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Contents

REVIEW ARTICLE

POWER OPERATED PADDY SEEDER FOR DRY AND WET SEEDING

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Abstract: Power operated paddy seeder is an important Seeding device of pre-germinated rice seed and dry seed increasingly considers and alternate to manual transplanting because of reduce labour and drudgeries, higher profit and comparable yields. The developed the power operated paddy seeder unit could be useful in eliminating drudgery in transplanting or pulling of manual drum seeder besides other advantages of pre-germinated line seeding. It is possible to reduce the seeding rate variation by maintaining a desirable drum fill condition. The crop and yield parameter of crop sown by develop unit, were comparable to transplanted and manual drum seeded crop; whereas they were better in comparison to broadcasted crop.

Keywords: Power operated paddy seeder, Pre-germinated, Dry seeding, Metering device

INTRODUCTION

Rice (*Oryza sativa* L.) is an important food crop of India. Directed seeded rice plays an important role in satisfying the rice grain requirement of the people of the world. Transplanting of rice seedlings, being a high labour-intensive and expensive operation needs to be substituted by direct seeding which could reduce labour needs by more than 20 per cent in terms of working hours. For line sowing many designs of manual drum seeders have been fabricated but pulling capacity them on puddle fields involves drudgeries problem and is classified as heavy work. Direct dry seeding is one of the best methods under rain fed field condition. In the rainy season friable field conditions soil is available for limited period. If rains continue the soil becomes saturated. Under such circumferences using the conventional seed drill becomes difficult to operate due to clogging and chocking of furrow openers. Therefore it is necessary a machine which can be operated in both dry and wet field conditions.

Dry Direct Seeding

Rao *et al.* (1973) reported from a comparative study of different planting methods on sandy soil during Kharif and Rabi seasons on a number of paddy varieties. It was observed from the experiment that the hand dibbling resulted in maximum yield during the two seasons. Venkateswarlu (1980) reported that soaked seeds for a period of 12 to 24 hr, which will increase weight by imbibing water, would not pose any problems for sowing. Nakamura *et al.* (1983) developed a new cultivation system called Direct Seeding with coated rice in submerged paddy (DSSP System). A successful operation of the DSSP system currently requires rice drilling, coating machine and chemicals necessary for the preparation of rice seeds and pyrazolate herbicide for initial weed controls. Maru and Sirripurapu (1986) reported that field trials of drilling of paddy seeds of different densities, in separate strips indicated that the seeds with density of about 1.7 g/cc could effectively be imbedded in puddle field when they were allowed to fall freely from about 10 cm height from the seed tubes of a drill. Park *et al.* (1998) reported that a corrugated furrow seed drill was developed for direct rice seeding at the National Yeongnam Agricultural Experiment Station (NYAES) Korea Republic between 1992 and 1999. The seeder is considered as a compromise direct seeding method for both the dry and water seeding. In dry seeding, seeding is carried out simultaneously either the corrugated furrow preparation. Corrugated furrows seeding has advantages such as improved lodging tolerance and reduced weed problems on the basis of regional yield trials and farmer's field trails over 4 years period this technology recorded an average milled rice yield of 5.19 t/ha, 14 % higher than that of conventional water seeded rice and 3 % higher than that of conventional dry seeded rice system. The technology is also reported to reduce labour cost (time) by 37 % and production cost by 17 % compared to machine transplanting with seedlings. Rautaray *et al.* (1997) reported that at higher levels of puddling the water content at all the depths were higher and the rate of decrease on water content was also reported with low over 24 hours of setting time. Senapati *et al.* (1988) tested six seeding devices plastic roller with small round depression for two different seed drills, drum with holes on the periphery, circular iron belt to regulate the size of openings, for two different implements and wooden roller with small round depressions mounted on the shaft for two different seed drills have been tested under dry land condition of broadcasting. In each case the amount of energy utilization in drilling the seeds and seed distribution efficiency were determined and grain yield on the experimental fields was observed. The placement of seeds at proper depth of 2.85 cm by seed cum fertilizer drill results in a better crop stand. The

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overall efficiency of seed cum fertilizer drill developed by the Department of Agriculture, Government of Orissa, was the highest and thus it was recommended for farmers of Odisha, to use seed drill for sowing paddy seeds under dry land situation. Kachroo (2006) observed that the direct wet seeding offers the advantage of faster and easier planting, minimize labour requirement and less drudgery, 7-10 days earlier crop maturity, more efficient water use and higher to water deficit less methane mission and often higher profit in areas with assured water supply.

Direct Paddy seeder (Power Operated)

Baqui and Lantin (1982) reported about the human energy expenditure in rice transplanting using the IRRI manual rice transplanted (model TRI) and the traditional hand transplanting method. Energy expenditure was determined by indirect calorimeter. The maximum energy expenditure per plant was reported to be much lower in machine (0.019 kcal) as compared to hand transplanting (0.069 kcal). Khan *et al.* (1989) reported that rice seedling withdrawal force was a good index of seedling anchorage in puddled soil. The study was carried out to obtain basic information on rice seedling and puddled soil characteristics needed for the rational design and development of bar root rice transplanter. The seedling withdrawal force was found to increase with soil aging. The effect of planting speed (strain rate) was found inconsistent on the withdrawal force. A minimum of 3 days of puddled soil aging and rice seedlings with 2 cm root lengths were found necessary for evaluating the performance of the root washed paddy transplanted. Gupta and Herwanto (1992) reported that to overcome high human stress and drudgery in transplanting operation, a direct paddy seeder to match a two-wheel tractor was designed and developed. The seeder has a working width of 2 m row length and 8 rows. It had field capacity of about 0.5 ha/h at forward speed of 0.81 m/sec and field efficiency of 78%. The seed rate was 15 to 20 kg/ha. Damage due to metering mechanism was nil for soaked seeds and 3 % of pre-germinated seeds. Sahoo *et al.* (1994) developed a six-row power tiller operated pre-germinated paddy seeder. The effective field capacity of this seeder was 0.168 and 0.114 ha/h for 9.9 cm and 25.3 cm hardpan depth, respectively. A net saving of Rs. 327/ha and Rs. 452/ha can be obtained by using the power tiller operated paddy seeder in lieu of the manual-hill dropping and transplanting methods. Jinfu (1997) developed a new direct paddy seeder at the Department of Agricultural Engineering, Huazhong Agricultural University. The performance test showed that the feed quantity could be adjusted from 30 to 150 kg/ha, the standard deviation of feed quantity was 2.95 g , the drilling rate was nil, the damage rate due to metering mechanism was 0.045 %, the field capacity was 0.67-0.8 ha/h, and the fuel consumption was 1.2-1.54 kg/ha. As compared with mechanical transplanting, manual broadcasting and manual transplanting the seeder obtained the yield of grain by 12.72-14.48 %, reduced production cost by 1.0-15 %, saved manpower by 27.0-484.5 men days h/ha, and increased net income RMB Yen 429.60-740.55/ha. Geo *et al.* (1997) developed the new seeder, which is used in direct paddy seeding. The high field capacity and low fuel consumption was founded (0.67-0.8 ha/h) and (1.2-1.5 kg/ha). As compared with mechanical transplanting, manual broadcasting and manual transplanting, drilling with the new seeder can increased grain yield (14.48 %, 12.72 %, and 12.96% respectively), reduced production cost, save manual power and increase net income. Dalin *et al.* (2005) developed a check valve mechanism as an attachment to a power tiller operated cup feed seeder in the Department of Machinery, Tamil Nadu Agricultural University, Result showed that the field capacity of the seeder with check valve (0.06 ha h^{-1}) was lesser by 11.2 to 34.5 % than that of the seeder without check valve. The field efficiency of the seeder with or without the check valve was almost the same, at ground approximately 70 to 75 %. Mathankar *et al.* (2006) developed a self propelled rice ridge seeder for pre-germinated seeding at Central Institute of Agricultural Engineering Bhopal. They reported that, the effective field was 5.3 t/ha and it was comparable to manual transplanting 5.7 t/ha and manual drum seeder 5.1 t/ha and it was higher than manual broadcasting 4.4 t/ha.

Paddy Seeder (Manually Operated)

Tewari and Datta (1983) have developed a manually operated 4-row sprouted paddy seeder in Agricultural Engineering Department of I.I.T. Kharagpur. It was reported to be capable of sowing 6 seeds per hill at a hill to hill spacing of 16.0 cm the average output of the machine was 43.2 kg/ha for paddy at a field capacity of 0.08 ha/h. The performance of the machine appeared to be satisfactory. Krishnaiah (1999) reported that the Directorate of Rice Research, Hyderabad India, developed a 8-row modified seeder in 1997-98. The cost of seeder was about Rs. 2000 and weight was only 12 kg. A single drum with 8-rows of holes was mounted on two wheels at the ends. The seed rate was adjustable to 50-75 kg/ha. Two workers were used for operating the machine in the field. The seeds were soaked for 24 hours and incubated for 24 hours before they were sown in the field. Patel *et al.* (1999) concluded that a manually operated 4-row seed drill developed for direct seeding of pre-germinated paddy. The drill was tested both in the laboratory and field for various conditions, and performed with average field capacity 0.114 ha/h, and 76.83 % average field efficiency at 1.8 km/h. The seed metering device resulted in 3.7 % seed damage according to the rice variety (3 varieties tested). The power required to pull the drill varied from 0.054 to 0.070 kW. Devnani (2002) reported in one of his reviewing the

technology of pre-germinated paddy seeding that, the use of seeders for direct seeding as aerobic or anaerobic sowing of rice crop reduces the labour requirement in range of 5 to 14 man-hours per hectare. This value is very low as compared to 300 man-hours required for transplanting of rice seedlings under wet conditions. The experiments in India have shown that 4 to 5 t ha^{-1} yields obtained under for dry seeded rice and 6 to 7 t ha^{-1} for wet seeded crop. Lacayanga and Valdez (2008) revealed that manually operated four row rice hill seeder achieved an effective field capacity of 0.631 ha day^{-1}, field efficiency of 65.22 %, work capacity of 8.2 h ha^{-1}, seeding rate of 16-20 kg ha^{-1} and missed hills of 13.79 %, seeding efficiency of 83.11 % and acceptable -6.12 % slippage. Devnani (2008) developed and evaluated a low cost two row pre germinated drum seeder of manually pull type that was able to sow the seeds in small ruts along the rows at a proper depth with seed rates of 127 to 215 kg ha^{-1}. At this seed rate, the plant stands in the test plots were in the range of 240 to 505 per sq meter. The four varieties of paddy that were sown through drum seeder resulted in crop yields of 3 to 4 tons ha^{-1} which is close to the transplanted rice. Islam and Ahmad (2010) studied to determine the field and economic performance of machines and techniques for crop establishment in lowland paddy in Bangladesh. Result showed that the effect of rice seeding techniques, using pre-germinated rice seed of variety BR-1 on the effective field capacity, was highly significant. BRRI modified drum type row seeder, with a seeding rate of 60 kg per ha was shown to be better for an optimum crop yield. Sengar *et. al.* (2011) conducted the performance evaluation of rice cum green manure crops seeder and comparing the other seed drill. The study showed that the average tillering and plant population (No/m^2) at maturity were 5-6 and 268, respectively of RCGM. The field test result showed draft of 37 kgf with effective field capacity of 0.06 ha/h at field efficiency of 80 %. The mechanical damage of seed was found to be negligible. Ratnayake and Balasooriya (2013) conducted an evaluation study on the performance of new design conical drum seeder in the paddy fields in relation to manual broadcasting. The theoretical and effective field capacity, field efficiency and missing hill percentage were observed to be 0.22 ha h^{-1}, 0.18 ha h^{-1}, 81% and 3.7 %, respectively. The saving of pre-germinated paddy seed was about 75 % and increase in yield was about 37 % in conical drum seeder as compared to manual broadcasting. Karim (2014) designed and developed a drum seeder cum granular urea applicator. The field capacity of the applicator for applying seeds was 0.33 ha/hr and field efficiency was 86.75 %. The machine was very easy to pull because pulling force was only 11 kg. This is the main advantage over push type applicator. Overall performance of the applicator was reported satisfactory. Prakash *et. al*. (2015) carried out a study for fabrication and evaluation of 4-row drum seeder with seeder with 25 and 30 cm spacing in the same implement during kharif 2013. From the results 30 cm row spacing has got more yield and less operating cost which is more economical and suitable for farmers

Calibration test

Singh *et al.* (2016) study was conducted of performance Evaluation of manually operated paddy drum seeder in puddle field and the laboratory calibration was carried out and studied that laboratory calibration test the combination of half drum fill level and 1 km/h speed were selected for field evaluation of drum seeder. The theoretical field capacity 0.16 ha/h While effective field capacity of the drum seeder was observed to be 0.13 ha/h. The field efficiency of the seeder was found to be 82.08 percent. Chavan and palkar (2010) concluded from the laboratory calibration test, the combination of 75 % drum fill and 1 km h^{-1} speed were selected for the field evaluation of drum seeder. The drum seeder was tested on puddled field. The theoretical field capacity was calculated as 0.2 ha h^{-1} while effective field capacity of the drum seeder was observed to be 0.11 ha h^{-1}. Agidi and Moyosore (2014) developed a 12-row manually operated rice drum planter. A laboratory calibration was carried out with different combinations of drum fill *viz.*,1/2, 2/3, 3/4 and travel speed *viz.*, 1km/h, 1.2 km/h and 1.5 km/h. From the laboratory calibration test the combination of 2/3 drum fill and 1 km/h speed were selected for field evaluation of the drum seeder. The theoretical, effective field capacity and field efficiency of the machine were observed to be 0.38 ha/h, 0.33 ha/h and 86.8 % respectively. This performance indicates that the planter was suitable for adoption by small scale farmers.

Seed Metering Device

Sivakumar *et al.* (2006) reported that the hyperboloid drum shape was optimized with 200 mm drum diameter, 9 numbers of seed metering holes having 10 mm diameter of seed metering hole and 1.0 km h^{-1} forward speed of operation. The seeder developed using the hyperboloid drum performed better when compared to the existing seeder. Kumar *et al*. (2009) conducted an experiment was conducted to design the complex flow rate of paddy rice through the orifices on the circumference of the horizontal rotating cylindrical drum of a hand tractor drawn or self-propelled drum seeder using regression analysis and Artificial Netural Network (ANN). Result show that the optimum drum configuration was found to be the one with 36 orifices of 6 mm diameter on its total volume. Optimum speed of rotation of drum was 61 rpm which resulted in the forward speed of operation of 4.6-6.9 km/h. Pradhan and Ghosal (2012) studied five different size of cups feed metering in seed drill *i.e.* 14.83 mm, 11.71 mm, 9.48 mm, 7.84 mm and 6.58 mm depths with diameters of 8 mm, 9 mm, 10

mm, 11 mm and 12 mm, respectively were prepared keeping the volume constant. It was found that the dimensions of cup of 10 mm x 9.48 mm were found best with a permissible peripheral velocity up to 23.56 m/min. and an overall efficiency of 80.94 per cent. The above dimensions of the cup may be taken to develop a suitable seed drill for use in the field condition for sowing of paddy seeds. Dabbaghi *et al.* (2010) studied effect of fluted roller seed metering device with upside feed mechanism on different rice varieties length (3, 4, 5, 6 and 7cm) and rotational speed (5, 10, 15, 20 and 25 rpm) of metering unit was investigated on seed flow rate, variation of seed flow rate and percent of damaged seed. Seed flow rate of pre-germinated paddy seed had a highly significant effect due to rice varieties, rotational speed, length of fluted roller metering unit and their interaction. For each type of paddy variety, the seed flow rate increased with increase in length and rotational speed of metering device from 3 to 7 cm and 5 to 25 rpm respectively. Average seed flow rate of Hashemi (2.91 g s^{-1}) was higher than Binam (2.65 g s^{-1}) and Hasan (2.44 g s^{-1}). Tajuddin *et al.* (1994) reported that an evaluated a low land direct paddy seeder and reported that, the paddy seeder could give 104 kg/ha seed rate for 28 holed opening and 138 kg/ha for 40m holed opening. Seed germination tests conducted with the seeder showed that germination of paddy seeds was not affected by continuous rotation of seed drum. Field tests showed that, the effective field capacity of the seeder was 0.12 ha/h with 63 per cent efficiency. Cost of seeding by the seeder was Rs. 585/ha as compared to Rs. 2060/ha for manual transplanting.

Sprout length of pre-germinated seed

Islam and Ahmed (1999) observed that the sprout length of seeds to be used in the drum type seeder was 1 to 2 mm achieved by incubating 24 to 36 hours after soaking during the monsoon seasons in Bangladesh. Srivastava and Panwar (1988) suggested that, pre-germinated paddy seeding in puddle soil is often recommended as an alternative to manual transplanting. The study was conducted to determine the effect of sprout length of pre-germinated paddy seed on the plant population, crop growth and yield. Plant emergence, crop growth and yield were found higher in treatment for sprouted seed as compared to dry and water soaked seed. Sprout length of 2-5 mm was reported to be optimum for maximum plant population and grain yield.

SUMMARY

The literature is related the parameter of power operated paddy seeder such as metering device, sprout length, furrow opener, forwarded speed, and pulling capacity, seeding rate and yield parameters. The developed the power operated paddy seeder unit could be useful in eliminating drudgery in transplanting or pulling of manual drum seeder besides other advantages of pre-germinated line seeding. The concluded that it is possible to reduce the seeding rate variation by maintaining a desirable drum fill condition. The crop and yield parameter of crop sown by develop unit, were comparable to transplanted and manual drum seeded crop; whereas they were better in comparison to broadcasted crop.

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RESEARCH ARTICLE

COMPARATIVE STUDY OF ESTIMATION OF SOIL ERODIBILITY FACTOR FOR THE LOWER TRANSACT OF RANIKHOLA WATERSHED OF EAST SIKKIM

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Abstract: Soil erosion is a two phase process consisting of the detachment of individual particles from soil mass and their transport by erosive agents such as running water and wind. When sufficient energy is no longer available to transport the particles, a third phase (deposition) occurs. The amount of erosion from raindrops has been linked to the rainfall characteristics such as the rainfall intensity, drop diameter, impact velocity and rainfall kinetic energy. The size, distribution and shape of rain drops influence the energy, amount and erosivity of rainstorm. On the other hand, the soil properties, particles size distribution and organic matter content determine whether soil can be detached and transported. Soils with faster infiltration rates, higher levels of organic matter and improved structure have a greater resistance to erosion. Hence soil erodibility is another important parameter in the estimation of soil erosion. In the present study the main objective was to determine the soil erodibility indices of Ranikhola watershed area so that the values of the soil erodibility index can be established for future works. Runoff Plot method and Soil Physical Properties Analysis method was used for determination of 'K' factor in transact of Ranikhola watershed (Sikkim). The range of 'K' factor in study area varied from 0.0086 to 0.034 with an average value of 0.025 (t ha h/ha mm MJ) by Runoff Plot method. Using Soil Physical Properties Analysis method, the 'K' values were found in between 0.051 to 0.073 with an average value of 0·064 (t ha h/ha mm MJ). From the study it was concluded that the study areas falls under low erodibility (K) class. Among the both methods, the runoff plot methods were under estimated than the other method. Soil textural analyses revealed all the important soil components affecting directly soil inherent properties to resist erosion or to become susceptible to erosion, hence the 'K' values as obtained from Soil Physical Properties Analysis method was considered appropriate for the lower transact of Ranikhola watershed.

Keywords: Soil Erodibility, USLE, Runoff plot, Sikkim

INTRODUCTION

Soil erosion is the most widespread form of soil degradation worldwide (Bridges and Oldeman, 1999). Soil erosion by water involves the interaction of a complex set of physical and chemical processes governed by many factors; soil erodibility describes the degree to which the soil surface is susceptible to soil erosion. Universal Soil Loss Equation (USLE) is one of such empirical equation which is used extensively to estimate the soil loss from a given watershed (Wischmeier and Smith, 1965). Soil erodibility is an important parameter for estimating soil loss and implementing soil conservation practices (Wang et al., 2014). Soil erodibility has been found to be influenced by soil properties such as particle size distribution, structural stability, soil organic matter content, soil chemistry and clay mineralogy and water transmission characteristics (Lal, 1994). Therefore, a common way to investigate soil erodibility would be to produce soil-property maps based on a vast number of traditional field soil samplings and property analyses. Soil erodibility also can be evaluated by using runoff plots. Naturally experimental plots have become one of the most important methods of data gathering in surface runoff and soil erosion studies. Basic data for developing most empirical models such as USLE, MUSLE and RUSLE were originated from natural plots. This is because soil erosion is a function of many factors as stated in the universal soil loss equation (USLE).

$$A = R\ K\ LS\ C\ P \qquad (1)$$

Where, these factors include rainfall factor (R), soil erodibility factor (K), slope length (LS), crop factor (C) and control practice factor (P) and annual average soil loss (A).

The formulation of proper soil management for sustainable development requires an explicit inventory and rating of vulnerable areas. This information is very useful in the decision making context to avoid land degradation in erosion risk areas, or, alternatively, to recommend soil conservation measures to reduce soil loss if developments continue.

In this study, a transact of Ranikhola watershed in high rainfall areas of Sikkim, which is located near Ranipool, East Sikkim district has been taken for estimating soil erodibility (K) factor. Both the methods *i.e.* by soil physical properties analysis and by runoff plot were used to determine the soil erodibility indices of Ranikhola watershed area so that the values of the soil erodibility index can be established for future works.

MATERIALS AND METHODS

Description of study area

Study area comprises the Ranikhola watershed located in the district of East-Sikkim. Ranikhola watershed lies between latitude 27°13'N to 27°24'N and longitude 88°29'E to 88°43' E and the total geographical area is 254·5 square kilometers. In the present study, however, a transact of the watershed as shown in the Fig. 2.1 was considered. The

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topography of this area is hilly and it is a part of eastern Himalayan region as per the classification of agro climatic zone (Planning Commission, 1989) and the elevation ranges from 600 m to 5000 meters above MSL. The average annual rainfall is 2525 mm consisting of 135 rainy days in a year. The major drainage in the study area is provided through the Ranikhola River.

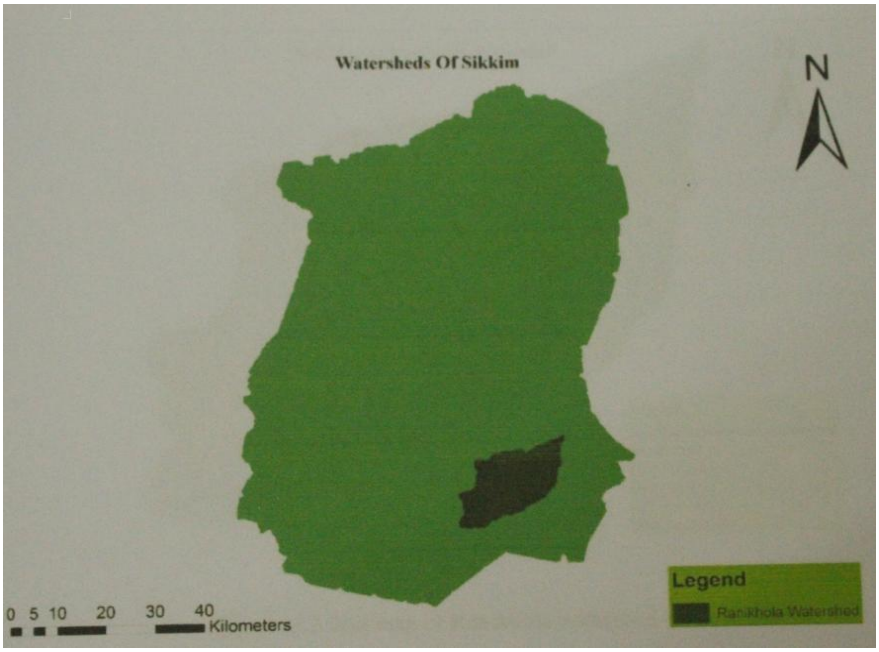

Fig: 1. Study area

Determination of Soil Erodibility Index

Two different methods namely as, a) Runoff Plot method and b) Soil Physical Properties Analyses method were used for determination of soil erodibility factor in Ranikhola watershed of East-Sikkim.

Runoff Plot method

Plot lay out:

Three plots having an equal size of 4.05m ×1m (4.05 m^2 equal to $1/1000^{th}$ of 1 acre) with the natural uniform slope of 16.73% was prepared. The original plot size was 22.13m × 1.83 m (equal to $1/100^{th}$ of 1 acre, Wischmeier and Smith, 1978).

Fig. 2. Runoff plot

Plots were cleaned from the vegetation and were tilled along the slope and bunds were made on all the sides. The bunds were covered with tin and polythene sheet. An outlet made from polythene sheet was fixed to channelize the flow of runoff from plots to the plastic bucket of 20 litres capacity fixed on the lower end of each plot.

Sampling of Soil from Runoff Plot

After each rainstorm, depth of runoff in drums was measured using measuring cylinder and one litres of water sample was taken for determination of soil loss. Drums were emptied and cleaned after each rainstorm manually and plots tilled and cultivated again. The observations were recorded for 8 rainstorms during the month of August, 2015. The duration of rainstorm varied from 1 to 1·5 hours and the intensity varied from 10·74 to 14·92 mm/h. The field experiment was conducted under natural rainfall condition in Ranikhola watershed (Sikkim).

Observation of Storms:

After collecting the samples, these were filtered through the filter paper of 42 no. grade and the soil was separated from the water. Then the soil was kept in oven at 105℃ for 24 hours and then weights of samples (soil) were noted down.

Calculation of K

The soil erodibility factor (K) was calculated by using USLE (Wischmeier and Smith, 1978) formula,

A = R K L S C P (2)

Where, average annual soil loss (A), rainfall factor (R), soil erodibility factor (K), topography factor (LS), crop factor (C) and control practice factor (P).

$LS = (l/22{\cdot}13)^m \times (0{\cdot}065 + 0{\cdot}045s + 0{\cdot}0065s^2)$ (3)

Where:

l = slope length; s = slope gradient;

m = an exponent depending on the slope.

Current recommendation for 'm' is:

m = 0·5 if s >5%,

m = 0·4 if s ≤5% to >3%,

m = 0·3 if s ≤ 3% to > 1%,

m =0·2 if s ≤1%.

And, 'C' & 'P' are taken 1.

Soil Physical Properties Analyses method

In this study, 20 samples of surface soil (0-15 cm) were collected from different places (location is given in table, 3.3 and Fig 3.3) of Ranikhola watershed. Using USDA method were determined the percentage of silt, sand and clay and used STFR meter for determine percentage of organic matter content. Soil erodibility factor (K) determined by using USLE monograph (Wischmeier et al. 1971).

$K = [2{\cdot}73 \times 10^{-4} M^{1{\cdot}14} (12 - OM) + 3{\cdot}25 \times (S - 2) + 2{\cdot}5 (P - 3)] / 759$ (4)

Where, K is soil erodibility factor ($t{\cdot}ha{\cdot}h{\cdot}ha^{-1}{\cdot}Mj^{-1}{\cdot}mm^{-1}$) and M is texture from the first 15 cm of soil surface. OM is % of organic matter content that was determined by STFR method.

$M = [(100 - Ac) \times (Si + Armf)]$ (5)

Where, Ac is % of clay (<0·002 mm), Si is % of silt (0·002 - 0·05 mm) and Armf is % of very fine sand (0·05 - 0·1mm).

S is the structural class of soil (Wischmeier *et al.*, 1971).

Table 1. Structural class of soil.

Structural class	Range	Aggregates size(dia.),mm
1	Very fine granular	1 to 2
2	Fine granular	2 to 3
3	Medium or coarse granular	3 to 5
4	Blocky, platy, or massive	Usually construction sites

And **P** is the permeability class index

Table 2. Permeability class index (Wischmeier *et al.*, 1971)

Class	Range (mm/hr)	
1	150	Rapid
2	50 to 150	Moderate rapid
3	12 to 50	Moderate
4	5 to 15	Slow to moderate
5	1 to 5	Slow
6	>1	Very slow

RESULTS AND DISCUSSION

As previously discus the study was done by using two methods namely a) Runoff Plot method and b) Soil Physical Properties Analyses method

Runoff plot methods

R-values:

The rainfall erosivity factor (R) was calculated by using EI_{30} method (Wischmeier and Smith, 1978). The R factor was varies with storm by storm, with the assumptions that 60% of the storm rainfall of storm duration about 1 hour occur within 30 minutes, I_{30}values were calculated for different storms. The assumption was considered based on the observation of actual pattern of storm occurred in Ranikhola watershed area during the period of study. The values of 'R' obtained with the assumption are given in Table 3.1.

Table 3. R-values with obtained from 60% storm rainfall occurred in 30 minutes

Date	Intensity (mm/hr)	I_{30}	E= (e × *p*)	R = (E*I_{30})/100
02/08/2015	15.67	18.80	3.50	0.66
05/08/2015	14.42	17.30	3.97	0.69
10/08/2015	13.33	15.99	3.62	0.58
11/08/2015	13.79	16.50	3.16	0.53
12/08/2015	14.25	17.10	3.76	0.64

21/08/2015	12.79	15.35	2.90	0.44
27/08/2015	14.92	17.90	5.77	1.03
29/08/2015	12.84	15.41	3.32	0.51

The storm rainfall recorded in the study area by installing one non-recording type of rain gauge. This was nevertheless expected due to the fact that in the project area the total rainfall collected in the non-recording type of rain gauge and 60% of the rainfall was used to calculate the intensity, which might not be happening in reality during the storms.

The topographic (LS) factor of the study area was found 1.09 whereas the crop management factor (C) and the supporting conservation practice Factor (P) were took 1, because the vegetation were removed and tillage was done in the runoff plots and there was no conservation practices situated.

Soil Erodibility Index

The soil erodibility index was calculated plot wise and storm wise. It was found that storm wise values of erodibility factors in the erosion plot area was varying from 0.0086 to 0.034 with an average value of 0.025 (t ha h/ha mm MJ). The K factor from different at different storm was given in table 3.2.

Table 4. ‘K’ value by USLE with 60% storm rainfall data

Date	Plot	soil loss (A) (t/ha/h)	Avg (A) (t/ha/h)	Erosivity (R)	Topography factor (LS)	Erodibility (K)	Average (K) (t ha h/ha mm MJ)	Avg (K)
02-08-2015	1	0.031		0.658	1.089	0.043		
	2	0.024		0.658	1.089	0.034	0.0343	
	3	0.018		0.658	1.089	0.026		
05-08-2015	1	0.0065		0.686	1.089	0.009		
	2	0.0051		0.686	1.089	0.007	0.0086	
	3	0.0075		0.686	1.089	0.012		
10-08-2015	1	0.024		0.578	1.089	0.038		
	2	0.014		0.578	1.089	0.022	0.034	
	3	0.028	0.0175	0.578	1.089	0.044		0.025
11-08-2015	1	0.013		0.522	1.089	0.023		
	2	0.013		0.522	1.089	0.022	0.022	
	3	0.013		0.522	1.089	0.022		
12-08-2015	1	0.018		0.642	1.089	0.026		
	2	0.012		0.642	1.089	0.017	0.019	
	3	0.012		0.642	1.089	0.017		
21-08-2015	1	0.015		0.439	1.089	0.031		
	2	0.014		0.439	1.089	0.029		
	3	0.014		0.439	1.089	0.029	0.03	
27-08-2015	1	0.022		1.033	1.089	0.019		
	2	0.025		1.033	1.089	0.022	0.026	
	3	0.042		1.033	1.089	0.037		
29-08-2015	1	0.023		0.512	1.089	0.041		
	2	0.016		0.512	1.089	0.029	0.032	
	3	0.012		0.512	1.089	0.025		

The K-values as obtained with the help of Eq. No. (4) in material and methods are presented in Table 3.3.

The soil textural analyses revealed that the soils of Ranikhola watershed are sandy to sandy loam with the silt content ranging from 21% to 48.66%, clay content ranging from 13.16% to 21.83% and very low organic matter content ranging from 0.24% to 0.41%. The component of very find was also higher which is ranging from 19.61 to 32.48. As such the soil is very susceptible to erosion due to higher amount of very fine sand and silt content. Based on the Eq. No. (4) the 'K' values are found which are ranging from 0.051 to 0.073 with an average value of 0·064.

Table 5. 'K' values obtained from soil textural data.

% of silt	% of clay	% OM	% of very fine sand	K Factor	Average k
36·29	16·20	0·28	26·99	0·0647	
37·01	16·20	0·31	26·58	0·0649	
37·01	16·20	0·33	26·58	0·0647	
38·68	16·20	0·32	25·63	0·0652	
42·00	17·55	0·30	22·98	0·0653	
33·67	13·83	0·28	29·82	0·0667	
35·33	13·83	0·29	28·88	0·0675	
31·61	16·83	0·28	29·26	0·0617	0·064
34·00	16·83	0·41	27·93	0·0622	
30·67	20·16	0·24	27·93	0·0572	
45·67	13·16	0·30	23·39	0·0732	
39·33	13·16	0·26	26·99	0·0704	
40·33	13·83	0·32	26·04	0·0696	
45·33	16·83	0·37	21·50	0·0674	
48·66	16·83	0·25	19·60	0·0694	
46·66	13·83	0·29	22·44	0·0727	
27·00	18·49	0·37	30·97	0·0573	
21·00	21·83	0·31	32·48	0·0510	
30·67	20·16	0·38	27·93	0·0567	
29·00	18·49	0·33	29·83	0·0583	

Where, 'K' in t ha h/ha mm MJ

The K-values as obtained from the soil physical data are found to be higher than the values obtained with USLE (from actual rainfall data).

The soil textural analyses of the surface soil collected from the lower transact of Ranikhola watershed yielded values of all the components of soil responsible for soil aggregation and soil susceptibility to erosion. The analysis was also done on control conditions and hence the 'K'-values obtained from soil textural analyze were considered to be the true value of soil erodibiltiy in Ranikhola watershed of East-Sikkim district.

CONCLUSION

Soil erodibility factor (K) is strongly correlated with soil loss and known as a key factor in soil erosion prediction. Runoff Plot method and Soil Physical Properties Analysis method was used for determination of 'K' factor in transact of Ranikhola watershed (Sikkim). The range of 'K' factor in study area varied from 0.0086 to 0.034 with an average value of 0.025 by Runoff Plot method. Using Soil Physical Properties Analysis method, the 'K' values were found in between 0.051 to 0.073 with an average value of 0·064. In the erosion plot methods, the 'R' value of Universal Soil Loss Equation was determined with the rainfall intensity collected at the experimental plots. From the study it can conclude that the study area is comes under low erodibility (K) class. Among the both methods, the runoff plot methods were under estimated than the other method. Soil textural analyses revealed all the important soil components affecting directly soil inherent properties to resist erosion or to become susceptible to erosion, hence the 'K' values as obtained from Soil Physical Properties Analysis method was considered appropriate for the lower transact of Ranikhola watershed.

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RESEARCH ARTICLE

INCIDENCE OF SHOOT AND FRUIT BORER, *LEUCINODES ORBONALIS* GUEN. ON BRINJAL IN RELATION TO WEATHER PARAMETERS IN ALLAHABAD REGION

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Abstract: The seasonal incidence of *Leucinodes orbonalis* Guen. (Brinjal Shoot and Fruit Borer) on brinjal was studied at Central Research Farm of the Department of Entomology, Naini Agricultural Institute, SHUATS, Allahabad during 2017. The resultsrevealed thatInitial incidence of the BSFB on shoot was occurred on the 40th standard week (First week of October) and reached the peak in the 43th standard week (Last week of October - 1st week of November); whereas Initial incidence of the BSFB on fruit wasoccurred on the 42nd standard week (Third week of October) and reached the peak in the 45th standard week (2nd week of November). BSFB incidence on shoot showed significant positive correlation with Maximum temperature (r=0.591) and sun shine hours (r=0.657). It was negatively correlated with Evening Relative Humidity (r=-0.610).BSFB incidence on fruit showedsignificant positive correlation with maximum temperature (r = 0.488, on number basis and r = 0.493, on weight basis) and sun shine hours (r = 0.641, on number basis and r = 0.645, on weight basis); whereas it had negative correlation with evening relative humidity (r = -0.650, on number basis and r = 0.655, on weight basis) and evening cloud cover (r = -0.475, on number basis and r = 0.471, on weight basis).The statistically significant values indicated that occurrence of brinjal shoot and fruit borer was influenced by the prevailing ecological conditions specially Temperature, Relative Humidity, wind speed and sun shine hours .Hence the management of brinjal pest during rabisown crop under central plain agro-climatic zone should therefore be promoted and tailored from September onwards using an integrated approach.

Keywords: Brinjal, *Leucinodes orbonalis*, Seasonal incidence, Correlation, Weather parameters, Allahabad

INTRODUCTION

The prospect of climatic changes has simulated considerable research interest across the world and most of the research pursuits are aiming to predict the production of crops. The success of any crop depends on its adoptability to the ambient environment including soil and escape/tolerance to pests that include insects, diseases and weeds (Rao and Bhavani, 2010). The climate change studies in agriculture sector rely on the simulation of crop-growth models that seldom include any crop-pest sub-routine. Often the growth of the crop in the models is considered as function of accumulated thermal time and some pest models also consider thermal time to simulate the crop-pest interactions (Boote *et al*., 1983; Rabbinge *et al.*, 1989). Most studies on crop-pest interactions quantify the pest population by using empirical approaches or observations (Pinnschmidt *et al.*, 1995).

Vegetable is an utmost important source of nutritional input in human diet throughout the world as its excellent source of vitamins, minerals, and plant.Olericulture is one of the most important and major branches of agriculture, and crucial from the point of view of ability to generate economic revenueVegetables are rapidly becoming an important source of income for the rural population (Singh *et al. (b)*, 2009).

Brinjal (*Solanum melongena* Linnaeus) originated from India and now grown as a vegetable throughout the tropical, sub-tropical and warm temperate areas of the world. Nutritive value per 100 g of raw brinjal indicates that it supplies 25 calories,0.2 gm total fat, 2 mg sodium, 229 mg potassium, 6 gm total carbohydrate, 3 gmdietary fibre, 3.5 gm sugar, 1 gm protein, vitamins (B-6, B-12 and C), iron,magnesium, phosphorus, etc. (USDA, 2013).

In India,brinjal is extensively grown under diverse agro-climaticconditions throughout the year (Nayak *et al.* 2014). It is grown in almost all states, with an area of 679.4 thousand hectares under cultivation and production of 12438.7 thousand metric tons (Anonymous, 2015). The major brinjal growing states in India are Andhra Pradesh, Karnataka, West Bengal, Maharashtra, Orissa, Madhya Pradesh, Bihar, Gujarat and Chhattisgarh. As per FAOSTAT (2016) data, China is the top producer (61% of world output) while India rankssecond (25%) in brinjal production.

Several biotic and abiotic factors contribute in lowering the yield in brinjal. Amongvarious biotic factors, insect pests are important which greatly affect the qualityand productivity of brinjal crop through inflicting a direct damage (Gupta *et al.*, 1987). In the tropics, brinjal production is severely constrained by several insectand mite pests. The major insect pests of brinjal include fruit and shoot borer(BSFR), leafhopper, whitefly, thrips, aphid, spotted beetles, leaf roller, stem borer,blister beetle, red spider mite, etc. (AVRDC, 2009).

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Arthropod biodiversity in the brinjal field showed that the brinjal shoot and fruit borer was the major and serious insect pest of brinjal crop. (Kumar*et al*., 2017).It infests both vegetative as well as reproductive stages of the crop which cause heavy losses in the yield to a tune of 40 to 80% (AVRDC, 2003). Besides brinjal it also attacks potato and other Solanaceous crops.The apparent yield loss due to BFSB varies from 20-90 per cent in various parts of the country (Raju *et al.*, 2007), 85–90 per cent have been reported (Patnaik, 2000; Misra, 2008 and Jagginavar *et al*., 2009).It may cause 100 per cent damage if no control measures are applied (Rahman 2007). It is estimated that the economic injury level equals to 6 per cent infestation of shoot and fruit in India (Alam *et al.*, 2003).

Along with Indian subcontinent it is also distributed in Thailand, Laos, South Africa, Congo, and Malaysia.*L. orbonalis*causes saviour incidence throughout the cropping season by virtue of its reproductive potential, short life period (hence more generations per season) and continuous perpetuation through intensively grown brinjal, potato and other Solanaceous crops, in both irrigated and rainfed condition. The incidence of this insect pest occurs either sporadically or in outbreak every year in the Indian subcontinent (Dhankar, 1988).The variability intheir population and damage can be related to changes in theambient environment. The best way to avoid pest outbreak is possible when the congenital weather condition for the insect infestation is fully known (Dubey and Thorat, 1994). Since theclimate change projections for India indicate a changein temperature and rainfall, an attempt has been made here to studythe impact of weather parameters in relation to seasonal incidence of shoot and fruit borer on brinjal crop under Allahabad Agro climaticconditions.

MATERIALS AND METHODS

The study on seasonal variation in the incidence of brinjal shoot and fruit borer (BSFB) wascarried out at the research farm of the Department of Entomology, Naini Agricultural Institute, SHUATS,Allahabad during kharif season of 2017.

A Variety ofRound Brinjal '*Kanshi Sandesh*' developed by IIVR Varanasi has been chosen for the field experiment. Seeds were sown in nursery of Department of Horticulture in the first week of August and theseedlings were raised on Disposable PVC Cups. Thirty days old seedlings were transplanted during the first week of September and the standard agronomic package ofpractices and irrigation schedule were followed to raise and maintain a healthy crop.

In this experiment, plant spacing of 60 x 50 $cm^2$was kept, on plot size 5x3 m^2area, with 3 replications. No pesticide was used throughout the experiment. Population of BSFB larvae, during the experimental period *i.e.* 31st standard week (First week of August, 2017) to 52ndstandard week (Last week of December, 2017) was recorded on these untreated experimental plots. The observations were taken regularly at 7 days interval (every Sunday of each standard week)till the final harvest of the crop.

Installation of sex pheromone trap has been done to record initial incidence. Population of BSFB larvae was first observed on brinjal shoots in the 40thstandard week (First week of October, 2017). As fruit bearing initiated, these larvae (BSFB) were observed migrating to developing fruits.

Incidence on *shoots*were recorded as percentage *shoot* infestationby counting infested and healthy shootsfrom a total of 10 randomly selected plants on each replication from the initiation of damage.At each count the affected shoots were removed.

During the fruitbearing stage the fruits were harvested at frequent intervals, as and when they attainedmarketable size.At each count the affected fruits were also removed and harvested. After each harvest, damaged and healthy fruits and their number andweight were recorded. From these results, the percentages of damaged fruits obtained fromthe different harvests were calculated for each week of the year.

To work out percent fruit damage weight of healthy fruits, weight of infested fruits and total weight of fruits were recorded at each harvest. Percent fruit and shoot infestation was calculated using following formula.

Shoot damage on number basis-

$$\textbf{\% Shoot Damage} = \frac{\text{Number of Damaged Shoot}}{\text{Total Number of Shoots (Damage + Healthy)}} \times 100$$

Fruit damage on number/weight basis-

$$\textbf{\% Fruit Damage} = \frac{\text{Weight/number of damaged fruits}}{\text{Total Weight/number of fruits (Damage + Healthy)}} \times 100$$

The data on ecological parameters like Temperature (minimum and maximum), Relative humidity (morning and evening), cloud cover (morning and evening), Rainfall, Sunshine and Wind velocity etc. have been collected from the meteorological observatory, available with Department of Agriculture Meteorology, Naini Institute of Agricultural, SHUATS, Allahabad.Simple correlationcoefficients (r) between themeteorological parameters, multiple linear regression equation and incidence of fruit infestation and shoot borer infestation were calculated with the help of Microsoft Excel software and "ICAR-Web Agri Stat Package (ICAR-WASP)".

RESULTS AND DISCUSSION

Seasonal incidence of brinjal shoot and fruit borer (*Leucinodes orbonalis*)

The data on shoot infestation and fruit infestation of brinjal shoot and fruit borer was recorded from first week of September to last week of December 2017. It is evident from tables-1 that the Shoot infestation of BSFB (Leucinodes orbonalis Guenee) commenced from 40rd standard week (1st week of October) on shoot with an average 3.30% of damaged shoot (Number basis) during commence of experiment. The borer population increased and gradually reached peak level of 46.61% of damaged shoot (Number basis) at 43rd standard week (last week of October - 1st week of November).

Fruit infestation of BSFB (Leucinodes orbonalis Guenee) commenced from 42ndstandard week (3rd week of October) with an average 33.33% of damaged fruit (Number basis) and 30.46% (Weight basis) during the experiment. The borer population increased and gradually reached peak level of 59.09% of damaged fruit (Number basis) and 57.98% of damaged fruit (weight basis) at 45th standard week (2nd week of November).thereafter there was a gradual decrease in per cent shoot infestation till the 48th standard week (5.92%) andgradual decrease in per cent infestation of fruit till 2nd week of December (6.82%, on number basis and 7.04%, on weight basis). Also after the initiation of fruits, infestation on shoots gradually shifted to fruit during 41st standard week to 43rd standard week (2nd week of October to 1nd week of November), thereafter continuously decreasing on shoots and completely eradicated by 48th standard week (3rd week of December), as the onset of winter.

Current study reveals that the shoot infestation of the pest occurred first time in the 40th standard week i.e. 36 days after transplanting. This is in agreement with Tiwari *et al.* (2011) who first seen incidence in 35th day after transplanting. However Kaur *et al.* (2014) reported first appearance in four week (30 DAT); Kumar *et al.(*2014) reported first appearance in 15 DAT and Chetan et al. (2017) reported the incidence on shoot started from one week after transplanting (i.e. during the month of November) in *Rabi* season brinjal.

The findings of current studies are in great accordance with Katiyar and Mukharji (1974) who reported the highest damage of 90 per cent in the month of November; Bharadiya and Patel (2005) who reported that the damage was highest on fruits during third week of November;Also in agreement with Rao and Bhavani (2010), who reported the highest damage of 62.83 per cent in November;Tiwari *et al.* (2012) reported that damage reached at its maximum level of 4.0 larvae/plant in 44thSW in first year 2005-2006And 4.67 larvae/plant in 45th SW during 2006-2007;andYadav*et al*., (2015) whorevealed that the highest percent fruit infestation of shoot and fruit borer was recorded on 43rd and 44th standard week (13.78% and 13.88%), in Varanasi. However Chetan *et al.* (2017) reported peak infestation of BSFB (59.16%) in the month of December in October transplanted crop.

Influence of weather parameters on shoot and fruit borer (*Leucinodes orbonalis*) Incidence on shoot.

Correlation analysis was worked out by correlating 9 weather parameters in consideration and percent fruit infestations with the use of Microsoft excel and ICAR-WASP software (http://www.ccari.res.in/wasp2.0/wasp2.zip) to understand the relationship among them. The correlation coefficients thus obtained and their significance at 0.05 levels (95% confidence level) are presented in Table-2.

It was found that the pest build up on shoot (Damage % number basis) was positively correlated with maximum temperature (r = 0.591) and sun shine hours (r = 0.657). However it was negatively correlated with evening relative humidity (r = -0.610).

Earlier various worker has revealed similar results as positive correlation of percentage infestation with maximum temperature by Shukla and Khatri, 2010 – (r = 0.319); Rao and Bhawani, 2010 – (r = 0.610); Anjali et al., 2012 – (r = 0.035); Sarnabati *et al*., 2014 – (r = 0.129); Kumar and Singh, 2015 – (r = 0.798); Indira Kumar *et al.*, 2016 – (r = 0.035); Kumar *et al*., 2017(a) – (r = 0.422); Ram kinker *et al.*, 2017 – (r = 0.572).

Positive correlation with sunshine hours is in agreement with, Tiwari *et al.* (2012) – (r = 0.476);Sarnabati *et al*., 2014 – (r = 0.350); Ram kinker *et al.* 2017 – (r= 0.860); Kumar *et al*., 2017(a) – (r = 0.381).While negative correlation with evening relative humidity was supported by Anjali et al., 2012 – (r = -0.250); Amit*et al*., (2015) – (r = -0.116); Indira Kumar *et al.*, 2016 – (r = -0.250); Ram kinker *et al.* 2017 – (r = - 0.536); Kumar *et al*., 2017(a) – (r = -0.109).

Table –1	Data of weather parameters obtained from dept. Of agriculture meteorology for the period of experiment										Insect infestation		
Standard week		Temperatures (^{O}C)		Rain fall Mm	Humidity %		Wind speed	Cloud cover (octa)		Sun shine (hours)	%Shoot damage	% fruits damage	
	Dates	T. Max	T. Min	24.h	Morning	Evening	KM/hr	Morning	Evening	24h	No.	No.	Wt.
35	3-09-2017	35.14	29.00	2.43	89.43	49.57	1.95	4.57	4.71	7.11	0	0	0
36	10-09-2017	36.77	30.31	0.00	83.43	45.14	1.64	2.00	3.71	7.21	0	0	0
37	17-09-2017	34.72	30.40	0.00	83.14	44.00	1.37	4.14	3.57	7.51	0	0	0
38	24-09-2017	36.00	28.60	3.31	89.71	56.57	1.22	6.14	5.57	7.89	0	0	0
39	01-10-2017	36.40	29.86	0.14	86.14	48.86	1.23	1.29	4.14	8.21	0	0	0
40	08-10-2017	36.53	30.23	0.00	71.00	49.57	0.96	1.00	2.43	8.63	3.30	0	0
41	15-10-2017	36.64	22.69	0.00	78.00	43.57	0.99	1.00	2.57	8.79	16.13	0	0
42	22-10-2017	37.83	22.77	0.00	80.57	42.29	1.12	0.00	1.71	8.87	26.09	33.33	30.46
43	29-10-2017	39.86	18.86	0.00	81.71	34.57	0.91	0.00	0.71	8.91	46.61	42.86	41.87
44	05-11-2017	39.46	18.83	0.00	84.29	39.14	1.07	0.00	0.43	8.97	30.66	51.85	52.75
45	12-11-2017	39.90	17.83	0.00	86.57	35.57	0.76	0.00	0.00	8.99	20.53	59.09	57.98
46	19-11-2017	32.14	15.97	0.00	90.00	42.29	0.75	0.29	1.00	8.83	15.10	36.47	35.20
47	26-11-2017	31.40	11.71	0.00	92.00	43.00	0.82	0.00	0.00	8.90	9.81	21.43	18.83
48	03-12-2017	28.89	8.89	0.00	92.43	40.14	0.74	0.00	0.71	8.21	5.92	12.24	11.04
49	10-12-2017	27.89	8.97	0.00	92.43	39.43	0.59	0.00	0.00	7.99	0	6.82	7.04
50	17-12-2017	28.71	9.51	0.00	92.14	39.14	0.70	0.43	0.00	7.45	0	0	0
51	24-12-2017	28.29	10.83	0.00	93.00	42.86	0.74	0.29	0.00	7.21	0	0	0
52	31-12-2017	25.77	10.06	0.00	94.71	47.86	0.62	0.00	0.43	5.57	0	0	0

Influence of Weather parameters On incidence of *Leucinodes orbonalis* on shoot and fruits of brinjal

Table - 2	**Temperature**		**Rain Fall**	**Humidity %**		**Wind Speed**	**Cloud Cover**		**Sun Shine**
	(Celsius)		**(mm)**			**(Km/hr)**	**(Octa)**		**(hr)**
	T. Max	**T. Min**	**24.h**	**MORNING**	**EVENING**	**Wind speed**	**MORNING**	**EVENING**	**24h**
Shoot - r	0.591	-0.075	-0.262	-0.362	-0.610	-0.151	-0.419	-0.340	0.657
T value	2.971	0.304	1.083	1.559	3.072	0.616	1.846	1.442	3.476
T tab at5%	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
Significance at 5%	S	NS	NS	NS	S	NS	NS	NS	s
Fruit (number) - r	0.488	-0.207	-0.262	-0.095	-0.655	-0.248	-0.459	-0.475	0.641
T value	2.247	0.843	1.086	0.389	3.445	1.038	2.069	2.157	3.416
T tab at5%	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
Significance at 5%	S	NS	NS	NS	S	NS	NS	S	s
Fruit (weight) - r	0.493	-0.200	-0.258	-0.098	-0.652	-0.243	-0.452	-0.471	0.645
T value	2.289	0.813	1.065	0.399	3.442	1.016	2.026	2.139	3.333
T tab at5%	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
Significance at 5%	S	NS	NS	NS	S	NS	NS	S	S

S **Positive correlation significantly established.**

S **Negative correlation significantly established.**

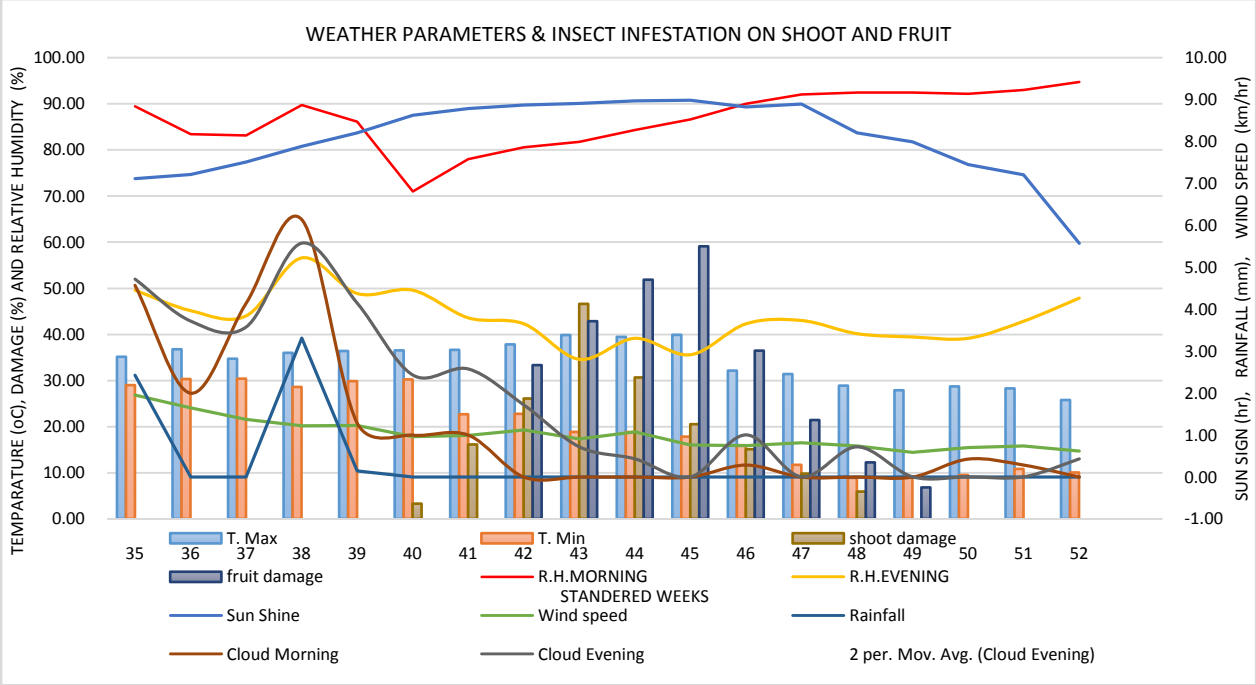

Fig .1 weather parameters and % shoot and % fruit damage in brinjal

Further, the multiple Linear Regression equation derived to predict the population fluctuation of *Leucinodes orbonalis* and extent of % shoot damage they can possibly cause, on brinjal, at Allahabad region, based on weather parameter was:

Shoot % D. = -2.421 + (1.391) x M. Temp+ (2.537) x Sun shine+ (-1.280) x Evn. RH%+8.218

Intercept (a) = -2.421Coefficient of determination (R Square) = 0.703
Multiple Correlation Coefficient (R) =0.834Standard Error = 8.218
Regression coefficients and their significance using t test.

Independent Variables	Average	Regression coefficients (b)	Standard Error(SE(b))	T Test	T table (0.05)	Significance at 5% level
Max. Temp	34.018	1.391	0.561	2.459	2.145	S
Sun Shine	8.064	2.537	3.031	0.832	2.145	NS
Evening R.H.	43.536	-1.280	0.410	-3.116	2.145	S

It was observed that the coefficient of determination for larval incidence was 0.703 which indicated that the climatic factors together were able to explain the variation in the larval incidence to the extent of 70.30 out of 100.

Influence of weather parameters on shoot and fruit borer(*Leucinodes orbonalis*)Incidence on fruit.

It is evident from the analysis that percent fruit infestation had positive correlation with maximum temperature (r = 0.488, on number basis and r = 0.493, on weight basis) and sun shine hours (r = 0.641, on number basis and r = 0.645, on weight basis); whereas it had negative correlation with evening relative humidity (r = -0.650, on number basis and r = 0.655, on weight basis) and evening cloud cover (r = -0.475, on number basis and r = 0.471, on weight basis).

Earlier various worker has revealed similar results as positive correlation of percentage fruit infestation with maximum temperature by Shukla and Khatri, 2010 – (r= 0.319), Rao and Bhawani, 2010 – (r = 0.610), Sarnabati *et al*., 2014 – (r = 0.962), Amit *et al*., 2015 – (r = 0.320), Kumar and Singh, 2015 – (r = 0.796, number basis and, r = 0.797, weight basis); Indira Kumar *et al.* (2016), Rattan *et al*., 2016 – (r= 0.490); Ram kinker *et al*., 2017 – (r = 0.572).
Positive correlation with sunshine hours is in agreement with, Tiwari *et al.* (2012) – (r = 0.476), Kumar *et al.*, 2017 – (r = 0.521); Ram kinker *et al.* 2017 – (r= 0.860).
While negative correlation with evening relative humidity was supported; Anjali *et al*., 2012 – (r = -0.204); Amit*et al*., 2015 – (r = -0.116); Indira Kumar *et al*., 2016 – (r = -0.204); Kumar *et al*., 2017 – (r = -0.632); Ram kinker *et al.* 2017 – (r = - 0.536); Sharma and Tayde, 2017 – (r = -0.395).

Further, the multiple Linear Regression equation derived to predict the population fluctuation of Leucinodes orbonalis and extent of % fruit damage they can possibly cause, on brinjal, at Allahabad region, based on weather parameter was:

Number basis:

var5 = -99.064 + (3.268) **x** var1+ (-0.016) **x** var2+ (-8.140) **x** var3+ (2.172) **x** var4+ 11.420

Where,

Var1= Maximum temperature, var2 = Evening Relative humidity,
Var3 = Evening cloud cover, var4 = sun shine
Var5 = % fruit Damage on number basis. Intercept (a) = -99.064
Coefficient of determination (R Square) = 0.767 Standard Error = 11.420
Multiple Correlation Coefficient (R) =0.877
Regression coefficients and their significance using t test.

Independent Variables	Average	Regression coefficients (b)	Standard Error(SE(b))	T Test	t table (0.05)	Significance at 5% level
Max. Temp	34.018	3.268	1.109	2.953	2.160	S
Evening R.H.	43.536	-0.016	1.008	-0.015	2.160	NS
Evening cloud cover	1.765	-8.140	3.380	-2.406	2.160	S
Sun Shine	8.064	2.172	4.441	0.480	2.160	NS

It was observed that the coefficient of determination for fruit damage % was 0.767 which indicated that the climatic factors together were able to explain the variation in the fruit damage % to the extent of 76.70 out of 100.

Weight basis:

var5 = -95.967 + (3.316) **x** var1+ (-0.022) **x** var2+ (-8.071) **x** var3+ (1.560) **x** var4+ 11.163

Where,

Var1= Maximum temperature, var2 = Evening Relative humidity,
Var3 = Evening cloud cover, var4 = sun shine
Var5 = % fruit Damage on weight basis. Intercept (a) = -95.967
Coefficient of determination (R Square) = 0.767 Standard Error = 11.163
Multiple Correlation Coefficient (R) =0.877

Independent Variables	Average	Reg. coefficients (b)	Standard Error(SE(b))	T Test	T table (0.05)	Significance at 5% level
Max. Temp	34.018	3.316	1.079	3.070	2.160	S
Evening R.H	43.536	-0.022	0.989	-0.025	2.160	NS
Evening cloud cover	1.765	-8.071	3.303	-2.447	2.160	S
Sun Shine	8.064	1.560	4.344	0.363	2.160	NS

It was observed that the coefficient of determination for fruit damage % was 0.767 which indicated that the climatic factors together were able to explain the variation in the fruit damage % to the extent of 76.70 out of 100.

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RESEARCH ARTICLE

A LINEAR PROGRAMMING APPROACH TO CROPS AND LIVESTOCK ENTERPRISES PLANNING IN SUGARCANE BASED FARMING SYSTEM FOR MEDIUM CATEGORY OF FARMS IN DISTRICT MEERUT OF UTTAR PRADESH

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Abstract: A livelihood system is the full range of activities available to the medium category of farms. The farmers are often faced with the problem of how to select the optimal cropping patterns that significantly contribute to sustainable production. The present study was conducted during the year 2013-14 in District Meerut of Uttar Pradesh to know the possibilities of optimum combination of different enterprises for the enhancement of the farms income and employment of medium category of farms household's. Multi stage stratified random sampling design was used to collect the primary data from; a sample of 19 respondents was selected on the basis of probability proportion to size of holdings. In this study, a linear program that reflects these choices by selecting a combination of farm activities that is feasible given a set of fixed farm constraints and that maximizes income while achieving other goals such as food security is developed. The results obtained by using the linear programming model are more superior. The difference in gross income is 25.08 per cent higher than the existing farm plan and labour man days 37.01 per cent higher compare to the existing farm plan.

Keywords: Linear programming, Whole-farm plan, Employment generation

INTRODUCTION

Agriculture has been a source of income for a significant percentage of India's population for centuries. Integrated activities of crop production, livestock raising still bear important roles in the subsistent farming systems in India. India is the world's second largest producer of sugarcane. Sugarcane is cultivated on 5.06 million ha. producing about 352.14 million tonnes of sugarcane with an average productivity of 69.84 tonnes per ha. during 2013-14. In India, area under sugarcane is highest, 22.12 lac. ha. in Uttar Pradesh, and production 130.50 million tonnes coupled with the productivity is 59.60 tonnes/ ha. during 2013-14. The Indian economy is predominantly rural and agricultural, and the declining trend in size of land holding poses a serious challenge to the sustainability and profitability of farming there by affecting the rural population. In view of the decline in per capita availability of land from 0.5 ha. in 1950-51 to 0.15 ha. by the turn of the century and a projected further decline to less than 0.1 ha. by 2020, No single farm enterprise is likely to sustain the farming by the Marginal, small and medium farmers without resorting to integrated farming systems (IFS) for the generation of adequate income and gainful employment round the year. (Behera and Mahapatra, 2004).

Their LP model considered both economic and environmental goals simultaneously in a composite objective function. The optimal plan obtained achieved 88 percent of the goals considered. Abdelaziz *et al* (2010) used LP technique to analyze data. The results of the analysis showed that the models gave a cropping pattern different from the existing farmers' production plan. The results from LP models gave a profit while the farmers' plan resulted in a loss (Abdelaziz *et al*, 2010).

Thus the average size of operational holding has declined to 1.15 ha. in 2010-11 as compared to 1.23 ha. in 2005-06.The semi-medium and medium operational holding (2.00 ha. – 10.00 ha.) in 2010-11 were 14.29 percent with the operated area at 44.88 percent. The corresponding figures for 2005-06 Censuses were 15.86 percent and 47.05 percent. In a total of 138.35 million operational holdings in the country, the highest one belonged to Uttar Pradesh (23.33 million) Agriculture census 2010-11. The objective of this paper is to examine the role and challenges of medium holding agriculture in achieving agricultural growth, food security and livelihoods in India. Medium holdings also face new challenges on integration of value chains, liberalization and globalization effects, market volatility and other risks and vulnerability, adaptation of climate change etc.

Mohamad and Said developed an LP crop mix model for a finite-time planning horizon. Given limited available resources such as budget and land acreage, the crop-mix planning model was formulated and transformed into a multi-period linear programming problem. The objective was the maximization of the total returns at the end of the planning horizon. Linear programming models have successfully been formulated under different scenarios to model different kinds of complexities.

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RESEARCH METHODOLOGY

Study Area

The study was conducted in Meerut district. Agriculture forms the economic base and the province is known for its rich soils. Traditionally, farmers depend on traditional methods, such as, instinct and experience, and comparisons with neighbours in order to make decisions about what commodities to produce and in what quantities. This does not guarantee optimal crop patterns. Effective tools like LP can address this problem. According to Hilderbrand and Cabrera, "Linear programming is a useful, and with the wide availability of laptop computers, easily available method for describing and analyzing family farm livelihood systems." Linear programming can be used to select optimal crop combinations subject to fixed farm constraints. The objective of this study is to address the resource allocation problem faced by a Medium-scale farmer in Meerut by applying LP.

District Meerut was purposively selected for present investigation. Being homogeneous of all the Blocks, two blocks were selected randomly i.e. Hastinapur and Sardhana. Three villages were selected randomly from each block. List of all the farmers of the selected villages was prepared according to their land holding size. A sample of 32 respondent having area upto 1-2 hectare were selected on the basis of probability proportional to their total numbers. Required primary data on crops, livestock and other allied enterprises was collected by personnel interviewed method and secondary data was also collected from various published sources. CACP cost concept and linear programming is a systematic and accurate method of determining mathematically the optimum combination of enterprises or inputs so as to maximize the income or minimize the cost within the limits of available resources.

Programming approach of the following form was used use to optimize the return from Sugarcane Based Farming System.

Objective function –I (Maximization of income)

$$\text{Maximize } Z = \sum_{j=1}^{n} C_j X_j$$

Where,

Z = Net returns (income) variable cost in rupees

C_j= Net return over variable costs per unit of j-th activity in rupees

X_j = The level of j-th activity,

Subject to constraints:

$$\sum_{j=1}^{N} a_{ij} x_{ij} \leq b_i$$

Non-negative decision variable:

$Xij \geq 0$

Where:

a_{ij}= amount of i-th resource required for the j-th activity,

b_i = total available quantity of i-th resources.

i = 1, 2, 3,……..m, resources)

j = 1, 2, 3, …….n, activities)

The farmer must decide how many hectares that should be allocated to each activity. So the decisions are:

X_1 = hectares allocated for paddy production.

X_2 = hectares allocated for Jawar production.

X_3 = hectares allocated for sugarcane production.

X_4 = hectares allocated for wheat production.

X_5 = hectares allocated for potato production.

X_6 = hectares allocated for mustard production.

X_7 = hectares allocated for oat production.

X_8 = number allocated for buffalo rearing.

X_9 = number allocated for cow rearing.

The Linear Programming Formulation:

To visit the villages with prepared schedule and 120 respondents were selected on the basis of probability proportions to their population and 19 respondents were selected under medium category farms (2-4 hectares). The household is interested in cropping combination that helps them to maximize their total annual net returns and employment. Before the optimization model was constructed the household's existing plan was to allocate paddy, jowar, sugarcane, wheat, potato, mustard and oat were 0.52, 0.39, 1.63, 0.85, 0.82, 0.27 and 0.13 hectare respectively. Of prime importance is whether this crop enterprise production combination is optimal? Does it yield maximum net returns and employment? The resource constraints considered in this study, are land, labor and operating capital.

The goals of the objective function are to maximize income and employment generation and land allocation at subject to land, labor and cash available for production constraints.

The linear programming formulation for medium farmers was presented in the in the table 5.4.5. The average land holding size and labor availability of medium farm household in the study area was 2.56 ha and 360 man-days respectively in both the season. The working capital availability was Rs. 85640 and Rs. 83470 respectively in kharif and rabi season. The sugarcane production is important crop for attaining maximum return by the medium farmers in the study area which was included as minimum area constraint and value was 2.56 hectare land.

Table 1 represents the LP matrix. The Right Hand Side (RHS) represents the constraints on the resources.

Maximum Z-

$67749X_1+42493X_2+112026X_3+55179X_4+80334X_5+46222X_6+39639X_7+40786X_8+29225X_9-200X_{10}-200X_{11}-0.1X_{12}-0.1X_{13}$ (Objective function)

Subjected to

$X_1+X_2+X_3+ \leq 2.56$ (Kharif land constraints)

$X_3+X_4+X_5+X_6+X_7 \leq 2.56$ (Rabi land constraints)

$106X_1+36X_2+75X_4+34X_8+24X_9-1X_{10} \leq 360$ (Kharif labour constraints)

$73X_3+46X_4+73X_5+30X_6+31X_7+26X_8+21X_9-1X_{11} \leq 360$(Rabi labour constraints)

$29835X_1+14643X_2+29280X_3+31382X_8+26254X_9-1X_{12} \leq 85640$ (Kharif working constraints)

$26881X_3+25761X_4+62572X_5+17029X_6+14314X_7+30091X_8+24823X_9-1X_{13} \leq 83470$ (Rabi working constraints)

$X3 \geq 0.60$ (Minimum area constraints)

$X_1,X_2,X_3,\ldots\ldots\ldots X_{13} \geq 0$ (non negative constraints)

Table 1. Linear Programming Matrix

Crop	**Paddy (0.30)**	**Jowar (0.21)**	**Sugarcane (0.59)**	**Wheat (0.35)**	**Potato (0.24)**	**Mustard (0.13)**	**Oat (0.05)**	**Buffalo* (1.3)**	**Cow* (1.1)**	**KHL**	**RHL**	**KB**	**RB**	**Constraints**
Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	
Kharif Land (hectare)	1	1	1	-	-	-	-	-	-	-	-	-	-	≤ 2.56
Rabi Land (hectare)	-	-	1	1	1	1	1	-	-	-	-	-	-	≤ 2.56
Kahrif Laboure (man-days)	106	36	75	-	-	-		34	24	200	-	-	-	≤ 360
Rabi Laboure (man-days)	-	-	73	46	73	30	31	26	21	-	200	-	-	≤ 360
Kahrif working capital (Rs.)	29835	14643	29280	-	-	-	-	31382	26254	-	-	-1	-	≤ 85640
Rabi working capital (Rs.)	-	-	26881	25761	62572	17029	14314	30091	24823	-	-	-	-1	≤ 83470
Minimum area (hectare)	-	-	-	-	-	-	-	-	-	-	-	-	-	**≥ 0.60**
Net Return (Rs.)	67749	42493	112026	55179	80334	46222	39639	40786	29225	-	-	-	-	

KHL-Kharif Hired Laboure, RHL-Rabi Hired Laboure, KB- Kahrif Borrowing, RB-Rabi Borrowing

RESULT AND DISCUSSION

Optimum Combination of Different Enterprises

The linear programming formulation was solved by using computer based software and results of existing and optimum resource allocation plan of medium farmers are presented in table- 2. In existing plan area under paddy, jowar, sugarcane, wheat, potato, mustard and oat were 0.52, 0.39, 1.63, 0.85, 0.82, 0.27 and 0.13 hectare respectively whereas all the area in optimum farm plan covered fewer than three crops viz: sugarcane, potato and oat with 0.52, 0.25 and 0.52 hectare respectively and other crops were not feasible in selected area due to their minor importance in returns. Similarly buffalo and cow were in number of 3.30 and 2.15 respectively in the existing farm plan but due to greater importance of buffalo in planning, it appears 11.48 in numbers in to optimum farm plan.

Table 2. Optimum Combination of Different Enterprises Suggested by LP Model

Crop	Variables	Land Allocation			Labour			Net Return		
		Existing	Optimum	%Δ	Existing	Optimum	%Δ	Existing	Optimum	%Δ
Paddy	X_1	0.52	0	-100	55.12	0	-100	35229.48	0	-100
Jowar	X_2	0.39	0	-100	14.04	0	-100	16572.27	0	-100
Sugarcane	X_3	1.63	0.60	-63.19	241.24	88.08	-63.19	182602.40	67215.60	-63.19
Wheat	X_4	0.85	0	-100	39.10	0	-100	46902.16	0	-100
Potato	X_5	0.82	1.96	139.02	59.86	143.08	139.02	65873.88	76894.29	139.02
Mustard	X_6	0.27	0	-100	8.10	0	-100	12479.94	0	-100
Oat	X_7	0.13	1.96	1407.69	4.03	60.76	1407.60	5153.07	157454.64	1407.60
Buffalo	X_8	3.30	11.48	247.81	198	688.66	247.81	134593.80	468127.43	247.81
Cow	X_9	2.15	0	-100	96.75	0	-100	62833.75	0	-100
Total					**716.24**	**981.30**	**37.01**	**562240.70**	**703235.58***	**25.08**

Further linear programming resulted into a net return of □703235.58 in optimum farm plan as compared to □ 562240.72 in existing farm plan. There is an absolute improvement in net return which was 25.08 per cent higher than the existing farm plan. The land was fully utilized in optimum farm plan, whereas, requirement of labor man-days was 37.01 per cent higher in optimum farm plan than the existing farm plan. Analysis indicates that optimal farm plan seems more feasible because it create more opportunity for employment to the medium farm families in the study area. Thus from the optimal plans for medium categories of households, it could be inferred that there are significant potentials for income and employment generation in the study area.

The increased labour requirement has arisen, because the new optimal plans suggest inclusion of a higher number of the existing livestock species in the farming systems, which are believed to be labour intensive.

CONCLUSION

In this paper, a medium farm livelihood system in District Meerut of Uttar Pradesh is modelled with LP. The LP model developed solves the problem of how to select a combination of farm activities that is feasible given a set of fixed constraints and that maximizes profit while achieving other goals such as employment generation. Comparison of results obtained by using traditional method of planning and LP model reveal that results obtained from the LP model are more superior.

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RESEARCH ARTICLE

SENSORY CHARACTERISTICS OF FRESH EXTRUDED *PEDA*

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Abstract: The traditional dairy products carry value in the indian society as they are nutritious and have become the invitable part of feasts, celebrations, festivals and religious rites. *Peda* is one of the most popular khoa based traditional dairy sweets enjoyed by everyone due to its taste and health aspects.Traditionally, it is prepared by heating a mixture of *khoa* and sugar in a *karahi* (iron pan) with the help of *khunti*until the desired granular, hard texture and flavour develops. Present study was undertaken to investigate the possibilities of inducting extrusion technology for production of acceptable quality *peda*. The extruded *peda* were prepared by introducing product mixes C_0 (70% *khoa*& 30% sugar); C_1 (60% *khoa*, 05% SMP, 05% *ghee*& 30% sugar); C_2 (55% *khoa*, 10% SMP, 05% *ghee*& 30% sugar) and C_3 (50% *khoa*, 15% SMP, 05% *ghee*& 30% sugar) into the extruder system and processed at barrel temperature of 60, 70 & 80^0C and screw speed 14, 21 & 28 rpm. Among different set of treatment combinations, product mix C_2(i.e. 55% *khoa*, 10% SMP, 05% *ghee*& 30% sugar) processed at 80^0C barrel temperature and 28 rpm screw speed resulted in most acceptable extruded *peda* in terms of sensory characteristics.

Keywords: Khoa, Peda, Extruded peda, Extrusion technology

INTRODUCTION

Traditional dairy products and sweets are an integral part of Indian heritage and have great social, religious, cultural, medicinal and economic importance. It is estimated that about 50-55% of total milk produced in India is converted into variety of traditional dairy products by the traditional unorganised sector i.e. *halwais*by using various processes such as heating, heating cum acid coagulation, heat dessication and fermentation (Bandyopadhyay *et al*., 2006). It is also estimated that out of these around 7% of milk is used for manufacture of popular heat desiccated traditional dairy products. *Khoa* occupies a prominent place in traditional indian dairy products sector. Among the different traditional dairy products prepared from *khoa*, *peda* have high commercial significance because of their popularity throughout the country and relatively longer shelf life than other sweets (Naresh *et al.*, 2009). Traditionally, *peda* is mostly prepared by heating a mixture of *khoa* and sugar in a *karahi* (iron pan) with the help of *khunti*until the desired granular, hard texture and flavour develops. Its mechanized process invloves heating *khoa* to 60^0C and adding sugar, flavour and other ingredients in a planetary mixer. The dough after cooling to 5^0C is fed to *peda* shaping machine followed by packaging (Banerjee, 1997).

Extrusion technology has become very popular and is being increasingly used for the manufacture of various food products. In the extrusion technology, single or twin screw food extruder are used to transport, mix, knead, shear and/or cook multiple ingredients into a uniform food product by forcing the ingredient mix through die to produce specific shapes and lengths (Riaz, 2000). Extrusion is currently utilized to produce textured protein products, snack foods, toast and confectionary products. In spite of its immense potential, in the dairy industry extrusion technology is rarely utilized. Some research work has been done, on only very few products examples is casein/caseinate production (Fichtali, 1990), production of processed cheese (Zuber *et al.*, 1987; Kazuo *et al.*, 1993; Adhikari *et al.*, 2009), mozzarella cheese (Ferrari *et al.*, 2003), *sandesh* (Kumar and Das, 2007) etc. Extrusion is a very useful technology for dairy processing operations involving conveying, mixing, kneading, cooking, shearing and shaping which is yet to be exploited by the dairy industry.Considering the capability of extrusion machine, a study was undertaken to investigate the possibilities of inducting extrusion technology for production of acceptable quality extruded *peda*.

MATERIALS AND METHODS

Good quality fresh *khoa* and *ghee*were obtained from Chhattisgarh State Cooperation Dairy Federation Ltd., Urla, Raipur. Skim Milk Powder, (SAGAR,

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AmulFed Dairy, Bhat) and sugar of commercial grade were procuredfrom local market of Raipur city.

Details of product mix

The quality of any finished product depends on the properly balanced high quality raw ingredients. In this study *khoa* (75% total solid) @ 70, 60, 55 & 50% were used as base materails for making extruded *peda* in all four treatment combinations i.e. C_0, C_1, C_2& C_3 respectively. Skim milk powder (SMP) @ 0, 5, 10 & 15% were used as a source of milk solid not fat to replace amount of *khoa* in C_0, C_1, C_2& C_3 respectively. *Ghee* @ 5% were used as a source of milk fat and kept constant in combination C_1, C_2 and C_3. Cane sugar @ 30% by weight of *khoa* was added to sweeten the product in all four combinations in ground form in order to enhance degree of mixing. The details of treatment combinations used for preparation of extruded *peda* were as below:

C_0 : 70% *khoa*0% SMP, 0% *ghee*& 30% sugar (control)

C_1 : 60% *khoa*, 5% SMP, 5% *ghee*& 30% sugar

C_2: 55% *khoa*, 10% SMP, 5% *ghee*& 30% sugar

C_3: 50% *khoa*, 15% SMP, 5% *ghee*& 30% sugar

Twin screw extruder system

In the food process industry single or twin- screw extruder is commonly employed to produce range of food products due to its versatility in nature. In this study, a twin screw co-rotating extruder(Model: SY 30-IV, Jinan Saibainuo Technology Development Co. Ltd., China) was used in order to evaluate its functionality and applicability for manufacturing extruded *peda*.The complete specifications of the twin screw extruder used in the study for manufacture of extruded *peda* is presented in Table 01.

Table 1. Specifications of the TSE for production of extruded *peda*

Diameter of screw	2.6 cm
Root diameter	1.9 cm
No. of flight	33
Flight clearance	0.5 mm
Pitch	3.4 to 1.8 cm
Channel width	2.6 to 1.2 cm
Axial Flight width	4 to 2 mm
Flight depth	3 to 4 mm
Total axial length of flighted section of screw	65 cm
Helix angle	17^0
Diameter of barrel	5.7 cm
Barrel length	65 cm
Length of feeding zone	7 cm
Length of heating zone	58 cm
Diameter of mould plate die	2 cm

The extruder had four temperature control zones along the barrel where heating was performed by four induction heaters. Every heating zone also had water jacket for cooling function. The twin screw speed of extruder system was controlled by variable frequency drive (VFD) motor (3 phase, 7.5 HP) with gear box. All the parameters of the extruder were controlled through the LCD computer control system.

Processing parameters

The performance characteristics were investigated as a function of barrel temperature and screw speed. Preliminary trials have been conducted to optimize the operational parameters in which three levels of barrel temperature i.e. 60, 70 & 80^0Cand three levels of screw speed i.e. 14, 21 & 28 rpm were selected. The product mixes C_0, C_1, C_2& C_3were subjected to above process parameters to produce extruded *peda*.

Manufacture of extruded *Peda*

The process chart for manufacture of extruded *peda* is shown in Fig. 01. The extruder system was put into the operation after setting of processing parameters and stabilization of barrel temperatures. The product mix which consisted of C_0 (70% *khoa*0% SMP, 0% *ghee*& 30% sugar); C_1 (60% *khoa*, 05% SMP, 05% *ghee*& 30% sugar); C_2 (55% *khoa*, 10% SMP, 05% *ghee*& 30% sugar) and C_3 (50% *khoa*, 15% SMP, 05% *ghee*& 30% sugar) was introduced into the feeding section of twin screw co-rotating extruder. The product mixes C_0, C_1, C_2& C_3were extruded at each of the three different barrel temperatures (60, 70, 80^0C) and screw speeds (14, 21, 28 rpm). The extruder was emptied and cleaned between each run. During the extrusion processing, the product mixes was handled by the screw flight while moving and conveyed forward through a mixing/kneadingsection, evaporation/cooking section and finally extruded through the mould plate fitted at the exit. *Peda* mass was collected in a clean tray and after cooling to room temperature, it was then formed manually to round balls of about 20-25 g each. Fresh product was then subjected to sensory evaluation.

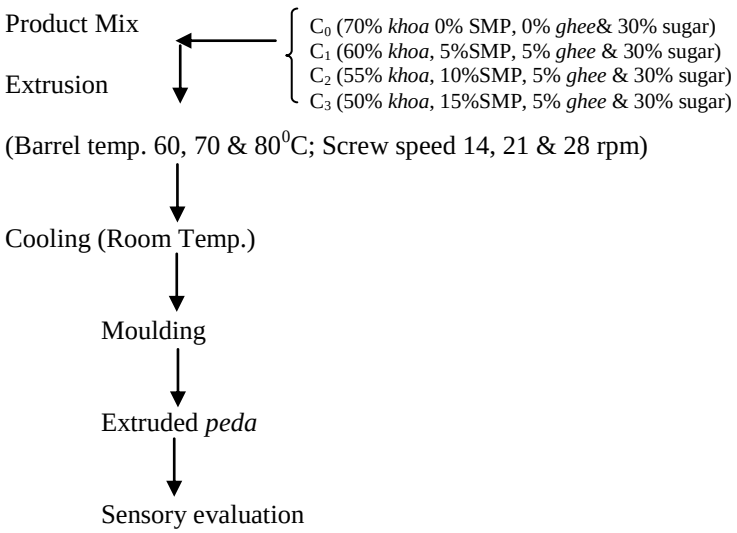

Fig.1: Process chart for manufacture of extruded *peda*

Sensory evaluation

In order to check the consumer acceptance and opinion sensory evaluation was carried out for fresh extruded *peda*samples by using 9 point Hedonic scale (ranging from 1 = disliked extremly to 9 = liked extremly) as developed by Gupta (1976). The product was made in replicates of three and served to a panel of five judges for sensory properties such as colour and appearance, flavour, sweetness, body & texture and overall acceptability.

RESULTS AND DISCUSSION

Effect of barrel temperature

Three-barrel temperature i.e. 60, 70 and 80^{0}C were selected for study. Below the barrel temperature of 70^{0}C the sensory qualities of the extruded *peda* was found to be undesirable. It was observed that during extrusion cooking of product mixes, barrel temperature of 60^{0}C resulted in under-cooked product. The lowest sensory score recorded were 7.02, 6.54, 7.06, 7.26 and 6.90 for sensory characterisics colour and appreance, body and texture, flavour, sweetness and overall acceptability respectively. It was observed from Table 2 that sensory characteristics of extruded *peda*increased significantly ($P< 0.05$) with increasing barrel temperature.

The sensory quality of *peda* with respect to flavour (sweet pleasant), body and texture (smooth and soft texture) and colour and apperance (slight yellow brown) was found to be good (acceptable) at barrel temperature of 80^{0}C. It was noticed that, beyond the highest selected temperature of 80^{0}C and screw speed of 28 rpm the flavour, body & texture and colour and appearance of extruded *peda* resulted in slightly nutty and cooked flavour, firm body and pronouced brown colour respectively.At very high temperature squeezing of free fat was observed which may be due to the rupturing of fat globule membrane which resulted in firm body & texture of the finished product. The results are in agreement with Boghra and Mathur (1996) where they reported that there is release of free fat due to rupturing of fat during high heat treatment processing of *khoa* and *peda*. The exit temperature of melt of the extruded *peda* mass was somewhat higher than the selected barrel temperature during the extrusion processing. This may be due to the frictional heat generated between the screw and barrel surfaces. This observation is consistent with studies done by Riaz (2000) and Guy (2001). The desirbale brown colour at a barrel temperature of 80^{0}C with screw speed of 28 rpm could be attributed to the maillard browning when the product exposed to high temperature.

Table 2. Effect of barrel temperature on sensory properties of freshextruded *peda*

Barrel temp. (^{0}C)	Sensory properties				
	Colour &Appearance	Body & Texture	Flavour	Sweetness	Overall Acceptability
60	7.02^a	6.54^a	7.06^a	7.26^a	6.90^a
70	7.17^{ab}	6.87^b	7.35^b	7.38^{ab}	7.10^b
80	7.27^b	7.15^c	7.37^b	7.40 ^{b}	7.23^b

F value	1.13	18.71	9.58	2.53	5.78
SE	0.22	3.40	1.04	0.22	1.01
CD (5%)	0.21	0.20	0.15	0.14	0.19

Effect of screw speed

In order to avoid burning of milk solids due to sticking over the inner surface of extruder barrel and uniform distribution of product mix during processing, it is required to be scraped countinously. Three screw speed i.e. 14, 21 and 28 rpm were selected for this study.

In *peda* making, the speed of screw plays an important role in deciding the quality of product in general and body and texture in particular. It was observed from Table 3 that the increased speed of screw improved the overall quality of extruded *peda*. Moreover, the body and texture score and thereby overall acceptability increased significantly ($P< 0.05$) with increasing speed of screw. Shorter residense time is desirable for better product characteristics, which are achieved at higher screw speeds. The maximum score for colour and appreance (7.30), body and texture (7.37), sweetness (7.40) and overall acceptability (7.15) were recorded for the *peda* processsedat the higher screw speed of 28 rpm while flavour (7.41) obtained at screw speed 14 rpm. Higher scew speeds promotes shorter residence time, efficient mixing and better dispersion of the product within extruder barrel. Narwade *et al.*, (2007) obtained higher sensory score for *peda* samples made traditionally at higher speed of stirrer. Similarly, Reddy (1985) also recorded higher sensory score and recommended high speed of stirrer for the manufacture of *peda*. However, the mixer/extruder screw speed influences some compositional (moisture & fat) and functional (free oil) characteristics of the product after some extent (Renda *et al.*, 1997). They reported higher screw speed causes higher fat loss which resulted in lower moisture and fat content in final finished product. This findings is also in agreements with Chennigaraju *et al.* (2005). They recorded increased hardness in recombined butter from 0.3353 kg/cm^2 at a linear screw speed of 0.14 m/s to 0.4126 kg/cm^2 at the screw speed of 0.38 m/s. The increase in hardness with the increase in screw speed may be attributed to the increase in pressure developed at the end of the screw forming system. But, in present study twin screw extruder were operated with an open end, therefore the pressure gradient along the down stream direction was small. The dominant flow were drag flow by the screw root. The selected highest screw speed i.e. 28 rpm was found to be optimum to produce acceptable quality products.

Table 3. Effect of screw speed on sensory properties of fresh extruded *peda*

Screw speed (rpm)	Sensory properties				
	Colour &Appearance	Body & Texture	Flavour	Sweetness	Overall Acceptability
14	7.05^a	6.83^a	7.41^b	7.21^a	6.95^a
21	7.16^{ab}	6.86^a	7.28^b	7.33^{ab}	7.13^{ab}
28	7.30^b	7.37^b	7.09^a	7.40^b	7.15^b
F value	0.07	0.05	8.24	0.80	2.61
SE	0.01	0.01	0.90	0.07	0.45
CD (5%)	*0.21*	*0.20*	*0.15*	*0.14*	*0.19*

Effect of product mix

Four levels of spray dried skim milk powder viz. 0, 5, 10 & 15 parts and khoa 70, 60, 55 & 50 parts were used for making extruded *peda*. In all the combinations sugar level were kept constant viz. 30 parts while ghee level were kept constant viz. 5 parts in all SMP added formulations. Extruded *peda* were prepared according to the method already described in Fig.01. Most of the judges preferred extruded *peda*samples prepared from C2 combination. The effect of the levels of ingredients on sensory quality of extruded *peda* has been shown in Table 4.

The maximum score for colour and apprearance (7.40), sweetness (7.43) and overall acceptability (7.40) were recorded for the combination C_2. The highest score for body and texture (7.17) were recorded for combination C_3 while flavour (7.44) for combination C_1. However, combination C_2 were at par with combination C_3& C_1in body & texture and flavour attributes respectively. During the experiment it was observed that combination C_0 produces dark colour and loose body which resulted in poor overall acceptability score. combination C_3 resulted in powdry taste, under cooked and hard body in finished products. It may be due to the higher

concentraion of solid not fat and lesser amount of fatty material content. This observation is consistent with studies done by Londhe (2006) and Suryawanshi *et al.*(2014).

Table 4. Effect of product mix on sensory properties of fresh extruded *peda*

Product mix	Sensory properties				
	Colour & Appearance	Body & Texture	Flavour	Sweetness	Overall Acceptability
C_0	6.95^{a}	6.54^{a}	7.20^{ab}	7.24^{a}	6.66^{a}
C_1	7.26^{bc}	6.58^{a}	7.44^{c}	7.39^{ab}	7.00^{b}
C_2	7.40^{c}	7.11^{b}	7.30^{bc}	7.43^{b}	7.40^{c}
C_3	7.13^{ab}	7.17^{b}	7.11^{a}	7.34^{ab}	7.25^{c}
F value	4.93	16.65	5.06	1.84	15.91
SE	0.99	3.02	0.55	0.16	2.78
CD (5%)	0.24	0.23	0.17	0.16	0.22

CONCLUSION

The present investigation provides information on feasibility of extrusion processing on the quality of *peda*. Based on the statistical analysis of sensory data treatment combination C_2 (i.e. 55% *khoa*, 10%SMP, 5% *ghee*& 30% sugar) processed at 80^0C barrel temperature and 28 rpm screw speed were found the best. Hence, the twin screw co-rotating extruder could be used for cooking of *khoa*, sugar, SMP mix to get the soft garde extruded *peda* with desired quality.

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RESEARCH ARTICLE

IMPACT OF PRICING POLICY ON DOMESTIC PRICES OF SUGAR IN INDIA

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Abstract: The present study is based on secondary data collected from the various published sources, *viz.* various issues of Cooperative Sugar, Indian Sugar, Published by Indian Sugar Mills Association, Statistical Abstract of India, Indian Agriculture in Brief and Agriculture Prices in India, Data on various aspects including domestic prices of sugar, production of sugar and sugarcane, prices of sugarcane, consumption of sugar, stocks of sugar, quantity of sugar exported and sugar imported for the period 1947-48 to 2013-14 were collected. The main objective of paper is to analyses the impact of price policy on domestic prices of sugar in India. Multiple regression function was used to ascertain the impact of pricing policy on domestic prices of sugar. The study revealed that the increased sugar production had a negative impact on price of sugar. Positive and significant impact of sugarcane price on sugar was observed for all periods under study.

Keywords: Consumption**,** Export-import, Multiple Regression, Price policy, Sugar prices

INTRODUCTION

Sugar is one of the most important commodities; produced and consumed around the world. Sugar is produced in over 123 countries worldwide but over 70 per cent of world sugar production is consumed domestically and the remaining is traded in the world. In 2014-15, the global production of sugar was 1743.08 lakh tonnes and the global consumption was 1706.00 lakh tones (USDA Report, 2015).World sugar markets have experienced over the last decade a number of fundamental changes which translated into both challenges and opportunities for sugar producing countries. There is substantial government intervention in world sugar markets. Almost all the developed and developing countries protect their domestic sugar production. World sugar market has also been characterized by periods of short-lived price spikes followed by low and downward trending price patterns. This price behavior emerges as a result of extensive use of protective policy measures by governments that isolate sugar producers from the world market. These features make the world sugar market a vital target for policy analysis. There are broad areas of public intervention that regulate the sugar market in India. The government continues to use a buffer stock policy and adjusts its trade policy instruments, depending on domestic production, the price situation, and the global scenario. The guiding principle behind this is allowing domestic prices to move in tandem with trends in world prices but insulating them from sharp troughs and spikes. This has helped India maintain stability in domestic market prices compared to international prices. There are broad areas of public intervention that regulate the sugar market in India, which include domestic price support in form of minimum statuary price/fair and remunerative price (FRP), stock policy, Government's policy of control, Decontrol and partial control, sugar levy. In addition, policy decision on import tariff rates, export and import subsidies, export restrictions, import licensing *etc.* are also taken from time to time to maintain stability in domestic prices of sugar. How such interventions have impacted the domestic prices of sugar has been attempted in the present paper.

METHODOLOGY

The main objective of paper is to analyses the impact of price policy on sugar prices in India. The present study is based on secondary data collected from the various sources, *viz.* Cooperative Sugar, Indian Sugar, Statistical Abstract in India, Indian Agriculture in Brief and Agriculture Prices in India *etc*, Data on various aspects including domestic prices of sugar, production of sugar and sugarcane, prices of sugarcane, consumption of sugar, stocks of sugar, quantity of sugar exported and sugar imported for the period 1947-48 to 2013-14 were collected. The data were grouped into four periods depending upon the extent of government intervention in terms of control, decontrol or partial control through various levels of levy on sugar. Period-I is characterized by decontrol of government on sugar and ranged from 1947-48 to 1966-67. Period-II ranged from 1967-68 to 1987-88 which was the period of partial control and extent of levy sugar was 50 per cent or more. Period-III ranged from 1988-89 to 2011-12 and again was the period of partial control, when levy sugar was less than 50 per cent. Period-IV denotes overall period of study ranging from 1947-48 to 2013-14.Wide range of government policies interventions like subsidy policies, import and export policies, general macroeconomic policies; change in exchange rate, trade policies, export quotas, minimum export price(MEP), increasing/decreasing credit availability, removal of quantitative restrictions, non-tariff barriers, import licensing and import restrictions etc do exist

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however, in the present study to ascertain the impact of government intervention on domestic prices of sugar, the variables included were domestic prices of sugar, production of sugar and sugarcane, prices of sugarcane, consumption of sugar, stocks of sugar, quantity of sugar exported and sugar imported. Multiple regression function of the following form was used to analyze the data:

$Y_i = b_0 + \sum_{i=1}^{9} b_i X_i + U_i$

Where,

Y_i= Domestic prices of sugar (Rs./q)

b_0 = Intercept

b_1= Partial regression coefficients

X_1= Production of sugar (lakh tonnes)

X_2= Production of sugarcane (lakh tonnes)

X_3= Price of sugarcane (Rs./q)

X_4= Consumption of sugar (lakh tonnes)

X_5= Stocks of sugar (lakh tonnes)

X_6=Quantity of sugar imported (lakh tonnes)

X_7= Quantity of sugar export (lakh tonnes)

X_8=Dummy variable for control/decontrol

(X_8=1if control)

(X_8= 0 if decontrol)

X_9= Dummy variable for partial control

(X_9= 1if partial control)

(X_9= 0 otherwise)

U_i= Error term

RESULTS AND DISCUSSION

In the early forties and prior to independence, there was complete control on sugar trade in India. Immediately after independence, trade was totally decontrolled. However, it was put under control again after two years. At the start of planning era in India in 1950-51, for the first time, the sugar trade was put under partial control for two years. It stood decontrolled for continuous six years for the period 1952-53 to 1957-58, there after sugar was again put under control for seven years i.e. 1958-59 to 1966-67 except two years of decontrol (1961-62 and 1962-63). The extent of partial control ranged between 10 per cent to 50 per cent of levy sugar and 90 per cent to 50 per cent of free sale sugar. Since 1967-68, the domestic sugar trade in country has more or less been under partial control barring a few years (decontrol during 1977-78 and control during 1978-79). Thus, sugar trade in India witnessed a mixed trend of control, decontrol and partial control in terms of various levels of levy. Similar results were found by C.P Timmer in his work that continuous market interventions and price controls have an impact on the development of a private marketing sector. Investments in physical and human capacity in this sector are not forthcoming if margins arc squeezed, policy implementation is erratic or the middle man is held responsible for policy failures. The loss is the absence of competitive traders in search of marketing opportunities for new commodities or greater volumes. Similar findings were observed by Jyothi and K.C. that since independence, the Government control varied from total control to partial control and total decontrol. The Government control covers all aspects of Sugar business, i.e. licensing, capacity, cane area, procurement, cane pricing, sugar pricing, sugar distribution, imports and exports. The Government control varies from full control to partial and hill decontrol which depends upon the local demand. Due to highly politicized and fluctuating policies of the Government, Sugar imports and Exports also vary to a great extent from time to time. Also similar results found in report of Cabinet which approves Partial Decontrol of Sugar Industry Prime Minister Manmohan Singh abolished the sugar levy and deregulated sale of sugar in the open market. The proposal was based an expert committee report. Sugar industry will continue to be subject to production control by state governments, including sugar industry licensing, specifying area for procurement of cane for each sugar mill and cane pricing. Decontrol of sugar marketing will be reviewed in two years after assessing its effect on farmers and market prices. And on other hand Rangarajan Committee which recommended complete decontrol of the sugar industry dispensing with the sugar levy, decontrolling sugar sales, deregulating sugar purchases by mills and substituting FAR pricing for state-set prices.

Impact of Government Intervention and Other Factors Influencing Domestic Prices of Sugar

Period-I

Table 1 shows the results of the analysis for period-I. The value of R^2 revealed that the independent variables explained the dependent variable by 97 per cent. There was a positive and significant impact of sugarcane prices on sugar prices. An Increase in theprices of sugarcane by 1.00 Rs./q increased prices of sugar by 19.08 Rs./q. All other variables were found to be non-significant.

Period-II

The sugarcane production and sugarcane prices had positive and significant impact on prices of sugar whereas, the increase in sugarcane production by one lakh tonne decreased the sugar price by 1.97Rs./q. Increase in sugarcane price by 1.00 Rs./q significantly increased the sugar price (by 60.34Rs./q).sugar stocks had significant but negative impact on sugar prices whereas, increase in sugar stocks led to decline in the sugar prices by 7.79Rs./q with one lakh tonne increase.Results presented in Table 4.2.2 revealed that during the period-II, value of coefficient of multiple determination was 0.92 and it suggested that the model of multiple regression was well fitted and variable mentioned explained the price of sugar by 92 per cent.

Period-III

The results presented in Table 3 revealed that during the period-III, the 0.97 value of coefficient of multiple determination suggested that the model of multiple regression was well fitted and variable

mentioned affected the prices of sugar by 97 per cent. Results further revealed that with increase in production of sugar by one lakh tonne, sugar price will be decreased by 5.93Rs./q. Further increase in price of sugarcane by 1.00Rs./q will increase the price of sugar by 20.10Rs./q. The increase in stocks of sugar by one lakh tonne resulted in decrease of sugar price by 3.56Rs./q. Remaining variables were found to be non-significant.

Period-IV

Data presented in Table 4 showed that during the period-IV there was a positive and significant impact of sugarcane production, sugarcane prices and sugar consumption on prices of sugar. The increased sugarcane price and sugar consumption increased sugar price by 13.46Rs./q and 3.34Rs./q, respectively. Similar to previous periods, increased sugar stocks decreased the sugar price by 3.90Rs./q. The value of coefficient of multiple determination obtained was 0.97 and it suggested that multiple regression model was well fitted and variable mentioned affected the sugar price by 97 per cent.

Comparative analysis of impact of government intervention and the effect of other explanatory variables on domestic prices of sugar for all the four periods have been given in table 4.2.5. The results reveal that the increased sugar production had a negative impact on price of sugar. With an increase in production of sugar by one lakh tonne, the prices decline by Rs.5.92/q in period-III. The coefficient was also found to be significant for period-III. However, for other periods, the regression coefficients were negative and non-significant. Positive and significant impact of sugarcane price was observed for all periods under study indicating that as the price of sugarcane increases, the sugar price will increase in a significant manner. The values of regression coefficients were found to be 19.08, 60.34, 20.10 and 13.46 respectively.

The value of regression coefficient for sugar stocks was found to be negative and significant for period-II, period-III period- IV. For period-I, such figure was negative but not significant. Negative signs of the regression coefficients indicate that with increase in stocks of sugar, the prices of sugar in the domestic market will decline.

Comparative analysis of impact of government intervention and the effect of other explanatory variables on domestic prices of sugar for all the four periods revealed that the increased sugar production had a negative impact on price of sugar with an increase in production of sugar by one lakh tonne, the prices decline by Rs.5.92/q in period-III. However, the coefficient was found to be significant for period-III only. Positive and significant impact of sugarcane price was observed for all the periods under study indicating that as the price of sugarcane increases, the sugar price will increase in a significant manner. The values of regression coefficients were found to be 9.08, 60.34, 20.10 and 13.45, respectively.The value of regression coefficients for sugar stocks was found to be negative and significant for period-II, period-III period- IV and period-I, such figure was negative but not significant. Negative signs of the regression coefficients indicate that with increase in stocks of sugar, the prices of sugar in the domestic market will decline.

Table 1. Impact of government intervention and other factors influencing domestic prices of sugar during period-I

Variables	Regression coefficients	Standard Error	t-value
b_0(constant)	-6.49	-	-
Sugar production (lakh tonnes)	-0.06	0.992	-0.06
Sugarcane production (lakh tonnes)	0.023	0.02	0.82
Sugarcane prices (Rs./q)	19.08**	5.78	3.29
Sugar consumption (lakh tonnes)	0.27	0.77	0.35
Sugar stocks (lakh tonnes)	-0.52	0.77	-0.67
Dummy variable for control/decontrol	2.529	5.043	0.50
R^2	**0.97**		

**Significant at 5% level of probability

Table 2. Impact of government intervention and other factors influencing domestic prices of sugar during period-II

Variables	Regression coefficients	Standard Error	t-value
b_0(constant)	-484.23	-	-
Sugar production (lakh tonnes)	-1.97	3.80	-0.52
Sugarcane production (lakh tonnes)	0.44**	0.19	2.30
Sugarcane prices (Rs./q)	60.34**	17.01	3.55
Sugar consumption (lakh tonnes)	-4.66	2.01	-2.31
Sugar stocks (lakh tonnes)	-7.79**	3.03	-2.57

Dummy variable for partial control	75.70	68.47	1.11
R^2	0.92		

**Significant at 5% level of probability

Table 3. Impact of government intervention and other factors influencing domestic prices of sugar during period-III

Variables	**Regression coefficients**	**Standard Error**	**t-value**
b_0(constant)	21.40	-	-
Sugar production (lakh tonnes)	-5.93**	2.01	-2.95
Sugarcane production (lakh tonnes)	0.68**	0.24	2.81
Sugarcane prices (Rs./q)	20.10**	2.40	8.37
Sugar consumption (lakh tonnes)	1.62	1.90	0.85
Sugar stocks (lakh tonnes)	-3.56**	1.49	-2.40
Dummy variable for partial control	-605.50	88927.33	-0.01
R^2	**0.97**		

**Significant at 5% level of probability

Table 4. Impact of government intervention and other factors influencing domestic prices of sugar during period-IV

Variables	**Regression coefficients**	**Standard Error**	**t-value**
b_0(constant)	-233.45	-	-
Sugar production (lakh tonnes)	-1.65	1.40	-1.17
Sugarcane production (lakh tonnes)	0.27**	0.09	2.87
Sugarcane prices (Rs./q)	13.46**	1.32	10.14
Sugar consumption (lakh tonnes)	3.34**	1.12	2.97
Sugar stocks (lakh tonnes)	-3.90**	1.39	-2.80
Dummy variable for control/decontrol	23.93	71.06	0.33
Dummy variable for partial control	115.15	65.47	1.75
R^2	**0.97**		

**Significant at 5% level of probability

Table 5. Comparative analysis of impact of government intervention and other factors influencing domestic prices of sugar for selected periods

Variables	**Period-I**	**Period-II**	**Period-III**	**Period-IV**
b_0(constant)	-6.49	-484.23	21.40	-233.45
Sugar production (lakh tonnes)	-0.06 (0.99)	-1.97 (3.80)	-5.92** (2.01)	-1.65 (1.40)
Sugarcane production (lakh tonnes)	0.02 (0.02)	0.44** (0.19)	0.68** (0.24)	0.27** (0.09)
Sugarcane prices (Rs./q)	19.08** (5.78)	60.34** (17.01)	20.10** (2.40)	13.46** (1.32)
Sugar consumption (lakh tonnes)	0.27 (0.77)	-4.66** (2.01)	1.62 (1.90)	3.34** (1.12)
Sugar stocks (lakh tonnes)	-0.52 (0.77)	-7.79** (3.03)	-3.56** (1.48)	-3.90** (1.39)
Dummy variable for control/decontrol	2.529 (5.04)	-	-	23.93 (71.06)
Dummy variable for Partial control	-	75.70 (68.470)	605.50 (88927.33)	115.15 (65.47)
R^2	0.97	0.92	0.97	0.97

**Significant at 5% level of probability

CONCLUSION

Multiple regression analysis revealed that production of sugar and sugarcane, consumption of sugar, stocks of sugar, price of sugarcane, were the major components to impact the domestic prices of sugar.Keeping in view, the stability and to check increase in prices of sugar. The partial control may be a desirable policy intervention; however the extent of levy may be decided depending upon the

production of sugar, availability of stocks, domestic demand and supply situation prevailing in the domestic market.

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RESEARCH ARTICLE

EXISTING CULTIVATION PRACTICES OF TURMERIC BY THE TURMERIC GROWERS

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Abstract: The study was undertaken on 'existing cultivation practices of turmeric by the turmeric growers' of Chhattisgarh Plains. A total of 320 farmers were considered as respondents for this study. Respondents were interviewed through personal interview. Collected data were analyzed with the help of suitable statistical methods for assessing the different components of turmeric cultivation like improved variety, recommended seed rate, recommended fungicide for seed treatment, fertilizers application and chemicals for plant protection.

Keywords: Existing, Cultivation practices, Turmeric growers, Turmeric cultivation

INTRODUCTION

Turmeric is one of the important cash crops in India. India is the larger producer and exporter of turmeric in the world. Turmeric occupies about 6 per cent of the total area under spices and condiment products in India. In the year 2012-13 turmeric cultivation was 194 thousand ha with the production of 971 thousand tonnes. It reached to 233 thousand ha with the production of 1190 thousand tonnes in the year 2014-15 (Anonymous, 2015).

Chhattisgarh is also one of the important states of turmeric cultivation. In the Chhattisgarh state about 11.021 thousands ha of cultivation area and produce 113.34 thousand tonnes of turmeric. Looking towards increase in area under turmeric present is carried out (Anonymous, 2014).

MATERIALS AND METHODS

The present study was conducted in Chhattisgarh plains. The state comprises 27 districts, out of which 5 districts were selected purposively on the basis of maximum area and maximum number of turmeric growers. From each selected districts, 2 blocks were selected purposively for the study on the basis of maximum area and maximum number of turmeric growers. From each selected block, 4 villages were selected purposively on the basis of maximum area and maximum number of turmeric growers. From each selected villages, 4 beneficiaries and 4 non-beneficiaries were selected randomly for the comparison between both groups. In this way total 320 farmers were considered as respondents for the study. Data were collected by the personal interview method using structured schedule. The *ex-post-facto* research design was used for the study. Appropriate statistical tools used for analysis and interpretation of data.

RESULTS AND DISCUSSION

Recommended varieties of turmeric

The data regarding distribution of the respondents according to recommended varieties of turmeric are presented in Table 1 reveals that out of total, 46.88 per cent respondents were sowing Roma variety, followed by 29.68 per cent were sowing Narendra haldi-1, whereas 13.44 per cent B.S.R.-2 and 10.00 per cent of them were sowing Prabha variety of turmeric in the study area.

Table 1. Distribution of the respondents according to recommended varieties of turmeric

S. No.	Variety	Respondents					
		Beneficiaries		Non-beneficiaries		Total	
		F	%	F	%	F	%
1	Roma	128	80.00	22	13.75	150	46.88
2	Prabha	32	20.00	0	0.00	32	10.00
3	Narendra Haldi-1	0	0.00	95	59.37	95	29.68
4	B.S.R.-2	0	0.00	43	26.88	43	13.44

F – Frequency, % - percentage

In case of beneficiaries, 80.00 per cent respondents were sowing Roma variety and 20.00 per cent of them were sowing Prabha variety of turmeric.

Similarly, in case of non-beneficiaries, 59.37 per cent respondents were sowing Narendra haldi-1, whereas

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26.88 per cent B.S.R.-2 and 13.75 per cent of them were sowing Roma variety of turmeric.

It can be concluded that majority of the beneficiaries had adopted Roma variety and in case of non-beneficiaries, it was adopted Narendra haldi-1.

Recommended seed rate in turmeric

The data regarding distribution of the respondents according to use of recommended seed rate of turmeric are presented in Table 2 reveals that out of total, 57.50 per cent of the respondents had adopted below recommended seed rate and 42.50 per cent of them adopted as per recommended seed rate of turmeric in study area.

Table 2. Distribution of the respondents according to recommended seed rate in turmeric

S. No.	Seed rate	Respondents					
		Beneficiaries		Non-beneficiaries		Total	
		F	%	F	%	F	%
1	Up to 18 q ha^{-1}	88	55.00	96	60.00	184	57.50
2	Above 18 q ha^{-1}	72	45.00	64	40.00	136	42.50

F – Frequency, % - percentage

In case of beneficiaries, 55.00 per cent of the respondents had adopted below recommended seed rate and 45.00 per cent respondents adopted as per recommended seed rate of turmeric.

Whereas, in case of non-beneficiaries, 60.00 per cent of the respondents had adopted below recommended seed rate and 40.00 per cent respondents adopted as per recommended seed rate.

It can be comprehended from the above data that majority of the beneficiaries and non-beneficiaries had adopted below recommended seed rate.

Recommended fungicide for seed treatment

The data regarding distribution of the respondents according to use of chemicals for seed treatment of turmeric are presented in Table 3 reveals that out of total, 10.31 per cent of the respondents used mancozeb, whereas 10.00 per cent used rhizobium and 5.93 per cent of them used dithem, M-45 for seed treatment of turmeric.

In case of beneficiaries, 20.00 per cent of the respondents used rhizobium, followed by 15.62 per cent mancozed and 10.00 per cent of them used dithem, M-45.

Table 3. Distribution of the respondents according to seed treatment in turmeric

S. No.	Chemicals	Respondents					
		Beneficiaries		Non-beneficiaries		Total	
		F	%	F	%	F	%
1	Mancozeb	25	15.62	8	5.00	33	10.31
2	Dithem, M-45	16	10.00	3	1.88	19	5.93
3	Rhizobium	32	20.00	0	0.00	32	10.00

F – Frequency, % - percentage

Similarly, in case of non-beneficiaries, 5.00 per cent of the respondents used mancozed and 1.88 per cent of them used dithem, M-45 for seed treatment.

A close observation of the above results shows that majority of the beneficiaries used rhizobium and in case of non-beneficiaries, it was used mancozed for seed treatment.

Fertilizer application in turmeric

The data regarding distribution of the respondents according to application of fertilizers in turmeric are presented in Table 4 indicates that out of total, 56.56 per cent respondents used below recommended dose of nitrogenous fertilizers and 42.81 per cent used as per recommended dose of nitrogenous fertilizers, whereas regarding phosphoric fertilizers 62.50 per cent of the respondents used below recommended dose of phosphoric fertilizers and 36.87 per cent used as per recommended dose of phosphoric fertilizers. On other hand, regarding application of potassium fertilizers, 69.06 per cent respondents used below recommended dose of potassium fertilizers and 30.31 per cent respondents used as per recommended dose of potassium fertilizers.

In case of beneficiaries, 53.12 per cent of the respondents used below recommended dose of nitrogenous fertilizers and 46.88 per cent respondents used as per recommended dose of nitrogenous fertilizers, whereas 60.62 per cent respondents used below recommended dose of phosphoric fertilizers and 39.38 per cent respondents used as per recommended dose of phosphoric fertilizers. On other hand, 67.50 per cent respondents used below recommended dose of potassium fertilizers and 32.50 per cent respondents used as per recommended dose of potassium fertilizers.

Table 4. Distribution of the respondents according to application of fertilizers in turmeric

S. No.	Fertilizers	Respondents					
		Beneficiaries		Non-beneficiaries		Total	
		F	%	F	%	F	%
I	**Nitrogen**						
1	Up to 120 kg ha^{-1}	85	53.12	96	60.00	181	56.56
2	Above 120 kg ha^{-1}	75	46.88	62	38.75	137	42.81
II	**Phosphorous**						
1	Up to 80 kg ha^{-1}	97	60.62	103	64.37	200	62.50
2	Above 80 kg ha^{-1}	63	39.38	55	34.37	118	36.87
III	**Potash**						
1	Up to 100 kg ha^{-1}	108	67.50	113	70.62	221	69.06
2	Above 100 kg ha^{-1}	52	32.50	45	28.12	97	30.31

F – Frequency, % - percentage

Similarly, in case of non-beneficiaries, 60.00 per cent of the respondents used below recommended dose of nitrogenous fertilizers and 38.75 per cent respondents used as per recommended dose of nitrogenous fertilizers, whereas 64.37 per cent respondents used below recommended dose of phosphoric fertilizers and 34.37 per cent respondents used as per recommended dose of phosphoric fertilizers. On other hand, 70.62 per cent respondents used below recommended dose of potassium fertilizers and 28.12 per cent respondents used as per recommended potassium fertilizers.

It can be concluded that majority of the beneficiaries and non-beneficiaries had used below recommended dose of nitrogenous, phosphoric and potassium fertilizers.

Weed control in turmeric

The data regarding distribution of the respondents according to weed control in turmeric by chemical methods are presented in Table 5 reveals that out of total, 4.68 per cent of the respondents used pendimethelin and 2.18 per cent were used oxyfluorfen.

In case of beneficiaries, 4.37 per cent of the respondents used pendimethelin and 3.12 per cent were used oxyfluorfen.

Table 5. Distribution of the respondents according to weed control in turmeric by chemical methods

S. No.	Herbicide	Respondents					
		Beneficiaries		Non-beneficiaries		Total	
		F	%	F	%	F	%
1	Pendimithelin	7	4.37	8	5.00	15	4.68
2	Oxyfluorfen	5	3.12	2	1.25	7	2.18

F – Frequency, % - percentage

Similarly, in case of non-beneficiaries, 5.00 per cent of the respondents were using pendimethelin and 1.25 per cent respondents used oxyfluorfen.

Hence, it can be concluded that majority of the beneficiaries and non-beneficiaries were using pendimethelin for weed control.

Insect-pest control in turmeric

The data regarding distribution of the respondents according to application of pesticide in turmeric are presented in Table 6 indicates that out of total, 34.37 per cent of the respondents used chloropyriphos, whereas 8.43 per cent respondents used dimethoate and 2.50 per cent respondents were used phosphomidon.

Table 6. Distribution of the respondents according to application of pesticide in turmeric

S. No.	Pesticide	Respondents					
		Beneficiaries		Non-beneficiaries		Total	
		F	%	F	%	F	%
1	Chloropyriphos	62	38.75	48	30.00	110	34.37
2	Dimethoate	20	12.50	7	4.37	27	8.43
3	Phosphomidon	8	5.00	0	0.00	8	2.50

F – Frequency, % - percentage

In case of beneficiaries, 38.75 per cent of the respondents used chloropyriphos, followed by 12.50 per cent respondents used dimethoate and 5.00 per cent respondents used phosphomidon.

Similarly, in case of non-beneficiaries, 30.00 per cent of the respondents used chloropyriphos and 4.37 per cent respondents used dimethoate.

Thus, it can be concluded that majority of the beneficiaries and non-beneficiaries were using chloropyriphos for insect-pest control.

Disease control in turmeric

The data regarding distribution of the respondents according to application of fungicide in turmeric are presented in Table 7 indicates that out of total, 21.25 per cent of the respondents had used carbomdenzim, whereas 7.81 per cent respondents used mancozed and 5.00 per cent respondents used hexaconazol.

Table 7. Distribution of the respondents according to application of fungicide in turmeric

S. No.	Fungicide	Respondents					
		Beneficiaries		Non-beneficiaries		Total	
		F	%	F	%	F	%
1	Carbondenzim	32	20.00	36	22.50	68	21.25
2	Mancozeb	20	12.50	5	3.12	25	7.81
3	Hexaconazol	16	10.00	0	0.00	16	5.00

F – Frequency, % - percentage

In case of beneficiaries, 20.00 per cent of the respondents had used carbondenzim, followed by 12.50 per cent used mancozed and 10.00 per cent used hexaconazol.

Similarly, in case of non-beneficiaries, 22.50 per cent of the respondents had used carbondenzim and 3.12 per cent respondents used mancozeb.

It can be concluded that the majority of the beneficiaries and non-beneficiaries were used carbondenzim for disease control.

CONCLUSION

The findings of the study most of the respondents (46.88%) were sowing roma variety. About 57.50 per cent of the respondents had adopted below recommended seed rate up to 18q/ha. About 10.31 per cent of the respondents used mancozeb for seed treatment. About 56.56 per cent respondents used below recommended dose of nitrogenous fertilizers up to 120 kg/ha. Whereas 62.50 per cent of the respondents used below recommended dose of phosphoric fertilizers and 69.06 per cent respondents used below recommended dose of potassium fertilizers up to 100 kg/ha. As regards to application of herbicide 4.68 per cent of the respondents used pendimethelin. With respect to application of pesticide 34.37 per cent of the respondents were used chloropyriphos. As for as application of fungicide for disease control out of total 21.25 per cent of the respondents were used carbomdenzim.

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RESEARCH ARTICLE

EFFECT OF PLANT GROWTH REGULATORS ON QUALITY PARAMETERS OF SWEET POTATO (*IPOMOEA BATATAS* (L.) LAM.)

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Abstract: A field experiment was carried out during *kharif*2016-17 at Kittur Rani Channamma College of Horticulture, Arabhavi (Karnataka) to study the effect of growth regulators on quality parameters of sweet potato [*Ipomoea batatas* (L.) Lam.]. The maximum beta carotene content (7.65 mg) was recorded in combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}), followed by single treatment GA_3 @ 100 ppm (T_3) (6.72 mg/100g). significantly maximum reducing sugar content (7.40%) was recorded in treatment combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}), significantly maximum starch content (22.50%) was recorded in treatment combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}),

Keywords: *Ipomoea batatas*, Plant growth regulators, Quality parameters

INTRODUCTION

Sweet potato [*Ipomoea batatas* (L.) Lam.] is an important tuber crop belonging to the family Convolvulaceae. This family includes 55 genera and more than 1000 species (Watson and Dallwitz, 2000). In southern part of United States, it is popularly known as 'White potato' or 'Irish potato'. It is popularly called as 'Sakarkand' in India. Sweet potato is a crop of considerable economic and social importance and is a potential staple food in the developing world. It is estimated that root and tuber crops are the third most important food crops after cereals and legumes. For one fifth of the people of the world, they form either staple or important subsidiary food. Sweet potato is the second important tuber crop, first being the potato and is grown in more than 100 countries as a source of starch, protein and carotene (Woolfe, 1992).

Sweet potato tubers are consumed usually after boiling, baking and frying and may also be candied as 'Puree'. Tubers are utilized for canning, dehydration and flour manufacturing and also as an important source of starch, glucose, pectin and sugar hence used in syrup and industrial alcohol preparation. Sweet potato 'vine tips' are used as leafy vegetable in China, Japan and Korea (Dhankhar, 2001).

Sweet potato is second only to potato in area and production among the tuber crops of the world. The total area under sweet potato in the world is estimated to be 9.08 M/ha with a production of 135.19 MT. Asia is the largest producer of sweet potato in world with 92 per cent of world's sweet potato production is from Asia (Villareal, 1982). In India, sweet potato is being cultivated in almost all the states with an area of 111 ha, with a production of 1450 metric tonnes and productivity of 10.4 MT/ha (Anonymous, 2015). India accounts for about 68% of the total production of South Asia followed by 27% in Bangladesh and about 5% in Sri Lanka. In India, Sweet potato is cultivated mainly in Odisha, Uttar Pradesh, West Bengal, Bihar, Karnataka, Andhra Pradesh, Tamil Nadu and Kerala.

One of the recent developments in the field of agricultural science has been the use of growth regulators, which have brought about a sort of revolution in boosting up yield of different crops. The growth regulators when applied in a suitable manner and concentration regulate the growth, development and increase production of crops. Recently, the response of plant growth regulators in increasing the growth and yield has been recognized in many vegetable crops (Muthoo *et al.*, 1987, Singh and Yadav, 1987). Plant growth regulating substances have been reported to exert favourable effect on physiological and other biochemical activities of crop plants. Now days the use of plant growth regulating chemicals have become an important component of agritechnical procedure for most of the cultivated crops.

The role of plant growth substances in the physiology of plant is one of the most interesting chapters in the science. The plant growth substances are organic compounds, other than nutrients which in small concentration influence the physiological processes of plants. They have been used for various beneficial effects such as promoting plant growth, increasing number of flowers, fruit size and inducing early and uniform fruit ripening.

Since the crop can be grown in marginal lands without much input and is rich in starch, it provides cheap source of energy for millions and can form the source of various industrial products, hence there has been renewed interest in this crop. A careful and biochemical study is needed for increasing the yield and quality of sweet potato. The favourable subtropical climate of Karnataka with deep sandy or sandy loam soil provides ample scope for improving the yield and quality parameters of sweet potato by application of growth regulating chemicals and modern cultural practices. With this background, the

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studies on effect of growth regulators on quality of Sweet potato was undertaken during *Kharif* 2016

MATERIAL AND METHODS

The field experiment was conducted at the Kittur Rani Channamma College of Horticulture, Arabhavi, Gokak Taluk, Belgaum district of Karnataka state during the *Kharif -2016*. Arabhavi is situated in northern dry zone of Karnataka state at 16^0 13' 39.6" north latitude, 74^0 50' 13.5" east longitude and at an altitude of 612.03 m above the mean sea level.Arabhavi, which lies in Zone-3 of Region-2 of agro-climatic zones of Karnataka, is considered to have the benefit of both South-West and North-East monsoons. The average rainfall of this area is about 530 mm, distributed over a period of five to six months (May-October) with peak (226.10 mm) during September. The area receives water from Ghataprabha Left Bank Canal from mid-July to mid-March. During the experimental period, the mean minimum temperature varied from 11.80^0 C (December 2016) to 23^0 C (August 2016), whereas the mean maximum temperature varied from 26.10^0 C (December 2016).

The experiment was laid out in Randomized block design and replicated thrice.Vine cuttings of 15-20 cm length were planted at a spacing of 60 x 30 cmand 5-7 cm depth. Standard recommended cultural practices were followed during the entire crop grown period.The experiment consisted of different PGR concentrations (GA_3 @ 25, 50 and 100 ppm, CCC @ 100, 250 and 300 ppm and IBA @ 100 and 200 ppm and control). In each treatment, the plants were sprayed twice at 45 and 60 days after transplanting. The data on vegetative growth parameters were recorded and analyzed statistically.The experimental data collected on various growth, yield and quality aspects were subjected to Fisher's method of analysis of variance (ANOVA) as per methods outlined by Panse and Sukhatme (1967). The critical difference (CD) was calculated wherever the 'F' test was found significant. The data were analyzed and presented with the level of significance at 5 per cent.

RESULTS AND DISCUSSION

Total soluble solids (^{0}Brix)

Among the treatments, highest TSS (13.57^{o}brix) was recorded in treatment combination T_{10} – GA_3 @ 100 ppm and CCC @ 250 ppm as compared to other treatments. In case of single treatment T_3 – GA_3 @ 100 ppm (11.45^{o}brix) recorded maximum TSS content. However, the lowest TSS content (6.92^{o}brix) was noticed in control (T_{11}). The increase in TSS may be accounted to the hydrolysis of polysaccarids, conversion of organic acids into soluble sugars and enhanced solubalization of insoluble starch and pectin present in cell wall and middle lamella. These results are in accordance with the finding of Mandal *et al.* (2012) in Okra, Sawant *et al.* (2010) in cabbage, Sinnadurai and Amuti (1973) in tomato.

Starch content (%)

It was observed that significantly maximum starch content (22.50%) was recorded in treatment combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}), followed by single treatment GA_3 @ 100 ppm (T_3) (21.40%). Whereas, the minimum starch content (15.75%) was recorded in control (T_{11}). Increase in starch content in the tubers might be due to accumulation of metabolites as a result of increase in chlorophyll content in the leaves. Similar results of increase in starch by application of GA_3 were recorded by Gizawy *et al.* (2006) in potato and Rao *et al*. (2017) in sweet potato.

Reducing sugar (%)

It was observed that significantly maximum reducing sugar content (7.40%) was recorded in treatment combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}), followed by single treatment GA_3 @ 100 ppm (T_3) (7.15%). Whereas, the minimum reducing sugar content (5.23%) was recorded in control (T_{11}). The increase in content of total sugars might be due to the quick transformation of starch into soluble solids and rapid mobilization of photosynthetic metabolites and minerals from other parts of the plant to developing parts, Similar results were observed by Rao *et al*. (2017) in sweet potato, Kumar *et al.* (2012) in potato, Sinnadurai and Amuti (1973) in tomato and Chakrabortty (2001) in ground nut, Indira *et al.* (1980) in coleus.

Beta carotene content (mg/100g of fresh weight)

With respect to different levels of plant growth regulators, the maximum beta carotene content (7.65 mg) was recorded in combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}), followed by single treatment GA_3 @ 100 ppm (T_3) (6.72 mg/100g). Whereas, the minimum beta carotene content (4.60 mg/100g) was recorded in control (T_{11}). Similar results were observed by Rao *et al*. (2017) in sweet potato, Singh *et al*. (2012) in coriander

Table 1. Effect of different concentration of plant growth regulators on quality parameters of sweet potato

Sl. No.	Treatments	TSS (^{o}Brix)	Starch (%)	Reducing sugar (%)	B- Carotene (mg/100g FW)
1.	T_{1-} GA_3 @ 25 ppm	8.11	17.20	6.10	5.85

2.	T_2- GA_3 @ 50 ppm	8.70	19.25	6.29	6.10
3.	T_3- GA_3 @ 100 ppm	11.45	21.40	7.15	6.72
4.	T_4- CCC @ 200 ppm	9.68	17.58	6.13	6.22
5.	T_5- CCC @ 250 ppm	10.45	18.20	6.27	6.45
6.	T_6- CCC @ 300 ppm	11.23	19.55	6.55	6.68
7.	T_7- IBA @ 100 ppm	7.75	16.85	5.43	5.60
8.	T_8- IBA @ 200 ppm	8.53	17.10	5.68	5.73
9.	T_9- Combination of GA_3 @ 50 ppm + IBA @ 200 ppm	10.31	21.15	6.56	6.55
10.	T_{10}- Combination of GA_3 @ 100 ppm + CCC @ 250 ppm	13.57	22.50	7.40	7.65
11.	T_{11}- Control	6.92	15.75	5.23	4.60
	S.Em ±	**0.12**	**0.28**	**0.14**	**0.14**
	C. D. at 5%	**0.35**	**0.86**	**0.43**	**0.42**
	C.V.	**2.14**	**2.71**	**4.03**	**4.04**

FW: Fresh weight

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RESEARCH ARTICLE

EFFECT OF 2-BENZOXAZOLINONE (BOA) ON MORPHO-PHYSIOLOGICAL AND BIOCHEMICAL ASPECTS OF *CASSIA OCCIDENTALIS* L.

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Abstract: The present laboratory experimental study was carried about to evaluate the allelopathic potential of an allelochemical, 2-benzoxazolinone (BOA) on some morpho-physiological and biochemical parameters of *Cassia occidentalis*. 100, 500, 1000 µM concentrations of BOA were applied to determine their effect on morpho-physiological parameters(seed germination, root length, shoot length, fresh weight, dry weight etc.) and biochemical parameters (chlorophyll, carotenoids, protein and α-amylase) of test plant under laboratory condition. Study was conducted on 10 day seedlings of *Cassia occidentalis*. Not only seedling growth parameters even the chlorophyll, carotenoids, protein and α-amylase were appreciably reduced, thereby indicating that BOA negatively affects the growth of *Cassia occidentalis*. The study was concluded that BOA possesses weed suppressing ability.

Keywords: Allelopathy, Allelochemical, Weed, BOA, *Cassia occidentalis*

INTRODUCTION

Among the natural plant products, the allelochemicals create one of the major groups and provide allelopathic property to the donor plant, being biologically active. The allelopathic interactions, in general, and the allelochemicals, in particular, are regarded as an important tool for sustainable weed and pest management, and disease control (Singh *et al*., 2001). The purified allelochemicals and /or their derivatives and even the compounds synthesized on their chemistry can be utilized as novel agrochemicals for sustainable management in an eco-friendly manner (Singh *et al*., 2001). Allelochemicals represent a diversity of chemical nature. One of the groups of allelochemicals that has been in focus during the last two decades is the benzoxazinoids and their derivatives (Villagrasa *et al*., 2006). The group of chemical compounds named benzoxazinoid derivatives has been subdivided into hydroxamic acids (Hx), lactams, benzoxazolinones and methyl derivatives of the hydroxamic acids. The cyclic hydroxamic acids (Hx) and lactams (together also referred to as benzoxazinones) are naturally present in the seedlings of several members of family Poaceae, Scrophulariaceae, Ranunculaceae and Acanthaceae (Hartenstein and Sicker, 1994; Pratt *et al*., 1995). Weeds are unwanted and undesirable plants that interfere with the utilization of land and water resources and thus, adversely affect crop production and human welfare. Weeds compete with crop plants for nutrients, soil moisture, space and sunlight (Rajan and Sankaran, 1974). The world food loss due to weeds has been estimated to be about 11.5 percent of the total food production (Parker and Fryer, 1975).

MATERIALS AND METHODS

Seeds of *Cassia occidentalis* were collected locally from wildly growing area of Distt. Muzaffarnagar. 2-benzoxazolinone (BOA) was purchased from Sigma-aldrich, Germany.

Seeds were surface sterilized with 0.1% mercuric chloride. Seeds were dipped in distilled water for 24 h for imbibition prior to germination trials. These were then equidistantly placed in normal size petri dishes lined with two layers of moistened Whatman no.1 filter paper. The filter paper was treated with 100, 500, 1000 µM (T_1, T2 and T_3 respectively) of 2-benzoxazolinone (BOA). For each treatment three replicates were kept. A similar set up of three replicates without treatment served as control (T_0).

The entire set up was kept in an environmentally controlled seed germinating chamber at 25^0C and 75 % relative humidity with a photoperiod of 16/8 day/night. After 10 days, the number of seeds that germinated was counted, root length, shoot lenght, seedling fresh weight and dry weight were measured and the total chlorophyll, total carotenoids, total protein and α-amylase activity were estimated.

RESULTS AND DISCUSSION

Morpho-physiological attributes of *Cassia occidentalis* were recorded in terms of % germination, root and shoot length, fresh and dry weight, vigour index, tolerance index and germination speed in different treatments of BOA. It is very clear from the results that in response to different concentrations of BOA, Germination was considerably reduced in compared to control (Fig.1). Reduction in germination was more at 1000 µM as compared to others. At the lowest concentration of 100 µM BOA treatment, germination was reduced by about 7.5% while at 500 µM, a reduction of over 13% was observed. An appreciable inhibition of

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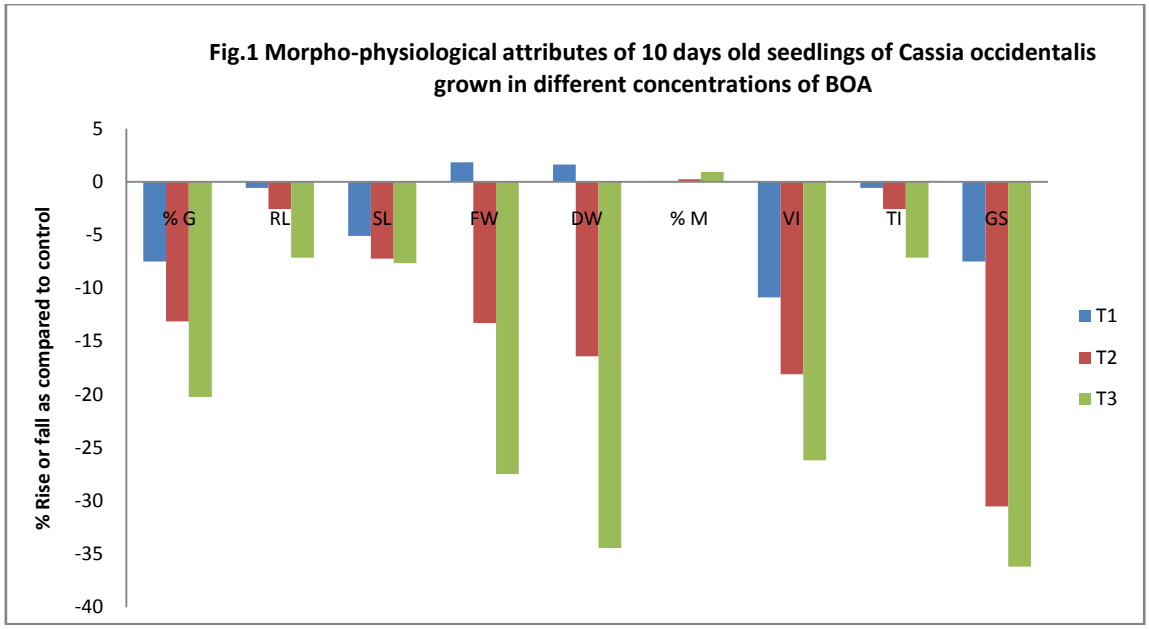
germination of the test weed was observed at a concentration of 1000 µM. The root length and shoot length of the test weed was also appreciably reduced but not significant reduction was observed (Fig.1). The fresh weight of test weed was slightly increased at 100 µM conc. but significant reduced in 500 and 1000 µM (13% and 27.5% respectively) as compared to control (Fig.1). Similarly dry weight was slightly increased at 100 µM conc. but significantly reduced at 500 and 1000 µM conc. (16% and 34.5% respectively) as compared to control (Fig.1). In case of % moisture, a little increase was observed at lower to higher conc. as compared to control (Fig.1). Vigour index, tolerance index and germination speed were also significantly reduced at different conc. as compared to control (Fig.1).

Table.1 Morpho-physiological attributes of 10 days old seedlings of *Cassia occidentalis* grown in different concentrations of BOA

Treatment (µM)	% Germination	Root length	Shoot length	Fresh weight	Dry weight	% Moisture content	Vigour Index	Tolerance index	Germination speed
0	89.00±2.00	3.51±0.17	7.47±0.11	65.5±3.7	6.1±0.42	90.73	977.22	100	22.25
100	82.33±2.52	3.49±0.12	7.09±0.10	66.7±3.5	6.2±0.40	90.7	871.05	99.43	20.58
500	77.33±2.08	3.42±0.03	6.93±0.10	56.8±1.3	5.1±0.31	90.96	800.36	97.43	15.46
1000	71.00±2.00	3.26±0.20	6.90±0.90	47.5±2.5	4.0±0.20	91.58	721.36	92.87	14.2

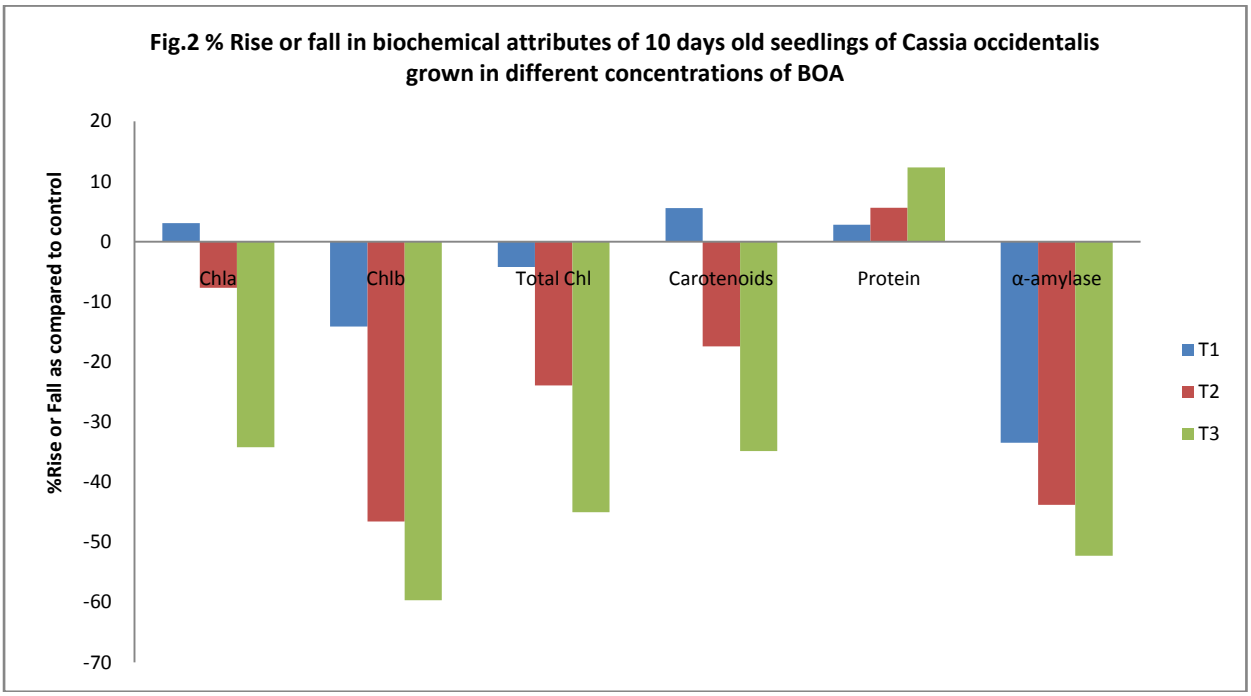


Biochemical attributes of *Cassia occidentalis* were recorded in terms of Chl.a, Chl.b, total chl., total carotenoides, total proteins and α-amylase activity. Chl.a was slightly increased at 100 µM conc. but significantly reduced at 500, 1000 µM conc. (8% and 34% respectively) as compared to control (Fig.2). Chl.b was significantly reduced at 100, 500 and1000 µM conc. (14%, 47% and 60% respectively) as compared to control (Fig.2). Total chl. was slightly reduced at 100 µM conc. but significantly reduced at 500 and 1000 µM conc. (24% and 45% respectively) as compared to control (Fig.2). Total carotenoides were slightly increased at 100 µM conc. but significantly reduced at 500 and 1000 µM conc. (18% and 35% respectively) as compared to control (Fig.2). Total protein was appreciably increased at all conc. 100, 500 and 1000 µM (3%, 6% and 12.5% respectively) as compared to control (Fig.2). α-amylase activity was significantly reduced at all conc. 100, 500 and 1000 µM (34%, 44% and 52% respectively) as compared to control (Fig.2).

Table.2 Biochemical attributes of 10 days old seedlings of *Cassia occidentalis* grown in different concentrations of BOA

Treatment (µM)	Chla (mg/g fwt)	Chlb (mg/g fwt)	Total Chl (mg/g fwt)	Total Carotenoides (mg/g fwt±)	Protein (mg casein eq./g fwt±SD)	α-amylase (mg starch degraded/min/gfwt±SD)
0	0.260±0.006	0.191±0.005	0.451±0.000	0.304±0.003	14.24±0.18	32.43±2.01

100	0.268±0.004	0.164±0.011	0.432±0.015	0.321±0.005	14.64±1.10	21.58±2.38
500	0.240±0.006	0.102±0.018	0.343±0.012	0.251±0.004	15.04±0.42	18.23±1.43
1000	0.171±0.004	0.077±0.001	0.248±0.002	0.198±0.004	16±0.66	15.48±0.85



CONCLUSION

It is clear from the present study that 2-benzoxazolinone (BOA) has a potential to reduce the some morpho-physiological parameters as well as biochemical parameters (germination, early growth and development of the weed species and thus could prove very useful for future weed management programmes.

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RESEARCH ARTICLE

SCREENING OF DIFFERENT MAIZE GENOTYPES TO CURVULARIA LEAF SPOT

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Abstract: A total of 55 genotypes of maize as listed below, were screened under field condition at ARS, Arabhavi. Each genotype was sown in a single row of 3 mt length with a spacing of 60 cm X 20 cm. The results revealed that, among 55 genotypes screened, none was found immune or highly resistant, one was found moderately resistant (CI 4), ten genotypes showed moderately susceptible reaction (KDMI 6, NAH 137, African Tall, MAH 974, MAH 957, GH 110204, KDMI 10, CM 111, GH 110145 and Pop corn), 25 genotypes were) and remaining 19 genotypes were found highly susceptible.

Keywords: Curvularia leaf spot, Maize genotypes, Screening

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the world and ranks third next to wheat and rice. It is grown throughout the world under a wide range of climatic conditions. Since pre-Hispanic time, it has been the basic food for the majority of the people in Mexico, Central America and Latin America. Maize was introduced to India from America at the beginning of 17th century. In addition to staple food for human being and quality feed for animals, it serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries *etc*. In the last one decade, it has registered the highest growth rate among all food grains including wheat and rice because of newly emerging food habits as well as enhanced industrial requirements.

In India, maize is the third most important cereal crop after rice and wheat that serves as a source of raw material for developing hundreds of industrial products (Anon., 2007). Maize kernel contains about 77 per cent starch, two per cent sugar, nine per cent protein, two per cent ash on a water free basis, five per cent pentosan and five per cent oil. It has more than 1000 industrial uses and mainly used for production of starch due to its high starch content of 77 per cent. Maize seed oil contains the highest polyunsaturated fatty acids (PUFA), linoleic acid (61.99%) and it remains as liquid at fairly low temperature which is helpful in combating heart disease. Maize seed oil is also low in linolenic acid (0.7%) and contains a high level of natural flavor.

Maize is being plagued by an array of diseases which include the leaf spot of maize caused by *C. lunata* (Singh *et al.,* 2002) exhibiting symptoms as small chlorotic spots which gradually expand into round or oval shaped lesion surrounded by a wide translucent straw yellow halo. A number of lesions can be connected leading to the formation of leaf necrosis. This cause significant damage to maize up to 60% due to great loss of photosynthetic area of the crop (Dia Hong-hai *et al.,*1995; Huang *et al.,* 2004; Li-FuHua *et al.,* 2006). This disease is an important seed and soil borne disease prevalent mostly in subtropical and tropical regions. Despite extensive damage caused by the pathogen, scanty literature is available. Keeping in view the destructive nature of the disease, the present investigation was under taken to screening of different maize genotypes against Curvularia leaf spot

MATERIALS AND METHODS

Screening of maize genotypes to Curvularia leaf spot

A total of 55 genotypes of maize as listed below, were screened under field condition at ARS, Arabhavi. Each genotype was sown in a single row of 3 mt length with a spacing of 60 cm X 20 cm. The inoculum of *C. lunata* was sprayed 20 days after sowing to create high disease pressure. The disease severity was recorded using 0-9 scale by (Mayee and Datar, 1986) randomly selecting five plants in each genotype. Based on their reaction genotypes were categorized into immune, resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible.

Table 1. Details of Genotypes

Sl. No	Germplasm	Pedigree	Origin	Sl. No	Germplasm	Pedigree	Origin
1	ARYP 81	YP ⊗ 6 # 81	AICMIP, Arabhavi	29.	ARYP 2	YP ⊗ 6 # 2	AICMIP,

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							Arabhavi
2	ARYP 83	YP ⊗ 6 # 83	AICMIP, Arabhavi	30.	KDMI 6		
3	ARYP 82	YP ⊗ 6 # 82	AICMIP, Arabhavi	31.	NAH 137		
4	ARYP 33	YP ⊗ 6 # 33	AICMIP, Arabhavi	32.	African Tall		
5	ARYP 53	YP ⊗ 6 # 53	AICMIP, Arabhavi	33.	MAH 974		
6	ARYP 36	YP ⊗ 6 # 36	AICMIP, Arabhavi	34.	MAH 957		
7	ARYP 64	YP ⊗ 6 # 64	AICMIP, Arabhavi	35.	NAH 1137		
8	ARYP 47	YP ⊗ 6 # 47	AICMIP, Arabhavi	36.	NAH 2049		
9	ARYP 63	YP ⊗ 6 # 63	AICMIP, Arabhavi	37.	Thaipop		
10	ARYP 60	YP ⊗ 6 # 60	AICMIP, Arabhavi	38.	SKV 50		
11	ARYP 74	YP ⊗ 6 # 74	AICMIP, Arabhavi	39.	Madhuri		
12	ARYP 46	YP ⊗ 6 # 46	AICMIP, Arabhavi	40.	NAC 6002		
13	ARYP 24	YP ⊗ 6 # 24	AICMIP, Arabhavi	41.	NAC 6004		
14	ARYP 6	YP⊗ 6 # 6	AICMIP, Arabhavi	42.	GPMH 1111		
15	ARYP 43	YP ⊗ 6 # 43	AICMIP, Arabhavi	43.	GPMH 1101		
16	ARYP 28	YP ⊗ 6 # 28	AICMIP, Arabhavi	44.	GH 1043		
17	ARYP 30	YP ⊗ 6 # 30	AICMIP, Arabhavi	45.	DMH 100-3		
18	ARYP 68	YP ⊗ 6 # 68	AICMIP, Arabhavi	46.	BGMH 2		
19	ARYP 53	YP ⊗ 6 # 53	AICMIP, Arabhavi	47.	BGMH 1		
20	ARYP 23	YP ⊗ 6 # 23	AICMIP, Arabhavi	48.	GH 110204		
21	ARYP 76	YP ⊗ 6 # 76	AICMIP, Arabhavi	49.	GH 110145		
22	ARYP 39	YP ⊗ 6 # 39	AICMIP, Arabhavi	50.	CM 501		
23	ARYP 78	YP ⊗ 6 # 78	AICMIP, Arabhavi	51.	CI 4		CIMMYT, Mexico
24	ARYP 47	YP ⊗ 6 # 47	AICMIP, Arabhavi	52.	CI 5		
25	ARYP 25	YP ⊗ 6 # 25	AICMIP, Arabhavi	53.	KDMI 10		
26	ARYP 79	YP ⊗ 6 # 79	AICMIP, Arabhavi	54.	CM 111		DMR, Delhi
27	ARYP 14	YP ⊗ 6 # 14	AICMIP, Arabhavi	55.	Pop corn		
28	ARYP 61	YP ⊗ 6 # 61	AICMIP, Arabhavi				

Where, YP = Yellow Pool

The severity of Curvularia leaf spot disease was recorded by using 0 - 9 scale of Mayee and Datar (1986).

Scale:

Rating value	Description
0	No symptoms on the leaf.
1	Up to 1% of leaf area covered with leaf spots
3	1-10% of leaf area covered with leaf spots.
5	11-25% of leaf area covered with leaf spots.
7	26-50% of leaf area covered with leaf spots
9	More than 50% of leaf area covered with leaf spots

Further, these scales were converted to per cent disease index (PDI) using the formula given by Wheeler (1969).

$$\text{Per cent disease index (PDI)} = \frac{\text{Sum of the individual disease ratings}}{\text{Number of leaves assessed} \times \text{Maximum grade}} \times 100$$

Table 2. Screening of maize genotypes against Curvularia leaf spot disease

Sl. No	Disease grade	Disease reaction	Genotypes	No. of genotypes
1	0	Immune	-	Nil
2	1	Resistant	-	Nil
3	3	Moderately Resistant	CI 4	1
4	5	Moderately susceptible	KDMI 6, NAH 137, African Tall, MAH 974, MAH 957, GH 110204, KDMI 10, CM 111,GH 110145 and Pop corn	10
5	7	Susceptible	ARYP 81, ARYP 36, ARYP 64, ARYP 60, ARYP 6, ARYP 43, ARYP 28, ARYP 30, ARYP 68, ARYP 53, ARYP 76, ARYP 78, ARYP 47, ARYP 14, ARYP 2, NAH 1137, NAC 6004, GPMH 1111, GPMH 1101, GH 1043, DMH 100-3, BGMH 2, BGMH 1, CM 501 and CI 5	25
6	9	Highly susceptible	ARYP 83, ARYP 82, ARYP 33, ARYP 53, ARYP 47, ARYP 63, ARYP 74, ARYP 46, ARYP 24, ARYP 23, ARYP 39, ARYP 25, ARYP 79, ARYP 61, ARYP 33, NAH 2049, Thaipop, SKV 50 and NAC 6002	19

RESULTS AND DISCUSSION

Fifty five maize genotypes were screened during *kharif* 2014 against *C. lunata* under artificial epiphytotic condition in the field to identify the resistant sources as described in "Material and Methods" and the data are presented in Table 2.

The results revealed that, among 55 genotypes screened, none was found immune or highly resistant, one was found moderately resistant (CI 4), ten genotypes showed moderately susceptible reaction (KDMI 6, NAH 137, African Tall, MAH 974, MAH 957, GH 110204, KDMI 10, CM 111, GH 110145 and Pop corn), 25 genotypes were susceptible (ARYP 81, ARYP 36, ARYP 64, ARYP 60, ARYP 6, ARYP 43, ARYP 28, ARYP 30, ARYP 68, ARYP 53, ARYP 76, ARYP 78, ARYP 47, ARYP 14, ARYP 2, NAH 1137, NAC 6004, GPMH 1111, GPMH 1101, GH 1043, DMH 100-3, BGMH 2, BGMH 1, CM 501 and CI 5) and remaining 19 genotypes were found highly susceptible (ARYP 83, ARYP 82, ARYP 33, ARYP 53, ARYP 47, ARYP 63, ARYP 74, ARYP 46, ARYP 24, ARYP 23, ARYP 39, ARYP 25, ARYP 79, ARYP 61, NAH 2049, Thaipop, SKV 50 , NAC 6002 and Madhuri). Management of the disease through host plants resistance has been the best choice in all crop improvement programmes. Utilization of resistant cultivars in farming system is the most simple, effective and economical method in the management of plant diseases. Besides this, these resistant cultivars conserve natural resources and reduce the cost, time and energy when compared to the other methods of disease management. In the present study 55 maize genotypes were screened under artificial epiphytotic field condition for resistance against Curvularia leaf spot. The study revealed that none of the genotypes were found to be immune or highly resistant and one genotype was show moderately resistant, ten genotype showed moderately susceptible, 25 were susceptible and remaining 19 were highly susceptible. Choudhary *et al.*(2011) evaluated 35 maize inbred lines against *C. lunata* and identified five lines *viz.*, EI 460, EI 585, EI 582, EI 586-1 and LM 10 as resistant, six as moderately resistant, 14 as susceptible and remaining ten lines as highly susceptible. The screening of maize genotypes to different diseases at All India Coordinated Maize Improvement Project centers in India during *kharif* 2010 to 2012 has yielded 77 lines with resistant to moderately reaction one or more diseases. Two lines *viz.*, WINPOP-3 and HKI 1040-5 have shown resistant against reaction to Curvularia leaf spot (Anon., 2013 and Anon., 2014). Thus the promising high yielding CLS resistant maize genotypes identified through this investigation can be deployed in disease endemic areas to aim for sustainable productivity or can be used in resistance breeding programme.

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