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RESEARCH ARTICLE

MORPHO-PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERIZATION OF WHEAT UNDER THE WATER DEFICIT CONDITIONS

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Abstract: In present study the 10 wheat genotypes were evaluated for their morphological, physiological and biochemical characters under drought stress. Drought is one of the most important phenomena which limit crop production and yield. Analysis of variance for morpho-physiological and biochemical traits and yield revealed highly significant differences among the entries under irrigated and non irrigated condition. In this study parameter like plant height, leaf length, number of tiller, spike length, spikelets per spike, seeds per spike, chlorophyll content, RWC, MSI and proline content was recorded. Analysis of the data showed that under water stress condition HD 2733 showed highest no. of tiller (4.37), Spikeletes per spike (17.20) and seeds per spike (21.20). While highest chlorophyll content genotype DBW 71 (34.37). RWC and MSI under the stress condition genotype HD 2733 performance better. Proline accumulation is believed to play adaptive roles in plant stress tolerance. Accumulation of proline has been advocated as a parameter of selection for stress tolerance. Therefore, the objective of the present investigation was to find out suitable morpho-physiological and biochemical traits that could be invariably used for the yield improvement of wheat grown under drought stress condition, responses to drought is essential for a holistic perception of plant resistance mechanisms to water-limited conditions. Crops demonstrate biochemical responses to tackle drought stress. All these parameters were found to greatly affect under imposed drought condition. Almost all the parameters were showed decline under imposed drought condition except proline content which is known as a stress tolerant indicator.

Keywords: Wheat, Morpho-physiological character, Proline, Drought Stress

INTRODUCTION

Wheat (*Triticum aestivum* L.), the world's most important and widely adopted crop in terms of area and production and contributes more calories and proteins to the world's diet than any other food crop (Hanson *et. al*., 1982). Three types of wheat are grown in India, 1) *Triticum aestivum* (bread wheat), 2) *Triticum durum* (durum wheat) and 3) *Triticum dicoccum* (dicoccum wheat). The green revolution, which was initiated in the country in the late 1960s, has had a very significant effect in increasing the yield of wheat. At present Uttar Pradesh, Punjab and Haryana are the three major wheat producing states. They account for nearly 70 % of the total wheat produced in the country. Though Uttar Pradesh the highest production in India, it lags behind Punjab and Haryana in terms of productivity. Drought is one of the most common environmental stresses that affect growth and development of plants. Drought stress, which is the most serious environmental problem limiting crop production in rainfed agriculture (Bahieldin *et al.*, 2005), can severely impact plant growth and development, limit plant production and the crop performance (Shao *et. al.*, 2009). Drought and its effects on wheat productivity Drought stress affects the plant growth, development and productivity in all the cereal crops which is the major threat to world's agriculture (Hamayun *et al*., 2010 and Subhani *et al*., 2011). The circumstances thus demand breeding of crop for drought stressed areas using modern and traditional techniques. Signal transduction and stress response trigger physiological events that help the plant to withstand drought stress (Zhou *et al*., 2010). Simane *et al*., (1993) and Solomon *et al*., (2003) observed the effect of water stress on the yield and yield components of durum wheat at different growth stages. Water stress leads to closure of stomata which in turn reduces the transpiration rate and diffusion of CO2. Stomata of leaf close in response to light (generated by pigment zeaxanthin) and CO2 concentration in the leaves (dehydrating roots send abscisic acid to the leaves signaling them to close stomata). The major driving force of water from the soil to the leaves is difference in the water potential between outside and inside of the leaf. As water vapour diffuses from the inside of the leaf it passes through the stomata into the atmosphere. This diffusion generates a negative pressure through the xylem down to the roots. With declining soil water reserves the plant closes the stomata in a response to water loss and maintains the continuous column of water from the root hairs to the leaf mesophyll. The surroundings under which plants are grown will affect the expression of certain physiological and morphological characters based on which they can be selected. Blum *et al*., (1999) reported that osmotic adjustments were specifically

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and positively related with plant production under drought stress but not with plant production under irrigated conditions.

MATERIAL AND METHOD

The experiment was conducted in 2015-16 at Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. The experiment was designed in pot with 10 wheat varieties PBW 533, UP 2425, PBW 226, DBW 17, PBW 590, DBW 71, DBW 16, K 802, K 9107 and HD 2733. Wheat genotypes selected on the basis of diverse backgrounds were grown in pots. The crop was exposed to partial drought (at different growth stages) with re-watering after produced a specific drought. The experiment was conducted in three replications having drought condition and another was raised under irrigated conditions. Irrigation water was supplied by sprinklers to provide two water regimes during plant growth. Drought was created in this rain free environment by with-holding irrigation after 15 days from sowing and giving supplementary irrigations every three weeks during 90 days post-sowing. Wheat genotypes were evaluated for morphological, physiological and biochemical traits (irrigated conditions) and for drought tolerance (water stressed conditions) at different growth stages.

Plant height

The plant height was measured from bottom of the plant i.e. from soil level to the base of the spike and (five selected plants) at reproductive stage of crop and average plant height was worked out.

Number of Tillers

Wheat seedling of different cultivars in their in early stages of growth show marked difference in their growth habit. The number of tillers per plant was counted of five selected plants at reproductive stage of plant and an average tiller per plant was worked out.

Flag leaf length

Flag leaf length measured from the base of ligula to the tip of leaf in cm.

Spike length

The average spike length of five plants on the main culm from the base of the spike to the top of the last spikelet excluding awns was recorded in centimeter.

Number of spikelet's per spike

Total numbers of spikelet's on main spike of all five plants were counted at the time of maturity and average was recorded.

Seeds per spike

Mean number of seeds counted from 5 randomly sampled spikes at maturity is recorded as seed per spike.

Chlorophyll content

The chlorophyll content in the flag leaf was determined using a SPAD meter. Five flag leaves of each genotype grown in rainfed condition were measured after anthesis stage. Three measurements in the middle of the flag leaf were made randomly for each plant and the average sample was used for analysis.

Relative Water Content (%)

Relative water content of leaf was determined by method developed by Barrs and Weatherly (1962). Completely extended leaves were removed and fresh weight of leaf was taken immediately. The leaves were soaked in distilled water for 4 hrs under a constant light at room temperature. The turgid weight of leaf was calculated. The sample was dried at 80 °C for 24 hrs. The total dry mass of the sample was recorded. Finally, the relative water content of the leaf was calculated by employing following formula: Relative water content (RWC) = $[\{(FW-DW) / (TW-DW)\}] \times 100$

Where, FW = Fresh weight, DW = Dry weight, TW = Turgid weight

Leaf membrane stability

Membrane stability index of leaf during temperature induction was determined according to the method of Sairam (1994). Leaf section of 2 cm length was taken from the flag and penultimate leaves from drought stressed and irrigated plants. Leaf of (0.2g) of uniform size was taken in to test tubes containing 10mL of double distilled water in two sets. Test tube in one set were kept at 40ºC in water bath for 30min. Test tubes were cooled under running water and electric conductivity of the water containing samples was measured(C_1) using conductivity bridge. Test tube in the other set incubated at 100 ^{0}c in the boiling water bath for 15 minute and after cooling the test tube their EC was measured as above (C_2). The leaf tissues were then killed by autoclaving all the samples for desiccation (T) and control (C) treatments. Leaf membrane stability of leaf tissues was calculated as percentage of injury using the equation: Injury (%) = $1-(T1-T2)/1-(C1-C2) \times 100$

Where, T1 and T2 are the first and second conductivity measurement for the desiccation treatment, respectively. C1 and C2 are the first and second measurement of the control.

Proline concentration (PC)

The PC was determined according to the method of (Bates *et al.,* 1973). Plant material (0.5 g) after anthesis stage was grinded with 10 ml of 3% sulfosalicylic acid. The homogenate was filtered, and 1 ml of glacial acetic acid and 1 ml of acid ninhydrin reagent were added to a 1 ml of filtrate. Then the mixture was shaken by hand and incubated in boiling water bath for 1 h. After that, it was transferred to ice bath and warmed to room temperature. Toluene (2 ml) was added to the mixture and the upper toluene layer was measured at 520 nm using UV spectrophotometer.

Proline (µg/g fresh weight) = $36.2311 \times OD \times V/2 \times F$

Where, OD = Optical density at 520 nm, V = total volume of extract in ml, f = Milligram of fresh weight of leaf taken for one proline estimation.

RESULT AND DISCUSSION

Plant height

Plant height in wheat it is an important growth parameter, which is affected by genetic as well as environmental factors. Plant height is measured in centimetres from bases of the plant to the tip of the spike at the time of maturity. All the wheat genotype showed wide range of variation for plant height i.e. 63.40-69.00 (in irrigated condition) and 61.23-65.97 (in non-irrigated condition). The genotype K 802 showed the highest plant height (69.00) and the genotype PBW 590 showed lowest plant height (63.40) in irrigated condition. The genotype PBW 533 showed the highest plant height (65.97) and the genotype DBW 17 showed lowest plant height (61.23) in non-irrigated condition. The total mean of plant height (66.65) under irrigated condition and (62.58) non-irrigated condition. plant height is decrease due to water stress and Less reduction in plant height in stress conditions may be an important adaptive mechanism for environments characterized as drought tolerant at anthesis in moisture stress observed by Mirbahar *et al*., 2009 ; Singh *et al.* 2001.

Number of tillers

All the wheat genotype showed wide range of variation for number of tillers i.e. 3.30-5.40 (in irrigated condition) and 2.63-4.37 (in non-irrigated condition). The genotype HD 2733 showed the highest number of tillers (5.40) and the genotype DBW 71 showed lowest number of tillers (3.30) in irrigated condition. The genotype HD 2733 also showed the highest number of tillers (4.37) and the genotype DBW 71 showed lowest number of tillers (2.63) in non-irrigated condition. The total mean of number of tillers (4.45) under irrigated condition and (3.41) non-irrigated condition similar result was reported by (Khakwani *et al*, 2011). They observed higher number of tillers in range 2.67 to 4.83.

Flag Leaf Length

Flag leaf measured from the bases of ligula to the tip of leaf in cm. All the wheat genotypes showed wide range of variation for flag leaf length i.e. (20.57-29.37cm) in irrigated condition) and (16.57-24.77cm) in non-irrigated condition. The genotype PBW 533 showed the maximum flag leaf length (29.37 cm) and the genotype K 802 showed minimum flag leaf length (20.57cm) in irrigated condition. The genotype PBW 533 showed the maximum flag leaf length (24.77cm) and the genotype K 802 showed minimum flag leaf length (16.57cm) in non-irrigated conditions. The total mean of flag leaf length (25.39 cm) under irrigated condition and (21.56 cm) non-irrigated condition). Similar results were also reported by (khakwani *et al*., 2011 and khakwani *et al*., 2012). They observed higher leaf area in range 12.48 to 41.91 cm. In general all genotypes showed reduced leaf area under drought condition, it may be due to decrease in the photosynthetic activity of plant leaves due to water stress. In many research, it was observed that due to water shortage cell sap of leaves decreases so volume of cell and parenchymatous cell size decreased.

Spike length

Wide range of variation also showed by all the genotypes with the range (7.50-9.57) in irrigated condition and (5.50-8.60 cm) in non-irrigated condition. The genotype HD 2733 showed the maximum spike length (9.57 cm) and the genotype DBW71 showed minimum spike length (7.50 cm) in irrigated condition. The genotype K 9107 showed the maximum (8.60 cm) and the genotype UP 2425 showed minimum spike length (5.50 cm) in non-irrigated condition. The total mean of spike length (8.44 cm) under irrigated condition and (7.30 cm) non-irrigated condition. Similar result observed Abassi *et al.*, (2014) reported that length of spike also affected by the drought stress and decreases grain yield is associated with reduction in spike length

Number of Spikeletes /spike

Number of spikelets per spike directly play important role in wheat productivity. Water deficit condition also affects the number of spikelets per spike. All the wheat genotype showed a wide range of variation for spikelets per spike i.e. 16.20-20.03 (in irrigated condition) and 14.10-17.20 (in non-irrigated condition). The genotype HD 2733 showed the highest spikelets per spike (20.03) and the genotype PBW 226 showed lowest spikelets per spike (16.20) in irrigated condition. The genotype HD 2733 also showed the highest spikelets per spike (17.20) and the genotype PBW 226 showed lowest spikelets per spike (14.10) in non-irrigated condition. The total mean of spikelets per spike (17.82) under irrigated condition and (16.03) non-irrigated condition. similar result find Zhao *et al.*, (2013) reported in our study that spikelets per spike show positive agronomic performance under well water condition and reduce in drought stress condition Water deficit condition that limits the area under cultivation and yield of crops and show negative role against spikelets per spike specially yield more sensitive to drought stress, while in the landraces traits not differ under stress as compare to optimum conditions observed by Dencis *et al*. (2000).

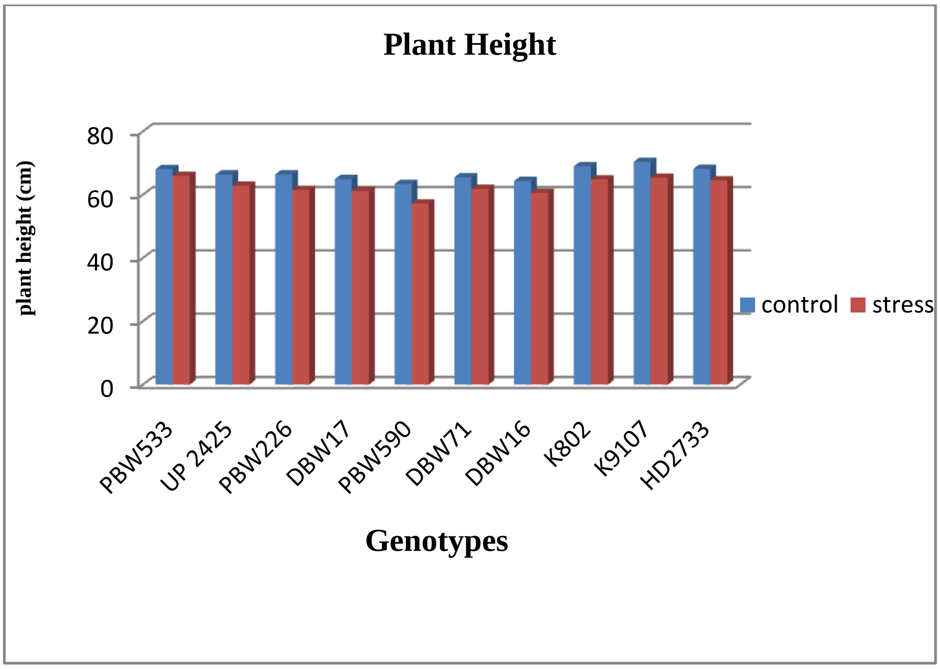
Seeds per spike

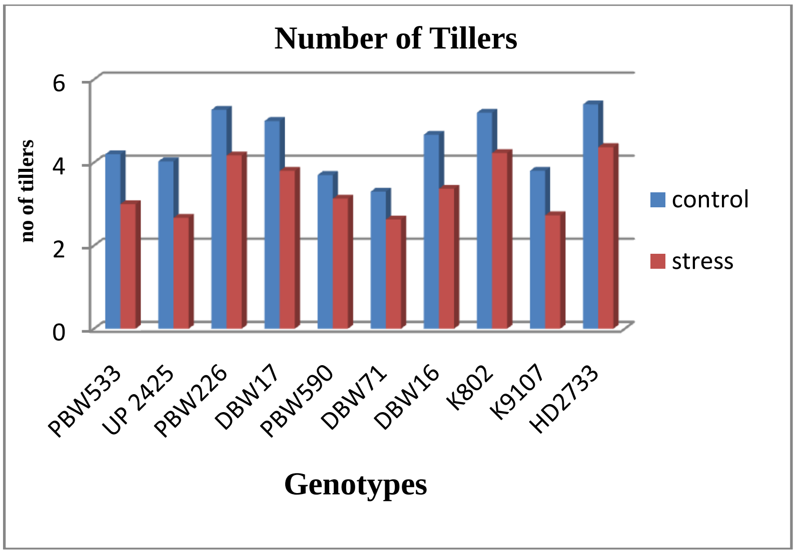
Measurement of seeds the number of seed counted from spike at maturity is recorded as seeds per spike. It is evident from the present data that wide range of variation existing among the genotypes with respect to number of seed per spike. All the wheat genotypes showed wide range of variation for seed per spike i.e. 19.30-25.00 (in irrigated condition) and 13.83-21.20 (in non-irrigated condition). The genotype HD 2733 showed the maximum seed per spike (25.00) and the genotype K 9107 showed minimum seed per spike (19.30) in irrigated condition. The genotype HD 2733 also showed the maximum seed per spike

(21.20) and the genotype K 9107 also showed minimum seed per spike (13.83) in non-irrigated condition. The total mean of seed per spike (22.70) under irrigated conditions and (18.21) in non-irrigated condition. Similar result find Sokoto *et al.*, (2013) reported that the effect of drought on grains per spike which resulted in reduction of yield.

Table 1. Morphological characterization of wheat under the water deficit conditions.

Genotypes	Plant height (cm)		No. Of tillers/plant		Flag leaf length (cm)		Spike lenght (cm)		Spikeletes/spike		Seeds per spike	
	irrigated	Non-irrigated	irrigated	Non-irrigated	irrigated	Non-irrigated	irrigated	Non-irrigated	irrigated	Non-irrigated	irrigated	Non-irrigated
PBW533	68.10	65.97	4.20	3.00	29.37	24.77	7.67	6.63	18.23	16.40	24.40	20.47
UP 2425	66.37	62.80	4.03	2.67	26.77	24.33	8.00	5.50	16.43	14.17	22.93	19.17
PBW226	66.40	61.50	5.27	4.17	26.27	22.93	9.07	8.60	16.20	14.10	22.03	18.07
DBW17	64.93	61.23	5.00	3.80	24.57	21.73	8.20	6.97	17.40	16.07	22.43	17.30
PBW590	63.40	57.23	3.70	3.13	24.87	20.33	8.93	8.50	18.33	16.60	24.23	19.43
DBW71	65.50	61.83	3.30	2.63	23.80	18.57	7.50	6.97	18.03	16.57	22.73	17.67
DBW16	64.33	60.57	4.67	3.37	24.23	19.47	8.60	6.10	18.20	16.63	22.90	20.03
K802	69.00	64.83	5.20	4.23	20.57	16.57	7.73	7.00	17.33	16.43	21.13	18.00
K9107	70.37	65.37	3.80	2.73	27.77	23.90	9.20	8.60	18.03	16.13	19.30	13.83
HD2733	68.17	64.53	5.40	4.37	25.73	23.07	9.57	8.20	20.03	17.20	25.00	21.20
Mean	66.65	62.58	4.45	3.41	25.39	21.56	8.44	7.30	17.82	16.03	22.70	18.51
CD	0.80	2.35	0.23	0.15	1.46	1.00	0.22	0.21	0.36	0.22	0.73	0.44
SE (m)	0.27	0.79	0.07	0.05	0.49	0.33	0.07	0.07	0.12	0.07	0.24	0.15
SE (d)	0.38	1.12	0.11	0.07	0.69	0.47	0.10	0.10	0.17	010	0.35	0.21
C.V.	0.70	2.19	3.01	2.56	3.36	2.70	1.52	1.73	1.20	0.81	1.89	1.40




Number of Tillers
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4
2
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PBW226
DBW17
PBW590
DBW71
DBW16
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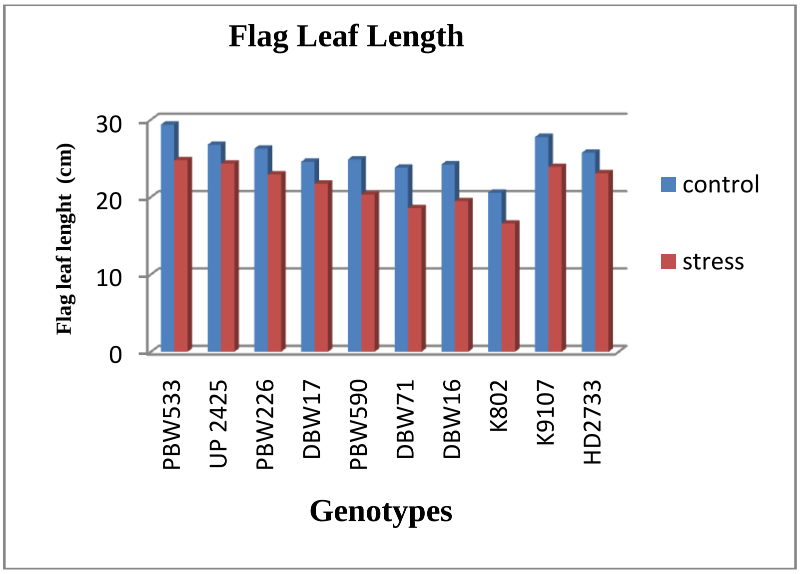
HD2733
Genotypes
control
stress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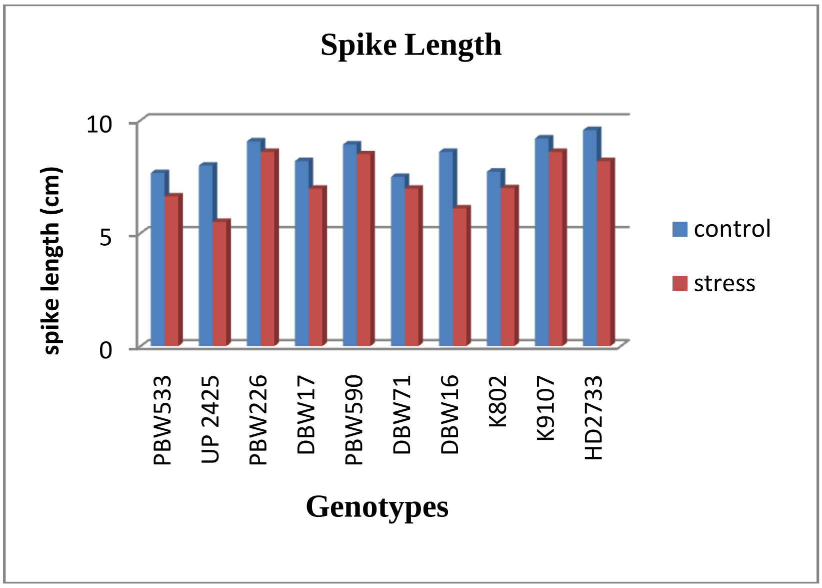
HD2733
Genotypes
control
stress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Genotypes
control
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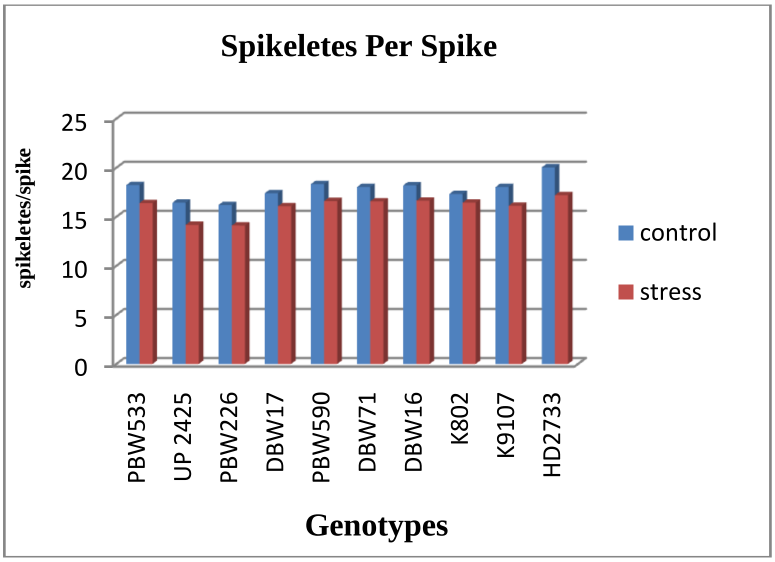


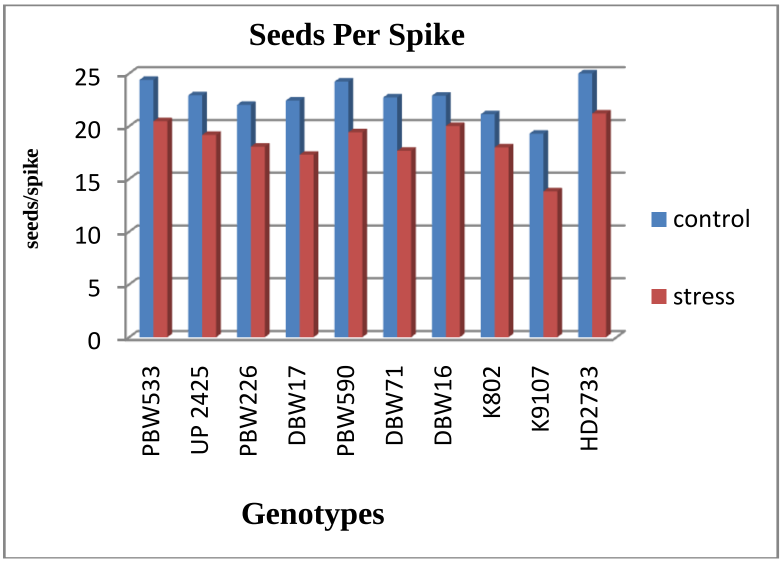


Fig. 1. Morphological character viz: plant height (cm), no of tillers, flag leaf length (cm), spike length (cm), spike length (cm), Spikeletes per spike and seeds per spike of wheat under the water deficit conditions.

2 Physiological and biochemical characterization of wheat genotypes under the water deficit conditions.

Chlorophyll content

Chlorophyll content was measured using a portable Minolta chlorophyll SPAD meter. The result showed that the chlorophyll content under control condition and water deficit condition. In water deficit condition show less chlorophyll content in wheat genotypes. The chlorophyll content ranged from 41.10-52.57 (in irrigated condition) and 34.37-45.40 (in non-irrigated condition).The higher chlorophyll content observed in genotype HD2733 (52.59) and the genotype DBW 71 showed lower chlorophyll value (41.10) in irrigated condition. The genotype PBW 533 showed the higher value of chlorophyll (45.40) and the genotype DBW 71 showed lower value of chlorophyll (34.37) in non-irrigated condition. The total mean of chlorophyll content (46.88) under irrigated condition and (39.73) in non-irrigated condition. Similar results were reported by (Sibomana*et al.*, 2013) The lower chlorophyll content was recorded under drought condition means a genotype may be a drought tolerant in nature. Our results are in agreement with the study of (Nyachiro *et al*., 2001).

Relative water content

All the wheat genotypes showed wide range of relative water content i.e. 69.23-82.37 % (in irrigated condition) and 61.77-73.23 % (in non-irrigated condition). The highest value of relative water content observed in genotype HD 2733 (82.37%) and lowest value relative water content observed in genotype K 9107 (69.23%) under irrigated condition. Genotype HD 2733 showed highest value (73.23%) and genotype K 9107 showed lowest value (61.77%) under non irrigated condition. The total mean of relative water content (76.15%) under irrigated condition and (67.40%) (in non-irrigated condition.). Mationn *et al.*, (1989) presented similar result as regards drop in the amount of relative water content in sensitive and tolerant genotype of barley similar result was reported by (Bajji*et al*, 2001. and khakwani *et al.*, 2011) in wheat. They observed higher relative water content in range 69.3% to81.1%, 75.67% to 90% and 52.44% to 96.87%, respectively.

Leaf membrane stability

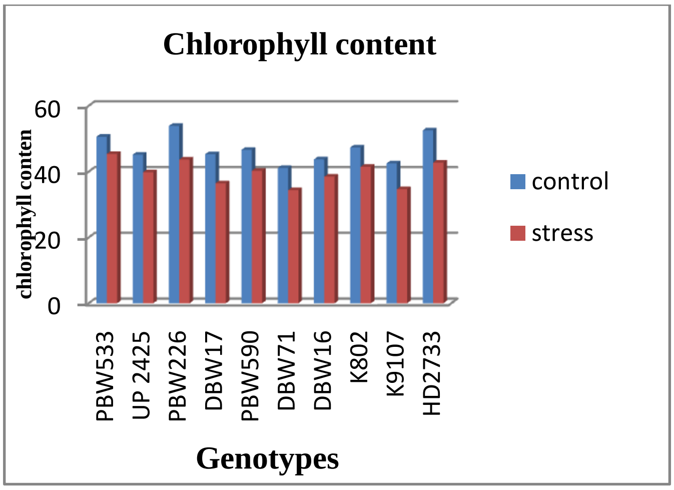
All the wheat genotypes showed wide range of Cell membrane stability i.e. 47.60-64.13% (in irrigated condition) and 39.27-56.20 % (in non-irrigated condition). The highest value of leaf membrane stability observed in genotype DBW 71 (64.13%). and lowest value of leaf membrane stability observed in genotype PBW 226 (47.60%) under irrigated condition. Genotype HD 2733 showed highest value (56.20%) and genotype PBW 226 showed lowest value (39.27%) under non irrigated condition (Table 4.2 a). The total mean of leaf membrane stability (55.77%) in irrigated condition and (47.09%) in non-irrigated condition). Similar results were also discussed by Bayoumi *et al.*, (2008).

Proline content

Proline accumulation is believed to play adaptive roles in plant stress tolerance. Accumulation of proline has been advocated as a parameter of selection for stress tolerance. All wheat genotypes showed wide range of proline content observed (0.218 -0.413 µg g^{-1} fresh wt.) irrigated condition and (0.313-0.493 µg g^{-1} fresh wt.) non-irrigated condition. The highest proline content observed in genotype HD 2733 (0.413 µg g^{-1} fresh wt.) and lowest amount proline accumulated in genotype K 802 (0.218 µg g^{-1} fresh wt.) under irrigated condition. Genotype HD 2733 showed highest proline content (0.493 µg g^{-1} fresh wt.)) and genotype PBW 533 showed lowest proline content (0.313 µg g^{-1} fresh wt.)) under non irrigated condition (Table 2). The total mean of proline content (0.303 µg g^{-1} fresh wt.) under irrigated condition and (0.380 µg g^{-1} µg g^{-1}) in non-irrigated condition. Proline, generally, functions through counteracting the injury exerted by water stress by accumulation in the main plant organs (Heikal and Shaddad 1982). Similar results were obtained by some other authors (Chen *et al*., 2001, Claussen 2005; Hassanein *et al*., 2009; Kadam *et al*., 2017.)

Table 2. Physiological and biochemical characterization of wheat genotypes under the water deficit conditions.

Genotypes	Chlorophyll content		Relative water content %		Membrane stability index %		Proline content µg g^{-1} fresh wt.	
	irrigated	Non-irrigated	irrigated	Non-irrigated	irrigated	Non-irrigated	irrigated	Non-irrigated
PBW533	50.60	45.40	77.37	71.63	52.47	41.37	0.220	0.313
UP 2425	45.17	39.83	75.50	67.60	57.57	47.53	0.318	0.377
PBW226	53.90	43.70	76.27	69.67	47.60	39.27	0.319	0.425
DBW17	45.30	36.47	70.63	66.43	61.23	54.20	0.245	0.331
PBW590	46.63	40.27	79.00	70.63	48.47	42.37	0.285	0.345
DBW71	41.10	34.37	77.43	72.47	64.13	52.53	0.369	0.411
DBW16	43.73	38.47	75.63	68.23	62.27	55.23	0.321	0.401
K802	47.33	41.47	78.10	70.43	48.27	41.43	0.218	0.321
K9107	42.50	34.67	69.23	61.77	52.53	40.77	0.326	0.383
HD2733	52.57	42.73	82.37	73.23	63.20	56.20	0.413	0.493
Mean	46.88	39.73	76.15	67.40	55.77	47.09	0.303	0.380
CD	6.45	3.95	3.87	3.27	3.24	4.05	0.007	0.007
SE (m)	2.17	1.33	1.30	1.10	1.09	1.36	0.002	0.002
SE (d)	3.07	1.88	1.84	1.55	1.54	1.93	0.003	0.003
C.V.	8.02	5.80	2.96	2.75	3.38	5.02	1.302	1.124



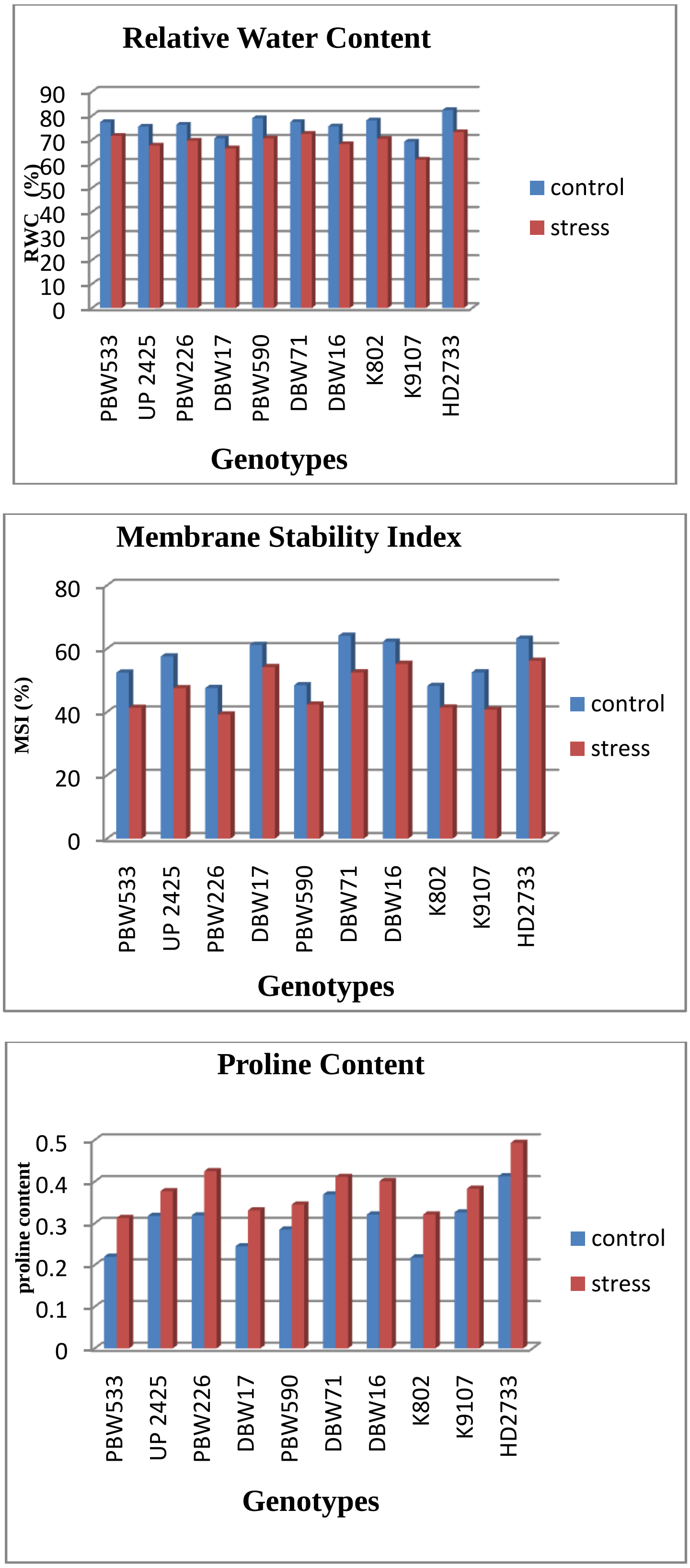


Fig. 2. Physio-biochemical character viz: chlorophyll content ,relative water content , membrane stability index and proline content of wheat under the water deficit conditions.

CONCLUSION

In the present investigation a continuous range of variability for morphological, physiological and biochemical traits indicate the presence of several minor genes having small but additive effect for drought tolerance among wheat genotypes. Substantial variability is present among wheat genotypes for morphological traits *viz.* Plant height, tiller per plant, flag leaf length, spike length, number of spikelets/spike and Seeds/spike are efficient parameters to evaluate germplasm for drought tolerance. Physio-biochemical traits chlorophyll content, relative water content, membrane stability index and proline content were affected by water stress. Different genotypes were showed variable response to drought stress we observed that HD 2733 tolerant variety under water deficit condition. So we can say for the production of wheat yield RWC, MSI and proline content used for the screening of drought tolerant cultivars.

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RESEARCH ARTICLE

EFFECT OF POST EMERGENCE HERBICIDE ON WEEDS AND ECONOMICS OF FINGER MILLET

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Abstract: Weeds are the major biotic stresses for finger millet cultivation. Initial slow growth of the finger millet favours weed growth. *Echinochloa colona* among grasses, *Cyperus iria* among sedges and *Alternanthera triandra, Eclipta alba* and *Phyllanthus urinaria* among broad leaf weeds were dominant. Weed index (loss of yield due to weeds) was found to be minimum with application of ethoxysulfuron (34.37 %). The maximum weed index was found with application of fenoxaprop-p- ethyl (93.62 %) at higher level (45.0 g ha^{-1}). In the experimental field, the most dominant species was *Echinochloa colona* which ranged between 24-46 per cent at all the growth stages. It was followed by *Phyllanthus urinaria* (13-18 %), *Eclipta alba (5-26 %), Cyperus iria* (3-23%) and *Alternanthera triandra* (5-12 %).There was complete control of broad leaf weeds *viz. Alternanthera triandra, Eclipta alba* and *Phyllanthus urinaria* and sedges *i.e. Cyperus iria* by the application of metsulfuron methyl + chlorimuron ethyl and ethoxysulfuron, where as grassy weed *i.e. Echinochloa colona* was completely killed by the application of fenoxaprop-p-ethyl and showed 100% weed control efficiency, respectively. Hand weeding twice recorded the highest grain yield and net return. Application of ethoxysulfuron registered the highest B:C ratio which was at par with metsulfuron methyl + chlorimuron ethyl and hand weeding twice.

Keywords: Weed management, Finger millet, Herbicide, Weed

INTRODUCTION

Finger millet is grown in *kharif* for grain purpose and it is the only millet, which is consumes directly after threshing as whole grain. It is a tetraploid and self-pollinating species probably evolved from its wild relative *Eleusine africana*. Interesting crop characteristics of finger millet are the ability to withstand cultivation at altitudes over 2000 meters above sea level, its favorable micronutrient contents (high iron and methionine content in particular), its high drought tolerance and the very long storage time of the grains. Finger millet is a high statue crop with slower initial growth which remains under smothering due to the infestation of weeds at early stages of growth. This situation causes higher competition and may result in drastic reduction in yield (Kushwaha *et al*. 2002). Finger millet (*Eleusine indica*) is an important small millet crop that is hardy and grows well in dry zones as rain-fed crops. It is used both as medicinal and traditional purposes.The production and productivity of the country is lower because of weeds pose one of the major constraints in the production of finger millet. Owing to initial slow growth of the finger millet favours weed growth, which cause more competition for sunlight, nutrient and water in early stages of growth lead in lowering productivity (Kumara *et al*. 2007). The critical period of crop weed competition for the finger millet varies from 25-45 days after sowing (Lall and Yadav, 1982). Weeds compete with crop plants for water, nutrients, space and solar radiations by reduction of yield upto 20 to 50 per cent. (Kushwaha *et al*. 2002) reported that weeds caused an appreciable reduction in density, dry weight and depletion of nutrients. Manual weed management, which is the most prevalent method for weed management in finger millet, requires a lot of labour. Now a day, due to the scarcity of labours, chemical weed management is considered as better option than the hand weeding. Chemical weed management practices might be an answer to achieve greater weed control efficiency, which in turn, may increase over all benefit of finger millet cultivation. The work on effect of post emergence herbicides in weed management of finger millet is very limited; therefore, keeping these points in view the present investigation was carried out to evaluation of post-emergence herbicides for weed management in direct sown finger millet.

MATERIAL AND METHOD

The present investigation entitled "Evaluation of post-emergence herbicides for weed management in direct sown Finger millet." was carried out at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) India, during the *kharif* season (July-November) 2012. The soil of experimental field was Clayey *(Vertisols)*, which was low in nitrogen, medium in phosphorus and high in potassium contents with neutral in pH. The experiment was laid out in randomized block design (RBD) with three replications. There were thirteen treatments of post-emergence herbicides along with two hand weeding and untreated control. The finger millet cultivar "GPU-28" was sown and harvested on 11th July, 2012 and 20th November, 2012 respectively, using seed rate of 10 kg ha^{-1} at 25 cm distance and gaps were maintained by thinning to

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obtain proper plant population. Sowing was performed by manually and crop was fertilized with 60:40:40 N: P_2O_5:K_2O kg ha^{-1}. Half dose of nitrogen (30 kg/ha) and full dose of P and K (40 and 20 Kg/ha respectively) were applied as basal and remaining half of nitrogen (30 kg/ha) was top dressed one month later. Plant protection measures were followed as per recommendation. The treatments were *viz*. T_1- Fenoxaprop-p-ethyl (37.5 g ha^{-1}), T_2- Fenoxaprop-p-ethyl (45.0 g ha^{-1}), T_3- Metsulfuron methyl + Chlorimuron ethyl, T_4- Ethoxysulfuron, T_5 – Cyhalofop-butyl, T_6- Fenoxaprop-p-ethyl (37.5 g ha^{-1}) + metsulfuron methyl + chlorimuron ethyl, T_7- Fenoxaprop-p-ethyl (45.0 g ha^{-1}) + metsulfuron methyl + chlorimuron ethyl, T_8- Fenoxaprop-p-ethyl (37.5 g ha^{-1}) + ethoxysulfuron, T_9- Fenoxaprop-p-ethyl (45.0 g ha^{-1}) + ethoxysulfuron, T_{10}- Cyhalofop-butyl + metsulfuron methyl + chlorimuron ethyl, T_{11}- Cyhalofop-butyl + ethoxysulfuron, T_{12}- Hand weeding twice and T_{13}- Weedy check. The observations of weeds were recorded from the area left for distractive sampling and the net plot area was kept undisturbed. The important weed species associated with the Finger millet crop in the experimental field were observed at different intervals. The density of different weed species and dry weight of weeds was studied at 15, 30, 45, 60, 75 and 90 DAS and at harvest. The density of different weed species study in each plot was made from marked area outside the net plot area using a quadrate of 50 cm x 50 cm (0.25 m^2). Only green weeds sample were taken. Thedata were calculated for m^{-2} for statistical analysis. Weed density was subjected to square root transformation *i.e.*

$$\sqrt{X + 0.5}$$

Weeds present in quadrate were uprooted carefully along with roots. The roots of the samples were cut and only aerial parts were cleaned, sun-dried and finally oven-dried at 60^oC for 48 hours. After complete oven drying, the dry weight was recorded species-wise and as well as total dry weight of weeds for different treatments. Weed dry weight was subjected to square root transformation *i.e.*

$$X + 0.5$$

The weed control efficiency was calculated at 15, 30, 45, 60, 75 and 90 DAS and at harvest on the basis of reduction in dry matter production of weeds in treated plots in comparison with weedy check and expressed in percentage as suggested by Mani *et al.* (1973).

$$\text{WCE (\%)} = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$$

Where,

WCE = Weed control efficiency (%)

DWC = Dry weight of weeds in weedy check plot (g) DWT = Dry weight of weeds in treated plot (g)

Weed Index is an index expressing the reduction in yield due to presence of weeds in comparison with weed free situation. It was expressed in per cent and calculated by using the formula given below as suggested by (Reddy 2007).

Weed Index (%) =

$$\frac{\text{Seed yield from weed free plot} - \text{Seed yield from treated plot}}{\text{Seed yield from weed free plot}} \times 100$$

RESULT AND DISCUSSION

The major weeds species were observed in weedy check plot of the experimental field which have been presented in Table1.

Table 1. Major weeds species observed in the experiment field

S. No.	Scientific name	Family	Common name	Group
1	*Echinochloa colona*	Poaceae	Sawan/Jungle rice	Grasses
2	*Cyperus iria*	Cyperaceae	Motha/Yellow nutsedge	Sedges
3	*Alternanthera triandra*	Compositae	Resham kanta	Broad leaf
4	*Eclipta alba*	compositeae	Bhringraj/False daisy	Broad leaf
5	*Phyllanthus urinaria*	Euphorbiaceae	Dodania	Broad leaf

Cyperus iria

Echinochloa colona

Eclipta alba

Phyllanthus urinaria

Alternanthera triandra

Plate 1. Major weed species observed in the field

The most dominant species was *Echinochloa colona* which ranged between 24-46 per cent at all the growth stages. It was followed by *Phyllanthus urinaria* (13-18 %), *Eclipta alba (5-26 %)*, *Cyperus iria* (3-23 %) and *Alternanthera triandra* (5-12%). Other weed species like *Commelina benghalensis, Cynodon dactylon, Cynotis axillari, Fimbristylis miliacaea etc*. were also observed in the experiment field in negligible quantum.

Weed density at 30 DAS the minimum was observed with application of cyhalofop-butyl + metsulfuron methyl + chlorimuron ethyl (Table 2). The highest weed density was noticed in weedy check. At 60 DAS Weed density was recorded the lowest in fenoxaprop-p-ethyl (45.0 g ha^{-1}) + metsulfuron methyl + chlorimuron ethyl. The highest weed density was recorded in weedy check. At 90 DAS lowest weed density was observed with application of metsulfuron methyl + chlorimuron ethyl or ethoxysulfuron was applied in combination with cyhalofop-butyl or fenoxaprop-p-ethyl at both levels which was at par with each other. The highest weed density was recorded with application of metsulfuron methyl + chlorimuron ethyl. At harvest there was no plant alive in hand weeding twice which was at par with metsulfuron methyl + chlorimuron ethyl. The highest weed density was recorded in weedy check. In the present study, the individual herbicide killed some of the grasses, sedges and broad leaf weeds individually but the some of the other weeds were not controlled by this herbicide due to which the result exhibited variation in total weed density and complete controlled of weeds by any herbicide alone or in combination was not observed. However, the combined application of cyhalofop-butyl or fenoxaprop-p-ethyl with metsulfuron methyl + chlorimuron ethyl exhibited the appreciable lower total weed density.

Total dry weight of weed species at various stages as influenced different herbicidal treatments in finger millet are presented in Table 3. At 30 DAS the minimum total dry weight was recorded with application of fenoxaprop-p-ethyl (37.5 g ha^{-1}) + ethoxysulfuron (Table 4.19). The highest total weed dry weight was recorded in weedy check. At 60 DAS lowest total dry weight was recorded in hand weeding twice. The highest total dry weight was recorded in weedy check. At 90 DAS the lowest total dry weight was recorded in hand weeding twice. The highest total weed dry weight was recorded in weedy check. At harvest there was no plant alive so total dry weight was zero with application of metsulfuron methyl + chlorimuron ethyl or ethoxysulfuron alone or in combination with cyhalofop-butyl or fenoxaprop-p-ethyl at both levels and hand weeding twice.The highest total weed dry weight was recorded in weedy check which was at par with cyhalofop-butyl. In conclusion, the combined application of cyhalofop-butyl or fenoxaprop-p-ethyl with metsulfuron methyl + chlorimuron ethyl exhibited the appreciable lower total weed dry weight.

The weed control efficiency (WCE) of weeds of different species was noted at 30, 45, 60, 75 and 90 DAS and at harvest. Weed control efficiency (%) of total weed species is given in Fig. 1. Hand weeding twice recorded highest weed control efficiency followed by metsulfuron methyl + chlorimuron ethyl ethoxysulfuron, fenoxaprop-p- ethyl. Lowest weed control efficiency was exhibited with application of cyhalofop- butyl.

Table 2. Total weed density (m $^{-2}$) as influenced by different herbicidal treatments in finger millet

Treatment	Dose (g ha^{-1})	Weed density (m^{-2})						
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	At harvest
T_1 : Fenox	37.5	8.16 (66.33)	9.80 (95.67)	11.93 (142.00)	13.33 (177.33)	10.97 (120.00)	8.58 (73.33)	4.71 (21.67)
T_2 : Fenox	45.0	7.86 (61.33)	9.17 (83.67)	11.61 (134.33)	12.82 (164.00)	11.77 (138.00)	8.57 (73.00)	4.18 (17.00)
T_3 : MSM+CME	2.0+2.0	7.84 (61.00)	7.07 (49.67)	7.59 (57.33)	8.56 (73.00)	7.42 (54.67)	6.41 (40.67)	0.71 (0.00)
T_4 : Ethox	15.0	7.61 (57.67)	8.37 (69.67)	8.76 (76.33)	9.47 (89.33)	8.74 (76.00)	7.62 (57.67)	0.71 (0.00)
T_5 : Cyhalo	62.5	7.40 (54.33)	8.95 (79.67)	10.42 (108.00)	12.26 (150.00)	10.63 (112.67)	8.53 (72.33)	3.08 (9.00)
T_6 : Fenox+MSM+ CME	37.5+2.0+2.0	7.66 (58.33)	4.81 (22.67)	3.96 (15.33)	2.81 (7.67)	2.17 (4.67)	1.83 (3.67)	0.71 (0.00)

T_7 : Fenox+MSM+ CME	45.0+2.0+2.0	7.58 (57.33)	2.76 (7.33)	2.19 (4.33)	1.81 (3.00)	1.72 (2.67)	1.27 (1.33)	0.71 (0.00)
T_8 : Fenox+Ethox	37.5+15.0	8.06 (64.67)	7.35 (53.67)	6.82 (46.00)	6.84 (46.33)	6.26 (38.67)	4.98 (24.33)	0.71 (0.00)
T_9 : Fenox+Ethox	45.0+15.0	7.98 (63.33)	6.35 (40.00)	6.36 (40.00)	6.53 (42.33)	5.48 (29.67)	4.67 (21.33)	0.71 (0.00)
T_{10} : Cyhalo+MSM+ CME	62.5+2.0+2.0	7.93 (62.33)	1.97 (3.67)	2.55 (6.00)	3.06 (9.00)	2.02 (3.67)	1.77 (2.67)	0.71 (0.00)
T_{11} : Cyhalo+Ethox	62.5+15.0	7.67 (58.33)	6.08 (36.67)	6.69 (44.33)	6.74 (45.00)	5.94 (35.00)	5.04 (25.00)	0.71 (0.00)
T_{12} : Weed free (HW at 20 and 40 DAS)		7.86 (61.33)	3.06 (9.00)	2.26 (4.67)	2.26 (4.67)	2.20 (4.33)	1.87 (3.00)	0.71 (0.00)
T_{13}: Weedy check		8.64 (74.34)	13.64 (185.67)	16.68 (277.67)	17.21 (296.33)	14.81 (219.00)	12.20 (148.33)	5.18 (26.33)
SEm ± CD at 5 %		0.24 NS	0.25 0.75	0.16 0.48	0.26 0.78	0.26 0.77	0.26 6.76	0.05 0.16

The observations are square root transformed. Figures in parentheses indicate the original value. Fenox = Fenoxaprop-p-ethyl, MSM = Metsulfuron methyl,CME = Chlorimuron ethyl, Ethox = Ethoxysulfuron, Cyhalo = Cyhalofop–butyl, HW = Hand weeding.

Table 3. Total weed dry weight of weeds as influenced by different herbicidal treatments in finger millet

Treatment	Dose (g ha^{-1})	Dry weight (g m^{-2})						
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	At harvest
T_1 : Fenox	37.5	1.42 (1.53)	4.74 (22.06)	7.16 (50.74)	8.48 (71.37)	9.82 (96.23)	10.89 (118.47)	6.15 (37.49)
T_2 : Fenox	45.0	1.42 (1.52)	4.29 (17.91)	6.26 (38.88)	8.42 (70.37)	10.15 (102.53)	11.34 (128.20)	6.96 (48.04)
T_3 : MSM+CME	2.0+2.0	1.58 (2.02)	2.99 (8.47)	4.27 (17.77)	5.46 (29.30)	5.57 (30.60)	6.45 (41.25)	0.71 (0.00)
T_4 : Ethox	15.0	1.48 (1.69)	3.01 (8.60)	4.93 (23.90)	5.60 (30.86)	6.37 (40.26)	8.27 (68.03)	0.71 (0.00)
T_5 : Cyhalo	62.5	1.45 (1.62)	3.65 (12.83)	8.27 (68.01)	9.40 (87.94)	13.03 (169.22)	13.61 (184.93)	9.42 (88.3)
T_6 : Fenox+MSM+ CME	37.5+2.0+2.0	1.44 (1.57)	2.58 (6.19)	4.47 (19.50)	5.11 (25.67)	5.45 (29.23)	6.34 (39.71)	0.71 (0.00)
T_7 : Fenox+MSM+ CME	45.0+2.0+2.0	1.48 (1.71)	2.95 (8.22)	4.54 (20.20)	4.66 (21.26)	5.17 (26.46)	5.79 (33.06)	0.71 (0.00)
T_8 : Fenox+Ethox	37.5+15.0	1.46 (1.64)	2.07 (3.80)	4.93 (23.87)	5.20 (26.75)	6.48 (41.52)	6.92 (47.48)	0.71 (0.00)
T_9 : Fenox+Ethox	45.0+15.0	1.46 (1.65)	3.21 (9.83)	3.55 (12.11)	3.90 (14.70)	5.91 (34.58)	6.24 (38.48)	0.71 (0.00)
T_{10} : Cyhalo+MSM+ CME	62.5+2.0+2.0	1.49 (1.73)	2.90 (7.97)	4.25 (17.70)	4.55 (20.23)	4.84 (23.10)	5.88 (34.61)	0.71 (0.00)
T_{11} : Cyhalo+Ethox	62.5+15.0	1.55 (1.91)	3.36 (10.80)	5.65 (31.51)	6.46 (41.35)	7.77 (59.83)	8.44 (70.80)	0.71 (0.00)
T_{12} : Weed free (HW at 20 and 40 DAS)		1.54 (1.91)	2.62 (6.42)	3.19 (9.66)	3.29 (10.37)	3.51 (11.89)	3.52 (11.89)	0.71 (0.00)

T_{13}: Weedy check		1.65 (2.24)	5.98 (35.22)	10.16 (102.67)	12.06 (145.21)	15.12 (228.02)	15.99 (255.51)	9.77 (95.17)
SEm ±		0.05	0.10	0.16	0.17	0.20	0.29	0.15
CD at 5 %		NS	0.30	0.49	0.51	0.60	0.86	0.43

The observations are square root transformed. Figures in parentheses indicate the original value. Fenox = Fenoxaprop-p-ethyl, MSM = Metsulfuron methyl, CME = Chlorimuron ethyl, Ethox = Ethoxysulfuron, Cyhalo = Cyhalofop–butyl, HW = Hand weeding

Table 4. Weed control efficiency (%) of total weeds at different stages of finger millet as influenced by different herbicidal treatments

Treatment	**Dose (g ha^{-1})**	**Weed control efficiency of total weeds (%)**					
		30 DAS	**45 DAS**	**60 DAS**	**75 DAS**	**90 DAS**	**At harvest**
T_1 : Fenox	37.5	37.37	50.58	50.85	57.80	53.63	60.61
T_2 : Fenox	45.0	49.15	62.13	51.54	55.03	49.83	49.52
T_3 : MSM+CME	2.0+2.0	75.95	82.69	79.82	86.58	83.86	100.00
T_4 : Ethox	15.0	75.58	76.72	78.75	82.34	73.37	100.00
T_5 : Cyhalo	62.5	63.57	33.76	39.44	25.79	27.62	7 .
T_6 : Fenox+MSM+ CME	37.5+2.0+2.0	82.42	81.01	82.32	87.18	84.46	100.00
T_7 : Fenox+MSM+ CME	45.0+2.0+2.0	76.66	80.33	85.36	88.40	87.06	100.00
T_8 : Fenox+Ethox	37.5+15.0	89.21	76.75	81.57	81.79	81.42	100.00
T_9 : Fenox+Ethox	45.0+15.0	72.09	88.20	89.88	84.83	84.94	100.00
T_{10} : Cyhalo+MSM+ CME	62.5+2.0+2.0	77.37	82.76	86.07	89.87	86.45	100.00
T_{11} : Cyhalo+Ethox	62.5+15.0	69.34	69.31	71.52	73.76	72.29	100.00
T_{12} : Weed free (HW at 20 and 40 DAS)		81.77	90.59	92.86	94.79	95.35	100.00
T_{13}: Weedy check		–	–	–	–	–	–

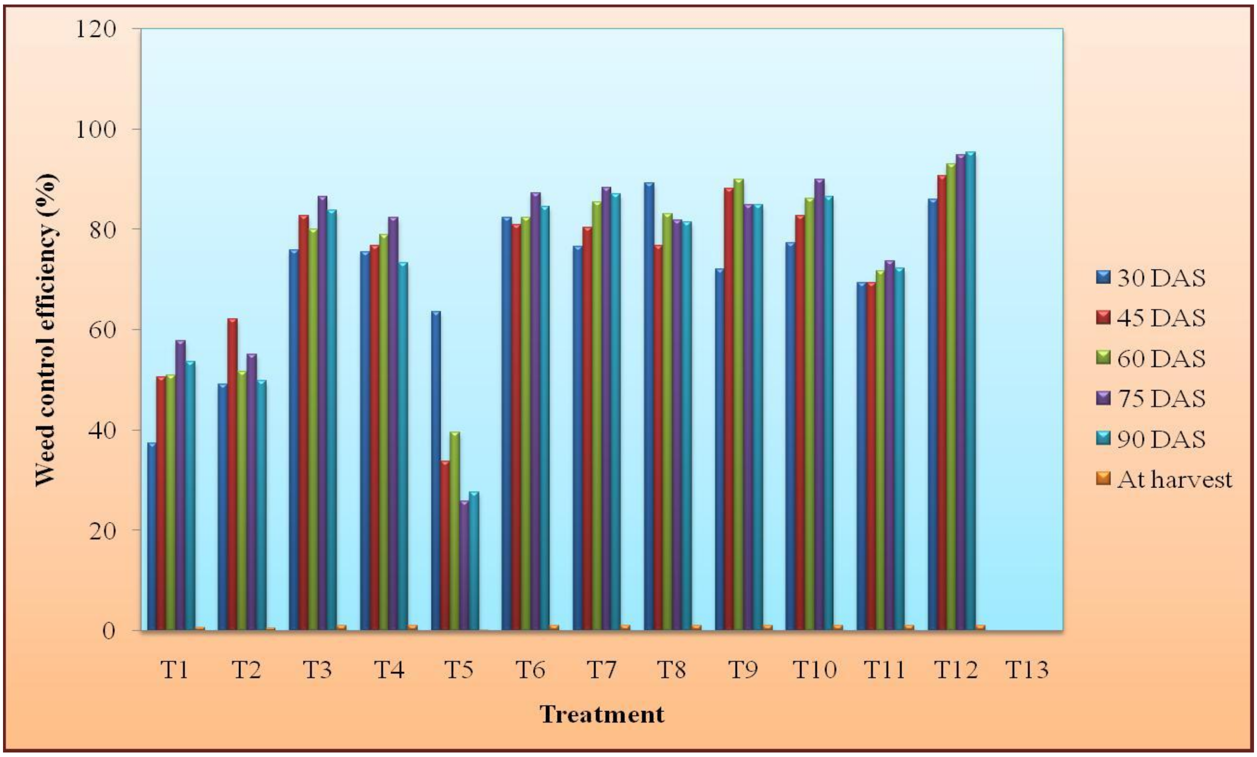

Fig. 4.3. Weed control efficiency (%) of total at different stages of finger millet as influenced by different herbicidal treatments

Economics

Hand weeding twice recorded the highest gross return. Among herbicides ethoxysulfuron gave maximum gross return which was at par with that of metsulfuron methyl + chlorimuron ethyl. Fenoxaprop-p-ethyl (45.0 g ha^{-1}) gave minimum gross return. The maximum net return was observed in hand weeding twice which was at par with application of ethoxysulfuron and metsulfuron methyl + chlorimuron ethyl and B:C ratio was observed with ethoxysulfuron which was at par with that of metsulfuron methyl + chlorimuron ethyl and hand weeding twice.

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RESEARCH ARTICLE

CROP PRODUCTION PROFILE OF GARLIC IN THE RAIN SHADOW REGION OF IDUKKI DISTRICT, KERALA

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Abstract: Commercial garlic cultivation in Kerala is confined to Kanthalloor and Vattavada panchayaths of Devikulam block, Idukki. A unique system of production, curing and storage of garlic exists in this high range, having an annual temperature of 23.7^{0}C and rainfall 1276mm. The study revealed that the extent and experience in garlic cultivation was more in Vattavada though two cropping seasons were practiced in Kanthalloor. "Mettupalayam", "Singapore" and land race "Malapoondu" are the major ecotypes grown in this area. Storability is more in "Singapore" and "Malapoondu" but farmers prefer "Metupalayam" because of its short duration. Yield contributing parameters like equatorial diameter(4.3cm), polar diameter(4.2cm) and bulb weight(21.8g) were significantly high in Singapore. The skin thickness(1.58mm) and average number of cloves per bulb(18.3) were more in "Malapoondu". The major constraints in garlic production as perceived by farmers were small size of garlic cloves, high incidence of pest and disease and attack by wild animals.

Keywords: Bulb characters, Constraints in production, Ecotypes, Garlic, Kerala

INTRODUCTION

Kerala, with its varied agro- ecological conditions encourage the cultivation of an array of spice crops. Idukki being the spice hub of Kerala accounts for maximum area and production in almost all spices. The unique climatic condition and the varied agro ecological situations prevailing in the district, favours cultivation of both tropical, subtropical and temperate spices.

The commercial cultivation of Garlic is confined to Kanthalloor and Vattavada panchayaths of Devikulam Block of Idukki district (Miniraj *et al.*, 2005). The area represents low rainfall region having tropical sub humid monsoon climate with an annual temperature 23.7^{0}C and rainfall 1276mm. The area comes under the Marayur Dry Hills Agro Ecological Unit number 17. Here garlic is cultivated in an area of about 80ha with production 630 T (2015-16) as per the Spice statistics of Directorate of Arecanut and Spice Development, Calicut, Kerala. However, there has been a drastic reduction in the area and production of garlic as indicated by the published statistics (DASD, 2016). It indicated that an area of 170 ha with 1510T production of garlic during 2010-11 has been reduced to 80 ha with a production of 630T during 2014-15. It was in this back drop the present study was conducted in Vattavada and Kanthaloor panchayath to assess the crop production profile and the major constraints perceived by farmers in garlic production.

METHODOLOGY

The total sample size for the study was 100. Random sampling was followed in the selection of 50 farmers each from Vattavada and Kanthalloor panchayats. Rapid survey was conducted among the selected farmers through structured pretested interview schedule. Focused group discussions and key informant interviews were also carried out to generate adequate qualitative and quantitative data to assess the crop production profile in this region.

The informations collected from farmers of the two panchayaths and other stakeholders were analysed using descriptive statistics like frequencies and percentages. Separate questionnaires, based on the peculiarities of the region were used among the farmers of the two panchayaths to analyse the constraints in production of garlic. The data were analysed using Garrett ranking method.

Garrett's formula for converting ranks into percent is: Percent position = 100 * (Rij – 0.5)/Nj

Where,

Rij = rank given for ith constraint by jth individual

Nj = number of constraint ranked by jth individual

The per cent position of each rank will be converted into scores referring to the table given by Garrett and Woodworth (1969). For each factors, the scores of individual respondents will be added together and divided by the total number of the respondents for whom scores will be added. These mean scores for all the constraints will be arranged in descending order, the constraints will be accordingly ranked.

The bulbs of the three prevailing genotypes of garlic were collected randomly from farmers' fields and were characterized morphologically as per IBPGR descriptors and analysed statically in the experimental design CRD and compared by DMRT.

RESULT AND DISCUSSION

The crop production profile

Experience in garlic cultivation: The survey revealed that there exist a unique system of crop production, curing and storage of garlic in both the

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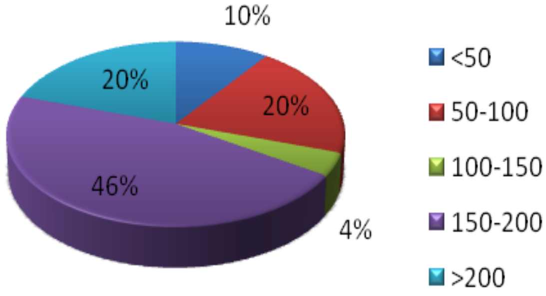
panchayaths of Devikulam block. In Vattavada panchayath, about 86% of farmers had been engaged in garlic cultivation for more than 20 years, whereas in Kanthalloor it was only 26%. Kanthalloor farmers were of recent cultivators and having an experience of less than 20years in garlic cultivation (73%). It was also interesting to note that in Vattavada, 38 % of farmers' have involved in garlic cultivation for about 31-40 years (Table 1).

Table 1. The years of experience in garlic cultivation

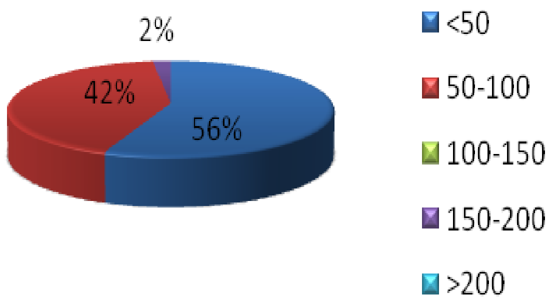
Experience in garlic cultivation (Years)	Vattavada (N=50) (%)	Kanthalloor (N=50) (%)
< 10	0	4.08
11-20	14	69.39
21- 30	18	16.33
31-40	38	10.26
>40	30	0

Area under garlic cultivation: The per capita average area under garlic cultivation in Vattavada was 1.5-2.0 acres (46%) whereas it was less than 50 cents (56 %) in Kanthalloor (Figure 1).



Vattavada

Figure 1. The average area under garlic cultivation



Kanthalloor

Cropping season: Two cropping seasons (May-June to Aug-Sept and Nov-Dec to March-April) were prevailing in Kanthalloor panchayath (62%) as there was enough irrigation facilities. In Vattavada cultivation was only in one cropping season (90 %) and the major cropping season was April –May to August –September.

Market access: The data show that Mettupalayam and Vadakampatty were the main markets for garlic grown in this area. Some small farmers depend on the local markets at Kovilloor, Vattavada. A part of the produce was also marketed through Vegetable and Fruit Promotion Council of Kerala.

Ecotypes: 'Mettupalayam', 'Singapore' and some local collection, 'Malapoondu' are the major ecotypes cultivating in this area (Menon *et al*, 2017). In Kanthalloor there is a practice of growing both the types 'Singapore' and 'Mettupalayam' (86%), whereas in Vattavada, 'Mettupalayam' is the leading type (65%) (Figure.2). But some people prefer 'Malapoondu' in isolated places because of its field resistance and long storability.

Seventy two per cent farmers of Vattavada select the 'Mettupalayam' variety because of its short crop duration of three months. Twenty per cent farmers opined that they cultivate these varieties as the oil content in the garlic grown in the locality was high. In Kanthalloor 64 per cent farmers prefer 'Singapore' because of its high storability.

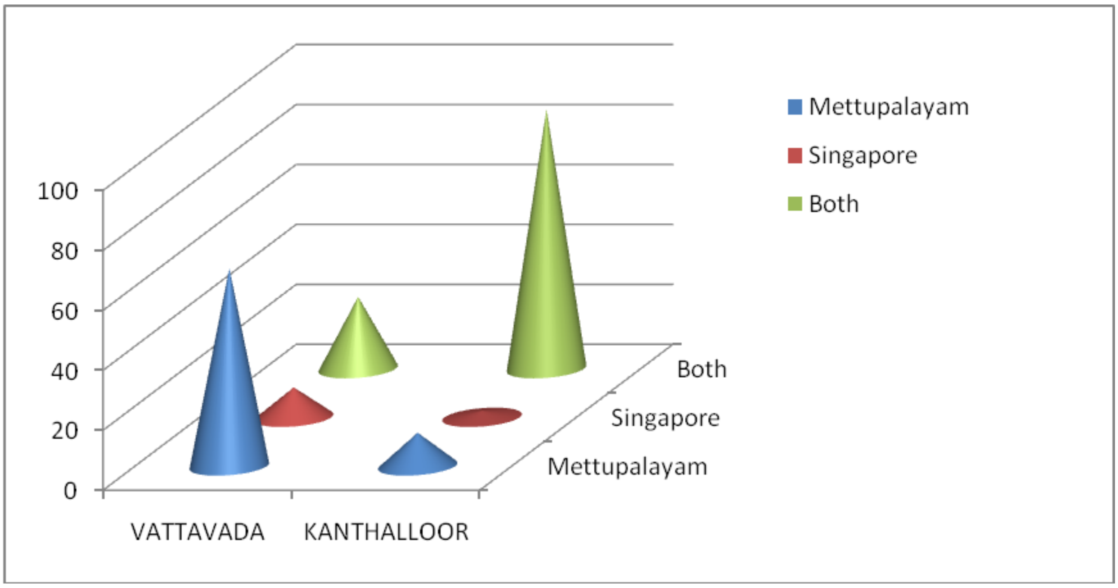


Figure 2. The pattern of preference of garlic ecotype for cultivation

Field curing: There exists a unique system of curing of the crop in the field. Immediately after harvest the bulb with leaves were heaped in a circular manner with bulb inside and leaves towards periphery. It was kept as such for three days and then the bulbs were stalked and dried along with leaves in hanging position and smocked from beneath. These were marketed as small bundles and can be stored for long.

Storage: The storability of garlic is more in "Singapore" and "Malapoondu" genotypes (7-9 months). Hence for the cultivation of this genotype they use their own seeds and they will not depend on open markets, whereas the storability of "Mettupalayam" genotype is 2-3 months and for seed of this ecotype they depend on Mettupalayam market on each growing season (88%).

The morphological characterization of garlic bulb

The bulbs of 'Mettupalayam', 'Singapore' and 'Malapoondu' were collected from three randomly selected farmers' field and morphologically characterized as per IBPGR descriptors and compared with nationally released variety Bhima Omkar. The qualitative characters like Bulb shape, Bulb colour, Clove skin colour and Clove flesh colour were observed (Table 2).

The bulbs of all the varieties were oval in shape except 'Mettupalayam' which was round shaped. Bulb colour was Cream in 'Mettupalayam' and 'Malappoondu'. The bulb and clove were light purple coloured in ecotype 'Singapore' and white in Bhima Omkar. Clove flesh colour of all the ecotypes were yellow.

Table 2. Morphological characters of garlic bulbs

Genotypes	Bulb shape	Bulb colour	Clove skin colour	Clove flesh colour
Mettupalayam	Round	Cream	Yellow	Yellow
Singapore	Oval	Light purple	Light purple	Yellow
Malapoondu	Oval	Cream	Cream	Yellow
Bhima Omkar	Oval	White	White	Yellow

Bulb characters of garlic genotypes like Bulb weight (g), Equatorial diameter (cm), Polar diameter (cm), Number of clove per bulb, Clove weight (g), Clove length (cm) and Clove skin thickness (mm) were depicted in table 3.

Among the four ecotypes the equatorial diameter, polar diameter and bulb weight were significantly higher in 'Singapore'. Bhima Omkar, the national variety released by Directorate of Onion and Garlic Research recorded maximum number of cloves per bulb, but the clove weight was low (0.995g). The clove length was also low in Bhima Omkar (2.8cm). A significantly higher clove thickness was observed in 'Malapoondu' (0.158mm) which was on par with 'Singapore' (0.098mm). Of the three varieties grown in the high ranges of Idukki, 'Singapore' recorded highest equatorial diameter, polar diameter, bulb weight and clove weight. Equatorial diameter, polar diameter, bulb weight and clove weight are the major components that influence the bulb size which ultimately contributes to the bulb yield (Umamaheswarappa *et al*, 2014).

Table 3. Bulb characters of garlic genotypes:

Varieties	Equatorial diameter (cm)	Polar diameter (cm)	Bulb weight (g)	Number of cloves per bulb	Clove weight (g)	Clove length (cm)	Clove skin thickness (mm)
Mettupalayam	3.660^{b}	3.560^{c}	17.193^{b}	11.900^{b}	1.654^{a}	3.610^{a}	0.095^{b}
Singapore	4.330^{a}	4.200^{a}	21.781^{a}	12.100^{b}	2.035^{a}	3.400^{a}	0.098^{ab}
Malappundu	3.740^{b}	3.920^{b}	16.787^{b}	13.400^{b}	1.872^{a}	3.660^{a}	0.158^{a}
Bhima Omkar	3.780^{b}	3.650^{c}	16.373^{b}	19.500^{a}	0.995^{b}	2.800^{b}	0.043^{b}
CD(0.01)	0.333	0.337	4.153	4.077	0.770	0.561	0.081

Preliminary quality analysis

There was a general opinion that the garlic produced from these high ranges have a better aroma and taste. It was generally stored by the farmers after proper curing in the field and smocked in the households for long storage. These bundles of bulbs were usually hanged in households and were marketed in the nearby tourist locations apart from the bulk sale through government marketing systems like Kerala State Horticultural Products Development Corporation and Swasraya Karshaka Samithies of VFPCK. Random market samples were analysed for essential oil extracted from the cloves. The oil recovery ranges from 0.2-0.4%. Dziri *et al*., 2014 reported the yield of 0.1% oil from air dried garlic samples.

Constraints in production

The major constraints in garlic production as perceived by garlic farmers of Kanthalloor and Vattavada region are the small size of the garlic cloves as indicated in table 5. It recorded highest total and average Garrett scores of 43833 and 456.60 respectively. High pest and disease incidence (43332) and wild animal attack (43147) were also ranked 2 and 3 respectively by the farmers. However, majority of farmers did not perceive climate change, lack of irrigation facility, low productivity and non availability of high yielding variety as a serious constraint in garlic cultivation of the area. This was indicated from the relatively low Garrett scores of 9174, 17952, 26658 and 35262 respectively for these factors.

The small size of the garlic cloves can be mostly attributed to the continuous use of local varities and low fertility of the soil. With introduction of appropriate technology and better extension support these constraints can be overcome and better production can be attained.

Table 4. Constraints perceived by garlic growers of Kanthalloor and Vattavada

Sl. No.	**Constraints**	**Garrett Score**		**Rank**
		Total Score	**Avg Score**	
1	Climate change	9174	95.56	12
2	Lack of irrigation facility	17952	187.00	11
3	Low productivity	26658	277.69	10
4	Non availability of high yielding variety	35262	367.31	9
5	**Small size of cloves**	**43833**	**456.60**	**1**
6	**High pest and disease incidence**	**43332**	**451.38**	**2**
7	Lack of awareness on newer production technology	43049	448.43	4
8	Lack of advisory service from Officials	42710	444.90	5
9	Lack of assistance from the Government	42534	443.06	7
10	Lack of proper storage facility	42519	442.91	8
11	Low price of the product	42621	443.97	6
12	**Wild animal attack**	**43147**	**449.45**	**3**

CONCLUSION

Vattavada and Kanthalloor are the two isolated panchayaths of Kerala where a unique system of garlic production, curing and storage exists. The ecotypes in cultivation were short duration "Mettupalayam" and high storable "Singapore". Another land race "Malapoondu" having good shelf life was also cultivated especially in Vattavada. The oil content of cured samples were high and the peoples claim a peculiar aroma and taste for the product. Detailed evaluation of production practices and chemoprofiling are required to elucidate conclusive results.

ACKNOWLEDGEMENT

This study forms a part of workshop conducted by Kerala Agricultural University. The authors wish to express sincere thanks to all farmers participated in the survey and delivering sincere facts. Acknowledgements are also owe to the development department officials and people representatives who participated. Sincere thanks to Directorate of Onion and Garlic Research, Pune for giving the samples and guidance at times of need. The Authors express their gratitude to Kerala Agricultural University for the conduct of this study

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RESEARCH ARTICLE

SURVEY FOR THE INCIDENCE OF RICE BLAST DISEASE IN DIFFERENT AGRO CLIMATIC ZONE OF CHHATTISGARH

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Abstract: Rice blast disease caused by *Pyriculariaoryzae*Cavara has become the one of major fungal disease covering in major rice growing area and the first time a survey was conductedduring *Kharif* -2016-17in different rice growing districts of Chhattisgarh State, to determine thedisease incidence, occurrence, disease severity and spread of rice blast disease in three agro climatic zone *viz*., Bastar Plateau Zone (Zone-I), Chhattisgarh Plains Zone (Zone-II) and Northern Hills Zone (Zone-III). Theassessment of rice blast was carried out in thirteen major rice growing districts viz., Jagdalpur (Bastar), Dantewada, Narayanpur, Bilaspur, Janjgir-Champa, Kanker, Bemetara, Raipur, Dhamtari, Gariyaband, Balrampur, Surajpurand Surguja from August last week to October 2016 and September first week to October 2017. Among the thirteen districts, percent disease index was varied from 20 to 87.78%. The highest percent disease index (PDI) was recorded (87.78%) in Jagdalpur(Bastar)district with Swarna cultivar which is followed by Surguja (85.56%) and Balrampur (84.44%)and lowest PDI was recorded (20%) in Surajpur (Maheshwari) and Bastar (Safari). The more severity of rice blast disease might be due to the highly favorable factors like application of excessive doses of nitrogenous fertilizers, intermittent drizzles, cloudy weather, highy relative humidity (>90%), low night temperature (<26 C), more number of rainy days, longer duration of dew, slow wind movement and availability of collateral hosts. Thus, their serve as basic to evaluate location specific integrated disease management strategy against rice blast disease.

Keywords: Rice blast, Severity, Incidence, Disease

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereals of the world and is consumed by 50% of the world population (Luo *et al*., 1998). In Chhattisgarh, Rice used as primary food and 85% farmers depend on rice crops for economical and social status. It is popularly known as “bowl of rice”, rice occupied average of 3.6 million ha with 6322.1 thousand tonnes production and 1.2 to 1.6 t/ha productivity. Rice crop suffers from many diseases caused by fungi, bacteria, viruses, phytoplasma, nematodes and other non-parasitic disorders. Among the fungal diseases, blast caused by *Pyriculariaoryzae*is considered as a major threat to rice production because of its wide spread distribution and its destructiveness under favorable conditions. This disease was recorded from 85 countries (Hawksworth, CMI, 1990) and it is estimated to cause 14-18% grain yield losses worldwide (Mew and Gonzales, 2002). The yieldlosses due to pests and diseases are estimated to be around 37% (IRRI, 2014) of which blast accounts to 14-18 per cent.Rice blast caused by *Pyriculariaoryzae*Cavara [synonym *Pyriculariagrisea*Sacc. the anamorph of *Magnaporthegrisea* (Herbert) Yaegashi and Udagawa], is one of the most destructive and wide spread disease (Jia*et al*., 2000). Rice blast was first recorded in China (1637) later from Japan (1704). In India, the disease gained importance when a devastating epidemic occurred in Thanjavur (Tanjore) delta of Tamil Nadu in 1913 (Padmanabhan, 1965, M.S. Prasad *et al*., 2011). The disease results in yield loss as high as 70-80% (Ou, 1985) when predisposition factors (high mean temperature values, degree of relative humidity higher than 85-89%, presence of dew, drought stress and excessive nitrogen fertilization) favor epidemic development (Piotti*et al*., 2005).

Verma and Sengupta (1985) reported that, survey for diseases of rice, the principal cereal crop of Tripura, had led to the identification of as many as 17 diseases caused by fungi, bacteria, viruses and nematodes. Pawar*et al*. (2000) conducted simple rapid roving disease survey on major field crops during 1999 in Karnataka. The survey was carried out in three districts, *viz*., Bangalore rural, Tumkur and Hassan. Sixty one per cent of rice blast incidence was recorded in the surveyed villages of Hassan, Alur and Sakleshpur. Hossain and Kulakarni (2001) conducted survey for blast of rice during *Kharif* 1999 in different villages of Dharwad, Belgaum and Uttara Kannada districts and reported maximum disease incidence in Haliyal (61.66%) and Mundagod (54.00%) talukas of North Karnataka.Puri*et al*. (2006) stated that, the higher PDI at dough stage (30.45%) followed by booting stage (29.77%) and tillering stage (15.4%) in low land rice growing areas.In Andhra Pradesh BPT- 5204 suffers with

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moderate blast severity because of use of nitrogen fertilizers above the recommended doses (Mukundvariar*et al.,* 2006).Shahijahandar*et al.* (2010) recorded prevalence and distribution of blast in Kupwara district of Jammu and Kashmir and reported 25% disease incidence and 15% severity and the incidence was more from transplanting to panicle initiation stage. Akhilesh*et al*. (2017) conducted survey, collection, isolation and identification of isolates of *Pyriculariaoryzae* causing rice blast in southern Karnataka by using host differential lines and concluded that the highest percent disease severity of the rice leaf blast was recorded (38.92%) in Krishnarajpet Taluk and lowest incidence was recorded (27.39%) in Maddur Taluk.

Therefore present survey was conducted in different agro climatic zone of Chhattisgarh state to know the incidence and severity of rice blast diseases in major rice growing area, cropping systems, rice varieties, agronomic practices and management methods in the state which is prerequisite to take decision on sustainable integrated disease management strategy.

MATERIAL AND METHOD

Purposive sampling survey was conducted during *Kharif* -2016 and*Kharif* -2017 in different rice growing districts of Chhattisgarh State to study the occurrence, disease intensity and spread of rice blast disease. Rice is cultivated in three agro climatic zone *viz*., Bastar Plateau Zone (Zone-I), Chhattisgarh Plains Zone (Zone-II) and Northern Hills Zone (Zone-III), of the state. Hence, survey was conducted for collection of rice blast infected leaf samples and to assess the disease incidence from different rice growing area of Chhattisgarh during *Kharif*2016 and *Kharif* 2017. Sampling sites also included hot spots where blast occurs regularly in severe form. All collections were made from tissues infected in field with naturally occurring inoculum. A total of 63 isolates were collected from Chhattisgarh state. From Chhattisgarh state a total of 63 isolates were collected. Seventeen samples were collected from Jagdalpur (Madhya Bastar), fifteen samples were collected from Surguja, seven were collected from Surajpur, five were collected from Kanker and Balrampur, six were collected from Dhamtari, two were collected from Bemetara, one isolate from each district of Dantewada, narayanpur, Janjgir-Champa, Bilaspur and Gariyabandh. The samples were separately bagged, air dried and stored in a refrigerator at 4 ^{0}C for further studies (Table 1 and Figure 1).

Ten plots in each field having an area of one square meter were selected at random. For assessing the Percent disease index (PDI), Sum of all rating hills, total number of observed plants and maximum disease grade in each field were recorded. The PDI was calculated using the formula.

$$\text{PDI} = \frac{\text{Sum of all rating hills}}{\text{Total No.of observed plants} \times \text{Maximum disease grade } (1-9)} \times 100$$

From each district ten to twenty rice growing villages were identified based on production oriented survey reported from ICAR-IIRR and randomly 5-8 rice field are selected.

Symptoms on leaf portions the disease isolate at each observation during the survey are recorded. Besides, information like plant characters and geographical information (longitude/latitude) were collected. The fungus was isolated by tissue segmentation method (Bonman*et al*., 1987). Blast infected leaf tissues stored in refrigerator were cut into small bits. These bits were washed in sterilized distilled water twice, surface sterilized in 0.1% mercuric chloride for 30 seconds, rinsed three times in sterilized water and allowed for sporulation on sterilized glass slides by incubating in a moist chamber at 25 ^{0}C for 48 h. Well sporulated lesions were placed in double distilled water in the test tubes and vortexed for 1 min. About 1 ml of spore suspension was added to sterilized plates and 2% agar was added. Single spores were located and picked up microscopically and transferred to fresh sterilized Petri plates containing OMA medium. The Petri plates were incubated at 28^{0}C for 7 days and the fungus was identified following mycological description given by Ou (1985). All the sixty three isolates proved Koch's postulates at glasshouse conditions on susceptible cultivar HR-12*Kharif*-2017 and *Kharif*-2018 at ICAR-IIRR Rajendranagar, Hyderabad.

Isolates were assigned code numbers from PO-CG-01 to PO-CG-63, where named with 3-part code such as PO-CG-1, PO-CG-2 and PO-CG-63 and so on. The first part of the two letters represented the causal organisms of crop disease (e.g. PO: *Pyriculariaoryzae*). The next two alphabet letters represented the location name of state (CG: Chhattisgarh) and final numeral number indicated isolate serial number. The identity was assigned to each isolate based on place from which sample collected (Table 1).

RESULT AND DISCUSSION

In Chhattisgarh state it was the first time purposive disease survey was conducted during *Kharif*-2016 and *Kharif* 2017 to know the occurrence and spread of rice blast disease in three different agro climatic condition *i.e.*Bastar Plateau Zone (Zone-I), Chhattisgarh Plains Zone (Zone-II) and Northern Hills Zone (Zone-III)(Table 1). Systematically, a roving survey was carried out in thirteen districts of Chhattisgarh state to assess the incidence of rice blast and to collect the blast infected leaf samples for isolation of *P. oryzae* isolates during *Kharif* 2016 and *Kharif* 2017. The percentage disease index was more during *Kharif*

2016 (43.69) over *Kharif* 2017 (43.37). Based on microscopic examination the pathogen was identified as *Pyriculariaoryzae*Cavara. (Anamorph =*Pyriculariagrisea*Sacc.). A total of 63 blast diseasesamples from rice were collected from different locations of Chhattisgarh regions during the *Kharif* 2016 (32 sample) and *Kharif* 2017 (31 samples). The collection sites include hot spots for blast disease in both the regions. These isolates were collected from different locally cultivated rice varieties. The results indicated that disease incidence in different agro climatic regions ranged from 20.00% on Safari and Maheshwari varieties, Bastar district to 87.78% on Swarna, Jagdalpur district. The maximum disease incidence was noticed in Jagdalpur (87.78%) followed by Surguja (85.56) and Balrampur (84.44). The PDI of blast among different cultivars and locations was significant. (Table 1 and Figure 1).

The results indicate that, the mean blast PDI recorded in Chhattisgarh plain zone was 35.49, in North hills zone 47.16, and in Bastar Plateau 47.25 (Table 1).Among the cultivars highest PDI of 87.78 was recorded on Swarna (Jagdalpur) variety in PO-CG-16 and lowest PDI of 20.00 was recorded on Safari (Bastar) and Maheshwari (Surajpur) in PO-CG-14 and PO-CG-52, respectively. These results indicate variation in PDI which was influenced by the geographical area under cultivation. In Swarna, the mean PDI of 31.11 was lowest in Chhattisgarh Plains Zone and highest PDI of 87.78 was in Bastar Plateau Zone indicating variation in per cent blast disease index was influenced by geographical area under cultivation and the race of *P. oryzae* prevailing in these areas. In Mahamaya, the lowest PDI in Chhattisgarh Plains Zone was 26.67, highest PDI in North Hills Zone it was 65.56. This shows a variation in PDI influenced by geographical area under cultivation. In Bamleshwari, the lowest PDI in North Hills Zone was 33.33 while highest PDI in Bastar Plateau Zone was 65.56. The variation in PDI may be influenced by geographical area under cultivation or the race prevailing in the region or interaction of the variety and the weather condition in these areas. In Indira Sona, the lowest PDI was 42.22 in North Hills Zone whereas highest PDI in Bastar Plateau Zone was 56.67. In Safari, the lowest PDI was 20.00 and highest PDI was 30.00 in Bastar Plateau Zone. This shows a variation in PDI influenced by geographical area under cultivation. In Maheswhwari, the lowest PDI was 20.00 and highest PDI was 65.56 in North Hills Zone. This shows a variation in PDI influenced by geographical area under cultivation. The mean PDI of MTU 1001 was 26.67, MTU1010 was 23.33, Indira SugandhitDhan was 30.56, Karma Mahsuri was 32.22, PusaSugandhit was 38.89, PAC 507 was 58.33, Poineer 575 was 42.22, US 312 was 34.44, US 350 was 44.44, Jirafal was 21.11, IR 36 was 33.33, Badshah was 25.00, Gomati was 32.22, Indira Barani Dhan-1 was 44.44, Dayal was 36.67 and Danteshwari was 33.33. The isolates (PO-CG-1, PO-CG-16, PO-CG-40, PO-CG-45, PO-CG-47, PO-CG-55, PO-CG-59 and PO-CG-61) which produced excellent sporulation recorded variation in PDI on different rice varieties (Table 2). In different agro climatic zones the PDI varied from 20 (PO-CG-14 and PO-CG-52) to 87.78 (PO-CG-16) under artificially inoculated conditions and on susceptible HR-12 variety these isolates showed high disease incidence.

Ramesh Babu*et al.* (2015) conducted survey in Andhra Pradesh and Telangana found that the most severity of blast diseases found mean PDI in BPT-5204 was 53.48, in MTU-1010 was 43.33, NLR-145 was 55.97, HR-12 was 78.88, RGL-2624 was 55.41, MTU-1001 was 49.86 and WGL-44645 was 51.78.Shahijahandar*et al.* (2010) recorded prevalence and distribution of blast in Kupwara district of Jammu and Kashmir and reported 25% disease incidence and 15% severity. In all the districts of Southern Telangana Zone of Andhra Pradesh (Jagadeeshwar*etal*., 2014) reported 30-35% incidence of neck blast if the crop was in flowering stagecoinciding with North-East monsoon. Ali Anwar *et al*. (2009) surveyed temperate districts of Kashmir for the severity of rice blast and reported that the leaf blast severity ranged from 3.7 to 41.3% whereas highest nodal blast was found in Kulgam (7.3%) followed by Khudwani (5.4%) and Larnoo (3.8%) zones of Anantanag district. The most destructive phase of neck blast severity was found in every district with an average range of 0.3-4.9%. Mukundvariar*et al.* (2006) conducted survey in Andhra Pradesh and found that BPT- 5204 suffers with moderate blast severity because use of high nitrogen fertilizers.Hossain and Kulakarni (2001) conducted survey for rice blast during *Kharif* 1999 in different villages of Dharwad, Belgaum and Uttara Kannada districts of Karnataka and reported maximum disease incidence in Haliyal (61.66%) and Mundagod (54.00%) talukas of North Karnataka.

CONCLUSION

Servey on occurrence, severity and spread of blast disease of rice in major rice growing areas of Chhattisgarh sate revealed that disease is a major problem of zone. Among the thirteen districts surveyed Jagdalpur (Bastar) district recorded highest PDI 87.78% in Swarna variety and Surajpur and Bastardistricts were recorded lowest PDI of 20% in Maheshwari and Safari cultivar, respectively. The moreseverity of rice blast disease might be due to the highly favorable factors like application of excessive doses of nitrogenous fertilizers, intermittent drizzles, cloudy weather, highy relative humidity (>90%), low night temperature (<26), more number of rainy days, longer duration of dew, slow wind movement and availability of collateral hosts on these locations during the period of survey. Large scale cultivation of susceptible varietiesas mono crop continuously on the same field might have increased the possibility of perpetuating the pathogen in the crop debris. The present study may serve as a precursor for evolving management strategies against the disease effective for the zone in an integrated way for sustainable development of crop in the state.

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Table 1. Leaf blast incidence and percentage disease index on different rice varieties cultivated in major rice growing areas of Chhattisgarh during *Kharif*2016 and *Kharif* 2017

S. No.	Cultivar	Agroclimatic Zone	Season & Year	Isolates	Latitude	Longitude	Altitude	PDI %	Score (Mean±Stdev)
1	Swarna	Bastar plateau	*Kharif*2016	PO-CG-1	19.088	81.961	1785	64.44	5.80±0.79
2	Bamleshwari		*Kharif*2016	PO-CG-2	19.087	81.964	1821	65.56	5.90±0.74
3	Indira Sona		*Kharif*2016	PO-CG-3	19.087	81.964	1821	56.67	5.10±0.57
4	Mahamaya		*Kharif*2016	PO-CG-4	19.088	81.961	1785	61.11	5.50±0.71
5	MTU 1001		*Kharif*2016	PO-CG-5	19.088	81.961	1785	26.67	2.67±0.50
6	Mahamaya		*Kharif*2016	PO-CG-6	19.120	81.944	1811	32.22	2.90±0.57
7	Swarna		*Kharif*2016	PO-CG-7	19.120	81.944	1811	58.89	5.30±0.67
8	Safari		*Kharif*2016	PO-CG-8	19.120	81.944	1811	30.00	2.70±0.67
9	Swarna		*Kharif*2016	PO-CG-9	19.117	81.964	1772	67.78	6.10±0.88
10	Mahamaya		*Kharif*2016	PO-CG-10	19.117	81.964	1772	32.22	2.90±0.74
11	MTU 1010		*Kharif*2017	PO-CG-11	19.117	81.964	1772	23.33	2.10±0.74
12	Swarna		*Kharif*2017	PO-CG-12	19.043	81.939	1814	65.56	5.90±0.88
13	Mahamaya		*Kharif*2017	PO-CG-13	19.043	81.939	1814	62.22	5.60±0.84
14	Safari		*Kharif*2017	PO-CG-14	19.046	81.914	1808	20.00	1.80±0.79
15	Swarna		*Kharif*2017	PO-CG-15	19.046	81.914	1808	42.22	3.80±0.79
16	Swarna		*Kharif*2017	PO-CG-16	19.002	81.046	1798	87.78	7.90±0.74
17	Indira Sugandhit		*Kharif*2017	PO-CG-17	19.002	81.046	1798	32.22	2.90±0.57
18	Karma mahsuri		*Kharif*2017	PO-CG-18	18.416	81.334	1148	31.11	2.80±0.63
19	Mahamaya		*Kharif*2017	PO-CG-19	19.714	81.209	1745	37.78	3.40±0.84
20	Swarna	Chhattisgarh Plain	*Kharif*2016	PO-CG-20	20.226	81.516	1329	36.67	3.30±0.48
21	Mahamaya		*Kharif*2016	PO-CG-21	20.226	81.516	1329	26.67	2.40±0.70
22	Swarna		*Kharif*2016	PO-CG-22	20.209	81.506	1307	40.00	3.60±0.70
23	Karma mahsuri		*Kharif*2017	PO-CG-23	20.209	81.506	1307	33.33	3.00±0.67
24	Swarna		*Kharif*2017	PO-CG-24	20.569	81.606	1311	37.78	3.40±0.52
25	Mahamaya		*Kharif*2016	PO-CG-25	20.709	81.55	1063	34.44	3.10±0.74
26	Swarna		*Kharif*2016	PO-CG-26	20.709	81.55	1063	35.56	3.20±0.79
27	PusaSugandhit		*Kharif*2016	PO-CG-27	20.709	81.55	1063	38.89	3.50±0.53
28	Mahamaya		*Kharif*2017	PO-CG-28	20.709	81.55	1063	36.67	3.30±0.67
29	Swarna		*Kharif*2017	PO-CG-29	20.709	81.55	1063	33.33	3.00±0.82
30	Mahamaya		*Kharif*2017	PO-CG-30	20.709	81.55	1063	35.56	3.20±0.79
31	Swarna		*Kharif*2016	PO-CG-31	21.236	81.703	735	48.89	4.40±0.70
32	Swarna		*Kharif*2016	PO-CG-32	21.948	82.549	856	31.11	2.80±0.63
33	Mahamaya		*Kharif*2016	PO-CG-33	21.948	82.549	856	27.78	2.50±0.53
34	Swarna		*Kharif*2017	PO-CG-34	21.949	82.582	901	38.89	3.50±0.53
35	Indira SugandhitDhan		*Kharif*2017	PO-CG-35	22.103	82.140	883	28.89	2.60±0.52
36	Swarna		*Kharif*2017	PO-CG-36	20.645	82.074	1250	38.89	3.50±0.53
37	PAC-507	North Hills	*Kharif*2016	PO-CG-37	23.056	83.319	1867	74.44	6.70±0.95
38	Poineer-575		*Kharif*2016	PO-CG-38	23.056	83.319	1867	42.22	3.80±0.79
39	Bamleshwari		*Kharif*2016	PO-CG-39	23.116	82.962	1896	48.89	4.40±0.52
40	Swarna		*Kharif*2017	PO-CG-40	23.116	82.962	1896	84.44	7.60±0.70
41	Mahamaya		*Kharif*2017	PO-CG-41	23.257	83.210	1909	48.89	4.40±0.97
42	US-312		*Kharif*2016	PO-CG-42	23.157	83.153	1949	45.56	4.10±0.88
43	US-350		*Kharif*2016	PO-CG-43	23.157	83.153	1949	44.44	4.00±0.82
44	Maheshwari		*Kharif*2016	PO-CG-44	23.157	83.153	1949	65.56	5.90±0.88
45	Swarna		*Kharif*2016	PO-CG-45	23.157	83.153	1949	66.67	6.00±0.82
46	Jirafal		*Kharif*2016	PO-CG-46	23.157	83.153	1949	21.11	1.90±0.57
47	IR-36		*Kharif*2016	PO-CG-47	23.157	83.153	1949	33.33	3.00±0.67
48	US-312		*Kharif*2016	PO-CG-48	23.176	83.127	1884	23.33	2.10±0.88
49	Swarna		*Kharif*2016	PO-CG-49	23.176	83.127	1884	62.22	5.60±0.97
50	Mahamaya		*Kharif*2016	PO-CG-50	23.176	83.127	1884	62.22	5.60±1.17
51	Badshah		*Kharif*2016	PO-CG-51	23.176	83.127	1884	24.44	2.20±0.79
52	Maheshwari		*Kharif*2017	PO-CG-52	23.176	83.127	1884	20.00	1.80±0.63
53	Indira Sona		*Kharif*2017	PO-CG-53	23.218	81.277	1886	42.22	3.80±0.97
54	Gomati		*Kharif*2017	PO-CG-54	23.218	81.277	1886	32.22	2.90±0.32
55	Swarna		*Kharif*2017	PO-CG-55	23.696	82.216	1878	85.56	7.70±0.82

56	Maheshwari		*Kharif*2017	PO-CG-56	23.696	82.216	1878	64.44	5.80±1.03
57	Mahamaya		*Kharif*2017	PO-CG-57	23.696	82.216	1878	65.56	5.90±0.88
58	Indira Barani Dhan-1		*Kharif*2017	PO-CG-58	23.696	82.216	1878	44.44	4.00±0.82
59	PAC-507		*Kharif*2017	PO-CG-59	23.696	82.216	1878	42.22	3.80±0.79
60	Badshah		*Kharif*2017	PO-CG-60	23.218	81.277	1886	25.56	2.30±0.95
61	Dayal		*Kharif*2017	PO-CG-61	23.218	81.277	1886	36.67	3.30±0.95
62	Bamleshwari		*Kharif*2017	PO-CG-62	23.218	81.277	1886	33.33	3.00±0.67
63	Danteshwari		*Kharif*2017	PO-CG-63	23.218	81.277	1886	33.33	3.00±0.82
Mean (*Kharif*2016)								**44.69**	
Mean (*Kharif* 2017)								**43.37**	

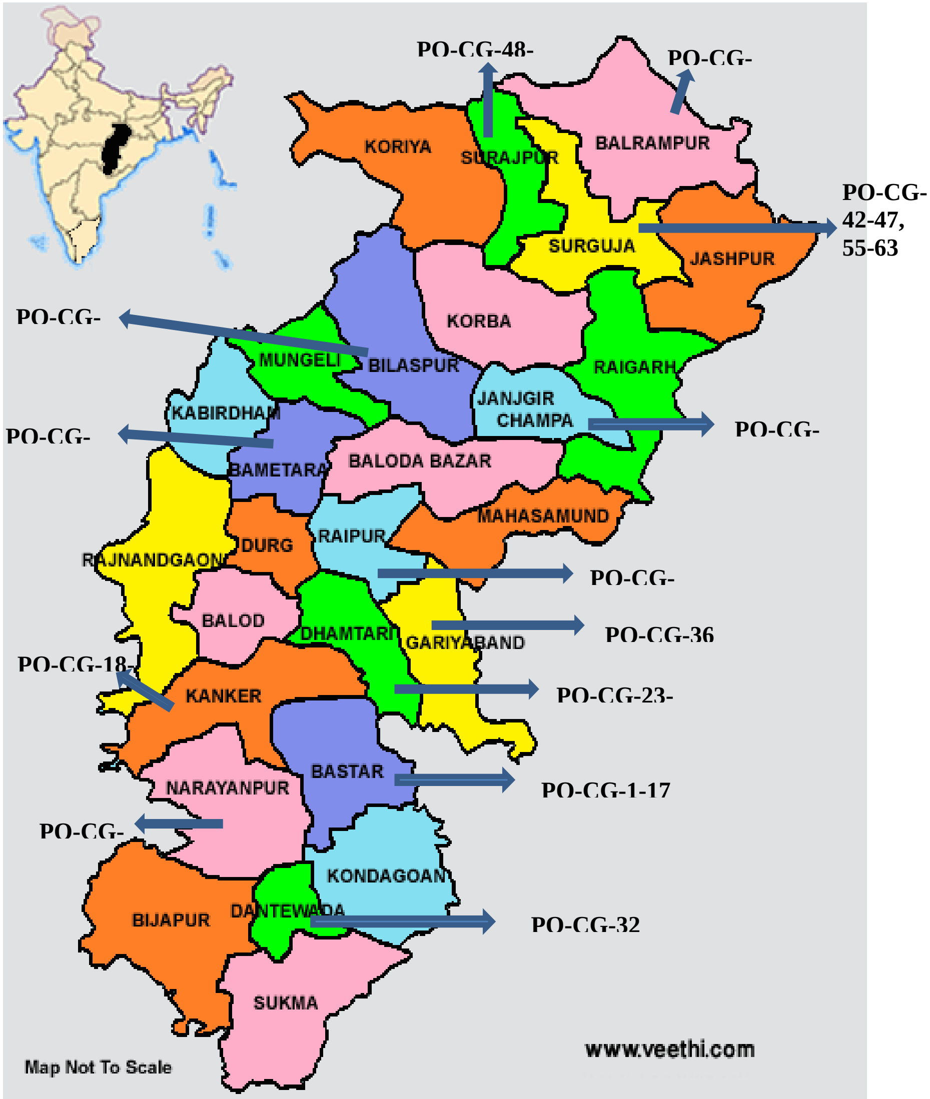

Figure 1. Map showing the collection sites of *Pyriculariaoryzae* isolates inChhattisgarh

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RESEARCH ARTICLE

EFFECT OF ENVIRONMENTAL CONDITIONS ON THE DEVELOPMENT OF ALTERNARIA BLIGHT OF TOMATO (*LYCOPERSICON ESCULANTUM* MILL.)

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Abstract: The environmental factor play very important role in the development of the plant disease. Alternaria blight of tomato during two year is observed 2014-15 and 2015-16 crop season. The disease appears in the 3rd week of November in both the year. Maximum disease incidence 40.5% was observed in the 4th week of January 2014-15 and 2nd week of January 2015-16 crop season. When the average temperature and relative humidity 14.1 and 84.2% on the average disease incidence was observed 3rd week of January 2014-15 and 2nd week of January 2015-16 crop.

Keywords: Environmental factor, Alternative, Tomato

INTRODUCTION

The tomato (*Lycopersicon esculantum*) is one of the most popular vegetable crops in India. The center of origin of Tomato (*Lycopersicon esculantum*) is south America. Tomato (*Lycopersicon esculantum*) is belong to family-Solanaceae and genus - Lycopersicon. Hybrid variety in India are of the recent origin with the technology most successful in Tomato(*Lycopersicon esculantum*) result in large area coverage. Tomato is grown on variety of soil ranging from sandy to clay. Soil pH level should be between 6.0 to 7.0 for getting a good crop.

Tomato (*Lycopersicon esculantum*) dose not come up well under extreme weather conditions. Excess humidity predisposes tomato to many diseases. Day temperature of 28 ^{o}C and night temperature of 18 ^{o}C is ideal for its growth. Sun light is essential for the crop to produce vitamin 'C'. Tomato (*Lycopersicon esculantum*) is also reached in medicinal value. Tomato (*Lycopersicon esculantum*) is most severely affected by various (Viral, Nematodes, Mycoplasma, Bacterial and Fungal diseases) twenty diseases of tomato (*Lycopersicon esculantum*) reported from different part of country. Alternaria blight of tomato caused by *Alternaria alternata* f.sp. *lycopersici* is the serious disease the crop in U.P. . It's well documented that environmental factors play very important role in the development of the plant diseases. The symptoms like dark brown, sunken lesion often with irregular yellow margin may occur on many germplasm. The leaf symptom of dark brown to black canker with concentric zonation occur on stem near the soil line or above ground . Therefore, the present investigation was under taken to find out the role of atmospheric temperature and relative humidity in the development of Alternaria blight of tomato. To study the effect of atmospheric temperature and relative humidity on disease development, the plant were raised in a highly sick plot (3 X 2 m) with previous known history of Alternaria blight of tomato during two consecutive crop season *viz.*, 2014-15 and 2015-16. The experimental was carried out in a randomized block design (RBD) with four replications at Students from Pilikothi of T.D.(.P.G.) College, Jaunpur. Disease incidence was recorded at weekly interval in experimental plots.

The disease appeared in the third week of November in both the years during 2014-15 and 2015-16 which increase gradually with decrease in temperature and increase in relative humidity. Maximum disease incidence (40.5%) was observed in the fourth week of January during 2014-15 crop seasons when the average temperature and relative humidity were 14.1 and 84.2% respectively. On an average the disease incidence was at par with third week of January 2014-15and second week of January 2015-16 (Table 1 & 2). Thus it may be concluded that in general the disease incidence increased with the decrease of atmospheric temperature and increase the relative humidity (Fig. 1 & 2). There was no further increase in disease incidence as the temperature raised though the relative humidity was sufficient enough.

MATERIAL AND METHOD

To study the effect of atmospheric temperature and relative humidity on disease development. The plant were raised in a highly sick plot (3x 2 m^2) with previous known history of Alternaria blight of tomato during two constutive crop season *viz.*, 2014-15 and 2015-16. The experiment was carried out of RBD with four replication. As soon as the disease was observed the number of plant infected were recorded. Subsequently the disease incidence was recorded weekly and it was correlated with atmospheric data. Thus the data on the maximum and minimum temperature and relative humidity for

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growth and development of the disease were recorded. The information of atmospheric temperature and relative humidity was collected from the meteorological observation Babatpur, Varanasi.

RESULT AND DISCUSSION

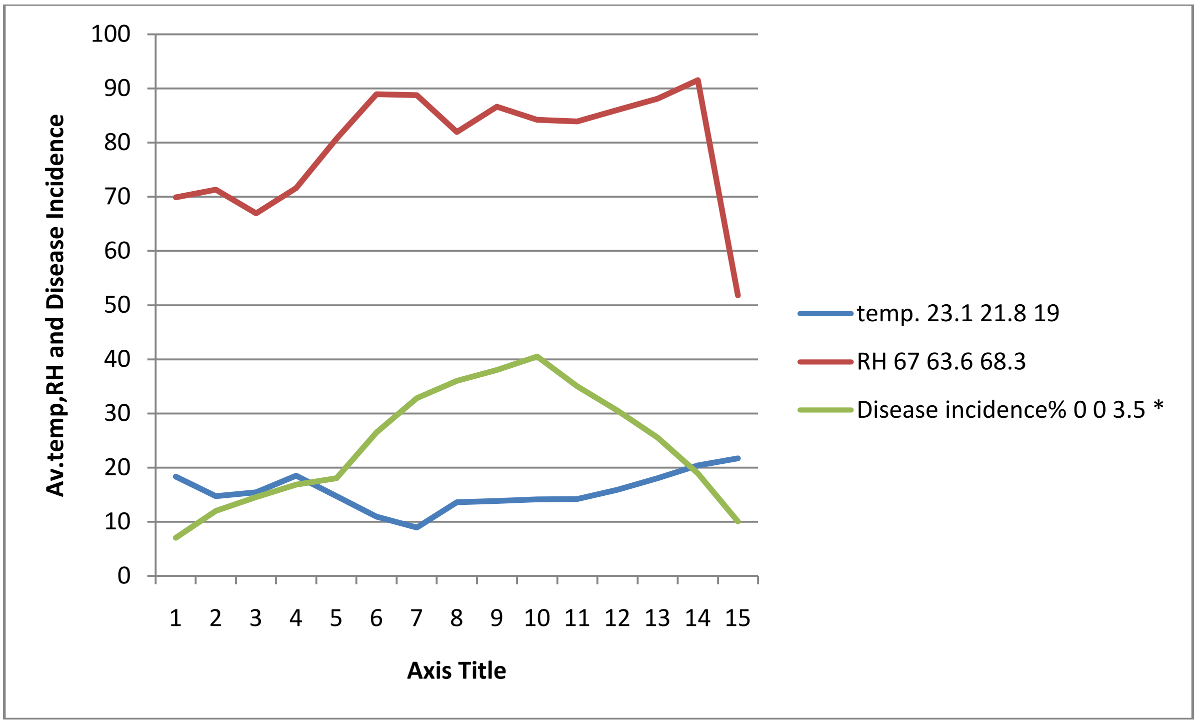
It is well documented that environmental factor play very important role in the development of plant disease. There for the present investigation was under taken to find out the role of atmospheric temperature and relative humidity in the disease development of Alternaria blight of Tomato (*Lycopersicon esculantum*). The disease incidence was recorded at weekly interval in the experimental plot.

The data presented in the table – (1) and table – (2) and corresponding histogram Fig – (1 and 2) related with environmental factor *viz.* atmospheric temperature and relative humidity that play an important role in the disease development and also significant correlation was observed between that environmental factor and disease incidence. The disease appeared in the 3rd week in the both crop season during 2014-15 and 2015-16. Which increase gradually within the decrease the temperature and increase relative humidity.s Maximum disease incidence (40.5%) was observed in the 4th week of January during 2014-15, when the temperature and relative humidity were 16.1 ^{o}C and 63.5% during 2015-16 respectively. Further it was noted that disease incidence was observed when atmospheric temperature was near about 8.9 ^{o}C with 88.7% relative humidity. Hence it could be inferred from the result that tomato plant were most susceptible to infection when atmospheric temperature was near about 13.8 ^{o}C to 1 ^{o}C followed by maximum relative humidity.

Table 1. Effect of atmospheric temperature and relative humidity on the disease incidence during 2014-15.

Standard Week	Date	Temperature ^{o}C		Average temperature ^{o}C	Humidity	Average disease incidence %
		Maximum	Minimum			
44	29 Oct - 4 Nov.	31.5	14.7	23.1	67.0	00.0
45	05-11 Nov	31.5	12.6	21.8	63.6	00.0
46	12-18 Nov.	27.4	10.6	19.0	68.3	3.5 (10.78)*
47	19-25 Nov	26.6	10.0	18.3	69.9	7.0(15.34)
48	26Nov- 02Dec	25.0	4.4	14.7	71.3	12.0(20.26)
49	03-09 Dec	24.8	6.0	15.4	66.9	14.5(22.38)
50	10-16Dec	27.2	9.9	18.5	71.6	16.8(24.19)
51	17-23 Dec	20.1	9.5	14.7	80.7	18.0(25.10)
52	24-31Dec	14.3	7.5	10.9	88.9	26.5(30.98)
1	01-07Jan	12.7	5.2	8.9	88.7	32.8(34.93)
2	08-14Jan	18.9	8.2	13.6	81.9	36.0(36.85)
3	15-21 Jan	17.7	10.0	13.8	86.6	38.5(38.35)
4	22-28 Jan	18.8	9.3	14.1	84.2	40.5(39.52)
5	29Jan - 04 Feb	09.8	8.7	14.2	83.9	35.0(36.27)
6	05-11 Feb	23.8	8.0	15.9	86.0	30.5(33.52)
7	12-18 Feb	25.5	10.5	18.0	88.1	25.5(30.32)
8	19-25 Feb	27.5	13.2	20.4	91.5	18.9(25.76)
9	26 Feb- 04 March	30.1	13.2	21.7	51.8	10.0(18.43)
C.D. at 5%						(1.16)

*Transferred values indicated in parenthesis.

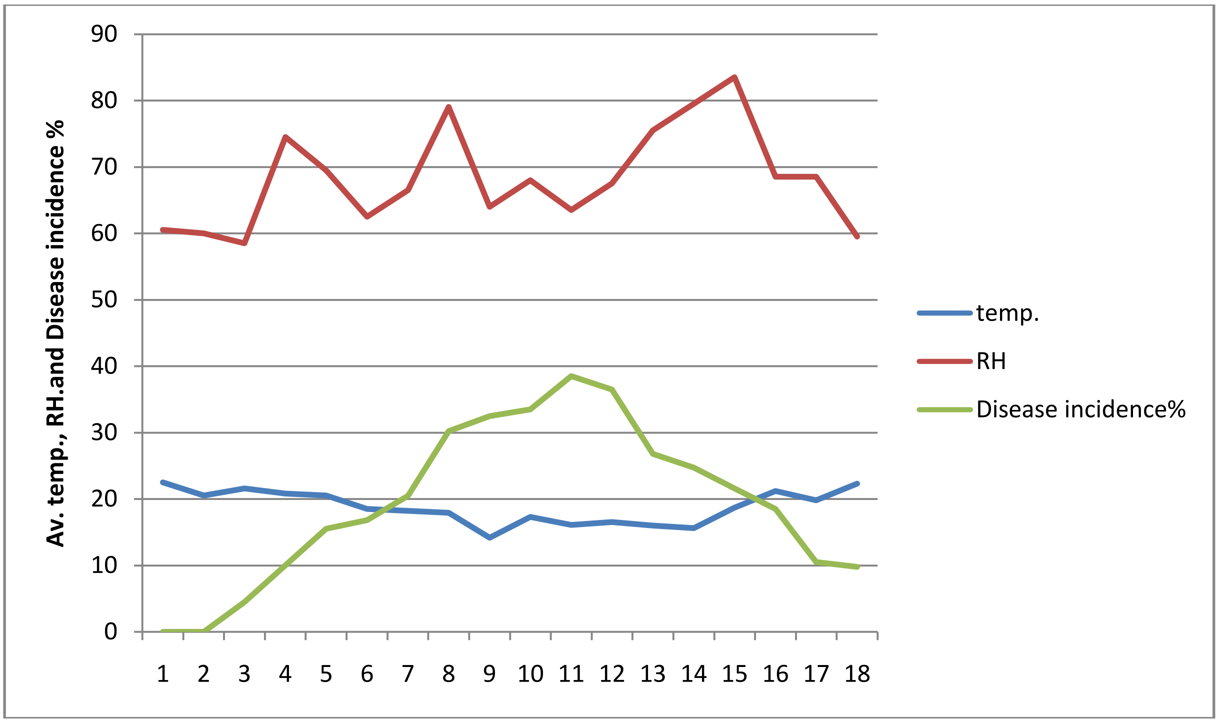


1-29 Oct - 4 Nov., **2** - 05-11 Nov., **3**-12-18 Nov.,**4** - 19-25 Nov, **5** - 26Nov- 02Dec, **6** - 03-09 Dec,**7**- 10-16 Dec, **8**- 17-23 Dec, **9**- 24-31 Dec, **10**- 01-07 Jan, **11**- 08-14 Jan, **12**- 15-21Jan, 13 – 22 – 28 Jan, **14** – 29Jan – 04 Feb, **15** – 05-11Feb, **16** – 12-18 Feb, **17** – 19 – 25 Feb,**18** – 26 Feb.-04 March.

Table 2. Effect of atmospheric temperature and relative humidity on the disease incidence during 2015-16.

Standard week	Date	Temperature °C		Average temperature °C	Humidity	Average disease incidence %
		Maximum	Minimum			
44	29 Oct - 4 Nov.	29.8	14.3	22.5	60.5	00.0
45	05-11 Nov	29.0	12.0	20.5	60.0	00.0
46	12-18 Nov.	30.2	13.0	21.6	58.5	4.5 (12.24)*
47	19-25 Nov	27.4	14.3	20.8	74.5	10.0(18.43)
48	26Nov- 02Dec	27.4	13.6	20.5	69.5	15.5(23.18)
49	03-09 Dec	26.2	11.5	18.5	62.5	16.8(24.19)
50	10-16Dec	25.2	11.3	18.2	66.5	20.5(26.92)
51	17-23 Dec	23.5	12.4	17.9	79.0	30.2(33.33)
52	24-31Dec	20.0	8.3	14.15	64.0	32.5(34.75)
1	01-07Jan	23.5	11.1	17.3	68.0	33.5(35.36)
2	08-14Jan	22.8	9.3	16.1	63.5	38.5(38.35)
3	15-21 Jan	23.2	9.8	16.5	67.5	36.5(37.16)
4	22-28 Jan	21.5	10.5	16.0	75.5	26.8(31.17)
5	29Jan - 04 Feb	20.4	10.8	15.6	79.5	24.7(29.80)
6	05-11 Feb	24.9	12.6	18.7	83.5	21.6(27.69)
7	12-18 Feb	27.7	14.8	21.2	68.5	18.5(25.47)
8	19-25 Feb	25.5	14.2	19.8	68.5	10.5(18.90)
9	26 Feb- 04 March	29.1	15.6	22.3	59.5	9.8(18.24)
C.D. at 5%						(0.69)

*Transferred values indicated in parenthesis.



1-29 Oct - 4 Nov., **2** - 05-11 Nov., **3**-12-18 Nov.,**4** - 19-25 Nov, **5** - 26Nov- 02Dec, **6** - 03-09 Dec,**7**- 10-16 Dec, **8**- 17-23 Dec, **9**- 24-31 Dec, **10**- 01-07 Jan, **11**- 08-14 Jan, **12**- 15-21Jan, 13 – 22 – 28 Jan, **14** – 29Jan – 04 Feb, **15** – 05-11Feb, **16** – 12-18 Feb, **17** – 19 – 25 Feb,**18** – 26 Feb.-04 March.

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RESEARCH ARTICLE

EFFECT OF PHOSPHORUS, ZINC AND IRON ON GROWTH ATTRIBUTES AND YIELD ATTRIBUTES OF WHEAT IN LOAMY SAND SOILS OF WESTERN RAJASTHAN

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Abstract: A field experiment was carried out during two consecutive *rabi* seasons of 2009-10 and 2010-11 at the Agronomy farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner to find out the effect of phosphorus, zinc and iron on growth attributes and yield attributes of wheat (*Triticum aestivum* L.) in Loamy sand soils of Western Rajasthan with ten treatments comprising 4 levels of phosphorus (0, 20, 40 and 60 kg ha^{-1}) and zinc (0, 3 and 6 kg ha^{-1}) in main plots and 3 levels of iron (0, 3 and 6 kg ha^{-1}) in split-plot design with three replications. Application of phosphorus up to 40 kg P_2O_5 ha^{-1} significantly increased the dry matter production, CGR and RGR of wheat over control at 30, 60, 90 DAS and at harvest in pooled analysis. Yield attributes viz. effective tillers $plant^{-1}$ and number of grains ear^{-1} were also significantly enhanced with the increasing level of phosphorus up to 40 kg P_20_5 ha^{-1} in pooled analysis. Application of phosphorus up to 40 kg P_2O_5 ha^{-1} significant]y increased the grain, straw and biological yields beyond which it increased non-significantly and registered a mean increase of 26.2, 30.6 and 28.8 per cent, respectively over control.

Keywords: Phosphorus, Zinc, Iron, Growth attributes, Yield attributes, Wheat

INTRODUCTION

Wheat is the world's number one crop, growing on about 216.63 million hectare area which is about 14 per cent of the global arable land and the production is about 674.88 million tonnes (FAO, 2012). India occupies second position next to China in the World with regard to area 30.96 million hectares and production 88.94 million tonnes with average productivity of 28.72 q ha^{-1} of wheat (Anonymous, 2014-15). In India, main wheat growing states are UP, Punjab, Haryana, M.P., Rajasthan and Bihar. In Rajasthan, wheat has an area of 2.94 million hectares with the production of 9.86 million tonnes. The average productivity of wheat in the state is 33.65 q ha^{-1} (Anonymous, 2014-15). This clearly indicates that in spite of considerable improvement in genetic potential of the crop, productivity is still very poor in the country as well as in the state of Rajasthan. The high productivity of wheat can only be achieved by the adoption of suitable variety and improved agronomic practices with balanced and judicious use of chemical fertilizers in an integrated way.

With the increase in the high yielding varieties, irrigated area, fertilizer use and appropriate agro-technology, it has been possible to achieve continuous increase in production and productivity of wheat but at the same time, nutrient removal by crop has also increased. Therefore, nutrient must be supplied to replace those removed from the soil to achieve higher yield from limited land resources. To meet these demands, nutrient needs must be accurately worked out. Large scale depletion of soil fertility is an index towards the occurrence of even more extensive and acute nutrient deficiencies. This calls for a serious thought on the nutrient management to sustain food grain production. Fertilizer is the single most important input in modern agriculture to raise the crop productivity. It has, therefore, become imperative to dwell upon the rationalization of efficient and balanced use of fertilizers for increasing the wheat productivity.

Deficiency of soil Phosphorus is one of the important chemical factors restricting plant growth in soils. Therefore, sufficient quantity of soluble form of phosphorus fertilizers is applied to achieve maximum plant productivity. Zinc exerts a great influence on basic plant life processes, such as: nitrogen metabolism and uptake of nitrogen and protein quality; photosynthesis and chlorophyll synthesis, carbon anhydrase activity; resistance to abiotic and biotic stresses and protection against oxidative damage. Iron is taken up as ferrous ions by plants. Iron is necessary for the synthesis and maintenance of chlorophyll in plants and it is essential component of many enzymes viz., nitrogenase, catalase, peroxydase, aconitase and cofactor like ferrodoxin, cytochromes etc. The present investigation was carried out to evaluate and describe the fertilizer phosphorus, zinc and iron application on growth attributes and yield attributes of wheat in Loamy sand soils of Western Rajasthan.

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MATERIAL AND METHOD

The experiment was conducted at the Agronomy farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *rabi* seasons of 2009-10 and 2010-11. The experimental site is located at 28.01^0N latitude and 73.22^0E longitude at an altitude of 234.7m above mean sea level and falls under Agro-ecological region No. 2 (M9E1) under Arid ecosystem (Hot Arid Eco-region), which is characterized by deep, sandy and coarse loamy, desert soils with low water holding capacity and hot and arid climate. Annual PET in this region ranges between 1500-2000 mm.

The maximum and minimum temperature range between 15.4 to 42.1 ^oC and 3.6 to 25.3 ^oC during 2009-10 and 15.5 to 37.3 ^oC and 2.0 to 19.1 ^oC during 2010-11. The relative humidity of the locality fluctuates in between 8 to 97 per cent during 2009-10 and 10 to 99 per cent during 2010-11. The total rainfall in *rabi* season was 2.5 and 15.2 mm with 0 and 3 rainy days during 2009-10 and 2010-11, respectively. The soils of experimental field was loamy sand in texture having pH -8.2, EC -0.22 dS m^{-1}, available N – 90.1 kg ha^{-1}, available P_2O_5 – 14.2 kg ha^{-1}, available K_2O – 160.4 kg ha^{-1}, avalable Zinc- 0.34 mg kg^{-1}, avalable iron- 2.90 mg kg^{-1} and organic carbon-0.15%.

The field experiment on wheat in *rabi* seasons of 2009-10 and 2010-11 was laid out comprising 4 levels of phosphorus (0, 20, 40 and 60 kg ha^{-1}) and zinc (0, 3 and 6 kg ha^{-1}) in main plots and 3 levels of iron (0, 3 and 6 kg ha^{-1}) in sub plots. A total of 36 treatment combinations were tested in split plot design with three replications. The treatment details are follows:

(A) Main plot treatments

Phosphorus levels

P_0 = Control, P_1 = 20 Kg ha^{-1}, P_2 = 40 Kg ha-1 and P3 = 60 Kg ha^{-1}

Zinc levels

Zn_0 = Control, Zn_1 = 3 Kg ha^{-1} and Zn_2 = 6 Kg ha^{-1}

(B) Sub plot treatments

Iron levels

Fe_0 = Control, Fe_1 = 3 Kg ha^{-1} and Fe_2 = 6 Kg ha^{-1}

Nitrogen was applied @ 120 kg N ha^{-1} was applied RDF. Half dose was applied as basal through urea after adjusting the quantity of N supplied by DAP. Remaining half dose of N was applied through broadcasting of urea in two equal split doses just after irrigation at 25 and 75 DAS. Potassium was applied @20 kg K_2O ha^{-1} was applied through muriate of potash before sowing. Phosphorus: Phosphorus was applied through DAP, zinc was applied through zinc sulphate and iron was applied through ferrous sulphate before sowing as per treatment. Seeds were treated with thiram (2 g kg^{-1} seed) as prophylactic measures against seed borne diseases. The wheat variety 'Raj-3077' was sown by "*kera"* method at a depth of 5 cm in rows spaced at 22.5 cm apart on 25th and 28th November in the years 2009-10 and 2010-11, respectively using seed rate of 120 kg ha^{-1}.

The data on periodical changes in dry matter accumulation were recorded by uprooting of plants from 1.0 m row length from sampling rows of each plot at 30, 60, 90 DAS and at harvest stages. The harvested plant material was air dried first and then in an oven at 70^0C till constant weight. The dried samples were then weighted and expressed in terms of g m^{-1} row length.

Crop growth rate (CGR) from periodical dry matter recorded was calculated using following formula (Hunt, 1978)

$$\text{CGR (g m}^{-2}\text{ day}^{-1}) = \frac{W_2 - W_1}{(T_2 - T_1) \times A}$$

Where,

W_1 = Total dry weight of plants (g) at time T_1

W_2 = Total dry weight of plants (g) at time T_2

T_1 = Time of first observation (day)

T_2 = Time of second observation (day)

A = Land area of plants under W_1/W_2 in m^2

The Relative growth rate **(**RGR) of the crop was calculated using the following relationship:

RGR (mg g^{-1} day^{-1})

$$= \frac{(\mathrm{Log_e} W_2 - \mathrm{Log_e} W_1)}{T_2 - T_1} \text{ X } 1000$$

Where,

W_1 = Total dry weight of plants (g) at time T_1

W_2 = Total dry weight of plants (g) at time T_2

T_1 = Time of first observation (day)

T_2 = Time of second observation (day)

The number of tillers having fully developed ear were non-destructively, counted from five randomly selected plants. These were averaged and effective tillers per plant were worked out. Randomly selected five productive ear heads $plot^{-1}$ was threshed separately and grains were counted and average number of grains ear^{-1} was worked out. A small seed sample was taken from the produce of each of the net plot harvested and 1000-seeds were counted and their weight was recorded as test weight (g).

The grain yield of each net plot was recorded in kg $plot^{-1}$after cleaning the threshed produce and was converted as kg ha^{-1}. Straw yield was obtained by subtracting the grain yield (kg ha^{-1}) from biological yield (kg ha^{-1}). The harvest index was calculated by using following formula and expressed as percentage (Singh and Stoskoof, 1971).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \text{ x } 100$$

RESULT AND DISCUSSION

Growth attributes

The growth parameters viz. dry matter accumulation, CGR and RGR were significantly influenced by the application of phosphorus, zinc and iron. A perusal of data (Table 1) showed that application of phosphorus @ 40 kg P_2O_5 ha^{-1} being at par with 60 kg P_2O_5 ha^{-1} significantly increased the dry matter production of wheat over control and 20 kg P_2O_5 ha^{-1} at all the stages of its growth (30, 60, 90 DAS and at harvest) in pooled mean basis. Application of zinc @ 3 kg ha^{-1} also significantly increased the dry matter accumulation of wheat at all the periodical growth stages over control but remain at par with 6 kg Zn ha^{-1} in pooled mean. Similarly, iron fertilization up to 3 kg ha^{-1} significantly enhanced the dry matter production of wheat over control at all the stages of crop growth beyond which it increased non-significantly in pooled analysis. The favourable effect of phosphorus on growth parameters could be attributed to effective utilization of nutrients through the extensive root system developed by crop plants under phosphorus application Increased availability of N, P and K owing to phosphorous application in the soil which was otherwise low to medium in their content improved nutrients availability resulting in their higher uptake from the soil.

The favourable effect of applied zinc on these characters may be ascribed to its catalytic or stimulatory effect on most of the physiological and metabolic processes of plants. The significant response of zinc in terms of overall improvement of growth parameters is further supported by the fact that the soil of experimental field was low in zinc status and its early supply corrected the deficiency and considerably improved the overall crop growth. Thus, increase in growth parameters is a function of cell division and its enlargement, which depend upon availability of nutrients. These results are in close conformity with the findings of Singh *et al.* (2015) and Ghasal *et al.* (2015). Increased dry matter production as function of increased photosynthctic efficiency with the application of zinc might have seen from increase in CGR Zinc helps in chlorophyll formation which might have resulted in better interception and utilization of radiant energy leading to higher photosynthetic rate and finally increased dry matter production. It is a known fact that photosynthetic efficiency depends on leaf area, chlorophyll content and the stomatal response/gas exchange. Meena *et al.* (2013) and Jat *et al.* (2013) provides further support to the findings of the present experiment.

A perusal of data (Table 1) revealed that successive increase in phosphorus level up to 40 kg P_2O_5 ha^{-1} significantly increased CGR beyond which it increased non-significantly at all the four crop growth phases studied during the experimentation. Application of zinc @ 3 kg ha^{-1} increased the CGR at 0-30, 30-60, 60-90 days and 90-harvest growth phases in pooled analysis. However, application of iron @ 3 kg ha^{-1} being at par with 6 kg Fe ha^{-1} increased the CGR at 0-30, 30-60, 60-90 days and 90-harvest growth phases . Data presented in Table 2 revealed that application of phosphorus at 40 kg P_2O_5 ha^{-1} significantly improved RGR over control and 20 kg P_2O_5 ha^{-1} in pooled analysis. Application of zinc @ 3 kg ha^{-1} significantly increased the RGR over control but remain at par with 6 kg Zn ha^{-1}. Similarly, application of iron @ 3 kg ha^{-1} being at par with 6 kg Fe ha^{-1} significantly improved the RGR over control in pooled analysis.

The increased dry matter production as a function of increased photosynthetic efficiency due to phosphorus application might have been as a result of increased CGR and RGR. Significant increase in RGR at all growth stages by phosphorous fertilization may be due to higher dry matter production and CGR at P_{40} level. Phosphorus fertilization thus promoted rapid and increased plant growth in terms of number of tillers $plant^{-1}$ and dry matter accumulation. The findings of the present investigation are in close conformity with those of Yadav *et al.* (2015) and Arshad *et al.* (2016) who reported that number of tillers $plant^{-1}$ and dry matter production increased significantly due to phosphorus fertilization.

The stimulating effect of iron on these parameters might be due to increased availability of iron owing to its application as ferrous sulphate. The Fe availability might have also increased carbohydrate, fat and protein synthesis and thus resulting in vigorous root development of plant and ultimately dry matter production. Results showed that application of 6 kg Fe ha^{-1} significantly increased the chlorophyll content in plant leaves of wheat. This might be due to the fact that iron plays an important role in the synthesis of common precursors of chlorophyll-protoporphyrin-9 and aminolevulinic acid and iron porphyrin enzyme such as catalase, per-oxidase and cytochrome oxidase and is also an essential component of many haem and non-haem Fe enzymes and thus biosynthesis of chlorophyll. This ultimately increased the chlorophyll content in leaf tissue. These results are in line with the findings of Choudhary *et al.* (2013).

Yield attributes

Application of phosphorus at 40 kg P_2O_5 ha^{-1} significantly increased the effective tillers $plant^{-1}$, number of grains ear^{-1} and test weight over control (Table 2). In general, significant improvement in yield attributes of wheat due to P fertilization could be ascribed to overall improvement in vigour and crop growth as reflected by dry matter production and CGR. The favourable effect of phosphate fertilization on yield components might be due to the fact that phosphorus is well known for its role as 'Energy currency' and plays a key role in development and energy transformation in various vitally important metabolic processes in the plant. Similar results were also reported by Dadhich *et al.* (2011) and Yadav *et al.* (2015). The significant increase in grain yield of wheat due to application of phosphorus up to 40 kg P_20_5 ha^{-1} was largely a function of improved growth and the consequent increase in different yield attributes as mentioned above. The grain yield of wheat increased by 762 kg ha^{-1} due to application of 40 kg P_2O_5 ha^{-1} over control. Thus, the simple response to phosphorus at this level worked out to be 19.05 kg grain kg^{-1} of phosphorus applied. Jat *et al.* (2007) also recorded significant improvement in wheat grain yield with increase in phosphorus levels.

The significant increase in straw yield due to application of phosphorus could be attributed to the increased vegetative growth as evident from dry matter production and CGR (Table 3) possibly as a result of the effective uptake and utilization of nutrients absorbed through its extensive root system developed under phosphorus fertilization. Sepat and Rai (2013) and Arshad *et al.* (2016) have also reported similar findings.

The biological yield is a function of grain and straw yields. Thus, significant increase in biological yield with the application of phosphorus could be ascribed to the increased grain and straw yields. The faster rate of improvement in grain yield as compared to straw yield to phosphorus fertilization led to significant improvement in biological yield thereby suggesting better source and sink relationship. These results are in conformity with those of Jat *et al.* (2007) and Sepat and Rai (2013).

The increase in yield attributes may be due to increased supply of available zinc to plants by way of its addition to soil which resulted in proper growth and development. The increase in the yield attributes might be due to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordia for reproductive parts and partitioning of photosynthates towards them, which resulted in better flowering and fruiting. The significant increase in straw yield due to zinc fertilization could be attributed to the increased plant growth and biomass production possibly as a result of the uptake of nutrients.

The biological yield is a function of grain and straw yields. Thus, increase in biological yield with the application of zinc could be ascribed to increase grain and straw yields. Similar results showing the increase in wheat yield with the application of zinc were reported by Singh *et al.* (2015) and Arshad *et al.* (2016).

Application of 3 kg Fe ha^{-1} significantly increased the number of effective tillers $plant^{-1}$ and number of grains ear^{-1} over control but showed at par results with 6 kg Zn ha^{-1} during both the years, however, test weight was not influenced by application of increasing levels of iron (Table 2). It might be probably due to the fact that application of iron in soil increased the synthesis of chlorophyll and other enzymes which in turn helped in increased photosynthesis and metabolites, nitrogen metabolism and absorption of nutrients. Thus, the increased metabolites owing to better photosynthesis and metabolism of nutrients might have favoured efficient partitioning of photosynthates in different vegetative and reproductive structures particularly the grain which is ultimate sink. The higher translocation of photosynthates in reproductive structures resulted increased number of tillers and number of grains ear^{-1}. A non significant increase in test weight may be probably due to fast utilization of metabolites for grain formation and development. These results corroborative with the findings of Choudhary *et al.* (2013).

Application of 3 kg Fe ha^{-1} significantly increased the grain yield (Table2) over control but it was found statistically at par with 3 kg Fe ha^{-1}. An increase in grain yield may be attributed to the significant increase in number of effective tillere per plant and number of grains per ear. Further, increase in grain yield due to iron application in the soil could possibly be due to the enhanced metabolites of carbohydrates and protein and their transport to the site of grain production.

Significant increase in straw yield was recorded with the application of 3 kg Fe ha^{-1}. This might be due to increased crop growth and development viz. dry matter accumulation and yield attributes of plants under better nutritional environment, under the application of iron. Significant increase in grain and straw yield due to iron application has also been reported by Habib, (2009). The biological yield is a function of grain and straw yields. Thus, increase in biological yield with the application of iron could be ascribed to increase grain and straw yields. Similar findings of increase in wheat yield with the application of iron also reported by Naga *et al.* (2013) and Gill and Walia (2014).

Table 1. Effect of phosphorus, zinc and iron on growth attributes of wheat at different stages (pooled basis)

Treatments	Dry matter accumulation (g m^{-1} row length)				CGR (g m^{-2} day^{-1})				RGR (mg g^{-1} day^{-1})		
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30-60 DAS	60-90 DAS	90 DAS- At harvest
Phosphorus levels (P_2O_5 Kg ha^{-1})											
Control	15.77	85.96	151.73	202.48	0.526	2.865	5.058	6.749	1.891	2.111	2.225
20	17.14	94.99	167.47	222.85	0.574	3.166	5.582	7.428	1.935	2.154	2.271
40	18.31	100.46	178.06	234.82	0.608	3.349	5.935	7.827	1.958	2.181	2.292
60	18.49	101.56	180.32	241.05	0.616	3.385	6.011	8.035	1.961	2.186	2.304

SEm±	0.26	1.12	2.23	2.37	0.009	0.037	0.074	0.079	0.005	0.006	0.005
CD (P=0.05)	0.73	3.19	6.36	6.76	0.024	0.106	0.212	0.225	0.014	0.018	0.014
Zinc levels (Zn Kg ha^{-1})											
Control	15.73	90.48	160.90	212.75	0.524	3.016	5.363	7.092	1.913	2.137	2.249
3	18.04	97.25	171.54	229.84	0.601	3.242	5.718	7.661	1.943	2.165	2.280
6	18.51	99.49	175.74	233.31	0.616	3.316	5.858	7.777	1.952	2.173	2.291
SEm±	0.22	0.97	1.93	2.05	0.007	0.032	0.064	0.068	0.004	0.005	0.004
CD (P=0.05)	0.63	2.76	5.50	5.85	0.021	0.092	0.183	0.195	0.013	0.015	0.012
Iron levels (Fe Kg ha^{-1})											
Control	16.05	90.51	160.79	211.97	0.535	3.017	5.360	7.066	1.913	2.137	2.248
3	17.88	97.30	172.46	228.90	0.596	3.243	5.749	7.630	1.942	2.166	2.277
6	18.36	99.42	174.94	235.03	0.612	3.314	5.831	7.834	1.954	2.172	2.295
SEm±	0.26	0.91	1.38	2.32	0.009	0.030	0.046	0.077	0.004	0.004	0.006
CD (P=0.05)	0.73	2.55	3.88	6.50	0.024	0.085	0.129	0.217	0.011	0.010	0.016

Table 2. Effect of phosphorus, zinc and iron on yield and yield attributes of wheat (pooled basis)

Treatment	Effective tillers plant^{-1}	Number of grains ear^{-1}	Test weight (g)	Grain yield kg ha^{-1}	Straw yield kg ha^{-1}	Biological yield kg ha^{-1}	Harvest index
Phosphorus levels (P_2O_5 Kg ha^{-1})							
Control	2.83	28.50	37.61	2901	4192	7093	40.01
20	3.09	34.27	38.51	3416	4975	8392	41.02
40	3.31	36.96	38.95	3663	5476	9140	40.09
60	3.40	38.18	39.26	3735	5593	9331	40.10
SEm±	0.05	0.51	0.53	36	49	80	0.55
CD (P=0.05)	0.13	1.47	NS	101	138	228	NS
Zinc levels (Zn Kg ha^{-1})							
Control	2.83	31.55	37.73	3127	4733	7860	39.21
3	3.27	35.32	38.72	3539	5170	8709	40.77
6	3.37	36.56	39.30	3620	5275	8898	40.93
SEm±	0.04	0.45	0.46	31	42	69	0.47
CD (P=0.05)	0.12	1.27	NS	88	120	197	NS
Iron levels (Fe Kg ha^{-1})							
Control	2.90	31.29	37.93	3109	4658	7771	39.47
3	3.25	35.58	38.86	3538	5202	8739	40.60
6	3.32	36.55	38.96	3640	5317	8957	40.85
SEm±	0.04	0.44	0.41	38	43	78	0.51
CD (P=0.05)	0.12	1.24	NS	107	119	220	NS

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RESEARCH ARTICLE

SYSTEM PRODUCTIVITY AND PROFITABILITY OF BABY CORN (*ZEA MAYS* L.) – HORSE GRAM (*MACROTYLOMA UNIFLORUM*L.) CROPPING SEQUENCE AS INFLUENCED BY SOWING SCHEDULE AND INTEGRATED NUTRIENT MANAGEMENT

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Abstract: A field experiment was conducted in two consecutive rainy (*kharif*) seasons of 2012 and 2013 at Ambikapur to work out the effect of sowing schedule and integrated nutrient management systems on the productivity and profitability of baby corn (*Zea mays* L.) and horse gram (*Macrotylomauniflorum* L.) cropping system. The horse gram was sown as utera crop just before harvesting of baby corn. Baby cob, baby corn, green fodder, horse gram yield and economics were higher in sowing of first schedule (1st week of July) showed parity with second (2nd week of July) and third (3rd week of July) sowing schedule but significantly superior to fourth sowing schedule *i.e.* 4th week of July. Further, application of 125% RDF + 5 t FYM significantly increased the baby cob, baby corn, green fodder, horse gram yield over 100% RDF and125% RDF but at par with 100% RDF + 5 t FYM. Combined effect of sowing of first schedule of baby corn and horse gram and application of 125% RDF + 5 t FYM resulted in significantly higher baby corn-equivalent yield in terms of system productivity (2.8 t/ha) which was comparable to sowing of second schedule with 125% RDF + 5 t FYM (2.7 t/ha), sowing of third schedule with 125% RDF + 5 t FYM (2.3 t/ha), sowing of first schedule with 100% RDF + 5 t FYM (2.7 t/ha), sowing of second schedule with 100% RDF + 5 t FYM (2.5 t/ha) and sowing of first schedule with 125% RDF (2.5 t/ha). Hence, Sowing of baby corn on first schedule (1st July) with 125% RDF + 5 t FYM produced maximum system productivity in terms of baby corn-equivalent yield, net profit and benefit-cost ratio. Since, harvesting large amount of baby corn at a time will deteriorate the quality, marketing problem as well as heavy monetary loss. Based on the present study, sowing of baby corn in different schedules, *i.e.* first (1st week of July), second (2nd week of July) and third (3rd week of July) followed by horse gram as utera crop in combination with 125% RDF + 5 t FYM produced comparable higher net profit, hence, recommended for commercial cultivation at farmers' fields of Northern hills of Chhattisgarh, provided all other scientific management practices are followed.

Keywords: Baby corn, Horse gram, Green fodder, Net return, System productivity

INTRODUCTION

Ninety five per cent areas of Northern hills of Chhattisgarh are rain fed and after harvesting of kharif crop, second crop is quite not possible due to non-availability of irrigation or non-adoption of moisture-conserving techniques. Poor adoption of water-conservation measures is one of the important factors, which restricts agriculture production and reduces land-use efficiency in the region. Besides adoption of proper input management technologies, diversification or intensification through crops of diverse nature may be a good proportion to break the monotony of the system (Tripathi and Singh, 2008).

Corn is a versatile crop, which finds a place in the human diet, animal feed, fodder and industrial raw material. Due to changing food preferences in Indian life style, the urban population is switching to new food items: the 'Baby corn (*Zea mays* L.)' is a new addition to Indian foods. A baby corn is dehusked maize ear, harvested within 2-3 days of silking, *i. e.* prior to fertilization. High nutritive value, eco-friendly, and crispy nature of baby corn has made it special choice for various traditional and continental dishes apart from canning in elite society. As the product is freshly consumed, the quality of the corn is considered to be the most important. Timely harvesting is very crucial for quality of baby corn for marketing and harvesting large amount of baby corn at a time will deteriorate the quality as well as heavy monetary loss. Being a short duration crop, baby corn is easily fits in an intensive cropping system and addition to baby corn it provides green, soft, succulent, nutritious, palatable delicious fodder to cattle (Das *et al*., 2008).Cultivation has started gaining popularity in peri-urban areas owing to its export potential besides a huge employment generation. Being a short duration crop (50-60 days) and short duration pulse crop like horse gram (*Macrotylomauniflorum*L.) can be included and sown just after harvest of baby corn as utera crop. Horse gram is the most protein-rich pulse consumed by tribal peoples grown mostly in dry agricultural lands. Traditional medicinal texts describe its use for asthma, bronchitis, leucoderma, urinary discharge, kidney stones and heart disease. The net monetary return of a cropping system can be quantified and qualified by sound planning for sustainable systems.

Baby corn is new introduction, particularly as short duration crop; so efforts are required to standardize and economize its cultivation. Although the agronomic requirements like plant geometry and

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nitrogen levels (Dar *et al*., 2014), integrated nutrient management (Saha and Mondal, 2006) and weed control methods (Barod*et. al*., 2012) for baby corn has been worked out for irrigated conditions but work on intensive cultivation of baby corn and horse gram (as utera crop) at different sowing schedule and at different nutrient management systems having both inorganic and organic sources has not been done for rainfed conditions. Therefore, the present experiment was conducted to work out the effect of sowing schedule and different integrated nutrient management systems on intensive cultivation, marketing and availabilityof baby corn and horse gram.

MATERIAL AND METHOD

The present investigation was conducted during rainy (*kharif*) seasons of 2012 and 2013 at the Research Farm, RMD Collage of Agriculture & Research Station, Ambikapur (Chhattisgarh) situated at $23^0 18'$ N latitude and $83^0 15'$ Elongitude and at altitude of 611 meter above mean sea level. The soil of experimental field was sandy loam in texture. Chemical analysis of the soil (top 15 cm) showed an acidic pH (5.7), organic carbon 0.56%, 234 kg/ha nitrogen,8.4 kg/ha phosphorous, 268 kg/ha potassium. The meteorological data recorded at meteorological observatory of the station indicated that rainfall received during the crop seasons was 1120 mm (53 rainy days) and 1000.2 mm (50 rainy days) in 2012 and 2013, respectively. The crop experienced mean weekly maximum temperature ranging from 24.1 to 31.7 ^{0}C and 24.4 to 32.0^{0}C during 2012 and 2013, respectively, whereas mean weekly minimum temperature ranging from 4.7 to 20.4 ^{0}C and 6.1 to 23.6 ^{0}C during 2012 and 2013, respectively. The field experiment was laid out in split block design with four treatments of sowing schedule (1st week of July, 2nd week of July, 3rdweek of July and 4thweek of July) in main plots and four levels of fertilizer application (100% RDF, 125% of RDF, 100% RDF + 5 t FYM, 125% of RDF + 5 t FYM)with three replications. The recommended dose of fertilizer (RDF) given to the crop was 150:60:40 kg N, P_2O_5 and K_2O/ha (Thakur 2000).Baby corn variety "Syngenta 5414" was sown at one week interval starting from 4th July and 6th July in 2012 and 2013, respectively.Horse gram (Indira kulthi-1) was taken as utera crop sown 45 days after sowing of each schedule at an interval of one week as main plot treatment. Inorganic and organic source of nutrients were applied as per treatments. Nitrogen as per treatment was applied in three splits. Half dose of nitrogen along with full dose of phosphorous and potassium was applied at the time of sowing of baby corn. The remaining dose of nitrogen was applied equally in two splits at 30 and 45 days after sowing. Common dose of nutrients 20 kg/ha nitrogen, 50 kg/ha phosphorous and 20 kg/ha potassium were applied as starter dose for horse gram which was taken as utera crop. Baby corn was sown at spacing of 50 cm with plant to plant spacing of 20 cm to maintain the plant population of 1,00,000 plants/ha using 30 kg seeds/ ha whereas horse gram was sown both sides of baby corn maintaining 25 cm spacing and plant to plant spacing of 10 cm using 12 kg seeds/ ha. Gap filling and thinning were done within 10 days after sowing to maintain the optimum plant population. Weeds were controlled in baby corn by pre-emergence application of Atrazine (1.5 kg*a.i*./ha) to control the initial weed flusheswhereas latter weed flushes were controlled by mechanical weedingat 25 days after sowing and no weed management practices were done in horse gram. Regular detasseling was done just after tassel emergence to avoid fertilization. Five random plants were tagged randomly from each plot for recording of growth and yield attributes. Immature baby corn was harvested within 2-3 days after silk emergence and same were counted, weighed dehusked and baby corn yield was recorded. Standard yield of baby corn referred to those corn which were straight, having 7 – 10 cm length and 1 – 1.5 cm diameter mostly preferred for marketing purpose (Mondal*et al*. 2006). The baby corn yield was calculated by adding the yield from all the pickings. Total green fodder yield was calculated by adding tassel weight, husk weight and green fodder weight of plants per plot at the time just after final pickings. Gross returns, net returns and benefit: cost ratios were calculated on the basis of prevailing market price of inputs and produce.To compute the productivity of system baby corn-equivalent yield (BCEY) was obtained by dividing the economic value of the produce (yield of produce x price of produce) with the price of baby corn.

System productivity was worked out by adding baby corn yield and baby corn-equivalent yield of total green fodder of baby corn, horse gram grain or horse gram straw of respective year. Economics of different treatments was worked out on the basis of input and output on the prevailing market price. All data obtained in the cropping sequence experiment for 2 consecutive years of study were statistically analyzed using *F*- test, the procedure given byGomez & Gomez (1984), critical difference (CD) values at $P= 0.05$ were used to determine the significance of differences between means.

RESULT AND DISCUSSION

Yield attributes

Sowing schedule significantly affected the yield attributes of baby corn as well as horse gram taken as utera crop. Yield attributes, *viz* number of baby corns/plant, weight of baby cob, weight of baby corn and weight of baby corn/plant, decreased from sowing of first schedule (1st week of July) to fourth schedule (4th week of July) but sowing of first schedule (1st week of July) was statistically at par with second (2nd week of July) and thirdschedule (3rd week of July) but significantly superior to fourth schedule *i.e.*4th week of July (Table 1). Yield attributes of horse gram, *viz* number of branches/plant, number of pods/plant, pod length, number of seeds/pod and 1000 seed weight, decreased from first schedule of sowing to fourth schedule but first sowing schedule was statistically at par with second and third schedule and significantly superior to fourth schedule (Table 1). It seems possible that earlier sowing of crop might have provided longer duration for better growth attributes, *viz.* plant height, number of green leaves and dry matter/plant (data are not shown) and consequently enhanced the yield attributes of baby corn and horse gram.

Application of 125% RDF + 5 t FYM significantly increased the yield attributes *viz* number of baby corns/plant, weight of baby cob, weight of baby corn and weight of baby corn/plant over 100% RDF and125% RDF but at par with 100% RDF + 5 t FYM (Table 1). Horse gram grown as utera crop by using common starter dose (20:50:20), maximum yield attributes of horse gram, *viz.* number of branches/plant, number of pods/plant, pod length, number of seeds/pod and 1000 seed weight were observed under 125% RDF + 5 t FYM treatment of baby corn which was significantly superior to 100% RDF and125% RDF treatments but comparable with 100% RDF + 5 t FYM treatment. Optimum supply of nutrients throughout the crop growth period owing to the combination of organic and inorganic sources resulted in higher yield attributes (Choudhary*et al.*, 2011).

Table 1. Yield attributes of baby corn and horse gram as influenced by sowing schedule and integrated nutrient management system (pooled data of 2 years)

Treatments	Baby corn					Horse gram				
	Baby corns/ plant (Nos)	**Weight of baby cob (g)**	**Weight of baby cobs/ plant (g)**	**Weight of baby corn (g)**	**Weight of baby corns/ plant (g)**	**No of branches/ plant**	**No of pods/ plant**	**Pod length (cm)**	**No of seeds/ pod**	**1000 seed weight (g)**
Sowing schedule (Main Plot)										
1st week of July (1st schedule)	2.7	37.56	100.30	7.80	20.81	7.78	70.51	5.40	6.01	19.9
2nd week of July (2nd schedule)	2.5	35.83	91.08	7.45	18.90	7.54	63.63	5.03	5.49	19.6
3rd week of July (3rd schedule)	2.3	32.94	76.59	6.87	15.95	7.20	56.25	4.75	5.45	19.0
4th week of July (4th schedule)	2.1	28.46	59.04	5.97	12.36	6.75	49.99	4.39	4.74	18.7
SEm±_	0.12	1.96	8.06	0.57	1.69	0.21	5.21	0.20	0.06	0.3
CD (P=0.05)	0.42	6.56	27.93	1.67	5.97	0.72	16.35	0.69	0.60	0.9
Integrated nutrient management (Sub Plot)										
100% RDF	2.1	31.99	67.68	6.85	14.48	6.78	55.58	4.78	5.09	18.7
125% RDF	2.3	32.68	78.16	6.99	16.38	7.08	57.25	4.83	5.30	19.0
100% RDF + 5 t FYM	2.5	34.69	85.46	7.06	17.71	7.53	61.04	4.93	5.54	19.6
125% RDF + 5 t FYM	2.7	35.43	95.69	7.20	19.45	7.89	65.51	5.05	5.75	19.9
SEm±	0.06	0.56	2.94	0.25	0.55	0.13	1.46	0.07	0.08	0.1
CD (P=0.05)	0.21	1.90	11.55	0.74	1.86	0.42	5.33	0.20	0.23	0.4

Baby cob, baby corn, fodder yield and yield of horse gram

Sowing schedulehad significant influence on baby cob, baby corn,green fodder and horse gram yield.Baby corn and baby cob yield decreased from sowing of first schedule (1st week of July) to fourth schedule (4th week of July) but sowing of first schedule (1st week of July) was statistically at par with second (2nd week of July) and third schedule (3rd week of July) but significantly superior to fourth schedule *i.e.* 4th week of July (Table 2). Yield of baby corn and baby cob from sowing of first, second and third schedule was comparable due to longer vegetative growth and higher yield attributes. Similarly, maximum green fodder was obtained from sowing of first schedule which was at par with second and third schedule. This was mainly because of the higher growth attributes in terms of plant height, number of leaves, leaf area index (LAI) and dry matter/plant (data are not shown) under favorable condition of earlier sowing schedule. Horse gram yield (grain and straw) decreased from first schedule of sowing to fourth schedule but first sowing schedule was statistically at par with second and third schedule and significantly superior to fourth schedule (Table 2). This might be because of higher crop duration during vegetative phase attributed to higher grain and straw yield.

The maximum baby corn and baby cob recorded under 125% RDF + 5 t FYM which was significantly superior to 100% RDF and125% RDF but comparable to 100% RDF + 5 t FYM (Table 2). This could be owing to favorable effect of integrated nutrient management system organic and inorganic sources on yield attributes, *viz.* number of baby corns/plant, weight of baby cob, weight of baby corn and weight of baby corn/plant (Table 2). Similar trend was obtained with respect of total green fodder of baby corn. This might be owing to higher growth attributes, viz. plant height, number of leaves, leaf area index (LAI) and dry matter/plant (data are not shown). Horse gram grown as utera crop by using common starter dose (20:50:20), maximum yield (grain and straw) were recorded under 125% RDF + 5 t FYM treatment of baby corn which was significantly superior to 100% RDF and125% RDF treatments but comparable with 100% RDF + 5 t FYM treatment. These results confirms the findings of Singh *et al.* (2010).

Table 2. Effect of sowing schedule and integrated nutrient management system on yield baby corn and horse gram (pooled data of 2 years)

Treatments	Baby cob yield (t/ha)	Baby corn yield (t/ha)	Baby corn Green fodder yield (t/ha)				Horse gram (t/ha)	
			Tassel yield	Cob husk yield	Fodder yield (without cob husk and tassel	Total green fodder	Grain yield	Straw yield
Sowing schedule (Main Plot)								
1st week of July (1st schedule)	10.03	2.08	1.27	7.95	30.85	40.07	1.00	3.48
2nd week of July (2nd schedule)	9.11	1.89	1.15	7.22	27.35	35.72	0.93	3.15
3rd week of July (3rd schedule)	7.66	1.60	0.97	6.06	24.02	31.05	0.85	2.84
4th week of July (4th schedule)	5.90	1.24	0.75	4.67	21.84	27.25	0.82	2.69
SEm±	0.81	0.17	0.10	0.64	2.78	3.85	0.05	0.25
CD (P=0.05)	2.79	0.59	0.35	2.21	7.71	9.95	0.16	0.72
Integrated nutrient management (Sub Plot)								
100% RDF	6.57	1.45	0.85	5.32	23.46	29.63	0.79	2.69
125% RDF	7.62	1.64	0.99	6.18	25.41	32.58	0.87	2.92
100% RDF + 5 t FYM	8.95	1.77	1.08	6.77	26.84	34.70	0.92	3.08
125% RDF + 5 t FYM	9.57	1.95	1.22	7.62	28.36	37.20	1.03	3.47
SEm±	0.26	0.06	0.06	0.21	0.79	1.37	0.04	0.15
CD (P=0.05)	0.76	0.20	0.17	0.60	2.14	3.36	0.12	0.45

System productivity

System productivity of the cropping system (baby corn – horse gram) expressed in terms of baby corn-equivalent yield was significantly affected due to different sowing schedule (Table 3). Significantly highest baby corn-equivalent yield was recorded under sowing of first schedule (1st week of July) which was statistically at par with second (2nd week of July) and third schedule (3rd week of July) but significantly superior to fourth schedule *i.e.* 4th week of July (Table 3). The highest baby corn-equivalent yield was attributed with the combined effect of growth as well as yield attributes.

Application of different integrated nutrient management systems had significant effect on productivity of different component of baby corn-horse gram cropping system in terms of baby corn-equivalent yield. The maximum system productivity in terms of baby corn-equivalent yield was recorded under 125% RDF + 5 t FYM which was significantly superior to 100% RDF and125% RDF but comparable to 100% RDF + 5 t FYM (Table 3). Islam and Munda (2012) reported increase in system productivity owing to combined application of organic and inorganic fertilizer on preceding crop and residual effect of organic fertilizer on succeeding crop.

Interaction

The system productivity or baby corn-equivalent yield was significantly influenced with interaction effect of sowing schedule of baby corn - horse gram as utera crop and different integrated nutrient management systems (Fig 1). Combined effect of sowing of first schedule of baby corn and horse gram and application of 125% RDF + 5 t FYM recorded significantly higher baby corn-equivalent yield in terms of system productivity (2.8 t/ha)which was comparable to sowing of second schedule with 125% RDF + 5 t FYM (2.7 t/ha), sowing of third schedule with 125% RDF + 5 t FYM (2.3 t/ha), sowing of first schedule with 100% RDF + 5 t FYM (2.7 t/ha), sowing of second schedule with 100% RDF + 5 t FYM (2.5 t/ha) and sowing of first schedule with 125% RDF (2.5 t/ha). The higher system productivity of the cropping system with the corresponding treatment combinations could be attributed to the adequate supply of nutrients through integrated nutrient management system, proper growth and yield attributes. This led to higher yield of both the crops, ultimately increased system productivity of the system in terms of baby corn equivalent yield. Aruna and Mohammad (2005) also reported the higher system productivity of rice- sunflower with combination of inorganic and organic source of nutrients.

Economics

Sowing of baby corn and horse gram at first schedule (1st week of July) recorded higher gross return, net return and benefit: cost ratio which was statistically at par with second (2nd week of July) and third schedule (3rd week of July) but significantly superior to fourth schedule *i.e.* 4th week of July (Table 3). This could be ascribed to higher yield of baby corn, green fodder and horse gram. Among integrated nutrient management systems, 125% RDF with 5 t FYM had maximum gross return, net return and benefit: cost ratio which was statistically comparable with 100% RDF with 5 t FYM but significantly superior to other nutrient management systems. This was owing to higher yield of baby corn, green fodder and horse gram.

Based on the present study, it was concluded that Sowing of baby corn on first schedule (1st July) with 125% RDF + 5 t FYM produced maximum system productivity in terms of baby corn-equivalent yield, net profit and benefit-cost ratio. Based on the present study, sowing of baby corn in different schedules, *i.e.* first (1st week of July), second (2nd week of July) and third (3rd week of July) in combination with 125% RDF + 5 t FYM produced comparable higher net profit by gradual harvesting of baby corn for long duration which ultimately reduce the risk of a farmers of rainfed conditions of Northern hills of Chhattisgarh and make baby corn available for market for long period along with horse gram.Singh *et al.* (2010) also reported similar reports of increased recommended fertilizer as well as organic fertilizer increasing baby corn and succeeding crop.

Table 3. Effect of sowing schedule and integrated nutrient management system on system productivity and economics of baby corn and horse gram (pooled data of 2 years)

	Baby corn equivalent yield (t/ha)				Economics of system (x 10^3 Rs/ha)		
Kharif (Baby corn)	**Total green fodder baby corn**	**Baby corn + Total green fodder yield**	**Horse gram Grain yield**	**System productivity (t/ha)**	**Gross returns**	**Net returns**	**Benefit: cost ratio**
Sowing schedule (Main Plot)							
1st week of July (1st schedule)	0.10	2.18	0.38	2.56	204.61	152.91	2.75
2nd week of July (2nd schedule)	0.09	1.98	0.35	2.33	186.20	134.50	2.59
3rd week of July (3rd schedule)	0.08	1.67	0.33	2.00	159.39	104.69	1.91
4th week of July (4th schedule)	0.07	1.30	0.30	1.60	128.78	74.08	1.55
SEm±_	0.01	0.17	0.02	0.17	13.79	14.79	0.25
CD (P=0.05)	0.02	0.59	0.05	0.60	47.79	49.79	0.88
Integrated nutrient management (Sub Plot)							
100% RDF	0.074	1.52	0.30	1.82	145.57	94.87	1.89
125% RDF	0.081	1.72	0.32	2.04	163.52	110.82	2.12
100% RDF + 5 t FYM	0.087	1.86	0.35	2.21	176.00	122.30	2.29
125% RDF + 5 t FYM	0.093	2.04	0.38	2.42	193.90	138.20	2.50
SEm±	0.01	0.07	0.01	0.08	5.59	5.59	0.09
CD (P=0.05)	0.02	0.20	0.03	0.24	20.37	18.37	0.25

Fig 1: Interaction Effect of sowing schedule and integrated nutrient management system on system productivity (t/ha) of baby corn and horse gram

CD for sowing schedule at the same rate of nutrients-0.5

CD for nutrient system at the same sowing schedule- 0.3

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RESEARCH ARTICLE

EFFECT OF CHLORIDE AND SULPHATE DOMINATED SALINITY ON MINERALS CONSTITUENTS OF SENNA (*CASSIA ANGUSTIFOLIA* VAHL.)

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Abstract: The present experiment was conducted to study the effect of chloride and sulphate dominated salinity on mineral constituents in leaves of Senna at pod maturity stage, a pot factorial experiment based on randomized complete design with three replicates was conducted in screen house. Four varying EC levels viz. control (without salt), 4, 8 and 12 dSm^{-1} of each salinity types along with nutrients supplemented in sand filled polythene bags. The study revealed that accumulation of sodium in leaves was recorded with the increase of salinity and it was more under sulphate dominated salinity treatment. Potassium on the hand declined with the increment of salinity and the decline was relatively higher under sulphate dominated salinity. Chloride and sulphate in leaves accumulation was found in chloride dominated salinity and sulphate dominated salinity respectively with the increase of salinity levels. The minerals estimated in leaves at the pod maturity stage an increase of their salts in the growing medium. Potassium on the other hand declined due to exchange with sodium.

Keywords: Chloride, Sulphate, Minerals, Senna

INTRODUCTION

Salt stress changes the morphological, physiological and biochemical response of plant. Plants exposed to stresses undergo changes in their metabolism in order to changes in the environment. Seed germination, water deficit, ion balance of the cellular ions (cause ion imbalance of the cellular ions resulting in ion toxicity) and osmotic stress is effected by salinity (Khan *et al*., 2002; Khan & Panda, 2008; Bala *et al*., 2016). Munns (2002) reported that salinity reduces the ability of plants to utilize water and causes a reduction in growth rate, as well as changes in plant metabolic processes. Excess of salt in many plants causes decreasing amount of $Ca^{2+,}$ K^+ and Mg^{2+} while increases amount of Na^+ and Cl^- (Yılmaz *et al*., 2011). It is also reported that the salt stress increases Na^+, Ca^{2+}, Mn^{2+}, Cu^{2+} and Fe^{2+} but it causes to decrease K^+ and P^{3-} (Erdal *et al*., 2000).

Cultivation of agricultural crops in soil is limited by salt stress, which arises from the excessive uptake of salt by plants and it is an unavoidable consequence of high salt concentrations. The world population is continuing to increase and the amount of the arable land to decrease. Greater emphasis must therefore be placed on bringing marginal productive and presently non-arable land under cultivation. With the diversification of agriculture, medicinal and aromatic plants are gaining importance in the national scenario. So, there is growing global demand for medicinal plants. *Cassia angustifolia* is an important medicinal plant species belonging to the family caesalpiniaceae. It is a native to Sudan and Arabia and cultivated mainly in India and Pakistan. It is now also grown on a small scale in Andhra Pradesh, Karantaka, Kerala, Madhya Pradesh, Maharasthra, Rajasthan and Haryana. The total export of senna leaves from India is of about Rs. 20 million. The leaves and pods of *Cassia angustifolia* are cathartic, contains sennosides A, B, C, D, rhein and aloe-emodin. It is useful in loss of apetite, hepatomegaly, spleenomegaly, indigestion, malaria, skin diseases, jaundice and anaemia. So, marginal and salt lands could be exploited for the cultivation of medicinal plants such as Senna. The present experiment was planned to study mineral constituents in leaves of Senna in response to salt stress.

MATERIAL AND METHOD

The experimental site was in the screen house, Department of Botany and plant physiology, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. Seeds of Senna var. sona for these experiments were obtained from the Institute of Herbal Heritage (A unit of Asian Medicinal plants and Health care trust) Sonamukhi Nagar, Sangaria Fanta, Salawas Road, Jodhpur-342005 (Rajasthan), INDIA.

Culture conditions: The plants were raised in polythene bags (18" X 15"), each containing 12 kg of dune sand. The sand filled polythene bags were saturated with the solution of respective salinity treatment along with the nutrient (Hogland and Arnon, 1950) before sowing. Two types of salinity i.e. chloride (Cl^-:SO_4^{2-}(7:3); Na^+:Ca^{2+}+Mg^{2+} (1:1); $Ca^{2+:}Mg^{2+}$ (1:3)) and sulphate (SO_4^{2-}:Cl^- (7:3); Na^+:Ca^{2+}+Mg^{2+} (1:1); $Ca^{2+:}Mg^{2+}$ (1:3) dominated salinity with three replication was given at 4 different salinity level such as 0 (control), 4, 8 and 12 dSm^{-1}. 15 seeds of Senna were sown on variously treated sand beds in polythene bags. The moisture in the bags was maintained at field capacity by adding water as and when required. After establishment of

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seedlings thinning was done to maintain 3 plants of uniform size in each bag.

Plant material: For mineral studies the leaves of each treatment were dried in an oven at 60ºC for 48h. The dried mass was ground to fine powder and used for analysis.

Digestion:- 500 mg of oven dried and well ground material was taken in taken in 50 ml conical flasks to which 5 ml of HNO_3 : $HClO_4$ (4:1) diacid mixture was added. The flasks were heated gently on a hot plate till the formation of dense white fumes. When fumes reduced and subsided at this stage and samples become transparent. The digest thus obtained was cooled and 25 ml of distilled water was added. Then it was filtered by using Whatman filter paper and use for analysis.

Sodium: The diluted and filtered acid digest was then used to analyses. Sodium with a flame photometer (Elico) using standard NaCl. The values measured were then expressed as mg g^{-1} tissue dry weight. **Potassium:** Estimated in the similar way as sodium above.

Chloride : 5 ml of the acid digest was further diluted to 50 ml. 1 ml of 5 M $NaNO_3$ was then added and the solution was analysed by ion analyser for chloride against standard NaCl. The values were expressed as mg g^{-1} tissue dry weight.

Sulphate: The sulphate was estimated by Turbidimetric method as suggested by Chesin and Yien (1950).

Reagents: i. Gum acacia solution: Dissolve 250 mg of gum acacia in distilled water and diluted to 100 ml.

ii. Barium chloride: Grind $BaCl_2.2H_2O$ crystals in a morter, until they pass through a 20-30 mesh sieve, but retained on 60 mesh sieve.

iii. Standard SO^{2-}_4 solution: Dissolve 0.1815g of reagent grade K_2SO_4 in 1litre distilled water. This is 100 mg/l stock solution of SO^{2-}_4. Transfer 1.25, 2.50, 5.0, 7.5, 10.0, 12.5, 15.0 ml. of the 100 mg/l SO^{2-}_4 stock solution in a series of 25 ml. volumetric flasks to obtain 5, 10, 20, 30, 40, 50, 60 mg/l SO^{2-}_4 respectively. Prepare a standard curve by plotting % transmittance (T) on Y- axis and concentration on X-axis on a semi-log graph paper. There should be straight line relationship between C and T.

Procedure: Transfer of a 5ml aliquot of digest to a 25ml volumetric flasks, add 1ml of gum acacia solution make the volume up to the mark and shake for 1 min. Further add 1g of a sieved $BaCl_2$ crystals and shake for 1 min Measure the turbidity in 25-30 min, after adding $BaCl_2$ crystals, on Spectrophotometer using a blue filter at a wavelength of 420 nm. Simultaneously carry out a blank (without sample). Data were expressed as mg g^{-1} tissue dry weight.

RESULT AND DISCUSSION

Sodium content of leaves significantly increased with the progressive increase of EC level in the growing medium (Fig. 1). Increased salinity level, in general, have been reported to enhance the accumulation of sodium in different crops (Georgive and Spasenovski, 1977; Cerda *et al*., 1979; Kara and Kesar, 2001; Surajkala, 2010). The differential effect of salinity type on sodium content was significant. More pronounced accumulation of sodium in leaves was noticed under sulphate dominated salinity. Kanta Rani (2000) in isabgol seedlings have also reported more accumulation of sodium under sulphate salt treatment than chloride salt treatment at comparable EC levels. Although the effect of salinity types was not distinct up to 8 dSm^{-1} EC level. But higher accumulation of sodium was observed under sulphate dominated salinity at 12 dSm^{-1} EC level.

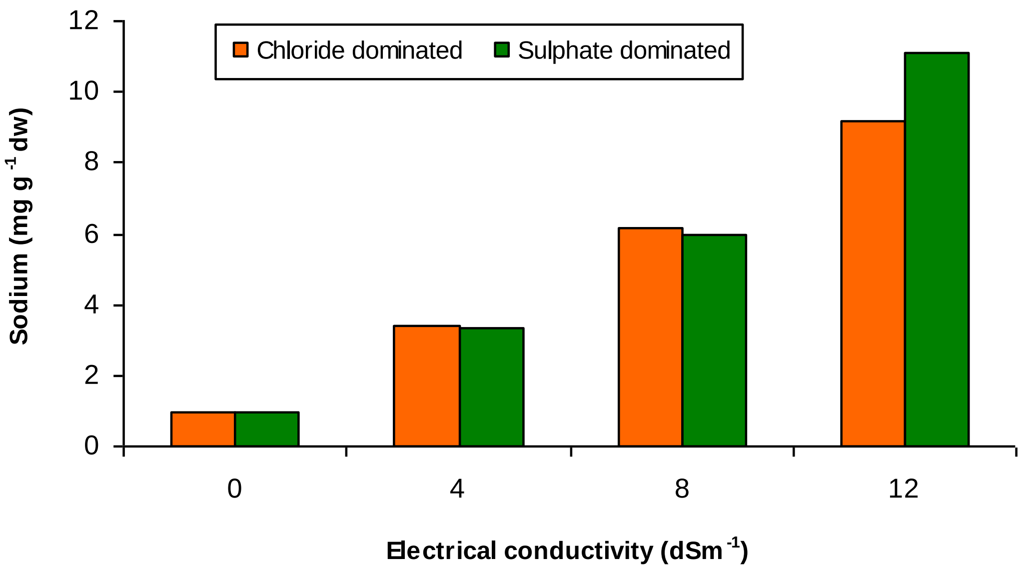

Fig 1: Sodium (mg g^{-1} dry weight) content of leaves of Senna at pod maturity stage under varying salinity
CD at 5%, ST = 0.149 EC = 0.210 ST×EC = 0.297

A significant decline in potassium content of leaves was noticed with the progressive increase of salinity right from 4 dSm^{-1} EC level (Fig. 2). Jaleel *et al*., (2008) in *catharanthus roseus* also found similar results Potassium content was relatively lower under sulphate dominated salinity than chloride dominated salinity. This accumulation of sodium and concomitant decline of potassium under salt stress is ascribed to fact that high external sodium content is known to have an antagonistic effect of potassium uptake in plants. Sodium competes with potassium uptake through common transport system because of its high concentration in saline environment. A number of workers have reported that sodium increased and potassium decreased under salt stress in guar (Francois *et al*., 1990), isabgol (Kanta Rani, 2000 and Nehru, 2003)**,** chickpea (Kukreja *et al*., 2005), ajwain (Ashraf and Orooj, 2006), tomato (Tantawy *et al*., 2009), canola (Bybordi, 2010) and *Mentha pulegium* (Queslati *et al*., 2010).

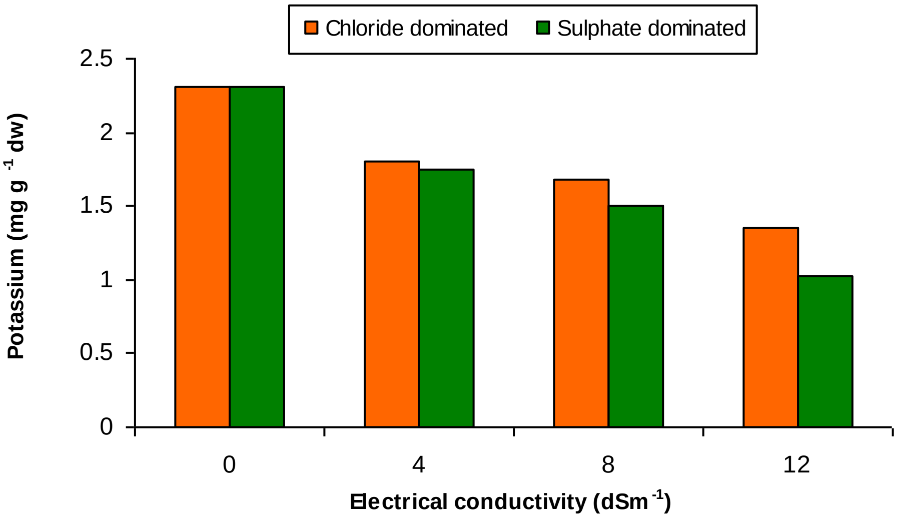

Fig 2: Potassium (mg g^{-1} dry weight) content of leaves of Senna at pod maturity stage under varying salinity
CD at 5%, ST = 0.113 EC = 0.160 ST×EC = N.S.

More accumulation of chloride in leaves was observed under chloride dominated salinity than sulphate dominated salinity (Fig. 3). In chloride dominated salinity, the increase of leaf chloride content with increase of salinity was significant right from 4 dSm^{-1} of EC level, whereas in sulphate dominated salinity no significant change was seen. A significant increase in chloride content of leaves of Senna under chloride dominated salinity was due to enhanced uptake of chloride by plant tissue. The uptake of chloride was concomitant with increasing EC levels. An increase in chloride content in different parts of pea plants with increase in soil salinity was also observed by Siddique (1980). Similar results were reported by Sharma and Kumar (1972), Kanta Rani (2000), Nehru (2003) in isabgol, Ashraf and Orooj (2006) in ajwain and Hussain *et al* (2009) in chasku.

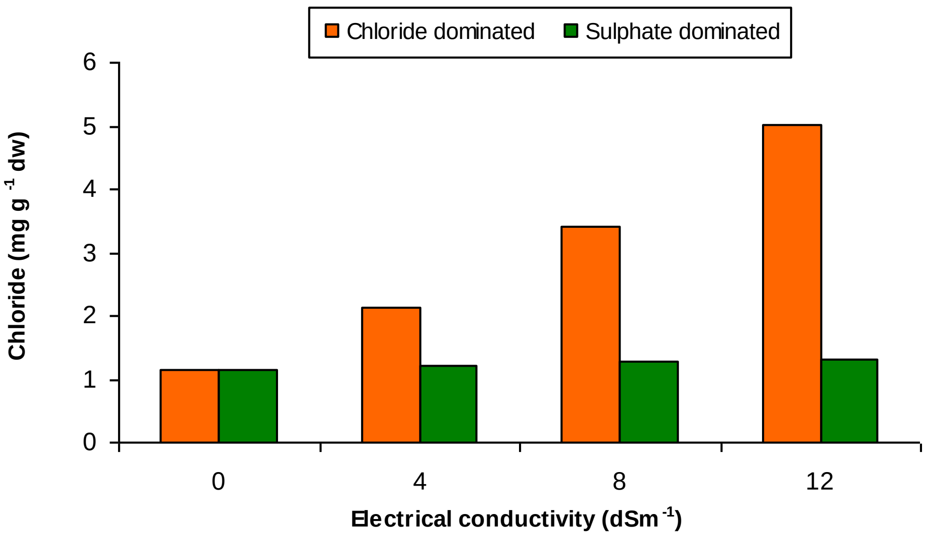

Fig 3: Chloride (mg g^{-1} dry weight) content of leaves of Senna at pod maturity stage under varying salinity
CD at 5%, ST = 0.105 EC = 0.149 ST×EC = 0.210

Sulphate content of leaves significantly increased with increasing EC level right from 4 dSm^{-1} EC level (Fig. 4). The differential effect of salinity type on leaf sulphate content was also highly significant. Under sulphate dominated salinity, significantly higher sulphate content was recorded than chloride dominated salinity. Sulphate uptake under Na_2SO_4 salinity have been reported in bean plants by Meiri *et al*. (1971), in wheat by Datta *et al*. (1995), and in isabgol by Kanta Rani (2000) and Nehru (2003).

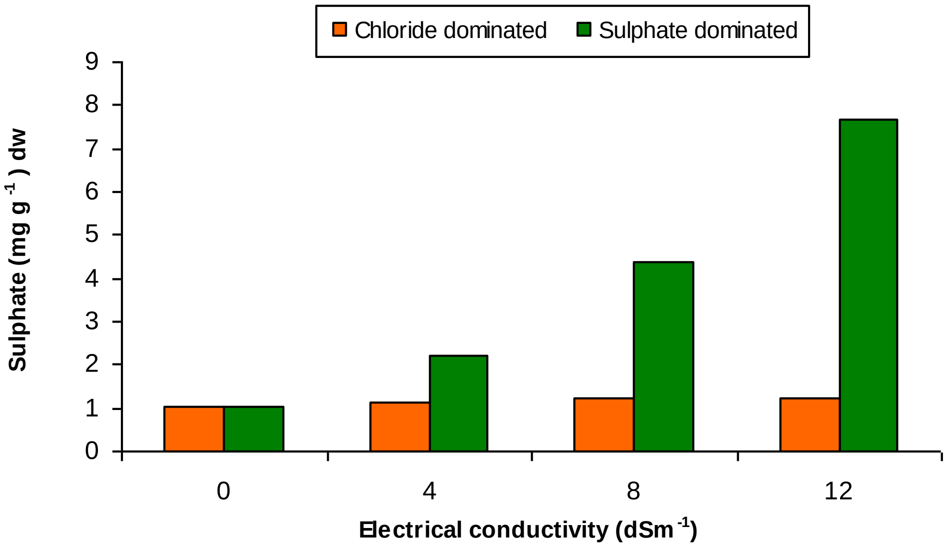

Fig 4: Sulphate (mg g^{-1} dry weight) content of leaves of Senna at pod maturity stage under varying salinity
CD at 5%, ST = 0.064 EC = 0.090 ST×EC = 0.128

CONCLUSION

Among the minerals estimated in leaves at the pod maturity stage an increase of their salts in the growing medium. Potassium on the other hand declined due to exchange with sodium.

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SHORT COMMUNICATION

EVALUATION OF ANTIMICROBIAL ACTIVITY OF THE AQUEOUS EXTRACT OF LEMON GRASS AGAINST SELECTED PATHOGENIC BACTERIA

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Abstract: In the present study, an antimicrobial activity of the aqueous extract of lemongrass species was assessed using both well diffusion and micro-dilution method in multi-well micro-titer plates. Lemongrass extract investigated for its antibacterial activity against four selected pathogenic bacteria: *Staphylococcus aureus*, *Escherichia coli*, *Salmonella choleraesuis* and *Proteus vulgaris*. Lemongrass extract at different concentrations (1:1, 1:5, 1:10, and 1:20) was active against all tested bacteria and the highest inhibitory effect was observed against *S. aureus* using the well diffusion method. Antibacterial activity of Aqueous extracts of selected commonly used lemongrass were screened against multi drug resistant bacteria, which concludes that their extracts can be used against multi drug resistance bacteria capable of causing both nosocomial and community acquired infections.

Keywords: Antimicrobial activity, Extract, Bacteria, Lemon grass

INTRODUCTION

Nature has been a resource of therapeutic agents for thousands of years and a remarkable number of contemporary drugs have been isolated from natural sources. The use of whole herbs and extractives has remained the main approach of folk medicine practitioners in the cure of ailments and debilitating diseases. They generally claimed that such whole herbs and extractives are effective against a number of ailments and diseases without recourse to scientific proofs. Increased cases of opportunistic diseases emanating from side effects associated with synthetic drugs continue to necessitate incremental efforts in searching for effective biological substitutes with little or no side effects. Therefore, efforts are being directed towards elucidating potential sources such as ethno-medicinal plants (Patil, 2010).

Lemon grass is a native aromatic tall sedge / grass. It is belong to Poaceae family with diverse medicinal value and grow in many parts of tropical and subtropical south East Asia and Africa (Rangari, 2009; Srivastava *et al.*, 2013). It was grown in India a century back and is now commercially cultivated in different parts of India. Lemon grass is tall, perennial grass about 1m in height. The culm is stout, erect, up to 1.8 m height. Leaves are long, green, glaucous, linear tapering upwards and along the margins; ligule very short, sheaths terete, those of the barren shoots widened and tightly elapsing at the base, other narrow and separating (Srivastava *et al.*, 2013). The crop flowers during November – December and seeds mature in next two months viz; February – March. For collection of seeds, the plants are maintained in good health, as the yield of seeds from plants subjected to regular harvest is low (Gupta and Sharma 2009).

MATERIAL AND METHOD

Plant Material

Lemongrass leaves were collected from Shushila Tiwari Harbal Garden, village Dhalwala, Rishikesh, Uttarakhand, India. The leaves were washed first under running tap water, followed by sterilized distilled water and dried at room temperature in dark then grinded to powder using an electrical blender.

Preparation of Extracts

The leaves of the plants were air dried at room temperature for 3 weeks and grounded to coarse powder. 15g of the powder was placed in 100ml of distilled water (cold water extract) in conical flask and the crude preparation was left overnight in the shaker at 35°C and

then centrifuged at 2500 rpm for 10 mins. The supernatant containing the plant extract was then transferred to a preweighed beaker and the extract was concentrated by evaporating the solvent at 60°C. The crude extract was weighed and dissolved in a known volume of dimethyl sulphoxide, to obtain a final concentration of 200mg / ml and sterilized by filtration through (0.45 µm) millipore filters. The aqueous extracts were stored in sample bottles at 4°C prior to use (De and Ifeoma, 2002).

Microbial Cultures

Four strains of bacteria were used as test microorganisms. All microbial strains were obtained from the Microbial Type Culture Collection (MTCC), Institute of Microbial Technology (IMTECH), Chandigarh, India.

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Standardization of Inoculum

Exactly 0.2ml of 24/hours old culture of each microorganism was dispensed into 20ml of sterile nutrient broth and was incubated for 3-5/hours to standardize the culture to 106cfu/ml (Collins *et al*, 1995).

Antibacterial Testing

This was done using the agar wells diffusion method of (Odeyemi and Fagbohun, 2005). 0.5ml of overnight broth culture of each clinical isolates containing 106 cfu/ml was gently transferred to the solidified nutrient agar and spread uniformly on the agar surface using a sterile glass spreader. Four 6mm wells were bored unto the agar and filled with the aqueous extracts (cold water extract) while the distill water serves as the control. The Petri dishes were incubated at 37°C for 18-24/hr and the inhibition zones were measured (mm).

Minimum Inhibition Concentration (MIC) of the Extract

The (MIC) was defined as the lowest concentration that completely incubated the growth of microorganisms for 24 hours (Thongson *et al*, 2004). The MIC of the extracts was also done using the agar well diffusion technique. Two fold dilution series was prepared to get a decreasing concentration range of 200 to 15% (V/V). A 0.5ml volume of each solution was added gently into the wells of Mueller Hinton agar plates that were already seeded with standardized inoculum (106 cfu/ml) of the bacterial isolates. The plates were incubated at 37°C for 24/hr. The lowest concentration of the extracts showing a clear zone of inhibition was considered as the MIC.

RESULT

The results of the antimicrobial activity of aqueous extract of lemon grass are presented in Table 1 and 2. The highest inhibitory effect was observed against *Staphylococcus aureus* (zone of inhibition: 10 mm) while the weakest activity was demonstrated against *Escherichia coli*, *Staphylococcus* typhi and *Proteus vulgaris* (zone of inhibition: 9, 8 and 2 mm respectively) (Table 1). In view of the result obtained by the well diffusion method, the minimum inhibitory concentration (MIC) of lemon leaf extract was determined by broth microdilution assay (Table 2). The highest MIC value (40, 50, 80 and 100 µg/ml) was observed against *Staphylococcus aureus*, *Escherichia coli*, *Staphylococcus* typhi and *Proteus vulgaris* respectively. The standard drug Ampicillin was active against all reference bacteria (zone of inhibition: 7-8 mm; MIC range 60- 256 µg/ml), Tetracycycline was active against all reference bacteria (zone of inhibition: 12-18 mm; MIC range 32- 128 µg/ml) and Chloramphenicol was active against all reference bacteria (zone of inhibition: 11-19 mm; MIC range 2- 125 µg/ml).

Table 1. Diameter of zone of inhibition (mm) of antimicrobial extracted from plant *C. flexuosus* against Bacterial isolates

S.No.	Test Microbes	*C. flexuosus* [mm]	Control		
			1	2	3
1	*S. aureus*	10	7	15	19
2	*E. coli*	09	8	18	11
3	*S. typhi*	08	7	14	16
4	*P. vulgaris*	02	8	12	12

Table 2. Minimum Inhibitory Concentration (MIC) of antimicrobial extracted from plant *C. flexuosus* against Bacterial isolates

S.No.	Test Microbes	*C. flexuosus* [µg/ml]	Control		
			1	2	3
1	*S. aureus*	40	125	60	2
2	*E. coli*	50	60	32	125
3	*S. typhi*	80	256	128	2
4	*P. vulgaris*	100	124	124	124

DISCUSSION

Plants have formed the basis of sophisticated traditional medicine system and natural products make excellent leads for new drug development (Newman et al, 2007). In this study, it was found that the aqueous extract of lemon grass plant is concentration around 40 to 100 µg/ml showing better antimicrobial activity against common pathogenic bacterial species. The minimum inhibitory concentration of aquous extract are 40 µg/ml, 50 µg/ml, 80 µg/ml and 100 µg/ml for *Staphylococcus aureus*, *Escherichia coli*, *Staphylococcus* typhi and *Proteus vulgaris* respectively. Therefore, the aqueous extract are more effective in killing *Staphylococcus aureus* (at lower dose).

Based on the obtained results, lemongrass has demonstrated varying degree of antibacterial activity against *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella typhi*. Therefore, this signifies that some bacteria that have not been tested with lemongrass extract in this research may also be susceptible to the antibacterial effect of lemongrass.

CONCLUSION

In the present study, Lemongrass has demonstrated antimicrobial properties which could be harnessed for the expansion of alternative means of therapeutic control of bacterial pathogens.

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SHORT COMMUNICATION

EVALUATION OF PLANT PRODUCTS AGAINST TOBACCO CATERPILLAR, *SPODOPTERA LITURE* (FABRICIUS) ON SOYBEAN

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Abstract: The tobacco caterpillar, *Spodoptera litura* (Fabricius) is the most serious pest of soybean. Plant products or botanical pesticides are the important alternatives to minimize or replace the use of synthetic pesticides.The present study was conducted during *kharif,* 2016 at S K College of Agriculture and Research Station, Kawardha (Kabirdham) Chhhattisgarh. The experiment was carried out in RBD design with eight treatments and three replications. Tobacco caterpiller, *S. litura* is the most damaging insect pest of soybean. In the evaluation of plant products against *S. litura* NSKE @5% was found second most effective botanicals after recommended insecticide on soybean after both the sprays 1st as well 2nd with benefit cost ratio of 1.14.

Keywords: Botanicals, Soybean, *Glycine max* (L.), *Spodoptera litura*

INTRODUCTION

Soybean, *Glycine max* (L.) occupied first rank in the world production. India ranks third in respect of area and production.Soybean is a major source ofedible oil (20%) and high quality protein (40%). It is a rich source of aminoacids, vitamins andminerals. Soybean oil is used as a raw material in manufacturing antibiotics, paints,varnishes, adhesives, lubricants. Soybean meal is used as protein supplement in humandiet, cattle and poultry feeds.Soybean is mainly cultivated in USA,China, Brazil, Argentina and India. Major Soybean growing states in India are Madhya Pradesh,Maharashtra, Rajasthan, Karnataka, Uttar Pradesh, Andhra Pradesh and Gujarat. In Chhattisgarh soybean is generally grown under rainfed conditions in*Kharif* season. Chhattisgarh is growing at fast pace in the farm sector. In 2015-16, area under oilseed in the state was 1.21 thousand hectares.Soybean is cultivated as one of the major oilseed crops in Kabirdham district of Chhattisgarh.The low productivity of soybean both at national and state level is attributed to abioticand biotic stresses like drought, weeds, insect pests and diseases. Among these, insect pestsoften pose a serious threat to soybean production by increasing cost of cultivation andimpairing quality of produce in many ways.Soybean crop is reported to be attackedby about 350 species of insects in many parts of the world (Luckmann, 1971, Rai *etal*., 1973; Adimani, 1976; Thippaiah, 1997 and Jayappa, 2000). Defoliators like *Spodoptera litura* (Fab.), *Thysanoplusia orichalcea* (Fab.) damagesoybean extensively by skelatalization of leaves in early stage and severe defoliation in laterstage and thus reducing the photosynthetic capacity of plants.The tobacco caterpillar, *Spodoptera litura* is serious pest of soybean at District Kabirdham. Excessive and indiscriminate use of pesticide come several problems like development of resistance in targeted species, resurgence of secondary pest, elimination of natural enemies and contamination of soil, water and food chain. Plant products or botanical pesticides are the important alternatives to minimize or replace the use of synthetic pesticides.Hence the present study was conducted during *kharif,* 2016 at S K College of Agriculture and Research station, Kawardha (Kabirdham) Chhhattisgarh against *S. litura*.

MATERIAL AND METHOD

Evaluation of plant products against tobacco caterpillar, *Spodoptera liture* (Fabricius) on soybeanwas studied at the experimental area of S. K. College of Agriculture & Research Station Kawardha (Kabirdham), Chhattisgarh during *kharif*, 2016-17. For the sustainable management of Tobacco caterpillar, *Spodoptera liture*at kabirdham different plant products viz. neem oil @ 2% (2 ml/L), karanj Oil @ 2% (2m/L), NSKE @ 5% (50gm of neem seed extract soaked overnight in one litter of water), karanj seed extract @30 Kg/ ha (60gm of extract soaked overnight in one litter of water), garlic 500 gm +green chilli @9 kg/ha and green chilli @ 10

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Kg/hawas examined as treatments. A field experiment was laid out in randomized block design (RBD) with eight treatments including untreated control, replicated three times. The crop was sown on last week of Junein plot size of 6X5=30 sq. meters. In this experiment from each plot thenumbers of caterpillars werecounted 24 hours before of treatment and the post treatment 1, 3, 5, 7, 10 and 15 days after treatment from randomly selected five different spots of one square meter area.B: C ratio wasalso calculated.

Table 1. Evaluation plant products against soybean defoliator *Spodoptera litura*at S. K. CARS, Kabirdham during *Kharif* 2016-17

Notation	Treatments	Dose /ha (g or ml)	Mean number of larvae per plant										
			1DBS	1st Spray					2nd Spray				
				1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
T_1	Neem oil	2%	0.57 (1.34)	0.50 (1.23)	0.60 (1.26)	0.57 (1.26)	0.59 (1.26)	0.63 (1.27)	0.73 (1.32)	0.70 (1.34)	0.60 (1.27)	0.03 (1.02)	0.03 (1.02)
T_2	NSKE	5%	0.53 (1.31)	**0.40 (1.19)**	**0.50 (1.22)**	**0.57 (1.25)**	**0.57 (1.26)**	**0.59 (1.26)**	**0.37 (1.17)**	**0.63 (1.28)**	**0.57 (1.25)**	**0.03 (1.02)**	**0.00 (1.00)**
T_3	Karanj oil	2%	0.59 (1.3)	0.59 (1.26)	0.69 (1.30)	0.80 (1.34)	0.72 (1.31)	0.75 (1.32)	0.53 (1.24)	0.70 (1.30)	0.70 (1.30)	0.10 (1.05)	0.00 (1.00)
T_4	Karanj Seed powder	30Kg	0.65 (1.33)	0.55 (1.25)	0.63 (1.28)	0.57 (1.26)	0.68 (1.29)	0.80 (1.34)	0.87 (1.37)	0.80 (1.34)	0.63 (1.27)	0.10 (1.05)	0.00 (1.00)
T_5	Chilli- garlic Solution	9Kg	0.50 (1.28)	0.57 (1.26)	0.67 (1.29)	0.87 (1.37)	0.70 (1.30)	0.69 (1.3)	0.57 (1.25)	0.67 (1.29)	0.70 (1.30)	0.07 (1.03)	0.00 (1.00)
T_6	Chilli Solution	10 kg	0.63 (1.28)	0.53 (1.24)	0.63 (1.27)	0.69 (1.30)	0.63 (1.27)	0.67 (1.29)	0.6 (1.26)	0.63 (1.28)	0.70 (1.30)	0.03 (1.02)	0.00 (1.00)
T_7	Triazophos	1000 ml	0.67 (1.23)	**0.30 (1.14)**	**0.40 (1.18)**	**0.43 (1.19)**	**0.48 (1.22)**	**0.53 (1.24)**	**0.1 (1.05)**	**0.40 (1.18)**	**0.47 (1.21)**	**0.00 (1.00)**	**0.00 (1.00)**
T_8	Untreated	-	0.70 (1.32)	0.93 (1.39)	1.03 (1.43)	0.93 (1.38)	1.17 (1.47)	1.31 (1.52)	1.17 (1.45)	1.33 (1.52)	1.03 (1.43)	0.17 (1.08)	0.03 (1.02)
	SE (m)±		**0.03**	**0.06**	**0.05**	**0.03**	**0.04**	**0.03**	**0.06**	**0.05**	**0.03**	**0.01**	**0.01**
	CD 5%		**NS**	**0.21**	**0.16**	**0.10**	**0.11**	**0.10**	**0.21**	**0.17**	**0.10**	**0.04**	**NS**

Note : Figure in parenthesis are Square root transformed value, DBS= Day before spray, DAS= Days after spray

Table 2. Economics of different plant products against soybean defoliator *Spodoptera litura*at S. K. CARS, Kabirdham during *Kharif* 2016-17

Notation	Botanicals	Dose /ha (g or ml)	Yield (q/ha)	Net profit over control (Rs./ha)	cost of cultivation (Rs./ha)	gross return	Benefit :cost ratio
T_1	Neem oil	2%	6.87	3458.00	13330.00	17862.00	**1:1.34**
T_2	NSKE	5%	6.93	3614.00	15810.00	18018.00	**1:1.14**
T_3	Karanj oil	2%	6.81	3302.00	13330.00	17706.00	**1:1.33**
T_4	Karanj Seed powder	30Kg	6.97	3718.00	16410.00	18122.00	**1:1.10**
T_5	Chilli- garlic Solution	9Kg	6.19	1690.00	13590.00	16094.00	**1:1.21**
T_6	Chilli Solution	10 kg	6.88	3484.00	13622.00	17888.00	**1:1.35**
T_7	Recommended Insecticide (Trizophos 40EC)	1000 ml	6.81	3302.00	13310.00	17706.00	**1:1.33**
T_8	Untreated	-	5.54		12042.00	14404.00	**1:1.20**

Cost of chemicals: Neem oil 1 Lit- Rs 240, NSKE 1 kg- Rs 120, Karanj oil 1 Lit- Rs 240, Karanj Seed powder l kg- Rs 120kg, Chilli 1 kg - Rs 40, garlic1 kg - Rs 160, Kerosin oil-1 Lit- Rs 50, Surf- 100gm- Rs 10, Teepol 1 Lit- Rs 280, Trizophos 40EC 1 Lit- Rs 500.**Cost of cultivation soybean** =Rs- 12042/ha,**Price of Soybean**= Rs 2,600 per quintal.

RESULT AND DISCUSSION

The incidence of tobacco caterpillar was recorded prior and post application of insecticide treatment on the basis of population density. The caterpillar population in the pre treatment observation ranged from 0.50 to 0.70larvae per plant showing statistically non significant difference in different treatments denoting as uniform population. In post treatment observation after 1st , 3rd , 7th , 10th and 14th day of first spray, all the tested doses of plant products showed significant differences over untreated control. Among the treatments, NSKE @5% was found second most effective after recommended insecticide with 0.04, 0.50,0.57,0.57 and 0.59 larvae per plant, respectively. Similar trend of result was foundafter 1st , 3rd , 7th , 10th and 14th day of second spray, all the tested doses of plant products showed significant differences over untreated control, NSKE @5% was found second most effective after recommended insecticide with 0.37, 0.63,0.57 and 0.03 larvae per plant, respectively (Table 1).

NSKE @ 5% caused highest mortality among treatment.The present findings of effect of NSKE are in line with Sayed (1983), Sahayaraj andSekar, (1996) and Patil (2000) who reported the effectiveness of NSKE against variousinstars of *S. litura*.Barapatre (2001) who recorded 20 and 24.65 per cent mortality of thirdinstar *S. litura* treated with neem oil (2.5%) and Garlic (0.5%) + Chilli (0.5%) + Kerosene(0.3%) + Ginger (1.5%), respectively. The difference in mortality may be due to variation inconcentration used and also different experimental conditions.

Among the plant products, the maximum benefit cost ratio was found in the treatment green chilli @ 10kg/ha having 1.35. In rest of the plant products, more or less similar benefit cost ratio was obtained like 1.34 in Neem oil @ 2% (1.34) which was followed by Karanj oil @ 2% (1.33), garlic+ green chilli @ 9kg/ha (1.21), NSKE @ 5% (1.14) and the minimum benefit cost ratio was recorded in the treatment having Karanj seed extract @ 30 kg/ ha only 1.10 and among the chemical treatment triazophos @ 1000ml/ha which was used for management of insect pests of soybean the benefit cost ratio was maximum with 1.33 (Table 2). Present findings are in agreement with the Raghuvanshi *et al.*, (2014) as they reported that triazophos gave the maximum better return on soybean crop. Panchabhavi *et al.*, (1994) obtained highest cost benefit ratio in NSKE sprayed at 15 days interval with a seed yield of 12.0 q/ha.

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