pest Aphids in mustard at Dryland Farming Research Station Arjia, Bhilwara during 2012-13,2013-14&2014-15. Mustard variety Laxmi was sown in Randomized Block Design with three replications The unit plot size was 5.0x3.6 m and mustard seed were sown in first fortnight of October during both years. Prior to sowing mustard seeds were treated with *Trichoderma viride @8g/kg seed* . In control plot seeds were sown without any treatment. Treatment details are as follows:

T_1- Seed treatment with *Trichoderma viride@* 8 g/kg seed + *NSKE* @ 5% spray at 5-10 DAS + 10 - 20DAS+30-40DAS+ 50-60 DAS + 60-75 DAS

T_2- Seed treatment with *Trichoderma viride* @ 8 g/kg seed +Neem oil @ 0.2% at 5-10 DAS + 10 -20 DAS +30-40DAS+50- 60 DAS+ 60-75 DAS

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T_3- Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *Azedirachtin* @3 ml/ lit. at 5-10 DAS + 10 -20 DAS + 30-40DAS+50-60 DAS+ 60-75 DAS.

T_4 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed +spray of milk whey @ 10% at 5-10 DAS + 10-20 DAS +cow urine @ 10 ml / lit. at 30-40DAS+ 50-60DAS+ 60-75 DAS.

T_5- Seed treatment with *Trichoderma viride* @ 8 g/kg seed + spray of NSKE @ 5% at 5-10 DAS+ Oak leaves extract spray @ 10% at 20-30 DAS+ Neem oil spray @2% at30-40 DAS+Cow urine spray@10% at 50-60 DAS+ *Azedirachtin* spray @ 3 ml/lit.at60-75 DAS

T_6- Seed treatment with *Trichoderma viride* @8g/kg seed +Spray of *Azadirachtin* @3 ml/lit at 5-10 DAS + Neem oil spray @ 2% at10-20 DAS+NSKE spray @5% at 30-40 DAS+cow urine spray @10% at 50-60 DAS+Milk whey spray @10% at 60-75 DAS.

T_7- Seed treatment with *Trichoderma viride* @8 g/kg seed +Spray of NSKE @ 5% at 5-10 DAS+cow urine @10% at10-20 DAS+ Neem oil spray @2% at30-40 DAS + Milk whey spray @10% at 50-60DAS+ Oak leaves Extract spray @ 10% at 60-75DAS.

T_8- Control (Without any treatment)

- NSKE = Neem seed kernel extract
  * DAS = Days after sowing

Preparation and application of the treatments

Mustard field was given. Farm Yard Mannure @2 ton/ha. prior to sowing crop. Sowing was done using seed treatment with *Trichoderma viride* @ 6g/Kg seed of mustard. Beside a pre sowing irrigation, crop was given four irrigations. For organic amendment in soil Neem cake @ 200 Kg/ha. were given at the time of field preparation, as a cultural practice summer sloughing was also done after the harvesting of previous crop in summer.

In order of preparation of two pesticides NSKE was prepared using 1.0 kg of Neem kernels. The kernels were dried and grounded in a grinding machine as course powder and added one lit. of water and kept it for overnight. Extracts was filtered through muslin cloth to get 100% stock solution of NSKE. 5ml of this solution adding in 100 ml of water will be treated as 5% NSKE solution. Oak leaves extracts was also prepared by using this method fresh 100 gm oak leaves were grounded in 100 ml of water and then filtered it by using muslin cloth. Obtained extracts (2ml) was added to 100 ml. water that is, it was of 2% oak leaves extract. Milk whey also applied this way in which we used 100 ml milk whey added in 1 lit. water then it becomes 10% milk whey spray solution. All bio pesticides were exercised as per scheduled, at initiation of the disease on the standing crop at 10-15 days interval according to the treatments,while control plots were sprayed with plain water. The experiment was irrigated four times and other inter cultural operations were done when necessary. The crop was harvested offer 125-130 days. The data were recorded farm randomly selected 10 plants/Plot for disease severity of *Alternaria blight* & *Powdery mildew* of mustard started from just before first spray of bio pesticide. Mustard yield (q/ha-1) and disease scoring data were recorded on, whole plot basis and then diseases score data converted in to disease severity. (PDJ) The efficacy of bio pesticides were measured by scoring the disease (PDI) in the individual plot on the basis of a standard score scale (Anonymous 1994) Where O= Leaf and pods free from in infection 1= 1-5% leaves are infected, 2=6-20% leaves are infected, 3 = 21-40% leaves & pods are infected 4=41-70% leaves & fruits are infected. The disease data were converted in to percent disease index (PDI) suggested by Sharma (1984) & Rahman et al (1986) Data were analyzed following the statistical procedure followed by Gomez & Gomez (1983)

RESULT AND DISCUSSION

All the bio pesticides used in trial significantly reduced the severity of *Alternaria blight* & *Powdery mildew* diseases in mustard. A significant variation among the bio pesticide treatment was observed. Data presented in Table No. 1,2 &3 revealed that treatment module comprising of seed treatment with *Trichoderma viride* @ 8g/Kg seed + spray & Azedirechtin @ 3 ml/lit at 5-10 DAS + Neem oil spray @ 2% at 10-20 DAS + NSKE spray @ 5% at 30-40 DAS + cow urine spray @ 10% at 50-60 DAS + Milk whey spray @ 10% at 60-75 DAS was found significant superior over control and gave maximum seed yield of mustard 13.65q/ha., in comparison to control which gave only10.16 q/ha mustard seed yield with highest (38.32%) PDI of *Alternaria blight* and 48.15% *Powdery mildew* diseases respectively in organic mustard. This module effectively controlled disease as well as Aphid population and showed least PDI of *Alternaria blight* (15.94%) and 17.67% Powdery mildew. Minimum aphid population 93.67/10cm of per plant were also recorded at 3 days after sowing under this module. This module showed effectively control of pest & disease management in organic mustard.

Above results clearly indicated that among plant extracts Neem cake, NSKE Neem oil, Azerachtin, cow urine, milk whey can be selected for further integration with *T. viride* as they showed satisfactory controlled the *Alternaria blight & Powdery mildew* as well as aphid population also. They all showed synergetic effect with each other it may be due to suitability of constituents present in bio pesticides & leaf extracts. Ravi Chander (1987) reported that growth of *Rhizoctonia solani* was completely inbihited with the leaf extract of subabul, but its efficacy was not tested against fungal antagonist by any worker earlier. Neem and Akven leaf extracts reduced the viability of *sclerotia* of *R.solani*

(Laxman and Nair 1984) and mycelia growth considerably *in vitro* (Mani Bhusan Rao et al. 1988)It has suggested that treatment with biocontrol agents initiated in the plants anumber of biochemical changes which can be considerd to be a part of plant defence responses(Sharma et al 2010) In Present finding Neem seed kernel and neem based formulations were found inhibitory nature against pathogen as well as antagonist effect against aphid population, therefore it can used for further investgation.

Economics

The study also indicate that initially organic farming attributed lower productivity and yield losses but there was an overall improvement in soil quality parameters indicating better soil health.It is economically feasible to practice organic farming when the farmers are able to get premium price for their produce and with the reduced cost of cultivation by not depending upon the purchased off farm inputs. On an average of three years productivity of mustard yield was found lower by 20-22% in comparison to conventional farming. However due to availability of premium price (20-40%) for organic mustard the average net profit was 25-30% higher in organic farming compared to the conventional farming (Table no. 3.)

The economics of organic mustard cultivation over a period of three years indicated that there is a reduction in cost of cultivation and increased gross and net returns compared to conventional mustard cultivation at research station.Three years pooled analysis data on pest and disease management and yield attributes are depicted in Table no. 3 revealed that application of organic treatments viz. seed treatment with *Trichoderma viride*@8g/kg seed +foliar spray of Azedirachtin @3ml/lit.+Neem oil spray @2% Foliar spray of Neem seed kernel Extract (NSKE)@5%+cow urine @10%+Milk whey spray @10% found significant superior over control plot during cropping period. All the organic treatments showed effective control of *Alternaria blight* and recorded minimum PDI (15.94%) while in control Maximum PDI Of *Alternaria blight* 38.32% was observed. Similar trends were observed in case of *Powdery mildew* disease and showed minimum infection (17.67%) of powdery mildew was observed in experimental trial of organic mustard.

The above treatment was found best in controlling sucking pest population also. This organic module also effectively controlled Aphid population and record minimum Aphid (114) population at per plant while in control 244 Aphids were found at every 10 cm terminal growth of mustard plants at seven days after sowing. All organic treatments effectively controlled pest and disease in organic mustard amongst eight treatments .The best treatment gave highest gross return and net return over control of Rs 50,552/&23,294/ respectively while Maximum B:C ratio of 1:1.88 was also recorded under best treatment in organic mustard cultivation during experimentation.

Table 1. Efficacy of different organic modules for Disease management in organic mustard(2012-13, 2013-14 & 2014-15)

Treatments	PDI of A.blight			
	2012-13	2013-14	2014-15	mean
T_{1} - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *NSKE* @ 5% spray at 5-10 DAS + 10-20 DAS+30-40 DAS+ 50-60 DAS + 60-75 DAS	**20.20 (26.65)**	**25.10 (30.07)**	**28.34 (32.15)**	**24.54 (29.68)**
T_{2} - Seed treatment with *Trichoderma viride* @ 8 g/kg seed +Neem oil @2% at 5-10 DAS + 10 -20 DAS + 30-40 DAS + 50-60 DAS+ 60-75 DAS	**26.50 (30.72)**	**30.28 (33.40)**	**35.41 (36.51)**	**30.73 (33.65)**
T_{3} - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *Azedirachtin* @3 ml/ lit. at 5-10 DAS+10-20 DAS+30-40 DAS+50-60DAS+ 60-75 DAS	**15.24 (22.94)**	**20.43 (26.85)**	**25.32 (30.20)**	**20.33 (26.78)**
T_{4} - Seed treatment with *Trichoderma viride* @ 8 g/kg seed +spray of milk whey @ 10% at 5-10 DAS + 10-20 DAS +cow urine@10ml/lit.at30-40 DAS+50-60 DAS+ 60-75 DAS	**17.70 (24.88)**	**22.50 (28.32)**	**24.23 (28.47)**	**21.47 (27.56)**
T_{5} - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + spray of NSKE @ 5% at 5-10 DAS + Oak leaves extract spray @ 10% at 20-30 DAS+ Neem oil spray @ 2% at 30-40 DAS + Cow urine spray@10% at 50-60 DAS + *Azedirachtin* spray @ 3 ml/lit.at60-75 DAS	**20.18 (26.67)**	**25.58 (30.40)**	**29.25 (32.75)**	**25.00 (30.00)**
T_{6} - Seed treatment with *Trichoderma viride* @ 8g/kg seed +Spray of *Azedirachtin* @3 ml/lit at 5-10 DAS + Neem oil spray @ 2% at10-20 DAS+NSKE spray @5% at 30-40 DAS+cow urine spray @10% at 50-60 DAS+Milk whey spray @10% at 60-75 DAS	11.25 (19.55)	16.45 (23.93)	20.14 (26.66)	15.94 (23.50)

T_7 - Seed treatment with *Trichoderma viride* @8 g/kg seed+Spray of NSKE @ 5% at 5-10 DAS+cow urine @10% at 10-20 DAS+ Neem oil spray @ 0.2% at 30-40 DAS + Milk whey spray @10% at 50-60 DAS + Oak leaves Extract spray @ 10% at 60-75DAS	18.35 (25.35)	25.20 (30.13)	32.22 (34.57)	25.25 (30.13)
T_8 - Control	29.38 (32.76)	40.34 (39.43)	45.26 (42.25)	38.32 (38.23)
SEM ±	1.09	1.10	1.12	
CD (0.05%)	3.21	3.29	3.35	
CV	8.33	10.40	10.94	

Table 2. Efficacy of different organic modules for Disease management against Powdery mildew in organic mustard(2012-13, 2013-14 & 2014-15)

Treatments	PDI of Powdery mildew			
	2012-13	**2013-14**	**2014-15**	**mean**
T_1 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *NSKE* @ 5% spray at 5-10 DAS + 10-20 DAS+30-40 DAS+ 50-60 DAS + 60-75 DAS	36.20 (37.41)	40.86 (39.73)	42.36 (40.57)	38.53 (38.57)
T_2 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed +Neem oil @2% at 5-10 DAS + 10 -20 DAS + 30-40 DAS + 50-60 DAS+ 60-75 DAS	35.30 (36.46)	40.44 (35.92)	45.25 (42.27)	37.87 (36.19)
T_3 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *Azedirachtin* @3 ml/ lit. at 5-10 DAS+10-20 DAS+30-40 DAS+50-60DAS+ 60-75 DAS	20.12 (26.63)	28.32 (32.15)	29.25 (32.75)	24.22 (29.39)
T_4 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed +spray of milk whey @ 10% at 5-10 DAS + 10-20 DAS +cow urine@10ml/lit.at30-40 DAS+50-60 DAS+ 60-75 DAS	30.32 (33.38)	36.56 (37.20)	39.32 (38.82)	33.44 (35.29)
T_5 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + spray of NSKE @ 5% at 5-10 DAS + Oak leaves extract spray @ 10% at 20-30 DAS+ Neem oil spray @ 2% at 30-40 DAS + Cow urine spray@10% at 50-60 DAS + *Azedirachtin* spray @ 3 ml/lit.at60-75 DAS	33.36 (35.50)	35.50 (36.57)	38.48 (38.32)	34.43 (36.03)
T_6 - Seed treatment with *Trichoderma viride* @ 8g/kg seed +Spray of *Azedirachtin* @3 ml/lit at 5-10 DAS + Neem oil spray @ 2% at10-20 DAS+NSKE spray @5% at 30-40 DAS+cow urine spray @10% at 50-60 DAS+Milk whey spray @10% at 60-75 DAS	15.22 (22.89)	20.12 (26.65)	25.32 (30.20)	17.67 (24.77)
T_7 - Seed treatment with *Trichoderma viride* @8 g/kg seed+Spray of NSKE @ 5% at 5-10 DAS+cow urine @10% at 10-20 DAS+ Neem oil spray @ 0.2% at 30-40 DAS + Milk whey spray @10% at 50-60 DAS + Oak leaves Extract spray @ 10% at 60-75DAS	26.79 (31.09)	29.87 (33.09)	33.36 (35.27)	28.33 (32.09)
T_8 - Control	45.55 (42.44)	50.76 (45.42)	52.47 (46.43)	48.15 (43.93)
SEM ±	1.08	1.12	1.10	
CD (0.05%)	3.17	3.35	3.30	
CV	6.49	9.80	9.80	

Table 3. Efficacy of different organic modules for Disease management and yield attributes in organic mustard (2012-13, 2013-14 & 2014-15)

Treatments	Yield (q/ha)			
	2012-13	**2013-14**	**2014-15**	**mean**
T_1 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *NSKE* @ 5% spray at 5-10 DAS + 10-20 DAS+30-40 DAS+ 50-60 DAS + 60-75 DAS	10.32	11.40	12 .40	11.37
T_2 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed +Neem oil @2% at 5-10 DAS + 10 -20 DAS + 30-40 DAS + 50-60 DAS+ 60-75 DAS	10.15	11.68	11.69	11.17
T_3 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *Azedirachtin* @3 ml/ lit. at 5-10 DAS+10-20 DAS+30-40 DAS+50-60DAS+ 60-75 DAS	12.54	13.30	13.55	13.13

T_4 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed +spray of milk whey @ 10% at 5-10 DAS + 10-20 DAS +cow urine@10ml/lit.at30-40 DAS+50-60 DAS+ 60-75 DAS	11.43	12.28	13.50	12.40
T_5 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + spray of NSKE @ 5% at 5-10 DAS + Oak leaves extract spray @ 10% at 20-30 DAS+ Neem oil spray @ 2% at 30-40 DAS + Cow urine spray@10% at 50-60 DAS + *Azedirachtin* spray @ 3 ml/lit.at60-75 DAS	11.21	11.88	12.51	11.86
T_6 - Seed treatment with *Trichoderma viride* @ 8g/kg seed +Spray of *Azedirachtin* @3 ml/lit at 5-10 DAS + Neem oil spray @ 2% at10-20 DAS+NSKE spray @5% at 30-40 DAS+cow urine spray @10% at 50-60 DAS+Milk whey spray @10% at 60-75 DAS	13.16	13.84	13.96	13.65
T_7 - Seed treatment with *Trichoderma viride* @8 g/kg seed+Spray of NSKE @ 5% at 5-10 DAS+cow urine @10% at 10-20 DAS+ Neem oil spray @ 0.2% at 30-40 DAS + Milk whey spray @10% at 50-60 DAS + Oak leaves Extract spray @ 10% at 60-75DAS	12.26	12.88	13.52	12.88
T_8 - Control	9.49	10.14	10.86	10.16
SEM ±	0.68	0.73	0.83	
CD (0.05%)	2.00	2.18	2.49	
CV	12.01	13.34	13.34	

Table 4. Efficacy of different organic modules for Aphid management in organic mustard (2012-13&2013-14 &2014-15)

Treatments	Mean no. of Aphids at 10cm/per plant(3DAS)				Mean no. of Aphids at 10cm/per plant(7DAS)			
	2012-13	2013-	2014-15	Mean	2012-	2013-	2014-15	Mean
T_1 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *NSKE* @ 5% spray at 5-10 DAS + 10-20 DAS+30-40 DAS+ 50-60 DAS + 60-75 DAS	125 *(11.20)	127 (11.29)	118 (10.88)	123.33 (11.12)	135 (11.64)	168 (12.98)	125 (11.20)	142.67 (11.96)
T_2 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed +Neem oil @2% at 5-10 DAS + 10 -20 DAS + 30-40 DAS + 50-60 DAS+ 60-75 DAS.	134 (11.59)	144 (12.02)	122 (11.06)	133.33 (11.56)	139 (11.81)	131 (11.46)	142 (11.93)	137.33 (11.74)
T_3 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *Azedirachtin* @3 ml/ lit. at 5-10 DAS+10-20 DAS+30-40 DAS+50-	143 (11.97)	149 (12.22)	125 (11.20)	139 (11.81)	115 (10.95)	150 (12.26)	135 (11.64)	133.33 (11.56)
T_4- Seed treatment with *Trichoderma viride* @ 8 g/kg seed + spray of milk whey @ 10% at 5-10 DAS + 10-20 DAS+cowurine@10ml/lit.at30-40DAS+50-60DAS+60-75 DAS	105 (12.27)	170 (13.06)	115 (10.74)	130 (11.42)	120 (10.97)	126 (11.24)	117 (10.83)	121 (11.02)
T_5 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + spray of NSKE @ 5% at 5-10 DAS + Oak leaves extract spray @ 10% at 20-30 DAS s+ Neem oil spray @ 2% at 30-40 DAS + Cow urine spray@10% at 50-60 DAS + *Azadirachtin* spray	110 (10.51)	114 (10.70)	109 (10.46)	111 (10.55)	131 (11.46)	146 (12.10)	115 (10.74)	130.67 (11.45)
T_6 - Seed treatment with *Trichoderma viride* @ 8g/kg seed +Spray of *Azadirachtin* @3 ml/lit at 5-10 DAS + Neem oil spray @ 2% at 10-20 DAS + NSKE spray @5% at 30-40 DAS + cow urine	95 (9.77)	96 (9.82)	90 (9.51)	93.67 (9.70)	119 (10.93)	121 (11.02	102 (10.12)	114 (10.70)
T_7 - Seed treatment with *Trichoderma viride* @8 g/kg seed+Spray of NSKE @ 5% at 5-10 DAS+cow urine @10% at 10-20 DAS+ Neem oil spray @ 0.2% at 30-40 DAS + Milk whey spray @10% at 50-60 DAS + Oak leaves Extract spray @ 10% at 60-75DAS	102 (10.12)	102 (10.12)	108 (10.41)	104 (10.22)	125 (11.20)	137 (11.72)	110 (10.51)	124 (11.15)
T_8 - Control	250 (15.82)	252 (15.85)	175 (13.24)	225.66 (15.03)	263 (16.23)	266 (16.32)	205 (14.33)	244 (15.63)
SEM ±	0.23	0.62	0.53		0.19	0.62	0.52	
CD (0.05%)	0.66	1.82	1.49		0.57	1.81	1.45	
CV	3.93	9.04	9.45		3.24	8.60	9.23	

*Figures in The parentheses are square root transformed value
DAS=Days after spraying

Table 5. Economics of Oeganic Musrard (2012-13&2013-14 &2014-15)

Treatments	(Gross return)				(Net return)			
	2012-13	2013-	2014-	Mean	2012-	2013-	2014-15	Mean
T_1 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *NSKE* @ 5% spray at 5-10 DAS + 10-20 DAS+30-40 DAS+ 50-60 DAS + 60-75 DAS	37152	39900	49600	42211	12172	13671	19400	15081
T_2 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed +Neem oil @2% at 5-10 DAS + 10 -20 DAS + 30-40 DAS + 50-60 DAS+ 60-75 DAS.	36540	40880	46760	41393	10900	13958	14219	13025
T_3 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *Azedirachtin* @3 ml/ lit. at 5-10 DAS+10-20	45144	46550	53200	48298	18064	28116	21955	22711
T_4- Seed treatment with *Trichoderma viride* @ 8 g/kg seed + spray of milk whey @ 10% at 5-10 DAS + 10-20 DAS+cowurine@10ml/lit.at30-40DAS+50-60DAS+60-75	41148	42980	54000	46042	17338	17980	21311	18873
T_5 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + spray of NSKE @ 5% at 5-10 DAS + Oak leaves extract spray @ 10% at 20-30 DAS s+ Neem oil spray @ 2% at 30-40 DAS + Cow urine spray@10% at 50-60 DAS +	40356	41580	50040	43992	15436	15414	20382	17071
T_6 - Seed treatment with *Trichoderma viride* @ 8g/kg seed +Spray of *Azadirachtin* @3 ml/lit at 5-10 DAS + Neem oil spray @ 2% at 10-20 DAS + NSKE spray @5% at 30-40 DAS + cow urine spray @10% at 50-60 DAS +	47376	48440	55840	50552	22246	22054	25582	23294
T_7 - Seed treatment with *Trichoderma viride* @8 g/kg seed+Spray of NSKE @ 5% at 5-10 DAS+cow urine @10% at 10-20 DAS+ Neem oil spray @ 0.2% at 30-40 DAS + Milk whey spray @10% at 50-60 DAS + Oak leaves Extract spray @ 10% at 60-75DAS	44136	45080	54080	47765	19696	19418	23859	20991
T_8 - Control	34164	35490	43440	37698	11994	12212	15856	13330

Table 6. Economics of Oeganic Musrard (2012-13&2013-14 &2014-15)

Treatments	(B:C Ratio)		
	2012-13	2013-14	2014-15
T_1 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *NSKE* @ 5% spray at 5-10 DAS + 10-20 DAS+30-40 DAS+ 50-60 DAS + 60-75 DAS	1.49	1.52	1.64
T_2 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed +Neem oil @2% at 5-10 DAS + 10 -20 DAS + 30-40 DAS + 50-60 DAS+ 60-75 DAS.	1.43	1.51	1.43
T_3 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + *Azedirachtin* @3 ml/ lit. at 5-10 DAS+10-20 DAS+30-40 DAS+50-60DAS+ 60-75 DAS	1.66	1.63	1.70
T_4- Seed treatment with *Trichoderma viride* @ 8 g/kg seed + spray of milk whey @ 10% at 5-10 DAS + 10-20 DAS+cowurine@10ml/lit.at30-40DAS+50-60DAS+60-75 DAS	1.72	1.71	1.65
T_5 - Seed treatment with *Trichoderma viride* @ 8 g/kg seed + spray of NSKE @ 5% at 5-10 DAS + Oak leaves extract spray @ 10% at 20-30 DAS s+ Neem oil spray @ 2% at 30-40 DAS	1.61	1.58	1.68
T_6 - Seed treatment with *Trichoderma viride* @ 8g/kg seed +Spray of *Azadirachtin* @3 ml/lit at 5-10 DAS + Neem oil spray @ 2% at 10-20 DAS + NSKE spray @5% at 30-40 DAS + cow	1.88	1.83	1.84
T_7 - Seed treatment with *Trichoderma viride* @8 g/kg seed+Spray of NSKE @ 5% at 5-10 DAS+cow urine @10% at 10-20 DAS+ Neem oil spray @ 0.2% at 30-40 DAS + Milk whey spray @10% at 50-60 DAS + Oak leaves Extract spray @ 10% at 60-75DAS	1.80	1.75	1.78
T_8 - Control	1.54	1.52	1.57

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RESEARCH ARTICLE

PRODUCTIVITY AND COMPATIBILITY OF WHEAT (*TRITICUM AESTIVUM* L.) AND INDIAN MUSTARD (*BRASSICA JUNCEA* L.) INTERCROPPING AS INFLUENCED BY FARMYARD MANURE AND FERTILIZER LEVELS

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Abstract: A field experiment was conducted during winter (*rabi*) seasons of 2010-11 and 2011-12 at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to evaluate the productivity, compatibility and economics of wheat and Indian mustard intercropping as influenced by row proportions, farmyard manure (FYM) and fertilizer levels under irrigated conditions. Among row proportions, 8:1 row proportion of wheat and Indian mustard intercropping recorded significantly the highest yield attributing characters *viz.*, grain spike^{-1}, spikelet length and yield in case of wheat, and number of siliqua plant^{-1} and number of seed siliqua^{-1} in case of Indian mustard. The seed yield and stover yield of mustard were higher in 6:2 row proportion which was remained at par with 8:2 and 10:2 row proportions. There was also recorded significantly higher land equivalent ratio, aggressivity index with 8:1 row proportion of wheat + Indian mustard intercropping over 10:2, 8:2 and 6:2 row proportions. Conversely, the highest net return as well as B: C ratio was recorded in 10:2 row proportion which was at par with 8:1 row proportion. To achieve higher yield advantage and efficient resource utilization in wheat + mustard intercropping, the application of 100% RDF along with 30 kg N through FYM observed significantly higher yield attributes, yield, competitive indices and economics of wheat and Indian mustard, but it was remained at par with 100% RDF plus 15 kg N through FYM.

Keywords: Farmyard manure, Fertilizer level, Intercropping, Mustard, Row proportion, Wheat

INTRODUCTION

Intercropping is an advanced agro-technique and is considered to be an effective and potential mean of increasing crop production per unit area and time, particularly for farmers having marginal and small holdings. It provides an efficient utilization of environmental resources, decreases the cost of production, provides higher financial stability for farmers, decreases the pest damage, inhibits weeds growth more than monocultures, and improves soil fertility through fertilizers increasing to the system and increase yield and quality (Francis *et al*., 1976; Willey, 1979). Substantial increase in total production over space and time not by means of costly inputs but by simple expedient of growing crops together are the unique advantage associated with intercropping, mainly micro-climatic manipulation is shown to be appreciably more limited in sole cropping than in intercropping (Stigter and Baldy, 1995).

In India, wheat (*Triticum aestivum* L.) with Indian mustard (*Brassica juncea* L.) intercropping is an old and important cropping system under both irrigated and rainfed conditions. Growing cereals with pulses and oilseeds endowed with varying rooting depth and growth pattern help better extraction of soil moisture and nutrients from different soil profile. Further, it is also known to intercept more solar energy and give comparatively higher stability and insurance of yield during aberrant weather conditions than sole crops (Willey, 1979a; Sinha *et. al*., 1985 and Mandal and Mahapatra, 1990). Intercropping of wheat with mustard is ecologically suitable, economically viable, operationally feasible and socially acceptable cropping system during winter season in India (Ghoniskar and Shinde, 1994). The country still is presently surplus in the production of wheat but in spite of quantum jump in oilseed production during the last two decades, its production is not sufficient to meet country's growing edible oil demands. This is attributed to improvement in standard of living with better purchasing power of people due to better economic growth as well as the high growth rate of Indian population. Its scarcity has necessitated the import of 51 per cent of our requirements at a huge cost of Rs. 56910 crores 2013-14 (Hedge and Sudhakara Babu, 2014). Mixed cropping of mustard with wheat is very common in eastern Uttar Pradesh which is one of the major causes of low productivity of mustard in the region. The reason might be use of improper proportion of the component crops. Accordingly, their compatible combination for the maximum utilization of natural resources based on complementarily is essential.

In intercropping system, the competition between main and subsidiary crops depend on the maturity periods, rooting pattern, canopy spread and plant habit etc. of the component crops (Singh and Gupta, 1994). It has been proved beyond doubt that in wheat + mustard intercropping, the competition offered by mustard is much higher than wheat. However, it can be altered to some extent by modification of row

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proportion and higher yield advantages as well as monetary return can be achieved by proper nutrient management (Verma *et al.*, 1997 and Srivastava and Bohra, 2006). Realising the importance of these facts, the present investigation is therefore, proposed to assess the productivity, compatibility and economics of wheat and Indian mustard intercropping system as influenced by row proportions, farmyard manure and fertilizer levels under irrigated conditions.

MATERIAL AND METHOD

The experiment was carried out during two consecutive winter (*rabi*) seasons of 2010-2011 and 2011-2012 at the Agricultural Research Farm of Banaras Hindu University, Varanasi in Northern Gangetic Alluvial Plain of India (83°03′0″ E longitude; 25°18′0″ N latitude and an altitude of 128.9 metre above sea level). The experimental soil was Gangetic alluvial with *p*H 7.41. It was moderately fertile-being low in available organic carbon (0.48%) as well as available nitrogen (190.50 kg ha^{-1}) and medium in available phosphorus (19.85 kg ha^{-1}) as well as available potassium (213.44 kg ha^{-1}). The experiment was laid out in split-plot design comprising four row proportions of wheat + mustard intercropping, *i.e*., 8:1, 6:2, 8:2 and 10:2 in main plot and two different levels of farmyard manure (15 and 30 kg N through farmyard manure) and two fertilizer levels (75 and 100% RDF) in sub-plots. The two extra plots of sole wheat 'HUW-234' and sole Indian mustard 'Vardan' were taken for the estimation of yield, competitive indices and monetary advantage. Thus, all the total sixteen {(4 main plots x 4 sub plots) + 2 additional plots} treatment combinations were replicated thrice. The experimental plot of 22.95 m^2 (7.65 m x 3.00 m) was separated by 1 m plot-border. Seed bed preparation including ploughing, disk harrowing and planking was done as per the requirement of main crop. Well decomposed farmyard manure was applied as per treatments. In replacement series of wheat and mustard intercropping, normally fertilizer is applied on the basis of wheat fertilizer requirement. So, a common recommended dose of fertilizer (RDF) i.e. 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} was applied to the crops in wheat + mustard intercropping. Similarly, the sole wheat and mustard recommended nutrient dose of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} and 90 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1}, respectively were applied. Half dose of N and full doses of P_2O_5, and K_2O were applied as basal before sowing. Remaining half dose of N to wheat was top dressed in two equal splits at tillering and spike emergence stages whereas to mustard, it was applied at one month stage of crop. Fertilizers used were urea, single super phosphate and muriate of potash. In sole as well as in intercropping system, wheat crop was sown at a row spacing of 22.5 cm and plant to plant distance was maintained as per seed rate. However in sole mustard, thick sowing was done at a row spacing of 45 cm. The plant to plant distance of mustard was maintained at 12 cm by two thinning at an interval of 14 and 21 days after sowing. Weather data of average temperature (^{0}C), average rainfall (mm) and evapo-transpiration (mm) were recorded daily at the experimental site with using meteorological observatory and are reported as mean weekly data for both the years. Grain or seed yield index was calculated according to Singh and Gupta (1994) where sole stand of wheat or Indian mustard was taken as 100.

Grain or Seed yield index (%)

$$= \frac{\text{Intercropping yield (kg ha}^{-1})}{\text{Sole cropping yields (kg ha}^{-1})} \times 100$$

The cost of cultivation, gross return and net return under different treatments were worked out on the basis of prevailing cost of different enterprises. Net return (Rs. ha^{-1}) and benefit: cost ratio was calculated with the help of the following formula:

Net return (Rs. ha^{-1}) = Gross return (Rs. ha^{-1}) - Cost of cultivation (Rs. ha^{-1})

Benefit: cost ratio = Net return (Rs. ha^{-1})/ Cost of cultivation (Rs. ha^{-1})

Competitive indices for assessing the yield advantage and competition in intercropping systems are given below:

Land Equivalent Ratio (LER)

Land equivalent ratio (LER) indicates the efficiency of intercropping in using the resources of the environment compared with sole cropping (Mead and Willey 1980). This is a widely used index to assess any yield advantage in intercropping and measures the efficiency of an inter/mixed crop. Moreover, LER indicates the total land area required by sole crops to achieve the same yield as the intercrops (Willey 1985). When the LER is > 1, intercropping favours growth and yield of species. By contrast, when LER is < 1, intercropping negatively affects growth and yield of plants grown in mixtures (Caballero *et al.*, 1995). LER was calculated based on formula given by Singh and Bohra (2012):

$$\mathrm{LER} = \mathrm{LERa} + \mathrm{LERb}$$

$$\mathrm{LERa} = \frac{\mathrm{Yab}}{\mathrm{Yaa}}$$

$$\mathrm{LERb} = \frac{\mathrm{Yba}}{\mathrm{Ybb}}$$

Where, LERa and LERb are the partial LER of crops 'a' and 'b', respectively. Yab and Yba are the yields of two component crops; Yaa and Ybb are the yields per unit area when 'a' and 'b' are grown as sole crops under those conditions with which comparison are to be made.

Aggressivity index

A indices, which has been attempted to measure the inter crop competition, by relative yield changes of

both the component crops is the aggressivity proposed by Mc Gilchrist (1965) originally for replacement situations. Moreover it gives a simple measure of how much the relative yield increase in crop 'a' is greater than that for crop 'b' and *vice-versa* in an intercropping system and can be expressed as 'A'.

Aggressivity index of crop 'a' with 'b' is given as according to Singh and Bohra (2012):

$$Aab = \frac{Yab}{Zaa \times Zab} - \frac{Yba}{Ybb \times Zba}$$

Similarly, aggressivity index of crop 'b' with 'a' is given as

$$Aba = \frac{Yba}{Zbb \times Zba} - \frac{Yab}{Yaa \times Zab}$$

Where,

Yaa = pure stand yield of crop 'a', Ybb = pure stand yield of crop 'b', Yab = mixture yield of crop 'a' in combination with 'b' Yba = mixture yield of crop 'b' in combination with 'a', Zab = sown proportion of crop 'a' in mixture with 'b' and Zba = sown proportion of crop 'b' in mixture with 'a'

An aggressivity value of zero indicates that the component crops are equally competitive. For any situation, both components will have the same numerical value but the sign for the dominant component will be positive and that for the dominated crop will be negative. The greater the numerical value, the larger the difference in competitive abilities.

Statistical analysis

The data pertaining to each of the characters of the experimental crops were tabulated and finally analyzed statistically by applying the standard technique to draw a valid conclusion. Analysis of variance for split plot design was worked out as per the standard procedure given by Cochran and Cox (1957) and the significance was tested by 'F' test. Treatment mean differences were separated and tested by Fisher's protected least significant difference (LSD) at a significance level of $p \leq 0.05$.

RESULT AND DISCUSSION

Yield attributes and yield

The yield attributing characters *viz.*, grain spike^{-1}, spikelets spike^{-1} and 1000-grain weight of wheat in wheat + mustard intercropping recorded significantly lower as compared to sole stand of wheat (Table 1). Among row proportions of wheat + mustard intercropping, the significantly higher wheat grain spike^{-1}, spikelets spike^{-1} and 1000-grain weight, grain yield and straw yield and mustard siliqua plant^{-1}, seed siliqua^{-1}, 1000-seed weight in wheat and mustard intercropping was recorded in 8:1 row proportion which was followed by 10:2, 8:2 and 6:2 row proportions except mustard seed yield and stover yield which was maximum in 6:2 row proportion remained at par with 8:2 row proportion. This could be ascribed to the inter-generic competition between the component crops for possible under and above ground resources *viz.*, space, nutrients, moisture. These results find supported from the works of Sharma *et al*. (1986), Singh *et al*. (1995) and Srivastava *et al.* (2007).

Farmyard manure and fertilizer levels from 75% RDF + 15 kg N through FYM to 100% RDF + 30 kg N through FYM applied to wheat and mustard correspondingly increased wheat, *viz.*, grain spike^{-1}, spikelets spike^{-1} and 1000-grain weight, grain yield and straw yield and mustard, *viz.*, siliquae plant^{-1}, seed siliqua^{-1}, 1000-seed weight, seed yield and stover yield of wheat and mustard intercropping. Among the farmyard manure and fertilizer levels, wheat *viz.*, grain spike^{-1}, spikelets spike^{-1} and 1000-grain weight, grain yield and straw yield, and mustard *viz.*, siliqae plant^{-1}, seed siliqua^{-1}, 1000-seed weight, seed yield and stover yield significantly the highest at 100% RDF + 30 kg N through FYM which was remained at par with 100% RDF + 15 kg N through FYM over rest of the treatments.

A close examination of the data indicated the adverse effect of mustard on wheat under different row proportions of wheat + mustard intercropping. Grain yield index increased with increasing wheat proportion. On the contrary, the lowest grain yield index was recorded at highest mustard proportion on area basis when two row of mustard was sown after every six rows of wheat. In wheat + mustard intercropping, the area under wheat reduced 25, 20, 18 and 16%, respectively in 6:2, 10:2, 8:2 and 8:1 row proportions respectively, with corresponding yield reduction in wheat yield on percent wheat grain yield index basis was noted 92.85, 85.37, 76.91 and 70.40% during first year and 94.71, 85.54, 77.31 and 70.94 (8:1, 10:2, 8:2 and 6:2) per cent during second year, respectively in comparison to sole stand. In mustard crop, seed yield index of mustard decreased with every increase in proportion of wheat rows. Accordingly, the seed yield index was recorded maximum with six rows of mustard alternated with two rows of mustard. Mustard replaced 11.12, 16.67, 20 and 25% area of wheat in 8:1, 10:2, 8:2, and 6:2 row proportions respectively, with corresponding seed yield of 35.73, 42.55, 46.33and 51.22% during first year and 37.16, 43.49, 45.12 and 50.38% during second year, respectively in comparison to sole stand. It shows that the seed yield of mustard was proportionately higher as compared to area replaced. Application of fertility doses from 75% RDF + 15 kg N through FYM to 100% RDF + 30 kg N through FYM applied to wheat correspondingly increased grain yield index of wheat during both the years of experimentation. The farmyard manure and fertilizer level, grain yield index significantly highest at 100% RDF + 30 kg N through FYM, which was at par with 100% RDF + 15 kg N through FYM during both the years. However, the lowest grain yield index was

observed in 75% RDF + 15 kg N through FYM and 75% RDF + 30 kg N through FYM. Similar resulted was corroborated by Srivastava *et al*. (2007).

Yield advantage and competitive indices

In wheat + Indian mustard intercropping, 8:1 and 10:2 row proportions were found comparable, but both were recorded significantly higher yield advantage and greater biological efficiency over 8:2 and 6:2 row proportions. Yield advantage of 25% and 25% first year 28% and 29% in second year was registered in 8:1 and 10:2 row proportion, which indicates similar yield to that of the pure stand of both the crops even with 29 % and 32% reduced land, justifying their desirability over monoculture of wheat or Indian mustard. This result corroborates the findings of Singh and Gupta (1994) and Srivastava *et al*. (2007). The aggressive nature of Indian mustard, made it more competitive than wheat. The aggressivity of Indian mustard was the maximum at 8:1 row proportion of wheat + mustard intercropping, followed by 10:2, 8:2 and 6:2 row proportions.

Aggressivity index of Indian mustard in wheat + Indian mustard intercropping enhanced markedly with increasing levels of fertility to Indian mustard causing corresponding decline in these indices for wheat because mustard uptake quickly in compression to wheat. The maximum total LER was observed at the highest farmyard manure and fertilizer level 100% RDF + 30 kg N through FYM followed by 100% RDF + 15 kg N through FYM. These results are in agreement with the findings of Srivastava *et al*. (2007).

Protein and oil contents and their yields

Variation in the row proportions of Indian mustard with wheat pertaining to intercropping system produced lucid impact on the oil production of mustard during both the years. Maximum protein content, protein yield, oil content and oil yield was recorded under 6:2 row proportion remained at par with 8:2 row proportion. The farmyard manure and fertilizer level doses maximum seed protein content was recorded in highest farmyard manure and fertilizer level. However, the reverse trend was noticed in seed oil content. In spite of that protein yield and oil yield was recorded in 100% RDF + 30 kg N through FYM, which was at par with 100% RDF + 15 kg N through FYM. This could be attributed to the highest seed yield obtained under the highest farmyard manure and fertilizer level, which decreased markedly with every curtailment in farmyard manure and fertilizer level (Table 4). Singh (1983) and Tomer *et al*. (1996) also obtained higher oil yield with increasing levels of fertility.

Economics

As evident from data on Table 4, in general, intercropping of wheat and mustard in 10:2 and 8:1 row proportions was found more remunerative than growing either of the component crops in pure stand as well as wheat + mustard in 6:2 row proportion. Among four row proportions in wheat + mustard intercropping,10:2 row proportion recorded highest gross return and net return benefit: cost which was at par with 8:1 row proportion and both proved remunerative over 8:2 and 6:2 row proportion during both the years of experimentation. Nevertheless, the lower yield remained associated with 6:2 row proportion followed by 8:2 and 8:1 row proportions. Increase in farmyard manure and fertilizer levels from lower to higher level markedly increased the gross return and net return (Rs.ha^{-1}), but decreased the benefit: cost ratio due to increased cost of cultivation. Accordingly, application of 100% RDF + 30 kg N through FYM significantly higher gross return, net return and also increase cost of cultivation, which was at par with 100% RDF + 15 kg N through FYM . While, B: C ratio was highest in the application of 100% RDF + 15 kg N through FYM.

Thus, to achieve higher yield advantage and efficient resources utilization in wheat + Indian mustard intercropping, ten rows of wheat be taken after every 2 rows of Indian mustard and the component crops can be fertilized with 100% RDF + 15 kg N through FYM.

Table 1. Effect of row proportion, farmyard manure and fertilizer level on yield attributes and yields of wheat in wheat + Indian mustard intercropping

Treatment	Grain spike^{-1}		Spikelets spike^{-1}		1000-grain weight (g)		Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Grain yield index (%)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Wheat + Mustard intercropping (Row proportion)												
8:1	43.78	46.41	16.64	16.69	42.11	43.12	4174	4358	5227	5627	90.83	92.69
6:2	34.91	35.95	14.08	14.11	36.77	37.50	3165	3265	4105	4405	68.86	69.43
8:2	37.43	38.93	14.91	14.94	38.51	39.32	3457	3557	4334	4634	75.24	75.66
10:2	39.80	41.79	15.73	15.77	39.93	40.85	3838	4004	5125	5491	83.52	85.13
SEm±	0.63	0.70	0.23	0.24	0.39	0.40	106	116	111	120	-	-
CD (P=0.05)	2.18	2.42	0.81	0.82	1.36	1.39	367	402	383	416	-	-
Farmyard manure and fertilizer level												
75% RDF + 15% N through FYM	36.79	38.48	14.06	14.10	35.94	36.74	3338	3482	4382	4723	72.65	74.04
100% RDF* + 15% N through FYM	40.26	42.11	16.50	16.53	42.14	43.06	3841	3964	4852	5193	83.58	84.31
75% RDF + 30% N through FYM	37.79	39.53	14.14	14.17	36.24	37.04	3471	3607	4513	4863	75.54	76.72

100% RDF + 30% N through FYM	41.07	42.96	16.66	16.70	43.00	43.95	3983	4131	5045	5378	86.67	87.85
SEm±	0.56	0.59	0.16	0.16	0.38	0.39	72	89	88	91	-	-
CD (P=0.05)	1.63	1.71	0.47	0.48	1.12	1.14	209	259	258	265	-	-
Sole vs. Intercrop												
Sole (Control)	49.07	52.50	26.60	26.68	41.23	42.22	4495	4702	5601	5971	100.00	100.00
Intercrop	38.98	40.77	15.34	15.38	39.33	40.20	3658	3796	4698	4981	79.61	80.73
SEm±	1.15	1.23	0.61	0.62	1.86	1.90	155	184	185	192	-	-
CD (P=0.05)	3.32	3.54	1.77	1.78	5.35	5.47	445	530	532	552	-	-

*RDF: Recommended dose of 120 N, 60 P_2O_5, 60 K_2O kg ha^{-1}

Table 2. Effect of row proportion, farmyard manure and fertilizer level on yield attributes and yields of mustard in wheat + Indian mustard intercropping

Treatment	Siliquae plant^{-1}		Seed siliqua^{-1}		1000-seed weight (g)		Seed yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Seed yield Index (%)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Wheat + Mustard intercropping (Row proportion)												
8:1	389.91	413.31	12.18	12.79	3.85	4.00	647	702	2374	2552	34.00	35.60
6:2	347.46	361.36	10.44	10.65	3.29	3.36	945	978	3120	3268	49.90	49.70
8:2	350.70	364.72	10.63	10.95	3.36	3.46	851	901	2978	3119	44.90	45.80
10:2	354.00	371.70	10.73	11.16	3.45	3.59	777	867	2916	3101	41.00	44.10
SEm±	6.09	7.15	0.28	0.29	0.40	0.41	36	41	97	106	-	-
CD (P=0.05)	21.07	24.75	0.98	1.02	NS	NS	125	143	335	368	-	-
Farmyard manure and fertilizer level												
75% RDF + 15% N through FYM	348.17	364.86	10.38	10.74	2.86	2.95	677	724	2442	2664	35.69	36.74
100% RDF* + 15% N through FYM	369.48	387.14	11.55	11.96	3.79	3.91	861	926	3124	3204	45.44	47.07
75% RDF + 30% N through FYM	350.18	366.96	10.44	10.80	3.34	3.45	744	794	2523	2812	39.29	40.38
100% RDF + 30% N through FYM	374.25	392.14	11.63	12.04	3.97	4.10	938	1004	3300	3360	49.48	51.07
SEm±	5.51	6.33	0.17	0.17	0.30	0.30	27	31	68	78	-	-
CD (P=0.05)	16.09	18.47	0.49	0.51	NS	NS	78	89	200	227	-	-
Sole vs Intercrop												
Sole (Control)	400.45	428.48	15.41	16.34	4.23	4.49	1896	1969	6586	6756	100.00	100.00
Intercrop	360.52	377.77	11.00	11.39	3.49	3.60	805	862	2847	3010	42.48	43.82
SEm±	10.95	12.65	0.52	0.55	0.63	0.65	56	65	147	164	-	-
CD (P=0.05)	31.55	36.45	1.51	1.59	NS	NS	162	187	424	471	-	-

*RDF: Recommended dose of 120 N, 60 P_2O_5, 60 K_2O kg ha^{-1}, NS: Non significance

Table 3. Effect of row proportion, farmyard manure and fertilizer level on land equivalent ratio and aggressivity Index of wheat and mustard in wheat + Indian mustard intercropping

Treatment	Land equivalent ratio (LER)						Aggressivity Index			
	Wheat (Lw)		Mustard (LM)		Total (Lw+ Mw)		Wheat (Awm)		Mustard (Amw)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Wheat + Mustard intercropping (Row proportion)										
8:1	0.908	0.927	0.340	0.356	1.25	1.28	-2.04	-2.16	2.04	2.16
6.2	0.689	0.694	0.499	0.497	1.19	1.19	-1.08	-1.06	1.08	1.06
8:2	0.752	0.757	0.449	0.458	1.20	1.21	-1.30	-1.34	1.30	1.34
10:2	0.835	0.851	0.410	0.442	1.25	1.29	-1.46	-1.63	1.46	1.63
SEm±	0.015	0.017	0.016	0.019	0.02	0.02	0.07	0.08	0.07	0.08
CD (P=0.05)	0.052	0.060	0.054	0.066	0.06	0.06	0.23	0.28	0.23	0.28
Farmyard manure and fertilizer level										
75% RDF + 15% N through FYM	0.743	0.755	0.373	0.375	1.08	1.11	-1.17	-1.23	1.17	1.23
100% RDF* + 15% N through FYM	0.854	0.858	0.468	0.471	1.29	1.31	-1.57	-1.66	1.57	1.66
75% RDF + 30% N through FYM	0.772	0.780	0.408	0.408	1.15	1.17	-1.35	-1.42	1.35	1.42
100% RDF + 30% N through FYM	0.886	0.892	0.508	0.508	1.36	1.39	-1.79	-1.89	1.79	1.89
SEm±	0.013	0.013	0.015	0.015	0.02	0.02	0.05	0.05	0.05	0.05

CD (P=0.05)	0.038	0.039	0.042	0.044	0.04	0.05	0.15	0.15	0.15	0.15

*RDF: Recommended dose of 120 N, 60 P_2O_5, 60 K_2O kg ha^{-1}

Table 4. Effect of row proportion, farmyard manure and fertilizer level on protein content (%),protein yield (kg ha^{-1}), oil content and oil yield of mustard in wheat + mustard intercropping

Treatment	Seed protein content (%)		Seed protein yield (kg ha^{-1})		Seed oil content (%)		Seed oil yield (kg ha^{-1})	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Wheat + Mustard intercropping (Row proportion)								
8:1	18.35	18.52	118.91	130.36	37.80	37.88	244.07	265.52
6:2	19.84	20.10	189.08	198.82	39.38	39.51	370.63	384.41
8:2	19.19	19.44	163.82	175.86	39.19	39.29	333.10	353.51
10:2	18.78	18.94	146.30	165.26	38.83	38.91	301.10	336.73
SEm±	0.29	0.31	9.62	9.92	0.32	0.32	14.72	15.46
CD (P=0.05)	0.99	1.07	33.27	34.34	1.09	1.10	50.94	53.51
Farmyard manure and fertilizer level								
75% RDF + 15% N through FYM	18.17	18.31	123.14	132.74	39.68	39.78	269.09	288.32
100% RDF* + 15% N through FYM	19.47	19.82	168.58	184.68	38.19	38.29	329.57	355.26
75% RDF + 30% N through FYM	18.67	18.75	139.24	149.06	39.38	39.48	293.57	313.99
100% RDF + 30% N through FYM	19.85	20.11	187.16	203.83	37.94	38.04	356.67	382.61
SEm±	0.24	0.27	6.57	7.55	0.22	0.22	10.16	11.50
CD (P=0.05)	0.69	0.80	19.16	22.03	0.63	0.63	29.66	33.56
Sole vs. Intercrop								
Sole (Control)	14.64	14.86	277.45	292.55	40.05	40.18	759.21	790.84
Intercrop	19.04	19.25	154.53	167.58	38.80	38.90	312.22	335.04
SEm±	0.48	0.54	14.15	15.71	0.52	0.56	22.09	24.33
CD (P=0.05)	1.38	1.57	40.76	45.25	1.49	1.62	63.62	70.09

Table 5. Effect of row proportion, farmyard manure and fertilizer level on economics of wheat and mustard in wheat + Indian mustard intercropping

Treatment	Cost of cultivation (x 10^3 Rs. ha^{-1})	Gross return* (x 10^3 Rs. ha^{-1})		Net return (x 10^3 Rs. ha^{-1})		B:C ratio		Monetary advantage (x 10^3 Rs. ha^{-1})	
		2010-11	2011-2012	2010-11	2011-2012	2010-11	2011-2012	2010-11	2011-2012
Wheat + Mustard intercropping (Row proportion)									
8:1	34.97	118.70	126.06	83.73	90.09	2.40	2.61	27.12	35.01
6:2	34.67	110.96	115.60	76.29	80.93	2.20	2.33	21.36	25.63
8:2	34.78	112.47	117.78	77.69	83.00	2.24	2.39	22.14	27.26
10:2	34.85	119.28	127.58	84.43	92.73	2.43	2.66	27.34	37.80
SEm±	-	19.23	23.64	13.06	15.77	0.05	0.07	-	-
CD (P=0.05)	-	66.56	81.82	45.18	54.58	0.18	0.26	-	-
Farmyard manure and fertilizer level									
75% RDF + 15 kg N through FYM	31.89	103.24	109.43	71.35	77.54	2.24	2.43	8.69	12.92
100% RDF* + 15 kg N through FYM	33.74	121.50	127.88	87.76	94.14	2.60	2.79	32.15	40.22
75% RDF + 30 kg N through FYM	35.89	108.71	115.04	72.81	79.14	2.03	2.20	15.51	20.55
100% RDF + 30 kg N through FYM	33.74	127.95	134.68	90.21	96.94	2.39	2.57	41.59	52.00
SEm±	-	18.54	22.82	12.90	14.92	0.05	0.06	-	-
CD (P=0.05)	-	54.10	66.61	37.66	43.56	0.14	0.15	-	-
Sole									
Wheat	27.36	97.44	101.03	69.18	72.77	2.45	2.58	-	-
Mustard	23.60	85.71	88.88	61.37	64.55	2.52	2.65	-	-
SEm±	-	36.21	44.57	25.17	29.32	0.10	0.13	-	-
CD (P=0.05)	-	104.31	128.40	72.49	84.45	0.28	0.38	-	-

*Selling price of wheat grain: Rs.14.00 kg^{-1}, Selling price of wheat straw: Rs. 4.5/kg, Selling price of mustard seed: Rs. 40.00 kg^{-1} and stover: Rs. 1.50 kg^{-1}

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RESEARCH ARTICLE

PERFORMANCE EVALUATION OF VACUUM TYPE METERING MECHANISM UNDER LABORATORY AND FIELD CONDITION FOR BOLD SEEDS

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Abstract: Groundnut, pigeonpea and maize are major bold seeds crop in India. Planting of these bold seeds is a very drudgery and time consuming operation. To address this issue, vacuum type metering mechanism is done. Vacuum is created in this rod and goes down the vacuum cylinder. The metering cylinder rotates over rod and pick up the seeds through the seed hopper while passing through it. To evaluate the working of vacuum cylinder pickling % & metering efficiency of metering mechanism were considered under different suction pressure i.e. for groundnut seed 4500 Pa, 5000 Pa and 5500 Pa, for maize seeds 3500 Pa, 4000 Pa and 4500 Pa while for pigeonpea seeds 1500Pa, 2000 Pa and 2500 Pa. On the basis of superior performance the optimum suction pressure inside the vacuum cylinder for groundnut seed was found to be 5000 Pa with a metering efficiency of 106.67 % and maximum picking percentage of 96%. Similarly the optimum suction pressure for maize seed was found to be 4000 Pa with a metering efficiency of 108.88 % and maximum picking percentage of 97% while for pigeonpea seed these values were found to be 2000 Pa, 110 % and 92 %.

Keywords : Vacuum type metering mechanism, Vacuum cylinder

INTRODUCTION

Vacuum metering mechanism is a relatively new concept of planting the seeds. These machines use vacuum seed metering principle. The principle offers several advantages, especially the single seed picking, no mechanical damage to the seed and their capability to deal with bolder seeds. Several researchers in India and abroad have developed tractor operated pneumatic planters. Adoption of these machines has been quite limited, due to their higher initial cost. Still considering the high accuracy and precision of the machinery, these machines have great potential for production of high value cash crops; especially requiring highly viable seeds.

Presently, among different sowing techniques, precision sowing is the preferred method since it provides more uniform seed spacing than other methods.

MATERIAL AND METHOD

Physical Characteristics of Bold Seeds

The seeds of Groundnut, Maize and Pigeonpea were procured from Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur. The shape and size of the groundnut, maize and pigeonpea was ascertained with three perpendicular dimensions, length (L), width (W) and thickness (T).

Table. Dimensions and test weight of the seeds considered for study

		Seed dimensions, mm (average)				
S. No.	Seeds	Length (mm)	Width (mm)	Thickness (mm)	Sphericity (s), %	1000-seed weight (g)
1	Groundnut	11.55	7.68	6.98	64.27	445
2	Maize	10.50	8.24	4.44	76.55	437.0
3	Pigeonpea	5.52	6.16	4.37	92.2	107.92
	Average	9.19	7.36	5.26	77.67	329.97

Fig: weight and physical dimensions of seeds

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Techniques of Measurement

In this section, the techniques and procedure for measurement of various parameters associated with the evaluation of the machine under laboratory and field conditions has been presented. The parameters and the methodology for their measurement are given below.

Laboratory test

Theoretical seed rate (R_{st})

The number of bold seeds planted per hectare was calculated by using the following relationship (Bakhtiari and Loghavi, 2009)

$$R_{st} = \frac{10^8}{w \times x_s}$$

Where,

R_{st} = Theoretical seeding rate, seed/ha;

W = Row width, cm;

X_s = Seed spacing along the row,

Seeding mass rate (R_{sm})

The total mass of bold seeds planted per hectare expressed in Mg/ha was calculated by using the following relationship (Bakhtiari and Loghavi, 2009):

$$R_{sm} = \left[\frac{M}{w \times x_s}\right] \times 100$$

Where,

R_{sm} = Seeding mass rate, Mg/ha;

M = Average mass of one seed, g;

W = Row width, cm; and

X_s = Seed spacing along the row, cm.

Seed metering efficiency

Metering efficiency of the pneumatic planting system was calculated on the basis of percent drop of seeds for definite number of drops.

$$\text{Metering efficiency} = \frac{Total\ no.of\ seeds\ obtained\ acctuly}{ecpected\ no.of\ seeds} \times 100$$

Independent and dependent test variables

The study was conducted with the following independent and dependent variables:-

Independent variables

Following independent test variables were recorded:-

1. Suction pressure
2. Orifice size

Dependent variables

Following dependent test variables were recorded

1. Seed spacing
2. No. of seeds per hill

Theoretical Observation

1. Skip : Skip is the number of cases, where the seeds rotor fails to pick a seed.
2. Single : Single is the number of seeds (1) observed while testing.
3. Multiple : Multiple is the number of cases, where the seed plate picks more than one seed per orifice.

Measures of Accuracy of the Metering Mechanism

To analyze the performance of the mechanism, the following statistical tools were used (Kachman and Smith, 1995);

1. **Mean spacing :** Mean spacing is the average of the total number of measured spacing.
2. **Multiple index :** It is the total number of spacing, which are less than 0.5 times theoretical spacing.
3. **Miss index :** It is the total number of observation with spacing more than 1.5 times theoretical spacing.
4. **Quality of feed index :** It is the number of observations, which are 0.5 to 1.5 times theoretical spacing.
5. **Precision :** It is the ratio of the standard deviation of the observed spacing, between 0.5 to 1.5 times theoretical spacing to the theoretical spacing, expressed as percentage.

Field Test

The field performance was conducted in order to obtain actual data for overall machine performance, operating accuracy, work capacity, and field efficiency. After a thorough laboratory test, study on vacuum- planting system for planting bold seeds and its distribution pattern was checked in the field condition. The testing was carried out with the seed metering cylinder and vacuum rod, which was tested in the laboratory. The field trial was carried out at different travel speed (4, 4.17 and 4.13 kmph) and with seed metering cylinder with metering orifices (54) to observe the effect of travel speed and metering orifices on hill spacing.

Field capacity and field efficiency of the machine

Theoretical field capacity and effective field capacity were determined on the basis of area covered per unit time.

Theoretical field capacity

On the basis of width of furrow and speed, theoretical field capacity was calculated by following formula :

Theoretical field capacity (ha/h) = W ×S/10

Where,

S = Speed of operation, km/h

W = Theoretical width covered,

m = Number of furrow openers multiplied by distance between the furrow Opener, m

Effective field capacity

The seed drill was continuously operated in the field for 0.366 ha to assess its actual coverage. The time

required for complete sowing was recorded and Effective field capacity was calculated.

Effective field capacity (ha/h) = A/T

Where,

A = Actual area covered, ha

T = Total time required to cover the area, h

Field efficiency

Field efficiency (%) = actual field capacity/theoretical field capacity × 100

RESULT AND DISCUSSION

Physical Properties of Different Bold Seeds

The average length, width and thickness of seeds varied over a wide range. Groundnut was the largest of the seeds. The average length, width and thickness of the seeds were 11.55 mm, 7.68mm and 6.98 mm respectively. The average length, width and thickness of the maize seed were 10.58 mm, 8.24 mm and 4.44 mm and the average length, width and thickness of the pigeonpea were 5.52 mm, 6.16 mm and 4.37 mm respectively.

Bulk density of bold seeds

The bulk density of groundnut seeds, maize and pigeonpea was found to be 610 kg/m^3, 720 kg/m^3 and 674 kg/m^3 respectively.

Moisture content of bold seeds

The moisture content of groundnut seeds, Maize and pigeonpea was found to be 9.02%, 8.09% and 4.07% respectively.

Laboratory Test

Performance of the vacuum cylinder under varying suction pressure for bold seeds

Table. Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for groundnut seed.

S. No.	Suction pressure inside vaccume cylinder, Pa	Particulars of seeds per hill	(%) picking
1	4500	Skip (0)	15
		Single (1)	85
		Multiple (>1)	0
2	5000	Skip (0)	0
		Single (1)	96
		Multiple (>1)	4
3	5500	Skip (0)	0
		Single (1)	93
		Multiple (>1)	7

*desired number of seeds per hill (1).

Table. Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for maize seed.

S. No.	Suction pressure inside vaccume cylinder, Pa	Particulars of seeds per hill	(%) picking
1	**3500**	Skip (0)	**14**
		Single (1)	**86**
		Multiple (>1)	**0**
2	**4000**	Skip (0)	**0**
		Single (1)	**97**
		Multiple (>1)	**3**
3	**4500**	Skip (0)	**0**
		Single (1)	**94**
		Multiple (>1)	**6**

*desired number of seeds per hill (1).

Table. Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for pigeonpea seed.

S. No.	Suction pressure inside vaccume cylinder, Pa	Particulars of seed per orifice	(%) Picking
1	**1500**	Skip (0)	**17**
		Single (1)	**83**

		Multiple (>1)	**0**
2	**2000**	Skip (0)	**0**
		Single (1)	**95**
		Multiple (>1)	**5**
3	**2500**	Skip (0)	**0**
		Single (1)	**92**
		Multiple (>1)	**8**

*desired number of seeds per hill (1)

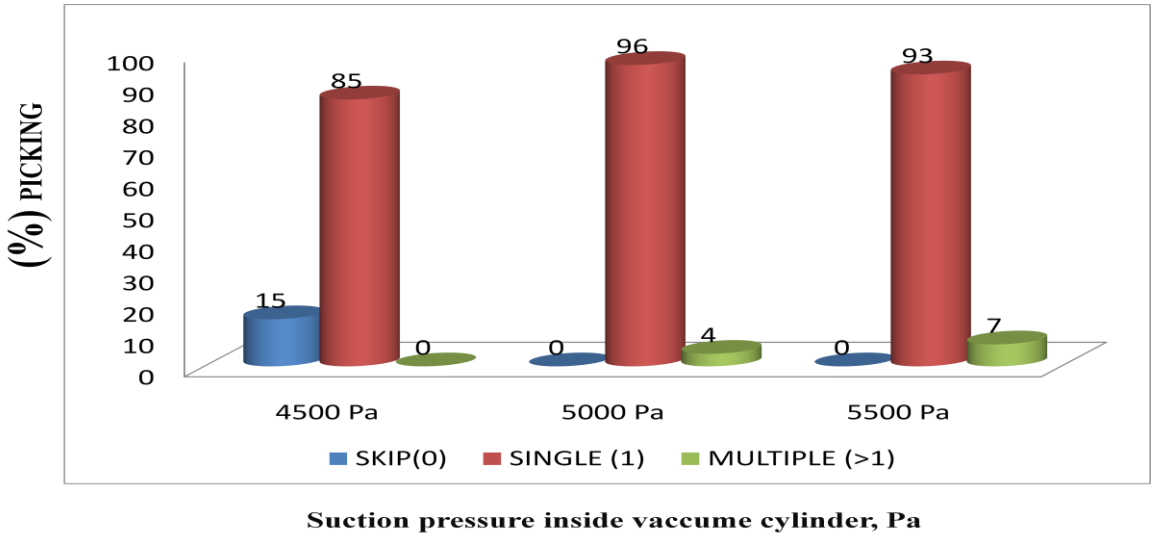

Fig: Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for groundnut seed.

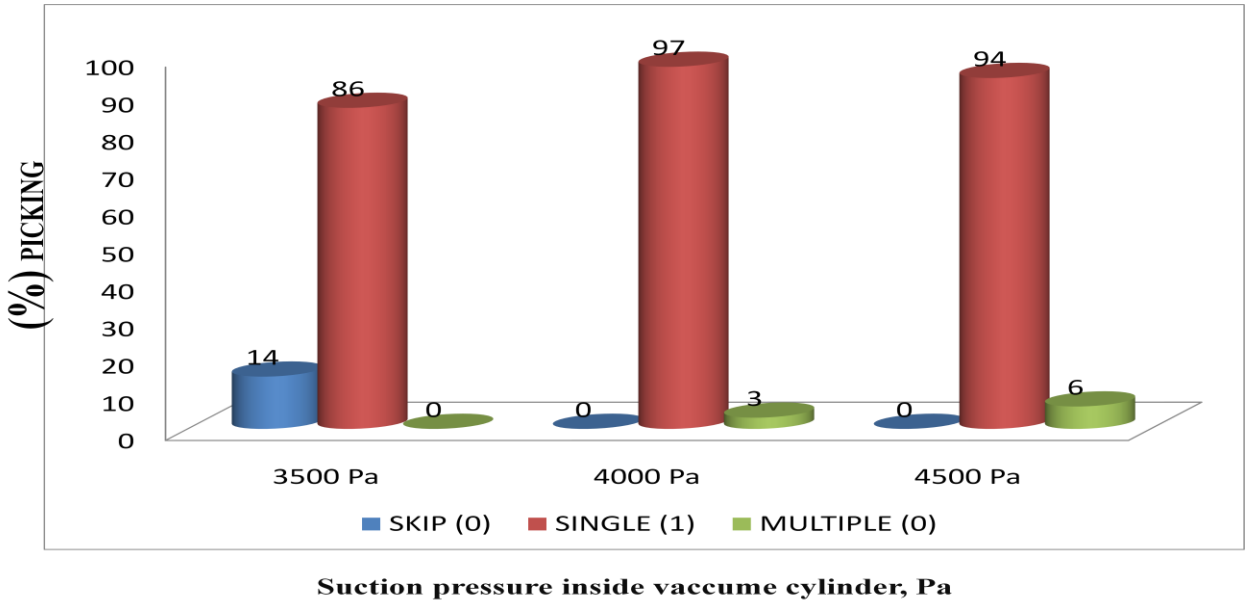

Fig: Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for Maize seed

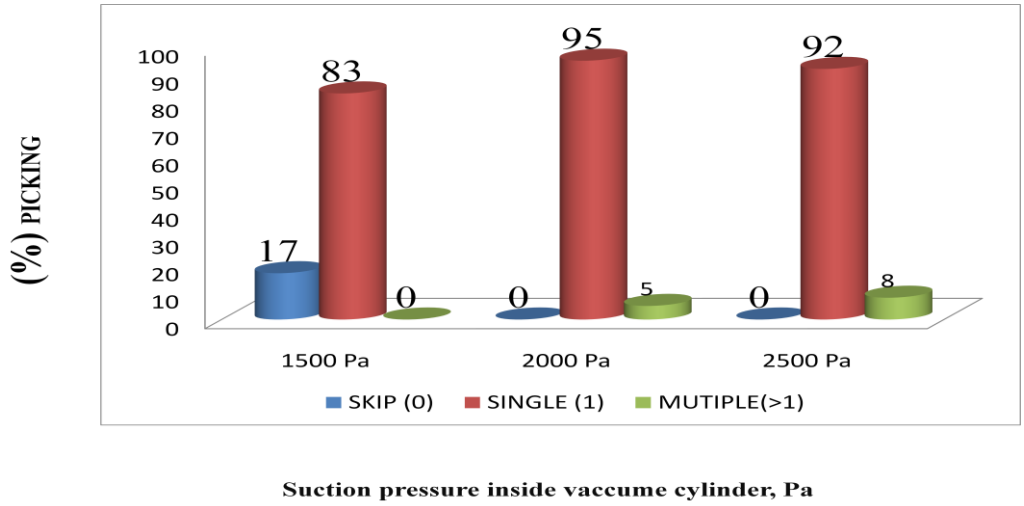

Fig: Performance of the 2.5 mm circular orifice vacuum cylinder under varying suction pressure for Pigeonpea seed

Metering efficiency of vacuum planter

Metering efficiency of the vacuum planting system was calculated from At different pressure levels and is presented in it was observed that with the increase in suction pressure inside the vaccume cylinder the metering efficiency also increased from 93.33 to 111.33 percent as pressure increased from 4500 to5500 Pa for groundnut seeds and for maize seeds metering efficiency increased from 90 to 112.22 percent as pressure increased from 3500 to 4500 Pa and for pigeonpea seeds metering efficiency increased from 91.11 to 113.33 percent as pressure increased from 1500 to 2500 Pa.

Table: Effect of suction pressure in the vacuum drum on the metering efficiency of metering mechanism, for groundnut maize and pigeonpea seeds

S. No.	Seeds	Suction pressure in vacuum rod, Pa	Metering efficiency of metering mechanism ,(%)
1	Groundnut	**4500**	**93.33**
		5000	**106.67**
		5500	**111.33**
2	Maize	**3500**	**90**
		4000	**108.88**
		4500	**112.22**
3	Pigeonpea	**1500**	**91.11**
		2000	**110**
		2500	**113.33**

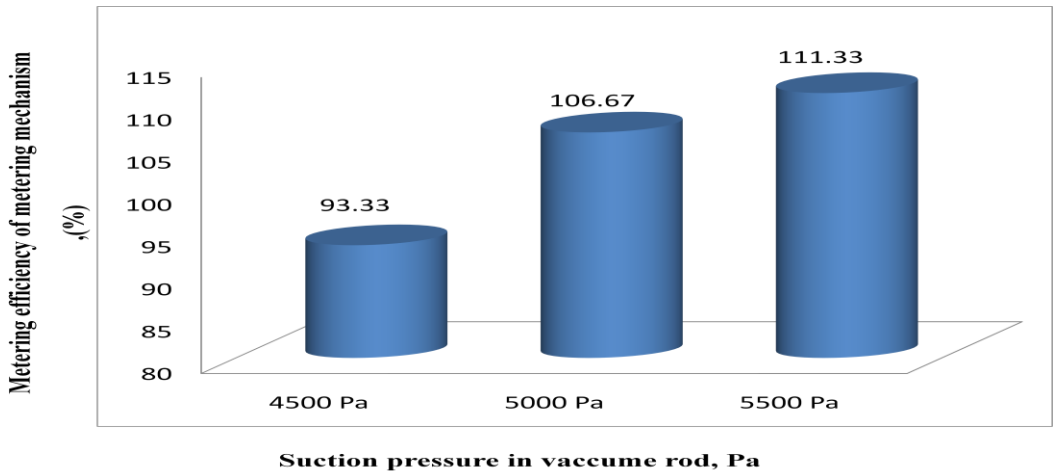

Fig. Effect of suction pressure in the vacuum drum on the metering efficiency of metering mechanism for Groundnut

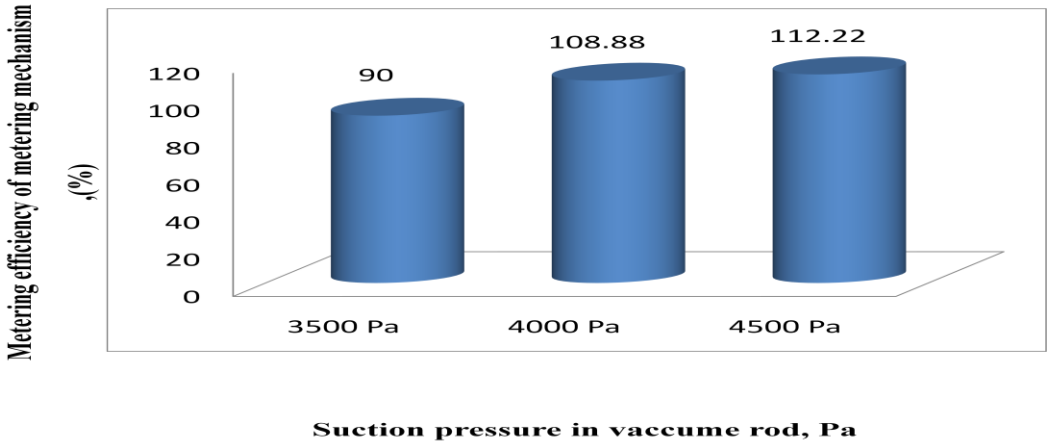

Fig. Effect of suction pressure in the vacuum drum on the metering efficiency of metering mechanism for Maize

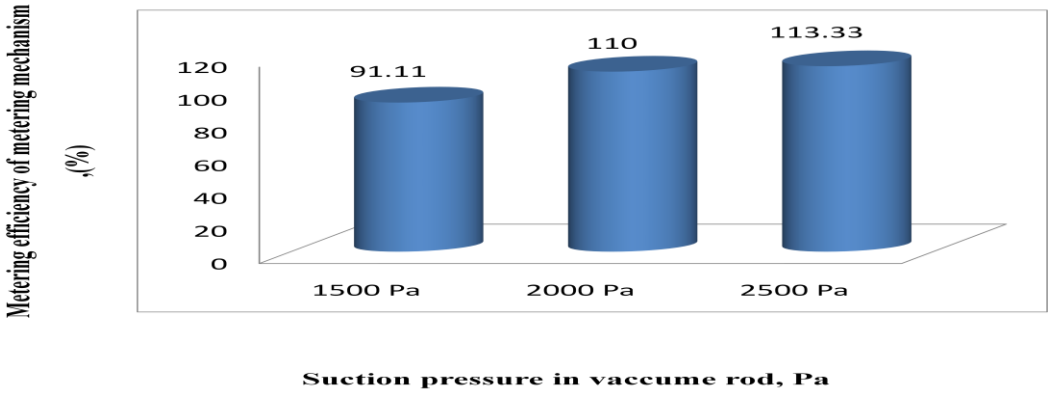

Fig. Effect of suction pressure in the vacuum drum on the metering efficiency of metering mechanism for pigeonpea

Calculation of seed rate (kg/ha)

Theoretical seed rate (R_{st})

For groundnut seeds

Row width = 30 cm

$$R_{st} = \frac{10^8}{30 \times 15} = 222230 \text{ seeds/ha}$$

For maize and pigeonpea seeds

Row width = 60 cm

R_{st} = 83340 seeds/ha

Seeding mass rate (R_{sm})

The total mass of bold seeds planted per hectare expressed in Mg/ha was calculated by using the following relationship (Bakhtiari and Loghavi, 2009):

For groundnut seed

Average mass of one seed = 0.35g

Row width = 30 cm

$$R_{sm} = \left[\frac{0.335}{30 \times 15}\right] \times 100$$

= 0.0744 mg/ha

= 74.44 kg/ha

For maize seed

Average mass of one seed = 0.204g

Row width = 60 cm

R_{sm} = 0.017 mg/ha

R_{sm} = 17.00 kg/ha

For pigeonpea seed

Average mass of one seed = 0.131g

Row width = 60 cm

R_{sm} = 0.01091 mg/ha

R_{sm} = 10.91 kg/ha

Mechanical damage to seed by metering mechanism

Visual observations for mechanical damage due to metering mechanism were recorded and it was found that there was no visual damage to the seeds of groundnut, maize and pigeonpea. However the internal damage of seeds was measured by sowing of seeds in steel trays and found that the seed damage for groundnut, maize and pigeonpea was not significant at one per cent level of significance.

Table. Mechanical damage to seeds by planter

Sr. No	Crop	Weight of broken seeds, g	Total weight of sample, g	Broken seeds %
1	Groundnut	09.8	1000	0.98
2	Maize	07.2	1000	0.72
3	pigeonpea	06.1	1000	0.61

Seed collected in 20 revolutions

Found that the seed damage for groundnut, maize and pigeonpea was 0.98%, 0.72 % and 0.16% respectively.

Measures of accuracy of the metering mechanism
Missing Index (MI)
For Groundnut Seeds
Therefore,

$$\text{Missing Index} = \left[\frac{3}{60}\right] \times 100 = 5\%$$

In present study values of the missing index i.e. 5 %. Hence, the machine works properly in field. These missing were perhaps due to the jerk or vibration which produced opening of seed dropping unit during operation. It may also due to the clogging/segregation motion of groundnut seeds.

For Maize Seeds
Therefore,

$$\text{Missing Index} = \left[\frac{3}{60}\right] \times 100 = 5\%$$

In present study values of the missing index i.e. 5 %. Hence, the machine works properly in field. These missing were perhaps due to the jerk or vibration which produced opening of seed dropping unit during operation. It may also due to the clogging/segregation motion of maize seeds.

For Pigeonpea Seeds
Therefore,

$$\text{Missing Index} = \left[\frac{2}{60}\right] \times 100 = 3.33\ \%$$

In present study values of the missing index i.e. 3.332 %. Hence, the machine works properly in field. These missing were perhaps due to the jerk or vibration which produced opening of seed dropping unit during operation. It may also due to the clogging/segregation motion of maize seeds.

Multiple Index (DI)
For Groundnut Seeds
Therefore,

$$\text{Multiple Index} = \left[\frac{4}{60}\right] \times 100 = 6.66\ \%$$

The average multiple index for the data taken along the planted rows was found to be 6.66% that means only 6.66 hills of the groundnut seeds were dropped at more than one seeds.

For Maize Seeds
Therefore,

$$\text{Multiple Index} = \left[\frac{4}{60}\right] \times 100 = 6.66\ \%'$$

The average multiple index for the data taken along the planted rows was found to be 6.66 % that means only 6.66 hills of the groundnut seeds were dropped at more than one seeds.

For Pigeonpea Seeds
Therefore

$$\text{Multiple Index} = \left[\frac{6}{60}\right] \times 100 = 10\ \%$$

The average multiple index for the data taken along the planted rows was found to be 10 % that means only 10 hills of the pigeonpea seeds were dropped at more than one seeds.

Quality of Feed Index
It is the number of observations, which are 0.5 to 1.5 times theoretical spacing. Higher is the quality of feed index, better is the performance of the metering mechanism.

For Groundnut Seeds

$$\text{Quality of feed index} = \frac{56}{60} \times 100$$

Quality of feed index = 93.33%

For Maize Seeds

$$\text{Quality of feed index} = \frac{56}{60} \times 100$$

Quality of feed index = 93.33%

For Pigeonpea seeds

$$\text{Quality of feed index} = \frac{58}{60} \times 100$$

$$\text{Quality of feed index} = 96.66\ \%$$

The quality of feed index for groundnut, maize and pigeonpea seeds are 93.33%, 93.33% and 96.66% respectively.

Field Test
The average moisture content and bulk density was found to be 13.88% and 1.53 g/cm^3. respectively.

Cone index (penetration test)

The soil resistance was measured by a cone penetrometer. The data reveals that the cone index was found to be 234.38 kPa.

Depth of Seed Placement

The average depth of placement of Groundnut, Maize and Pigeonpea seeds in the field was 5.60, 5.57 and 4.63 cm respectively. The depth of placement of seeds was adjusted by hitching system.

Table. Depth of seed placement

		Depth of seed placement, cm		
S. No.	Particulars	Groundnut	Maize	Pigeonpea
1	Average depth of seed placement	5.60	5.57	4.63
2	SD	0.28	0.32	0.36
3	CV%	5.00	5.84	7.77

Theoretical field capacity

Theoretical field capacity (ha/h) = $\frac{W \times S}{10}$

Where,

S = Speed of operation, km/h = 4.1 km/h

W = Theoretical width covered, m = 1.8 m

= Number of furrow openers multiplied by distance between the furrow Opener, m

Theoretical field capacity (ha/h) = $\frac{1.8 \times 4.1}{10}$

Effective field capacity

Effective field capacity (ha/h) = $\frac{A}{T}$

Where,

A = Actual area covered, ha = 0.366 ha

T = Total time required to cover the area, h = 0.59 h

Effective field capacity (ha/h) = $\frac{0.366}{0.59}$ = 0.623

Field efficiency

Field efficiency η (%) = $\frac{\text{actual field capacity}}{\text{theoretical field capacity}} \times 100$

Field efficiency η (%) = $\frac{0.623}{0.738} \times 100$ = 84.5%

Operational speed

To get optimum operational speed the machine was run at different speeds viz. 4.0 km/h, 4.17 km/h and 4.13 km/h for groundnut, maize and pigeonpea seeds .

CONCLUSION

1. The optimum suction pressure of groundnut, maize and pigeonpea seed for single seed pick up through circular orifice were 5.0, 4.0 and 2.0 kPa respectively. Increase in the suction pressure increased the number of seed selected per orifice.
2. The seed rate varies with the vacuum pressure, and forward speed of travel. Seed rate is increased with increase in vacuum pressure of vacuum rod. The seed rate of groundnut, maize and pigeonpea was found 74.44 kg/ha, 17.00 kg/ha and 10.91 respectively.
3. To get optimum operational speed of the machine was 4.1 km/hfor groundnut, maize and pigeonpea seeds respectively.
4. The implement is capable of planting groundnut, maize and pigeonpea at the rate of 1.60 h/ha.
5. The average field efficiency was found 84.53%.

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RESEARCH ARTICLE

INFLUENCE OF *GLOMUS FASCICULATUM* AND BIO FORMULATIONS ON GROWTH OF JAMUN (*SYZYGIUM CUMINII* SKEELS)

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Abstract: An experiment was conducted at Horticulture Research Station, Bijapur (Tidagundi) to know the influence of *Glomus fasciculatum* and bioformulations on growth of jamun stocks. Rootstocks treated with *Glomus fasciculatum* had registered highest stock height (23.85cm and 30.70cm in both *in-situ* and *ex-situ* respectively), stock diameter (6.31mm and 7.56mm in both *in-situ* and *ex-situ* respectively) and number of leaves (25.97 and 28.15 in both *in-situ* and *ex-situ* respectively) in *both in-situ* and *ex-situ*. Among sub-treatments, stocks treated with microbial consortia had recorded significantly highest stock height (23.45cm and 30.52cm in both *in-situ* and *ex-situ* respectively) stock diameter (6.19mm and 7.47mm in both *in-situ* and *ex-situ* respectively) and number of leaves (24.79 and 26.88 in both *in-situ* and *ex-situ* respectively) in organic conditions.

Keywords: *Syzygium cuminii*, *Glomus fasciculatum*, Bioformulations

INTRODUCTION

Jamun is an indigenous, underexploited fruit crop of high commercial value belong to the family Myrtaceae. It has recently attained utmost importance as an arid zone crop because of its hardy nature, high yielding potential, quality fruits and also for its nutritive and medicinal properties especially in diabetes. Lack of recognised varieties, relatively long pre-bearing period and lack of standardised propagation techniques and non-availability of elite planting materials are major hurdles in the area expansion of this fruit crop. Maximum number of jamun trees are found scattered throughout the tropical and subtropical regions of the country. Information regarding the area under jamun is not available as it is seldom planted in the form of an orchard and generally scattered trees are found in fruit orchards. They are also seen growing in parks, on roadsides, avenues and as windbreaks. However, in recent years organised orchards are being established.

Chemical free traditional farming technology (organic, biodynamics, homa, panchagavya, agnihotra, rishi krishi, *etc*) are gaining a new momentum not only in India but also all over the world. These systems of organic cultivation offer a means to address self-reliance, rural upliftment and conservation of natural resources. Keeping this in view the study was undertaken to know the influence of these organics and *Glomus fasciculatum* on growth of jamun stocks under *in-situ* and *ex-situ* cultivation.

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MATERIAL AND METHOD

An investigation was carried out at Horticulture Research and Extension Centre, Bijapur (Tidagundi) to know the combined influence of *Glomus fasciculatum* and bioformulations on growth of jamun stocks in both *in-situ* and *ex-situ*. The experiment consists of 10 treatment combinations consisting of two main plots (M_1- with *Glomus fasciculatum*, M_2- Un inoculated-control) and five sub plots (S_1- Amrit pani, S_2- Microbial consortia, S_3- Panchagavya, S_4- Inorganic fertilizer (60:30:90 g NPK per plant per year), S_5- Control) and was laid out in split plot design with three replications. Seeds were sown by placing five gram inoculum. Arboscular Mycorhizal (AM) fungi inoculation was done by spreading five gram inoculum uniformly at five centimeter depth after putting a thin layer of soil on the inoculum. The bioformulations were applied as soil application at three per cent at monthly interval.

Bioformulations were prepared and applied as soil drenching. Amrit pani was prepared by thorough mixing of 10 kg of cow dung and 250 g cow ghee. To this mixture, 500 g of honey was added and mixed thoroughly. This mixture was kept for incubation for 24 hours (Pathak and Ram, 2004) before use. Microbial consortium consisted of 15 local isolates of bacteria, fungi and actinomycetes comprising of bioinoculants, PGPRs and biocontrol agents in cow dung slurry. Where as panchagavya can be prepared with Seven kilograms of fresh cow dung and one kilogram of fresh cow ghee were mixed thoroughly and incubated for two days. On the third day, three litres of cow urine and 10 litres of

water were added to the above mixture and kept for incubation. After 15 days of incubation, three litres of sugarcane juice, two litres of cow milk, two litres of cow curd, three litres of tender coconut water and 12 ripe bananas were added and mixed thoroughly. This mixture was again kept for 15 days for incubation and then used (Pathak and Ram, 2004).

RESULT AND DISCUSSION

Stocks that are inoculated with AM fungus *Glomus fasciculatum* recorded significantly highest growth parameters when compared to uninoculated stocks at all the stages of growth period (both 90 and 180 Days after sowing (DAS)). Stocks that are inoculated with *Glomus fasciculatum* recorded significantly highest stock height (23.85cm and 30.70cm in *in-situ* and *ex-situ* respectively), stock diameter (6.31mm and 7.56mm in *in-situ* and *ex-situ* respectively) and number of leaves (25.97 and 28.15 in *in-situ* and *ex-situ* respectively) compared to uninoculated stocks.

Influence of sub-treatments on growth parameters was found to be significant during all the stages of stock growth compare to untreated stocks. At 180 DAS, the stocks treated with microbial consortia recorded significantly highest stock height (23.45cm and 30.52cm in *in-situ* and *ex-situ* respectively), stock diameter (6.19mm and 7.47mm in *in-situ* and *ex-situ* respectively) and number of leaves (24.79 and 26.88 in *in-situ* and *ex-situ* respectively) in both *in-situ* and *ex-situ* followed by panchagavya treatment compared to control. Interaction effects were found non significant for stock height, stock diameter and number of leaves at all stages of crop growth in both *in-situ* and *ex-situ.*

Increase in the growth of the rootstocks observed in the present investigation (Tables 1 and 2) may be attributed to the beneficial synthesis of the hormones and growth factors by AM fungi leading to increased cell multiplication and cell division with overall increase in the vegetative parameters. PGPR might had effected on plant growth directly by providing metabolites which promote plant growth without any interactions with native soil microflora (Kloepper *et al.,* 1981). Indirectly, they inhibit deleterious rhizobacteria and phytopathogens through different mechanisms. Hooker *et al*. (1992) demonstrated both direct nutrient uptake and indirect growth effects of fungus inoculation on plants which are in agreement with the results of present work of AM fungus and its beneficial effects on jamun seedlings. These effects were evident from the increased vegetative parameters, *viz*., rootstock height, stem diameter, number of leaves, when compared to uninoculated control. Undoubtedly, more nutrients and growth regulators available to stocks grown in both *in-situ* and *ex-situ.* The vegetative growth depends on the availability of nutrients, as stated by Nemec and Vu (1990).

Increase in growth parameters observed in the present investigation may be attributed to the activity of microorganisms. The availability of nutrients due to microbial transformations be an account of their direct role in nitrogen fixation by N fixers like Azospirillum sp. (Jeeva *et al.,* 1988) and Azotobacter sp. (Alvarez *et al.,* 1996), P solubilisation by P solubilisers like *Pseudomonas striata* and plant growth promoting substances produced by these organisms in bioformulations which fix nitrogen, solubilises P and make K available contributing higher values of growth parameters.

Stocks inoculated with *Glomus fasciculatum* recorded significantly highest fresh weight (32.94g and 36.92g in both *in-situ* and *ex-situ* respectively) and dry weight (9.98g and 11.16g in both *in-situ* and *ex-situ* respectively) compared to uninoculated stocks. Among different sub-treatments, stocks inoculated with panchagavya recorded significantly highest fresh weight (32.80g and 36.71 in both *in-situ* and *ex-situ* respectively) and dry weight (9.83g and 10.68g in both *in-situ* and *ex-situ* respectively) compared to uninoculated stocks. Where as *Glomus fasciculatum* and bioformulations did not interact significantly for both fresh weight and dry weight under *in-situ* and *ex-situ*.

Increased fresh and dry weight observed in the present investigation might be due to higher carbohydrate production (Tables 3 and 4). Auxins, gibberellins and cytokinins like substances produced by Rhizosphere bacteria might had helped plants to produce more of biomass as reported by Barea *et al*. (1976). Our findings also corroborate with the findings of Nemac and Vu (1990) for increase of biomass in AM inoculated plants. Further, it is well documented that infection of plant roots by AM fungi has beneficial effects on vegetative parameters and biomass production (fresh and dry weight) of host plants compared to untreated stocks. (Waterer and Coltman, 1998; Adivappar *et al*., 2004).

Table 1. Influence of *Glomus fasciculatum* and bioformulations on the growth parameter of Jamun in in-situ grown stocks.

Treatments	90 DAS																	
	plant height						stock diameter						Number of leaves					
	S_1	S_2	S_3	S_4	S_5	mean	S_1	S_2	S_3	S_4	S_5	mean	S_1	S_2	S_3	S_4	S_5	mean
M_1	12.83	13.55	13.23	12.28	10.46	12.47	3.25	3.60	3.45	2.79	2.39	3.10	13.50	13.92	13.67	13.17	12.09	13.27
M_2	10.94	11.83	11.50	10.43	8.39	10.62	2.23	2.86	2.55	2.07	1.96	2.33	11.58	12.00	11.75	11.25	10.17	11.35
Mean	11.89	12.69	12.36	11.36	9.42		2.74	3.23	3.00	2.43	2.18		12.54	12.96	12.71	12.21	11.13	
For comparing the means of	S. Em±		CD at 5%		CD at 1%		S Em±		CD at 5%		CD at 1%		S Em±		CD at 5%		CD at 1%	
M	0.18		1.08		2.50		0.15		0.92		2.12		0.07		0.44		1.01	
S	0.25		0.76		1.05		0.14		0.41		0.56		0.15		0.46		0.63	
S at same M	0.36		NS		NS		0.19		NS		NS		0.22		NS		NS	
M at same S	0.37		NS		NS		0.23		NS		NS		0.21		NS		NS	
180 DAS																		
Treatments	S_1	S_2	S_3	S_4	S_5	mean	S_1	S_2	S_3	S_4	S_5	mean	S_1	S_2	S_3	S_4	S_5	mean
M_1	24.52	25.62	25.06	23.62	20.45	23.85	6.35	7.07	6.62	6.05	5.47	6.31	26.25	26.75	26.58	26.08	24.17	25.97
M_2	20.23	21.28	20.77	19.48	16.33	19.62	4.55	5.31	4.92	4.23	3.64	4.53	22.33	22.83	22.58	21.83	19.58	21.83
Mean	22.37	23.45	22.92	21.55	18.39		5.45	6.19	5.77	5.14	4.55		24.29	24.79	24.58	23.96	21.88	
For comparing the means of	S Em±		CD at 5%		CD at 1%		S Em±		CD at 5%		CD at 1%		S Em±		CD at 5%		CD at 1%	
M									1.50		3.46				0.44		1.01	
S	0.05		0.32		0.74		0.25		0.59		0.82		0.07		0.45		0.62	
S at same M	0.09		0.28		0.39		0.2		NS		NS		0.15		NS		NS	
M at same S	0.13		NS		NS		0.28		NS		NS		0.21		NS		NS	

M_1- *Glomus fasciculatum* M_2- Un inoculated S_1- Amrit pani S_2- Microbial Consortia S_3- Panchagavya S_4- RDF S_5- Control
DAS- Days after sowing NS- Non-significant

Table 2. Influence of *Glomus fasciculatum* and bioformulations on the growth parameter of Jamun in *ex-situ* grown stocks.

Treatments	90 DAS																	
	plant height						stock diameter						Plant leaves					
	S_1	S_2	S_3	S_4	S_5	mean	S_1	S_2	S_3	S_4	S_5	mean	S_1	S_2	S_3	S_4	S_5	mean
M_1	19.05	20.18	19.37	18.55	18.31	19.09	4.49	4.90	4.69	3.91	3.68	4.33	16.92	17.25	17.08	16.75	16.08	16.82
M_2	17.13	18.11	17.81	16.73	16.37	17.23	3.30	3.53	3.38	2.97	2.80	3.19	15.17	15.58	15.42	15.00	14.33	15.10
Mean	18.09	19.15	18.59	17.64	17.34		3.89	4.22	4.03	3.44	3.24		16.04	16.42	16.25	15.88	15.21	
For comparing the means of	S. Em±		CD at 5%		CD at 1%		S Em±		CD at 5%		CD at 1%		S Em±		CD at 5%		CD at 1%	
M	0.30		1.80		4.16		0.15		0.89		2.05		0.23		1.43		3.30	
S	0.24		0.73		1.00		0.21		0.63		NS		0.13		0.40		0.55	
S at same M	0.34		NS		NS		0.30		NS		NS		0.19		NS		NS	
M at same S	0.43		NS		NS		0.30		NS		NS		0.29		NS		NS	
180 DAS																		
Treatments	S_1	S_2	S_3	S_4	S_5	mean	S_1	S_2	S_3	S_4	S_5	mean	S_1	S_2	S_3	S_4	S_5	mean
M_1	31.03	32.46	31.52	30.24	28.22	30.70	7.68	8.37	7.97	7.25	6.51	7.56	28.42	29.17	28.92	28.17	26.08	28.15
M_2	27.50	28.57	27.95	26.52	24.65	27.04	5.89	6.57	6.22	5.52	4.86	5.81	24.17	24.58	24.42	24.08	21.58	23.77
Mean	29.26	30.52	29.74	28.38	26.44		6.79	7.47	7.10	6.39	5.68		26.29	26.88	26.67	26.13	23.83	
For comparing the means of	S Em±		CD at 5%		CD at 1%		S Em±		CD at 5%		CD at 1%		S Em±		CD at 5%		CD at 1%	
M	0.08		0.51		1.19		0.15		0.91		2.11		0.04		0.26		0.60	
S	0.39		1.17		1.62		0.20		0.60		0.83		0.13		0.40		0.55	
S at same M	0.55		NS		NS		0.28		NS		NS		0.19		NS		NS	
M at same S	0.50		NS		NS		0.29		NS		NS		0.17		NS		NS	

M_1- *Glomus fasciculatum* M_2- Un inoculated S_1- Amrit pani S_2- Microbial Consortia S_3- Panchagavya S_4- RDF S_5- Control
DAS- Days after sowing NS- Non-significant

Table 3. Influence of *Glomus fasciculatum* and bioformulations on fresh and dry weight (g) of Jamun in *in-situ* grown stocks.

Treatments	Fresh weight (180 DAS)						Dry weight (180 DAS)					
	S_1	S_2	S_3	S_4	S_5	mean	S_1	S_2	S_3	S_4	S_5	mean
M_1	33.59	34.46	35.37	32.47	28.81	32.94	10.17	10.23	10.35	9.82	9.32	9.98
M_2	28.48	29.63	30.23	27.63	23.52	27.90	9.13	9.27	9.32	8.87	8.37	8.99
mean	31.03	32.05	32.80	30.05	26.17		9.65	9.75	9.83	9.34	8.85	
For comparing the means of	S. Em±		CD at 5%		CD at 1%		S. Em±		CD at 5%		CD at 1%	
M	0.08		0.48		1.10		0.12		0.72		1.65	
S	0.20		0.60		0.82		0.16		0.47		0.65	
S at same M	0.28		NS		NS		0.22		NS		NS	
M at same S	0.26		NS		NS		0.23		NS		NS	

M_1- *Glomus fasciculatum*, M_2- Un inoculated, S_1- Amrit pani, S_2- Microbial Consortia, S_3- Panchagavya, S_4- RDF, S_5- Control
NS- Non-significant DAS- Days after sowing

Table 4. Influence of *Glomus fasciculatum* and bioformulations on fresh weight (g) and dry weight (g) of Jamun in *ex-situ* grown stocks.

Treatments	Fresh weight (180 DAS)						Dry weight (180 DAS)					
	S_1	S_2	S_3	S_4	S_5	mean	S_1	S_2	S_3	S_4	S_5	mean
M_1	37.82	38.58	39.54	35.86	32.79	36.92	11.23	11.34	11.53	11.08	10.62	11.16
M_2	31.51	33.32	33.87	29.56	26.69	30.99	9.56	9.71	9.83	9.29	8.79	9.43
mean	34.67	35.95	36.71	32.71	29.74		10.39	10.52	10.68	10.18	9.70	
For comparing the means of	S. Em±		CD at 5%		CD at 1%		S. Em±		CD at 5%		CD at 1%	
M	0.09		0.53		1.23		0.10		0.58		1.33	
S	0.21		0.63		0.87		0.13		0.39		0.53	
S at same M	0.30		NS		NS		0.18		NS		NS	
M at same S	0.28		NS		NS		0.19		NS		NS	

M_1- *Glomus fasciculatum*, M2- Un inoculated, S1- Amrit pani, S2- Microbial Consortia, S3- Panchagavya, S4- RDF, S5- Control
NS- Non-significant DAS- Days after sowing

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RESEARCH ARTICLE

PROCESS TECHNOLOGY FOR PREPARATION OF JAMUN JAM AND SQUASH AND QUALITY EVALUATION

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Abstract: Jamun has a shelf life of 2-3 days only, it is harvested and marketed daily under unhygienic conditions which further reduces its self life. To make this jamun fruit available in off season we have to preserve it. The jamun jam was preserved by boiling fruit pulp with sugar to a consistency of 68-70% TSS. Jamun squash was prepared by adding sugar syrup of 45% TSS to the juice and the cooled. Jamun jam and squash was stored for a period of 4 weeks, then the variations in protein content, ascorbic acid content, carbohydrates, and total lipids of jamun jam and squash was observed . The quality parameters remained constant and these parameters was similar to that of fruit except that of carbohydrate content of jam which was 58% compared to 17% in the fruit .

Keywords: Jamun jam, Jamun squash, Preservation of Jamun jam, Squash

INTRODUCTION

Jamun (*Syzygium cumini L*) is an important underutilized fruit of Indian origin; it is an evergreen tropical tree which belongs to the flowering plant family of Myrtaceae. It is also known as jambu, jambula, jamboola(1).

Jamun trees start flowers from March to April. The flowers of jamun are fragrant and small, about 5 mm in diameter. The development of fruit takes place by May or June and resemble large berries. A jamun tree yields 80 to 100 kg of fruit. The fruit is oblong, ovoid, starts green and turns pink to shining crimson black as it matures. The fruit is harvested in June – July months. These are non cliometric fruits. The ripe fruits drop from the tree and are collected by spreading a blanket or canvas under a tree. Harvesting can also be done manually by hand-picking as well as by shaking the tree(2). The flower and fruit drop are main problems of jamun with only 12-15% of flowers reaching maturity.

The fruit has received more recognition in folk medicine and in pharmacy. Jamun is a healthy fruit with absolutely no trace of sucrose. It is therefore, the only fruit with minimum calories. Not only the fruit, but the seed and also the leaves and bark of the jamun tree are believed to have medicinal properties (3). The acidic, sour, sweet, and soothing fruit is used to treat diabetes, diarrhoea and ringworm. In fact, a mixture of equal quantities of jamun and mango juice is said to be an ideal drink for diabetics.The main problem with the fruit is the shelf life of jamun, it has a shelf life of 2-3 days only, and it is harvested and marketed daily under unhygienic conditions which further reduce its shelf life. Researchers reported that pre-cooled jamun fruit in perforated polythene bags can be stored for 6 days at room temperatures, and or 21 days at low temperature of 9 °C and 85-90% relative humidity.

To make this jamun fruit available in off season we have to preserve it. The various preservation techniques can be used such as, modified atmospheric packaging, by preparation of jam, by preparation of jelly, by preparation of squash. The shelf life of jamun can be increased by one month by using modified atmospheric packaging and the advantage with this technique is we get the fruit with farm freshness. But by preparing jam, squash and jelly we can make available the fruit for more than one year. By preparation of jamun jam and squash we are adding value to the fruit and increasing the income of the farmer and also making the fruit with its medicinal properties available in the market throughout the year to diabetic patients and the people. The present study was undertaken to determine the self life of jamun products such as jamun jam and jamun squash by quality parameters.

MATERIAL AND METHOD

Preparation of jamun jam and squash

Jamun jam was prepared by cooking 560g of sugar with 560 g of jamun pulp. Where as jamun squash was prepared by 600g of sugar syrup with 600g jamun juice. For preparation of jamun jam and juice the fruit is first washed and then boiled in equal amounts of water to soften the pulp. The cooked jam was made into fine pulp by mashing and the seeds was removed, the pulp was made into fine pulp by using grinder. For the preparation of jam sugar was

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added to the pulp and cooked to the consistency of 68-70% TSS of jam. But for squash preparation 600g of sugar was dissolved in 1liter of water and it was boiled to get a consistency of 40-50% TSS. Finally citric acid and sodium benzoate were added for jam and squash and filled hot in sterilized bottles. The sequential steps involved in preparation of jamun jam and squash are given below fig.

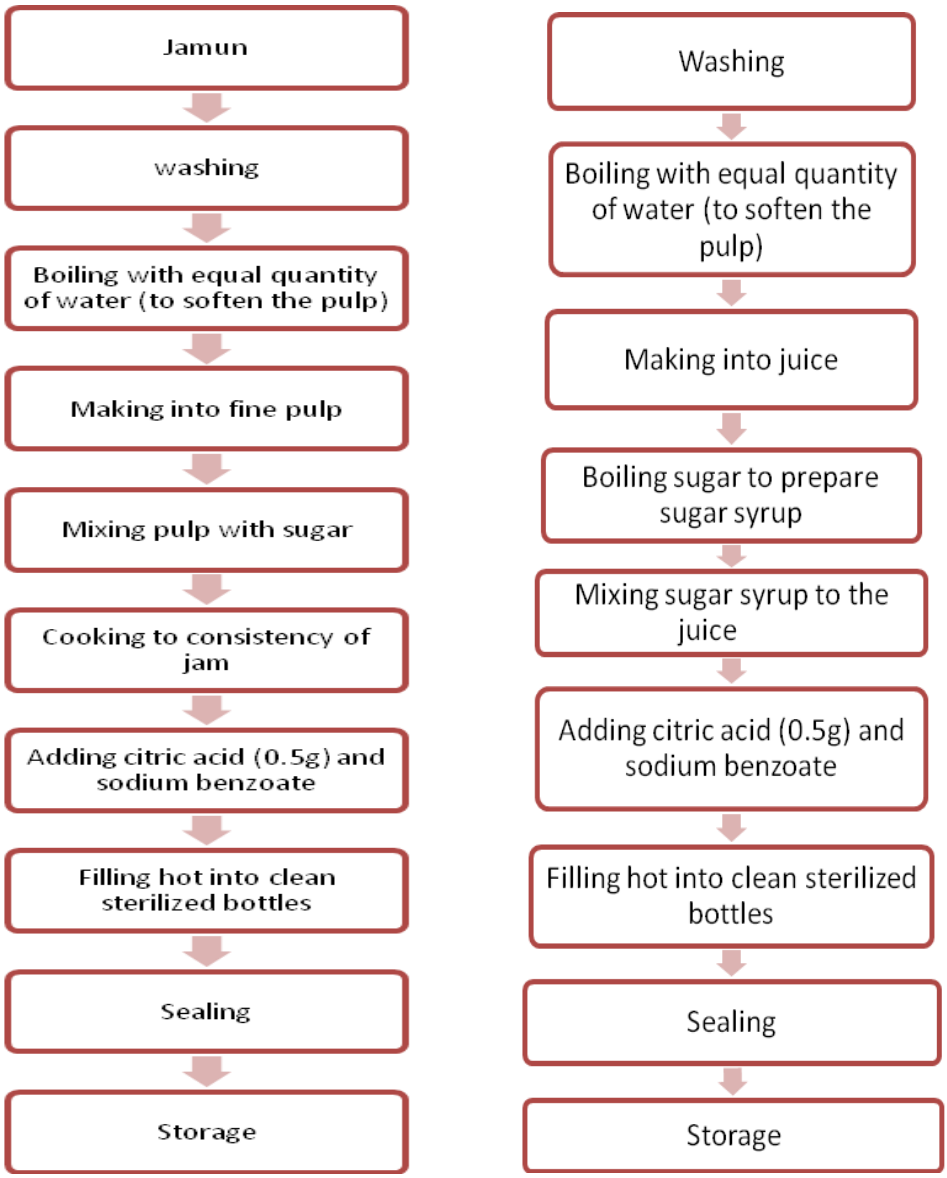

Fig: Flowchart for preparation of jamun jam and squash

Determination of proteins, carbohydrates, ascorbic acid, lipids

Estimation of total carbohydrates (phenol sulphuric acid method) Reagents required

1. Phenol 5%: redistilled (reagent grade) phenol (50g) dissolved in water and diluted to 1 liter.
2. Sulphuric acid (96%) reagent grade.
3. Standard stock: 100mg glucose in 100ml of water.
4. Working standard: 10ml of stock diluted to 100ml with distilled water.

METHODOLOGY

Sample weighing 1000 mg was taken in a boiling tube and it was hydrolyzed by keeping it in water bath for three hours with 5 ml of 2.5 N HCl and was cooled to room temperature. The solution was neutralized by adding sodium carbonate until the effervescence ceased. Now the neutralized solution was made to 100 ml using distilled water and solution was centrifuged at 5000 rpm for 5 minutes. 0.2 ml of centrifuged extract was pipetted in a test tube and made to 100 ml using distilled water. 1 ml of 5 % phenol reagent and 5 ml of sulphuric acid was added. Test tubes were put in water bath at 25-30 °C

for 20 min. the optical density at 490 nm was measured using a spectro-photometer. The amount of total carbohydrate present in the sample was calculated with the help of standard curve for carbohydrates.

Amount of carbohydrate present in 100 mg of the sample =

$$\frac{mg\ of\ glucose}{volume\ of\ test\ sample} \times 100$$

Estimation of protein (Lowry's method 1951)

Reagents required

1. Reagent A: 2% sodium carbonate in 0.1N sodium hydroxide.
2. Reagent B: 0.5% copper sulphate ($Cuso_4.5H_2o$) in 1% potassium sodium tartarate (Rachelle salt).
3. Reagent C: Alkaline copper solution: Mix 50 ml of reagent A and 1 ml of reagent B prior to use.
4. Reagent D: Folin and Ciocalteau (2N) phenol reagent. (Readily available).
5. Solution A: Protein solution (Stock standard)
6. Solution B: Working standard

METHODOLOGY

Extraction of protein from sample

Protein was extracted from the sample using buffer solution. 500 mg of sample was weighed and was ground well in mortar and pestle in 10 ml of buffer solution. The extract was centrifuged and supernatant was used for protein estimation.

Estimation of protein

0.1 ml of centrifuged extract was taken into test tube and volume was made to 1 ml by adding 0.9 ml of distilled water. 5 ml of reagent C was added to test tube and allowed to stand for 10 minutes. 0.5 ml of reagent D was added to the test tube and was allowed to incubate in dark for 30 minutes. Optical density readings were taken at 660 nm. The protein was calculated using standard curve for protein.

Estimation of ascorbic acid

Reagents Required

1. Oxalic acid (4%).
2. Dye solution: 2, 6 Dichloro phenol indophenol dye solution: - Weigh 42mg of sodium bicarbonate. Add 52mg of dye to dissolved solution. Make up the volume to 200ml with distilled water.
3. Stock standard solution: Dissolve 100mg pure ascorbic acid in 100ml of 4% oxalic acid.
4. Working standard: Dilute 10ml of the stock solution to 100ml with 4% oxalic acid. The concentration of working standard is 100µg/ml.

METHODOLOGY

500 mg of sample was weighed and homogenized in 5 ml of 4% oxalic acid and centrifuged in a centrifuge and the supernatant was collected in a beaker and it was made up to 100 ml using 4 % oxalic acid. Charcoal was added to decolorize the solution. 5 ml of the supernatant solution was taken in a porcelain basin and 10 ml of oxalic acid was added to it. The contents in porcelain basin were titrated against the dye until the end point of light pink color appeared. The amount of dye was noted down.

Estimation of lipids (Bligh and Dryer method)

Reagents required: Solvent mixture: chloroform and methanol (2:1) (v/v).

METHODOLOGY

In Bligh and Dryer method, a mixture of chloroform and methanol (2:1 v/v) wass used. The sample about 1 g weight was first ground in a pestle and mortar with about 10ml distilled water. The pulp was transferred to conical flak (250 ml capacity) and 30ml of chloroform-methanol mixture was added and mixed well. For complete extraction, it was kept overnight at room temperature, in the dark. At the end of this period, 20ml chloroform and 20ml water was added. The resulting solution was centrifuged, 3 layers were seen. A clear lower layer of chloroform containing all the lipids, a colored aqueous layer of methanol with all water soluble material and a thick pasty interface were seen.

The methanol layer was discarded and the lower layer was carefully collected free of interphase either by sucking out with a fine capillary or by filtration through glass wool. The organic layer from either of the extraction method was taken in a pre-weighed or vial and carefully evaporated. Sample was covered with a dark paper to protect from light. This was done because some lipids get polymerized or decomposed on exposure to light, heat and oxygen.

When the solution was free of organic solvents, the weight was determined again. The difference in weight gave the weight of the lipids. The results are expressed in terms of weight in milligrams of total lipid per gram of fresh sample.

RESULT AND DISCUSSION

In this chapter the effect of shelf life on protein content, carbohydrates, ascorbic acid and total lipids of jamun jam and squash are discussed. And also these parameters are determined for fruit pulp and compared with value added products of jamun i.e. jam and squash.

Initial values of protein content, carbohydrates, ascorbic acid, total lipids and pH of the fresh jamun fruit, jam and squash

It was observed that the ascorbic acid decreased in jam and squash than in fresh fruit, this deterioration may be because ascorbic acid deteriorates by application of heat. As the jam is boiled ascorbic acid

content is less than fresh fruit and as jam is more concentrated than squash, the ascorbic content in jam is more than squash. From the results it was observed that there is little decrease in protein content in jam and squash than in fresh fruit. As the jam is more concentrated than squash, the protein content is more than squash. There is negligible change in protein content due to processing of fruit. The carbohydrate content is very high in jam than in fresh fruit because of addition of sugar in preparation of jam. In squash the carbohydrate content is less than fruit and jam, this may be because the sugar added is in diluted form and it is not as concentrated as jam. The jam contained 58.11 % of carbohydrates compared to 15.89% and 5.60 % of fruit and squash respectively. As it is well known that total lipids or fat content in the fruit is very less, the products of the fruit showed similar results. Total lipids decreased in the processed products than in fruit. The pH of the fruit and its products showed that the fruit and its products were acidic in nature. The pH of fruit was 3.71 while that for jam and squash was 4.01 and 3.19. Squash showed more acidity than jam and fruit.

The initial values of protein content, carbohydrates, ascorbic acid, total lipids and pH of the fresh jamun fruit, jam and squash are presented in Table 1.

Table 1. Ascorbic acid, protein, carbohydrate, lipids and pH of the fruit and its products

PRODUCTS	Ascorbic acid (mg/100g)	Protein (%)	Carbohydrates (%)	Lipids (%)	pH
Fruit	19.16	1.19	15.89	0.253	3.71
Jam	8.86	1.04	58.11	0.1535	4.01
Squash	4.46	0.991	5.60	0.083	3.19

Effect of shelf life on ascorbic acid content of jam and squash

The effect of shelf life on ascorbic acid content of jam and squash is shown in fig. The ascorbic acid content decreased from 8.86 mg/100 g of fresh jam to 8 mg/100 g of jam stored for 4 weeks. While the ascorbic acid content of squash decreased from 4.46 mg/100 g of fresh squash to 4.28 mg/100 g for squash stored for 4 weeks. The decrease in ascorbic content is because the ascorbic acid deteriorates on storage.

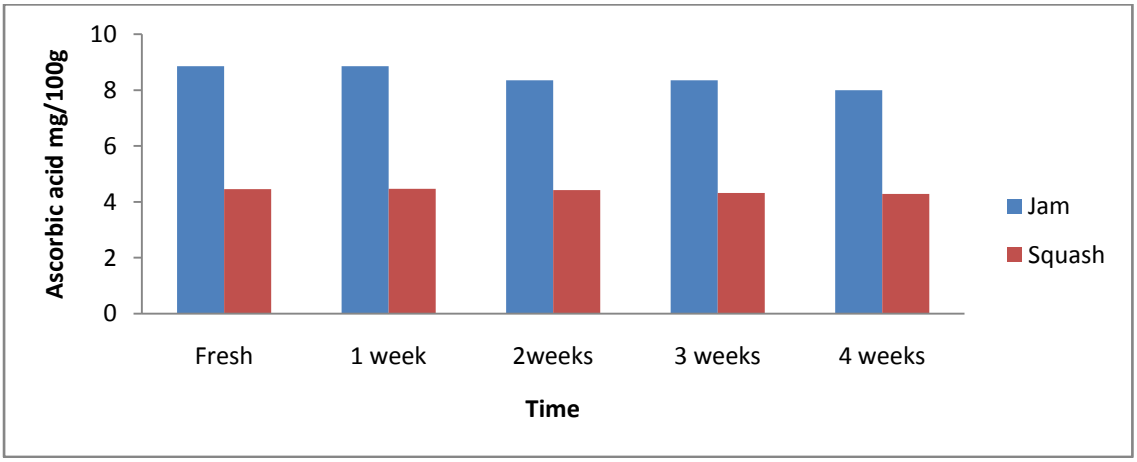

Fig. Effect of shelf life on ascorbic acid content of jam and squash

Effect of shelf life on protein content of jam and squash

The effect of shelf life on protein content of jam and squash is shown in fig.. The protein content did not change during a storage period of 4 weeks. The protein content of jam remained constant at 1.04% during the storage period of 4 weeks while for squash it decreased from 0.99% to 0.92%.

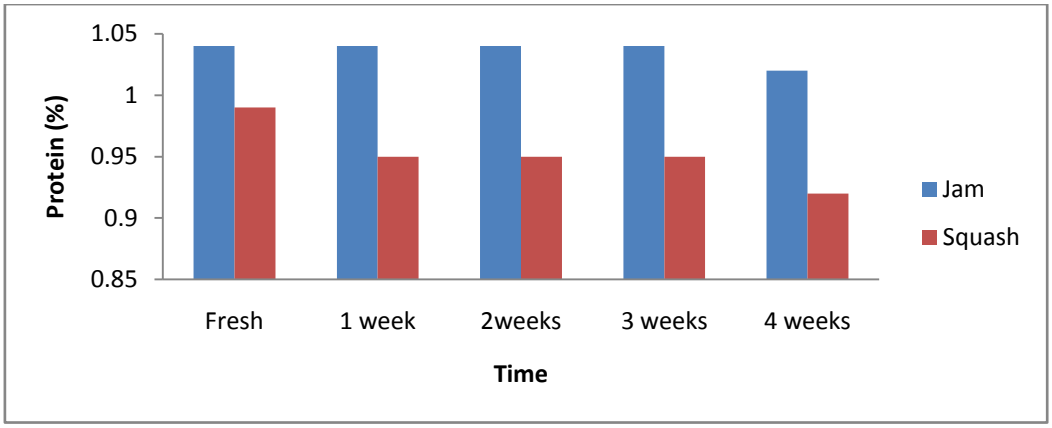

Fig. Effect of shelf life on protein content of jam and squash

Effect of shelf life on carbohydrates of jam and squash

The effect of shelf life on carbohydrates of jam and squash is shown in fig. The carbohydrates did not change during a storage period of 4 weeks for jam, but it decreased for squash. The carbohydrates of jam remained constant at 58.11% during the storage period of 4 weeks while for squash it decreased from 5.60% to 4.7%.

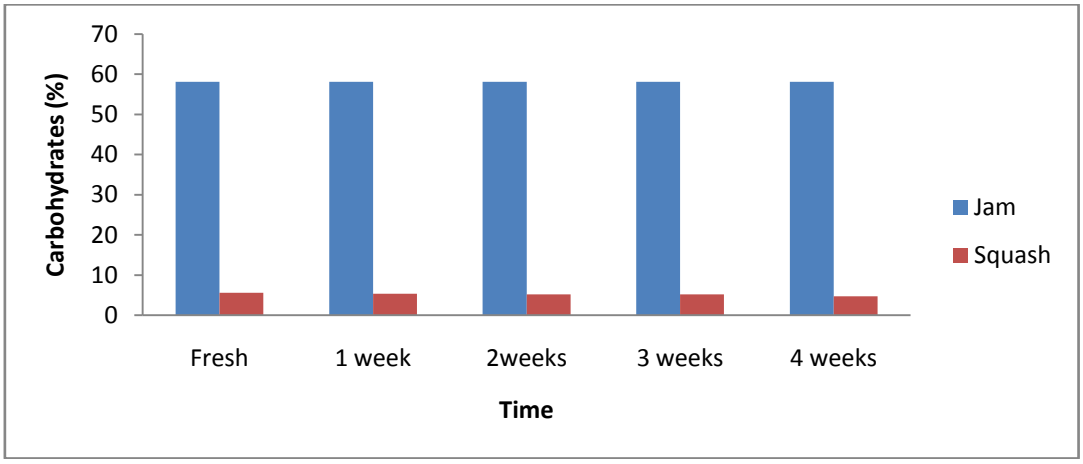

Fig. Effect of shelf life on carbohydrates content of jam and squash

Effect of shelf life on total lipids of jam and squash:

The effect of shelf life on total lipids of jam and squash is shown in fig. The total lipids remained constant during a storage period of 4 weeks for jam and squash. The total lipids of jam remained constant at 0.1535% during the storage period of 4 weeks while for squash it was at 0.083%.

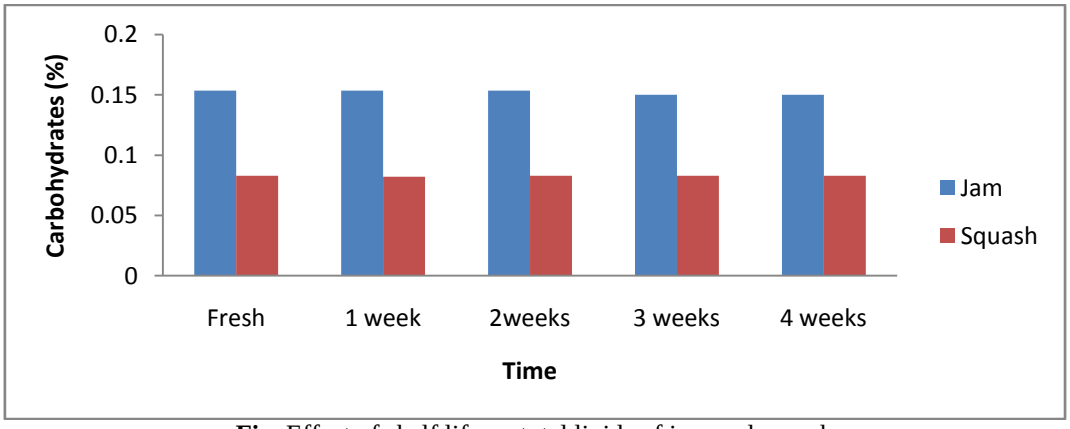

Fig. Effect of shelf life on total lipids of jam and squash

SUMMARY AND CONCLUSION

The jamun jam was prepared by boiling the jamun fruit pulp with sugar to a consistency of 68 – 70 % TSS. Jamun squash was prepared by adding sugar syrup of 45% TSS was added to sugar and then cooled. The data was analyzed for determining the protein content, ascorbic acid content, carbohydrates, total lipids, pH and sensory score of jamun jam and squash.

Based on the results from the present study it can be concluded that jamun squash and jam prepared from jamun fruit showed significantly high acceptability. Utilization of jamun jam and squash can serve as healthy product for diabetic products as it contains an alkaloid, jambosine and glycoside jambolin or antimellin which halts the conversion of starch into sugar.

Therefore it was suggested that jamun fruit up to 100% can be incorporated for preparation of nutritious and acceptable jam and squash. The estimated fruit waste in jamun fruit is around 2 kilo and hence the utilization of jamun seed in the preparation of seed powder will result in fruit waste utilization and also increase value addition of fruit.

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RESEARCH ARTICLE

IMPACT OF ABIOTIC FACTORS AND AGE OF HOST PLANT ON PURPLE BLOTCH OF ONION CAUSED BY *ALTERNARIA PORRI* (ELLIS) AND ESTIMATION OF YIELD LOSSES

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Abstract: An experiment was conducted on" Impact of abiotic factors and age of host plant on purple blotch of onion *(Allium cepa* L.) caused by *Alternaria porri* (Ellis) and estimation of yield losses "was carried out in Department of Plant Pathology, cage house and experimental field of Horticulture farm, Rajasthan College of Agriculture, Udaipur during 2014-2015. Sixty-days-old plants were more susceptible for infection of *A. porri*. However, susceptibility increased with increased age and after 60-days age decreased in susceptibility was recorded. In field trial conducted for yield loss estimation revealed that maximum yield loss (50.11%) was obtained in control plots followed by one, two and three spray of Mancozeb @ 0.2 per cent concentration. In relation to environmental factors study, temperature ranged from 13 to 32°C, relative humidity more than 75 per cent, wind velocity 2.4 Kmph, sunshine 8.4 hrs and optimum rainfall was found favourable for purple blotch disease development.

Keywords: Purple blotch, Onion, Abiotic, Age of host, Yield loss

INTRODUCTION

Onion (*Allium cepa* L.) belongs to family Amaryllidaceae, is a bulbous, biennial herb, rightly called as "Queen of kitchen". It is one of the most important vegetable cum condiment crop grown throughout the world. In India onion is cultivated in three seasons mainly – *Kharif*, late *Kharif* and *Rabi*. *Rabi* accounts for 60 per cent production and other two season's accounts for 20 per cent each. India occupies second rank in productivity next to China with an area of 12.04 lakh hectares with an annual total production of 194.02 lakh tons and an average productivity of 16.1 mt/ha. In Rajasthan, it is cultivated in 5.75 lakh hectares with a total production of 7.05 lakh tons and productivity of 12.3 mt/ha.([1]Anonymous, 2013-14).Onion crop suffers from number of disease among them purple blotch of onion caused by *A. porri* (Ellis) is the most destructive disease, prevalent in almost all onion growing areas of the world causing heavy losses under field conditions and is the major constraints to the onion production and due to this disease yield loss ranging from 2.5 to 87.8 per cent during *Kharif* season ([2]Srivastava *et al*., 1994). The fungus attacks both leaves and flower stalk ([3] Bock, 1964), reducing foliar production by 62-92% ([4] Suheri and Prince, 2001). The disease can cause a yield loss of 30% ([5] Everts and Lacy, 1990) and 100% of the seed crop, when the weather is favourable ([6] Daljeet *et al*., 1992 and Schwartz, 2004). The yield loss of onion in India due to this disease under favorable conditions varies from 5.0 to 96.5 per cent ([7]Gupta and Pathak, 1988) and 97 per cent ([8] Lakra, 1999).

Keeping in view, economic importance and yield losses caused by purple blotch present investigation were undertaken.

MATERIAL AND METHOD

Effect of plant age on disease development

A pot experiment was laid out in completely randomized design with five replications. Each pot had four plants. The susceptible onion cultivars Nasik red seedlings were transplanted in pots. After 15 days of transplanting (i.e. 15 day plant age) five pots were taken and inoculated with culture of *A. porri* by spray inoculation technique. Inoculated plants were kept in humid chamber for 20 hrs and then transferred to cage house and high humidity was maintained throughout the disease development period by regular spraying with water. Observations for disease severity were recorded periodically after 10 days of inoculation on 0-5 disease rating scale given by [9] Sharma (1986). The process was repeated similarly for 30, 45, 60, 75 and 90 day plant age.

The details of 0-5 rating scales is listed below:

Per cent area covered	Score
No disease symptom	0
A few spots towards tip covering 10 per cent leaf area	1
Several purplish brown patches covering upto 20 per cent of leaf area	2

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Several patches with paler outer zone covering upto 40 per cent leaf area	3
Leaf streaks covering upto 75 per cent leaf area or breaking of the leaves from center and	4
Complete drying of the leaves or breaking of leaves from center	5

The per cent disease index (PDI) was calculated using following formula given by [10] Wheeler 1969 :

$$\text{Percent disease index (PDI)} = \frac{\text{Sum of all individual disease rating}}{\text{Total No. of plant assessed} \times \text{Maximum rating}} \times 100$$

Estimation of losses of onion bulb under field conditions

The losses caused by a disease vary with the host pathogen combination and the disease severity. Since limited information is available on the losses caused by *A. porri* in onion, field trials were conducted in *Rabi* 2014-15 to assess the reduction in yield under field conditions. The experiment was conducted taking local susceptible land race(Nasik red) of onion. The seedlings were prepared in nursery and after attaining one month age these were transplanted in field in 3 x 2 m size plots, taking 15 cm row to row distance and 10 cm plant to plant distance. Recommended agronomical practices for fertilizers (N-100, P-50 and K-100 kg ha^{-1}) and for weeds mechanical removal was followed. The onion plants were inoculated uniformly with the pure culture of *A. porri*. In first treatment one spray with Mancozeb @ 0.2 per cent concentration, similarly, two and three spray in 2nd& 3rd treatments with the same fungicide were given and 4th treatment was maintained as untreated control. Five replication of each treatment were maintained and treatments were planned in randomized block design. The inoculations were done in the late evening.Spore suspension was prepared by gently flooding the scraping dislodge conidia 7 days old culture with distilled water (1:1) in a warring blender and filtering through muslin cloth. The desired inoculum density 1×10^3 conidia ml^{-1} was prepared with the help of a haemocytometer. The inoculum was prepared fresh just before inoculations in the field. These were spray-inoculated on 45 days-old plants with the help of hand held sprayer to the run off level.

Observations for disease severity were recorded periodically (15 days after inoculation) by visual scoring as per the standard continuous rating 0-5 scale ([9] Sharma, 1986). Numbers of plants in each score were recorded and the PDI in each plot was determined as:

$$\text{PDI} = \frac{n\,x1 + n\,x2 + n\,x3 + n\,x4 + n\,x5}{N} \;\text{X}\; \frac{100}{\text{Maximum disease score (5)}}$$

Where,

n = Number of plants in each score, 0-5 = disease score

N = Total number of plant under observation

At maturity, plants from each plot were harvested and bulb yield/ plot were determined. The per cent losses in bulb yield were calculated by using formula given by [11] Klem (1940) as:

$$Q = \frac{a - b}{b} \times 100$$

Where,

a = Mean yield per plot from healthy plant

b = Mean yield per plot from diseased plant

Q = Per cent loss in yield

Epidemiological studies

Epidemiology of the disease, aerobiological studies such as appearance of spores and development of disease were carried out. Study on air borne conidia of *A. porri* was carried out in cage house throughout the cropping season after 30 days of inoculation under different environmental conditions to understand the development of the disease. The pathogen released the inoculum continuously in the form of conidia throughout the crop season. Later on intensity of purple blotch were correlated in relation to weather parameters. The weather data *i.e*. maximum and minimum temperature, morning and evening relative humidity, total rainfall per week, total rainy days per week, wind velocity (Kmph) and sunshine hrs per day were collected from agronomy farm observatory at RCA, Udaipur.

RESULT AND DISCUSSION

Effect of plant age on disease development

As the age of plants of cv. Nasik red increased, the percentage of leaf area showing symptoms and the percentage of defoliation increased. The most susceptible age of onion plants was found to be 60-days with 52.48 PDI. Inoculation at 30, 45-days-old plants resulted in 18.60 and 33.86, PDI respectively. At the later stage (75 and 90-days-old) onion cultivar showed decline in PDI 50.40 and 43.72 while no disease occurred at 15-days-old plant age. Increased susceptibility to infection with increasing host age has been reported in many *Alternaria*–host systems, such as *A. brassicae* and *A. brassicicola* on brassica crops ([12] Babadoost & Gabrielson, 1979), *A. porri* on onions ([13]Gupta & Pathak, 1986) and *A. macrospora* on cotton ([14] Rotem *et al*., 1990). [15]

Kareem *et al*. (2012) studied the onion plants at different age*viz*., 15, 30, 45, 60 and 75 days were inoculated separately with conidial suspension of *A. porri*. With the increased host age there was a significant increased in disease development. Highest PDI (54.43) recorded at 60 days age followed by 75 days (51.75), 45 days (36.25) and 30 days (28.83 PDI) whereas 15 days age plant showed less PDI (21.08).(Table 1)

Estimation of losses of onion bulb under field conditions

All the treatments resulted in higher yield ranging from (12.02-16.04 kg/plot) over the untreated control (8.98 kg/plot). In the inoculated control plots, onion yield was 8.98 kg/plot. The maximum yield loss (50.11%) was obtained in control plots followed by one spray (33.22%), two spray (22.38%) and three spray (10.89%). Purple blotch of onion has been reported to cause heavy losses in yield and as per reports it causes 20-25 per cent yield loss ([16] Thind and Jhooty, 1982). In present investigation Mancozeb @ 0.2 per cent concentration was used as protective spray and untreated control was also maintained, taking three treatments of one, two and three sprays. PDI was also recorded and based on PDI it was found that three sprays of Mancozeb @ 0.2 per cent concentration at 10 days interval was best to control the disease with least PDI *i.e*. 26.04 with maximum yield of 16.04 kg/plot and yield loss 10.89 per cent respectively. Loss increased with the decreased in number of sprays *viz.*, two sprays with PDI 30.14 per cent and losses in yield 22.38 per cent followed by one spray with 33.22 per cent over healthy plots. Spray schedule and frequency is decisive in the disease management. Huq *et al.* (1999) showed average yield reduction in garlic cv. GC-018 with 21.54 per cent when yield was taken in different disease severity levels. [17] Upmanyu and Sharma (2007) observed extent of seed yield losses due to purple blotch of onion and reported that as the PDI increased yield of seed decreased. [18]Singh *et al* (2014) reported yield losses upto 58.44 per cent due to *A. lini* and *A. linicola*.(Table 2)

Epidemiological study

The PDI were recorded from December third week (standard week 51) to April fourth week (standard week 17) and February weeks were found favourable for initiation of purple blotch disease development in onion, whereas December third week was found least favourable. Maximum disease index was observed during February second, third, fourth and first week of March, there was increase in mean PDI 28.5 to 39.2, 39.2 to 47.8, 47.8 to 56.9 and then 56.9 to 64.7, respectively. Subsequently in later weeks disease declined with mean PDI 64.9 to 60.2, 60.2 to 51.3, 51.3 to 46.5 and 46.5 to 36.7 in second, third, fourth and fifth week of March, respectively and finally disease declined with mean PDI 17.4 in third week of April.

Table 1. Effect of plant age on purple blotch development on onion cultivar Nasik red

S.No.	Plant age (days)	Per cent disease index (PDI)*
1.	15	0.00 (0.00)
2.	30	18.60 (25.54)
3.	45	33.86 (35.58)
4.	60	52.48 (46.42)
5.	75	50.40 (45.23)
6.	90	43.72 (41.39)
SEm±		0.78
CD (P = 0.05)		2.29
CV (%)		5.28

*Mean of five replications

Figures in parentheses are arcsine √per cent angular transformed values

Table 2. Yield losses in onion due to *Alternaria porri* in field during *Rabi* 2014-15

S.No.	Treatments	Per cent disease Index (PDI)*	Bulb yield* (kg/plot)	Per cent loss in bulb yield
1.	Healthy plot	0.00	18.00	0.00
2.	Three spray	26.04 (30.68)	16.04	10.89 (19.27)

3.	Two spray	30.14 (33.29)	13.97	22.38 (28.23)
4.	One spray	34.37 (35.88)	12.02	33.22 (35.20)
5.	Control	52.81 (46.61)	8.98	50.11 (45.06)
	SEm±	0.711		1.18
	CD (P = 0.05)	2.04		3.49
	CV (%)	3.97		9.01

*Mean of five replications;
Figures in parentheses are arcsine √per cent angular values

Table 3. Effect of environmental factors in relation to purple blotch disease of onion during *Rabi* 2014-15 at RCA Udaipur

Standard week	Meteorological Weeks 2014, 2015	Average Temperature (°C)		Average Relative Humidity (%)		Wind velocity (Kmph)	Sunshine (hrs)	Avg. rainfall (mm)	Rainy days (days)	PDI* (%)
		Max.	Min.	Max.	Min.					
51	17 Dec-23 Dec	22.6	5.0	86.9	31.4	1.6	7.7	0.0	0	0.0
52	24 Dec-31 Dec	22.9	4.8	84.1	26.9	1.9	8.6	0.0	0	0.5
1	1 Jan-7 Jan	21.8	8.8	90.4	43.4	3.0	5.3	3.2	2	5.5
2	8 Jan-14 Jan	27.4	7.7	85.7	25.1	1.2	8.7	0.0	0	8.2
3	15 Jan-21 Jan	22.8	6.9	91.3	36.0	2.0	7.4	6.0	1	12
4	22 Jan-28 Jan	21.0	9.1	88.1	52.4	2.9	4.9	6.2	1	20.4
5	29 Jan-4 Feb	25.2	6.9	86.9	28.6	2.0	8.8	0.0	0	28.5
6	5 Feb-11 Feb	25.3	8.6	87.9	36.6	2.1	8.2	0.0	0	39.2
7	12 Feb-18 Feb	29.8	10.6	78.9	30.7	2.3	9.0	0.0	0	47.8.
8	19 Feb-25 Feb	32.5	13.7	78.0	31.0	2.4	8.4	0.0	0	56.9
9	26th Feb-4thMarch	25.0	10.3	76.90	33.00	3.7	6.8	13.2	2	64.7
10	5March-11March	28.0	11.3	76.7	27.6	2.7	8.9	0.0	0	60.2
11	12March-18March	28.6	14.0	79.4	30.4	3.1	7.3	10.6	3	51.3
12	19March-25March	33.8	15.9	68.6	24.7	2.1	9.2	0	0	46.5
13	26March-1April	36.3	19.5	66.1	19.4	3.4	7.2	0	0	36.7
14	2April-8April	34.1	21.7	53.9	25.7	5.8	7.8	0	0	27
15	9April-15April	32.6	18.5	60.9	30.9	3.8	7.4	15.6	3	20.2
16	16April-22April	37.9	22.2	37.0	14.4	4.7	7.4	0	0	17.4
17	23April-29April	39.4	24.3	28.9	12.0	6.0	8.5	0	0	14.3

*Mean of five replications

Temperature from 13 to 32°C was found most favourable however, maximum temperature showed positive correlation (r = +7.09) while minimum temperature showed negative correlation (r = -2.19) more than 40°C and less than 12°C was found not favourable. Relative humidity more than 75 per cent was found more favourable, however morning and evening relative humidity showed positive correlation (r = +2.38 and +1.12). Optimum rainfall was favourable for purple blotch of onion, however, rainfall showed positive correlation with spread while rainy days showed negative correlation. Wind velocity and sunshine hrs showed positive correlation. However, [19] Bassey and Gabrielson (1983) studied plants inoculated with *A. brassicicola* developed symptoms most quickly at 25°C, while seedlings raised from infected seeds developed symptoms most quickly at 30°C. [15] Kareem *et al.* (2012) reported infection of *A. porri* on onion over a temperature range of 15 to 35°C, with maximum infection at 25°C. The optimum RH for the infection of onion by *A. porri* was found to be 95 per cent, though disease development occurred over the range of 75 to 100 per cent relative humidity. [20] Mohammad and Dabbas (2012) studied the influence of environmental factors on the development of purple blotch of onion under field conditions; temperature and RH play an important role in the disease development. Range of temperature 25.50-28.00 and 26.50-27.20, relative humidity 88-76 per cent and 80-78 per cent favoured highest disease incidence during 2008 and 2009 seasons, respectively. (Table 3)

The present data of experiment are again confirmed and strongly supported the results obtained by earlier workers on this disease.

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RESEARCH ARTICLE

EFFICACY OF BIOCONTROL AGENTS, PLANT EXTRACTS AND ORGANIC AMMENDMENT AGAINST BLIGHT, POWDERY MILDEW AND WILT DISEASES IN CUMIN

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Abstract: Field experiment was conducted to study the effect of the different organic modules for management of *Alternaria blight Powdery mildew* and wilt diseases of cumin (Cuminum cyminum L.).Treatment module comprising of seed treatment with *Trichoderma herzeanum*@8g/kg seed + three foliar spray of Azadirachtin @2ml/lit.at 45-60DAS+ 60-75DAS+and at 90-100 DAS was found significantly superior over control and gave maximum seed yield of cumin 5.76q/ha. in comparison to control which gave only 3.43q/ha. cumin seed yield.This organic module was found superior in respect to disease control and effectively controlled all three diseases and record minimum disease intensity of *Alternaria blight(*12.49%) *Powdery mildew* 14.93% and wilt (6.20%). Where as in control 26.33.% ,28.66% and12.28%disease intensity was observed respectively. This module gave the highest net return of Rs.28013 /over control.

Keywords Cumin, *Alternaria blight, Powdery mildew, Trichoderma viride, Azedirachtin*

INTRODUCTION

Cumin is one of the most important spice seed crops of India and state of Rajasthan dominates in production ofcumin in India. Being a cash crop, there is a great demand of organic cumin (Sahota, 13) Organic cumin in Rajasthan represent a very negligible part of our total cumin production. The one of the constraints in increasing the area under cumin production is lake of suitable organic production practices for different agro climate regions. The present investigation was aimed to study the influence of certain bioagent, organic manures bio pesticides on diseases control and yield of cumin in southern Rajasthan.

Organic farming is gaining gradual momentum across the world. In India about 5,28,171 hectare area is under organic farming with 69,256 numbers of certified organic farms (willer, 2011)

Among various spice seeds crop cultivated in India, the cumin is important for both internal consumption and exports.The crop is generally grown as rabi crop in cool and dry climateCumin is grown extensively in Rajasthan, Fujarat,and Uttar Pradesh.Rajasthan and Gujarat together accounts for more than 90 percent of total area under cumin grown in india.Cumin is cultivated in India in 5,14,000 ha. with annual production of 79,000tonnes(Anonymous 2012) The aromatic flavor in the cumin seed is due to presence of volatile oil.It is chief ingredient in mixed spices and curry powders used for flavouring different beverages (Chattopadhyay and Maiti 1990) *Alternaria* blight caused by *Alternaria burncii*(Uppal et al,1938) *Alternaria* blight ,*Powdery mildew* and *Wilt* diseases cause severe yield losses in cumin and have been identified as major production constraints. Wilt of cumin is a important soil borne disease while *Alternaria* blight and *Powdery mildew* are important foliar diseases that affect the crop. The diseases causes serious yield losses under favourable weather conditions which may as highas 83 percent under congenial weather condition (Patel and Desai1971)

Alternaria blight, Powdery mildew and *wilt* disease are most important diseases of cumin in India. Till now, the diseases are managed mostly through the use of pesticides. The indiscriminate use of pesticides causes environmental and ecological hazards. Botanical pesticides have received attention of the growers because these are considered as less toxic and environmentally safe. The anti microbial property of some plant extracts under in vitro and in vivo have been reported(Mehta and Mehta2005;Kumar et al 2006) We investigated on the effect of plant extracts Neem oil, Azedirachtin against *Alternaria burncii*, *Erysiphe poligony* and *fusarium oxysporum* in field condition Chemical management of all three diseases is un economical and environmentally hazardous. Therefore, there is a need to look for non hazardous and eco friendly control measures for plant diseases management. In this context an investigation was planned to evaluate the efficacy of organic module against *Alternaria burncii Erysiphe polygony and Fusariun oxysporum* pathogens causing *Alternaria blight , Powdery mildew and wilt* diseases in cumin respectively.

MATERIAL AND METHOD

The efficacy of six different modules were tested against *Alternaria blight,Powdery mildew* & and *wilt* diseases in cumin at Dryland Farming Research

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Station Arjia, Bhilwara during 2009-10,2010-11&2011-12. Cumin variety RZ-19 was sown in Randomized Block Design with three replications.The unit plot size was 5.0x4.2m and Cumin seed were sown in second fortnight of November during all three years. Prior to sowing cumin seeds were treated with *Trichoderma harzeanum @8g/kg seed* . In control plot seeds were sown without any treatment. Treatment details are as follows:

Treatments

T_1 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% (two spray at 45 & 60 DAS + milk whey spray @ 100 ml/l at 75 and 90 DAS

T_2 - Seed treatment with TH @ 8 g/kg seed +foliar spray with NSKE @ 5% three spray at 45-60 + at 60-75 & at 90-100 DAS

T_3 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% spray at 45-60 DAS + @ 2% garlic extract spray followed by vermiwash spray (5%) at 60-75 & 90-100 DAS

T_4 - Seed treatment with TH @ 8 g/kg seed + *Azadirachtin* @ 2 ml/lit three spray at 45-60 + 60-75 and at 90-100 DAS

T_5 - Seed treatment with TH @ 8 g/kg seed + foliar spray with spray of BD 501 at 45-60 DAS + foliar spray with *Azadirachtin* @ 2 ml/lit at 60-75 + and at 90-100 DAS

T_6 - Control

Note : TH = *Trichoderma harzanium*

NSKE = Neem seed kernel extract

DAS = Days after sowing

Preparation and application of the treatments

Cumin field was given. Farm Yard Mannure @2 ton/ha. prior to sowing crop. Sowing was done using seed treatment with *Trichoderma harzeanum* @ 8g/Kg seed of cumin. Beside a pre sowing irrigation, crop was given four irrigations. For organic amendment in soil Neem cake @ 200 Kg/ha. was given at the time of field preparation, as a cultural practice summer ploughing was also done after the harvesting of previous crop in summer.

In order of preparation of two pesticides NSKE was prepared using 1.0 kg of Neem kernels. The kernels were dried and grounded in a grinding machine as course powder and added one lit. of water and kept it for overnight. Extracts was filtered through muslin cloth to get 100% stock solution of NSKE. 5ml of this solution adding in 100 ml of water will be treated as 5% NSKE solution. Milk whey also applied this way in which we used 100 ml milk whey added in 1 lit. water then it becomes 10% milk whey spray solution. All bio pesticides were exercised as per scheduled, at initiation of the disease on the standing crop at 10-15 days interval according to the treatments,while control plots were sprayed with plain water. The experiment was irrigated four times and other inter cultural operations were done when necessary. The crop was harvested offer 125-130 days. The data were recorded farm randomly selected 10 plants/Plot for disease severity of *Alternaria blight* & *Powdery mildew* of cuminstarted from just before first spray of bio pesticide. Cumin yield (q/ha-1) and disease scoring data were recorded on, whole plot basis and then diseases score data converted in to disease severity. (PDJ) The efficacy of bio pesticides were measured by scoring the disease (PDI) in the individual plot on the basis of a standard score scale (Anonymous 1994) Where O= Leaf and twigs free from in infection 1= 1-5% leaves are infected, 2=6-20% leaves are infected, 3 = 21-40% leaves & twigs are infected 4=41-70% leaves & twigs are infected. The disease data were converted in to percent disease index (PDI) suggested by Sharma (1984) & Rahman et al (1986) Data were analyzed following the statistical procedure followed by Gomez & Gomez (1983)

RESULT AND DISCUSSION

All the bio pesticides used in trial significantly reduced the severity of *Alternaria blight Powdery mildew* & wilt diseases in cumin .A significant variation among the bio pesticide treatment was observed. Data presented in Table No. 1,2 &3 revealed that treatment module comprising of seed treatment with Seed treatment with *Trochoderma herzeanum* @ 8 g/kg seed +foliar spray of *Azadirachtin* @ 2 ml/lit three spray at 45-60 + 60-75 and at 90-100 DAS was found significant superior over control and gave maximum seed yield of cumin5.76.q/ha., in comparison to control which gave only3.43 q/ha cumin seed yield with highest PDI 26.33% PDI of *Alternaria blight* 28.66.% *Powdery mildew* and 12.28..%*wilt* infected diseasesd plants respectively in organic cumin . This module effectively controlled disease and showed least PDI of *Alternaria blight* (12.49 %) 14.93 % *Powdery mildew* and 6.20%wilt infection..

Above results clearly indicated that among plant extracts Neem cake, NSKE Neem oil, Azerachtin, milk whey can be selected for further investigation with *T. harzeanumm* as they showed satisfactory controlled the *Alternaria blight & Powdery mildew* as well as *wilt* infection also. They all showed synergetic effect with each other it may be due to suitability of constituents present in bio pesticides & leaf extracts. Ravi Chander (1987) reported that growth of *Rhizoctonia solani* was completely inbihited with the leaf extract of subabul, but its efficacy was not tested against fungal antagonist by any worker earlier. Neem and Akven leaf extracts reduced the viability of sclerotia of *R.solani* (Laxman and Nair 1984) and mycelia growth considerably in vitro (Mani Bhusan Rao et al. 1988) It has suggested that treatment with biocontrol agents initiated in the plants a number of biochemical changes which can be considerd to be a part of plant defence responses(Sharma et al 2010) In Present finding

Neem seed kernel and neem based formulations were found inhibitory nature against pathogens involved in causing different diseases.

Similarly *T. harzeanum* is known to produce certain volatile and non volatile compounds which adversely affect the growth of pathogens (Dennis and Webster,1971)*T. Harzeanum* has been recognized as astrong mycoparasite against soil borne plant pathogens such as *R.solani*, *Sclerotium rolfsii*,and *Fusarium oxysporum (*Papavizas, 1985; Chet, 1987).

Economics

The study also indicate that initially organic farming attributed lower productivity and yield losses but there was an over all improvement in soil quality parameters indicating better soil health.It is economically feasible to practice organic farming when the farmers are able to get premium price for their produce and with the reduced cost of cultivation by not depending upon the purchased off farm inputs. On an average of three years productivity of cumin yield was found lower by 15-20 % in comparison to conventional farming. However due to availability of premium price (20-40%) for organic cumin the average net profit was 35-40% higher in organic farming compared to the conventional farming.

The economics of organic cumin cultivation over a period of three years indicated that there is a reduction in cost of cultivation and increased gross and net returns compared to conventional cumin cultivation at research station.Three year's pooled analysis data on disease management and yield attributes are depicted in Table no 1. revealed that application of organic treatments viz. Seed treatment with *Trichoderma herzeanum* @ 8 g/kg seed + *Azadirachtin* @ 2 ml/lit three spray at 45-60 + 60-75 and at 90-100 DAS found significant superior over control plot during cropping period.

The best treatment gave highest net return of Rs 28,013.33over control while Maximum B:C ratio of 1:23.95 was also recorded under best treatment in organic cumin cultivation during 2009-10,2010-11&2011-12.

Table 1. Effect of different modules of disease management of *Alternaria blight* in organic cumin

Treat-ment	PDI (%) of *A. blight*			
	2009-10	2010-11	2011-12	mean
T_1 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% (two spray at 45 & 60 DAS + milk whey spray @ 100 ml/l at 75 and 90 DAS	21.08 (27.35)	25.70 (30.46)	16.50 (23.96)	21.09 (27.25)
T_2 - Seed treatment with TH @ 8 g/kg seed +foliar spray with NSKE @ 5% three spray at 45-60 + at 60-75 & at 90-100 DAS	17.85 (24.99)	22.80 (28.52)	14.45 (22.33)	18.36 (25.61)
T_3 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% spray at 45-60 DAS + @ 2% garlic extract spray followed by vermiwash spray (5%) at 60-75 & 90-100 DAS	23.87 (29.27)	27.75 (31.78)	20.33 (26.79)	23.98 (29.28)
T_4 - Seed treatment with TH @ 8 g/kg seed + *Azadirachtin* @ 2 ml/lit three spray at 45-60 + 60-75 and at 90-100 DAS	11.86 (20.13)	15.26 (22.98)	10.36 (18.78)	12.49 (20.63)
T_5 - Seed treatment with TH @ 8 g/kg seed + foliar spray with spray of BD 501 at 45-60 DAS + foliar spray with *Azadirachtin* @ 2 ml/lit at 60-75 + and at 90-100 DAS	15.75 (23.38)	20.26 (26.78)	12.70 (20.87)	16.23 (23.67)
T_6 - Control	25.19 (30.10)	30.31 (33.40)	23.49 (28.98)	26.33 (30.82)
SEm±	1.16	1.40	0.26	
CD(0.05)	3.50	4.21	0.78	

Table 2. Effect of different modules of disease management of *Powdery mildew* in organic cumin

	PDI (%) of *A. blight*			
	2009-10	2010-11	2011-12	mean
T_1 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% (two spray at 45 & 60 DAS + milk whey spray @ 100 ml/l at 75 and 90 DAS	21.08 (27.35)	25.70 (30.46)	16.50 (23.96)	21.09 (27.25)
T_2 - Seed treatment with TH @ 8 g/kg seed +foliar spray with NSKE @ 5% three spray at 45-60 + at 60-75 & at 90-100 DAS	17.85 (24.99)	22.80 (28.52)	14.45 (22.33)	18.36 (25.61)
T_3 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% spray at 45-60 DAS + @ 2% garlic extract spray followed by vermiwash spray (5%) at 60-75 & 90-100 DAS	23.87 (29.27)	27.75 (31.78)	20.33 (26.79)	23.98 (29.28)
T_4 - Seed treatment with TH @ 8 g/kg seed + *Azadirachtin* @ 2 ml/lit three spray at 45-60 + 60-75 and at 90-100 DAS	11.86 (20.13)	15.26 (22.98)	10.36 (18.78)	12.49 (20.63)
T_5 - Seed treatment with TH @ 8 g/kg seed + foliar spray with spray of BD 501 at 45-60 DAS + foliar spray with *Azadirachtin* @ 2 ml/lit at 60-75 + and at 90-100 DAS	15.75 (23.38)	20.26 (26.78)	12.70 (20.87)	16.23 (23.67)
T_6 - Control	25.19	30.31 33.40	23.49 (28.98)	26.33 (30.82)

• (Figures in Parentheses are transformed values)

Table 3. Effect of different modules of disease management of *wilt disease* in organic cumin

Treatment	PDI (%) of powdery mildew			
	2009-10	2010-11	2011-12	Mean
T_1 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% (two spray at 45 & 60 DAS + milk whey spray @ 100 ml/l at 75 and 90 DAS	25.30 (30.32)	25.30 (30.32)	25.30 (30.32)	25.30 (30.32)
T_2 - Seed treatment with TH @ 8 g/kg seed +foliar spray with NSKE @ 5% three spray at 45-60 + at 60-75 & at 90-100 DAS	23.75 (29.17)	23.75 (29.17)	23.75 (29.17)	23.75 (29.17)
T_3 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% spray at 45-60 DAS + @ 2% garlic extract spray followed by vermiwash spray (5%) at 60-75 & 90-100 DAS	28.74 (32.43)	28.74 (32.43)	28.74 (32.43)	28.74 (32.43)
T_4 - Seed treatment with TH @ 8 g/kg seed + *Azadirachtin* @ 2 ml/lit three spray at 45-60 + 60-75 and at 90-100 DAS	15.87 (23.46)	15.87 (23.46)	15.87 (23.46)	15.87 (23.46)
T_5 - Seed treatment with TH @ 8 g/kg seed + foliar spray with spray of BD 501 at 45-60 DAS + foliar spray with *Azadirachtin* @ 2 ml/lit at 60-75 + and at 90-100 DAS	21.37 (27.53)	21.37 (27.53)	21.37 (27.53)	21.37 (27.53)
T_6 - Control	32.15 (34.54)	32.15 (34.54)	32.15 (34.54)	32.15 (34.54)
SEm±	1.40	1.40	1.40	1.40
CD(0.05)	4.25	4.25	4.25	4.25

(Figures in Parentheses are transformed values)

Table 4. Effect of different disease management modules on yield and economics of organic cumin

Treatment	Percent infection of wilt(%) (30 DAS)			
	2009-10	2010-11	2011-12	Mean
T_1 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% (two spray at 45 & 60 DAS + milk whey spray @ 100 ml/l at 75 and 90 DAS	8.00 (16.43)	8.00 (16.43)	8.00 (16.43)	8.00 (16.43)
T_2 - Seed treatment with TH @ 8 g/kg seed +foliar spray with NSKE @ 5% three spray at 45-60 + at 60-75 & at 90-100 DAS	5.6 (13.69)	5.6 (13.69)	5.6 (13.69)	5.6 (13.69)
T_3 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% spray at 45-60 DAS + @ 2% garlic extract spray followed by vermiwash spray (5%) at 60-75 & 90-100 DAS	6.0 (14.18)	6.0 (14.18)	6.0 (14.18)	6.0 (14.18)
T_4 - Seed treatment with TH @ 8 g/kg seed + *Azadirachtin* @ 2 ml/lit three spray at 45-60 + 60-75 and at 90-100 DAS	5.12 (13.05)	5.12 (13.05)	5.12 (13.05)	5.12 (13.05)
T_5 - Seed treatment with TH @ 8 g/kg seed + foliar spray with spray of BD 501 at 45-60 DAS + foliar spray with *Azadirachtin* @ 2 ml/lit at 60-75 + and at 90-100 DAS	7.90 (16.32)	7.90 (16.32)	7.90 (16.32)	7.90 (16.32)
T_6 - Control	10.19 (18.62)	10.19 (18.62)	10.19 (18.62)	10.19 (18.62)
SEm±	0.90	0.90	0.90	0.90
CD(0.05)	2.75	2.75	2.75	2.75

Treatment	Seed yield (q/ha)				% increase in seed yield over control				Net returns over control (Rs. / ha)			
	2009-10	2010-11	2011-12	mean	2009-10	2010-11	2011-12	mean	2009-10	2010-11	2011-12	mean
T_1 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% (two spray at 45 & 60 DAS + milk whey spray @ 100 ml/l at 75 and 90 DAS	3.61	2.28	6.28	4.06	9.72	18.13	23.86	17.24	3255	4550	15125	7643.33
T_2 - Seed treatment with TH @ 8 g/kg seed +foliar spray with NSKE @ 5% three spray at 45-60 + at 60-75 & at 90-100 DAS	3.84	2.69	6.71	4.41	16.41	38.86	32.35	29.21	5670	9750	20500	11973.33
T_3 - Seed treatment with TH @ 8 g/kg seed + foliar spray with NSKE @ 5% spray at 45-60 DAS + @ 2% garlic extract spray followed by vermiwash spray (5%) at 60-75 & 90-100 DAS	3.89	2.74	6.85	4.49	18.23	41.97	35.11	32.18	6195	10530	22250	12991.66
T_4 - Seed treatment with TH @ 8	5.24	3.78	8.25	5.76	59.2	95.3	62.7	72.4	2037	2392	39750	28013.

g/kg seed + *Azadirachtin* @ 2 ml/lit three spray at 45-60 + 60-75 and at 90-100 DAS					7	3	2	4	0	0		33
T_5 - Seed treatment with TH @ 8 g/kg seed + foliar spray with spray of BD 501 at 45-60 DAS + foliar spray with *Azadirachtin* @ 2 ml/lit at 60-75 + and at 90-100 DAS	4.11	3.46	7.64	5.07	24.29	79.27	50.69	51.41	8505	19890	32125	20173.33
T_6 - Control	3.30	1.93	5.07	3.43	-	-	-	-	-	-	-	-
SEm±	0.21	0.11	0.33									
CD(0.05)	0.64	0.33	0.99									

Net return from control Rs. 63375/- ha.

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RESEARCH ARTICLE

AWARENESS AND INVOLVEMENT OF PEOPLE IN CONSERVATION ACTIVITIES OF WESTERN GHATS OF KARNATAKA, INDIA

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Abstract: The Uttara Kannada (U.K) district being a bio-diversity hotspot and 80 percent of its area forested, need to be conserved by creating awareness regarding conservation among the forest dwellers. Thus there is a growing need for concentrated efforts on making people of U.K. district aware about forest conservation, involving them in protecting the forest and communicating to others about conserving the Western Ghats. Hence, in the present paper an effort is made to study the awareness level, involvement of people in forest conservation and their socio economic correlates. The results revealed that majority of the respondents were on medium level of awareness with a awareness index of 86.33 and more than eighty percent were involved in forest conservation activities and the major conservation activities were regeneration, plantation and fire control along with replacement of non conventional energy resources with fossil fuels.

Keywords: Betta lands, Conservation, Awareness, Conservation activities

INTRODUCTION

Ancient Indian culture, religion and folklore are linked to forest. Indian people worshipped trees and sages meditated under them. Wild life was dear to holy men and wild animals live around them. Our epics like Mahabharata and Ramayana are based on episodes in forest and our sage composed music in ashrams in forests. The total geographical area of India is 32, 88,000 Km2 of their 7, 47,800 Km2 (22.74 %) was occupied by forest at the time of independence. At present the total forest and tree cover is 7,01,673 Km2, (21.34 %) according to India State of Forest Report(2015).The propose area under forest in Forest Policy of 1988 is 33% of the total geographical area.

Human beings have always had impact on the environment. However, during the past two centuries and more particularly in the past 50 years economic activity has increased. Majority of the deforestation has occurred during the British Government as well as early years of Independence that include the time period of 1880-1960.The forest policy of the British government, significant emphasis was given to generate maximum revenue through timber cultivation as well as permanent agricultural crops rather than forest sustainability in India. However, in the recent past there has been growing awareness about increasing the forest cover by all the stakeholders who directly or indirectly depend on the forests. Many movements like Chipko movement in the Kumaon region, Appiko movement in Uttara Kannada district and Silent Valley revolution prove that importance of forest is better understood by the common man now.

The Uttara Kannada(U.K) district being a bio-diversity hotspot and 80 percent of its area forested, need to be conserved by creating awareness regarding conservation among the forest dwellers. Thus there is a growing need for concentrated efforts on making people of U.K. district aware about forest conservation, involving them in protecting the forest and communicating to others about conserving the Western Ghats. Hence, in the present paper an effort is made to study the awareness level, involvement of people in forest conservation and their socio economic correlates.

Therefore, the present study was conducted with the following objectives.

1. To study the awareness and involvement of people about conservation of Western Ghat.
2. To study the relationship between the personal and socio-economic characteristics of the respondents and awareness level.

MATERIAL AND METHOD

The study was conducted in 2014-15 at Uttara Kannada district situated in Central Western Ghats which is revered as one of the bio- diversity hotspots of the world. The Uttara Kannada district comprises of 11 taluks including all types of vegetation with a forest cover of 8,14,455 hectares . Three hundred respondents from all the 11 talukas were selected through simple random sampling technique across the district which formed the sample of the study. The data was collected with the help of a semi - structured interview schedule and focussed group discussions. The statistical tests for analysing the data such as Mean, Standard Deviation, Percentage, t- test, Pearson's Product Moment Correlation tests were applied

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RESULT AND DISCUSSION

Forests form one of the largest and compact natural resource which is exploited for both economical and ecological services. Increase in deforestation worldwide has resulted in sensitive issues like climate change and food security. The study which has been carried out in all the taluks of Uttara Kannada district throws light on awareness level of respondents on forest conservation. To study the awareness level a scale was developed on four point continuums after checking its relevancy with the help of experts in the concerned field. The final scores were used to categorise the respondents in to High, low and Medium level category based on the mean scores and standard deviation. The results about the awareness is depicted in the table 1

Awareness about forest Conservation

The awareness about forest conservation of the respondents was studied and it was found that 86.33 per cent of the farmers were having medium awareness about Western Ghat conservation followed by low awareness (10.00 per cent) and high awareness (3.67 per cent).

Table 1. Awareness of respondents about western ghat conservation N = 300

Categories	Number	Percentages
High ≥ 41.735	11	3.67
Medium (22.026 – 41.734)	259	86.33
Low ≤ 22.025	30	10.00

X = 31.88 SD = 9.855 X± S.D.

This indicates that maximum numbers of respondents are aware about forest conservation. The possible reason could be that most of the respondents resided in the interiors of forest and were mainly dependent on adjoining forest for fuel wood, fodder ,Non Timber Forest products and leaf litter. From many generations they were using the forest as an important natural resource for their day today needs and at the same time were involved in conservation for sustainable use. The main conservation activity undertaken was planting seedlings, use of bio gas as a non conventional energy source and Stall feeding of exotic breeds etc.

Activities detrimental to the forest like dam construction mining, lopping, poaching, illegal logging are discouraged and immediately reported to concerned authorities mainly the Forest Department. Forest fires were also reported to the Department of Forest. The respondents were very unhappy about the Kaiga – Narendra power line and dam constructed across the Kali river. The results comply with findings of Singh *et al*. (2005).

The semi focussed interviews have revealed the displeasure of respondents over developmental activities. Majority of the respondents have developed a close intimacy with the forests because the forest dwelling communities have been there from three to four generations and relate their day today activities with the forests. Monoculture plantations are other woes which have added fuel to the fire because indigenous and endemic diverse species are lost forever; The forest is always seen only as a commercial entity by the outside world which is not accepted by the communities living in the forest areas. Indicator species like tigers are almost nonexistent now. Leopards are found here and there in deep forests. Veteran respondents expressed that modern mans greed, expansion of areca gardens and material economy is depleting the forest at a faster rate and efforts have to be made by the younger generation. These views can be supported by a study conducted by Nimish Kapoor 2011.

Involvement in Forest Conservation Activities

Table 2. Involvement of respondents in forest conservation N= 300

Sl. No.	Particulars	No. of Respondents	Percentage
1	**Involvement in forest conservation activities**		
	Yes	247	82.67
	No	53	17.67
2	**Conservation Activities carried out in**		
	Minor Forest	230	76.77
	Betta land (Hill adjacent to the valley)	175	58.33
3	**Type of Activities**		
	Fire Control	254	89.67
	Plantation	239	79.67
	Prevention of poaching and illegal felling of trees	199	66.33
	Joint Forest Planning and Management Activities(Active Village Forest Committees)	200	66.66
4	**Conservation activities at household level**		

	Use of non conventional energy sources like Solar energy, ASTRA chulla and Bio gas	120	40
	Slurry as alternate to green leaves for farms	203	67.66
	Rearing exotic varieties, Stall feeding to reduce pressure in grass lands	134	44.66
	Cultivation of Fodder crops	10	3.33
	Maintaining a medicinal plant garden	52	17.33
	Planting trees in Betta land	242	80.66

From the table 2, it is evident that 82.67 per cent of the respondents were involved in forest conservation activities, as these respondents were living in forest from past many generations they expressed that it was their duty to conserve the forests. The day today needs like fuel wood, fodder, small timber and Non Timber Forest Products of the respondents were mainly met by the resources obtained from the forest. Seventy six percent of the respondents carried conservation activity in minor forest and and about sixty percent in Betta land. Most of the respondents in the study area are plantation holders with small sized holdings. However, they have been depending on betta lands for fodder and manure. They are all dependent on forest for their daily requirement such as fuel wood, soil, leaves to mulch the arecanut garden for manuring, wood to boil arecanut etc. Wild pickle mango, *Garcinia indica* (Murugalu fruits), *Garcinia gummigatta* (uppage), nutmeg and cinnamon leaves are collected for household consumption and sale in the local market. They invariably plant seedlings, resist poaching and illicit felling apart from preventing forest fire.

Cultivators of Western ghat region of Karnataka are enjoying a unique forest privileges from the colonial period. The foremost is Soppina betta(Hill) privileges enjoyed by areca nut cultivators of Uttar Kannada district whereby, each cultivator has exclusive access to approximately 9 acres of forest for every one acre of the arecanut orchard he owns at the time of the creation of the privileges during British period. Therefore the betta land owners are utilizing the forest to a greater extent They also protect this land by fencing, planting new saplings, rotational lopping of leaves etc. But still the betta lands are degraded due to inappropriate utilization.

The forest dwellers are very much interested in conserving their surrounding minor forest and betta forest. Village Forest Committee under the Joint Forest Planning and Management Programme and other forestry extension activities are the important activities in which respondents were involved which included regeneration of degraded land, management of plantations and establishment of nurseries.

At the household level the respondents are involved in Use of non conventional energy sources like Solar energy, ASTRA chulla and Bio gas, Slurry as alternate to green leaves for farms, Rearing Exotic varieties, Stall feeding to reduce pressure in grass lands, Cultivation of Fodder crops Maintaining a medicinal plant garden Planting trees in Bettaland

Correlation between Awareness and personal and socio-economics characteristics of respondents

The correlation between awareness of the respondents with their personal and socio-economic characteristics was studies and are results the presented in Table 3. From the table, it could be seen that except age, all other variables education, total family income, social participation, mass media participation, extension contact, land holding are positively and significantly (significant at 1% level) are related with awareness the age is negatively related with awareness (significant at 5% level)

Table 3. Correlation between awareness and personal and socio-economic characteristics of the respondents

Sl. No.	Independent Variables	'r' value
1	Age	- 0.0761*
2	Education	0.3307**
3	Total Family income	0.2367**
4	Social Participation	0.3655**
5	Mass-media participation	0.4919**
6	Extension participation	0.4349**
7	Extension contact	0.6449**
8	Land Holding	0.2151**

* Significant at 5% level ** Significant at 1% level

Age and Awareness

The correlation results revealed that age is negatively resulted with awareness of the respondents (significant at 5 per cent level). This shows that as the age increases the awareness decreases. It may be due to the reason that, from the study it could be observed that 43.33 per cent of the respondents belong to old age group (nearly half of the respondents) the older generation are not much bothered about environmental issues.,

Education and Awareness

It was found that there is a positive and significant relation between education and awareness about forest conservation by the respondents. It is always true that education is the single and ultimate weapon to solve most of the social problems. Since it creates awareness at the initial stage, motivates the person to think and collect the information about his surroundings. Hence in the study also education might have influenced the respondents to gather information from different sources like literature, radio, television, newspaper etc. and moreover the respondents living with the forest Which might have made them to be aware about the issues related with forest conservation.

Total Family Income and Awareness

In the present study analysis of the data has shown that there is a positive relationship between family income and awareness. This is due to when there is high income naturally one can have information accessibility from different sources like mass media, cosmopolite contacts etc usually people with high income and education have tendency to seek new information. In the interior forest the arecanut growers are having high income and also very much aware about their surrounding forest area.

Social participation and Awareness

From the results it could be observed that there is positive correlation (0.3655) between social participation and awareness about forest conservation. It indicates that when social participation increases the awareness about forest conservation also increases. It may be due to the reason that whenever a person participates in social activities and social organizations they will get more knowledge on, which might have increased awareness about forest conservation.

Mass-Media Participation and Awareness

The correlation between awareness and mass-media participation showed that there is a positive correlation (0.4919) between these two variables. It again indicates that as we expose to mass media we can accumulate lot of information about general issues and also about our surroundings which increases the awareness about day today happenings. The mass-media such as Radio, T.V., Newspaper, Magazines play a very important role in improving the knowledge about general issues. Therefore the results shows that as mass-media participation increase the awareness about forest conservation also increased.

Extension participation and awareness

The results shows that there is a positive relation between extension participation and awareness about forest conservation. It might be due to participation in different activities such as trainings, workshops, study tours etc. might have helped to increase the outside knowledge, exchange of information which is of non-formal education makes a person to be aware about most of the things related to a person and his surroundings.

Extension Contact and Awareness

The awareness about forest conservation of the respondents was positively (0.6449) correlated with extension contacts. It might be due to the contact of respondents with RFO, AAO's AHO's and officers of other Developmental Departments made the respondents to be aware about forest and also there officers continuously providing needed information about forest which might have resulted in positive correlation with awareness of forest conservation.

Land holding and awareness

From the results, it is clear that land holding is positively correlated with awareness i.e. as land holding increases the awareness also increases. This may be due to the reason that, the farmers of Uttar Kannada district mainly dependent on forest for green leaves and dry leaves, soil, fuel wood on Sopina betta land and minor forest. Hence, they are growing arecanut. Due to increased pressure on forest for these inputs they are observing that the forest is degrading. It is reinforcing them to think about future problem which is resulted in increase awareness about forest conservation.

Therefore all the independent variables except age all other variables showed positive correlation with awareness about forest conservation.

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RESEARCH ARTICLE

HERBICIDAL WEED CONTROL IN INDIAN MUSTARD (*BRASSICA JUNCEA* L.)

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Abstract: Field investigations were carried out at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) during the winter (*rabi*) seasons of 2010-11, 2011-12 and 2012-13 to assess the effect of different herbicidal weed control practices on yield and economics of Indian mustard (*Brassica juncea* L.).The treatments comprised pre-emergence applications of pendimethalin 1.0 kg/ha, oxadiargyl 0.09 kg/ha, oxyfluorfen 0.15 kg/ha and isoproturon 1.0 kg/ha, quizalofop 0.06 kg/ha, clodinafop 0.06 kg/ha and isoproturon 1.0 kg/ha 30 days after sowing (DAS), weedy check and weed free. Broadleaved weeds like *Chenopodium album* L., *Anagallis arvensis* L., *Melilotus indica* (L.) All., *Vicia sativa* L. and *Rumex acetosella* L. were more predominant than grass and sedge weeds, accounting for 57.9% of total weed flora.Based on the three years studies, weeds in mustard annually caused 23-42% loss in yield. Among all herbicidal treatments, oxadiargyl 0.09 kg/ha was found to be the most effective in reducing the population of broadleaved weeds, grasses and sedges as compared to other herbicidal treatments. Pre-emergence application of oxadiargyl at 0.09 kg/ha recorded minimum weed population and dry weight of weeds which was found to be the most effective and gave maximum seed yield of mustard. Herbicide, oxadiargyl 0.09 kg/ha gave higher net return due to weed control over other treatments and also resulted in highest net return per rupee invested (1.69) on weed control.

Keywords*:* Herbicidal weed control, Mustard, Yield, Economics

INTRODUCTION

Indian mustard (*Brassica juncea* (L.) Czernj and Cosson) is one of the most important winter oilseed crops of India. India occupies third position in rapeseed-mustard production in the world after China and Canada. In India, during 2013-14, the rapeseed-mustard crop had production of about 7.96 million tonnes from an area of 6.70 million hectares with an average productivity of 1188 kg/ha. As this crop is grown in poor soils with poor management practices, weed infestation is major causes of low productivity (Singh *et al*., 2013). Yield losses due to crop weed competition in rapeseed and mustard has been estimated to be in range of 10-58% (Bhan, 1992; Banga and Yadav, 2001; Singh *et al*., 2013). Weed competition at initial stages of crop growth causes maximum loss to the crop in terms of yield. Manual weeding is considered to be the best weed control measure for complete weed control without any harm to the crop and ecosystem. But on the other hand, scarcity of labour and increasing labour rates have made manual weeding a costly affair. So, it brings a need for search of other effective and feasible alternatives. The most common among them is herbicidal weed control method. Herbicidal weed control measure is very easy, effective and economical method of weed management. Different herbicides are available with respect to different modes of application like pre-emergence and post-emergence which are found helpful in managing weeds with various degree of efficacy. A limited number of herbicides have been tested against the weeds in mustard. These herbicides are applied as pre-emergence and can control weeds up to a limited period. During recent past a number of broad spectrum herbicides have been launched which are capable of reducing competition for a longer period of time. The efficacy and selectivity of these herbicides are yet to be explored in mustard. The information available on herbicidal weed control practices in Indian mustard in the northern region is also sparse and inadequate.

MATERIAL AND METHOD

The field experiment was conducted during winter (*rabi*) seasons of 2010-2011, 2011-12 and 2012-13 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25°18′ N latitude, 83°03′E longitude and altitude of 129 m above mean sea level), Uttar Pradesh, India. Mean minimum and maximum temperature during crop seasons ranged from 5.8 to 22.1^{o}C and 17.1 to 39.2^{o}C, respectively. During the years, weather conditions were extremely favourable for both crop and weed growth. The soil of experimental site is sandy clay loam, slightly alkaline (*p*H 7.6) in reaction and moderately fertile being low in organic carbon (0.38%) and available nitrogen (190.4 kg/ha) and medium in available phosphorus (20.75 kg/ha) and potassium (205.0 kg/ha). Nine treatments consisting of pendimethalin 1.0 kg/ha (pre-emergence, P.E.), oxadiargyl 0.09 kg/ha (pre-emergence, P.E.), oxyfluorfen 0.15 kg/ha (pre-emergence, P.E.), quizalofop 0.06 kg/ha (30 DAS), clodinafop 0.06 kg/ha (30 DAS), isoproturon 1.0 kg/ha (pre-emergence, P.E.), isoproturon 1.0 kg/ha (30 DAS), weedy check and weed free were evaluated in randomized block design with three

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replications. 'Ashirwad' Indian mustard variety was sown in 30 cm apart at a seed rate of 5.0 kg seed/ha on the last week of October. The crop was thinned 15 days after sowing to maintain a plant to plant spacing of 10 cm. A fertilizer dose of 80 kg N/ha, 40 kg P_2O_5/ha and 40 kg K_2O/ha were applied in each season. Required amounts of nitrogen, phosphorus and potassium were supplied through urea, single super phosphate and muriate of potash, respectively. Full amount of phosphorus and potash and half of nitrogen was applied at the time of sowing. The remaining dose of nitrogen was top dressed 35 days after sowing. The recommended cultural practices and plant protection measures were followed to raise the healthy crop. Herbicides were applied using a spray volume of 800 litre water/ha with a knapsack sprayer fitted with flat-fan nozzle. Weed population was recorded by placing 25 cm x 25 cm quadrates at two random places in each plot and after drying them in hot air oven (70±1 ^{o}C for 72 hrs), weed dry weight was recorded. Data on weed population and weed dry weight were subjected to square root transformation to ($\sqrt{x + 1}$). The seed yield and stover yield were computed from the harvest of net plot and expressed in kg/ha. Economics of the treatments were computed in terms of gross return (` /ha), net return (`/ha) and benefit: cost ratio, respectively based on the prevalent market prices and selling price of mustard seeds was ` 18.50/kg in 2010-11, ` 20.00/kg in 2011-12 and `30.00/kg in 2012-13.

RESULT AND DISCUSSION

Among the grassy weeds, *Cynodon dactylon* (L.) Pers. was the predominant weed followed by *Phalaris minor* Retz. and accounted 32.5% of total weed flora. *Cyperus rotundus* L. was the only sedge present in the experimental field. The broadleaved weeds like *Chenopodium album* L., *Anagallis arvensis* L., *Melilotus indica* (L.) All., *Vicia sativa* L. and *Rumex acetosella* L. as a whole constituted 57.9% of total weed flora.

Effect on weeds

Grassy weeds population m^{-2} reduced significantly with all herbicide weed control methods compared to weedy check. Amongst herbicides, pre-emergence application of oxadiargyl 0.09 kg/ha showed maximum effectively in controlling grasses population but remained at par with other pre-emergence applied herbicides like oxyfluorfen 0.15 kg/ha, isoproturon 1.0 kg/ha and pendimethalin 1.0 kg/ha except during 2011-12, where oxadiargyl 0.09 kg/ha maintained a lowest population of grassy weeds. Post-emergence application of herbicides remained least effective in decreasing grassy weeds population. Meanwhile, effect of treatments on broadleaved weeds was not very conspicuous during 2010-11 and 2012-13, however, during 2011-12, all treatments were significantly superior to weedy check in reducing their population. Pre-emergence application of oxadiargyl 0.09 kg/ha maintained the lowest population of broadleaved weeds and proved superior to all other herbicidal weed control methods during 2011-12. Similarly, oxadiargyl recorded minimum population of sedges and was significantly superior to all the other herbicides (Table 1). The application of oxadiargyl 0.09 kg/ha as pre-emergence being at par to oxyfluorfen 0.15 kg/ha, isoproturon 1.0 kg/ha and pendimethalin 1.0 kg/ha during 2010-11 and 2012-13, reduced significantly lower population of total weeds than other herbicides. Amongst herbicides, oxadiargyl recorded minimum total weed dry weight and was significantly superior to all other herbicidal treatments except pre-emergence application of oxyfluorfen, isoproturon and pendimethalin which were at par to them during 2010-11 and 2012-13. Consequently, pre-emergence application with oxadiargyl 0.09 kg/ha maintained comparatively higher weed control efficiency in comparison to other herbicidal weed control methods giving maximum weed control efficiency closely followed by oxyfluorfen (Table 2). Many researchers have reported lower weed population in mustard and similar crops with the use of herbicides like pendimethalin (Chauhan *et al*., 2005), isoproturon (Yadav *et al.*, 2007), oxyfluorfen (Sharma *et al.*, 2001) and clodinafop (Sharma *et al.*, 2007).

Effect on crop

Herbicidal weed control treatments brought about significant variation on yield attributes, *viz.*, number of siliquae per plant, number of seeds per siliqua and 1000-seed weight of Indian mustard (Table 3). Pre-emergence application of oxadiargyl 0.09 kg/ha being at par to oxyfluorfen 0.15 kg/ha produced significantly higher number of siliquae plant^{-1} than the rest of weed control treatments. It is also evident that weed free had significantly higher number of seeds siliqua^{-1} and 1000-seed weight than all the herbicidal treatments, except pre-emergence application of oxadiargyl 0.09 kg/ha which was found at par to weed free treatment. Sharma and Jain (2002) had also obtained higher yield attributes with weed control treatments over untreated control.

The yield attributes were reflected in yield of Indian mustard. Significantly higher seed yield was recorded in weed free treatment which was statistically at par with pre-emergence application of oxadiargyl 0.09 kg/ha (Fig. 1). Weed free treatment also resulted in the highest stover yield, which was statistically at par with pre-emergence application of oxadiargyl 0.09 kg/ha, oxyfluorfen 0.15 kg/ha and isoproturon 1.0 kg/ha except during 2011-12 where weed free treatment was on par with oxadiargyl 0.09 kg/ha and clodinafop 0.06 kg/ha, all these treatments proved significantly superior to other weed control treatments. Weedy check had the lowest seed yield and stover yield due to higher weed population and dry weight (Table 4). Weeds in weedy check reduced

seed yield of mustard by 41.7% in 2010-11, 22.8% in 2011-12 and 41.5% in 2012-13.

Economics

The viability of any practice depends on its economic feasibility. A better treatment in terms of weed control if not fetching good returns may not be acceptable to the farmers. Among weed control treatments, pre-emergence treatment with oxadiargyl 0.09 kg/ha resulted in highest gross and net return due to weed control over other treatments (Table 5). The higher return under this treatment was attributed to higher seed yield of mustard owing to better control of weeds. All the herbicides obtained more net return and benefit: cost ratio as compared to weedy check. The pre-emergence of oxadiargyl 0.09 kg/ha also observed the highest net return per rupee invested i.e. benefit: cost ratio of 1.69) on weed control. Weed free treatment registered lower monetary returns due to high cost involved in repeated weedings to keep crop weed free despite having higher seed yield.

Therefore, it can be concluded that unrestricted growth of weeds affected seed yield of Indian mustard and pre-emergence application of oxadiargyl 0.09 kg/ha was the most remunerative and highly effective herbicide for reducing weed population and dry weight and gave seed yield comparable to the weed free condition in Indian mustard.

Table 1. Effect of weed control methods on population of broadleaved weeds, grasses and sedges of Indian mustard

Treatment	Broadleaved weeds (per m^2)			Grasses (per m^2)			Sedges (per m^2)		
	2010-11	2011-12	2012-13	2010-11	2011-12	2012-13	2010-11	2011-12	2012-13
Pendimethalin 1.0 kg/ha (P.E.)	16.43 (269.77)	11.88 (141.00)	17.18 (294.65)	11.35 (128.33)	8.23 (67.63)	12.10 (145.91)	5.15 (26.03)	5.82 (33.97)	5.90 (34.31)
Oxadiargyl 0.09 kg/ha (P.E.)	15.78 (248.63)	9.15 (83.71)	16.53 (272.74)	10.27 (105.20)	4.71 (23.33)	11.02 (120.94)	4.31 (18.13)	2.73 (7.10)	5.06 (25.10)
Oxyfluorfen 0.15 kg/ha (P.E.)	16.12 (259.63)	12.90 (166.05)	16.87 (284.09)	10.71 (114.30)	9.40 (88.00)	11.46 (131.29)	4.76 (22.17)	7.07 (49.47)	5.51 (29.86)
Quizalofop 0.06 kg/ha (30 DAS)	16.94 (286.67)	13.21 (174.25)	17.69 (312.43)	11.68 (136.00)	9.74 (94.67)	12.43 (154.00)	6.00 (35.50)	7.40 (54.54)	6.75 (45.06)
Clodinafop 0.06 kg/ha (30 DAS)	17.15 (293.67)	11.56 (133.25)	17.90 (319.91)	11.92 (141.67)	7.86 (61.33)	12.67 (160.02)	5.05 (25.00)	5.43 (29.17)	5.80 (33.14)
Isoproturon 1.0 kg/ha (P.E.)	16.33 (266.53)	12.37 (153.46)	17.08 (291.22)	11.12 (123.73)	8.77 (77.77)	11.87 (140.39)	5.03 (24.83)	6.38 (41.68)	5.78 (32.90)
Isoproturon 1.0 kg/ha (30 DAS)	16.75 (280.00)	13.54 (182.86)	17.50 (305.75)	11.48 (131.33)	10.23 (104.33)	12.23 (149.07)	5.38 (28.50)	7.26 (52.26)	6.13 (37.07)
Weedy check	17.23 (308.00)	14.01 (198.03)	17.98 (322.78)	12.84 (166.27)	10.58 (114.00)	13.59 (184.18)	6.50 (41.83)	7.82 (60.63)	7.25 (52.06)
Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
SEm±	0.84	0.49	0.84	0.39	0.60	0.40	0.12	0.43	0.13
CD (P=0.05)	NS	1.45	NS	1.16	1.77	1.19	0.35	1.27	0.37

DAS: Days after sowing; NS: Non-significant; Data is transformed to $\sqrt{x + 1}$; Values in the parenthesis are original values

Table 2. Effect of weed control methods on total weed population, total weeds dry weight and weed control efficiency of Indian mustard

Treatment	Total weed population (per m^2)			Total weeds dry weight (g per m^2)			Weed Control Efficiency (WCE)		
	2010-11	2011-12	2012-13	2010-11	2011-12	2012-13	2010-11	2011-12	2012-13
Pendimethalin 1.0 kg/ha (P.E.)	20.60 (424.13)	15.55 (242.60)	21.35 (455.32)	4.70 (21.67)	4.36 (18.57)	5.20 (26.54)	39.25	35.14	35.22
Oxadiargyl 0.09 kg/ha (P.E.)	19.30 (371.97)	10.66 (114.15)	20.05 (401.50)	4.02 (15.67)	3.22 (9.88)	4.52 (19.93)	56.07	65.48	51.35
Oxyfluorfen 0.15 kg/ha (P.E.)	19.91 (396.10)	17.43 (303.52)	20.66 (426.33)	4.22 (17.33)	4.70 (21.64)	4.72 (21.77)	51.40	24.43	46.86
Quizalofop 0.06 kg/ha (25-30 DAS)	21.41 (458.17)	17.98 (323.46)	22.16 (490.56)	5.05 (25.00)	4.83 (22.80)	5.55 (30.30)	29.91	20.37	26.04
Clodinafop 0.06 kg/ha (25-30 DAS)	21.46 (460.33)	14.97 (223.76)	22.21 (492.78)	5.51 (29.87)	4.12 (16.49)	6.01 (35.62)	16.26	42.41	13.06
Isoproturon 1.0 kg/ha (P.E.)	20.38 (415.10)	16.43 (272.91)	21.13 (445.97)	4.56 (20.33)	4.60 (20.72)	5.06 (25.10)	42.99	27.65	38.74
Isoproturon 1.0 kg/ha (30 DAS)	20.98 (439.83)	18.43 (339.45)	21.73 (471.69)	4.81 (22.67)	4.95 (24.05)	5.31 (27.69)	36.45	16.01	32.41
Weedy check	22.55 (516.10)	19.20 (372.66)	23.30 (542.39)	5.94 (35.67)	5.40 (28.63)	6.44 (40.97)	-	-	-
Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	100.00	100.00	100.00
SEm±	0.69	0.79	0.70	0.23	0.09	0.24	-	-	-
CD (P=0.05)	2.07	2.35	2.12	0.70	0.26	0.73	-	-	-

Data is transformed to $\sqrt{x + 1}$; Values in the parenthesis are original values

Table 3. Effect of weed control methods on yield attributes of Indian mustard

Treatment	Siliquae/ plant				Seeds/siliqua				1000-seed weight (g)			
	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean
Pendimethalin 1.0 kg/ha (P.E.)	274.7	312.0	274.8	287.2	12.39	14.82	12.42	13.21	4.77	4.20	4.79	4.59
Oxadiargyl 0.09 kg ha^{-1} (P.E.)	317.3	349.0	317.4	327.9	13.23	16.03	13.21	14.16	5.00	4.95	5.04	5.00
Oxyfluorfen 0.15 kg ha^{-1} (P.E.)	300.7	326.0	300.9	309.2	12.87	15.21	12.93	13.67	4.90	3.85	4.94	4.56
Quizalofop 0.06 kg/ha (30 DAS)	254.3	270.0	254.4	259.6	11.60	12.02	11.62	11.75	4.49	3.75	4.50	4.25
Clodinafop 0.06 kg/ha (30 DAS)	224.7	278.0	225.0	242.6	10.60	13.01	10.61	11.41	4.31	4.45	4.32	4.36
Isoproturon 1.0 kg ha^{-1} (P.E.)	285.0	286.5	285.2	285.6	12.45	14.03	12.51	13.00	4.83	3.95	4.84	4.54
Isoproturon 1.0 kg ha^{-1} (30 DAS)	265.7	252.0	265.8	261.2	12.01	11.51	12.03	11.85	4.71	3.25	4.73	4.23
Weedy check	176.0	240.0	176.0	197.3	8.50	10.62	8.52	9.21	3.90	3.00	3.93	3.61
Weed free	339.9	367.0	340.0	349.0	13.90	16.72	13.91	14.84	5.05	5.40	5.06	5.17
SEm±	7.41	9.28	7.42	-	0.36	0.43	0.37	-	0.13	0.15	0.14	-
CD (P=0.05)	22.22	27.54	22.27	-	1.09	1.29	1.12	-	0.40	0.46	0.43	-

Table 4. Effect of weed control methods on yield of Indian mustard

Treatment	Seed yield (kg/ha)				Stover yield (kg/ha)			
	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean
Pendimethalin 1.0 kg/ha (P.E.)	1663	1754	1665	1694	5650	4894	5660	5401
Oxadiargyl 0.09 kg/ha (P.E.)	1836	1824	1838	1833	5876	5274	5882	5677
Oxyfluorfen 0.15 kg/ha (P.E.)	1742	1700	1750	1731	5739	4700	5741	5393
Quizalofop 0.06 kg/ha (30 DAS)	1590	1691	1595	1625	5438	4679	5439	5185
Clodinafop 0.06 kg/ha (30 DAS)	1546	1788	1548	1627	5332	5080	5334	5249
Isoproturon 1.0 kg/ha (P.E.)	1704	1721	1708	1711	5665	4730	5666	5354
Isoproturon 1.0 kg/ha (30 DAS)	1614	1651	1620	1628	5502	4652	5509	5221
Weedy check	1141	1513	1147	1267	4884	4283	4885	4684
Weed free	1957	1961	1961	1960	6038	5512	6040	5863
SEm±	63.4	55.3	64.9	-	161.6	154.1	163.6	
CD (P=0.05)	190.1	164.3	195.4	-	484.4	457.7	484.9	

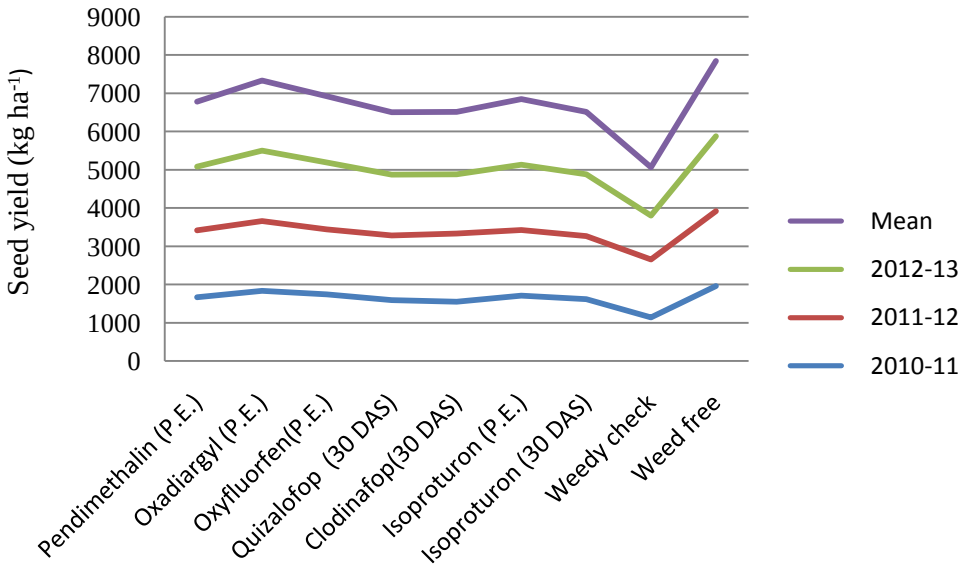

Fig 1. Effect of weed control methods on seed yield of Indian mustard

Table 5. Effect of weed control methods on economics of Indian mustard

Treatment	Gross return* (x 10^3 `/ha)				Cost of cultivation (x 10^3 `/ha)				Net return (x 10^3 `/ha)				Benefit: cost ratio			
	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean
Pendimethalin1.0 kg/ha (P.E.)	30.77	34.90	49.95	38.54	14.57	17.24	15.67	15.83	16.20	17.66	34.28	22.71	1.11	1.02	2.19	1.44
Oxadiargyl 0.09 kg/ha (P.E.)	33.97	36.38	55.14	41.83	14.37	16.99	15.47	15.61	19.60	19.39	39.67	26.22	1.36	1.14	2.56	1.69
Oxyfluorfen 0.15 kg/ha (P.E.)	32.23	33.80	52.50	39.51	14.32	16.99	15.42	15.58	17.91	16.81	37.08	23.94	1.25	0.99	2.40	1.55
Quizalofop 0.06 kg/ha (30 DAS)	29.42	33.62	47.85	36.96	14.07	16.74	15.18	15.33	15.35	16.89	32.67	21.64	1.09	1.01	2.15	1.42
Clodinafop 0.06 kg/ha (30 DAS)	28.61	35.62	46.44	36.89	14.17	16.84	15.27	15.43	14.44	18.78	31.17	21.46	1.02	1.12	2.04	1.39
Isoproturon 1.0 kg/ha (P.E.)	31.52	34.20	51.24	38.99	14.32	16.99	15.42	15.58	17.20	17.22	35.82	23.41	1.20	1.01	2.32	1.51
Isoproturon 1.0 kg/ha (30 DAS)	29.86	32.87	48.60	37.11	14.32	16.99	15.43	15.58	15.54	15.89	33.12	21.51	1.09	0.93	2.15	1.39
Weedy check	21.11	30.13	34.41	28.55	13.57	16.24	14.68	14.83	7.54	1.39	19.74	9.55	0.56	0.86	1.34	0.92
Weed free	36.21	39.03	58.83	44.69	16.82	19.49	17.92	18.08	21.39	21.55	42.91	28.62	1.27	1.11	2.39	1.58
SEm±	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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RESEARCH ARTICLE

RESPONSE OF PRECISION APPLICATION OF WATER AND FERTILIZER ON PRODUCTIVITY AND ECONOMICS OF BT COTTON

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Abstract: A field experiment was conducted during the *kharif* season of 2013-14 and 2014-15 at Agricultural Research Station (MPUAT), Banswara, Rajasthan to find out the response of precision application water and nutrient through drip with fertigation on productivity and economics of Bt cotton hybrid (*Gossypium hirsutum* L.). The treatments comprised of three irrigation regimes viz. 0.6 Etc (I_1), 0.8ET_C (I_2) and 1.0 Etc in main plot and three nutrient management practices viz. 100% RDF (120:60:40kg NPK/ha) (N_1), 75 % RDF (N_2) and 50 % RDF (N_3) in sub plot of spit plot design with three replications. Results indicated that scheduling irrigation at 1.0 Etc was produced significantly higher seed cotton yield (3443kg/ha) over rest irrigation scheduling. Application of 100% RDF gave significantly higher seed cotton yield (3556kg/ha) compared to lower doses of nutrients. The maximum seed cotton yield (3851kg/ha) recorded at the interaction of 1.0 Etc with 100% RDF which was at par with 0.8 Etc with 100% RDF and found significantly superior over rest interactions. Contribution of yield attributes was significantly reflected on economical yield. The water requirement at 0.6, 0.8 and 1.0 was 75.79, 96.45 and 177.77 mm/ha respectively, compared to 183.6 mm/ha under 0.6 IW/CPE ratios. Maximum water use efficiency (6.11kg/ha-mm) recorded at the interaction of 1.0 Etc with 100RDF which was at par with 0.8Etc at 100% RDF and 75% RDF and significantly superior over rest interactions. Highest nitrogen use efficiency (47.62kg/kgN/ha) was recorded at the interaction of 1.0 ETc with 50% RDF which was at par with 0.8Etc at 75% RDF and significantly superior over rest interactions. Maximum B:C ratio (3.40) recorded with interaction of 1.0Etc at 100RDF which was at par with 0.8 Etc at 100RDF and 1.0Etc at 75% RDF and found significantly higher than other interactions. Overall, it is concluded that drip fertigation at 0.8 Etc with 75% RDF found more precision technique for Bt cotton hybrid under humid condition of Rajasthan.

Keywords: Seed cotton yield, Bt cotton, Fertigation, Water use efficiency, B:C ratio

INTRODUCTION

India annually cultivates more than eleven million hectares of cotton which is the largest in the world. Around 60 million people are estimated to depend on it one way or the other to make out their living. Bt. Cotton was released in 2002-03 for commercial cultivation in India. Since the release of Bt. Cotton technology, it has emerged as an effective alternative to traditional cotton varieties by inhibiting bollworm attack, thereby improving yield and income. This has resulted in fast adoption of Bt cotton over conventional cotton. Cotton production in India has accelerated more than 4 times and reached a peak of 359.02 lakh bales during 2013-14 as compared to 86.24 lakh bales in 2002-03. Introduction of Bt cotton has played a catalytic role in enhancing cotton production in India. During 2013-14, the production of cotton received was 359.02 lakh bales which was all time high in cotton history. In 2014-15 and 2015-16, the cotton production kept reducing to 348.05 and 301.47 lakh bales respectively due to drought condition in main area of cotton in the country. Water and nutrient are most important production factors for crop production. Days to day availability of both inputs are scarce; hence its judicious use in a scientific manner is essential for increasing the productivity. Introduction of drip irrigation can help to bring more area under cotton irrigation with substantially improved crop yield. Method of application along with appropriate schedule is one of the several factors that affect fertilizer efficiency. Application water soluble fertilizers through drip irrigation has gained widespread popularity as an efficient method for fertilizer application (Mmolawa and Or 2000). The roots are developed extensively in a restricted volume of the soil wetted zone by drip irrigation. Thus, the drip fertigation system can place nutrients efficiently in wetted zone and are used by the plant from the soil easily. It helps in achieving higher productivity and enhancing of the crop (Zhenam et al 2007 and Mark et al (2009). However, several basic principles must be followed in applying nutrients through the irrigation system in order to place the fertilizer currently, decrease potential nutrient losses, avoid excessive fertilizer application and prevent clogging of the system by precipitating compounds. Cotton is a long duration and widely spaced crop, drip irrigation and fertigation offers much scope in enhancing the productivity of water and yield/unit area. Application of irrigation based on crop evapotranspiration (Etc.) and fertigation are the new approaches for water and nutrient management Adoption of micro-irrigation might help in increasing, productivity of crop, irrigated area and water use efficiency (Pawar *et al*,2013). In view of the above, it was carried out to standardize fertigation schedule for Bt cotton cultivation under humid condition of southern Rajasthan.

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MATERIAL AND METHOD

A field experiments was conducted in two consecutive rainy season (June-October) of 2014 and 2015 at Agricultural Research Station (MPUAT), Banswara (Rajasthan) located at 23^0 33' N latitude, 74^0 27'E longitude, and altitude of 220M above Mean Sea Level. It is covered under humid southern plain agro-climatic zone of Rajasthan. The soil of experimental field was clay loam in texture, slightly alkaline in reaction with low in organic carbon (0.48%), low in available N (218kg ha^{-1}), medium in available P (18k_g/ha) and high in available K (362 kg /ha) content. The treatments comprised of three irrigation regimes viz. $I_{1:}$ 1.0 ETc, I_2: 0.8 ETc and I_3: 0.6 ET_C in main plots and three nutrient level viz. N_1: 100% RDF (100% recommended dose of 120+60+30 kg NPK/ha) , N_2: 75% RDF and N_3: 50% RDF in sub-sub plots were randomized in split plot design with three replications. Bt cotton hybrids Jai Bt were sown on first fortnight of June by dibbling at 90X45cm plant spacing on the leveled bed for single row planting. Fertilizers were applied as per treatments. The half dose of P and K and 1/5 dose of N were applied as basal dose and remaining dose of P and K was applied in two splits at square formation and boll development stages and N dose was applied in 4 splits with irrigation water. water soluble fertilizers viz. Urea (46:0:0), NPK grade (18:18:18) and sulphate of potash (0:0:50) were used for fertigation. Out-line lateral dripper were fixed at 45cm spacing of seed dibbling place**.** It maintained the lateral to lateral spacing of 90 cm. The fertigation was done using atomized fertilizer system at 15 days interval as per schedule. Adequate plant protection measures were adopted as and when required. The amount of water (litre/day) to be applied through drip irrigation was calculated by using following formula:

V= Eo X Kc X Kp

Whereas, V= Volume of water to be given /dripper (litres); Eo= Pan evaporation of two days (mm); Kc= Crop factor as per growth stages of cotton; Kp, pan factor.

For cotton Kc values were 0.45, 0.75, 1.15 and 0.70 for seedling (0-25 DAS), crop development stage (26-70 DAS), boll development (71-120 DAS) and maturity stage (>121 DAS) respectively as per FAO irrigation water management training manual no 3 (Brouwer and Heibloem1986).Based on the above formula quantity of water was calculated on alternate days and irrigation was scheduled. Time for irrigation was decided as per the discharge of water per dripper. The out-line having emitters of 4lph discharge capacity were operated at pressure of 1kg/cm^2. The average emission uniformly of drip irrigation system was estimated as 91% for all treatments. For conventional irrigation 6cm depth of irrigation was considered and irrigation given on basis of cumulative pan evaporation (100 mm CPE). The irrigation was cut off after starting the boll brusting. The field capacity of the soil was 35.5 and permanent wilting point was 18.0%. The irrigation at 0.6, 0. water requirement 8, 1.0 Etc and 0.6 IW/CPE WR=ETc 75.79, 96.45 and 177.77 mm/ha respectively.

RESULT AND DISCUSSION

Yield and yield attributes

The pooled data of two years presented in Table 1 revealed that plant height was varied with irrigation regimes. Maximum plant height (167cm) observed at 1.0 Etc which was at par with 0.8 Etc and significantly superior over 0.6 ETc . 100% RDF gave significantly higher plant height (167cm). The interaction effect of irrigation at 1.0 ETc with 100% RDF attended the highest plant height (187cm) which was found significantly superior over rest interactions. Numbers of bolls per plant were significantly influenced due to application of water and nutrients. Maximum number of bolls/plant (48.41) recorded with 1.0ETc followed by 0.8ETc and significantly superior over 0.6 ETc. Among the nutrient levels, 100% RDF produced highest bolls/plant (47.06) which was significantly higher than other nutrient levels. The interaction of 1.0ETc at 100% RDF recorded maximum bolls/plant (54.33) followed by 0.8 ETc at 100% RDF and significantly superior over other interaction. Boll weight was also influenced with water and nutrient levels. Irrigation regimes at 1.0 ETc gained maximum boll weight (4.69g/boll) followed by 0.8 ETc and significantly higher than 0.6 ETc. Among, the nutrients levels, maximum boll weight (4.69g/boll) gained by 100% RDF followed by 75%RDF and significantly higher over 50%RDF. Interaction of irrigation and nutrient was influenced boll weight, the highest boll weight(4.84g/boll) at 1.0ETc with 100% RDF which was significantly higher than 0.6 ETc at 75% RDF and 0.8 ETc at 50% RDF. Maximum plant growth parameters and yield attributes were recorded with irrigation regime at 1.0 ETc (through drip) with 100% RDF followed by 1.0 ETc with 75% RDF and significantly more than other interactions. This might be due to favorable micro-climate. These results are confirmatory with reported by Aruna and Reddy (2009).Irrigation applied at 1.0 ETc recorded significantly higher seed cotton yield (3443kg/ha) other irrigation levels. Halemani *et al*. (2003) and Bhatoo *et al*. (2009) also reported that drip irrigation at 1.0 ETc produced maximum yield than other levels of drip irrigation and furrow irrigation. Irrigation at 0.8 ETc significantly superior to 0.6 Etc. Similar results were reported by Bhalerao et at (2011). Application of 100% RDF recorded significantly higher seed cotton yield (3556kg/ha) than other nutrient levels. Seed cotton yield was significantly influenced by interaction of irrigation and nutrient levels. Highest seed cotton yield (3851kg/ha) was recorded with application of

irrigation at 1.0 ETc through drip with 100% RDF followed by 0.8 ETc with 100% RDF and significantly superior over other interactions. Nalayini et al. (2006) at Coimbatore reported that scheduling of irrigation at 1.0 ETc was on par 0.8 Etc through drip for cotton crop. Mark et al (2009) also reported increase seed cotton yield under fertigation. Results are might be due moisture conserved in root to supply adequate amount of nutrient to the plant.

Table 1. Effect of irrigation regimes and nutrient levels on growth parameters, yield attributes and yield of cotton.

Treatment	Plant height (cm)	Bolls/plant	Boll weight (g)	Seed cotton yield (kg/ha)
Irrigation regimes				
I_1: 0.6ETc	**125**	**29.65**	**4.25**	2723
I_2: 0.8ETc	**157**	**45.00**	**4.58**	3274
I_3: 1.0ETc	**167**	**48.41**	**4.69**	3443
CD (P=0.05)	10.28	4.71	0.42	138
Nutrient levels				
N_1: 100% RDF	**167**	**47.06**	**4.69**	3556
N_2: 75% RDF	**152**	**42.65**	**4.56**	3376
N_3: 50% RDF	**131**	**33.35**	**4.26**	2508
CD (P=0.05)	7.02	3.40	0.30	102
I x N Interaction				
$I_{1X}N_1$	**137**	**36.23**	**4.47**	**3107**
$I_{1X}N_2$	**123**	**33.01**	**4.30**	**2989**
$I_{1X}N_3$	**114**	**19.69**	**3.97**	**2072**
$I_{2X}N_1$	**176**	**50.60**	**4.77**	**3710**
$I_{2X}N_2$	**159**	**46.92**	**4.67**	**3517**
$I_{2X}N_3$	**137**	**37.46**	**4.30**	**2595**
$I_{3X}N_1$	**187**	**54.33**	**4.84**	**3851**
$I_{3X}N_2$	**174**	**48.00**	**4.72**	**3622**
$I_{3X}N_3$	**141**	**42.89**	**4.51**	**2857**
CD (P=0.05)	12.16	5.89	0.50	176

Input use efficiency

The pooled data of two years presented in Table 2 revealed that water use efficiency (WUE), nitrogen uptake and nitrogen use efficiency (NUE) influenced with irrigation and nutrient levels. Highest WUE (5.46) was recorded with application of irrigation at 1.0 ETc followed by 0.8 and significantly superior over 0.6 ETc. The enhanced water use efficiency (WUE) in drip system is due to moisture availability in root zone to decrease surface evaporation; runoff and percolation losses of water.WUE might be higher in 1.0 ETc followed by 0.8ETc due higher yield production. These results are in agreement with Oweis and Hachum (2002). Water use efficiency (5.87) was significantly higher with 100%RDF as compared to other levels. It is might be due to higher yield gained to plant response at nutrient availability. This is conformed to the findings of Ramamurthy *et al* (2009) and Pawar *et al* (2013). Maximum WUE (6.11) was recorded with interaction of 1.0 ETc at 100% RDF fallowed by 0.8 ETc at 100% RDF which significantly higher than rest interaction. It is might be due to yield response at the availability of water and nutrients. Nitrogen availability was improved with fertigation. Maximum nitrogen uptake (217.14 kg/ha) recorded at 1.0ETc followed by 0.8ETc and significantly higher than 0.6 ETc. It may be cleared that N availability is reduced with water availability in root zone of plant. 100% RDF gave significantly higher N uptake (226.14kg/ha) than other nutrient levels. It might be due to adequate quantum availability of nutrient in soil. Maximum N uptake (250kg/ha) was recorded with the interaction of 1.0 ETc at 100% RDF followed by interaction of 0.8 ETc at 100% RDF which significantly higher to rest interaction of water and nutrients. The results conformed to the finding of Results conformed to the finding of Panwar *et al* (2013). It might be due availability of nutrient at adequate soil moisture to uptake by plant. Maximum NUE (41.80) recorded with 1.0 ETc which was significantly higher than other irrigation levels. It might be due to optimum utilization of N at adequate moisture availability. The interaction of 1.0 ETc at 50% RDF gave significantly

higher NUE (47.62) compared to other interactions. Similar results were rep[orted by Nalayini et al (2013).

Table 2. Effect of irrigation regimes and nutrient levels on water use efficiency, nitrogen uptake and nitrogen use efficiency of Bt cotton.

Treatment	Water use efficiency (kg/ha-mm)	Nitrogen uptake (kg/ha)	Nitrogen use efficiency (kg/kg N)
Irrigation regimes			
I_1: 0.6ETc	**4.70**	**152.53**	**31.20**
I_2: 0.8ETc	**5.41**	**204.32**	**37.75**
I_3: 1.0ETc	**5.46**	**217.14**	**41.80**
CD (P=0.05)	**0.23**	14.80	2.11
Nutrients			
N_1: 100% RDF	**5.87**	**226.75**	**29.64**
N_2: 75% RDF	**5.57**	**203.29**	**37.15**
N_3: 50% RDF	**4.13**	**143.94**	**41.80**
CD (P=0.05)	0.17	9.40	1.35
IxN interaction			
$I_{1X}N_1$	**5.37**	**187.81**	**25.89**
$I_{1X}N_2$	**5.16**	**167.37**	**33.21**
$I_{1X}N_3$	**3.58**	**102.40**	**34.53**
$I_{2X}N_1$	**6.14**	**241.50**	**30.92**
$I_{2X}N_2$	**5.82**	**217.69**	**39.08**
$I_{2X}N_3$	**4.29**	**153.76**	**43.25**
$I_{3X}N_1$	**6.11**	**250.94**	**32.09**
$I_{3X}N_2$	**5.74**	**224.82**	**40.25**
$I_{3X}N_3$	**4.53**	**175.67**	**47.62**
CD (P=0.05)	0.29	16.30	2.35

Economics

Pooled data of two year presented in Table 3 revealed that maximum gross return (Rs 1, 37,740/ha) recorded at 1.0 ETc which was significantly higher than rest irrigation levels. Among, the nutrient levels, 100% RDF gave maximum gross return (Rs 1, 42,249/ha) which was significantly higher than other levels. The interaction of 1.0 ETc at 100% RDF recorded maximum gross return (Rs 1, 48,416/ha) followed by 1.0 ETc at 50% RDF which was significantly higher than rest interactions. Maximum Net return (Rs, 1,03.523/ha) was found significantly higher at 1.0 ETc than other irrigation regimes. Among nutrient levels, maximum net return (Rs 1,07,452/ha) was recorded at 100% RDF followed by 75% RDF and significantly higher than 50% RDF. Irrigation at 1.0ETc obtained significantly higher B:C ratio (3.02) than other irrigation regimes. Among, the nutrient levels.100% RDF found significantly higher B:C (3.09) than other levels. Interaction of 1.0 ETc at 100% RDF gained higher B:C ratio (3.40) followed by interaction of 0.6 ETc at 100% RDF and 1.0 ET at 75% RDF which was found significantly higher than rest interactions. Economic returns might be increased with response inputs on yield of crop. Results are conformed with finding of Bhatoo et al (2009) and Ramamurthy et al (2009).

Table 3. Effect of irrigation regimes and nutrient levels on economics of Bt cotton

Treatment	Gross return (Rs/ha)	Net return (kg/kg N)	B:C ratio
Irrigation regimes			
I_1: 0.6ETc	**108901**	**75126**	**2.22**
I_2: 0.8ETc	**130969**	**96974**	**2.84**
I_3: 1.0ETc	**137740**	**103523**	**3.02**
CD (P=0.05)	**5343**	**5509**	**0.17**

Nutrients			
N_1: 100% RDF	**142249**	**107452**	**3.09**
N_2: 75% RDF	**135039**	**191943**	**2.97**
N_3: 50% RDF	**100322**	**67128**	**2.02**
CD (P=0.05)	**4243**	**4010**	**0.11**
IxN interaction			
$I_{1X}N_1$	**124284**	**89707**	**2.59**
$I_{1X}N_2$	**119542**	**85766**	**2.54**
$I_{1X}N_3$	**82878**	**49904**	**1.51**
$I_{2X}N_1$	**148416**	**113619**	**3.27**
$I_{2X}N_2$	**140690**	**106695**	**3.14**
$I_{2X}N_3$	**103801**	**70608**	**2.13**
$I_{3X}N_1$	**148416**	**119030**	**3.40**
$I_{3X}N_2$	**140690**	**110668**	**3.23**
$I_{3X}N_3$	**103801**	**80872**	**2.42**
CD (P=0.05)	**7305**	**6946**	**0.21**

CONCLUSION

Based on two years study, it can be concluded that high yielding Bt cotton hybrid responded to water and nutrients. The drip irrigation at 0.8 ETc with 75% RDF through festigation of nutrient in splits is found precision use of inputs for realizing yield and economics of Bt cotton and save the input over surface irrigation and manual application of fertilizers in the crop under humid condition of Southern Rajasthan.

Table 1: Effect of irrigation regimes and nutrient levels on growth parameters, yield attributes and yield of cotton

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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF ENTOMOPATHOGENIC FUNGI AND CHEMICAL INSECTICIDES AGAINST WHITE GRUB (*HOLOTRICHIA* SP.) IN SUGARCANE

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Abstract: Field trials were conducted in sugarcane crop for management of white grub (*Holotrichia* sp.) using talc based formulations of entomopathogenic fungi *Metarhizium anisopliae* and *Beauveria bassiana* and chemical insecticides namely carbofuran 3G, Chloropyriphos 20 EC and Fipronil 40%+ Imidaclorpid 40% WG. Pretreatment count of white grub larvae was taken for every individual microplot. Fipronil 40%+ Imidaclorpid 40% WG @ 375 gm/ha proved to be the best treatment against white grub and provided up to 100% control of white grub. Chloropyriphos was second most effective treatment and checked 100% soil population of white grub followed by *M. anisopliae* which resulted in 80.97% decrease in soil population of white grub. After economic analysis *M. anisopliae* appeared to be significantly cost effective as compare to Fipronil 40%+ Imidaclorpid 40% WG. Net return of Rs. 31153/ha was recorded in this treatment whereas, net return of Rs. 27816/ha was recorded in case of *M. anisopliae.*

Keywords: White grub, *M. anisopliae*, *B. bassiana*, Biological control, Chemical control

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is the most important crop and plays main role in Indian economy. More than 200 insect pests has been reported causing damage to sugarcane crop (David *et al*., 1986). Among them, white grub has become the most important polyphagous pest causing serious threat to sugarcane crop since 1960 (Mohalkar *et al*., 1977). Their infestation has been reported throughout the country, and the magnitude of the problem has been wide spread over the past years. Nearly 20 species of white grubs are reported to attack sugarcane in India. Of these, *Holotrichia* sp., *Anomala varicolor* (GryII), *A. viridis* (F), *Apogonia destructor* (Bos.), *Cyclocephala parallela* (Casey), *Dermolepidia pica* (Arrow), *Lepidota stigma*, *Ligyrous subtropicus* (Blench), *Leucopholis* sp. (F.), *Phyllophaga helleri* (Brsk), and *Schizonycha* sp. have been reported to assume pest status in sugarcane-growing regions (Yubak Dhoj, 2006). Among these pests the subterranean white grub has potential to cause 80-100% damage to sugarcane cane. White grubs (Coleoptra-Scarabaeidae) are soil inhibiting and root feeding immature stages of scarab beetles. The white grub family, Scarabaeidae is the second largest and omnipresent family within the order coleoptra (Mishra and Singh, 1999). In a majority of the farming situation, Control of these pests has become increasingly difficult because of the lack of control over damages they cause. In general the management strategy depends primarily on the use of highly poisonous poor graded chemical pesticides. Application of chemical is practically uneconomical, difficult and associated with high cost and environmental pollution and other problems. Hence there is a strong need for the development of alternative strategies for the control of white grubs, which are ecofriendly and economically feasible. The success of control tactics is governed by the seasonality of adults and the susceptible stage of the grub. The chemical insecticides so far evaluated against the grub stage proved less effective since the pests are subterranean (Patil *et al*., 1986). The use of biological control agents in general and fungal based myco-insecticides in particular are lacking in the country (Manisegaran *et al*., 2011). The entomopathogenic fungi occupy the vital role in control of insect pests, some of the important entomopathogenic fungi genrea are *Metarhizium anisopliae* (Metschnikoff) Sorokin, *Beauveria bassiana* (Balsamo) Vuillrmin etc. are commonly used in microbial control (Agarwal and Rajak, 1985). The entomopathogenic fungi *M. anisopliae* and *B. bassiana* have been successfully utilized as potential biological control agents for many soil inhibiting insect pests (Milner *et al*., 1993; Robertson *et al*., 1997; Sharma and Gupta, 1998; Bhagat *et al*., 2003; Gupta *et al*., 2003; Mane and Mohite 2014).
Therefore present study was undertaken to explore the comparative efficacy of *M. anisopliae*, *B. bassiana*, and chemical insecticides for the management of white grubs in field conditions.

MATERIAL AND METHOD

A field survey was conducted during 2010-11. White grub infested sugarcane field in Qurar village of Tahsil-Milak, Rampur, Uttar Pradesh, India was selected as the test site to conduct field experiment

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by using different treatments for management of white grub. Two year trials were conducted in the year 2011-12 and 2012-13. A field was selected in which white grubs were found to occur at a density of 10-12 grubs/m^2. The sugarcane variety CoS 767 was planted during last week of April in the year 2011 and 2012 with a 60 cm row to row distance and bunds were made to demarcate small plots of plot size 13×15 m^2 and all the recommended package of practices were adopted except for white grub management. There were five treatments as described under details of treatments. Treatments were replicated thrice in a randomized block design. Talc formulations of entomopathogenic fungi were procured from biological control Laboratory, SVPUA&T, Meerut whereas chemical insecticides were purchased from local market. First application of treatments was done during mid June by making 10 cm. Wide and 10 cm. Deep furrow parallel to sugarcane plants. Before application formulations of *B. bassiana* and *M. anisopliae* were impregnated in well decomposed FYM for seven days. Chloropyriphos 20 EC and Fipronil 40% + imidaclorpid 40% WG were sprayed in furrows whereas, *B. bassiana* and *M. anisopliae* and carbofuran 3G were broadcasted in furrows. Treatments were applied in furrows extending front to back. The raised soil behind the furrow was pushed back to cover the chemical or biocontrol agent. Thereafter irrigation was done as per requirement Second application of treatments was done at 45 days after first application of treatments. No biopesticide or chemical insecticide was applied in control plot.

Treatment 1: *Beauveria bassiana* @ 5 kg/ha (2×10^9 cfu/g)

Treatment 2: *Metarhizium anisopliae* @ 5 kg/ha (2×10^9 cfu/g)

Treatment 3: Carbofuran 3G @ 33 kg/ha

Treatment 4: Chloropyriphos 20 EC @ 3 lit/ha

Treatment 5: Fipronil 40% + imidaclorpid 40% WG @ 375 g/ha

Treatment 6: Untreated control

Observations on the number of dead and alive white grubs per meter row in the root zone, were recorded a day before implementation of first application of treatments and after that at every 15 days after first application of treatments. Observations on cane/m^2, and damaged cane/m^2 were also recorded. Data on yield/ha was recorded at harvest of crop. Percent decrease in number of white grub, percent cane damage and percent increase in yield was calculated over control. Economics of treatments was calculated.

Statatistical analysis

The data on the number of grubs was subjected to square root transformation. These transformed values and data on other parameters was subjected to analysis of variance (Panse and Sukhatme, 1967) and Duncans multiple range test (Gomez and Gomez, 1984) was used to determine the significance among different treatments.

RESULT AND DISCUSSION

All the treatments were effective in checking the population of *Holotrichia* sp. Which ranged from 75.60-100.00 percent at 60 days after treatment. At 45 days after first application of treatments, all the treatments significantly checked soil population of *Holotrichia* sp. After second application of treatments, sharp decrease in soil population of *Holotrichia* sp. was recorded. This can be attributed to weakened and infected larvae which are prone for pathogenic and toxic effects of different treatments. Keller, 1998 suggested that repeated application of the entomopathogenic fungal formulations enhanced the pest control process and white grubs could be controlled in field situations in various crops, *H. consanguinea* infesting potatoes were controlled by *M. anisopliae* (Kulye and Pokharkhar, 2009). Similar results of repeated application of chemical insecticides were reported by Mane and Mohite (2014). Mohoiddein *et al.* (2006) tested the pathogenecity of nine fungi in the laboratory against *Holotrichia* spp. All the fungi proved to be pathogenic at a spore concentration of 1×10^8 spore/ml to grub with varying mortality. *B. bassiana* (local), *B. bassiana* (commercial) and *M. anisopliae* were found to be the most effective.

Fipronil 40% + imidaclorpid 40% WG and chloropyriphos 20 EC were most effective in controlling white grub soil population and provided 100% control. These findings are in conformity with that of Patel *et al.* (2010). However the dose they applied was quite low i.e. 187 g/ha (Fipronil 40% + imidaclorpid 40% WG) in groundnut for the control of white grub. *M. anisopliae* and carbofuran 3G which caused 80.97% and 79.12% reduction in white grub soil population. Reduction in white grub population caused but *B. bassiana* was significantly low (75.60%) as compare to *M. anisopliae*. Similar findings were reported by Manisegaran *et al.* (2011) and Bhagat *et al.* (2003).

From table 2, it is evident that the millable cane and sugarcane yield varied significantly among the treatments and was significantly superior to untreated check. In control plots white grub infestation caused 33% yield loss. Fipronil 40% + imidaclorpid 40% WG caused maximum control of damage caused by white grub, only 9% damage was recorded in microplots receiving above treatments followed by chloropyriphos (13%). *M. anisopliae* and carbofuran 3G application resulted in (78%) reduction in cane damage caused by white grub larvae. *B. bassiana* appeared to be least effective against damage caused by white grub but it was significantly at par with *M. anisopliae* and carbofuran 3G. Maximum yield (655.37 qt/ha) was recorded in plots receiving soil application of Fipronil 40% + imidaclorpid 40% WG

in this treatment 22.5% increase in yield was recorded followed by chloropyriphos 20EC, carbofuran 3G and *M. anisopliae* which caused 18.3%, 16.5% and 16.3% increase in yield respectively. *B bassiana* caused least (13%) increase in yield.

Maximum net return of Rs. 31153/- was recorded in case of treatment by Fipronil 40% + imidaclorpid 40% WG followed by chloropyriphos 20EC in which net return of Rs. 28012/- was recorded. Whereas, net return of Rs. 27816/- and Rs. 25365/- was recorded after application of *M. anisopliae* and carbofuran 3G respectively. Lowest net return of Rs. 22860/- was recorded in case of *B. bassiana*.

Economic analysis revealed that cost benefit ratio for every rupee investment in pesticide and net return was the highest in case of *M. anisopliae* (1:19.86) followed by *B. bassiana* (1: 16.32) chloropyriphos 20EC, Carbofuran 3G and Fipronil 40% + imidaclorpid 40% WG, recorded 1:6.51, 1:5.91 and 1:4.23 incremental benefit on white grub management respectively. Lowest C:B ratio was recorded in case of Fipronil 40% + imidaclorpid 40% WG.

The higher colony-forming unit counts of *M. Anisopliae* found in association with plant roots and root exudates suggest these fungi may be capable of survival in soil without an insect host (Hu and St. Leger, 2002). As mycopathogens persist in the soil for a long period than chemicals and under suitable conditions they are self perpetuating in nature. Therefore by keeping in the view the high cost of pesticide and significance of economic returns achieved by *M. anisopliae*, this entomopathogenic fungi can also be an ideal choice for the management of white grub in endemic areas.

Table 1. Effect of different treatments on soil population of *Holotrichia* sp. in sugarcane crop

Treatments	White grub larvae/meter row					% decrease over control
	1 DBT	15 DAT	30 DAT	45 DAT	60 DAT	
Beauveria bassiana @ 5kg/ha	10.46[a] (18.81)	10.00[c] (19.28)	5.85[b] (13.94)	4.65[b] (12.39)	2.50[b] (9.10)	75.60
Metarhizium anisopliae @ 5 kg/ha	10.95[a] (19.28)	9.50[c] (17.95)	4.85[b] (12.66)	3.38[a] (10.47)	1.95[b] (7.92)	80.97
Carbofuran 3G @ 33 kg/ha	10.46[a] (18.81)	7.55[b] (15.89)	6.00[b] (14.18)	3.63[a] (10.94)	2.14[b] (8.33)	79.12
Chloropyriphos 20 EC @ 3 lit/ha	10.00[a] (18.44)	6.85[a] (15.12)	4.40[a] (12.11)	2.65[a] (9.28)	0.00[a] (0.00)	100.00
Fipronil 40% + imidaclorpid 40% WG @ 375 g/ha	10.36[a] (18.72)	5.55[a] (13.56)	3.56[a] (10.78)	1.50[a] (7.04)	0.00[a] (0.00)	100.00
Control (untreated)	10.95[a] (19.28)	10.95[c] (19.28)	10.45[c] (18.81)	10.25[c] (18.63)	10.25[c] (18.63)	-
CD (P=0.05)	2.60	1.75	1.36	2.06	1.73	-

DBT: Days before treatment; DAT: Days after treatment

Figures in paranthesis are angular transformed values, In the columns means followed by same letter did not differ significantly (P=0.05) by DMRT.

Table 2. Effect of different treatments on white grub infested sugarcane crop

Treatments	No. Of millable canes/ha	% damage	Infected millable canes/ha	Yield qt/ha	% increase in yield
Beauveria bassiana @ 5kg/ha	108000[e]	18	19080[e]	604.55[b]	13.0
Metarhizium anisopliae @ 5 kg/ha	108500[d]	15	15975[c]	622.20[a]	16.3
Carbofuran 3G	108800[c]	15	16020[d]	623.77[a]	16.5

@ 33 kg/ha					
Chloropyriphos 20 EC @ 3 lit/ha	109300[b]	13	13949[b]	632.90[a]	18.3
Fipronil 40% + imidaclorpid 40% WG @ 375 g/ha	110100[a]	9	9729[a]	655.37[a]	22.5
Control (untreated)	105300[f]	33	34749[f]	535.0[c]	-
CD (P=0.05)	102.60	-	173.81	39.75	-

In the columns means followed by the same letter did not differ significantly (P=0.05) by DMRT.

Table 3. Economics of different treatments against white grub

Treatments	**Cost of pesticide/ha** (2 applications)	**Gross cost of cultivation**	**Gross return**	**Net return**	**CBR of additional income**
Beauveria bassiana @ 5kg/ha	1400.00	146400.00	169260.00	22860.00	1: 16.32
Metarhizium anisopliae @ 5 kg/ha	1400.00	146400.00	174216.00	27816.00	1: 19.86
Carbofuran 3G @ 33kg/ha	4290.00	149290.00	174655.00	25365.00	1: 5.91
Chloropyriphos 20 EC @ 3 lit/ha	4299.00	149200.00	177212.00	28012.00	1: 6.51
Fipronil 40% + imidaclorpid 40% WG @ 375 g/ha	7350.00	152350.00	183503.60	31153.60	1:4.23
Control (untreated)	-	145000.00	149800.00	4800.00	-

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RESEARCH ARTICLE

PRODUCTIVITY AND PROFITABILITY OF INDIAN MUSTARD (*BRASSICA JUNCEA* L.) UNDER SULPHUR LEVELS AND WEED MANAGEMENT PRACTICES

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Abstract: Field investigations were carried out during winter seasons of 2015-16 and 2016-17 at Varanasi to evaluate the effect of sulphur levels and weed management practices on density and dry matter of weeds and crop-weed competition for sulphur in Indian mustard (*Brassica juncea* (L.) Czernj and Cosson). Amongst sulphur levels, minimum weed density and dry matter production was recorded with the application of 60 kg S/ha which was found to be significantly superior to other sulphur treatments. Amongst weed management treatments, the minimum weed density and weed dry matter production was observed with pendimethalin (0.75 kg/ha) + Hand weeding (HW) at 30 DAS and was at par with the hand weeding twice during both the years, and in second year this was statistically similar to oxyfluorfen (0.2 kg/ha) and oxadiargyl (0.1 kg/ha). More seed yield was observed with 60 kg S/ha (2.19 t/ha) in first year, and in second year more yield was associated with 40 kg S/ha (2.07 t/ha). During the first year, maximum seed yield was registered with oxyfluorfen (0.2 kg/ha) amongst herbicidal treatments, and was at par with all treatments except weedy check, fluchloralin (0.75 kg/ha) and oxyfluorfen (0.15 kg/ha), and in the second year highest seed yield was recorded with the hand weeding twice (20 and 40 DAS), and was statistically at par with the oxyfluorfen (0.2 kg/ha), pendimethalin (0.75 kg/ha) + HW at 30 DAS and oxadiargyl (0.1 kg/ha). In main plot treatments, the least nutrient uptake by weeds was recorded with the application of 60 kg S/ha. Within sub-plot treatments, the least nutrient depletion by weed was registered with hand weeding twice during both the years of data and was at par with pendimethalin (0.75 kg/ha) + HW at 30 DAS. Economics revealed that application of 60 kg S/ha gave the maximum net return (` 19,380). However, highest benefit: cost ratio (2.03) was registered with the application of 40 kg S/ha. The highest net return (` 19,950) was observed with the hand weeding twice (` 19,950/ha), and was followed by application of pendimethalin (0.75 kg/ha) + HW at 30 DAS (` 19,850/ha). Maximum benefit: cost ratio (2.06) was recorded with the application of oxyfluorfen (0.2 kg/ha) and was closely followed by pendimethalin (0.75 kg/ha) + HW at 30 DAS (1.91).

Keywords: Economics, Sulphur level, Mustard, Nutrient uptake, Weed management, Yield

INTRODUCTION

India is blessed with diverse agro ecological conditions ideally suited for growing oilseed crops which account 12-15 per cent of the world's oilseed area, 7-8 per cent of oilseed output and 6-7 per cent of the vegetable oil consumption (Hegde, 2009). Oilseeds occupy 27.5 million ha which account for 14% of total cropped area in the country with a production of 24.7 million tonnes, accounting for nearly 5% of the gross national product and 10% of the value of all agricultural products. Rapeseed and mustard rank third in area (21%) and production (23%) after groundnut (*Arachis hypogaea* L.) and soybean (*Glycine max* L. Merr.). The productivity of rapeseed and mustard in the country is quite low (1.15 t/ha) against the world average of 1.40 t/ha (Puri and Sharma, 2006).The average productivity of rapeseed and mustard in India needs to be enhanced up to 2.56 t/ha by 2030 for ensuring edible oil self-reliance (DRMR, 2011). Mustard is one of the most important crops adopted by the farmers in the Eastern Uttar Pradesh region of India. This is a potential crop in winter season due to its wider adaptability and suitability to exploit residual moisture. Sulphur promotes oil synthesis, besides being an important constituent of seed protein, amino acids, enzymes, glucosinolates and chlorophyll (Holmes, 1980). Among the oilseed crops, rapeseed-mustard has the highest requirement of sulphur (Tandon, 1986). Sulphur uptake and assimilation in rapeseed-mustard are crucial for determining yield, oil, quality and resistance to various stresses. Sulphur increases the yield of mustard by 12 to 48% under rainfed, and by 17 to 124% under irrigated conditions (Aulakh and Pasricha, 1988). In terms of agronomic efficiency, each kilogram of S increases the yield of mustard by 7.7 kg (Katyal *et al*., 1997). It has been estimated that yield depression in rapeseed-mustard due to weed infestation varied from 20-70% depending on the composition and density of weed flora and time of their occurrence (Donovan *et al.*, 2007).

In the past, farmers of Eastern Uttar Pradesh were bound to follow traditional weed techniques such as hand-pulling, hand-hoeing or mechanical hoeing. These techniques, besides being labour and energy intensive and weather dependent, are very difficult to apply due to shortage and high cost of labour. Application of adequate fertilizer to plant crop increases their leaf growth, which facilitates either shading of the soil surface and thus, reduces weed seed germination (Wicks *et al.*, 2012). In the past, little attention has been given to improve mustard

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productivity through integrated weed management in the Indo-Gangetic plains. Therefore, the proposed study was carried out with the objective to develop suitable sulphur and weed management technology for mustard production under the Indo-Gangetic plain region.

MATERIAL AND METHOD

A field trial was conducted during winter (*Rabi*) seasons of 2015-16 and 2016-17 at the Agricultural Research Farm located at the South-Eastern part of Varanasi city at 25°18´ N latitude, 83°03´E longitude and at an altitude of 128.93 m above mean sea level in the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The soil was sandy clay loam in texture, medium in organic carbon (0.42%), low in available N (195.20 kg/ha) and medium in P_2O_5 (17.51 kg/ha) and K_2O (190.10 kg/ha) content with pH 7.8. The total rainfall recorded during crop growth period was 39.5 and 23.43 mm, minimum temperature ranges from 8 to 12 and 8.9 to 14.8, and maximum temperature 19.2 to 32.6 and 16.2 to 31.3°C during winter 2015 and 2016, respectively. The field experiment was conducted in split-plot design with three replications, having 44 treatment combinations of four sulphur levels *viz.*, 0 kg/ha, 20 kg/ha, 40 kg/ha and 60 kg/ha in main-plot and eleven weed control treatments *viz.*, weedy check, hand weeding twice (20 and 40 DAS), fluchloralin (0.75 kg/ha), fluchloralin (1.25 kg/ha), fluchloralin (0.75 kg/ha) + hand weeding (HW) at 30 DAS, oxyfluorfen (0.15 kg/ha), oxyfluorfen (0.2 kg/ha), pendimethalin (0.75 kg/ha) + HW at 30 DAS, oxadiargyl (0.07 kg/ha), oxadiargyl (0.1 kg/ha), alachlor (0.75 kg/ha) + HW at 30 DAS. Fluchloralin was applied one day prior to sowing of the crop and incorporated immediately into the soil to a depth of 5 cm while oxyfuourfen, pendimethalin, oxadiargyl and alachlor were applied three days after sowing through a manually operated foot sprayer with flat-fan nozzle using 800 liter water/ha. Sulphur was applied in the form of elemental sulphur15 days before sowing by broadcasting followed by incorporation in the soil.

The recommended dose of fertilizer (RDF) was 100, 50, 50 kg N, P_2O_5 and K_2O/ha, respectively for mustard. NPK were supplied through urea, diammonium phosphate (DAP) and muriate of potash (MOP). Full amount of phosphorus and potash and half of nitrogen was applied at the time of sowing. The remaining dose of nitrogen was top dressed at 35 days after sowing. Two quadrates of 25 cm × 25 cm were placed randomly in each plot and weeds within the quadrates were removed and after drying in hot air oven (70 ± 1 °C for 72 hours), weed dry weight was recorded. Mustard cultivar 'RH-749' was sown on 7th November, 2015 and 10th November, 2016, respectively. The seed and straw yield was computed from the harvest of net plot and expressed in ha. Plant and soil samples were analyzed for uptake of nitrogen, phosphorus and potash as per standard laboratory procedures (Jackson, 1973). Available phosphorus was determined by Olsen's method as outlined by Jackson (1973), using spectrophotometer (660 nm wavelength). Available potassium was extracted with neutral normal ammonium acetate and the content of K in the solution was estimated with flame photometer (Jackson, 1973). The experimental data were analyzed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test the significance of overall difference among treatments by the F test and conclusions were drawn at 5% probability level. Benefit: cost ratio (B: C) was obtained by dividing the gross income with cost of cultivation. The effect of treatments was evaluated on pooled analysis basis on growth, yield attributes and yields.

RESULT AND DISCUSSION

The most dominant weed species at experimental site were *Anagallis arvensis, Chenopodium album, Convolvulus arvensis, Centella asiatica, Melilotus indica, Melilotus alba, Medicago polymorpha, Coronopus didymus, Oxalis latifolia, Vicia sativa* and *Rumex* spp. During both the years dicot weeds were predominant in the field. The most prominent weeds of rapeseed were recorded as *Chenopodium album, Chenopodium murale, Anagallis arvensis, Convolvulus arvensis, Euphorbia heliscopia, Medicago polymorpha, Cynodon dactylon, Phalaris minor* and *Asphodalus* spp. (Bhowmik, 2003). Amongst sulphur levels, minimum weed density was recorded with the application of 60 kg S/ha, during both the years (Table 1). This might be due to better growth of crop over weeds and smothering effect of crop vegetative growth over the weeds leading to suppression of weeds population greatly. All weed management treatments significantly reduced the weed density at 60 days after sowing. The minimum weed density was recorded under pendimethalin (0.75 kg/ha) + HW at 30 DAS, and was at par with the hand weeding twice, during both the years, further in second year this was statistically similar with oxyfluorfen (0.2 kg/ha) and oxadiargyl (0.1 kg/ha). Maximum weed infestation was registered with the control, and was closely followed by oxyfluorfen (0.15 kg/ha) and oxadiargyl (0.07 kg/ha). Sulphur levels played significant role in reducing weed dry matter production. Application of 60 kg S/ha significantly reduced the weed dry matter production during both the years. All the weed management practices significantly reduced the weed dry matter compared to weedy check (Table 1). Significantly lower weed dry matter was registered under hand weeding, pendimethalin (0.75 kg/ha) + HW at 30 DAS and alachlor (0.75 kg/ha) + HW at 30 DAS during the first year and pendimethalin (0.75

kg/ha) + HW at 30 DAS and oxyfluorfen (0.15 Kg/ha) during the second year.

Application of 60 kg S/ha and 40 kg S/ha registered significantly more seed yield compared to other levels of fertilizers. During the first year, more seed yield was recorded with 60 kg S/ha (2.19 t/ha) and in the second year more seed yield was associated with the 40 kg S/ha (2.07 t/ha). S (60 kg/ha) gave 45% more mean grain yield over lower sulphur level (20 kg/ha). The higher seed yield due to higher sulphur levels was because of better growth and more translocation of photosynthates from source to sink (Tripathi *et al*., 2011, Rana *et al*., 2005). All the weed control treatments significantly increased the seed yields of mustard over weedy check. During first year, maximum seed yield was registered with oxyfluorfen (0.2 kg/ha), and was at par with all the treatments except weedy check, fluchloralin (0.75 kg/ha) and oxyfluorfen (0.15 kg/ha). In second year, peak seed yield was recorded with hand weeding twice, and was statistically at par with oxyfluorfen (0.2 kg/ha), pendimethalin (0.75 kg/ha) + HW at 30 DAS and oxadiargyl (0.1 kg/ha). Application of herbicidal treatments alongwith hand weeding at 30 DAS gave 32 to 68% more seed yield over weedy check. This was in conformity with the finding of Donovan *et al*. (2007).

Stover yield revealed that sulphur levels gave positive response during both the years of observation. More stover yield was registered with 60 kg S/ha in the first year, and with 40 kg S/ha in the second year. Both the treatments were at par with each other during both the years of experiment, and significantly better than other set of sulphur management practices. The greater strover yield at higher sulphur levels was attributed to increased plant height and leaf area and finally more accumulation of dry matter per plant. This greater straw yield was also concluded by Sah *et al.* (2006). Amongst sub-plot treatments, more stover yield was recorded with hand weeding twice during both the years. However in first year, this was statistically similar with pendimethalin (0.75 kg/ha) + HW at 30 DAS and fluchloralin (0.75 kg/ha) + HW at 30 DAS, and in second year with fluchloralin (1.25 kg/ha), pendimethalin (0.75 kg/ha) + HW at 30 DAS, fluchloralin (0.75 kg/ha) + HW at 30 DAS and alachlor (0.75 kg/ha) + HW at 30 DAS. This might be due to the efficient control of weeds with lower dry matter production of weeds and higher crop growth.

Amongst sulphur treatments, the least nutrient uptake by weed was recorded with the application of 60 kg S/ha. Uptake of nitrogen failed to produce any significant response during both years of study. Uptake of phosphorus gave positive response only in first year and the least nutrient uptake registered with 60 kg S/ha. Uptake of potassium was the least registered with higher sulphur levels *i.e.* 60 kg S/ha during both the years (Table 3). Uptake of sulphur was the least registered with 60 kg S/ha and it was at par with 40 kg S/ha during both the years. Among weed control treatments, maximum uptake of primary nutrients by weed was registered with weedy check. The least nutrient uptake by weed was registered with hand weeding twice during both the years and was at par with pendimethalin (0.75 kg/ha) + HW at 30 DAS. The removal of N, P, K and S by weeds were reduced significantly by various herbicidal and manual weeding treatments and it was almost nil under hand weeding twice, whereas the significantly highest N,P,K and S uptake by weeds were recorded in the weedy check treatments (Table 3). These results confirm the finding of Kaur *et al.* (2013).

Application of 60 kg S/ha registered more nitrogen uptake during both the years. The highest uptake of phosphorus and potassium was recorded with 60 kg S/ha and was statistically at par with 40 kg S/ha during both the years. Application of 60 kg S/ha gave higher uptake of sulphur by the crop during both the years. These observations are in agreement with the findings of Shekhawat *et al.* (2012). Among weed management practices, maximum uptake of NPK was recorded with the hand weeding twice during both the years. Application of pendimethalin (0.75 kg/ha) + HW at 30 DAS gave maximum nitrogen uptake by crops, and was at par with the oxyfluorfen (0.2 kg/ha) and alachlor (0.75 kg/ha) + HW at 30 DAS. Uptake of phosphorus was highest with pendimethalin (0.75 kg/ha) + HW at 30 DAS during the second year. However, it was at par with the oxyfluorfen (0.2 kg/ha) and alachlor (0.75 kg/ha) + HW at 30 DAS during the first year. Potassium uptake was more with pendimethalin (0.75 kg/ha) + HW at 30 DAS during the initial year of observation. However, in the second year this was at par with the fluchloralin (0.75 kg/ha) + HW at 30 DAS and alachlor (0.75 kg/ha) + HW at 30 DAS. Sulphur uptake was maximum with hand weeding twice followed by pendimethalin (0.75 kg/ha) + HW at 30 DAS during the first year. However during the second year, maximum uptake of sulphur was seen with hand weeding twice and it was at par with pendimethalin (0.75 kg/ha) + HW at 30 DAS.

Application of 60 kg S/ha gave maximum net return (`20,850/ha) during first year while in second year, 40 kg S/ha produced maximum net return (`18,650/ha) (Table 2). Mean net return of two years revealed that maximum net return was with 60 kg S/ha (`19,380). However, highest benefit: cost ratio (2.03) was registered with the application of 40 kg S/ha. Among weed management treatments, highest net return (`19,950) was obtained with the hand weeding twice (`19,950/ha), followed by application of pendimethalin (0.75 kg/ha) + HW at 30 DAS (`19,850/ha). Maximum benefit: cost ratio (2.06) was recorded with the application of oxyfluorfen (0.2 kg/ha) and closely followed by pendimethalin (0.75 kg/ha) + HW at 30 DAS (1.91).

Therefore, it may be concluded that application of sulphur at 40 kg/ha along with application of pendimethalin (0.75 kg/ha) plus hand weeding at 30 DAS was found to be best in terms of mustard yield and nutrient uptake by weeds and crop.

Table 1. Effect of sulphur levels and weed management practices on weed density and dry matter in Indian mustard

Treatment	Weed density (no./m^2)		Weed dry matter (g/m^2)	
	2016-17	2017-18	2016-17	2017-18
Sulphur level (kg/ha)				
0	23.1 (534)*	18.9 (358)	28.9	33.2
20	17.3 (300)	19.4 (374)	25.7	27.7
40	12.6 (157)	15.4 (235)	22.3	25.0
60	9.4 (87)	11.2 (125)	21.4	20.2
SEm±	0.31	0.44	0.47	0.65
CD (P=0.05)	0.93	1.31	1.40	1.96
Weed management practice				
Control	27.0 (789)	30.3 (897)	65.3	59.1
Hand weeding (HW) twice (20 and 40 DAS)	9.6 (92)	11.1 (124)	11.3	15.3
Fluchloralin (0.75 kg/ha)	18.3 (336)	21.0 (442)	25.1	28.1
Fluchloralin (1.25 kg/ha)	16.4 (267)	19.3 (373)	19.6	25.4
Fluchloralin (0.75 kg/ha) + HW at 30 DAS	11.2 (125)	16.3 (266)	13.3	19.1
Oxyfluorfen (0.15 kg/ha)	21.4 (456)	19.1 (365)	16.3	13.9
Oxyfluorfen (0.2 kg/ha)	13.4 (178)	12.4 (152)	14.6	18.4
Pendimethalin (0.75 kg/ha) + HW at 30 DAS	10.0 (100)	11.2 (126)	12.0	9.4
Oxadiargyl (0.07Kg/ha)	20.2 (409)	23.7 (561)	21.4	27.3
Oxadiargyl (0.1Kg/ha)	17.3 (300)	15.2 (231)	25.3	20.1
Alachlor (0.75Kg/ha) + HW at 30 DAS	11.1 (123)	12.7 (160)	10.3	16.4
SEm±	0.41	0.56	0.97	1.01
CD (P=0.05)	1.23	1.69	2.91	3.03

Data subjected to square root transformation. *Figures in parentheses are original values.

Table 2. Effect of sulphur levels and weed management practices on seed yield, stover yield and economics

Treatment	Seed yield (t/ha)		Stover yield (t/ha)		Net return* (×10^3 `/ha)		B:C ratio	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Sulphur level (kg/ha)								
0	1.20	1.03	2.97	2.98	8.05	6.98	0.87	0.76
20	1.70	1.58	3.01	3.33	12.11	13.25	1.75	1.68
40	2.07	1.95	4.08	3.98	19.16	18.65	2.10	1.97
60	2.19	1.87	4.51	3.21	20.85	17.91	1.82	1.55
SEm±	0.08	0.05	0.34	0.35				
CD (P=0.05)	0.23	0.14	1.01	1.05				
Weed management practice								
Hand weeding (HW) twice (20 and 40 DAS)	2.22	2.19	4.35	3.78	20.10	19.89	1.86	1.78
Fluchloralin (0.75 kg/ha)	1.52	1.36	3.02	3.08	16.83	14.25	1.25	1.42
Fluchloralin (1.25 kg/ha)	1.86	1.71	3.69	3.52	17.33	16.89	1.23	1.96
Fluchloralin (0.75 kg/ha) + HW at 30 DAS	1.93	1.79	4.01	3.66	19.63	17.06	2.05	1.61
Oxyfluorfen (0.15 kg/ha)	1.62	1.73	3.26	3.18	17.44	16.96	1.55	1.30
Oxyfluorfen (0.2 kg/ha)	2.01	1.91	3.59	3.42	19.02	18.78	2.14	1.98
Pendimethalin (0.75Kg/ha) + HW at 30 DAS	2.09	2.10	3.98	3.54	19.74	19.99	2.02	1.81
Oxadiargyl (0.07 kg/ha)	1.83	1.46	3.43	3.29	17.86	14.98	1.34	1.27
Oxadiargyl (0.1 kg/ha)	1.90	1.93	3.44	3.16	19.54	19.66	2.03	1.98
Alachlor (0.75 kg/ha) + HW at 30 DAS	2.01	1.71	4.01	3.65	19.09	16.86	1.14	1.21
Control	0.93	0.82	2.61	2.98	6.18	5.05	0.73	0.81

SEm±	0.09	0.11	0.19	0.13
CD (P=0.05)	0.26	0.34	0.56	0.39

*Price of mustard seeds (`30.50/kg); urea (`10.90/kg); DAP (`22.0/kg); MOP (`9.75/kg); cost of labour (`162.50/day).

Table 3. Effect of sulphur levels and weed management practices on NPKS uptake by weeds and crop

Treatment	Uptake by weeds (kg/ha)								Uptake by crop (kg/ha)							
	N		P		K		S		N		P		K		S	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Sulphur level (kg/ha)																
0	4.06	4.32	2.80	3.25	10.2	8.95	1.11	1.17	60.2	87.0	14.2	16.0	55.3	66.3	7.8	5.3
20	3.96	3.98	2.98	3.21	9.12	9.65	0.91	0.94	102.3	87.4	21.4	18.9	79.0	63.9	9.4	6.8
40	3.56	3.39	2.31	2.98	7.98	7.89	0.80	0.84	121.6	112.3	30.0	29.6	95.7	78.9	9.3	7.3
60	2.84	3.21	1.90	1.85	6.89	5.69	0.70	0.71	133.4	123.0	33.4	32.1	98.0	89.6	12.9	10.8
SEm±	0.28	0.29	0.04	0.07	0.17	0.24	0.05	0.06	2.67	2.12	1.15	1.72	1.89	3.34	0.38	0.39
CD (P=0.05)	NS	NS	0.12	NS	0.45	0.68	0.13	0.15	8.02	6.34	3.36	5.12	5.62	9.98	0.93	0.95
Weed management																
Hand weeding (HW) twice (20 and 40 DAS)	2.01	2.34	1.39	1.41	7.98	9.18	0.60	0.69	133.0	125.0	28.9	27.0	103.1	111.3	13.1	13.7
Fluchloralin (0.75 kg/ha)	4.98	4.10	2.36	2.98	11.10	10.10	0.86	0.84	107.6	109.3	20.0	21.9	71.2	79.3	11.4	11.5
Fluchloralin (1.25 kg/ha)	4.89	4.95	2.54	3.14	9.89	10.10	0.81	0.89	112.1	108.1	20.1	19.0	80.2	83.0	11.6	11.6
Fluchloralin (0.75 kg/ha) + HW at 30 DAS	3.91	4.11	2.11	3.00	8.91	9.06	0.79	0.80	110.1	105.6	111.9	21.6	20.1	94.0	91.1	11.9
Oxyfluorfen (0.15 kg/ha)	5.52	5.17	3.11	3.91	12.00	13.10	0.91	0.95	104.3	89.6	18.0	15.2	79.1	70.2	10.4	10.5
Oxyfluorfen (0.2 kg/ha)	3.11	3.68	2.81	2.16	9.11	10.20	0.93	0.97	123.1	116.9	26.0	21.9	89.4	82.5	10.6	10.6
Pendimethalin (0.75 kg/ha) + HW at 30 DAS	2.51	2.98	1.55	1.59	8.06	9.01	0.61	0.72	126.8	119.1	27.0	26.9	98.2	95.0	12.9	13.7
Oxadiargyl (0.07 kg/ha)	4.54	5.02	2.88	3.99	12.00	13.10	1.50	1.63	111.3	94.4	20.0	15.8	85.1	84.2	9.3	9.5
Oxadiargy l(0.1kg/ha)	3.91	4.28	2.58	2.91	10.10	11.00	1.56	1.71	114.2	107.3	21.1	21.3	90.9	91.1	9.7	9.7
Alachlor (0.75kg/ha) + HW at 30 DAS	3.71	3.80	1.90	3.10	9.96	10.00	0.64	0.75	120.9	116.9	25.4	19.1	96.0	94.9	12.7	13.5
Control	6.19	7.72	3.98	4.89	24.00	29.40	2.01	2.32	88.2	69.4	15.4	12.4	65.3	53.3	7.6	7.9
SEm±	0.34	0.35	0.15	0.19	0.37	0.44	0.02	0.01	2.84	2.53	0.78	0.66	2.44	2.97	0.04	0.02
CD (P=0.05)	0.99	1.04	0.44	0.57	1.10	1.32	0.03	0.02	8.53	7.58	2.35	1.98	7.33	8.91	0.11	0.06

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RESEARCH ARTICLE

RESPONSE OF MARIGOLD (*TAGETES ERECTA* L.) CV. DOUBLE ORANGE TO LIQUID FORMULATIONS OF EM CONSORTIA WITH GRADED LEVELS OF NPK ON FLOWER YIELD, QUALITY AND XANTHOPHYLLS YIELD

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Abstract: The present investigation entitled "response of Marigold (*Tagetes erecta* L.) cv. Double Orange to liquid formulations of effective microbial consortia with graded levels of NPK on flower yield and quality traits" was carried out at Department of Horticulture, College of Agriculture, Shivamogga, Karnataka, during 2014-15. The experiment was laid out in Randomized Block Design with 15 treatments replicated thrice. Studies showed significant effect on flower weight (8.37 g), flower diameter (8.04 cm), number of petals per flower (323.12), number of flowers per plant (91.34), flower yield per plant (572.86 g), flower yield per plot (20.62 kg) and flower yield per hectare (12.70 t) was recorded in the treatment which received 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia* (T_{14}). Petal meal yield per kilogram of fresh flower (90.84 g), petal meal yield per hectare (1156.40 kg), xanthophyll content (42.21 g) per kilogram of petal meal and xanthophyll yield per hectare (48.61 kg) were also recorded maximum with the same treatment *i.e.*, T_{14} (75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia*) compared to cent per cent RDF.

Keywords: Marigold, EM consortia, Flower yield, Quality, Xanthophyll

INTRODUCTION

Marigold (*Tagetes erecta* L.) occupying a prominent place in ornamental horticulture, is one of the commercially exploited flower crops belonging to the family Asteraceae. Its habit of free flowering, short duration to produce marketable flowers, wide spectrum of attractive colours, shape, size and good keeping quality have attracted the attention of flower growers. It is put to many uses like cut flowers, garden displays, garlands, bouquets and for worship. Apart from its significance in Ornamental Horticulture, it has been valued for other purposes too. Marigold is being cultivated today as commercially important source of carotenoid pigments. The principal pigment present in the flowers is xanthophyll, particularly lutein which accounts for more than 80 - 90 per cent and is present in the form of esters of palmitic and myristic acids (Alam *et al.*, 1968). Marigold carotenoids are the major sources of pigments for poultry industry as a feed additive to intensify the yellow colour of egg yolks and broiler skin (Scott *et al.*, 1968). The ground blossom meal (petal meal) or the extract, usually saponified for better absorption and is added to the poultry feed. These products are traded as 'Aztec marigold' or marigold extract as 'Adoptinal'.

In India, the present area under Marigold cultivation is 55,890 hectares with a production of 5, 11,314 metric tonnes. It is cultivated commercially in most parts of India. In Karnataka, the present area under Marigold cultivation is 9,100 hectares with a production of 74,900 metric tonnes (Anon, 2014). Presently, in our country the commercial extraction of Marigold carotenoids is done in Cochin (Kerala), Hyderabad (Telangana), Satyamangal forest (Tamil Nadu) and Telagi near Harihar, Davanagere, Haveri, Kolar, Chikkmagalur district and around Bangalore (Karnataka). The contents are being regularly exported to Mexico, Peru, USA, Japan, Spain, Turkey, Poland, Italy, Australia, Canada and Africa. Consequently large area in Karnataka, Andhra Pradesh, Tamil Nadu and Maharashtra are under contract farming of Marigold for xanthophyll extraction.

Though the African marigold is one of the important commercial flower crops of Karnataka, its yield levels are quite low and hence there is a need to standardize the optimum dose of nutrients particularly in the form of organic and integrated nutrients for improving the soil structure, physico-chemical properties, yield and quality of flowers. The microbial inoculants have attained special significance in modern agriculture keeping view the increasing fertilizers cost and poor purchasing capacity of Indian farmers. Chemical fertilizers have temporary effect while biofertilizer have permanent effect without any production problem. Uses of composite biofertilizers increase the soil fertility considering the prospects of biofertilizers in the country. Effect of liquid biofertilizers on flower crops has not been thoroughly evaluated under Indian conditions. Accordingly, the present investigation was aimed to study the response of Marigold (*Tagetes erecta* L.) cv. Double Orange to liquid formulations of EM consortia with graded levels of NPK on flower yield and quality traits under transitional tract of Karnataka.

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MATERIAL AND METHOD

The present investigation was carried out in the Department of Horticulture, College of Agriculture, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka during the period from September 2014 to January 2015. Shivamogga is situated at 13° 58' North latitude and 75° 34' East latitude with an altitude of 650 meters above mean sea level. It comes under Agro-climatic Region-4 and Zone-VII (Southern Transitional Zone) of Karnataka. The experiment was conducted in red gravely loam soil, having a pH of 6.40. During the experimentation period the rainfall was 790 mm and the average maximum temperature is 31.23^0 C and minimum temperature is 18.97^0 C and relative humidity was 84.57 to 86.27 per cent. The experiment was laid out in randomized complete block design with 3 replications and 15 treatment combinations *viz.*, T_1: 100 % RDF (C), T_2: 75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K', T_3: 100 % RDF + *Azotobacter*, T_4: 75 % RD'P' + *Bacillus megaterium* + 100 % RD'N' and 'K', T_5: 100 % RDF + *Bacillus megaterium*, T_6: 75 % RD'K' + *Frateuria aurantia* + 100 % RD'N' and 'P', T_7: 100 % RDF + *Frateuria aurantia*, T_8: 75 % RD'N' and 'P' + *Azotobacter* + *Bacillus megaterium* + 100 % RD'K', T_9: 100 % RDF + *Azotobacter* + *Bacillus megaterium*, T_{10}: 75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P', T_{11}: 100 % RDF + *Azotobacter* + *Frateuria aurantia*, T_{12}: 75 % RD'P' and 'K' + *Bacillus megaterium* + *Fruteuria aurantia* + 100 % RD'N', T_{13}: 100 % RDF + *Bacillus megaterium* + *Frateuria aurantia*, T_{14}: 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* and T_{15}: 100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*. Liquid EM cultures having population of 10^{13} cells/ml were inoculated by pouring uniformly @ 10 ml per/liter in furrows after seed sowing as seed treatment. Thirty days of healthy and uniform seedlings were used for transplanting. Seedlings were dipped in liquid microbial consortium @ 10 ml/liter of water for about 30 minutes and transplanting was done in the micro plots with a spacing of 60 cm x 45 cm at the rate of one seedling per hill. Well decomposed FYM @ 20 tonnes per hectare was applied at the time of land preparation. The recommended dose of 225:60:60 kg NPK/hectare was applied in the form of urea, single super phosphate and muriate of potash, respectively. One week after transplanting, 50 per cent N and full dose of P and K were applied in a circular band about 10 cm around each plant at a depth of 3 to 4 cm and remaining 50 per cent 'N' was applied in two split doses at 30 and 45 days after transplanting as a top dressing. All the recommended cultural operations were carried out during the course of study. The data recorded on flower yield and quality parameters were tabulated and subjected to statistical analysis (Sunderaraju *et al.*, 1972).

RESULT AND DISCUSSION

The plants inoculated with *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* + 75 % RDF (T_{14}) registered significantly more number of flowers (91.34) per plant and it was on par with T_9 (85.06). The treatment consisting of 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T_{14}) gave significantly maximum flower yield per plant (572.86 g) and it was on par with T_3 (570.00 g) and T_2 (541.53 g). The plants supplied with 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T_{14}) produced maximum flower yield (20.62 kg) per plot and per hectare (12.70 t) which was found on par with T_3 (19.16 kg and 11.80 t, respectively). Which resulted in 32.15 and 22.78 % increase in flower yield in T_{14} and T_3, respectively over 100 % RDF (T_1) (Table 1). Whereas, 100 % RDF (T_1) recorded least number of flowers (55.65), flower yield per plant (441.13 g), per plot (15.60 kg) and per hectare (9.61 t). The possible reason for better performance of yield attributes and higher yield could be due to the regular supply of nutrients leads to more vegetative growth leading to increase in photosynthetic area, which in turn resulted in more synthesis and accumulation of dry matter in the flower (Bosali *et al*., 2014). Moreover, presence of growth promoting substances such as auxin, gibberllins and cytokinin due to presence of biofertilizers would have also contributed in development and accumulation of sink resulting in better growth and subsequently higher number of flowers per plant and higher flower yield per hectare. The results are in agreement with the earlier findings of Thumhar *et al*., 2013 and Jadhav *et al*., 2014 in Marigold, Patanwar *et al*., 2014 in Chrysanthemum, Kirar *et al.*, 2014 in China aster and Sheergojri *et al.*, 2014 in Gladiolus.

Treatments varied significantly with respect to quality parameters (Table 2). The plants treated with 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T_{14}) registered maximum flower weight of 8.37 g, which was significantly higher than all other treatments and it was on par with T_{11} (8.04 g), T_3 (7.77 g) and T_9 (7.69 g). The flower diameter was recorded maximum (8.04 cm) when the plants were supplied with 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T_{14}) followed by T_3, T_{11}, T_{10}, T_5, T_9, T_{15}, T_2 and T_4 (7.64, 7.58, 7.57, 7.56, 7.45, 7.45, 7.43 and 7.43 cm, respectively). However, the above treatments were found on par with each other. The treatment T_{14} (75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*) produced significantly highest number of petals per flower (323.12) and it was on par with T_9 (315.51), T_{15} (309.30) and T_3 (300.10). Whereas, T_1 (100 % RDF) recorded minimum flower weight (6.44 g), flower diameter (6.61 cm) and number of petals per flower (231.73). The possible reason for increased quality might be due to better

physical condition of soil and increased population of microflora, thereby enhanced availability of nutrient through mineralization process. Moreover, biofertilizers produce the growth stimulating substances *viz*., auxin, gibberellins and cytokinins which contribute towards vigorous growth of the plant. This in turn increases photosynthesis and enhances food accumulation and also diversion of photosynthates towards sink resulting in better quality flowers. The earlier study of Panchal *et al*. (2010) and Swaroop (2011) also confirms these findings in Marigold, Kirar *et al*. (2014) in China aster, and Singh (2007) and Chaudhari *et al.* (2010) in Rose.

Different treatments significantly influenced on the petal meal yield and xanthophylls yield. The treatment T_{14} which received 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* recorded maximum petal meal yield (90.84 g/kg) and it was found statistically on par with T_9, T_3, T_{10}, T_5 and T_8 (87.42, 86.31, 84.56, 83.95 and 83.86 g/kg, respectively). The maximum petal meal yield of 1156.40 kg per hectare was recorded in the treatment T_{14} (75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*) and it was on par with T_9 (1031.37 kg/ha). Significantly higher xanthophyll content (42.21 g/kg) was recorded in the treatment T_{14} supplied with 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* which was closely followed by (40.92 g/kg) 100 % RDF + *Azotobacter* + *Bacillus megaterium* (T_9) and on par with each other. Inoculation of *Azotobacter*, *Bacillus megaterium* and *Frateuria aurantia* along with 75 % RDF (T_{14}) produced higher xanthophyll yield of 48.61 kg/ha, which was significantly superior over rest of the treatments followed by T_9 (42.17 kg/ha). This resulted in 265.21 and 216.82 % increase in xanthophyll yield in T_{14} and T_9, respectively compared to T_1 (100 % RDF). The treatments T_1 with 100 % RDF reported

Table 1. Effect of liquid formulations of EM consortia on yield and its attributes of *Tagetes erecta* L. cv. Double Orange

Treatment		No. of flowers/ plant	Flower yield/ plant (g)	Flower yield/plot (kg)	Flower yield/ ha (t)
T_1	100 % Recommended dose of fertilizer (C)	55.65	441.13	15.60	9.61
T_2	75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K'	76.01	541.53	18.89	11.64
T_3	100 % RDF + *Azotobacter*	79.07	570.00	19.16	11.80
T_4	75 % RD'P' + *Bacillus megaterium* + 100 % RD'N' and 'K'	67.46	510.26	17.56	10.81
T_5	100 % RDF + *Bacillus megatherium*	60.91	482.80	18.10	11.15
T_6	75 % RD'K' + *Frateuria aurantia* + 100 % RD'N' and 'P'	68.66	507.26	18.39	11.33
T_7	100 % RDF + *Frateuria aurentia*	60.99	508.20	17.81	10.97
T_8	75 % RD'N' and 'P' + *Azotobacter* + *Bacillus megaterium* + 100 % RD'K'	72.16	479.40	17.35	10.69
T_9	100 % RDF+ *Azotobacter* + *Bacillus megatherium*	85.06	532.00	19.12	11.78
T_{10}	75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P'	74.67	529.46	18.58	11.44
T_{11}	100 % RDF+ *Azotobacter* + *Frateuria aurentia*	71.93	483.40	17.43	10.73
T_{12}	75 % RD'P' and 'K' + *Bacillus megaterium* + *Frateuria aurantia* + 100 % RD'N'	64.83	489.73	17.70	10.90
T_{13}	100 % RDF + *Bacillus megaterium* + *Frateuria aurentia*	77.87	500.04	18.12	11.16
T_{14}	75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia*	91.34	572.86	20.62	12.70
T_{15}	100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia*	65.26	475.65	17.43	10.74
S. Em ±		3.72	11.00	0.50	0.31
C. D. @ 5 %		10.79	31.88	1.47	0.90

Table 2. Effect of liquid formulations of EM consortia on quality traits of *Tagetes erecta* L. cv. Double Orange

Treatment		Flower Weight (g)	Flower diameter (cm)	Number of petals per flower	Petal meal yield (g/kg)	Petal meal yield (kg/ha)	Xanthophyll yield (g/kg)	Xanthophyll yield (kg/ha)
T_1	100 % Recommended dose of fertilizer (C)	6.44	6.61	252.99	71.61	713.82	18.54	13.31
T_2	75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K'	7.07	7.43	288.38	82.05	956.92	19.44	18.67
T_3	100 % RDF + *Azotobacter*	7.77	7.64	300.10	86.31	1023.04	21.48	21.69
T_4	75 % RD'P' + *Bacillus megaterium* + 100 % RD'N' and 'K'	6.87	7.43	278.37	77.27	837.55	37.09	30.99
T_5	100 % RDF + *Bacillus megatherium*	6.62	7.56	282.88	83.95	937.30	31.38	29.59
T_6	75 % RD'K' + *Frateuria aurantia* + 100 % RD'N' and 'P'	7.12	7.27	270.07	81.66	925.98	33.08	30.78
T_7	100 % RDF + *Frateuria aurentia*	7.29	7.30	295.99	74.18	786.65	24.84	19.66
T_8	75 % RD'N' and 'P' + *Azotobacter* + *Bacillus megaterium* + 100 % RD'K'	6.86	7.28	263.26	83.86	898.00	27.93	24.98
T_9	100 % RDF + *Azotobacter* + *Bacillus megatherium*	7.69	7.45	315.51	87.42	1031.37	40.92	42.17
T_{10}	75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P'	7.15	7.57	273.07	84.56	968.43	28.53	27.71

T_{11}	100 % RDF + *Azotobacter* + *Frateuria aurentia*	8.04	7.58	278.17	80.95	870.27	19.75	17.32
T_{12}	75 % RD'P' and 'K' + *Bacillus megaterium* + *Frateuria aurantia* + 100 % RD'N'	7.07	7.38	280.18	78.58	855.97	23.57	20.35
T_{13}	100 % RDF + *Bacillus megaterium* + *Frateuria aurentia*	7.25	7.26	293.69	82.10	919.22	36.70	33.68
T_{14}	75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia*	8.37	8.04	323.12	90.84	1156.40	42.21	48.61
T_{15}	100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia*	7.25	7.45	309.30	82.87	893.99	27.04	23.93
S. Em ±		0.24	0.20	8.40	2.66	43.05	1.57	1.69
C. D. @ 5 %		0.69	0.60	24.34	7.70	124.72	4.55	4.91

minimum petal meal yield (71.61 g/kg), petal meal yield (713.82 kg) per hectare, xanthophyll yield (18.54 g) per kg petal meal and per hectare (13.31 kg). The difference in xanthophyll yield may be attributed to variation in flower yield and petal meal yield per hectare. The difference in the petal meal yield per hectare in the treatments may be attributed to the corresponding differences in yield components *viz*., individual flower weight, number of petals per flower, flower yield per plant and per hectare and petal meal yield per kilogram of fresh flower weight. The present results are in conformity with the research findings of Anuradha *et al*. (1990) and Naik (2003) in Marigold and Roelants (1973) in Carnation, who also observed higher number of petals per flower as well as petal meal yield and higher carotenioid contents.

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RESEARCH ARTICLE

EFFECT OF STORAGE TEMPERATURE ON SHELF LIFE OF AONLA FRUIT (*EMBLICA OFFICINALIS* G.)

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Abstract: The changes in aonla fruit quality were evaluated over 9 days storage at different storage temperatures (10, 25ºC and room temperature) packaged in cardboard boxes. Samples were analysed at two days interval for physiological loss in weight, decay loss, acidity and specific gravity. The results showed that fruits of aonla stored at 10^0C showed minimum physiological loss in weight, decay loss with the highest shelf life as compared to the other treatments whereas fruits of aonla stored at 25^0C had maximum physiological loss in weight and decay loss during all periods of storage. Specific gravity and acidity content decreased during storage at all the temperatures.

Keywords: Aonla, Decay loss, Shelf-life, Temperature

INTRODUCTION

Nowadays, quality has become one of the most important consumer decision factors in the selection among competing products and services. The quality of the food products in conformity with consumer requirements and acceptance is determined by their sensory attributes, chemical composition, physical properties, level of microbiological and toxicological contaminants, shelf-life, packaging and labelling (Khorshidi*et al*. 2010). Food quality management has become challenging the last years due to changes in consumption patterns, development in technology and increasing legislative requirements (Luning & Marcelis, 2006).

Fruits and vegetables are two of the most perishable categories of foods and two of the most important causes for malnutrition diseases in the developing world. Losses occur either on the pre-harvest phase or on the harvested product during handling in general. The fact that the fruits and vegetables have a soft texture means that they are easily damaged having as a consequence the deterioration of quality or even making the product inappropriate for human consumption. Temperature management is one of the most important tools for extending the shelf life of fruits (Lee & Kader, 2000), because it regulates the rate of all associated physiological and biochemical process.

Many studies on the effect of storage temperature on quality and storage life of fruits have been done which shows temperature plays an important role on quality of fruits after harvest. The objective of this study was to determine the effects of different storage temperature on thepostharvest quality changes in aonla fruits during storage.

MATERIAL AND METHOD

Samples were harvested from the orchard of the Horticulture department, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana with the help of secateurs keeping small intact pedicel with each fruit and immediatelyselected for uniformity in size and absenceof defects. 2kg of aonla fruits were packed in cardboard boxes with newspaper as cushioning material and stored at 10^0C, 25^0C and room temperature (15-17^0C). Each box was treated as one replicate and all the treatments were replicated four times. Storage at 10^0C was done by keeping the cardboard boxes in refrigerator and temperature was maintained. Storage at 25^0C was done by keeping the cardboard boxes in incubator and temperature was maintained. For room temperature, fruits were stored in room and average temperature was calculated. The physiological loss in weight was taken on each day of observation and calculated by the following formula suggested by Srivastava & Tandon (1968).

Physiological loss in weight (%)

$$= \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

Fruits showing rotting due to micro-organisms infection were considered as decayed ones and were weighed on each day of observation and were separated from the box. Weight of decayed fruits was taken on each day of observation. The percent decay loss was estimated by the following formula suggested by Srivastava & Tandon (1968).

Decay loss (%) =

$$\frac{\text{Weight of decayed fruits}}{\text{Initial weight of fruits at the time of packing}} \times 100$$

The total titrable acidity was determined by the standard method (AOAC, 1990). One gram of fruit pulp (0.2g for aonla powder) was macerated/ mixed in a pestle and mortar by adding water. The extract was titrated against 0.1N sodium hydroxide using 1% phenolphthalein as an indicator. The appearance of

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light pink color which persists for one minute was taken as end point. The acidity of fruit was expressed on percent basis.

$$\text{Total acidity (\%)} = \frac{\text{Titer value} \times \text{Normality of Alkali} \times \text{Volume made} \times \text{Equivalent weight of acid}}{\text{Volume of Sample taken} \times \text{weight of sample} \times 1000} \times 100$$

The water displacement method was used for measuring the specific gravity.

RESULT AND DISCUSSION

Results indicated that storage temperature had little effect on surface color of fruits. While marketable quality decreased with increase in temperature. Increase in physiological loss in weight (PLW) in aonla stored at all temperatures (Table 1) was observed throughout the storage period (0-9 days). Physiological loss in weight in fruits is mainly due to various physiological processes i.e. respiration and transpiration (Singh *et al*. 2003). After harvesting of fruits, during storage, the supply of photosynthates from plant is cut off and whatsoever is stored inside the fruit that has to be utilized for respiration, transpiration and other physiological processes. As all those physiological processes utilizes various photosynthates already stored in fruits, as result of which fruit weight decreases during storage which is expressed in terms of physiological loss in weight.

In present study, highest PLW was recorded in fruits of aonla stored at 25^0C and minimum PLW was observed in fruits of aonla stored at 10^0C followed by room temperature (15-17^0C) during storage. This could be due to the reason that at 10^0C, rate of various enzymatic activities might have been low, so rate of various physiological processes might have been low and this might have resulted in minimum PLW in 10^0C stored fruits. At high temperature storage i.e. on 25^0C, various physiological processes in aonla fruits might be occurring at higher rate which might have resulted in higher PLW. Results of higher PLW at high storage temperatures as compared to low storage temperatures are in conformity with results obtained by De Freitas & Mitcham (2012) in pitaya fruits (*Hylocereus undatus*), Roongruangsri *et al*. (2013) in tangerine fruits during storage.

Table 1. Physiological loss in weight (%) during storage at different temperatures in fruits of aonla (*Emblica officinalis* G.) cv. Chakaiya

Storage temperatures (T)	Physiological loss in weight (%)		
	Period of storage (D)		
	3	6	9
Room temperature (15-17^0C)	0.88	2.36	3.53
10^0C	0.34	1.02	1.98
25^0C	3.75	12.1	22.3
CD at 5%	**0.36**	**2.07**	**1.83**

Data in table 2 predicts that no decay loss was observed up to 3rd day of storage in fruits of aonla at all storage temperatures. Decay loss increased from 6th to 9th day in all the storage temperatures. On the 6th day of storage, minimum decay loss was observed in fruits stored at 10^0C (0.53%) whereas maximum decay loss was observed in fruits kept at 25^0C which was 8.63% on same period of storage. Similar trend was observed on 9th day of storage where fruits stored at 10^0C showed minimum decay loss of 0.71% and fruits kept at 25^0C had maximum decay loss i.e. 35.74% on same period of storage. Maximum decay loss in fruits stored at 25^0C might be due to higher rate of various physiological processes and degradation of pectin substance leading to softening and attacked by microflora whereas these physiological processes might be occurring at slower rate in fruits stored at 10^0C that's why fruits of aonla kept at 10^0C had minimum decay loss at all periods of storage. These results are in agreement with those reported by Ayala-Zavala *et al.* (2004) in strawberry fruits and Kivi *et al*. (2014) in raspberries stored at different temperatures.

Table 2. Decay loss (%) during storage at different temperatures in fruits of aonla (*Emblica officinalis* G.) cv. Chakaiya

Storage temperatures (T)	Decay loss (%)	
	Period of storage (D)	
	6	9
Room temperature	0.53	0.85
10^0C	0.37	0.71
25^0C	8.63	35.74
CD at 5%	**0.45**	**2.26**

Decrease in specific gravity with increasing period of storage observed in fruits of aonla kept at different storage (Table 3). This might be attributed to more evaporative and transpirational losses which might have resulted in decrease in mass however volume might not have been decreased to same extent. So, the specific gravity of aonla fruits decreased during the storage. Fruits of aonla stored at 25^0C had minimum specific gravity on 9th day of storage whereas fruits of aonla kept at 10^0C showed maximum specific gravity at same period of storage. This might be attributed to higher evaporative and transpirational losses in fruits stored at 25^0C which might have resulted in decrease in mass whereas 10^0C stored fruits might be having low evaporative and transpirational losses which resulted in slow decrease in specific gravity. These results are in agreement with reported by Antala *et al*. (2014) in sapota and Singh & Pal (2008) in guava.

Table 3. Specific gravity during storage at different temperatures in fruits of aonla (*Emblica officinalis* G.) cv. Chakaiya

Storage temperatures (T)	Specific gravity				Mean
	Period of storage (D)				
	0	3	6	9	
Room temperature	1.13	1.10	0.99	0.95	1.05
10^0C	1.13	1.08	0.97	0.96	1.03
25^0C	1.13	1.03	0.95	0.92	1.01
Mean	1.13	1.07	0.98	0.95	

Acidity content of aonla fruits stored at different temperatures decreased with increasing period of storage (Table 4). This is obvious because various acids might have been utilized in various physiological processes (i.e. respiration) going on in the fruits during storage. Decrease in acidity content during storage might also be associated with bio-conversion of organic acids to sugars (Bhullar *et al*. 1981).

Table 4. Acidity content (%) in fruits of aonla (*Emblica officinalis* G.) during storage in different cultivars at room temperature

Cultivars (C)	Acidity (%)						Mean
	Period of storage (D)						
	0	3	6	9	12	15	
CHAKAIYA	2.16	1.83	1.64	1.46	1.26	1.09	1.57
BANARASI	2.20	1.99	1.84	1.61	1.42	1.27	1.72
HATHIJHUL	2.19	1.99	1.82	1.65	1.45	1.29	1.73
KRISHNA	2.27	2.15	1.93	1.75	1.55	1.39	1.84
KANCHAN	2.24	2.07	1.90	1.72	1.52	1.33	1.80
Mean	2.21	2.01	1.83	1.64	1.44	1.27	
CD at 5%		**C= 0.01**		**D= 0.02**		**CxD = 0.03**	

Fruits of aonla stored at 25^0C had minimum acidity content on 9th day of storage whereas fruits of aonla stored at 10^0C retained maximum acidity content at the same period of storage. This might be due to the reason that fruits of aonla stored at 25^0C might have higher rate of various physiological processes which might have caused the rapid utilization of acids and decrease in acidity content to higher extent during storage. Fruits of aonla kept at low temperature i.e. 10^0C might be having slow rate of various physiological processes which might have caused less utilization and decrease in acidity content to lesser extent during storage. The results of decrease in acidity content to different extent in fruits stored at different storage temperatures are in accordance with findings of De Freitas & Mitcham (2012) in pitaya fruits and Roongruangsri *et al*. (2013) in tangerine fruits.

CONCLUSION

Fruits of aonla kept at 10^0C had minimum PLW as well as decay loss whereas fruits of aonla stored at 25^0C had highest PLW and decay loss on all days of storage. Specific gravity and acidity content of aonla decreased with increase in the period of storage at all storage temperatures. Fruits stored at 25^0C had minimum specific gravity and acidity content whereas fruits of aonla kept at 10^0C had maximum specific gravity and acidity content during storage.

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RESEARCH ARTICLE

RESPONSE OF DIFFERENT LEVELS OF ZINC AND MOLYBDENUM ON GROWTH AND YIELD OF BLACKGRAM (*VIGNA MUNGO* L.) UNDER AGRO-CLIMATIC EAST UTTAR PRADESH

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Abstract: A field experiment was conducted during the *Zaid* season 2016 at the Crop Research farm of Agronomy, Naini Agricultural Institute, SHUATS, Allahabad (U.P.) to Field evaluatation of blackgram (*Vigna mungo* L.) under Agro-climatic zone of Allahabad. The experiment was conducted to find out the effect of different levels of zinc and molybdenum on growth and yield of blackgram (*Vigna mungo* L.) laid out in RBD with 9 treatment and 3 replications. The treatment consisted of three levels of zinc (0, 5 and 7.5 kg ha^{-1}), three levels of molybdenum (0, 0.5 and 1.0 kg ha^{-1}). results revealed that the maximum plant height (9.76 and 15.11 cm at 15, 30 DAS), number of branch (4.33 and 7.40 at 30 and 45 DAS), dry weight(0.80, 3.10, 6.73 and19.73 g at 15, 30, 45 and 60 DAS), test weight (40.23gm), harvest index (23.49 %) and grain yield(1.18 t ha^{-1}), However significantly the highest straw yield (4.14 t ha^{-1}) in (T_6) R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 1.0 kg ha^{-1}.

Keywords: Blackgram, Zinc, Molybdenum

INTRODUCTION

Black gram (urdbean) is one of the important pulse crops grown throughout India. It is consumed in the from food 'dal' (whole or split, husked and unhusked) or parched. It is used as a nutritive folder especially for milch cattle .It is also used as a green manuring crop. Urd plant possesses deep root systems which binds soil particles and thus prevent soil erosion. Urad grain contains about 24 per cent protein, 60 per cent carbohydrates, 1.3 per cent fat, and is the richest among the various pulses in phosphoric acid, being five to ten times riche than in others. Black gram contributes 13% in total pulses area and 10% in total pulses production of India.

Urdbean [*Vigna mungo*(L.)Hepper] is an important *kharif* food legume, generally grown under marginal land by resource-poor farmers in west Bengal. Molybdenum is one of the most recognized nutrient elements considered to be essential for the growth of plant. Food insecurity in the 21st century will even increase due to heat and drought strees induced by the climate change, particularly in tropical and subtropical regions. Legumes are good and relatively cheaper source of proteins, carbohydrates and minerals for developing countries including India**.**

Pulses are one of the important segments of Indian agriculture after cereals and oilseeds. The split grains of the pulses called dahl are excellent source of high quality protein, essential amino acids, fatty acids, fibres, minerals and vitamins. Pulses also render improvement in soil health by enriching its N status, long term fertility and sustainability of the cropping systems. It meets up to 80% of its N requirement by biological/symbiotic nitrogen fixation (BNF) from air and leaves behind substantial amount of residual N and organic

matter for subsequent crops. Black gram (*Vigna mungo* L. Hepper) is an important pulse crop grown throughout India where micronutrients play an important role in its production.

Micronutrients play an important role in increasing yield of pulses and oilseed legumes through their effects on the plant itself and on the nitrogen fixing symbiotic process. Besides this, zinc is involved in auxin formation, activation of dehydrogenase enzymes and stabilization of ribosomal fractions while molybdenum is required for growth of most of the biological organisms including plants and animals (Shanti *et al.*, 2008), (Khan and Ved Prakash 2014)

MATERIAL AND METHOD

This experiment was conducted in the year 2016 during *Zaid* season at Crop Research Farm (CRF), Naini Agricultural Institute, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad. The geographical co-ordinates of Allahabad are $25^0 57^0$ N latitude and 87^0 19^0 E longitude and an altitude of 98 m above mean sea level. The area is situated on the south of the Allahabad (U.P.) on the side of the Yamuna River at Rewa road at a distance of about 5.0 km away from Allahabad city. All the facilities required for crop cultivation are available.

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The soil is experimental plot was sandy loam in texture having pH of 7.60 with low level of organic carbon 00.34 %, available medium level of P (13.5 kg ha^{-1}) and higher level of K (336 kg ha^{-1}). The experiment was laid out randomized block design, comprising of sixteen treatment combinations each replicated thrice.

The treatments consisted of three Zinc levels (0, 5 and 7.5 kg ha^{-1}) and three levels of molybdenum (0, 0.5 and 1.0 kg ha^{-1}) with recommended dose 20:60:20 NPK kg ha^{-1}. Total nine treatment combinations *viz.*, T_1 : R.D.F + Zinc 00 kg ha^{-1} + Molybdenum 00kg ha^{-1}, T_2 : R.D.F + Zinc 00 kg ha^{-1} + Molybdenum 0.5kg ha^{-1}, T_3: R.D.F + Zinc 00 kg ha^{-1} + Molybdenum 1.0 kg ha^{-1}, T_4 : R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 00 kg ha^{-1}, T_5 : R.D.F+ Zinc 5 kg ha-1 + Molybdenum 0.5 kg ha^{-1}, T_6 : R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 1.0kg ha^{-1}, T_7 : R.D.F+ Zinc 7.5 kg ha^{-1} + Molybdenum 00 kg ha^{-1}, T_8 : R.D.F+ Zinc 7.5 kg ha^{-1} + Molybdenum 0.5 kg ha^{-1}, T_9 : R.D.F+ Zinc 7.5 kg ha^{-1}+ Molybdenum 1.0 kg ha^{-1} . Five plants were taken from each plot to measure the plant height and yield attributes.

Statistical analysis

The value of table 'F at 5% level significance, where the treatment difference between were found significant the value of CD and CV % were also worked out to compare the treatment mean (Snedecor and Cochran 1967). At initial stage select random five plants from net plot area for further recording observations.

RESULT AND DISCUSSION

Effect of growth parameters on blackgram

Data presented in (Table-1) plant height at 15 DAS significantly higher in treatment (T_9): R.D.F+ Zinc 7.5 kg ha^{-1}+ Molybdenum 1.0 kg ha^{-1} with 9.76 cm. However at par with treatment (T_6): R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 1.0kg ha^{-1}, (T_7): R.D.F+ Zinc 7.5 kg ha^{-1} + Molybdenum 00 kg ha^{-1} and (T_8): R.D.F+ Zinc 7.5 kg ha^{-1} + Molybdenum 0.5 kg ha^{-1}.

At 30 DAS, significantly the highest value of plant height (15.11 cm) in treatment (T_9) R.D.F+ Zinc 7.5 kg ha^{-1}+ Molybdenum 1.0 kg ha^{-1}. The increased in plant height under zinc treatment be due to its effect in the metabolism of growing plants, which may effectively explain the observed response of zinc application. Favorable response of zinc application on plant height has also been reported.

Significantly the highest plant dry weight at (15, 30, 45 and 60 DAS) was observed value (0.80, 3.10, 6.73 and 19.73 g $plant^{-1}$) in treatment (T_9) R.D.F+ Zinc 7.5 kg ha^{-1}+ Molybdenum 1.0 kg ha^{-1} respectively.

The increase in nodulation was observed as
a result of enhanced and established root system following application of zinc (Pavadai *et al.* 2004).

With the respect significantly the highest number of branches at 30 and 45 DAS was observed value (4.33 and 7.40 plant $^{-1}$) in treatment (T_9) R.D.F+ Zinc 7.5 kg ha^{-1}+ Molybdenum 1.0 kg ha^{-1} respectively. It might be due to primary & secondary branches due to the its effect on structural component of nitrogenase, the enzyme activity involved in nitrogen fixation by root nodule bacteria of leguminous crops.

Yields attributes and yield of blackgram

The results indicated that treatment (Table-2) the effect of different levels of zinc and molybdenum on the significantly the highest value recorded in treatment (T_9) R.D.F + Zinc 7.5 kg ha^{-1}+ Molybdenum 1.0 kg ha^{-1} *viz.*, Grain yield (1.18 t ha^{-1}), and harvest index (23.49 %) with significantly higher test weight (40.23 g) same treatment. In case of test weight treatment (T_9) R.D.F + Zinc 7.5 kg ha^{-1}+ Molybdenum 1.0 kg ha^{-1} at par with treatment (T_4) R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 00 kg ha^{-1}, (T_5) R.D.F+ Zinc 5 kg ha-1 + Molybdenum 0.5 kg ha^{-1}, (T_6) R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 1.0kg ha^{-1}, (T_7) R.D.F+ Zinc 7.5 kg ha^{-1} + Molybdenum 00 kg ha^{-1} and (T_8) R.D.F+ Zinc 7.5 kg ha^{-1} + Molybdenum 0.5 kg ha^{-1} respectively. However significantly the highest straw yield (4.14 t ha^{-1}) was recorded in treatment (T_6) R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 1.0kg ha^{-1} respectively.

The increased in yield might be due to positive effect of zinc on yield attributes as it plays an important role in metabolic process (Shanti *et al.* 2008 and Ahmed *et al.* 2013).

The increase in seed yield might be due to application of molybdenum enhancing nodule formation and thus, seed yield of the crop (Singh *et al.* 2008)

This might be attributed due to the active role of molybdenum in regulating synthesis and activity of nitrogenase enzyme and thereby governing nitrogen fixation in urdbean. Beneficial effect of B, Mo and Zn
in french-bean (Kushwaha,1999), and Mo in soybean (Kumar and Singh, 1980) and urdbean (Mevada *et al.*, 2005 Chaudhary and Das,1996), Biswas *et al.*, (2009) was also reported earlier.

Table 1. Effect of different levels of zinc and molybdenum on growth attributes of blackgram (*Vigna mungo* L.)

Treatment combinations	Plant height (cm)		Dry weight (g) $plant^{-1}$				Number of branches $plant^{-1}$	
	15 DAS	30 DAS	15 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS

T_1 : R.D.F + Zinc 00 kg ha^{-1} + Molybdenum 00kg ha^{-1}	9.35	11.72	0.72	1.65	4.17	16.17	2.40	4.53
T_2 : R.D.F + Zinc 00 kg ha^{-1} + Molybdenum 0.5kg ha^{-1}	9.35	11.97	0.73	1.83	5.10	16.77	2.60	5.73
T_3 : R.D.F + Zinc 00 kg ha^{-1} + Molybdenum 1.0 kg ha^{-1}	9.33	12.49	0.74	2.59	5.63	18.37	3.47	6.80
T_4 : R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 00 kg ha^{-1}	9.09	12.28	0.73	2.36	5.00	16.67	2.67	5.47
T_5 : R.D.F+ Zinc 5 kg ha^{-1} + Molybdenum 0.5 kg ha^{-1}	9.33	12.69	0.75	2.64	5.47	17.23	2.93	6.60
T_6 : R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 1.0kg ha^{-1}	9.61	13.30	0.76	2.86	6.10	19.00	3.40	7.00
T_7 : R.D.F+ Zinc 7.5 kg ha^{-1} + Molybdenum 00 kg ha^{-1}	9.43	13.56	0.75	2.86	5.50	17.10	2.87	6.20
T_8 : R.D.F+ Zinc 7.5 kg ha^{-1} + Molybdenum 0.5 kg ha^{-1}	9.66	14.16	0.77	2.89	5.63	18.87	3.73	6.80
T_9 : R.D.F+ Zinc7.5 kg ha^{-1}+ Molybdenum 1.0 kg ha^{-1}	**9.76**	**15.11**	**0.80**	**3.10**	**6.73**	**19.73**	**4.33**	**7.40**
F test	S	S	S	S	S	S	S	S
SEd(_+)	0.16	0.07	0.01	0.04	0.05	0.12	0.14	0.09
CD (P=0.05)	0.35	0.15	0.01	0.08	0.11	0.25	0.29	0.19

Table 2. Effect of different levels of zinc and molybdenum on yield attributes of blackgram (*Vigna mungo* L.)

Treatment combinations	Test weight (g)	Harvest Index in %	Grain yield t ha^{-1}	Straw yield t ha^{-1}
T_1 : R.D.F + Zinc 00 kg ha^{-1} + Molybdenum 00kg ha^{-1}	39.17	21.38	1.01	3.71
T_2 : R.D.F + Zinc 00 kg ha^{-1} + Molybdenum 0.5kg ha^{-1}	39.27	22.55	1.10	3.80
T_3 : R.D.F + Zinc 00 kg ha^{-1} + Molybdenum 1.0 kg ha^{-1}	39.57	23.17	1.15	3.81
T_4 : R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 00 kg ha^{-1}	39.87	22.57	1.08	3.71
T_5 : R.D.F+ Zinc 5 kg ha^{-1} + Molybdenum 0.5 kg ha^{-1}	39.87	21.98	1.11	3.96
T_6 : R.D.F + Zinc 5 kg ha^{-1} + Molybdenum 1.0kg ha^{-1}	40.17	22.03	1.17	**4.14**
T_7 : R.D.F+ Zinc 7.5 kg ha^{-1} + Molybdenum 00 kg ha^{-1}	39.97	21.98	1.09	3.87
T_8 : R.D.F+ Zinc 7.5 kg ha^{-1} + Molybdenum 0.5 kg ha^{-1}	40.00	22.94	1.13	3.84
T_9 : R.D.F+ Zinc7.5 kg ha^{-1}+ Molybdenum 1.0 kg ha^{-1}	40.23	23.49	1.18	3.84
F test	S	S	S	S
SEd(_+)	0.18	0.07	0.003	0.01
CD (P=0.05)	0.39	0.16	0.010	0.03

CONCLUSION

From the above findings it is concluded that among all the treatment combination of T_9 (R.D.F + Zinc7.5 kg ha^{-1} + Molybdenum1.0 kg ha^{-1}.) was found to be the best for obtaining maximum growth, yield and yield attributes of Blackgram.

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RESEARCH ARTICLE

EFFECT OF NUTRIENT MANAGEMENT ON YIELD AND QUALITY IN INDIAN MUSTARD (*BRASSICA JUNCEA* L.)

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Abstract: A field experiment was conducted during *rabi* season, 2015-16 to study the Effect of nutrient management on yield and quality of Indian mustard (*Brassica juncea* L.) variety Pusa Bold at Crop Research Centre Chirori, Meerut. The experimental results revealed that significantly maximum growth parameters (plant height at harvest, and yield attributes (siliqua length, siliqua plant^{-1}, seeds siliqua^{-1} and test weight), yield (grain and stover), compared to rest of the treatments. The increment in seed yield under application of 100% NPK+40 kg S+1.5 B+20 kg Zn ha^{-1} was 25.32 % over 100% NPK..Maximum gross return, net return and B: C ratio was also recorded with the application of 100% NPK+40 kg S+1.5 kg B+20 kg Zn ha^{-1}. Besides, this combination also improves quality of produce and physico-chemical properties of soil.

Keywords: Nutrient management, Indian mustard, Quality

INTRODUCTION

Mustard (*Brassica juncea* L.) is the third important oilseed crop in the world after soybean (*Glycine max*) and palm (*Elaeis guineensis* Jacq.) oil. Among the seven edible oilseed cultivated in India, mustard contributes 28.6% towards the total oilseed production, being the second most important edible oilseed after groundnut. The share of oilseeds is 14.1% in the total cropped area of India and mustard accounts for 3% of it. The global production of mustard and its oil is around 38-42 and 12-14 mt, respectively. India contributes 28.3 and 19.8% in world acreage and production. India produces around 6.9 mt of rapeseed-mustard next to China (11-12 mt) and EU (10-13 mt) with significant contribution in world mustard industry (Anonymous, 2014). By 2050, India needs to produce 17.84 million tonnes of vegetable oils for its nutritional fat requirement of projected 1685 million populations. This target is difficult to achieve at current status of technology and resources management in Indian agriculture (Hegde, 2012). Thus, enhancing the productivity of oilseeds is imperative for self-reliance. India holds 11.3% of world's arable land and only 4% of the water resources to feed 16% of human population and 18% of animal population of the world. Indian oilseed scenario recently presented a picture of virtual stagnation. The technology mission on oilseed (TMO) launched by government of India in 1986 has impacted to overall production of oilseed significantly. The transformation in mustard scenario is commonly known as "Yellow-Revolution" the quantum jump in production of mustard is to be attributed to the development of improved technology. Mustard is coming up as a new crop in many parts of the country with increase in irrigation facilities. However, productivity of mustard and other oilseed crops is low. Oil seed production often suffers from a high degree of variation in annual production owing to their predominant cultivation under imbalance nutrient situation. The situation is further handicapped by input starved conditions with poor crop management. Oilseeds are energy rich crops and obviously the requirement of major nutrients is very high. Improving efficiency and factor productivity under complexities of diminishing quantity response and increasing eco-awareness is critical for sustainable oilseed production. Nitrogen is the most important nutrient, which determines the growth of the mustard crop and increases the amount of protein and yield. Phosphorus and potash are known to be efficiently utilized in the presence of nitrogen. It promotes flowering, setting of siliquae and increase the size of siliquae and yield (Singh and Meena, 2004).

Phosphorus is second most important major plant nutrient after nitrogen for crop production. It has been called as the "key of life for the plants". It is a structural component of cell membranes, chloroplast and mitochondria. It is necessary for such life process of plant as photosynthesis, development of plant cell as well as synthesis and breakdown of carbohydrates and transfer of energy within the plants. It also strengthens the stem of cereal plants and thus reducing their tendency to lodge. Phosphorous also enhances plant cell division. It also helps in flower and seed production and in the development of a strong root system.

Potassium plays an important role in the maintenance of cellular organization by regulating the permeability of cellular membranes and keeping the protoplasm in a proper degree of hydration by stabilizing the emulsion of high colloidal properties. Potassium has a great buffering action and stabilize various enzymes system. It plays role in

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photosynthesis and translocation of food from source to sink. It also enhance the plants ability to resist pest attack, moisture stress and cold condition. Adequate supply of this nutrient promotes the formation of fully developed grains with a high starch contents. Sulphur is a crucial element for rapeseed-mustard in determining its seed yield, oil content, quality and resistance to various biotic and abiotic stresses. Besides promoting chlorophyll formation and oil synthesis, it is an important constituent of seed protein, amino acids, various enzymes and glucosinolate. Sulphur increases the seed yield of mustard by 12 to 48% under irrigated and 17 to 124% under rainfed conditions. (Rathore *et. al.*, 2015).

MATERIAL AND METHOD

The experiment was conducted during *Rabi* season of 2015-2016 in the field at the Crop Research Centre, Chirori of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). The experiment consists of twelve treatments viz., (T_1) Control, (T_2) 100% NPK, (T_3) 100% NPK+20 kg S ha^{-1}, (T_4) 100% NPK+40 kg S ha^{-1}, (T_5) 100% NPK+1.5 kg B ha^{-1}, (T_6) 100% NPK+20 kg Zn ha^{-1}, (T_7) 100% NPK+20 kg S ha^{-1}+1.5 kg B ha^{-1}, (T_8) 100% NPK+20 kg S ha^{-1}+20 kg Zn ha^{-1}, (T_9) 100% NPK+40 Kg S ha^{-1}+1.5 kg B ha^{-1}, (T_{10}) 100% NPK+40 kg S ha^{-1}+20 kg Zn ha^{-1}, (T_{11}) 100% NPK+20 kg S ha^{-1}+1.5 kg B ha^{-1}+20 kg Zn $ha^{-1}$and (T_{12}) 100% NPK+40 kg S ha^{-1}+1.5 kg B ha^{-1}+20 kg Zn ha^{-1}. The experiment was laid out in randomized block design with three replications, P, K, S, Zn and B per plot was applied in the reported treatment from urea (46% N), di ammonium phosphate (46%P_2O_5), muriate of potash(60% K_2O), bentonite sulphur (90% S), zinc chelate (99% Zn) and borex (11% B). The half dose of nitrogen and full dose of phosphorus, potassium, sulphur, zinc and boron was applied as basal and rest half amount of nitrogen was applied as top dressing at 35 DAS. The various plant growth studies were carried out at 30, 60, 90 DAS and finally at harvest as per procedure are given below. The various plant growth studies were carried out at 30, 60, 90 DAS and finally at harvest as per procedure are given below. Five plants selected randomly from each plot were tagged. The height was measured in cm with the help of meter scale from the base of the plant to the top of the plant and mean values were presented. Five plants uprooted plant for dry matter accumulation were also used. The total number of primary and secondary branches of plant was counted and mean values per plant have been presented. Plants were uprooted from per plot at 30, 60, 90 DAS and at harvesting. The plants were sun dried separately and then oven dried at 72 ± 0.5^0C till the constant weight is obtained. The dry matter accumulation was expressed in g $plant^{-1}$.

Soil and plant Analysis

The processed plant samples were analyzed by micro-Kjeldahl method (Jackson, 1967) to determine nitrogen content. Wet digestion (di-acid) method (Jackson, 1973) was used for preparation of aliquot to determine P, K, S, Zn and B content in plant. The protein content (percent) was determined 'as is' via the standard Kjeldahl method using the nitrogen-protein conversion factor of 6.25, the accepted standard. (Kjeldahl, 1883) were as follows: Grain protein content (%) = Nitrogen content (%) X 6.25.Seed samples were collected from each number of plot and analysed for oil content (%) in seeds with the help of Soxhlet apparatus method taking petroleum ether as a solvent (Licitra *et al*., 1996).

Soil analysis

Soil samples were collected from 0-15 cm. depth from each plot. These samples were processed and analyzed for various physico-chemical properties in the laboratory of department of soil science, in Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. Available nitrogen in soil was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956).Available phosphorus was determined by Ascorbic acid method (Olsen *et al.*, 1954).Available K in the soil was determined by Extraction Method (Hanway and Heidal, 1952). Available sulphur was determined by the turbidimetric procedure (Williams, C.H. and Steinberg, A. 1969) after extraction with calcium chloride reagent. Available zinc was determined by the DTPA extractant method. The soil could be extracted by boiling with water directly on a hot plate.

RESULT AND DISCUSSION

Yield and Yield attributes

Increase in plant height with inorganic sources might be due to higher nutrient supply, rapid conversion of carbohydrates in to protein which in turn elaborated in to protoplasm. The highest plant heights of 198.9 cm at harvest were recorded in T_{12} (100% NPK+ 40 kg S + 1.5 kg B + 20 kg Zn ha^{-1}) crop growth respectively. However the shortest plant height was recorded in control plot (T_1). Nitrogen increased in size of cell, which expressed morphologically increased in plant height. The yield of *Brassica species* is a function of yield attributes like length of siliqua, number of siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$, 1000-seed weight. For these again a good mustard crop is required, which in turn depends upon optimum growth of photosynthetic organs, translocation of nutrients and photosynthesis to developing plant parts and finally larger frame to accommodate more number of yield attributes. The length of siliqua, number of siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$ and 1000-seed weight, g respectively found in T_{12} (100% NPK + 40 kg S + 1.5 kg B + 20 kg Zn ha^{-1}). However the minimum number recorded in control plot (T_1) which was significantly lower than other treatments at all the

stages. The balanced nutrient management practices contributed to a great extent influencing the seed yield of mustard. The seed yield increased with the increasing fertility levels and recorded highest grain, Stover and biological yield 22.32, 73.52 and 95.84, q ha^{-1} respectively in $T_{12,}$ where 100% NPK + 40 kg S ha^{-1} + 1.5 kg B ha^{-1} + 20 kg Zn ha^{-1} was applied. However the minimum yield was recorded in control plot (T_1) which was significantly lower than other treatments.

Economics

The total variable cost of cultivation increased slightly with different sources of fertilizer. The highest cost of cultivation (Rs.25726), gross income (Rs.87140), net income (Rs.61414) and benefit cost ratio (2.39) was noted in $T_{12,}$ while the lowest cost of cultivation (Rs.17456), gross income (Rs.39992), net income (Rs.22536) and benefit cost ratio (1.29) was observed in T_1 (control) plot. The highest net income (Rs.61414) of mustard was recorded in T_{12} (100% NPK + 40 kg S ha^{-1} + 1.5 kg B ha^{-1} + 20 kg Zn ha^{-1}) because of highest quantity of seed and stover yield and rates of respective yields. Similar trends were also observed by Singh and Meena (2004).

Table 1. Effect of nutrient management on plant height (cm) at harvest and B: C ratio.

Treatment	At harvest	B:C ratio
Control	128.2	1.29
100% NPK	154.1	2.12
100% NPK + 20 kg ha^{-1} S	167.1	2.26
100% NPK + 40 kg ha^{-1}S	176.6	2.24
100% NPK+ 1.5 kg ha^{-1}B	160.0	2.18
100% NPK+ 20 kg ha^{-1} Zn	165.0	2.05
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B	174.1	2.31
100% NPK + 20 kg ha^{-1} S + 20 kg ha^{-1}Zn	186.7	2.19
100% NPK + 40 Kg ha^{-1} S + 1.5 kg ha^{-1} B	184.4	2.34
100% NPK+ 40 kg ha^{-1} S + 20 kg ha^{-1} Zn	196.3	2.23
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1} Zn	192.1	2.16
100% NPK + 40 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1} Zn	198.9	2.39
SEM(±)	1.0	
C.D. (P=0.05)	3.0	

Table 2. Effect of nutrient management on length of siliqua (cm), number of siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$ and 1000- seed weight of mustard**.**

Treatment	Length of siliqua (cm)	Siliquae $plant^{-1}$	Seeds $siliqua^{-1}$	1000-Seed weight (gm)
Control	4.2	121.3	8.7	4.1
100% NPK	4.9	219.3	12.5	4.4
100% NPK + 20 kg ha^{-1} S	5.5	253.5	14.5	4.8
100% NPK + 40 kg ha^{-1} S	5.7	267.0	14.9	4.9
100% NPK + 1.5 kg ha^{-1} B	5.4	230.7	13.7	4.7
100% NPK + 20 kg ha^{-1}Zn	5.2	239.7	13.7	4.5
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B	5.7	276.0	15.1	5.1

100% NPK + 20 kg ha^{-1} S + 20 kg ha^{-1}Zn	5.6	260.8	14.6	4.9
100% NPK + 40 Kg ha^{-1} S + 1.5 kg ha^{-1} B	6.0	299.3	16.1	5.7
100% NPK + 40 kg ha^{-1} S + 20 kg ha^{-1}Zn	5.9	289.0	15.4	5.7
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1}Zn	5.8	283.3	15.1	5.6
100% NPK + 40 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1}Zn	6.1	311.4	16.6	5.8
SEm(±)	0.1	4.5	0.3	0.1
C.D. (P=0.05)	0.3	13.2	1.0	0.2

Table 3. Effect of nutrient management on seed, stover and biological yield (q ha^{-1}) of mustard, oil content and protein content (%) of mustard

Treatment	**Seed yield q ha^{-1}**	**Stover yield q ha^{-1}**	**Biological yield q ha^{-1}**
Control	10.32	35.87	46.19
100% NPK	17.81	61.88	79.69
100% NPK + 20 kg ha^{-1} S	19.40	66.43	85.84
100% NPK + 40 kg ha^{-1} S	20.09	67.92	88.01
100% NPK + 1.5 kg ha^{-1} B	18.75	64.50	83.25
100% NPK + 20 kg ha^{-1}Zn	18.25	62.95	81.20
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B	20.48	68.61	89.09
100% NPK + 20 kg ha^{-1} S + 20 kg ha^{-1}Zn	19.85	67.49	87.34
100% NPK + 40 Kg ha^{-1} S + 1.5 kg ha^{-1} B	21.44	70.97	92.41
100% NPK + 40 kg ha^{-1} S + 20 kg ha^{-1}Zn	20.91	69.42	90.33
100% NPK + 20 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1}Zn	20.35	68.58	88.93
100% NPK + 40 kg ha^{-1} S + 1.5 kg ha^{-1} B + 20 kg ha^{-1}Zn	22.32	73.52	95.84
SEm(±)	0.34	1.14	1.47
C.D. (P=0.05)	0.99	3.36	4.35

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RESEARCH ARTICLE

EFFECT OF PLANT NUTRIENTS AND INSECTICIDES INTEGRATION AGAINST RICE LEAF FOLDER, *CNAPHALOCROCIS MEDINALIS* (GUENEE)

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Abstract: Studies were carried to evaluate the influence of plant nutrients @ 50:30:20kg/ha (50% recommended NPK level), 100:60:40kg/ha (100% recommended NPK level) and 150:90:60kg/ha (150% recommended NPK level) on insecticide toxicity at 24hrs, 48hrs, 72hrs and 96hrs after spray against leaf folder, *Cnaphalocrocis medinalis* (Guenee) in *kharif* 2015 and 2016. Among the tested insecticides, Rynaxypyr 18.5%SC and Cypermethrin 25%EC recorded the highest percent mortality followed by Fipronil 5%SC, Monocrotophos 36%SL. Moderate toxicity was recorded by Imidacloprid 17.8%SL and Acephate 75%SP. Under different nutrient levels *i.e.*, 50%, 100% and 150%NPK leaf folder mortality was not affected in treatments Rynaxypyr 18.5%SC (90.83, 87.50 and 86.67% in *kharif* 2015; 90.00, 87.50 and 87.50% mortality in *kharif* 2016) and Cypermethrin 25%EC (85.00, 84.92 and 83.33% in *kharif* 2015; 83.00, 83.00 and 82.67% mortality in *kharif* 2016). Toxicity of Monocrotophos 36%SL (77.50, 71.67 and 66.67% mortality; 75.83, 71.67 and 67.50% mortality in *kharif* 2015 and 2016, respectively) was affected moderately with change in plant nutrition levels. Mortality of leaf folder in treatments Fipronil 5%SC (83.33, 74.17 and 65.00% mortality; 84.17, 74.17 and 65.83% mortality in *kharif* 2015 and 2016, respectively), Imidacloprid 17.8%SL (65.00, 56.67 and 48.33% mortality; 65.00, 58.33 and 49.17% mortality in *kharif* 2015 and 2016, respectively) and Acephate 75%SP (66.67, 58.33 and 50.83% mortality; 67.50, 57.50 and 50.83% mortality in *kharif* 2015 and 2016, respectively) were highly affected by different NPK levels *i.e.*, 50%NPK, 100%NPK and 150%NPK.

Keywords: Host plant nutrition, NPK levels, Insecticides, Rice leaf folder

INTRODUCTION

The rice crop provides food to more than half of the world's population and host to over 800 species of insect herbivores from nursery to harvest but only a few of them are of potential threat and have gained the major importance as far as loss in yields caused by them are concerned. Even though, there are many constraints in rice production, insects' pests remain a constant problem in all the rice growing regions (Manikandan Narayanasamy *et al.*, 2014). The rice leaf folder, Cnaphalocrocis medinalis (Guenee) once considered as minor pest has gained the status of an important pest. Bautista et al. (1984) reported that at 17.5% damaged leaves the yield loss was 16.5%, whereas at 26.6% damaged leaves it was 21.3%. Changes in the physical environments, cultural practices, multiple cropping patterns, reduced genetic variability of high yielding rice varieties, application of high levels of nitrogenous fertilizer and prophylactic use of pesticides are the major reasons of the leaf folder problem (De Kraker *et al.*, 2000). Reports also show that severe infestation of this pest leads to as high as 23.3% leaf damage (Ahmad et al., 2010) and causes significant yield loss. Nutrition management is one of the most important practices for high production system, but nutrition management may affect response of rice to pests, as well as development pattern of pest populations. The information on uptake of nutrients by the crop due to combined application of major plant nutrients NPK at different doses and rice varieties with differential susceptibility to pest under insecticidal protection is inadequate. Previous studies have demonstrated that host plant affects the susceptibility of insects to pesticides. The use of induced resistance through application of nutrients has been known to have tremendous potential in curtailing the insect pest populations. Previously studies taken up to know the effect of insecticides under different nutrition levels against rice leaf folder and green leaf hopper at field level by Dash (2008). But studies have not explained what will be effect of plant nutrition levels on insecticide toxicity at constant population levels. Hence the study been taken up to know exact toxicity change of insecticides at different NPK levels against rice leaf folder.

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MATERIAL AND METHOD

Pot culture studies were conducted during *kharif* 2015 and 2016 in factorial CRD at glass house, college of agriculture, IGKV, Raipur. The treatments comprised of 3 nutrient levels, 50:30:20kg/ha (50%NPK level), 100:60:40kg/ha (100%NPK level) and 150:90:60kg/ha (150%NPK level); and 6 insecticide treatments, Monocrotophos 36%SL@ 2.5ml/lit (T1), Acephate 75%SP@ 1.2g/lit (T2), Cypermethrin 25%EC@ 0.3ml/lit (T3), Imidacloprid 17.8%SL@ 1.6ml/lit (T4), Fipronil 5%SC@ 1.1ml/lit (T5), Rynaxypyr 18.5%SC@ 0.3ml/lit (T6) and control (T7) pot. Rice variety 'Mahamaya' were selected for the experiment. Experiment was replicated thrice.

Rearing rice leaf folder on different plant nutrition levels

Larvae of rice leaf folder reared on rice variety Mahamaya grown under different fertilizer levels *i.e.*, from 50%NPK, 100%NPK and 150%NPK. Small plastic pots were filled with soil from respective fertilizer regimes at LTF site and rice variety Mahamaya was grown for 30 days which were used for experiment and larval rearing. Adults of leaf folder were collected from the field by sweep net or by test tubes under lights at night times and released onto plants grown on different fertilizer levels. Adult moths are given with 10% sucrose solution along with Vitamin-E for increasing the fecundity of females. Larvae was continuously grown on respective fertilizer levels *i.e.*, from 50%NPK, 100%NPK and 150%NPK for 3- 4 generations was used for the study. New plants with soli from respective fertilizer regimes collected from LTF site was provided for continuous food supply to larvae.

Observation to be recorded

Rice variety Mahamaya were gown in plastic pots under different fertilizer levels *i.e.*, 50%, 100% and 150%NPK, was treated with recommended doses of respective insecticide. Larvae reared on different plant nutrition levels *i.e.*, 50%, 100% and 150%NPK were released and recorded mortality percent at 24hrs, 48hrs, 72hrs and 96hrs. For every observation new larvae were released on to insecticide treated plant and covered with plastic covers. Each replication was provided with ten larvae and experiment replicated thrice.

RESULT AND DISCUSSION

The results revealed that in *kharif* 2015 and 2016 among the tested insecticides, highest leaf folder mortality percent was recorded in treatments Rynaxypyr 5%SC (88.33 and 88.33% mortality) and Cypermethrin 25%EC (88.42 and 88.33 % mortality) followed by Fipronil 5%SC (74.17 and 74.12%) and Monocrotophos 36%SL (71.94 and 71.96%) recorded moderate percent mortality. Treatments Imidacloprid 17.8%SL (56.61 and 57.50%) and Acephate 75%SP (58.61 and 58.61%) recorded lower leaf folder mortality. The results are in accordance with Chanu and Sontakke (2015) who reported Rynaxypyr 0.4G found most effective in reducing the damage (80.27 and 86.12% reduction over control) percent followed by Fipronil 0.3G (71.48 and 80.49% reduction over control). Similar report given by Dhaka *et al.* (2012) that treatment with Fipronil 5%SC recorded higher leaf folder reduction compared to other treatments. The results also revealed that integration of plant nutrients at varied levels affecting toxicity of some insecticides. The data at 24hrs and 48hrs in *kharif* 2015 and 2016 showed that the toxicity of all the insecticides had no significant effect at different NPK levels *i.e.*, 50%NPK, 100%NPK and 150%NPK. The toxicity of some insecticides like Acephate 75%SP, Imidacloprid 17.8%SL and Fipronil 5%SC are affected with plant nutrient levels at 72hrs and 96hrs after spray (Table 1 and 2). At 72hrs after spray leaf folder mortality was highly affected by plant nutrition levels in treatment Fipronil 5%SC which recorded 83.33, 70.00 and 56.67% mortality in *kharif* 2015; 86.67, 70.00 and 56.67% mortality in *kharif* 2016 followed by Imidacloprid 17.8%SL with 63.33, 53.33 and 40.00 mortality in *kharif* 2015; 63.33, 50.00 and 40.00 mortality in *kharif* 2016 under different NPK levels *i.e.*, 50%NPK, 100%NPK and 150%NPK, respectively. Acephate 75%SP recorded 63.33, 56.67 and 43.33 mortality in *kharif* 2015; 66.67, 53.33 and 43.33 mortality in *kharif* 2016. The results are in accordance with Dash (2008) who conducted field experiment on effect of plant nutrients in response to insecticides against rice leaf folder, *Cnaphalocrocis medinalis* and revealed that the effectiveness of triazophos was more pronounced in nutrient level 60:30:30 kg NPK/ha in minimizing the leaf folder incidence (9.32% leaf infestation) at peak activity of pest than any other treatment combinations.

At 96hrs after spray leaf folder mortality was highly affected by plant nutrition levels in treatment Fipronil 5%SC which recorded 76.67, 66.67 and 56.67% mortality in *kharif* 2015; 73.33, 66.67 and 53.33% mortality in *kharif* 2016 followed by Imidacloprid 17.8%SL with 50.00, 40.00 and 30.00 mortality in *kharif* 2015; 53.33, 43.33 and 30.00 mortality in *kharif* 2016 under different NPK levels *i.e.*, 50%NPK, 100%NPK and 150%NPK, respectively. Acephate 75%SP recorded 50.00, 40.00 and 33.33 mortality in *kharif* 2015; 53.33, 43.33 and 30.33 mortality in *kharif* 2016. Similar reports are given by Dash *et al.*, 2008 against gall midge, *Orseolia oryzae* under field condition which revealed greater compatibility of nutrient dose 60:30:30 kg NPK/ha + ZnSO4 with granular fipronil in arresting the silver shoot (SS) incidence to a appreciable level (3.01% SS) at peak activity of the pest than other treatment combinations. From the entire investigation insecticides with systemic toxicity like Fipronil and Imidacloprid was highly affected due to different NPK levels compared to contact and stomach action insecticides like Cypermethrin and Rynaxypyr. The semi systemic insecticide like Monocrotophos and residual systemic insecticide like Acephate toxicity was moderately affected.

Table 1. Effect of plant nutrients and insecticides integration against rice leaf folder *Kharif* 2015

Treatments	Percent leaf folder mortality*											
	24hrs			48hrs			72hrs			96hrs		
	50% NPK	100% NPK	150% NPK	50% NPK	100% NPK	150% NPK	50% NPK	100% NPK	150% NPK	50% NPK	100% NPK	150% NPK
T1	90.00 (64.82)	86.67 (61.92)	86.67 (60.48)	80.00 (53.91)	76.67 (50.23)	70.00 (44.81)	76.67^{cA} (51.39)	66.67^{cB} (41.91)	60.00^{cB} (37.1)	63.33^{cA} (39.39)	56.67^{dAB} (34.58)	50.00^{cB} (30.15)
T2	76.67 (50.23)	73.33 (48.48)	66.67 (42.52)	73.33 (47.33)	66.67 (41.91)	60.00 (37.1)	66.67^{dA} (42.29)	53.33^{dB} (32.29)	43.33^{dC} (25.97)	50.00^{dA} (30.15)	40.00^{eAB} (23.68)	33.33^{dB} (19.66)
T3	93.33 (68.49)	96.67 (72.83)	96.67 (72.83)	90.00 (69.1)	86.67 (60.48)	86.67 (61.92)	83.33^{bcA} (56.81)	80.00^{bA} (53.13)	80.00^{bA} (53.91)	73.33^{bA} (48.48)	76.33^{bA} (50.23)	70.00^{bA} (44.81)
T4	76.67 (50.23)	73.33 (48.48)	70.00 (44.81)	70.00 (44.81)	60.00 (37.1)	53.33 (32.29)	63.33^{dA} (39.39)	53.33^{dB} (32.67)	40.00^{dC} (23.68)	50.00^{cA} (30.15)	40.00^{eB} (23.68)	30.00^{dB} (17.52)
T5	90.00 (64.82)	83.33 (56.81)	83.33 (57.58)	83.33 (57.58)	76.67 (51.39)	66.67 (42.52)	83.33^{bA} (57.58)	70.00^{cB} (44.81)	56.67^{cC} (34.81)	73.33^{bA} (48.48)	66.67^{cA} (42.52)	53.33^{cB} (32.44)
T6	96.67 (72.83)	96.67 (72.83)	93.33 (68.49)	90.00 (64.82)	83.33 (56.81)	83.33 (57.58)	90.00^{aA} (64.82)	86.67^{aA} (60.48)	86.67^{aA} (60.48)	83.33^{aA} (56.81)	83.33^{aA} (56.81)	83.33^{aA} (56.81)
T7	6.67 (4.3)	6.70 (4.3)	13.30 (7.67)	6.67 (4.3)	10.00 (5.74)	13.30 (7.67)	10.00^{eA} (5.74)	10.00^{eA} (6.24)	6.70^{eA} (4.30)	10.00^{eA} (6.24)	6.70^{fA} (4.3)	13.30^{eA} (7.67)
Sed±	4.34			4.95			3.08			3.25		
CD (0.05)	N.A			N.A			6.21			6.56		
CV (%)	10.66			11.36			13.12			14.47		

* Mean of three replications; Figures in parentheses are arc sine transformed values;
In a column, means followed by a common small letter(s) between the treatments are not significantly different by CD (P=0.05);
In a rows, means followed by a common large letter(s) between NPK levels within treatment are not significantly different by CD (P=0.05).

Table 2. Effect of plant nutrients and insecticides integration against rice leaf folder *Kharif* 2016

Treatments	Percent leaf folder mortality*											
	24hrs			48hrs			72hrs			96hrs		
	50% NPK	100% NPK	150% NPK	50% NPK	100% NPK	150% NPK	50% NPK	100% NPK	150% NPK	50% NPK	100% NPK	150% NPK
T1	90.00 (64.82)	86.67 (61.92)	86.67 (60.48)	80.00 (53.91)	76.67 (50.23)	73.33 (47.33)	70.00^{cA} (44.81)	66.67^{cAB} (41.91)	60.00^{bB} (37.10)	63.33^{cA} (39.39)	56.67^{cA} (34.58)	53.33^{cA} (32.44)
T2	76.67 (50.23)	70.00 (44.81)	66.67 (42.52)	76.67 (50.23)	73.33 (47.33)	66.67 (42.29)	66.67^{cA} (42.29)	53.33^{dB} (32.29)	46.67^{cB} (28.11)	50.00^{dA} (30.15)	40.00^{dAB} (23.68)	30.00^{dB} (17.52)
T3	93.33 (68.49)	96.67 (72.83)	96.67 (77.11)	86.67 (66.2)	86.67 (60.48)	86.67 (61.92)	80.00^{bA} (53.91)	80.00^{bA} (53.13)	80.00^{aA} (53.91)	73.33^{bA} (48.48)	70.00^{bA} (44.81)	70.00^{bA} (44.81)
T4	76.67 (50.23)	73.33 (48.48)	73.33 (47.33)	70.00 (44.81)	63.33 (40.00)	60.00 (37.1)	63.33^{cA} (40.00)	50.00^{dB} (32.67)	40.00^{cB} (23.68)	53.33^{cdA} (32.67)	43.33^{dB} (25.72)	30.00^{dC} (17.52)
T5	90.00 (64.82)	83.33 (56.81)	83.33 (57.58)	86.67 (60.48)	76.67 (51.39)	73.33 (47.33)	86.67^{abA} (60.48)	70.00^{cB} (44.81)	56.67^{bC} (34.81)	76.67^{bA} (51.39)	66.67^{bB} (42.52)	56.67^{cC} (34.58)
T6	96.67 (72.83)	96.67 (72.83)	96.67 (72.83)	90.00 (64.82)	83.33 (56.81)	83.33 (57.58)	86.67^{aA} (61.14)	86.67^{aA} (60.48)	86.67^{aA} (60.48)	86.67^{aA} (61.92)	83.33^{aA} (56.81)	83.33^{aA} (56.81)
T7	10.00 (5.74)	10.00 (5.74)	13.30 (7.67)	6.67 (4.3)	10.00 (5.74)	13.30 (7.67)	13.33^{dA} (7.67)	16.67^{eA} (9.60)	13.33^{dA} (7.67)	16.67^{eA} (9.60)	16.67^{eA} (9.60)	16.67^{dA} (11.54)
Sed±	4.19			3.61			3.57			3.75		
CD (0.05)	N.A			N.A			7.21			7.56		
CV (%)	11.01			9.25			10.16			11.34		

* Mean of three replications; Figures in parentheses are arc sine transformed values;
In a column, means followed by a common small letter(s) between the treatments are not significantly different by CD (P=0.05);
In a rows, means followed by a common large letter(s) between NPK levels within treatment are not significantly different by CD (P=0.05).

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SHORT COMMUNICATION

EFFECT OF GA_3 AND NAA ON GROWTH AND FLOWERING OF OKRA (*ABELMOSCHUS ESCULENTUS* L.) CV. GUJARAT OKRA- 2

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Abstract: A field experiment was conducted at Horticulture Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during the *Kharif* season 2012, respectively to study the effect of GA_3 and NAA on growth and flowering of Okra. Growth parameters like plant height and stem thickness (90 DAS), average length of interned and leaf area per plant (60 DAS) and number of nodes per plant and flowering parameters like days taken for initiation of first flower, days taken for flower initiation to edible maturity, days taken for sowing to first picking and days taken for sowing to last picking were analyzed. The experiment consisted of 16 treatments combination involving two growth regulators with four levels each (0, 25, 50 and 75 ppm). GA_3 and NAA (75 ppm) was found to be the most effective in increasing more stem thickness (1.95 cm), average length of interned (4.98 cm), Minimum days taken for flower initiation to edible maturity (5.88) and days taken for sowing to first picking (115.38). Treatment combination of (g_3n_2) increasing plant height (85.96 cm) and leaf area per plant (2427.86). Were as maximum number of nodes per plant (18.34) found combination with (g_3n_3) and minimum days taken for initiation of first flower (42.09) and days taken for sowing to first picking (49.10) was found treatment combination of (g_0n_1) respectively.

Keywords: Okra, GA_3, NAA, Growth, Flowering

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is an annual vegetable crop and belongs to family Malvaceae and is native of subtropical Africa. It is annual vegetable crop grown from seed in tropical and sub-tropical parts of the world. Now it is grown throughout the year for its tender green fruits. India is the largest producer of okra. Besides being a vegetable, it also has medicinal and industrial important. Role of plant growth regulators in crop production is well known phenomenon. Its use in promotes growth along the longitudinal area, increase number of branches, early flower initiation, fruit set and subsequently contributes towards higher production when applied at various concentration. Due to this it is possible to achieve the desirable standards and norms in term of quality for exportable production. Therefore, present investigation was carried out to find out suitable plant growth regulator, concentration and its effect on growth and flowering parameters of okra.

MATERIAL AND METHOD

An experiment entitled effect of GA_3 and NAA on growth and flowering of okra was carried out during the year 2012 at the Horticulture Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The design followed was Factorial Randomized Block Design with three replications. The treatments consist of different concentration of plant growth regulators viz. GA3 and NAA (0, 25, 50 and 75 ppm each) were applied as foliar spray at 25 days after sowing. Distilled water was sprayed as control. The recommended dose of fertilizers @ 50:50:50 kg NPK/ha were applied at the time of sowing and remaining half dose of N (50 kg) was applied in the form of urea (top dressing) one month after sowing and other standard culture practices recommended for okra were uniformly followed for all the treatments. The seeds were dibbled at the spacing of 45 x 30 cm. The observations regarding growth viz. plant height, stem thickness, average length of interned, number of nodes per plant and leaf area per plant and flowering viz. days taken for initiation of first flower, days taken for flower initiation to edible maturity, days taken for sowing to first picking and days taken for sowing to last picking of okra were taken and the data subjected to statistical analysis.

Table 1. Treatment combinations.

Treatments. No.		Details of treatment
g_0n_0	:	GA_3@ 0 ppm + NAA @ 0 ppm (Control)
g_0n_1	:	GA_3@ 0 ppm + NAA @ 25 ppm
g_0n_2	:	GA_3@ 0 ppm + NAA @ 50 ppm
g_0n_3	:	GA_3@ 0 ppm + NAA @ 75 ppm

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g_1n_0	:	GA_3@25 ppm + NAA @ 0 ppm
g_1n_1	:	GA_3@25 ppm + NAA @ 25 ppm
g_1n_2	:	GA_3@25 ppm + NAA @ 50 ppm
g_1n_3	:	GA_3@25 ppm + NAA @ 75 ppm
g_2n_0	:	GA_3@50 ppm + NAA @ 0 ppm
g_2n_1	:	GA_3@50 ppm + NAA @ 25 ppm
g_2n_2	:	GA_3@50 ppm + NAA @ 50 ppm
g_2n_3	:	GA_3@50 ppm + NAA @ 75 ppm
g_3n_0	:	GA_3@75 ppm + NAA @ 0 ppm
g_3n_1	:	GA_3@75 ppm + NAA @ 25 ppm
g_3n_2	:	GA_3@75 ppm + NAA @ 50 ppm
g_3n_3	:	GA_3@75 ppm + NAA @ 75 ppm

GA_3-Gibberellic Acid, NAA-Naphthalene Acid, PPM-Part Per Million, @-At the Rate

Table 2. Effect of GA_3 and NAA on growth and flowering of okra cv. Gujarat Okra-2.

Treatment		Plant height at 90 DAS (cm)	Stem thickness at 90 DAS (cm)	Average length of interned at 60 DAS	Number of nodes per plant	Leaf area per plant at 60 DAS	Days taken for initiation of first flower	Days taken for flower initiation to edible maturity	Days taken for sowing to first picking	Days taken for sowing to last picking
T_1	g_0n_0	72.88	1.77	4.17	15.50	1603.69	47.08	7.15	54.21	108.63
T_2	g_0n_1	79.09	1.88	4.31	16.21	1712.36	42.09	7.08	49.10	113.58
T_3	g_0n_2	78.80	1.86	4.73	18.04	1985.68	43.71	6.88	50.53	112.96
T_4	g_0n_3	82.75	1.92	4.60	16.15	1736.89	45.96	7.06	52.96	111.83
T_5	g_1n_0	78.92	1.86	4.22	16.21	2010.45	44.50	7.02	51.48	115.13
T_6	g_1n_1	78.46	1.85	4.52	17.71	2114.61	47.25	6.92	54.10	114.08
T_7	g_1n_2	82.84	1.92	4.49	17.79	1770.60	44.92	7.08	51.94	113.04
T_8	g_1n_3	78.38	1.86	4.62	17.61	2103.64	42.84	7.05	49.89	112.42
T_9	g_2n_0	80.25	1.90	4.55	16.59	2351.60	45.59	6.98	52.52	113.83
T_{10}	g_2n_1	75.50	1.94	4.46	17.09	2101.09	46.00	7.06	52.96	111.08
T_{11}	g_2n_2	79.21	1.94	4.65	16.71	2164.20	44.34	6.83	51.14	113.50
T_{12}	g_2n_3	85.71	1.76	4.25	18.34	2415.74	43.63	6.92	50.52	114.25
T_{13}	g_3n_0	79.04	1.89	4.74	17.54	2262.29	46.29	6.96	53.19	114.67
T_{14}	g_3n_1	84.96	1.90	4.45	17.92	2399.13	45.96	7.00	52.90	114.67
T_{15}	g_3n_2	85.96	1.89	4.53	16.22	2427.86	46.05	6.94	52.97	111.83
T_{16}	g_3n_3	83.38	1.95	4.98	17.76	2417.13	44.79	5.88	50.64	115.38
S.Em ±		1.65	0.02	0.11	0.43	73.25	0.76	0.15	0.76	1.12
C.D.@ 5%		4.76	0.06	0.34	1.24	210.86	2.21	0.44	2.20	3.24

RESULT AND DISCUSSION

Data revealed that interaction effect of GA_3 and NAA significantly influenced the growth and flowering of okra. Application of GA_3 75 ppm + NAA 50 ppm recorded significantly maximum plant height (85.96 cm) and leaf area per plant (2427.86 cm2) whereas, minimum plant height (72.88 cm) and leaf area per plant (1603.69 cm2) was recorded in control treatment.

Combined application of GA_3 and NAA also significantly influenced the growth and flowering of okra. Maximum stem thickness (1.95 cm), average length of internodes (4.98 cm), days taken for sowing to last picking (115.38) and minimum days taken for flower initiation to edible maturity (5.88) was recorded with treatment GA_3 75 ppm + NAA 75 ppm whereas, minimum stem thickness (1.77 cm), average length of internodes (4.17 cm), days taken for sowing to last picking (108.63) and maximum days taken for flower initiation to edible maturity (7.15) was recorded with control treatment.

The significantly minimum days taken for initiation of first flower (42.09) and days taken for sowing to first picking (49.10) was observed with treatment GA_3 0 ppm + NAA 25 ppm while, maximum number of nodes per plant (18.34) was recorded with treatment GA_3 50 ppm + NAA 75 ppm whereas, minimum number of nodes per plant (15.50) and maximum days taken for sowing to first picking (54.21) was recorded with control treatment while, maximum days taken for initiation of first flower (47.25) was observed with treatment GA_3 25 ppm + NAA 25 ppm.

The improvement in growth as a result of GA_3 and NAA might be attributed to their function in stimulation of metabolic activities and hormonal regulation. GA_3 and NAA that stimulates the growth of plant tissues there by enhancement in cell multiplication and cell elongation resulting in increased growth and flowering. Present results are

in close agreement with those of Arora *et al*. (1990), Syed *et al*. (1997), Hussaini and Babu (2004), Laxman *et al*. (2005), Tyagi *et al*. (2008), Patil and Patel (2010), Dhage *et al*. (2011) and Jaymala *et al*. (2012).

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SHORT COMMUNICATION

EFFECT OF PLANT GROWTH REGULATORS ON GROWTH AND FLOWER YIELD OF PETUNIA (*PETUNIA HYBRIDA* L.)

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Abstract: Effect of Plant Growth Regulators on Growth and Flower Yield of Petunia (*Petunia hybrida*) was carried out at research field of Department of Horticulture, Allahabad School of Agriculture, SHIATS Allahabad. The experiment included 10 treatments and three replications. It was concluded that application of GA_3 -200 ppm in treatment T_2 was found to be superior on plant height, plant spread, number of branches, number of leaves, number of flowers per plant, and higher yield and the application of CCC - 500 ppm in treatment T_5 was found superior on size of flower, fresh weight of flower and dry weight of flower and the application of NAA - 30 ppm in treatment T_7 was found superior on early bud flower bud emergence was observed as compared with control.

Keywords: Plant Growth Regulators, GA3, CCC, NAA, Petunia

INTRODUCTION

Petunia is a popular, easy to grow and versatile annual with showy flowers and has the longest season of bloom of all garden annuals. A wide range of colours and forms has been developed over the years, which are classified on the basis of the characteristics of flowers. Petunia plants are perennials but are generally grown as half-hardy annuals in open gardens. Petunia belongs to the family Solanaceae and Genus *Petunia*, has its origin in South America. Petunia has 25 species including synthetic garden species *Petunia hybrida* (Vilm), which has arisen in historical times from two wild sps. Viz; *Petunia axillaries and P. Violacea.* The petunia flower is funnel shaped, but hybridizers have created many variation including singles and doubles with petals that have wavy or fringed margins. Many patterns are available in strips, mauve, speckles and borders is an extensive colour palette that includes purple, mauve, lavender, pink, red, white, yellow and some cultivars are bicoloured. Leaves and stems are sticky to the touch and have a distinctive odour. The height may vary between 20-30 cm and 30-45 cm, depending upon the type. Petunia is a free flowering plant. In an experiment with five ornamentals found that the seeds which germinated poorly at 25^0C responded positively with gibberellic acid treatment in solution varying in concentration from 1 ppm to 1,000 ppm. Growth regulators like ethrel, B-Nine and Cycocel not only caused dwarfness but also extended the self-life some flowering annuals by several days. Cycocel (CCC) was very effective in inhibiting growth in many malvaceous plants. The leaves of the treated plants were thick in texture, small in size and dark green in colour.

MATERIAL AND METHOD

The experiment was conducted with 10 treatments viz; GA_3- 100ppm, GA_3- 200ppm, GA_3- 300ppm, CCC- 250ppm, CCC- 500ppm, CCC-750ppm, NAA-30ppm, NAA- 45ppm and NAA- 60ppm. Petunia var. Picourty was sown randomized block design with 3 replications during winter season in the year of 2011 at Floriculture research form of the Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences. Row to Row and Plant to Plant spacing were maintained at 50 cm and 55 cm, respectively. All the recommended agronomic package of practices was followed to grow a healthy crops. Observations were recorded on 10 characters viz. Plant height (cm), number of leaves, number of branches, plant spread (cm), days of the first bud ignition, number of flower per plant, flower diameter (cm), weight of flower (g), flower yield per plant (g), flower yield per plot (g) and per ha (t ha^{-1}). Data was statistically analyzed for the study of preference of variety.

Table 1. Performance of different treatment for various character of Petunia.

Treatments	Treatments & Combination	Plant height (cm)	Plant spread (cm)	Number of leaves / plant	Number of branches / plant	Days of the first flower bud initiation	Number of flowers / plant	Diameter of flower (cm)	Fresh weight of flower (gm)	Flower Yield/ ha (t)
T_0	Control	25.93	55.53	434.60	10.60	62.60	26.73	5.91	0.73	1.530
T_1	GA_3 @100ppm	27.80	66.80	575.00	14.13	58.87	45.60	7.82	0.86	2.835

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T_2	GA_3 @200ppm	**27.97**	**69.15**	**1559.93**	**18.07**	58.07	**54.47**	8.06	0.89	**3.524**
T_3	GA_3 @300ppm	27.35	63.87	529.73	13.27	60.40	43.00	7.64	0.86	2.657
T_4	CCC@250ppm	23.49	50.53	381.53	12.60	65.67	35.13	8.33	0.93	2.533
T_5	CCC@500ppm	24.81	54.13	408.87	12.80	63.87	36.27	**8.75**	**1.02**	2.579
T_6	CCC@750ppm	20.27	40.87	241.33	12.47	68.13	31.80	8.13	0.91	2.375
T_7	NAA @30ppm	26.90	61.80	494.13	12.00	52.87	41.47	7.31	0.81	2.150
T_8	NAA @45ppm	26.97	62.33	523.47	12.13	**49.87**	42.53	7.53	0.85	2.230
T_9	NAA @60ppm	26.54	58.00	462.40	11.40	56.60	38.27	6.92	0.80	2.015
	S.Ed(±)	0.76	0.92	25.82	0.21	1.06	1.19	0.09	0.02	71.35
	CD (P=0.05)	2.25	2.75	76.71	0.62	3.15	3.53	0.26	0.07	211.99

RESULT AND DISCUSSION

All the genotypes showed significant differences for all the 12 parameters of growth and yield of petunia. The maximum height of plant (27.97 cm) was recorded in treatments T_2 (GA_3- 200ppm). The next better treatment was T_1 (GA_3-100ppm) (27.80 cm). (Kadam *et al*. 2002.). The maximum spread of plant (69.15 cm) was recorded in treatments T_2 (GA_3 - 200ppm). The next better treatment was T_1 (GA_3-100ppm) spread of plant (66.80 cm). (Gautam *et al*. 2006).The maximum number of leaves per plant (1559.93) was recorded in treatments T_2 (GA_3 - 200ppm). The next better treatment was T_1 (GA_3-100ppm) (575.00). The maximum number of branches per plant (18.07 cm) was recorded in treatments T_2 (GA_3-200ppm). The next better treatment was T_1 (GA_3-100ppm) (14.13 cm) (Dabas *et al.* 2001).The number of days required for first flower bud emergence from transplanting (49.87 days) was recorded in treatment T_8 (NAA-45ppm) followed by treatment T_7 (NAA-30ppm) (52.87 days). The fresh and dry weight of flower (1.02 g and 0.87 g) was significantly increased in treatment T_5 (CCC-500ppm) respectively followed by treatment T_4 (CCC-250ppm) (0.93 g and 0.82 g) respectively. (Abadi 2010). The flower diameter (8.75 cm) was significantly increase in treatment T_5 (CCC-500ppm) followed by treatment T_4 (CCC-250ppm) (8.33 cm). Significantly increase in number of flowers per plant (54.47) was recorded in treatment T_2 (GA_3-200ppm) followed by treatment T_1 (GA_3-100ppm) (45.60). The maximum yield of flower per plant (105.73g) was recorded in treatment T_2(GA_3-200ppm) followed by treatment T_1 (GA_3-100ppm) (85.07g). Significantly increase in yield of flowers per plot (951.60g) and per hectare (3524.09t) were recorded in treatment T_2 (GA_3-200ppm) followed by treatment T_1 (GA_3-100ppm) (765.60t) per plot and (2835.27t) per hectare. Maximum gross return (Rs.88102.3/ha) was recorded in treatment T_2 (GA_3-200ppm) followed by treatment T_1 (GA_3-100ppm) (Rs.70881.8/ha) and the minimum (Rs.38273.95/ha) was recorded in treatment T_0 Control. Maximum net return (Rs.50925.3/ha) was recorded in treatment T_2 (GA_3-200ppm) followed by treatment T_1 (GA_3-100ppm) (Rs.37731.8/ha) and the minimum (Rs.9323.95/ha) was recorded in treatment T_0 Control. Maximum cost: benefit ratio (1:2.37) was recorded in treatment T_2 (GA_3-200ppm) followed by treatment T_1 (GA_3-100ppm) (1: 2.13).

On the basis of present investigation it is concluded that the application of T_2 (GA3@200ppm) was best in term of growth and yield of flower. The above findings are based on one year trial more scientific research is needed to confirm the above result.

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