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RESEARCH ARTICLE

COMBINING ABILITY ESTIMATION FOR MORPHOLOGICAL AND YIELD CONTRIBUTING CHARACTERS IN *DESI* COTTON (*GOSSIPIUM ARBOREUM*)

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Abstract: In the present study six arboreum lines (PA-720, PA-08, PA-528, PA-532, PA-255 and PA-402) were crossed with four testers (AKA-7, GAM-162, Dwd-arb-10-1 and JLA-802) to obtain twenty four hybrids following line × tester design. The resultant twenty four hybrids along with their parents were evaluated in a randomized block design with three replications at Cotton Research Station, Mahboob Bagh Farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2012-13. Observations were recorded on twelve parameters *viz.*, days to 50% flowering, days to 50% boll bursting, no. of sympodia per plant, no. of bolls per plant, no. of seeds per boll, boll weight, plant height, days to maturity, seed cotton yield per plant, lint yield per plant, seed index and oil content. The combining ability analysis indicated the presence of considerable variability in crosses for most of the traits under study. The lines *viz.,* PA-720, PA-08 and PA-532 and the tester AKA-7 was found the best general combiner. The crosses *viz.,* PA-528 × AKA-7, PA-528 × JLA-802 and PA-08 × AKA-7 showed significance of SCA effects for more number of traits so these can be used for future breeding programmes. The variance estimates due to GCA and SCA were highly significant for most of the characters. The magnitude of SCA variance was greater than GCA variance and more contribution of line × tester interaction to the total variability indicated the predominance of non additive gene action, so for improvement of these traits heterosis breeding is considered the more rewarding option.

Keywords: *Gossipium aboreum*, Seed, Cotton

INTRODUCTION

Cotton is an important commercial crop which accounts for 60% of total foreign exchange earnings through export of lint and value added cotton products (Eswari *et al.,* 2016). Cotton is also called as 'White Gold' or 'King of Apparel Fibre'. It is considered as most precious gift by nature to mankind as it provides clothing to all over the world. Other than fiber, it also provides edible oil which plays important role in country's economy. Cotton has four cultivated species, classified into new world cotton (*Gossypium hirsutum* L. and *Gossypium barbadense* L.) which are tetraploids (2n = 4x = 52) and old world cotton (*Gossypium herbaceum* L. and *Gossypium arboreum* L.) which are diploids (2n = 2x = 26). India is the native home of *G. arboreum* and there is wide climatic conditions in India which indicate the ample scope of crop improvement in India.

Fiber quality and seed cotton yield are two major objectives of cotton improvement programmes. Availability of variation among genotypes is important and it is controlled by strong genetic components. It is essential to identify superior parents for hybridization and crosses to increase the genetic variability. Combining ability helps in identification of superior genotypes, type of gene action and breeding procedures to be followed. The aim of this study was to estimate gene action and the type of inheritance for yield contributing traits which may be utilized in future breeding program of cotton.

MATERIAL AND METHOD

In the present study six arboreum lines (PA-720, PA-08, PA-528, PA-532, PA-255 and PA-402) were crossed with four testers (AKA-7, GAM-162, Dwd-arb-10-1 and JLA-802) to obtain twenty four hybrids following line × tester design. The L × T was performed according to Kempthorne (1957). The resultant twenty four hybrids along with their parents were evaluated in a randomized block design with three replications at Cotton Research Station, Mahboob Bagh Farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2012-13. Experiment was conducted by maintaining inter-row and intra-row spacing as 60cm and 30cm, respectively. Recommended cultivation practices and

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plant protection measures were adopted to raise a healthy crop.

Observations were recorded both as visual assessment and measurement on individual plants. Five competitive plants were selected randomly from each plot in each replication for recording observations on twelve parameters *viz.*, days to 50% flowering, days to 50% boll bursting, no. of sympodia per plant, no. of bolls per plant, no. of seeds per boll, boll weight, plant height, days to maturity, seed cotton yield per plant, lint yield per plant, seed index and oil content. All recorded datas were subjected to analysis of variance for testing the significance of treatments as suggested by Panse and Sukhatme, (1961). Combining ability analysis and the testing of significance of different genotypes was based on the procedure given by Kempthorne (1957).

RESULT AND DISCUSSION

Combining ability is defined as the ability of parents or cultivars to combine amongst each other or capability of transmission of favourable genes during the process of hybridization. Combining ability is of two types. Specific combining ability is the deviation in the performance of hybrids from the expected productivity. It occurs due to the genes with dominance or epistatic effect and non-fixable. On the other hand, general combining ability is the average performance of a line in a series of crosses. It occurs due to additive genes and is fixable (Sprague and Tatum, 1942). The higher magnitude of SCA than GCA indicates the preponderance of dominant genes (Desphande and Baig, 2003).

The combining ability analysis indicated the presence of considerable variability in crosses for most of the traits under study (Table-1). The female lines exhibited significant differences for the characters *viz.*, number of bolls per plant and lint yield per plant. Testers did not show significant difference for any character. L × T interaction was significant for all the characters except no. of sympodia per plant, no. of seeds/boll and days to maturity.

Estimation of GCA and SCA Effects- The GCA and SCA effects were worked out for all the traits which were presented in table-3 and table-4, respectively and discussed as under-

Days to 50% flowering and 50% boll bursting- The line PA-08 and the tester GMA-162 showed significant negative GCA effect for days to 50 percent flowering (-1.83 and -1.27, respectively) and days to 50% boll bursting (-2.18 and -1.81, respectively) which is in the desirable direction. None of the crosses showed significant SCA effect for days to 50% flowering but crosses *viz.*, PA-402 × Dwd-arb-10-01 (-2.056), PA-255 × GAM-162 (-1.722) and PA-255 × Dwd-arb-10-01 (-1.417) showed desirable negative SCA effect.

No. of sympodia per plant-Among parents, the line PA-532 (2.00) and the tester AKA-7 (1.54) showed the highest positive GCA effect. The cross PA-528 × Dwd-arb-10-01 (3.911), PA-402 × JLA-802 (2.961) and PA-720 × AKA-7 (2.378) showed non-significant but positive SCA effect.

Number of bolls/plant- PA-720 (1.81) and PA-08 (1.63) were the highest performing lines while AKA-7 (0.79) and Dwd-arb-10-1 (0.75) were the highest performing testers for bolls per plant. The cross PA-402 × JLA-802 (3.786) and PA-528 × AKA-7 (2.331) performed highest significant SCA value for number of bolls per plant.

No. of seeds/boll- None of the lines and tester was found with significant and positive GCA effect. None of the cross showed significantly positive SCA effect but positive SCA effects were shown by the cross PA-08 × AKA-7 (1.328) and PA-528 × Dwd-arb-10-1 (1.011).

Boll weight (g)- The line PA-532 (0.10) showed the positive and significant GCA while, the tester AKA-7 (0.08) showed the positive and significantGCA for boll weight.The crosses *viz.*, PA-402 × JLA-802 (0.149), PA-255 × JLA-802 (0.147) and PA-528 × AKA-7 (0.132) showed significant positive SCA effect in desirable direction.

Plant height (cm)- Among parents, the lines *viz.*, PA-532 (4.26) and PA-08 (4.07) showed significant and positive GCA effect while, only one tester AKA-7 (4.66) manifested positive GCA effect for plant height. The line PA-402 (-11.14) showed the highest negative GCA effect for plant height. It is suggested to use these parents in breeding programmes for development of plant height. PA-532 × AKA-7 (21.596) and PA-528 × JLA-802 (11.607) showed highest significant positive SCA effect and the crosses *viz.*, PA-08 × Dwd-arb-10-1 (-16.538) and PA-402 × AKA-7 (-11.154) showed highest significant negative SCA effect. These crosses can be used in different breeding programmes for tallness or dwarfness.

Days to maturity- None of the line and none of the tester performed significantly in desirable direction. Only one cross, PA-08 × AKA-7 (-5.708) showed desirable SCA effect in negative direction.

Seed cotton yield per plant- The lines PA-720 (3.11) and PA-532 (2.86) and the testers Dwd-arb-10-1 (3.84) and AKA-7 (3.54) were with significant and positive GCA effect for seed cotton yield. It indicates that these parents are good general combiners for the respective trait. A total seven crosses performed significant SCA effect in positive direction. Highest performing cross were PA-528 × AKA-7 (10.083), PA-255 × AKA-7 (7.200) and PA-08 × AKA-7 (6.239).

Lint yield per plant- PA-08 (9.58) and PA-528 (5.04) were significant and positive performing lines and no tester performed significant GCA effect in desirable direction. Only one cross PA-720 × GAM-162 (7.454) exhibited significant positive SCA effect.

Seed index- The line PA-720 (0.25) and the tester GAM-162 (0.38) showed significant positive GCA among parents. The crosses, PA-528 × JLA-802 (0.860) and PA-08 × AKA-7 (0.602) showed significant SCA effect in desirable direction.

Oil content- Highest significant GCA performance among parents was shown by one line PA-402 (0.50) and one tester JLA-802 (0.60) which can be used in breeding programmes targeted for oil improvement. Two crosses performed significant positive SCA effect for oil yield. These crosses are PA-08 × JLA-802 (1.545) and PA-528 × AKA-7 (0.805). The above all characters are in agreement with earlier results, observed by Karademr and Gencer (2010), Dhamaynthi (2011), Nadagundi *et al.,* (2011), Jatoi *et al.,* (2011), Mendez-Natera *et al.,* (2012) and DaiGang *et al.,* (2012).

Most of the significant SCA effects observed in the present investigation were resulted by a combination of low general combiner parents. Both the parents (PA 402 × Dwd-arb-10-1; PA-255 × AKA-7; PA-255 × Dwd-arb-10-1)were poor general combiner but, their progeny performed significant SCA effect for earliness (days to 50% flowering and days to 50% boll bursting). Similar performance exhibited by the parental combination *viz.,* PA-528 × Dwd-arb-10-1 and PA-402 × JLA-802 for number of sympodia per plant; PA-402 × JLA-802 and PA-528 × AKA-7 for number of bolls per plant; PA-08 × AKA-7 and PA-528 × Dwd-arb-10-1 for number of seeds per boll; PA-255 × JLA-802 and PA-402 × JLA-802 for boll weight; PA-528 × JLA-802 for plant height; PA-255 × JLA-802 and PA-255 × GAM-162 for seed cotton yield; PA-720 × GAM-162 for lint yield; PA-528 × JLA-802 for seed index and PA-528 × AKA-7 for oil content. These results indicate that for production of valuable hybrid for specific trait, it is not necessary that any one parent should possess higher GCA value. Similar pattern of combination was also observed by Patel *et al.,*(1997), Imran *et al.,* (2012) and Ali *et al.,* (2016) for various characters.The combination of low × high or high × low was also observed. It is performed by the parents, PA-720 × AKA-7 for number of sympodia per plant; PA-528 × AKA-7 for boll weight; PA-08 × GAM-162 and PA-532 × Dwd-arb-10-1 for plant height; PA-255 × AKA-7 for seed cotton yield; PA-08 × JLA-802 for oil content. The high × high general combiner also resulted in the higher SCA effect and it was observed for the crosses *viz.,* PA-08 × AKA-7 for days to maturity; PA-532 × AKA-7 for plant height; PA-528 × AKA-7 and PA-08 × AKA-7 for seed cotton yield.

Contribution of parents and their interaction

The estimates of variance due to general combining ability (GCA), variance due to specific combining ability (SCA), GCA and SCA ratio were worked out for different characters and presented in Table-2. The variance estimates due to GCA and SCA were highly significant for most of the characters except no. of seeds per boll (Ali *et al.,* 2016), days to maturity and seed index. It is indicating the importance of both additive and non-additive gene actions. The magnitude of SCA variance was greater than GCA variance for all the traits which indicates prevalence of non-additive gene action. Similar results also reported by Neelima *et al.* (2004), Kiani *et al.* (2007), Preetha and Raveendran (2008) and Pole *et al*. (2008). The ratio of variances of GCA and SCA (<1) indicated the prevalence of non-additive gene action. Similar results were reported by Azhar *et al.,* (2007), Tang and Xiao (2013), Nimbalakar *et al.,* (2014), Ali *et al.,* (2015) and Patel and Choudhary (2015). Contribution of L × T interaction, to the total variability was higher for most of the characters except no. of bolls per plant and lint yield per plant where contribution of lines was higher. Similarly, if we compare the role of lines and testers, contribution of tester was more for the traits *viz.,* days to 50% flowering, days to 50% boll bursting, days to maturity, seed cotton yield per plant, seed index and oil content while, the traits *viz.,* no. of sympodia per plant, no. of bolls per plant, no. of seeds per boll, boll weight, plant height and lint yield per plant exhibited more contribution of lines. Relatively more contribution of line × tester interaction also indicates the predominance of non additive gene action (Samreen *et al.,* 2008). For improvement in traits under non-additive genetic control, heterosis breeding is considered the more rewarding option (Imran *et al*., 2012; Ali *et al*., 2015) or other breeding methodologies like bi-parental mating, recurrent selection and diallel selective mating can be used (Prasad *et al.,* 2016).

Table 1. Analysis of variance for combining Ability for different characters including parents

Source	d.f.	Days to 50% flowering	Days to 50% boll bursting	No. of sympodia/ plant	No. of boll/ plant	No. of seed / boll	Boll Weight (g)	Plant height (cm)	Days to maturity	Seed cotton yield/ plant	Lint yield / plant	Seed index	Oil content (%)
Replications	2	1.098	8.009	9.026	0.871	2.503	0.001	63.965	12.127	112.384	31.735	0.015	0.166
Crosses	23	9.971**	18.753**	19.058**	15.386**	2.069	0.042**	356.190**	26.782	157.179**	182.804**	1.058**	2.288**
Females	5	10.433	17.247	23.980	34.263*	1.308	0.054	389.708	17.980	81.970	441.521*	0.559	1.421
Males	3	18.00	35.421	29.438	14.424	1.175	0.070	228.813	38.458	362.297	92.496	1.2524	2.980
M x F	15	8.211*	15.921*	15.342	9.287**	2.501	0.033**	370.494**	27.380	141.224**	114.62**	1.186**	2.440**
Error	66	3.582	8.373	7.915	2.152	2.916	0.010	48.107	23.076	7.020	29.565	0.164	0.386

Table 2. Variances for General and Specific Combining Ability and Percent contribution of lines, testers and LxT for morphological characters in cotton

Sr.no.	Character	δ^2 GCA	δ^2SCA	δ^2GCA / δ^2SCA	Percent contributions of		
					Lines	Testers	LxT
1.	**Days to 50 % flowering**	0.7089*	1.5427*	0.4595	22.74	23.54	53.70
2.	**Days to 50% boll bursting**	1.1974*	2.5160*	0.4759	19.99	24.63	55.36
3.	**No. of sympodia/ plant**	1.2529*	2.4755*	0.5061	27.35	20.14	52.15
4.	**No. of boll/ plant**	1.4794**	2.3781**	0.6221	48.40	12.22	39.36
5.	**No. of seed / boll**	-0.1116	-0.1384	0.8069	13.74	7.40	78.84
6.	**Boll Weight (g)**	0.0035*	0.0075**	0.4627	27.75	21.70	50.54

7.	**Plant height (cm)**	17.4103	107.4622**	0.1620	23.78	8.37	67.83
8.	**Days to maturity**	0.3428	1.4345	0.2390	14.59	18.73	66.67
9.	**Seed cotton yield/ plant**	14.3409*	44.7347**	0.3206	11.33	30.06	58.59
10.	**Lint yield / plant**	15.8296**	28.3538**	0.5583	52.50	6.59	40.89
11.	**Seed index**	0.0494	0.3404	0.1452	11.48	15.43	73.07
12.	**Oil content (%)**	0.1210	0.6842**	0.1768	13.50	16.98	69.50

Table 3. Estimates of General Combining Ability (GCA) for Lines and Testers

Parents	**Days to 50% flowering**	**Days to 50% boll bursting**	**No. of sympodia / plant**	**No. of boll/ plant**	**No. of seed / boll**	**Boll Weight (g)**	**Plant height (cm)**	**Days to maturity**	**Seed cotton yield/ plant**	**Lint yield / plant**	**Seed index**	**Oil content (%)**
Lines												
PA-720	0.75	1.23	-1.13	1.81**	-0.185	0.04	1.48	-1.06	3.11**	-6.24**	0.25*	-0.34
PA-08	-1.83**	-2.18*	1.40	1.63**	-0.056	-0.03	4.07*	-0.90	-1.91*	9.58**	-0.24*	-0.33
PA-528	0.00	-0.18	-0.28	-0.98*	-0.306	-0.00	1.12	0.68	-0.15	5.04**	-0.01	-0.06
PA-532	0.50	0.23	2.00*	0.53	-0.256	0.10**	4.26*	0.84	2.86**	-3.34*	0.11	0.30
PA-255	0.33	0.90	-0.40	-2.63**	0.511	-0.07**	0.19	1.68	-0.40	-1.13	-0.26*	-0.06
PA-402	0.25	-0.01	-1.58	-0.35	0.292	-0.03	-11.14**	-1.23	-3.51**	-3.89*	0.15	0.50**
S.E.(Gi)	0.546	0.835	0.8122	0.4235	0.4930	0.0294	2.0022	1.3868	0.7649	1.569	0.1171	0.1796
S.E.(Gi-Gj)	0.772	1.181	1.1486	0.5990	0.6972	0.0416	2.8316	1.9612	1.0817	2.219	0.1656	0.2539
CD @5%	1.099	1.681	1.6348	0.8525	0.9924	0.0592	4.0303	2.7914	1.5396	3.159	0.2357	0.3614

CD @1%	1.468	2.244	2.1823	1.1380	1.3248	0.0791	5.3800	3.7262	2.0553	4.217	0.3146	0.4825
Testers												
AKA-7	0.05	0.34	1.54*	0.79*	-0.094	0.08**	4.66**	-0.79	3.54**	2.32	-0.08	-0.19
GMA-162	-1.27**	-1.81*	0.55	-0.79*	0.306	-0.07**	0.87	-1.62	-2.20**	-0.42	0.38**	0.23
Dwd-arb-10-1	1.16*	1.56*	-0.98	0.75*	0.083	0.00	-2.33	0.87	3.84**	1.04	-0.22*	-0.17
JLA-802	0.05	-0.90	-1.11	-0.75*	-0.294	-0.01	-1.99	1.54	-5.38**	-2.95	-0.07	0.60**
S.E.(Gi)	0.446	0.682	0.6631	0.3458	0.4026	0.0240	1.6348	1.1323	0.6245	1.281	0.0956	0.1466
S.E.(Gi-Gj)	0.631	0.964	0.9378	0.4891	0.5693	0.0340	2.3120	1.6013	0.8832	1.812	0.1352	0.2073
CD @5%	0.898	1.681	1.3348	0.6961	0.8103	0.0484	3.2907	2.2791	1.2571	2.579	0.1924	0.2951
CD @1%	1.198	2.244	1.7819	0.9292	1.0817	0.0646	4.3928	3.0424	1.6781	3.443	0.2569	0.3939

Table 4. Estimates of specific combining ability (SCA) for yield contributing characters

Hybrids	**Days to 50% flowering**	**Days to 50% boll bursting**	**No. of sympodia/ plant**	**No. of boll/ plant**	**No. of seed / boll**	**Boll Weight (g)**	**Plant height (cm)**	**Days to maturity**	**Seed cotton yield/ plant**	**Lint yield / plant**	**Seed index**	**Oil content (%)**
PA-720 x JLA-802	0.194	-0.847	1.989	0.475	0.744	-0.050	-10.218*	3.125	-7.528**	-6.879*	0.063	0.035
PA-528 x AKA-7	-0.806	-0.681	0.111	2.331**	-0.589	0.132*	-9.096*	-3.042	10.083**	5.387	0.212	0.805*
PA-08 x GAM-162	-1.583	-1.069	-0.011	-0.558	-0.833	-0.013	9.476*	-2.208	4.172**	0.770	0.177	0.722
PA-532 x Dwd-arb-10-1	2.194	2.597	-2.089	-2.247*	0.678	-0.069	9.837*	2.125	-6.728**	0.721	-0.453	-1.562**
PA-255 x JLA 802	-0.889	-1.431	-1.278	0.858	-1.056	0.147*	1.390	-0.042	5.372**	1.256	0.153	-0.903*
PA-402 x AKA-7	0.111	0.069	-3.356*	0.114	-0.656	-0.072	-11.154**	-0.208	-4.483**	2.698	0.212	0.058
PA-720 x GAM 162	1.667	2.014	0.722	-0.308	0.700	-0.153*	5.851	0.625	-0.394	7.454*	-0.739**	0.224
PA-528 x Dwd-	-0.889	-0.653	3.911	-0.664	1.011	0.078	3.913	-0.375	-0.494	-11.408**	0.374	0.621

arb-10-1												
PA-08 x JLA-802	-1.056	-1.764	1.539	0.475	-0.939	0.097	-4.326	-2.958	1.672	5.888	-0.580*	1.545**
PA-532 x AKA -7	2.611*	3.403*	0.194	-0.469	0.061	-0.025	21.596**	1.875	-6.717**	-6.646*	-0.017	-0.325
PA-255 x GAM -162	0.500	0.681	-0.394	-0.492	0.950	0.013	-9.456*	1.708	4.772**	-1.170	0.128	-1.158**
PA-402 x Dwd-arb-10-1	-2.056	-2.319	-1.339	0.486	-0.072	-0.085	-7.804	-0.625	0.272	1.928	0.468	-0.062
PA-528 x JLA 802	-1.222	-1.514	0.122	1.558	-0.256	-0.022	11.607**	2.208	4.389**	-1.935	0.860**	0.778*
PA-720 x AKA-7	-0.222	-1.014	2.378	-1.586	0.011	-0.047	0.996	0.375	-6.267**	5.294	-0.838**	-0.373
PA-528 x GAM-162	1.667	2.597	1.056	1.258	-0.167	0.064	3.935	1.542	-1.178	-5.674	-0.153	-0.766*
PA-08 x Dwd-arb-10-1	-0.222	-0.069	-3.556*	-1.231	0.411	0.005	-16.538**	-4.125	3.056	2.315	0.131	0.361
PA-532 x JLA 802	1.278	2.153	0.056	-1.942*	0.178	-0.019	7.674	3.375	-10.144**	4.711	-1.098**	-0.775*
PA-255 x AKA-7	-1.722	-2.014	0.378	0.981	0.444	0.043	-4.604	-2.125	7.200**	-0.320	0.285	0.175
PA-402 x GAM -162	-0.833	-1.736	0.544	1.092	0.133	0.054	-5.665	-1.958	2.022	-5.331	0.433	0.542
PA-720 x Dwd-arb-10-1	1.278	1.597	0.111	-0.131	-0.756	-0.078	2.596	0.708	0.922	0.941	0.380	0.058
PA-08 x AKA-7	1.694	3.403*	-2.428	-1.425	1.328	-0.152*	-6.126	-5.708*	6.239**	-3.040	0.602*	-0.680
PA-532 x GAM-162	0.028	0.236	0.294	-1.369	0.728	-0.031	2.263	3.125	0.183	-6.414*	0.145	-0.340
PA-255 x Dwd-arb-10-1	-1.417	-2.486	-0.828	-0.992	-0.783	0.034	-4.132	0.292	-9.394**	3.941	0.153	0.437
PA-402 x JLA-802	-0.306	-1.153	2.961	3.786**	-1.272	0.149*	7.996	2.292	2.972	5.503	-0.900**	0.583
S.E. ±	1.092	1.670	1.624	0.8471	0.9860	0.0589	4.0045	2.7735	1.5298	3.1393	0.2342	0.3591

CONCLUSION

The identification of cross combinations having high mean performance, high heterosis, and desirable SCA effects with stability over environments is of immense value in breeding programme. The female parents *viz.*, PA-720, PA-08 and PA-532 exhibited highest GCA for different traits and among male parents, AKA-7 was found the best general combiner for most of the traits. It indicates that these lines and tester, being good general combiner, can be used as donor parent for desirable genes for the respective traits. The crosses *viz.*, PA-528 × AKA-7, PA-528 × JLA-802 and PA-08 × AKA-7 showed significance of SCA effects for more number of traits so these can be used for future breeding programmes for exploiting the potential. The variance estimates due to GCA and SCA were highly significant for most of the characters. The magnitude of SCA variance was greater than GCA variance and more contribution of line × tester interaction to the total variability indicated the predominance of non-additive gene action, so for improvement of these traits heterosis breeding is considered the more rewarding option.

REFERENCES

Ali, I., Shakeel A., Ali, A., and Sadia, B. (2015). Genetic basis of variation for within-boll yield components in cotton. *Turk J. Agr.For.* **39**:

Ali, I., Shakeel, A., Saeed, A., Nazeer, W., Zia, Z. U., Ahmad, S., Mahmood, K. and Malik, W. (2016). Combining ability analysis and heterotic studies for within-boll yield components and fibre quality in cotton. *The Journal of Animal & Plant Sciences*, **26**(1): 156-162.

Azhar, F. M., Khan, A. A. and Saleem, N. (2007). Genetic mechanisms controlling salt tolerance in *Gossypium hirsutum* L. seedlings. *Pakistan J. Bot.*, **39**(1): 115-121.

DaiGang Yang, Ma Xiong Feng, Zhou Xiao Jian, Zhang Xian Liang, Bai Feng Hu, Wang Hai Feng, Meng Qing Qin, Pei Xiao Yu and Yu Shuxun (2012). Correlation among combining ability, heterosis and genetic distance in upland cotton. [Chinese] *Cotton Sci.*,**24**(3): 191-198.

Deshpande, L. A. and Baig, K. S. (2003). Combining ability analysis for yield, economic and morphological traits in American cotton (*Gossypium hirsutum* L.). *J. Res. ANGRAU.*,**31**(3): 28-34.

Dhamayanthi, K. P. M. (2011). Study of inter-specific hybrids (*Gossypium hirsutum* × *G. barbadense*) for heterosis and combining ability. World Cotton Research Conference-5., Mumbai, India, 51-55.

Eswari, K. B., Kumar, S., Gopinath and Rao, M. V. B. (2016). Heterosis and combining ability studies for improvement of seed cotton yield and fibre quality traits in inter and intra-specific hybrids for allotetraploid cottons. *International Journal of Current Research*, Vol. **8**(7): 34546-34553.

Imran, M., Shakeel, A., Azhar, F. M., Farooq, J., Saleem, M. F., Saeed, A., Nazeer, W., Riaz, M., Naeem, M. and Javaid, A. (2012). Combining ability analysis for within-boll yield components in upland cotton (*Gossypium hirsutum*L.). *Genet. Mol. Res.*, **11**(3): 2790-2800.

Jatoi, W. A., Baloch, M. J., Veesar, N. F. and Panhwar, S. A. (2011). Combining ability estimates from line × tester analysis for yield and yield components in upland cotton genotypes. *J. Agri. Res.*, **49**(2): 165-172.

Karademr, E. and Gencer, O. (2010). Combining ability and heterosis for yield and fiber quality properties in cotton (*G. hirsutum* L.) obtained by half-diallel mating design. *Notulae Botanicae, Horti Agro botanici*, Cluj-Napoca., **38**(1): 222-227.

Kempthorne, O. (1957). *An Introduction to Genetic Statistics*, New York, John Wiley and Sons, 1st Edn., pp. 456-471.

Kiani, G., G. A. Nematzadeh, S. K. Kazemitabar and O. Alishah (2007). Combining ability in cotton cultivars for agronomic traits.*Int. J. Agri. Bio.***9**: 521-522.

Laxman, S. and Ganesh, M. (2003). Combining ability for yield components and fibre characters in cotton (*G. hirsutum* L.). *J. Res. ANGRAU.*, **31**(4): 19-23.

Mendez-Natera, J. R., Rondon, A., Hernandez, J. and Merazo-Pinto, J. F. (2012). Genetic studies in upland cotton (*G. hirsutum* L.) II. General and specific combining ability. *J. Agri. Sci. and Tech.*,**14**(3): 617-627.

Nadagundi, J. M., Deshpande, S. K., Patil, B. R. and Mane, R. S. (2011). Combining ability and heterosis for yield and fibre quality traits in American cotton. *Crop Improv*., **38**(2): 179-185.

Neelima, S., Reddy, V. C. and Reddy, A. N. (2004). Combining ability studies for yield and yield components in American cotton (*Gossypium hirsutum* L.). *Annals of Agri Bio Res.*, **9**(1): 1-6.

Nimbalkar, R. D., Mehtre, S. S., Shinde, G. C. and Mokate, A. S. (2014). Genetic analysis of seed cotton yield and yield components in intra-specific diploid cotton. *J. Cotton Res. Dev.*, **28**(2): 223-226.

Panse, V. G. and Sukhatme, P. V. (1961). Statistical methods for agricultural workers. Indian Council of Agricultural Research. New Delhi. pp: 381.

Patel, N. N. and Chaudhari, P. (2015). Combining ability study for yield and its component traits through line × tester mating design in Asiatic (*Gossypium herbaceum* L.) cotton. *J. Cotton Res. Dev.*, **29**(1) 19-22.

Patel, U. G., J. Patel, P. Patel, K. Vadodaria and C. Sutaria (1997). Combining ability analysis for seed cotton yield and mean fibre length in upland cotton (*G. hirsutum* L.). *The Ind. J. Genet.Plant Breed.* **57**(3): 315-318.

Pole, S., S. Kamble, I. Madrap and D. Sarang (2008). Diallel analysis for combining ability for seed cotton yield and its components in upland cotton (*Gossypium hirsutum* L.). *J. Cotton Res. Develop.* **22**(1): 19-22.

Prasad Indivar, Naik, M. R. and Patel, H. N. (2016). Combining ability studies in desi cotton (*G. herbaceum* L.) in vertisols of Gujarat. *International Journal of Applied and Pure Science and Agriculture*, Vol. **02**(7): 91-95.

Preetha, S. and T. Raveendran (2008). Combining ability and heterosis for yield and fibre quality traits in line × tester crosses of upland cotton (*Gossypium hirsutum* L.). *Int. J. Plant Breed. Genet.* **2**(2).64-74.

Samreen, K., M. J. Baloch, Z. A. Soomro, M. B. Kumbhar, N. U. Khan, N. Kumboh, W. A. Jatoi and N. F. Veesar (2008). Estimating combining ability through line × tester analysis in upland cotton. *Sarhad J. Agr.*, **24**(4): 581-586.

Sprague, G. F. and Tatum, L. A. (1942). General and specific combining ability in single crosses in corn. *J. American Soc. Agron.*, **34:** 923-932.

Tang, F. and W. Xiao (2013). Genetic effects and heterosis of within-boll yield components in upland cotton (*Gossypium hirsutum* L.). *Euphytica* **194**(1): 41-51.

Verma, S. K., Ahuja, S. L., Tuteja, O. P. and Monga, D. (2004). Line × tester analysis of yield, its components and fibre quality traits in cotton. *J. Indian Soc. Cotton Improv.,* **29**(3): 151-157.

RESEARCH ARTICLE

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH DYNAMICS AND PRODUCTIVITY TREND OF WHEAT (*TRITICUM AESTIVUM* L.) UNDER IRRIGATED CROPPING SYSTEM

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Abstract: A field experiment was conducted during rabi season of 2011-13 at C.S. Azad University of Agriculture and Technology, Kanpur, in randomized block design with three replication to assess the effect various type of organic, inorganic and bio-fertilizers on growth attributes, yield and their relationship acquisition. The 10 treatments were tested in RBD design. T1-Control, T2 - RDF (150:60:40 NPK Kg/ha), T3 - 125% RDF, T4 - RDF + Vermicompost @2.5 t/ha, T5 - RDF + Vermicompost @ 5t/ha, T6 - RDF + FYM @ 5t/ha, T7 - RDF + FYM @ 10t/ha, T8 - RDF + Vermicompost @2.5 t/ha + Azotobacter, T9 - RDF + FYM @ 5t/ha + Azotobacter, and T10 - RDF + Vermicompost @ 2.5 t/ha + FYM @ 5 t/ha + Azotobacter. Different levels of vermicompost and NPK fertilizers showed significant effect on growth attributes and yield contributing characters of wheat. Results showed that application of chemical fertilizer with organic manuresgave the maximum yield. Combined application of organic manures and inorganic fertilizers increased the dry matter accumulation, leaf area index, no of tillers and yield by wheat compared to treatments T2, T3 where only chemical fertilizer applied through urea, dia ammonium phosphate and murate of potash. The highest grain and straw yield of wheat to the extent of 56.2 and 75 q/ha respectively was obtained where FYM, vermicompost, bio-fertilizer and recommended dose of NPK was applied in the rate of 100% RDF + Vermicompost @ 2.5 t/ha + FYM @ 5 t/ha + Azotobacter, respectively. The results of the experiment indicated that combined application of inorganic fertilizer along with FYM, vermicompost and bio-fertilizer gave significantly improvements in growth parameters and productivity trend of wheat.

Keywords: Management, Productivity, Cropping system, Wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop, which plays an important role in food and nutritional security. In India, total area under wheat is 31.0 mha, with production of 86.53 mt and the productivity of 2.8 t/ha (India stat, 2016). It is the staple food and meets nearly 61% of the protein requirement of India. So, assured supply of wheat is very important for future food security of the country. In 21st century, there will be a need of approximately more than 250 mt of food grains to meet the demand of rapidly growingpopulation.As no additional land is vacant for wheat area expansion, this increase in wheat production has to come through amplified yield per unit of production area.Increasing grain yield of wheat is an important national goal to face the continuous increasing food demands of India.

Adoption of intensive cropping system will meet the food demands of growing population, requires high input energy, which are not only responsible for environment pollution but also amplified the production cost . The manufacture of synthetic fertilizer is highly cost effective and depends on non renewable fossil fuel that is in acute shortage. To compensate the supply and recent price hike in inorganic fertilizers, use of indigenous sources like FYM, vermicompost and bio-fertilizers should be encouraged as it supplies plant nutrient, improve the soil bio-diversity and thereby increase the fertility and productivity of the soil. It has been recognized that the soil contain free living bacteria which are capable of fixing nitrogen non-symbiotically. The positive effect of Azotobacter on plant is associated not only with the process of nitrogen fixation and improved nutrition of plants but also with synthesis of complex biologically active compounds such as nicotinic acid, pantothenic acid, pyridoxine, biotin,gibberellins and other compounds which stimulate the germination of seeds and accelerate the plant growth under favorable environmental conditions (Kiani *et al*., 2005).Soil also contain some specific group of soil micro-organisms which increase the availability of phosphate to plants, not only by mineralizing organic phosphorus compounds but also by rendering inorganic phosphorus compounds more available to plant (Soleimanzadeh *et al.*,2013).

Indiscrimate use of fertilizers adversely affects the physicochemical properties of the soil resulting in poor rice-wheat production. The declining response to inputs has been received to be the major issue challenging the sustainability of wheat based cropping system (Desai *et al*., 2015). Long term sustainable agricultural productivity might be achieved through a wise use of integrated nutrient management. It improved plant growth, water, and soil biodiversity. The use of organic soil amendments has been associated with desirable soil properties

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including higher plant available water holding capacity, nutrient availability and cation exchange capacity and lower bulk density, and can foster beneficial soil microorganisms. Organic fertilization was found to be advantageous for improving growth and yield of wheat. Application of Farm yard Manure and vermicomposthelps to increase the dry matter production, leaf area, yield and nutrient uptake by wheat (Singh and Tomer 1991). Also, the application of organic fertilizer increased nitrogen use efficiency (Sarma *et al*., 2007). The combination of mineral fertilizers, with organic manures, helped in increasing the productivity of wheat compared to a system with only mineral fertilization (Pandey *et al*., 2009).

Combined use of organic and inorganic sources of nitrogen increases the production and profitability of field crops and helps in maintaining the fertility status of the soil. Organic manure and bio-fertilizers are needed along with inorganic fertilizers for better yield and good soil health. It is evident that bio-fertilizers like Azotobacter in combination have great prospect for increasing productivity of wheat (Kumar and Ahlawat, 2004). Integration of inorganic fertilizers with organic manures and bio-fertilizers will not only help sustain the crop productivity but also will be effective in improving soil health and hastening the nutrient-use efficiency (Verma *et al*., 2005). The present studies were conducted with the aim to investigate benefits of integrated nutrient management in wheat under irrigated cropping systems.

MATERIAL AND METHOD

A field experiment was conducted at Students Instructional Farm (SIF) in C. S. Azad University of Agriculture and technology, Kanpur (UP) during the winter (*rabi*) seasons of 2011–12 and 2012–13. The experimental farm falls under the indo-gangetic alluvial tract and irrigated by tube well. The soil of the experimental site was sandy loam (coarse sand 0.72 %, fine sand 54.5 %, silt 22.1 % and clay 22.68 %) with pH 7.3 and electrical conductivity (EC) 0.26 dS/m in the top 15 cm of soil. The soil was low in available nitrogen (173 kg/ha) and organic carbon (0.46%) and medium in phosphorus (16.8 kg/ha) and potassium (164 kg/ha). The experiment was laid out in randomized block design, comprising ten treatment combinations. i.e. T1-Control, T2 – RDF (150:60:40 NPK Kg/ha), T3 - 125% RDF, T4 - RDF + Vermicompost @2.5 t/ha, T5 - RDF + Vermicompost@ 5t/ha, T6 - RDF + FYM @ 5t/ha, T7 - RDF + FYM @ 10t/ha, T8 - RDF + Vermicompost @2.5 t/ha + Azotobacter, T9 - RDF + FYM @ 5t/ha + Azotobacter andT10 - RDF + Vermicompost @ 2.5 t/ha + FYM @ 5 t/ ha + Azotobacter were replicated thrice. The source of nitrogen, phosphorus and potash was organic, inorganic and bi-fertilizer fertilizers respectively, Well-rotten FYM and vermicompost as per treatment was incorporated before sowing. Recommended dose of phosphorus as DAP and potassium as muriate of potash were applied at the time of sowing and one-third nitrogen was applied as basaland remaining in 2 equal splits-as urea at first irrigation and at boot stage as per treatments. The irrigations were given and other recommended packages of practices were adopted during the crop-growth periods in both the years. The wheat variety PBW- 343 was sown on 4th and 1st of December 2011 and 2012 respectively. The seed was treated with the Azotobacter as per treatments with rows spaced 20 cm.

RESULT AND DISCUSSION

Different yield parameters were appreciably affected with the different treatment of INM. Plant height pertaining to different treatments recorded at 30.60 90 days and at harvest has been presented in table 1.Plant height varied significantly due to INM. Among the treatments, T10(RDF + Vermicompost @ 2.5 t/ha + FYM @ 5 t/ha + Azotobacter) had maximum plant height at all the growth stages from 30 DAS till harvest, which was significantly higher than T1, T2, T3and T4(Table 1). But it wasat par with T5,T8 and T9 at all the growth stages. This difference in plant height may be due to various fertility levels given to different treatments. But, plant height at all the stages was not affected significantly by isolated application of fertilizers, however, plant height was more when organic and inorganic fertilizers were used in integration with each other. The variation in plant height due to nutrient sources was considered to be the variation in the availability of major nutrients. Synthetic fertilizer offers nutrients which are readily soluble in soil solution and thereby instantaneously available to crop. Nutrients availability from organic sources is due to microbial action and improved physical condition of soil. These results were supported by Devi*et al*. (2011), Desai *et al*., (2015).

INM had significantly influenced the dry matter accumulation at different growing days besides at 30 DAS. Among the treatments, T10 had maximum dry matter accumulation at 60 DAS till harvest, which was significantly higher than T1, T2, T3and T4(Table 2). But the different was not marked among T5,T7 and T10, whereas, T9 was at par with the T4, T5, T6,T7 and T8. This difference in dry matter accumulation may be due to beneficial effects of combined application of organic manures, inorganic fertilizers along with bio-fertilizers. This is might be due to the fact that addition of FYM, vermicompost, chemical fertilizer and inoculation of azotobacter in conjunction with all necessary macro and micro nutrients and their uptake by the wheat crop and as a resulted effect of higher dry matter accumulation and their translocation in plant parts favoured which growth and ultimately value of all yield parameters enhanced. These findings are in line with those reported by Singh, *et al.*, (2015), Pandey, *et. al*., (2009).

Leaf area index was significantly influenced by integrated application of nutrients with different sources and it was maximum with T10 and T5 treatments which was significantly higher than T1, T2, T3and T4(Table 2) at 60 DAS till maturity. However the difference was not significantly influenced at 30 DAS by this combination of fertilizers treatments tillit marginally more LAI was found under integrated use of organic source with chemical fertilizers.This is might be due to combined effect of organic manure(FYM), bio-fertilizers and chemical fertilizers in balanced proportion played a very vital role in decomposition and easy release of different nutrients and their uptake by the crop which led to higher dry matter accumulation and its translocation in different plant parts of growth and yield parameters, which in turn resulted into higher yield. These results are in complete agreement with those of Kumar, *et al*., (2004), Ram and Mir (2006).

Tillering is an important trait for grain production and is thereby an important aspect of rice growth improvement. Effective tillering depends primarily on soil physical conditions that were superior due to addition of organic manure (Sarma*et al.,* 2007; Gupta *et al.,* 2006). Significant variation was observed on the tillers of wheat when the field was incorporated with different doses of FYM and vermicompost, (Table 3).The number of tillers per meter square varied significantly among integrated fertilizer management, and T10 and T5 produced maximum number of tillers at 30, 60 and 90 DAS, which was significantly higher than T1, T2, T3 and T4 (Table 3). However the difference was not significantly influenced at 30 DAS by this combination of fertilizers treatments till it marginally more LAI was found under integrated use of organic source with chemical fertilizers.The increase in tillers in INM might be due adequate quantity and balanced proportion of plant nutrient supplied to the crop as per need during the growing period resulting in favorableenvironment for crop growth. Similar results also observed by Nawab*et al*., (2001), Upashyay and Vishwakarma (2014) and Suthar (2006).

Application of RDF+Vermicompost @ 2.5 t/ha + FYM @ 5 t/ha + Azotobacter produced significantly higher grain and straw yields than the rest treatments (Table 2) and application of RDF + Vermicompost @ 2.5 t/ha + Azotobacter and RDF + FYM @ 5t/ha + Azotobacter being statistically on par with RDF +Vermicompost @ 5t/ha (T5) and RDF + FYM @ 10t/ha (T3) respectively, over the control and recommended fertilizers alone. Similar grain and straw yield was found under the treatment T7 and T5. The increase in grain and straw yields might be due to adequate quantities and balanced proportions of plant nutrients supplied to the crop as per need during the growth period resulting in favourable increase in yield attributing characters which ultimately led towards an increase in economic yield. Improved physic chemical properties of the soil through the application of organic manure might be the other possible reason for higher productivity. This result alsoconfirm by Sarma*et al*., (2007) and Devi *et al*., (2011).Sushila (1998) also reported that increase in yield of wheat and soil micro- bial population in rhizosphere of wheat with Azotobacter inoculations.

Table 1. Effect of integrated use of organic and chemical fertilizers on plant height of wheat (data over two seasons)

Treatments	**plant height (cm)**			
	30 DAS	**60 DAS**	**90 DAS**	**at harvest**
Control	15.37^{F}	33.20^{F}	60.37^{F}	75.63^{G}
RDF(N,P,K 150:60:40 kg/ha)	15.87^{EF}	35.20^{EF}	64.13^{EF}	80.07^{F}
125 % RDF	16.50^{DEF}	36.73^{DEF}	66.77^{E}	83.45^{E}
RDF + Vermicompost (VC) @ 2.5 t/ha	17.63^{BCDE}	39.07^{CD}	71.03^{D}	88.83^{D}
RDF + VC @ 5 t/ha	19.50^{AB}	43.40^{AB}	78.83^{B}	98.53^{B}
RDF + FYM @ 5 t/ha	17.50^{CDE}	38.87^{CDE}	70.71^{D}	88.38^{D}
RDF + FYM @ 10 t/ha	19.13^{BC}	42.47^{BC}	77.37^{BC}	96.60^{B}
RDF + VC@ 2.5t/ha + Azotobacter	18.37^{BCD}	41.03^{BC}	74.50^{CD}	93.37^{C}
RDF+ FYM @ 5 t/ha +Azotobacter	18.10^{BCD}	40.30^{BCD}	73.20^{D}	91.53^{C}
RDF + VC @ 2.5 t/ha + FYM @ 5 t/ha + Azotobacter	21.23^{A}	47.00^{A}	85.50^{A}	106.60^{A}

Table 2. Effect of integrated use of organic and chemical fertilizers on dry matter accumulation and LAI of wheat (data over two seasons)

	dry matter (g/m2)				**Leaf area Index**		
	30 DAS	**60 DAS**	**90 DAS**	**at harvest**	**30 DAS**	**60 DAS**	**90 DAS**
Control	26.90^{A}	126.27^{E}	483.00^{F}	746.67^{F}	0.27	1.77^{E}	3.38^{F}
RDF(N,P,K 150:60:40 kg/ha)	28.50^{A}	134.00^{DE}	513.00^{EF}	1033.33^{E}	0.29	1.88^{DE}	3.59^{EF}
125 % RDF	29.87^{A}	139.67^{CDE}	538.33^{DE}	1085.33^{E}	0.30	1.96^{CDE}	3.77^{DE}
RDF + Vermicompost (VC) @ 2.5 t/ha	31.38^{A}	148.43^{BCD}	568.67^{CD}	1162.00^{CD}	0.31	2.08^{BCD}	3.98^{CD}
RDF + VC @ 5 t/ha	35.13^{A}	164.63^{AB}	630.67^{B}	1285.00^{A}	0.35	2.30^{AB}	4.41^{B}
RDF + FYM @ 5 t/ha	31.53^{A}	150.67^{BCD}	566.33^{CD}	1157.67^{D}	0.32	2.11^{BCD}	3.96^{CD}
RDF + FYM @ 10 t/ha	34.40^{A}	161.50^{AB}	618.47^{B}	1260.33^{AB}	0.34	2.26^{AB}	4.33^{B}
RDF + VC@ 2.5t/ha + Azotobacter	33.21^{A}	155.67^{BC}	596.67^{BC}	1221.67^{BC}	0.33	2.18^{BC}	4.18^{BC}
RDF+ FYM @ 5 t/ha +Azotobacter	32.60^{A}	153.00^{BC}	586.00^{BC}	1192.00^{CD}	0.33	2.14^{BC}	4.10^{BC}
RDF + VC @ 2.5 t/ha + FYM @ 5 t/ha + Azotobacter	36.00^{A}	173.33^{A}	683.33^{A}	1311.67^{A}	0.36	2.43^{A}	4.78^{A}

Table 3. Effect of integrated use of organic and chemical fertilizers on number of tillers and yield of wheat (data over two seasons)

Treatments	**Number of tillers / m2**				**Yield (q/ha)**	
	30 DAS	**60 DAS**	**90 DAS**	**harvest**	**Grain**	**Stover**
Control	187.83^{E}	328.67^{G}	311.00^{G}	2.87^{F}	29.06^{F}	40.70^{G}
RDF(N,P,K 150:60:40 kg/ha)	194.67^{DE}	347.67^{FG}	330.67^{FG}	3.04^{EF}	41.14^{E}	57.18^{F}
125 % RDF	203.67^{CDE}	363.67^{EF}	343.67^{EF}	31.73^{E}	43.70^{E}	59.83^{F}
RDF + Vermicompost (VC) @ 2.5 t/ha	216.00^{BCD}	384.33^{DE}	365.67^{DE}	33.70^{D}	46.73^{D}	64.49^{E}
RDF + VC @ 5 t/ha	238.33^{A}	428.00^{AB}	406.33^{AB}	37.5 0^{B}	51.86^{B}	71.57^{B}
RDF + FYM @ 5 t/ha	214.67^{BCD}	385.67^{DE}	364.00^{DE}	33.73^{D}	46.52^{D}	64.20^{E}
RDF + FYM @ 10 t/ha	222.33^{ABC}	419.67^{ABC}	398.67^{BC}	36.67^{BC}	50.85^{BC}	70.17^{BC}
RDF + VC@ 2.5t/ha + Azotobacter	225.33^{ABC}	405.67^{BCD}	384.33^{BCD}	354.33^{CD}	49.02^{CD}	67.68^{CD}
RDF+ FYM @ 5 t/ha +Azotobacter	222.67^{ABC}	396.67^{CD}	377.67^{CD}	348.33^{CD}	48.17^{D}	66.48^{DE}
RDF + VC @ 2.5 t/ha + FYM @ 5 t/ha + Azotobacter	223.33^{ABC}	446.67^{A}	429.00^{A}	395.00^{A}	56.23^{A}	75.29^{A}

CONCLUSION

Based on the findings of the present investigation, it can be inferred that the application of FYN, vermicompost, bio-fertilizers along with chemical fertilizers proved in significantly enhancing the growth attributes and yield. All the treatments showed significant influence on growth and productivity of wheat. Form the present study it was observed that RDF + Vermicompost @ 2.5 t/ha + FYM @ 5 t/ha + Azotobacter fertilizers gave the best result. Our results indicated that, organic fertilizer can be a better supplement of inorganic fertilizer to produce better growth and yield of wheat.

REFERENCES

Desai, H.A., Dodia, I.N., Desai, C.K., Patel, M.D. and. Patel H. K. (2015). Integrated nutrient management in wheat (Triticumaestivum L.). Trends in Biosciences 8(2), 472-475.

Devi, K.N., Singh, M.S., Singh, N.G. and Athokpam, H.S. (2011). Effect of integrated nutrient management on growth and yield of wheat (Triticumaestivum L.).Journal of Crop and Weed. 7 (2) : 23-27.

Gupta, V., Sharma, R.S. and Vishwakarma, S.H. (2006). Long-term effect of integrated nutrient management on sustainability and soil fertility of rice (*Oryza sativa*)– wheat (*Triticumaestivum*) cropping system. *Indian Journal of Agronomy* 51(3) : 160–164.

Kiani, M.J., Abbasi, M.K. and Rahim, N. (2005). Use of organic manure with mineral N fertilizer increases wheat yield at Rawalakot Azad Jammu and Kashmir" Archives of Agronomy and Soil Science 51(3):299-309.

Kumar, V. and Ahlawat, I.P.S. (2004). Carry-over effect of bio-fertilizers and nitrogen applied to wheat (*Triticumaestivum*) and direct applied N in maize (*Zea mays*) in wheat maize cropping systems. *Indian Journalof Agronomy.*49 (4) : 233–236.

Nawab, K., Arif, A.M., Shah P., Rab A., Khan, M.M. A., Khan A. and Khan K. (2011). Effect of fym, potassium and zinc on phenology and grain yield of wheat in rainfed cropping systems. Pak. J. Bot., 43(5): 2391-2396.

Pandey, I. B., Dwivedi, D. K. and Pandey, R. K. (2009). Integrated nutrient management for sustaining wheat (*Triticumaestivum*) production under late sown condition.*Indian Journal of Agronomy* 54(3): 306 – 309.

Ram, T. and Mir, M.S. (2006). Effect of integrated nutrient managemet on yield and yield-attributing characters of wheat (*Triticumaestivum*).*Indian Journal of Agronomy.*51(3) : 189–192.

Sarma, A., Singh H. and Nanwal, R.K. (2007). Effect of integrated nutrient management on productivity of wheat (*Triticumaestivum*) under limited and adequate irrigation supplies.*Indian Journal of Agronomy* 52(2) : 120-123.

SES (2016). Socio-Economic Statistical Information About India. www.indiastat.com

Singh, G.D., Vyas, A.K. and Dhar, S. (2015). Productivity and profitability of wheat (*Triticumaestivum*)-based cropping systems under different nutrient-management practices. *Indian Journal of Agronomy.*60 (1) : 52- 56.

Singh,V. and Tomer, J.S. (1991). Effect of K and FYM levels on yield and uptake of nutrients by wheat" *Journal of Potassium research* 7 (4): 309-313.

Soleimanzadeh, H. and Gooshchi, F. (2013). Effects of *Azotobacter*and Nitrogen Chemical Fertilizer on Yield and Yield Components of Wheat (*Triticumaestivum*L.).*World Applied Sciences Journal.*21 **(**8) : 1176-1180.

Sushila, R. (1998). Integrated nitrogen management in wheat under limited water supply. Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi.

Suthar, S. (2006). Effect of vermicompost and inorganic fertilizer on wheat (*Triticumaestivum*) production, *Nature, Env.and Poll. Technol.* 5 : 197-01.

Upashyay, V.B. and Vishwakarma, S.K. (2014). Long-term effect of integrated nutrient management in rice (*Oryza sativa*)–wheat (*Triticumaestivum*) cropping.

RESEARCH ARTICLE

INFLUENCES OF SPACING AND WEED MANAGEMENT PRACTICES ON YIELD AND ECONOMICS OF WET DIRECT SEEDED RICE (*ORYZA SATIVA* L.)

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Abstract: A field experiment was conducted during *kharif* season of 2014-15 at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment was laid out in randomized block design comprises of eleven treatments with three replications. Among the spacing 20×10 cm and 20×20 cm, the effective tillers m^{-2}, total grains panicle^{-1}, filled grains panicle^{-1} were significantly higher at 20×20 cm with respective level of weed management. However, hand weeding twice and herbicidal weed management was at par with both spacing. Among the spacing 20×10 cm and 20×20 cm, At spacing 20×20 cm, bidirectional mechanical weeding thrice (T_{10}) produced the maximum grain (49.12 q ha^{-1}) and straw yield which was at par with bidirectional mechanical weeding twice. Among the spacing 20×10 cm and 20×20 cm, the grain and straw yield was at par with respective level of weed management. Among different spacing and weed management practices the higher gross return (₹ 69,759 ha^{-1}) obtained under bidirectional mechanical weeding thrice. However, the maximum net return (₹ 38,565 ha^{-1}) and benefit cost ratio (2.61) were obtained at spacing 20×20 cm with herbicidal weed management (Pyrazosulfuran as pre-emergence followed by Bispyribac-Na as post emergence).

Keywords: Management, Rice, Seed, Weed, *Kharif* season

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the world's most important stable food crops. Currently, more than one third of the human population relies on rice for their daily sustenance. Rice is the vital food for more than two billion people in Asia and four hundred million people in Africa and Latin America (IRRI, 2006). In world, rice has occupied an area of 156.1 m ha, with a production of 680 m t. In India, total area under rice was 45.5 m ha, with production of 106.65 m t and average productivity of 2419 kg ha^{-1}during 2013-14 (Anonymous, 2014). Chhattisgarh state is popularly known as “Rice Bowl of India” because of maximum area covered under rice during *kharif* and contributes major share in national rice production. Rice was cultivated over an area of 3.7 m ha with the production of 7.44 m t and productivity of 2020 kg ha^{-1} during 2013-14 (Anonymous, 2015). The labour requirement for transplanting is very high and also for a short period of the time. Further, the availability of labour is decreasing day by day due to various reasons. Therefore, an alternate technology to substitute transplanting method is needed to gear up rice production in irrigated ecology. One of the alternate technology may be wet direct seeded method. Therefore, the study was conducted to evaluate effect of wet direct seeded rice on yield attributes, yield and economics of rice.

MATERIAL AND METHOD

The present investigation was conducted during *kharif* season of 2014-15 at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The soil of experimental field was *vertisol* in texture, low in nitrogen (223.30 kg ha^{-1}), medium in phosphorus (17.40 kg ha^{-1}) and medium in potassium (272.80 kg ha^{-1}) contents with neutral soil pH and 0.51 per cent organic carbon. The experiment was laid out in randomized block design comprises of eleven treatments with three replications. The treatments comprised spacing and weed management practices *viz*, T_1 – Direct Seeded 20×10 cm + hand weeding twice at 20 and 40 DAS, T_2 - Direct Seeded 20×10 cm + herbicidal weed management (Pre. eme. Pyrazosulfuron f.b. Bispyribac-Na), T_3 - Direct Seeded 20×10 cm + mechanical weeding unidirectional twice at 20 and 40 DAS, T_4 - Direct Seeded 20×10 cm + mechanical weeding unidirectional thrice at 20, 30 and 40 DAS, T_5 - Direct Seeded 20×20 cm + hand weeding twice at 20 and 40 DAS, T_6 - Direct Seeded 20×20 cm + herbicidal weed management (Pre. eme. Pyrazosulfuron followed by Bispyribac-Na), T_7 - Direct Seeded 20×20 cm + mechanical weeding unidirectional twice at 20 and 40 DAS, T_8 - Direct Seeded 20×20 cm + mechanical weeding unidirectional thrice at 20, 30 and 40 DAS, T_9 - Direct Seeded 20×20 cm + mechanical weeding bidirectional twice at 20 and 40 DAS, T_{10} - Direct Seeded 20X20 cm + mechanical weeding bidirectional thrice at 20, 30 and 40 DAS, T_{11} –

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Transplanting 20X10 cm + herbicidal weed management (Pre. eme. Pyrazosulfuron followed by Bispyribac-Na). The test variety was maheshwari. Sowing of sprouted seeds was done in puddle soil. Sowing was done on June 29, 2014 and harvesting was done on November 10, 2014. Recommended dose of nutrients (100 kg N : 60 kg P_2O_5 : 40 kg K_2O ha^{-1}) was applied through urea, single super phosphate and murate of potash, respectively. The whole quantity of P and K was applied as basal dressing, while nitrogen was applied in three equal splits at basal, active tillering and panicle initiation stages. 3±2 cm level of water was managed after established of crop till growth stage. Among the treatments when herbicidal weed management was adopted, applied of pre emergence of pyrazosulfuron at 3 days after sowing followed by bispyribac-Na at 25 days after sowing was done. All the growth characters *viz*. number of effective tillers m^{-2}, panicle length, test weight, grain yield, straw yield and harvest index of wet direct seeded rice were recorded. The total weed density and total dry matter production weeds were also recorded and subjected to square root $\sqrt{x+0.5}$ transformation and statistically analyzed.

RESULT AND DISCUSSION

Effect on yield attributes

The result observed that the yield attributes of wet direct seeded rice was significantly influenced by spacing and weed management practices are presented in Table (1). At spacing 20×10 cm, mechanical weeding thrice (T_4) observed the highest number of effective tillers m^{-2}, total grains panicle^{-1} and filled grains panicle^{-1} which was at par with mechanical weeding twice (T_3), transplanting with herbicidal weed management (T_{11}) and hand weeding twice (T_1). At spacing 20×20 cm, bidirectional mechanical weeding thrice (T_{10}) observed the highest number of effective tillers m^{-2}, total grains panicle^{-1} and filled grains panicle^{-1} which was at par with most of the treatments. Among the spacing 20×10 cm and 20×20 cm, the effect of weed management practices on number of effective tillers m^{-2}, total grains panicle^{-1} and filled grains panicle^{-1} was significantly higher at spacing 20×20 cm than 20×10 cm with the respective level of weed management, except hand weeding twice and herbicidal weed management.

Higher number of effective tillers under bidirectional mechanical weeding thrice (T_{10}) due to more space to the crop to show their potential due to lower weed competition and mechanical weeding allow to increase aeration in soil and enhances the root growth for better growth and number of effective tillers. Similar results were reported by Shad 1986 and Gogoi *at el* 2000.

The data in respective of panicle length and test weight revealed that spacing and weed management practices unaffected on panicle length and test weight of wet direct seeded rice. The mean value showing the influence of weed management practices on the unfilled grains panicle^{-1} and sterility percentage are presented in Table (1). At spacing 20×10 cm, the significantly lowest unfilled grains panicle^{-1} and sterility per cent was recorded under mechanical weeding thrice (T_4) which was at par with mechanical weeding twice (T_3) and hand weeding twice (T_1). At spacing 20×20 cm, the lowest unfilled grains panicle^{-1} and sterility per cent was found under bidirectional mechanical weeding thrice (T_{10}) which was at par with bidirectional mechanical weeding twice (T_9) and unidirectional mechanical weeding twice (T_7). Among the spacing 20×10 cm and 20×20 cm, the effect of weed management practices on unfilled grains panicle^{-1} and sterility per cent was at with the respective level of weed management.

Effect on Yield

The result reveals that the grain yield of rice was significantly influenced by spacing and weed management practices are presented in Table (2). At spacing 20×10 cm, mechanical weeding thrice (T_4) produced the highest grain yield (44.25 q ha^{-1}) which was at par with mechanical weeding twice (T_3), hand weeding twice (T_1) and transplanting with herbicidal weed management (T_{11}). At spacing 20X20 cm, bidirectional mechanical weeding thrice (T_{10}) produced significantly the highest grain yield (49.12 q ha^{-1}) which was at par with bidirectional mechanical weeding twice (T_9). Among the spacing 20×10 cm and 20×20 cm, the effect of weed management practices on grain yield was at par with the respective level of weed management.

Grain production, which is the final product of growth and development, is controlled by the growth and yield attributing characters such as effective tillers, dry matter accumulation, test weight, etc. Growth and all yield attributing characters were more in bidirectional mechanical weeding thrice (T_{10}) because of lesser weed competition and better aeration which enhances better uptake of nutrients through enhanced root growth. The beneficial effect of mechanical weeding in rice production by System of rice intensification is attributed by different workers (Vijayakumar *et al.* 2004 and Rajendran *et al.* 2007).

The straw yield of rice was significantly affected by spacing and weed management practices. At spacing 20×10 cm, mechanical weeding thrice (T_4) significantly produced the highest straw yield (53.74 q ha^{-1}) which was at par with mechanical weeding twice (T_3), hand weeding twice (T_1) and transplanting with herbicidal weed management (T_{11}). At spacing 20×20 cm, bidirectional mechanical weeding thrice (T_{10}) produced the highest straw yield (59.21 q ha^{-1}) which was at par with the bidirectional mechanical weeding twice (T_9) and unidirectional mechanical weeding (T_8). Among the spacing 20×10 cm and 20×20 cm, the effect of weed management practices on straw yield significantly higher at spacing 20×20 cm compared to spacing 20×10cm, except hand weeding twice with respective level of weed management. Maximum straw yield was obtained in bidirectional mechanical weeding thrice (T_{10}) because of mechanical weeding by Ambika paddy weeder not only helped in reducing weed competition, but also improving root growth by increasing soil aeration and root pruning therefore increased tiller density and straw yield. Similar results were found by different workers (Shad 1986 and Thiyagarajan *at el*. 2002).

The data on harvest index for different treatments have been presented in table (2). Its value ranged between 45.69 and 44.07. The harvest index of rice was statistically unaffected due to different treatments. However, numerically, the maximum harvest index (45.69 per cent) was found under the transplanting with herbicidal weed management (T_{11}).

Effect on Economics

The data on cost of cultivation, gross return, net return and B:C ratio from rice as affected by different spacing and weed management practices are presented in Table (2). The highest gross return (₹ 69,759 ha^{-1}) was obtained under bidirectional mechanical weeding thrice (T_{10}) followed by bidirectional mechanical weeding twice (T_9). However, the highest net return (₹ 37,381 ha^{-1}) was recorded under herbicidal weed management (T_6) followed by bidirectional mechanical weeding twice (T_9). The highest B:C ratio (2.61) was recorded under herbicidal weed management (T_6) and minimum was noted under bidirectional mechanical weeding thrice (T_{10}). The reason for higher net return in herbicidal weed management was due to lesser cost of cultivation compared to other methods of weed management. Similar result was reported by different workers Mahajan *et al.* 2009.

Use of mechanical weeding was an efficient method for weed control in wet direct seeded rice. Mechanical weeding can be adopted where labour scarcity occurs. Nonetheless, the use of crop residues was an environmentally benign approach.

CONCLUSION

Based on the findings of the experiment, the following conclusion could be drawn at spacing 20×20 cm, bidirectional mechanical weeding thrice (T_{10}) observed the highest number of effective tillers m^{-2}, total grains panicle^{-1} and filled grains panicle^{-1} which was at par with most of the treatments. Among the spacing 20×10 cm and 20×20 cm, the effect of weed management practices on number of effective tillers m^{-2}, total grains panicle^{-1} and filled grains panicle^{-1} was significantly higher at spacing 20×20 cm than 20×10 cm with the respective level of weed management, except hand weeding twice and herbicidal weed management. While Among the spacing 20×10 cm and 20×20 cm, the effect of weed management practices on unfilled grains panicle^{-1} and sterility per cent was at with the respective level of weed management.

However, sowing of wet direct seeded rice at spacing 20×20 cm with bidirectional mechanical weeding thrice at 20, 30 and 40 DAS produced the maximum grain yield (49.12 q ha^{-1}) which was par with that of bidirectional mechanical weeding twice at 20 DAS and 40 DAS with the same spacing.

Maximum net return (37,381 ha^{-1}) with B:C ratio (2.61) was recorded with sowing of wet direct seeded rice at spacing 20×20 cm with herbicidal weed management *i.e.* Pyrazosulfuran as pre-emergence f.b. Bispyribac-Na as post emergence. The lower net return and B:C ratio in these treatments were due to higher cost of mechanical weeding.

Table 1. Influences of spacing and weed management practices on yield attributing characters of wet direct seeded rice

	Treatment	Effective tillers (No. m^{-2})	Panicle length (cm)	Test weight (g)	Total grains panicle^{-1}	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Sterility per cent
T_1	DS 20X10 cm HW at 20 & 40 DAS	311.67	25.88	35.77	141.77	134.70	7.07	5.13
T_2	DS 20X10 cm HWM	305.00	25.93	35.14	139.87	130.93	8.93	6.72
T_3	DS 20X10 cm MWM at 20 & 40 DAS	314.67	25.99	33.96	146.60	139.33	7.27	4.97
T_4	DS 20X10 cm MWM at 20, 30 & 40 DAS	316.67	25.52	34.11	148.93	141.93	7.00	4.70
T_5	DS 20X20 cm HW at 20 & 40 DAS	317.00	26.75	35.57	147.97	140.30	7.67	5.18

T_6	DS 20X20 cm HWM	311.33	26.18	34.67	140.74	131.60	9.14	6.41
T_7	DS 20X20 cm MWM at 20 & 40 DAS uni.	326.00	26.64	35.18	147.77	140.90	6.87	4.64
T_8	DS 20X20 cm MWM at 20, 30 & 40 DAS uni.	328.33	26.65	35.29	150.30	142.97	7.33	4.89
T_9	DS 20X20 cm MWM at 20 & 40 DAS bi.	336.00	25.91	33.56	150.60	144.13	6.47	4.30
T_{10}	DS 20X20 cm MWM at 20, 30 & 40 DAS bi.	341.00	26.74	35.57	154.07	147.87	6.20	3.81
T_{11}	TP 20X10 cm HWM	315.00	26.69	34.29	141.33	132.63	8.70	6.46
SEm ±		**3.11**	**0.38**	**0.57**	**3.05**	**3.07**	**0.29**	**0.22**
CD (P=0.05)		**9.16**	**NS**	**NS**	**9.01**	**9.06**	**0.85**	**0.65**

DS=Direct seeded: HW= Hand weeding: MWM= Mechanical weed management: HWM= Herbicidal weed management: DAS= Days after sowing: TP= Transplanting: uni= Unidirectional: bi= Bidirectional.
***Significant at 5% level of significance**

Table 2. Influences of spacing and weed management practices on grain yield, straw yield, harvest index and economics of wet direct seeded rice

Treatment		Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	Cost of cultivation (₹ha^{-1})	Gross return (₹ha^{-1})	Net return (₹ha^{-1})	B:C ratio
T_1	DS 20X10 cm HW at 20 & 40 DAS	43.12	51.64	45.50	29699	61221	31522	2.06
T_2	DS 20X10 cm HWM	41.32	49.72	45.39	23547	58686	35139	2.49
T_3	DS 20X10 cm MWM at 20 & 40 DAS	43.18	52.04	45.37	26059	61331	35272	2.35
T_4	DS 20X10 cm MWM at 20, 30 & 40 DAS	44.25	53.74	45.17	28789	62867	34078	2.18
T_5	DS 20X20 cm HW at 20 & 40 DAS	43.40	53.34	44.86	29311	61695	32384	2.10
T_6	DS 20X20 cm HWM	42.64	50.90	45.59	23159	60540	37381	2.61
T_7	DS 20X20 cm MWM at 20 & 40 DAS uni.	43.58	54.13	44.62	25671	61980	36309	2.41
T_8	DS 20X20 cm MWM at 20, 30 & 40 DAS uni.	44.86	56.93	44.07	28401	63861	35460	2.25
T_9	DS 20X20 cm MWM at 20 & 40 DAS bi.	48.02	58.29	45.18	31131	68217	37086	2.19
T_{10}	DS 20X20 cm MWM at 20, 30 & 40 DAS bi.	49.12	59.21	45.34	36591	69759	33168	1.91
T_{11}	TP 20X10 cm HWM	43.43	51.63	45.69	30094	61651	31557	2.05
SEm ±		**0.78**	**1.31**	**0.32**				
CD (P=0.05)		**2.31**	**3.86**	**NS**				

DS=Direct seeded: HW= Hand weeding: MWM= Mechanical weed management: HWM= Herbicidal weed management: DAS= Days after sowing: TP= Transplanting: uni= Unidirectional: bi= Bidirectional.
***Significant at 5% level of significance**

REFERENCES

Anonymous (2015). Krishi Darshika, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) pp. 4.

Anonymous (2014). Ministry of Agriculture, Government of India. www. Indiastat .co.in/ agriculture/agriculture production/grains/rice.

IRRI (International Rice Research Institute) (2006). World Rice Statistics. http;//www.irri.org/science/wrs.

Rajendran, R., Ravi, V. and Balsubramaniyam, V. (2007). Individual and combined effect of management components of SRI on the productivity of irrigated rice. In: *proc.* SRI India 2007 Sym. Tripura, pp. 76-78.

Shad, R.A. (1986). Improving weed management in wetland rice. *Prog. Farm*, 6:49-53.

Thiyagarajan, T.M., Senthil Kumar, K., Bindraban, P.S., Hengsdijk, H. and Ramaswamy, S. (2002). Crop management options for increasing water productivity in rice. *J. of Agril Resour and Managet*, 34: 169-181.

Vijaykumar, M., Singh, S.D.S., Prabhakaran, N.K. and Thiyagarajan, T.M. (2004). Effect of SRI practices on yield attributes, yield and water productivity of rice (*Oryza sativa* L.). *Indian J. of Agron*, 52: 399-408.

Gogoi, A.K., Rajkhowa, D.J. and Khandali, R. (2000). Effect of varieties and weed-control practices on rice productivity and weed growth. *Indian J. of Agron*, 45:580-85.

Mahajan, G., Chouhan, B.S. and Johnson, D.E. (2009). Weed management in aerobic rice in northwestern Indo-Gangetic Plains. *J. of Crop Improv*, 23:366-382.

RESEARCH ARTICLE

EFFECT OF PRE AND POST EMERGENCE APPLICATION OF DIFFERENT DOSES OF IMAZETHAPYR ALONG WITH OTHER HERBICIDES ON NUTRIENT UPTAKE BY CROP AND WEEDS

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Abstract: A field experiment was conducted during the rabi season of 2012-13 and 2013-14 at Crop research center, Chirodi, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut U.P. to study the "Effect of pre and post emergence application of different doses of imazethapyr along with other herbicides on weed dynamics, yield of black gram and succeeding mustard crop". The soil of experimental field was sandy loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and available potassium with near to neutral in reaction. The experiment consisted of 10 treatment combination with pendimethalin @ 1000 g ha^{-1} as pre-emergence (T_1), Imazethapyr @50 g ha^{-1} at 3-4 leaf stage (T_2), Imazethapyr 70 g ha^{-1} at 3-4 leaf stage(T_3), Imazethapyr + pendimethalin @ 800 g as pre-emergence(T_4), Imazethapyr+pendimethalin @ 900 g ha^{-1} as pre-emergence(T_5), Imazethapyr+ pendimethalin @1000 g ha^{-1} as pre-emergence(T_6), Imazethapyr + imazamox @ 60 g ha-1at 3-4 leaf stage(T_7), Imazethapyr + imazamox @ 70 g ha^{-1} at 3-4 leaf stage(T_8), Two hand weeding at 20 & 40 DAS (T_9)and weedy check (T_{10}). The treatments were replicated three times in a randomized block design. All weed control practices proved effective in controlling the weeds in black gram and gave significantly higher grain yield over weedy. PRE application of imazethapyr + pendimethalin (RM) at 900 g ha^{-1} most effective control of all major weeds, resulting maximum grain yield among herbicide treatments which was at par with and PRE use of pendimethalin at 1000 g ha^{-1} provided control of weeds with slight crop suppression which although mitigated within 10-15 days after spray resulting reduction in grain yield. This treatment influenced the uptake of nutrient by black gram and reduced density and dry matter of weeds.

Keywords: Weed control, Herbicide, Weed, Black gram, Mustered

INTRODUCTION

Globally pulse crops are grown in area of 76 m ha with a production of about 68 mt. The average productivity at the global level is about 800 kg ha^{-1}. India is the largest producer, consumer, importer and processor of pulses in the world which accounts for 33% of the world area and 22% of the world production of pulses. In India, the total pulse area is about 25 m ha with production about 18 mt. and average productivity of 750 kg ha^{-1}. The area of pulse crops has not increased much during the past 60-65 years except in 2011 and 2012 it showed an increase of 1.5 to 2.0 m ha. Among the pulse the area under black gram crop in India is 3.19 m ha and production 1.9 mt with the yield of 596 kg ha^{-1} (Purushottam and Singh, 2015). In India, Maharashtra (23.36%), AP (18.50%), UP (12.29%), MP (11.86%), Tamil Nadu (8.64%), Karnataka (4.57%), Rajasthan (4.29%) and Orissa (3.0%) are major black gram producing states. Weed infestation causes around 50% yield reduction in black gram (Sumachandrika *et al.,* 2002). In general, yield loss due to uncontrolled weed growth in black gram ranges from 27 to 100% (Singh and Singh, 2010). To develop an effective crop management technology and to prevent the huge loss due to weeds one has to realize that the ecological relationship in weed crop competition is a complicated phenomenon (Ganiger *et al.,* 2003). Removal of weeds at appropriate time using a suitable method is essential to obtain high yields of black gram. Presently, only pre-emergence herbicides are available which are recommended to manage weeds in *kharif* black gram. Sometimes early rains soon after the sowing make it almost impossible to spray pre-emergence herbicides on this crop. Further, many a times weeds emerge at a later stage which can be controlled by hand-weedings (Chand *et al.,* 2004). Uncontrolled weeds at critical period of crop-weed competition reduce the yield of black gram to the tune of 80-90% depending upon type and intensity of weed infestation (Kumar *et al.,* 2001). Imazethapyr,a broad-spectrum herbicide, has soil and foliar activity that allows flexibility in its application timing and has low mammalian toxicity (Tan *et al.,* 2005). Imazethapyr applied as post-emergence at 50 to 75 g ha^{-1} shows season-long control of many weeds without injuring soybean (Ram *et al.,* 2013). In black gram, that post-emergence application of imazethapyr at 25 g ha^{-1} had no adverse effects on rainfed black gram growth characters and resulted in statistically similar grain

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yield to that of two hand-weedings at 20 and 40 days after sowing (Nandan *et al.,* 2011).

In black gram, weeds could be controlled by hand weedings (Chand *et al.,* 2004). The removal of weeds from growing crops facilitates easy harvesting and gives a high quality produce without admixture with weed seeds. Chemical weed control can be adopted quite in time and in situations. Which manual or mechanical weeding is difficult? The degree of reduction of yield in black gram depends on the density, biomass, and duration of weed species and the fertility status of soil. Therefore, weed control by mechanical means alone is not feasible and there is an urgent need of adopting chemical methods of weed control at least for the period when the crop plants are subjected to keen competition with weeds. Various research workers have tried imazethapyr and pendimethalin 30 EC in different pulse crops and reported positive results on grassy and non-grassy weeds. Pendimethalin 30 EC applied as pre emergence was also found effective to control mostly annual grasses and broad leave weeds.

MATERIAL AND METHOD

A field study entitled "Effect of pre and post emergence application of different doses of imazethapyr along with other herbicides on weed dynamics, yield of black gram and succeeding mustard crop, was carried out to find out the effect of different herbicides and mechanical weeding on control of weeds and crop performance. The experiment was conducted at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U. P.).Field experiment was carried out in the *kharif,* 2012 - 2013 and *Rabi* season 2012, 2013 and 2013-2014.The mean annual rainfall is 1220.8 mm and 458 mm received during 2012-13 and 2013-14, respectively, which 80- 90 % is received from June to September. Winter season extends from November to March, where in Frost occurs generally in the end of December and may continue up to the end of January. The mean minimum temperature ranges from 3 to 9^0c in winter while during summer the mean maximum temperature varies from 43 to 45^0c in May. Mean relative humidity varies in the range of 67 to 84 % from mid-July to end of February and decreases thereafter gradually to about 77.14% by the end of May till first week of June. The soil of experimental field was sandy loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and available potassium with near to neutral in reaction. The experiment consisted of 10 treatment combination with pendimethalin @ 1000 g ha^{-1} as pre-emergence, Imazethapyr @50 g ha^{-1} at 3-4 leaf stage, Imazethapyr 70 g ha^{-1} at 3-4 leaf stage, Imazethapyr + pendimethalin @ 800 g as pre-emergence, Imazethapyr+pendimethalin @ 900 g ha^{-1} as pre-emergence, Imazethapyr+ pendimethalin @1000 g ha^{-1} as pre-emergence, Imazethapyr + imazamox @ 60 g ha-1at 3-4 leaf stage, Imazethapyr + imazamox @ 70 g ha^{-1} at 3-4 leaf stage, Two hand weeding at 20 & 40 DAS and weedy check (T_{10}). The treatments were replicated three times in a randomized block design. Objectives of study were to study the bio-efficacy of different herbicides for weed control in black gram, to study the direct and residual effect of different weed control treatments on growth yields attributes and yields of black gram and succeeding mustard crop respectively, to work out the N, P and K uptake by crop and weeds by different weed control treatment and to compute the economics of different treatment.

EXPERIMENTAL FINDING

Total weed

The effect of weed management practices on total weeds density recorded at 20, 40 and 60 DAS was significant. The significantly minimum total weeds density was found with two hands weeding over rest of the treatment and at par with imazethapyr + pendimethalin@ 900 g ha^{-1}as pre emergence at all crop stages except 20 DAS during 2012 and 2013. At 60 DAS and at harvest stage total weeds density was found significantly minimum 15.83, 14.33 and 12.83, 11.90 m^{-2} with two hand weeding over rest of the treatment and at par with imazethapyr + pendimethalin @ 900 g ha^{-1}as pre emergence during 2012 and 2013.The maximum total weeds density was found with weedy check during both the years. Among the herbicide total weeds density was found significantly lower with imazethapyr + pendimethalin@ 900 g ha^{-1}as pre emergence over rest of the treatment during 2012 and 2013.All weed control treatments were able to check increase in weed population and biomass as compared to weedy check (Table 4.7). At initial stage of 20 and 40 DAS, pre-emergence application of imazethapyr + pendimethalin @ 900 g ha^{-1} were found superior in controlling weed population and biomass than other treatments which might be due to reason that pre-emergence application of these herbicides checked the emergence of germinated weeds seeds. Shaikh *et al*. (2002) reported the effectiveness of pendimethalin as pre-emergence application in black gram crop.

Total weeds dry matter

At all stage, the significantly minimum total dry matter was found under imazethapyr + pendimethalin@ 900 g ha^{-1}as pre emergence over other treatment during 2012 and 2013. The maximum total dry matter was found with weedy check during both the years. The total dry matter production of weeds in weedy check treatment increased up to 60 days crop stage (Table 4.13). The dry matter production of total weeds in weedy check treatment was increased with the advancement of crop growth till harvest. It might be due to early growth at population during subsequent stage. Walia (2009) also reported that weeds have an edge over the crop plants with respect to their growth and development because of early germination and quick initial growing habits.

Grain yield (qha^{-1})

All weed control treatments gave significantly higher grain yield over weedy check. Significantly highest grain yield was recorded 9.68 and 10.15 qha^{-1} under two hand weeding over rest of the treatment except at par with imazethapyr + pendimethalin@ 900 g ha^{-1} during 2012 and 2013, respectively. Among the herbicide application imazethapyr + pendimethalin@ 900 g ha^{-1} was found significantly higher grain yield 9.65 and 9.78 qha^{-1} over rest of the treatment during both the years. The minimum grain yield was recorded 4.15 and 5.13qha-^{1} under weedy check. Among the herbicide application imazethapyr + pendimethalin @ 900 g ha^{-1} was found significantly higher straw yield 18.22 and18.35 qha^{-1}over rest treatment and at par pendimethalin @ 1000 g ha^{-1} as pre emergence during both the years. The minimum straw yield was recorded 15.62 and 16.38qha^{-1} under weedy check. Two hand weedings at 20 and 40 DAS produced highest grain yield which might be attributed to desired plant stand per unit area and grain weight plant^{-1}. It was followed by the weed control imazethapyr + pendimethalin @ 900 g ha^{-1}. These treatments had lower density and dry weight of weeds right from 40 DAS till harvest stage which facilitated good growth of crop plants particularly in reproductive phase and weeds were not allowed to exert sufficient competition to reduce the crop yield. These results are in accordance with those of Punia (2014), Kumar *et al.* (2015).

Total nutrient (NPK) uptake by crop

All weed control treatments gave significantly higher total NPK uptake by crop kg ha^{-1} was recorded with two hand weeding over rest treatment except at par with pendimethalin @ 1000 g ha^{-1} and imazethapyr +pendimethalin @ 900 g ha^{-1} during 2012 and 2013, respectively. Among the herbicide application imazethapyr + pendimethalin@ 900 g ha^{-1} was found significantly higher total NPK uptake by crop kg ha^{-1} over rest treatment and at par with pendimethalin @ 1000 g ha^{-1} during both the years. The minimum total NPK uptake by crop kg ha^{-1} was recorded under weedy check during both years. Among weed control treatments, highest N, P, K uptake was recorded under treatment of two hand weedings followed by the treatments imazethapyr + pendimethalin @ 900 g ha^{-1}. These are attributed to higher grain and straw yield in these treatments. Due to best crop weed competition, crop plants in these treatments observed higher amount of nutrients and increased the production of grain and straw. These results corroborate with the findings of Chhodavadia *et. al* (2013) Kavita *et al*. (2014b) Singh and Yadav (2015).

Nutrient (NPK) uptake by weeds

All weed control treatments gave significantly lower NPK uptake by weed 2.01 and1.84 kg ha^{-1} was recorded with two hand weeding over rest treatment except at par with pendimethalin @ 1000 g ha^{-1} and imazethapyr + pendimethalin@ 900 g ha^{-1} during 2012 and 2013, respectively. Among the herbicide application pendimethalin @ 1000 g ha^{-1} was found sigtnificantly lower NPK uptake by black gram kg ha^{-1} over rest treatment and at par with imazethapyr + pendimethalin@ 900 g ha^{-1}during both the years. The maximum NPK uptake by 29.83 and 27.88 kg ha^{-1} was recorded under weedy check during both the years.

CONCLUSION

All weed control practices proved effective in controlling the weeds in black gram and gave significantly higher grain yield over weedy. Pre emergence application of imazethapyr + pendimethalin at 900 g ha^{-1} was found most effective herbicides for control of all major weeds resulting maximum grain yield among herbicide treatments. This treatment influenced the uptake of nutrient by black gram and reduced density and dry matter of weeds. As per the finding of imazethapyr + pendimethalin (RM) at 900 gha^{-1} or pendimethalin alone should be adopted for the control of weeds in black gram without any phytotoxity on black gram and succeeding mustard crop.

Table 1. Grain and Straw yield (qha^{-1}), Nutrient uptake by plant (Kg ha^{-1}) and Nutrient uptake by weeds (Kg ha^{-1}) as affected by different weed control treatments.

Treatment	Grain yield (qha^{-1})		Straw yield (qha^{-1})		Total Nutrient uptake by plant (Kg ha^{-1})						Nutrient uptake by weeds(Kg ha^{-1})					
					N		P		K		N		P		K	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Pendimethalin @ 1000 g ha^{-1} as pre-emergence	8.65	9.10	17.55	18.30	54.98	57.52	6.45	6.99	27.88	28.83	3.42	3.02	0.75	0.61	6.29	5.38
Imazethapyr @50 g ha^{-1} at 3-4 leaf stage	6.48	7.25	16.48	17.20	41.99	45.21	4.74	5.05	22.08	23.12	9.62	8.38	1.69	1.45	18.29	22.31
Imazethapyr 70 g ha^{-1} at 3-4 leaf stage	7.84	7.92	17.44	18.19	49.93	50.48	5.47	5.84	23.84	25.16	7.29	6.57	1.41	1.20	13.88	21.96
Imazethapyr + pendimethalin (RM) @ 800 g as pre-emergence	7.42	7.88	17.40	18.15	47.47	50.60	5.24	5.90	22.99	26.67	8.33	7.19	1.50	1.28	15.79	13.21
Imazethapyr+pendimethalin (RM) @ 900 g ha^{-1} as pre-emergence	9.65	9.78	18.22	18.35	57.22	62.90	6.99	8.00	29.00	30.31	2.28	2.05	0.51	0.45	4.14	3.61
Imazethapyr+ pendimethalin (RM) @1000 g ha^{-1} as pre-emergence	8.43	8.98	17.53	18.28	53.35	54.97	6.24	6.76	26.76	26.96	4.21	3.69	0.92	0.79	7.84	6.67
Imazethapyr + imazamox (RM) @ 60 g ha^{-1}at 3-4 leaf stage	7.96	8.52	17.42	18.17	49.61	53.46	5.93	6.57	24.26	26.16	5.23	4.59	1.04	0.87	9.84	15.37
Imazethapyr + imazamox (RM)@ 70 g ha^{-1} at 3-4 leaf stage	8.15	8.68	17.45	18.20	51.18	54.88	6.17	6.91	25.24	29.99	4.90	4.39	1.00	0.86	9.20	8.03
Two hand weeding at 20&40 DAS	9.68	10.15	18.25	19.00	60.65	65.82	8.27	9.38	31.82	34.45	2.01	1.84	0.47	0.41	3.65	3.36
Weedy check	4.15	5.13	15.62	16.38	27.30	34.69	3.42	4.20	16.32	20.32	29.83	27.88	7.36	6.58	53.94	50.33
SEm (±)	0.32	0.34	0.18	0.21	2.19	1.87	0.61	0.80	1.39	1.98	0.79	0.41	0.11	0.11	0.91	0.89
CD(P=0.05)	0.97	1.04	0.55	0.64	6.57	5.61	1.83	2.41	4.16	5.95	2.12	1.16	0.36	0.35	2.67	2.58

Table 2. Total weed density (no. m^{-2}) as affected by weed control treatments at various stages of crop growth.

Treatments	Crop growth stages								Weed dry matter	
	20 DAS		40 DAS		60 DAS		At harvest		At harves	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Pendimethalin @ 1000 g ha^{-1} as pre-emergence	4.16 (20.87)	4.46 (18.95)	4.65 (20.67)	4.48 (19.17)	5.42 (28.43)	5.13 (25.33)	4.85 (22.67)	4.61 (20.40)	5.02 (24.28)	4.77 (21.87)
Imazethapyr @50 g ha^{-1} at 3-4 leaf stage	10.78 (115.37)	10.57 (110.86)	8.13 (65.33)	7.69 (58.33)	9.03 (80.67)	8.71 (75.00)	8.28 (67.67)	7.87 (61.00)	8.62 (73.46)	8.18 (65.98)
Imazethapyr 70 g ha^{-1} at 3-4 leaf stage	11.02 (120.50)	10.79 (115.46)	6.67 (43.67)	6.34 (39.30)	7.70 (58.33)	7.41 (54.00)	7.12 (49.83)	6.84 (45.93)	7.44 (54.42)	7.14 (50.13)
Imazethapyr + pendimethalin (RM) @ 800 g as pre-emergence	6.56 (42.03)	5.60 (30.40)	7.61 (57.00)	7.35 (53.17)	8.42 (70.00)	8.05 (64.00)	7.68 (58.00)	7.25 (51.67)	7.97 (62.65)	7.53 (55.74)
Imazethapyr+pendimethalin (RM) @ 900 g ha^{-1} as pre-emergence	3.87 (14.03)	3.67 (12.57)	3.73 (13.50)	3.61 (12.17)	4.28 (17.40)	4.11 (16.00)	3.93 (14.57)	3.79 (13.40)	4.10 (15.91)	3.95 (14.61)
Imazethapyr+ pendimethalin (RM) @1000 g ha^{-1} as pre-emergence	5.27 (26.97)	5.05 (24.68)	5.03 (24.50)	4.91 (23.17)	6.05 (35.67)	7.41 (31.50)	5.40 (28.33)	5.13 (25.43)	5.60 (30.50)	5.32 (27.35)
Imazethapyr + imazamox (RM) @ 60 g ha^{-1}at 3-4 leaf stage	10.42 (107.73)	10.21 (103.43)	5.72 (32.17)	5.53 (29.90)	6.99 (48.00)	6.63 (43.00)	6.04 (35.60)	5.76 (32.23)	6.28 (38.44)	5.97 (34.77)
Imazethapyr + imazamox (RM)@ 70 g ha^{-1} at 3-4 leaf stage	10.23 (103.77)	9.99 (98.97)	5.50 (29.50)	5.26 (26.83)	6.58 (42.33)	6.27 (38.33)	5.84 (33.17)	5.62 (30.67)	6.06 (35.78)	5.82 (33.04)
Two hand weeding at 20&40 DAS	9.95 (98.07)	9.71 (93.30)	3.26 (10.17)	3.24 (9.57)	4.10 (15.83)	3.91 (14.33)	3.70 (12.83)	3.58 (11.90)	3.85 (13.93)	3.72 (12.96)
Weedy check	11.33 (127.19)	11.13 (123.00)	13.50 (181.33)	13.17 (172.50)	14.66 (214.00)	14.25 (202.33)	13.81 (190.00)	13.46 (180.33)	14.32 (204.32)	13.94 (193.58)
SEm (±)	0.10	0.12	0.16	0.14	0.11	0.11	0.11	0.13	0.12	0.13
CD(P=0.05)	0.31	0.36	0.48	0.42	0.34	0.33	0.35	0.38	0.36	0.40

REFERENCES

Ganiger, T.S., Kareekaatti, S.R. and Patil, B.C. (2003). Economic use of plant growth characters and yield performance of cowpea. *Karnataka Journal of Agricultural Science* **16** (1): 35–38.

Chand, R., Singh, N.P. and Singh, V.K. (2004). Effect of weed control treatments on weeds and grain yield of late sown urdbean (*Vigna mungo* L.) during *kharif* season. *Indian Journal Weed Science* **36**: 127-128.

Chhodavadia, S.K., Sagarka, B.K., Gohil, B.S. and Dobariya, V.K. (2013). Herbicidal weed control in green gram. Agriculture: *Towards a New Paradigm of Sustainability* ISBN: 978-93-83083-64-0.

Kavita, D., Rajput, A.S., Kamble, Sonawane, R.K. and Bhale, V.M. (2014b). Influence of herbicides and cultural practices on uptake of nutrients by weeds and black gram**.** *In: Extended Summary of Biennial Conference of Indian Society of Weed Science*, Feb. 15-17, DSWR, Jabalpur (M.P.): 212.

Kumar, P., Baghel., R.S. and Singh, S.P. (2001).Weed management in soybean (*Glycine max)*. *Progressive Agriculture* **1** (1): 38-41

Kumar, S., Bhatto, M.S., Punia, S.S. and Punia, R. (2015). Bioefficacy of herbicides in black gram and their residual effect on succeeding mustard. *Indian Journal of Weed Science* **47**(2): 211–213.

Nandan, B., Sharma, B.C., Kumar, A. and Sharma, V. (2011). Efficacy of pre and post emergence herbicides on weed flora of urdbean under rainfed sub tropical Shiwalik foot hills of Jammu & Kashmir. *Indian Journal Weed Science* **43**: 172–74.

Punia, R. (2014). Evaluation of some herbicides in green gram (*Vigna radiata* L.*)* and their residual effect on succeeding mustard crop. M.sc. Dissert. Department of Agronomy. Submitted to CCS Haryana Agric. University, Hisar.

Purushottam and Singh, D. (2015). Pulses production and productivity in India. *Pluses Hand Book*. pp. 38-40

Ram, H., Singh, G., Aggarwal, N., Buttar, G.S. and Singh, O. (2013). Standardization of rate and time of application of imazethapyr weedicide in soybean. *Indian Journal. Plant Prote* **41**: 33–37.

Shaikh, A.R., Lokhande, O.G., Bhosale, R.H., Giri, A.N. and Shinde, G.G. (2002). Weed management in black gram (*Phaseolus mungo*). *Indian Journal Agronomy* **47** (2): 231-233.

Singh, K. S.P. and Yadav, R.S. (2015). Effect of weed management on growth, yield and nutrient uptake of green gram. *Indian Journal of Weed Science* **47**(2): 206–210.

Singh, M. and Singh, R.P. (2010). Influence of crop establishment methods and weed management practices on yield and economics of direct seeded rice (*Oryza sativa*). *Indian Journal of Agronomy* **55** (3): 224–29.

Sumachandrika, V.B., Subbaiah, G. and Swarajyalaxmi, G. (2002). Efficiency and economics of weed management in *kharif* black gram, *Andhra Agriculture Journal* **49** (3&4): 271-273.

Tan, S., Evans, R.R., Dahmer, M.L., Singh, B.K. and Shaner, D.L. (2005). Imidazolinone-tolerant crops: history, current status and future. *Pest Management Science* **61**: 246–257.

Walia, U.S. and Gill, H.S. (2009). Influence of nitrogen and substituted urea herbicides on the uptake of N, P and K by *Phalaris minor* Ratz. And wheat *Indian Journal of weed science*, **17** (1): 12-17.

RESEARCH ARTICLE

EFFECT OF LAND CONFIGURATION METHODS AND SULPHUR LEVELS ON GROWTH, YIELD AND ECONOMICS OF INDIAN MUSTARD [*BRASSICA JUNCEA* L.] UNDER IRRIGATED CONDITION

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Abstract: A field experiment was conducted at Varanasi, during *rabi* season of 2015-16, to study the effect of land configuration and sulphur levels on yield attribute, yield and economics of Indian mustard [*Brassica juncea* (L.)] on a sandy clay loam soil at Agriculture research farm, Institute of Agricultural Sciences, B.H.U., Varanasi, U.P. The investigation was carried out in a spilt plot design with 3 replications. The treatment comprised of four land configuration methods(-M_1 - Flat bed broadcasting - M_2 - Furrow sowing M_3 - Flat line sowing and M_4 - Ridge side sowing) as main plot factor and four sulphur levels (control, 20 kg S ha^{-1}, 30 kg S ha^{-1} , 40 kg S ha^{-1}) as sub plot factor. Furrow sowing was significantly superior over other land configuration methods in terms of growth parameter, yield attributes and yield as well as economics of crop cultivation. The different levels of sulphur showed a positive response on influencing the growth attributes, yield attributes and yield of mustard. The application of 40 kg S ha^{-1} was significant over other sulphur levels in terms of growth parameters, yield attributes and yield and profitability of mustard crop cultivation.

Keywords: Economics, Growth and yield, Land configuration, Indian mustard, Sulphur levels

INTRODUCTION

Rapeseed-mustard is the most important edible oilseed crop after groundnut and soybean. Indian mustard occupies more than 70 % of the area under Rapeseed-mustard group of crops grown in India (1). It is a winter (*rabi*) season crop that requires relatively cool temperature, a fair supply of soil moisture during the growing season and a dry harvest period (Banerjee *et al.,* 2010) grown widely in 13 states of India including Rajasthan, Gujarat, Haryana, M.P., Uttarakhand, Uttar Pradesh, Bihar, West Bengal and Assam. India occupies third position in rapeseed-mustard production in the world after China and Canada. It plays an important role in the oilseed economy of the country. The estimated area, production and productivity of rapeseed-mustard in the world is 34.19 mha, 63.09 mt and 1,850 kg ha^{-1} (Anonymous, 2016). India account for 19.29 per cent and 10.07 per cent of the total acreage and production of rapeseed and mustard of the world (FAO statistics, 2015). In India, during 2014-15 the mustard crop had production of about 6.31 mt from an area of 6.51mha with an average productivity of 1089 kg ha^{-1}. Due to poor yield, oil seed production in the country does not meet the requirement of growing population. Yield obtained from mustard is low due to adoption of poor agronomic practices, of which nutrient management and planting methods are most important (Om *et al*., 2013)

Land configuration methods including the alteration of shape of seed bed and land surface among the various methods the broad bed and furrow sowing, Furrow sowing, tied ridge sowing, ridge with mulches, on ridge, alternate furrow sowing, ridge sowing are adopted by the crop grower for rapeseed and mustard and other crops for obtaining the better yield over the flat bed or conventional method of sowing. Better conditions for Plant growth are provided in-furrow planting due to higher soil moisture, higher salt leaching and reduction in evaporation from the soil surface (Zhang *et al*., 2007; Li *et al*., 2010).

Various nutrients and micronutrients are required for oilseed production, but the nutrient which plays a multiple role in providing nutrition to oilseed crops, particularly those belonging to cruciferae (brassicacae) family is sulphur (Yadav *et al*., 2010). Mustard is responsive to sulphur in comparison to other crops. Sulphur is essential for the growth and development of all crops. Oleiferous *Brassica* crops in general have high sulphur requirement owing to higher seed and oil yield (Aulakh *et al.,* 1980; Sing and Shahu, 1986).

The present study was therefore, undertaken to evaluate the effects of land configuration methods and sulphur levels on growth and yield of Indian mustard, and asses economics of crop cultivation under irrigated condition having sandy loam texture alluvial soil of eastern Uttar Pradesh.

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MATERIAL AND METHOD

The experiment was carried out at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (25°18'N and 83°03'E) during *rabi* 2015-16. The soil was sandy clay loam texture having 7.30 ph, EC (dSm-^{1} at 25°C), 0.35% organic carbon, 190.50-19.30-210.15 kg ha^{-1} available N-P-K and 20.73 mg kg^{-1} of sulphur. The experiment was laid out in split-plot design with three replications, consisting of four methods of land configuration *viz.* M_1= Flatbed broadcasting, M_2=Furrow sowing, M_3=Flatbed line sowing, M_4= Ridge side sowing as main plot factor and four sulphur levels of *viz.* S_0= Control (0 kg ha^{-1}), S_1= 20 kg ha^{-1}, S_2= 30kg ha^{-1}, S_3= 40kg ha^{-1} as sub plot factor. Before sowing of trial maize bean was taken as *kharif* crop in the field. Sowing of Indian mustard variety 'varuna' was done on 3rd December of 2015 by a help of spades and *kudali* with seed rate of 5.0 kg ha^{-1} at 5 cm depth and broadcasted as per treatment and was harvested on 26th March of 2016 during both the years, respectively. As per treatment fixed amount of was applied through bentonite sulphur (90 % S) 15 days before sowing, the other nutrient fertilizer applied as per recommendation for the crop in particular region under irrigated condition and well decomposed farmyard manure was applied 2–3 weeks before sowing and incorporated in the soil. Half dose of nitrogen and full dose of phosphorus and potash were applied as basal dressing and remaining dose of nitrogen as top dressing after 30 DAS and after first irrigation. Other cultural practices such as weeding, interculture, plant protection measures etc. were applied as per need. Data obtained from crop was statistically analyzed by using the F-test as per the procedure given by Gomez and Gomez (1984), CD at P=0.05 were used to determine the significance differences between treatment means.

RESULT AND DISCUSSION

Growth attributes

Variation in plant height, functional leaves plant^{-1} and leaf area index due to land configuration methods observed at all stages of plant growth. At most of the stages significant variation was observed only except 30 DAS, the furrow sowing recorded highest plant height at all stages. Increasing levels of sulphur from 0 to 40 kg S ha^{-1} caused marked improvement in plant height at all the growth stages. 40 kg S ha^{-1} recorded the maximum plant height than other treatments at all growth stages. There are also observed decline in No. of green leaves plant^{-1} sharply between 60 and 90 DAS. The furrow method of land configuration recorded the more leaf area index than other treatments at all growth stages up to 90 DAS and 40 kg S ha^{-1} recorded the highest LAI at different growth stages which is statistical significant, there was significant difference in number of branches plant^{-1} was recorded with furrow sowing method of land configuration. Application of 40 kg S ha^{-1} though remained comparable recorded significantly higher number of branches plant^{-1} at 60 and 90 DAS as well as harvest. With different methods of land configuration different quantity of dry matter accumulation are recorded and found that the furrow method of sowing have significantly higher accumulation showed than the other method of land configuration, and at 30,60, 90 DAS and at harvest application of 40 kg S ha^{-1} produced significantly higher dry matter plant^{-1} than lower level. These result are in conformity with those reported by Kuotsu *et al.*,(2014), Parihar *et al.*, (2009), Khanpara *et al.*, (1993) and Ali *et al.*, (1996).

Yield attributes

Among the land configuration methods No. of siliquae plant^{-1}, length of siliqua, seeds siliqua^{-1}, 1000-seed weight (g) was recorded with the furrow sowing methods over other treatments. Application of different sulphur levels also influenced the siliquae production in mustard. It was noted that increase in sulphur levels from 0 to 40 kg S ha^{-1} correspondingly enhanced the number of siliqua plant^{-1} and the sulphur applied at 20, 30 and 40 kg sulphur ha^{-1} produced significantly higher siliquae plant^{-1} over control. Similarly, 40 kg S ha^{-1} also proved its distinct superiority over 20 and 30 kg S ha^{-1}. The furrow method of sowing observed superior than other methods and found statistically significant over other treatments. Application of different levels of sulphur influenced siliqua length of mustard and 20, 30 and 40 kg S ha^{-1} over control and 40 kg S ha^{-1} found significantly superior over 20 and 30 kg S ha^{-1}.Among the all applied methods of land configuration furrow sowing of mustard recorded the highest No. of seeds per siliqua over other methods of land configuration, effect of sulphur application was also noticed on the production of seeds siliqua^{-1}. Increasing levels of sulphur application from 0 to 40 kg S ha^{-1} correspondingly observed increased No. of seeds per siliqua 20, 30 and 40 kg S ha^{-1} over control further 40 kg S ha^{-1} found significantly superior over 20 and 30 kg S ha^{-1}. Data given in table:- 2 showed that different methods of land configuration differed markedly in respect of test weight of 1000 seeds. Test weight varied with land configuration methods, Among the land configuration methods furrow sowing method of mustard sowing recorded highest test weight of (4.27 g), followed by ridge side sowing (3.83 g), flat bed line sowing (3.79 g) and flat bed broadcasting(3.76). However, the difference failed to touch the level of significance. As regards the sulphur application, test weight of mustard improved markedly with increasing levels of sulphur application from 0 to 40 kg S ha^{-1}, the present study is in accordance with the finding of Parihar *et al.*, (2010), Rathore *et al* (2010), Om *et al.*, (2013), Chiroma *et al*.,(2006) Verma *et al.* (2012) and Ray *et al.* (2015).

Seed and stover yields

The data of table: 3 showed that there was significant difference in seed yield with various methods of land configuration. The furrow method of sowing recorded the significantly highest seed yield of mustard (19.00 q ha^{-1}) followed by ridge side sowing (16.31 q ha^{-1}), flat line sowing (15.00 q ha^{-1}), and flat bed broadcasting method of sowing (14.85 q ha^{-1}). It is also cleared from the data that with increasing levels of sulphur application, the seed yield (q ha^{-1}) of mustard improved markedly with increase in sulphur levels up to 40 kg S ha^{-1} over the control. 40 kg S ha^{-1} found superior as production of mustard seed q ha^{-1} than other treatment (20 and 30 kg S ha^{-1}) however 20 kg S ha^{-1} at par with control. It is apparent from the data that stover yield (q ha^{-1}) was influenced due to land configuration methods. With different methods of land configuration there was found significantly difference among the treatments and furrow method of sowing recorded the highest seed yield over other methods. The observation revealed that with increasing of sulphur levels up to 40 kg S ha^{-1} increase in yield of stover and 40 kg S ha^{-1} found significantly higher than other treatment and control and also found that the stover yield is significantly higher with 20 and 30 kg of sulphur per hectare over the control. It is evident from the data that different methods of land configuration and sulphur levels markedly increased the harvest index but the differences could not reach to the level of significance, these finding are conformity with Parihar *et al*., (2010), Kuotsu *et al.*,(2014), and Om *et al.*, (2013), Chiroma *et al*., (2006), Jyoti *et al*., (2012), Singh and Kumar (2014) Tiwari *et al*. (2003).

Table 1. Effect of land configuration methods and sulphur levels on growth of Indian mustard [*Brassica juncea* (L.)] under irrigated condition

Treatments	**No. of Siliquae plant^{-1}**	**Siliqua length (cm)**	**Seeds siliqua^{-1}**	**1000-seed weight (g)**	**Seed yield (kg ha^{-1})**	**Stover yield (kg ha^{-1})**	**Harvest index (%)**
Land configuration methods							
M_1 - Flat bed broadcasting	218.15	3.55	13.46	3.76	13.85	46.93	22.79
M_2 - Furrow sowing	224.60	4.35	14.83	4.27	19.00	63.26	23.08
M_3 - Flat line sowing	218.62	3.69	13.52	3.79	15.00	50.46	22.90
M_4 - Ridge side sowing	219.49	3.68	13.92	3.83	16.31	54.54	23.01
SEm±	1.30	0.08	0.13	0.11	0.17	0.50	0.08
CD(P=0.05)	4.48	0.27	0.44	NS	0.59	1.74	NS
Sulphur levels (kg S ha^{-1})							
S_0-0	215.81	3.01	12.44	3.50	13.44	45.52	22.79
S_1-20	218.57	3.70	13.48	3.82	14.81	49.67	22.96
S_2-30	221.37	3.97	14.19	3.91	16.97	56.82	22.97
S_3-40	225.11	4.58	15.62	4.42	18.94	63.17	23.05
SEm±	0.70	0.08	0.14	0.09	0.20	0.59	0.07
CD(P=0.05)	2.04	0.23	0.42	0.27	0.57	1.72	NS

Table 2. Effect of land configuration methods and sulphur levels on yield of Indian mustard [*Brassica juncea* (L.)] under irrigated condition.

	Plant height (cm)				**Functional leaves plant^{-1}**			**LAI**			**Total branches plant^{-1}**			**Dry matter accumulation (g plant^{-1})**			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**60 DAS**	**90 DAS**	**At harv-est**	**30 DAS**	**60 DAS**	**90 DAS**	**At harv-est**
Land configuration methods																	
M_1 - Flat bed broadcasting	14.68	140.40	158.54	158.54	6.293	28.01	10.51	0.472	2.456	0.834	6.97	15.53	18.46	0.81	15.61	30.76	46.35
M_2 - Furrow sowing	15.86	152.04	165.03	165.03	6.904	31.75	11.78	0.504	2.771	0.899	8.28	19.01	23.61	0.86	18.72	34.48	52.03
M_3 - Flat line sowing	14.73	142.42	159.92	159.92	6.409	29.23	10.81	0.470	2.466	0.848	6.90	15.90	19.44	0.83	16.49	31.68	46.97
M_4 - Ridge side sowing	14.75	144.69	160.46	160.46	6.492	30.32	10.94	0.474	2.481	0.859	7.24	16.81	20.71	0.84	16.86	32.46	47.74
SEm±	0.27	1.05	1.13	1.13	0.163	0.61	0.16	0.007	0.039	0.013	0.17	0.24	0.42	0.007	0.27	0.37	0.43
CD(P=0.05)	NS	3.63	3.92	3.92	NS	2.12	0.54	0.024	0.135	0.044	0.57	0.82	1.44	0.024	0.92	1.28	1.50

Sulphur levels (kg S ha^{-1})																	
S_0-0	14.10	138.63	154.50	154.50	5.75	26.05	10.31	0.467	2.425	0.821	5.64	15.30	17.94	0.82	15.06	29.15	45.30
S_1-20	14.80	142.80	158.60	158.60	6.34	27.90	10.79	0.476	2.526	0.839	6.98	16.24	19.70	0.83	15.93	31.55	47.24
S_2-30	15.02	146.93	162.77	162.77	6.74	30.91	10.90	0.485	2.576	0.870	7.85	17.36	21.37	0.84	17.38	33.28	49.33
S_3-40	16.11	151.20	168.07	168.07	7.27	34.46	12.04	0.492	2.647	0.910	8.91	18.34	23.21	0.86	19.31	35.40	51.23
SEm±	0.14	0.87	1.04	1.04	0.11	0.42	0.18	0.004	0.046	0.008	0.16	0.18	0.30	0.004	0.24	0.35	0.39
CD(P=0.05)	0.41	2.55	3.04	3.04	0.31	1.24	0.53	0.011	0.134	0.023	0.47	0.54	0.89	0.012	0.71	1.03	1.15

Table 3. Effect of land configuration methods and sulphur levels on economics of Indian mustard [*Brassica juncea* (L.)] under irrigated condition

Treatments	Gross return (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Land configuration methods				
M_1 - Flat bed broadcasting	51077	25776	25301	0.98
M_2 - Furrow sowing	69964	26276	43688	1.65
M_3 - Flat line sowing	55304	25776	29528	1.14
M_4 - Ridge side sowing	60091	26276	33815	1.28
SEm±	616	-	616	0.02
CD(P=0.05)	2131	-	2131	0.08
Sulphur levels (kg S ha^{-1})				
S_0-0	49579	24276	25303	1.04
S_1-20	54584	25832	28752	1.11
S_2-30	62524	26609	35915	1.35
S_3-40	69749	27387	42362	1.55
SEm±	713	-	713	0.03
CD(P=0.05)	2081	-	2081	0.07

Economics

The data pertaining to economics of mustard as influenced by various treatments are presented in Table: 3. An insight into the data clearly demonstrated that, there was marked difference in the cost of cultivation, gross return and net return of mustard cultivation under different treatments. The cost of cultivation, gross return and net return was markedly different with different method of land configuration methods; similarly, with each increment of sulphur application there was corresponding increase in cost of cultivation, gross return and net return of mustard cultivation up to 40 kg S ha^{-1}. Data pertaining to benefit: Cost ratio as affected by various treatments is presented in Table 3. A close examination of data revealed improvement in B: C ratio due to different methods of land configuration. Among the all methods, furrow sowing recorded significantly higher B:C ratio fallowed by ridge side sowing, flat bed line sowing and flat bed broadcasting. Further, it was observed that benefit: cost ratio improved with increasing levels of sulphur application up to 40 kg S ha^{-1}, application of 40 kg S ha^{-1} recorded significantly higher B:C ratio over control and 30 and 20 kg S ha^{-1}. This is in conformity with the findings of Om *et al.*, (2013), Parihar *et al.*, (2009), Parihar *et al.*, (2012). Kumar and Trivedi, (2011), and Virendra *et al.*,(2008).

REFERENCES

Ali, M.H., Zaman, S.M.H. and SMA, Hossain, (1996). Variation in yield, oil and protein content of rapeseed(*B. campestris*) in relation to levels of nitrogen, sulphur and plant density, *Indian Journal of Agronomy*, **41**(2) : 290-295.

Anonymous (2016). Directorate of Rapeseed and Mustard Research, http://www.drmr.res.in/about_rm.html.

Aulakh, M.S., Pasricha, N.S. and Sahota, N.S. (1980). Yield, nutrient and quality of mustard crop as influenced by nitrogen and sulphur fertilizers. *J. Agric. Sci. Camb.*, **94**(1):545-549.

Banerjee, A., Dutta, J.K. and Mondal, N.K. (2010). Impact of different combined doses of fertilizers with plant growth regulators on growth yield of mustard (*Brassica campestris* cv. B9) under old alluvial soil of Burdwan, West Bengal, India. *Front. Agriculture*, China, **4**(3) :341-351.

Chiroma, A. M., Folorunso, O. A. and Alhassan, A. B. (2006). The effects of land configuration and wood-shavings mulch on the properties of a sandy loam soil in northeast Nigeria. 1. Changes in chemical properties, *Tropicultura*, ***24***(3) : 129.

Gomez, K.A. and Gomez, A.A. (1976). Statistical procedures for agricultural research, (2nd Ed. 1984), John Willey and Sons Inc. New York, USA.

Jyoti, Kumari, Sushanta Kumar, Naik, Mandal, Mitali and Kumar, Das Dilip (2012). Performance of different sources of sulphur on the yield and quality of rapeseed*(Brassica campestris* L.), *Journal of the Indian Society of Soil Science*, **60**(3) :218-224.

Khanpara, V.D., Porwal, B.L. and Patel, J.C. (1993). Effect of levels and modes of sulphur application on biochemical changes in mustard (*Brassica juncea*) leave, *Indian Journal of Agronomy*, **38**(3) : 410-413.

Kumar, R. and Trivedi, S.K. (2012). Effect of levels and sources of sulphur on yield, quality and nutrient uptake by mustard (*Brassica juncea* L.), *Progressive Agriculture*, **12**(1) :69 -73.

Kuotsu, K., Das, A., Lal, R., Munda, G. C., Ghosh, P. K. and Ngachan, S. V. (2014). Land forming and tillage effects on soil properties and productivity of rainfed groundnut*(Arachis hypogaea* L.)-rapeseed*(Brassica campestris* L.) cropping system in north-eastern India, *Soil and Tillage Research*, **142**: 15-24.

Li, Q.Q., Zhou, X.B., Chen, Y.H. and Yu, S.L. (2010). Seed yield and quality of winter wheat in different planting patterns under deficit irrigation regimes, *Plant, Soil and Environment*, **56**:482-487.

OM, H., Rana, K. S. and Ansari, M. A. (2013). Productivity and nutrient uptake of mustard (*Brassica juncea*) influenced by land configuration and residual and directly applied nutrients in mustard under limited moisture conditions, *The Indian Journal of Agricultural Sciences*, ***83***(9) : 933-938.

OM, H., Rana, K. S. and Ansari, M. A. (2013). Productivity and nutrient uptake of mustard (*Brassica juncea*) influenced by land configuration and residual and directly applied nutrients in mustard under limited moisture conditions. *The Indian Journal of Agricultural Sciences*, ***83***(9) : 933-38.

Parihar, C. M., Rana, K. S. and Kantwa, S. R. (2010). Nutrient management in pearl millet (*Pennisetum glaucum*)-mustard*(Brassica juncea*) cropping system as affected by land configuration under limited irrigation, *Indian Journal of Agronomy*, ***55*(**3) :191-196.

Parihar, C. M., Rana, K. S. and Parihar, M. D. (2009). Crop productivity, quality and nutrient uptake of pearl millet (*Pennisetum glaucum*)-Indian mustard (*Brassica juncea*) cropping system as influenced by land configuration and direct and residual effect of nutrient management, *Indian Journal of Agricultural Sciences*, ***79***(11) : 927-930.

Parihar, C. M., Rana, K. S., Jat, M. L., Jat, S. L., Parihar, M. D., Kantwa, S. R. and Sharma, S. (2012). Carbon footprint and economic sustainability of pearl millet-mustard system under different tillage and nutrient management practices in moisture stress conditions, *African Journal of Microbiology Research*, **23** :5052-5061.

Rathore, R. S., Singh, R. P. and Nawange, D. D. (2010). Effect of land configuration, seed rates and fertilizer doses on growth and yield of black gram [*Vigna Mungo* (L.) Hepper], *Legume Research-An International Journal*, ***33***(4) : 274-278.

Ray, Sen K., Gupta, K., Pal, A. K. and Banerjee, H. (2015). Effects of sulphur fertilization on yield, S uptake and quality of Indian mustard under varied irrigation regimes, *Plant, Soil and Environment,* **61**(1) :6-10.

Sing, H. G. and Sahu, M. P. (1986). Reponse of oilseed to sulphur. *Fert. News.*, **31**: 23-30.

Singh, M. and Kumar, M. (2014). Effect of nitrogen and sulphur levels on seed yield and some other characters in mustard (*Brassica juncea* L.), *International Journal of Agricultural Sciences*, **10**(1) : 449-452.

Singh, U.,Tomar, S.S. Rameshwar and Choudhary, S. (2015). Yield, nutrient uptake and economics of Indian mustard as influenced by varieties, sources and levels of sulphur. *Annals of Plant and Soil Research* **17**(3): 266-268.

Tiwari, R.C. Kumar, S. and Singh, D.P. (2003). Response of crop to doses and sources of Sulphur in Eastern U.P, *Fertilizer News*, **48**(8): 41-42.

Verma, C. K., Prasad, K. and Yadav, D. D. (2012). Studies on response of sulphur, zinc and boron levels on yield, economics and nutrients uptake of mustard (*Brassica juncea* L.), *Crop Research*, **44**(1/2) :75-78.

Sardana, Virendra, Atwal, A.K. and Sangha, M.K. (2008). Effect of foliar application of sulphur or yield, quality and economics of Indian mustard [*Brassica Juncea* (L.) Czern & Coss], Research on Crops, 9(3) :728-730.

Yadav, H.K., Thomas, T. And Khajuria, V. (2010). Effect of different levels of sulphur and biofertilizer on the yield of Indian mustard (Brassica juncea L.) and soil properties. *Journal of Agricultural Physics*,**10**:61-65.

Zhang, J., Sun, J., Duan, A., Wang, J., Shen, X. and Liu, X. (2007). Effects of different planting patterns on water use and yield performance of winter wheat in the Huang-Huai-Hai plain of China, *Agric. Water. Management*, **92**:41-43.

RESEARCH ARTICLE

EFFICACY AND ECONOMICS OF NEWER INSECTICIDES AGAINST YELLOW STEM BORER, *SCIRPOPHAGA INCERTULAS* WALKER IN BASMATI RICE

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Abstract: This investigation was conducted during *kharif* 2014 and 2015 at crop research centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India. Among all the treatments, chlorantraniliprole 18.5 SC was found most effective and minimum cumulative infestation of *S. incertulas* with 2.73 per cent DH and 2.06 per cent WE recorded after first and second spray, respectively. Whereas, among the treatments the maximum dead hearts (6.18 %) and white ears (7.47 % WE) infestation were recorded from chlorpyriphos 50 + cypermethrin 5 EC (Treated check). The untreated control was recorded with maximum dead hears (9.50 % DH after first spray) and white ears (8.67 % after second spray) infestation. The maximum yield (44.58 q/ha) was recorded from chlorantraniliprole 18.5 SC, whereas the highest cost benefit ratio (1:12.56) was calculated in fipronil 5 SC. Among all the treatments, the minimum yield (37.60 q/ha) was recorded from chlorpyriphos 50 + cypermethrin 5 EC and lowest cost benefit ratio (1:1.57) calculated from the treatment novaluron 10EC.

Keywords: Insecticide, *Kharif*, *Basmati* rice

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the major food crops among the cereals that provide necessary calories and nutrients to human. Rice is the life blood of the Asia-pacific region where 56 per cent of world's population lives, producing and consuming more than 90 per cent of world's rice. Damages by the insect pests are considered as one of the prime causes of low yield generation of rice in the tropical Asian countries. These pests occur regularly and ravage the crop from seedling stage to maturity and few acts as vectors of virus diseases also (Pradhan, 1971). Among the different insects associated with rice, the yellow stem borer, *Scirpophaga incertulas* Walker is one of the most destructive insect and is widely distributed monophagous insect in Indian subcontinent and has assumed the number one pest status and attacks the rice crop at all growth stages (Atwal and Dhaliwal, 2008). The extent of rice yield losses due to YSB has been estimated as 20–70 % (Chelliah *et al.*, 1989). It causes dead hearts at active tillering stage and white ears at harvest stage, which can lead to complete failure of the crop (Karthikeyan and Purushothaman, 2000). Pesticides are commonly used by the farmers to manage yellow stem borer in rice. Use of insecticides has shown a positive impact on rice production (Misra and Parida, 2004).

MATERIAL AND METHOD

The adaptive research trials were conducted during *Kharif* 2014 and 2015 at CRC, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) India to find out the effectiveness of novel insecticides. The studies were conducted with the rice cultivar Pusa 1121 found mainly attacked by yellow stem borer in basmati rice growing region. Experiment was conducted in a randomized block design with eleven treatments and three replications and the plot size was 4.0x3.0 m. 25 days old seedlings were transplanted with inter and intra row spacing of 20 × 10 cm. All the agronomic practices were followed as per the recommendations. All the novel insecticides under study were applied as foliar spray using knapsack sprayer except controlled release formulation (CRF) of chlorantraniliprole and cartap hydrocholoride granules. The dose of insecticides expressed in terms of ml or g per ha. The soluble insecticides were applied after duly mixing with water (300 lit/ha and 500 lit/ha each corresponding to the respective growth stage of the crop at the time of spraying) at 50 and 75 days after transplanting (DAT) with due care taken for preventing insecticidal drift. Bunds were formed around the treatment plot and the granular insecticide chlorantraniliprole 0.4 GR and cartap hydrocholoride 4G (CRF) were broadcasted on standing crop after

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50 and 75 days of transplanting. In control plot, only water was used.

To evaluate the efficacy of novel insecticides against yellow stem borer, 5 hills were selected randomly from each treated and untreated plot. The count of yellow stem borer infested panicles was taken one day before 1st spray and three, seven, fourteen and twenty one days after first and second spray of insecticides. Calculation of the per cent incidence of yellow stem borer was done by using the following formula.

$$\text{Per cent DH/WH} = \frac{\text{No. of DH/WH}}{\text{Total No. of tillers/Panicles}} \text{X100}$$

The grain yield of each plot was recorded separately at harvesting time and converted in to q/ha before statistical analysis. The economics of each treatment was also worked out on the basis of expenditure incurred on rice stem borer control and value of additional yield over control. Cost benefit ratio on net return per rupees invested was calculated using the following formula:

$$C{:}B\ Ratio = \frac{Net\ Return\ (Rs./Ha)}{\text{Cost of Treatment (Rs./ha)}}$$

Statistical analysis

The data, recorded during the course of investigation, were analyzed with the help of computer software “OPSTAT1” developed by O. P. Sheoren, CCS HAU Hisar.

RESULT AND DISCUSSION

The statistically analyzed pooled data (Table-1) regarding the effect of different novel insecticides on *S. incertulas* during *kharif*, 2014 and 2015 showed that chlorantraniliprole 18.5 % SC was the most effective treatments throughout the spray period (3,7,14 and 21 DAS) for minimizing the YSB infestation as dead hearts and white ears. The insecticide chlorantraniliprole has been observed to be very effective for reduce the *S. incertulas* infestation (Shui-jin *et al.*, 2009; Sarao and Kaur, 2014) which corroborated present finding. The next succeeding treatment was fipronil 5 % SC. Further, Dash and Mukherjee (2003) reported that fipronil 5% SC was more effective than other treatments to control the *S. incertulas*. Chlorantraniliprole 0.4 % GR was next from all the treatments. Similar results were reported by Chormule *et al.*, (2014) they found chlorantraniliprole 0.4 % GR best for reducing the infestation of YSB. It was followed by spinosad 45 % SC, flubendiamide 39.35 % SC, cartap hydrochloride 50 % SP, novaluron 10% EC, indoxacarb 14.5% SC, cartap hydrochloride 4 GR and chlorpyriphos 50% + cypermethrin 5% EC. These findings are in agreement with Prasad *et al.*, (2010) who reported flubendiamide, indoxacarb, lambda cyhalothrin and chlorpyriphos were effective against *S. incertulas*. Earlier some scientists also approved the efficacy of newer insecticides against *S. incertulas* (Gupta *et al.*, 2008; Rao *et al.*, 2008; Sarao and Mahal 2008; Rath *et al.*, 2010; Kulagod *et al.*, 2011; Rath 2012).

The grain yield data (Table-2) revealed that all the insecticidal treatments were significantly superior over untreated control and comparable to check insecticide chlorpyriphos 50% + cypermethrin 5% EC. During both the years, treatment chlorantraniliprole 18.5 % SC was found most effective with the highest pooled yield of 44.58 q/ha whereas, the highest cost benefit ratio as 1:12.56 was calculated in fipronil 5 % SC treated plot. A similar result was reported by Dhaka *et al.*, (2011), which revealed that the plots treated with fipronil 5 % SC had highest C:B ratio than other treatments. The results of Hugar *et al.*, 2009 differ from present investigation as they reported that in spite of high yields obtained in the case of fipronil, it showed the lowest (1:7.86) C:B ratio value due to its high cost.

The next succeeding treatments regarding highest yield were fipronil 5% SC followed by chlorantraniliprole 0.4 % GR, spinosad 45 % SC, flubendiamide 39.35 SC, cartap hydrochloride 50 % SP, novaluron 10 EC, indoxacarb 14.5 % SC and cartap hydrochloride 4 GR, with grain yield 43.53, 42.75, 41.60, 41.00, 40.08, 39.30, 38.62, 38.25 and 37.60 q/ha, respectively. These findings are in conformation with (Karthikeyan, *et al.*, 2007; Mahal, *et al.*, 2008 and Bhutto and Soomro, 2009) also recorded increased grain yield by using novel insecticides over control. In order to the cost benefit ratio, the next best treatments were flubendiamide 39.35 % SC, chlorantraniliprole 18.5 % SC, cartap hydrochloride 50 % SP, cartap hydrochloride 4 % GR, chlorantraniliprole 0.4 % GR, chlorpyriphos 50% + cypermethrin 5% EC, indoxacarb 14.5 % SC, spinosad 45 % SC and novaluron 10 EC with 1:10.61, 1:8.86, 1:7.32, 1:6.91, 1:6.81, 1:4.14, 1:3.12, 1:2.30 and 1:1.57 C:B ratio, respectively. The present findings corroborate with the results of Chakraborty, 2012 who reported flubendiamide with higher C:B ratio followed by chlorantraniliprole, emamectin benzoate and chlorpyriphos 50% + cypermethrin 5% EC.

Table 1. Pooled effect of certain new insecticides on YSB infestation (Dead hearts and White ears) in Basmati rice variety, Pusa 1121 during *kharif* 2014 and 2015

S. No.	Treatment	Dose/ha	% DH Before spraying	After first spray % DH (Days after spraying)				After Second spray % WE (Days after spraying)			
				3 DAS	7 DAS	14 DAS	21 DAS	3 DAS	7 DAS	14 DAS	21 DAS
1	**Indoxacarb 14.5 % SC**	**500 ml**	7.52(15.90*)^{a}	4.52(12.26)^{f}	4.57(12.32)^{c}	5.25(13.23)^{de}	5.88(14.03)^{cd}	4.02(11.56)^{e}	4.59(12.36)^{e}	5.03(12.88)^{cd}	6.00(14.17)^{d}
2	**Fipronil 5 % SC**	**1000 ml**	5.71(13.79)^{a}	1.41(6.81)^{b}	1.78(7.66)^{a}	2.85(9.72)^{b}	3.74(11.12)^{b}	1.17(6.20)^{b}	1.93(7.98)^{b}	2.83(9.08)^{ab}	3.22(10.34)^{b}
3	**Novaluron 10 EC**	**600 ml**	7.92(16.33)^{a}	3.97(11.49)^{e}	4.36(12.02)^{c}	4.93(12.81)^{de}	5.58(13.65)^{cd}	3.41(10.63)^{d}	4.44(12.15)^{e}	4.94(12.42)^{c}	5.81(13.94)^{d}
4	**Cartap hydrochloride 50 % SP**	**1000 g**	6.92(15.24)^{a}	3.40(10.62)^{d}	3.86(11.32)^{c}	4.72(12.54)^{d}	5.37(13.39)^{c}	3.08(10.09)^{d}	3.92(11.41)^{d}	4.07(11.78)^{bc}	4.77(12.61)^{cd}
5	**Cartap hydrochloride 4 GR**	**18 kg**	6.59(14.87)^{a}	4.95(12.84)^{f}	5.39(13.41)^{d}	5.52(13.58)^{de}	6.78(15.08)^{d}	4.28(11.92)^{e}	4.76(12.59)^{e}	5.21(13.26)^{d}	6.29(14.51)^{de}
6	**Spinosad 45 % SC**	**220 ml**	8.39(16.83)^{a}	2.54(9.16)^{c}	2.83(9.65)^{ab}	3.83(12.28)^{c}	4.75(12.56)^{c}	2.13(8.39)^{c}	2.76(9.55)^{c}	3.79(10.56)^{b}	4.39(12.10)^{c}
7	**Flubendiamide 39.35 SC**	**75 ml**	7.05(15.36)^{a}	2.96(9.91)^{cd}	3.14(10.19)^{b}	4.50(12.24)^{d}	4.92(12.79)^{c}	2.64(9.34)^{cd}	3.56(10.87)^{d}	3.81(11.05)^{b}	4.49(12.24)^{c}
8	**Chlorantraniliprole 18.5 % SC**	**150 ml**	5.84(13.94)^{a}	0.86(5.22)^{a}	1.07(5.94)^{a}	2.01(8.15)^{a}	2.73(9.47)^{a}	0.53(4.13)^{a}	1.13(6.09)^{a}	1.91(7.19)^{a}	2.06(8.26)^{a}
9	**Chlorantraniliprole 0.4 % GR**	**10kg**	7.64(15.92)^{a}	1.98(8.08)^{c}	2.46(9.02)^{ab}	2.98(9.94)^{b}	3.83(12.26)^{b}	1.95(8.02)^{c}	2.14(8.40)^{b}	2.92(9.28)^{b}	3.37(10.56)^{b}
10	**Chlorpyriphos 50% + Cypermethrin 5% EC (Treated check)**	**1200 ml**	7.05(15.36)^{a}	5.60(13.68)^{g}	6.08(14.26)^{d}	6.18(14.38)^{e}	7.23(15.59)^{d}	4.93(12.81)^{f}	5.45(13.49)^{f}	6.12(14.29)^{d}	7.47(15.85)^{e}
11	**Control**	------	6.26(14.49)^{a}	8.20(16.63)^{h}	8.69(17.14)^{e}	9.21(17.66)^{f}	9.50(17.94)^{e}	5.94(14.10)^{g}	6.39(14.64)^{g}	7.29(15.59)^{e}	8.67(17.12)^{f}
	SEm (±)		**0.88**	**0.17**	**0.22**	**0.13**	**0.25**	**0.16**	**0.15**	**0.31**	**0.09**
	CD at 5%		**NS**	**0.54**	**0.72**	**0.41**	**0.8**	**0.53**	**0.49**	**1.01**	**0.29**

*Figures in parentheses are angular transformed values
DAS= Days after spray

Table 2. Comparative efficacy of certain new insecticides on Yield and economics

Treatment	Doses/ha	Yield (q/ha)	Yield increased over control (q/ha)	Value of increased yield (Rs./ha)	Total cost of treatment application (Rs./ha)	Net income (Rs./ha)	Cost : benefit ratio
Indoxacarb 14.5 % SC	**500 ml**	38.62	4.22	9273	2250	7023	1:3.12
Fipronil 5 % SC	**1000 ml**	43.53	9.13	20075	1480	18595	1:12.56
Novaluron 10 EC	**600 ml**	39.30	4.90	10780	4200	6580	1:1.57
Cartap hydrochloride 50 % SP	**1000 g**	40.08	5.68	12485	1500	10985	1:7.32
Cartap hydrochloride 4 GR	**18.0 kg**	38.25	3.85	8470	1070	7400	1:6.91
Spinosad 45 % SC	**220 ml**	41.60	7.20	15829	4800	11029	1:2.30
Flubendiamide 39.35 SC	**75 ml**	41.00	6.60	14520	1250	13270	1:10.61
Chlorantraniliprole 18.5 % SC	**150 ml**	44.58	10.18	22385	2270	20115	1:8.86
Chlorantraniliprole 0.4 % GR	**10kg**	42.75	8.35	18370	2350	16020	1:6.81
Chlorpyriphos 50% + cypermethrin 5% EC (Treated check)	**1200 ml**	37.60	3.20	7040	1370	5670	1:4.14
Control	------	34.40					

Price of Basmati rice (Pusa 1121) = 2200/quintal
Labour charge = 140/labour/day
Rental value of sprayer = 50/day

CONCLUSION

Overall, the study revealed that chlorantraniliprole 18.5 SC was performed best with minimum cumulative infestation against stem borer in basmati rice among all the insecticidal treatments during both the year of study. The highest cost benefit ratio was calculated in fipronil 5 SC with 1:12.56. Novel molecule insecticides chlorantraniliprole which were found environmentally safer (safer for natural enemies) and cost effective could be used for chemical control of rice yellow stem borer.

REFERENCE

Atwal, A.S. and Dhaliwal, G.S. (2008). Agricultural Pest of South Asia and Their Management. Kalyani Publishers, New Delhi. P. 242

Bhutto, A.A. and Soomro, N.M. (2009). Comparative efficacy of different granular insecticides against yellow stem borer, *Scirpophaga incertulas* (Walker) under field condition. *Journal of Basic and Applied Science,* 5: 79-82.

Chelliah, A., Benthur, J.S. and Prakasa, R.P.S. (1989). Approaches to rice management-achievements and opportunities. *Oryza*, 26, 12–26.

Chormule, A.J., **Kharbade, S.B., Patil, S.C. and Tamboli, N.D.** (2014). Evaluation of granular insecticides against rice yellow stem borer, *Scirpophaga incertulas* (Walker). *Trends in Biosciences*, 7(12): 1306-1309.

Dash, A.N. and Mukherjee, S.K. (2003). Insecticidal control of major insect pest of rice. *Pest Management and Economic Zoology,* 11(2): 147-151.

Dhaka, S.S., Prajapati, C.R., Singh, D.V. and Singh, R. (2011). Field evaluation of insecticides and biopesticides against rice leaf folder, *Cnaphalocrosis medinalis. Annals of Plant Protection Science*, 19(2): 324-326.

Gupta, S.P., Singh, R.A. and Singh, A.K. (2008). Efficacy of some new insecticidal combinations against insect pests of rice. *Indian Journal of Plant Protection,*36: 156-157.

Hugar, S.V., Naik, M.I. and Manjunatha, M. (2009). Evaluation of new chemical molecules for the management of *Scirpophaga incertulas* (Lepidoptera:Pyralidae) in aerobic rice. *Karnataka Journal of Agricultural Science*, 22(4): 911-913.

Karthikeyan, K. and Purushothaman, S.M. (2000). Efficacy of carbosulfan against rice yellow stem borer, *Scirpophaga incertulas* Walker (Pyralidae, Lepidoptera) in rabi rice. *Indian Journal of Plant Prot*ection, 28(2): 212-214.

Karthikeyan, K., Jacob, S. and Purushothman, S.M., (2007). Effectiveness of cartap hydrachloride against rice stem borer and leaf folder and its safety to natural enemies. *Journal of Biological Control,* 21(1): 145-148.

Kulagod, S.D., Hegde, M., Nayak, G.V., Vastrad, A.S., Hugar P.S. and Basavanagoud, K. (2011). Evaluation of insecticides and bio-rationals against yellow stem borer and leaf folder on rice crop. *Karnataka Journal of Agriculture Science,* 24(2): 244-246.

Mahal, M.S., Sarao, P.S. and Singla, M.L. (2008). Bioefficacy of Fipronil for the control stem borer and leaf folder in Basmati rice. *Indian Journal of Plant Protection,* 36: 260-262.

Misra, H.P. and Parida, T.K. (2004). Field screening of combination insecticides against rice stem borer and leaf-folder. *Indian Journal of Plant Protection.,* 32 : 133-135.

Pradhan, S. (1971). In tropics, protection research more needed than production research. *Indian Journal of Entomology*, 33; 233-259.

Prasad, S.S., Gupta, P.K. and Yadav, U.S. (2010). Comparative efficacy of certain new insecticides against yellow stem borer, *Scirpophaga incertulas* (Walker) in semi deep water rice. *Research on Crops,* 11: 91-94.

Rao, B.S., Mallikarjunappa, S., Bhat, G. and Koneripalli, N. (2008). Bioefficacy of new generation insecticide Takumi 20 WG against rice yellow stem borer *Scirpophaga incertulas. Pestology,* 34(4): 33-34.

Rath, L.K., Mohapatra, R.N., Nayak, U.S. and Tripathy, P. (2010). Evaluation of new molecules against yellow stem borer infesting rice. In: National symposium on emerging trends in pest management strategies under changing climatic scenario, OUAT, Bhubaneswar, Odisha, p. 145.

Rath, P.C. (2012). Field evaluation of newer insecticides against insect pests of rice. *Indian Journal of Plant Protection,* 40: 148-149.

Sarao, P.S. and Kaur, H. (2014). Efficacy of Ferterra 0.4% GR (chlorantraniliprole) against stem borers and leaf folder insect-pests of *basmati* rice. *Journal of Environmental Biology*, 35: 815-819.

Sarao, P. S. and Mahal, M.S. (2008). Comparative efficacy of insecticides against major insect pests of rice in Punjab. *Pesticide Research Journal,* 20: 52-58.

Shui-jin, H., Wen-jing, Q. and Hui, L. (2009). Using chlorantraniliprole 18.5 SC to control rice stem borer, *Chilo suppressalis* (Walker). *Acta Agriculturae Jiangxi*, 21.

RESEARCH ARTICLE

PRODUCTIVITY OF RICE, WHEAT AND N REMOVAL BY RICE AS INFLUENCED BY ORGANIC AND INORGANIC SOURCES OF NITROGEN IN RICE AND THEIR RESIDUAL EFFECT ON SUCCEEDING WHEAT CROP

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Abstract: Soil health is towards deteriorating because of continuous use of chemical fertilizers keeping in view experiment were conducted on Integrated nutrient management with different treatment of Prilled Urea, FYM and Green manuring in rice crop and its effect on succeeding wheat crop. The experimental field having pH 7.9 (1:2.5 soil and water), cation exchange capacity 11.1 Cmol (p^+) kg $^{-1}$ and available N, P and K 165.5, 60 and 90.1 kg ha^{-1} respectively. Experiment were laid out in RBD with ten treatment combinations in four replications on rice Variety Pant-10 and Wheat var. K-8804. It is reveled that the addition of green manuring proved superior to FYM in terms of yield and their parameters of rice crop. On an average highest total uptake (128.90 q ha^{-1}) was recorded in treatment T_5 (N 60 through PU + N 60 through GM) followed by T_4 (120 kg N ha^{-1} through PU) i.e. 123.52 kg ha^{-1}.

Keywords: FYM, Grean manure, Productivity, Wheat crop

INTRODUCTION

The increasing cost of chemical fertilizers, poor purchasing capacity of farmers and ill effect on soil health due to continuous use of chemical fertilizers emphasis has to be given on the integrated nutrient management. Chemical fertilizer has to be reduced by sustaining it with green manuring and other organic sources of manuring like FYM, compost and plant residue.

Keeping in view the ill effect of sole use of chemical fertilizer on soil health as well as environment, low affordable capacity of poor farmers due to high cost and prevailing energy crises there is an urgent need to develop best combination of organic and inorganic source of nitrogen like FYM, dhaincha, renewable resource of plant nutrients. There is strong need to identify organic sources having little alternative uses like fodder, fuel, energy and are cost effective. Incidentally the potential of manurial resource and organic wastes is very high in India.

The present study was under taken with objective effect of organic and inorganic sources of nitrogen in rice and their residual effect on succeeding wheat crop; yield and N-uptake by Rice.

MATERIAL AND METHOD

The experiment was conducted for two consecutive crop years at the crop research farm Pura (Kanpur Dehat) of CSA university of agriculture and Tech. Kanpur (25^0 28' to 26^0 58' North latitude of 125. 30 mt MSL). The soil was sandy loam in texture. Important physico-chemical properties of soil were pH 7.9 (1:2.5 soil and water), cation exchange capacity 11.1 Cmol (p^+) kg $^{-1}$ and available N, P and K 165.5, 60 and 90.1 kg ha^{-1} respectively.

The uptake of nutrient (N) was calculated from data on concentration (%) of the given nutrient multiplied by the corresponding dry matter yield. The soil samples were collected at the end of experimentation to determine soil organic carbon, available N, P and K as per methods given by *walkly and Balck (1934), Subbiah and Asija (1956), Olsen et al., (1954) and Jackson (1973).*

Pooled data were analyzed by procedure laid down by Panse and Sukhatme (1978). Summary table prepared and data were interpreted on per standard procedure. The data were large consistent and comparable in both the years, therefore they were pooled.

The experiments were laid out in RBD with ten treatment combinations in four replications on rice Variety Pant-10 and Wheat var. K-8804. The treatments were, T_1 – control, T_2- N60 kg ha^{-1}, through PU (Prilled Urea), T_3 – 90 kg ha^{-1} through PU, T_4- N120 kg ha^{-1} Through PU, T_5- N120 kg ha^{-1} (N60 through PU+ N60 GM (green manure), T_6- N120 kg ha^{-1} (N90 through PU+ N30 GM (green manure), T_7- N120 kg ha^{-1} through GM, T_8-N120 kg ha^{-1} (N60 through PU + N60 through FYM) , T_9- 120 kg ha^{-1} (N90 through PU + N30 through FYM) and T_{10}- N120 through FYM and few residual response on succeeding wheat crop the wheat experiment was conducted on the same layout field N, P and K were applied @80, 40 and 40 kg ha^{-1} respectively in all plots.

The Dhaincha var. *Sesbania aculeata* incorporated in soil before transplanting of paddy in both the years of experiments, nursery was raised and after 30 days the 2 -3 seedlings per hill were transplanted in the main

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field. Recommended normal package and practices including fertilizer application as per the proposed treatments, weeding irrigation and plant protection measured were adopted.

RESULT AND DISCUSSION

Yield of rice and wheat

Significantly higher grain yield were obtained by the nitrogen application through Prilled Urea, green manure and FYM, over control, in case of rice as well as in residual effect on succeeding wheat crops. The maximum grain yield was produced T_5 (60 kg N (PU) + 60 kg N (GM) followed by T_4 (120 kg N (PU) and T_6 (90 kg N (PU) + 30 kg N (GM), showing the value 52.2q, 51.0 q and 50.4 q ha^{-1}, respectively.

Table 1. Effect of organic manure and inorganic fertilizer on grain yield (qha^{-1}) of rice and residual effect of on succeeding wheat crop (Pooled data) for two seasons.

Treatment	Rice	Wheat
T_1	32.00	34.17
T_2	43.40	34.62
T_3	46.95	35.23
T_4	51.00	36.67
T_5	52.20	38.61
T_6	50.40	37.24
T_7	45.10	39.86
T_8	48.20	41.45
T_9	49.50	37.95
T_{10}	44.10	42.30
SE (diff)	1.285	1.832
CD at 5%	2.637	3.760

Chemical fertilizer and organic manure both are important for rice cultivation, organic manure improve the physical condition of soil and supply limited quantities of plant nutrients through enhanced microbial activity rice crop remove large quantity of nutrients from soil. Green manure through root nodules helps in atmosphere nitrogen fixation. In addition of N fixation green manure enriched the soil with organic matter which helps in reduction on many nutrients such as Fe, Mn, P etc in soil, causing their higher availability to crop plant and in turn higher yield.

In paddy soil mostly reducing condition prevail and decomposition of organic matter reduces organic anions which help in maintaining reducing condition of the soil and also help in release of phosphate in which become availability to plant. Rice is NH_4 loving crop and due to hydrolysis of urea NH_4 -N is produced is become availability to plants. *(Patel 1971), Pongathai (1993), Hidayatullah et al. (2012) and Moola Ram et al. (2014).*

The residual response of added inorganic fertilizers and organic manure in rice to succeeding wheat crop, higher wheat grain yield was recorded in treatment T_{10} 120 kg N (FYM) followed treatment consisting of T_8 60 kg N (PU) + 60 kg N (FYM) T_9 120 kg N (GM) during the study. FYM is store house of a number of macro and micro Nutrients like P, S, K, Fe, Mn, Cu, and Zn. When wheat crop sown after rice the C: N ratios is reduced and availability of nutrients to the crop increases, consequently grain yield of succeeding wheat crop increased. These results collaborated with the findings of *Mulen et al, (1981), Nambiar and Abrol (1989), Davari et al. (2012), Hidayatullah et al. (2012) Moola Ram et al, (2014) and Mairan et al, (2014).*

Nitrogen uptake

Table 2. Effect of organic manure and inorganic fertilizer on total nitrogen uptake in rice crop (Pooled data two seasons).

Treatment	Total N uptake (Kg ha^{-1}) rice crop
T_1	73.48
T_2	100.08
T_3	111.08
T_4	123.52
T_5	128.90

T_6	120.61
T_7	105.68
T_8	114.36
T_9	113.36
T_{10}	102.42
SE (diff)	1.695
CD at 5%	3.478

Nitrogen uptake by both the crops increased significantly and consistently with the addition of organic manure with chemical fertilizer over control. Uptake of nutrients depends upon total yield and their concentration. The prolonged and spatial availability of green manure N or FYM seem to supply and supplement smaller amount of nitrogen to rice plant over a period of non availability of nitrogen from urea – nitrogen top dressing in limited quantities at tillering and panicle initiation stages. Maximum uptake was recorded in treatment T_5 (60 N(PU) + 60 kg N (GM) showing 123.52 kg N ha^{-1} followed by 128.90 kg N ha^{-1} in T_4 120 kg N (PU) and 120.6 kg ha^{-1} in T_6 90 kg N (PU) + 30 kg N (GM). These results are supported by the findings of *Jany and Chang (1992), Rokima and Prasad (1989), Singhundhup and Rajput (1990), Bacar (1990), Prasad and Rokima (1992), Moola Ram et al, (2014) and Mairan et al, (2014).*

CONCLUSION

Integrated use of organic manures viz: FYM and green manures along with chemical fertilizers give at par results over sole use of chemical fertilizers. The application of urea in 3 splits recorded better grain yield (51.0 q ha^{-1}) of rice. Highest grain yield (52.20 q ha^{-1}) was obtained in treatment consisting of 60 kg N through green manuring (dhaincha) incorporation in soil and 60 kg N through prilled urea application in splits. The addition of green manuring proved superior to FYM in terms of yield and their parameters of rice crop. On an average highest total uptake (128.90 q ha^{-1}) was recorded in treatment T_5 (N 60 through PU + N 60 through GM) followed by T_4 (120 kg N ha^{-1} through PU) i.e. 123.52 kg ha^{-1}.

REFERENCES

Davari, M. R., Sharma, S. N. and Mizakhari, M. (2012). The effect of combination of organic materials and biofertilizers on productivity, grain quality, nutrients uptake and economics in organic farming of wheat. *Journal of Organic System,* 7 (2), 29-35.

Hidayatullah, Ammanullah Jr, Ammanullah Jrn, and Shah, Zahir (2012). Residual effect of organic nitrogen sources applied to rice on the subsequent wheat crop. *International Journal of Agronomy and Plant Production*. 4 (4), 620-631.

Jackson, M.L. (1973). Soil chemical analysis *Prentice Hall India Pvt. Ltd*. New Delhi. 232-235.

Mairan N. R., Dhawan A. S. and Kausadikar H. K. (2014). Studies on nitrogen fractions as influenced by organic and inorganic sources of nutrients under different cropping systems in Vertisol. *An Asian Journal of Soil Science,* 9(1), 67-72.

Moola Ram, Davari, M. R., and Sharma, S. N. (2014). Direct residual and cumulative effect of organic manures and biofertilizers on yield NPK, grain quality and economics of wheat (*Triticum aestivum* L.) under organic farming of wheat cropping system. *Journal of Organic System,* 9 (1), 16-30.

Nambiar, K.K.M. and Abrol, I.P. (1989). Long-term fertilizer experiments in India (An overview). Fertilizer News, 34(4), 11-20.

Olsen, S.R., Cob, V.V., Watanabe, F.S and Dean, L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *U.S. Dept. Agric. Washington, D.C. Circ.* 939.

Panse, V.G., Sukhatme, P.V. (1985). Statistical methods for agricultural workers Published by Indian Council of Agricultural Research New Delhi.

Ramaswami, P.P. (1999). Recycling of agriculture and agro- industry wastes for sustainable agriculture production. *Journal of Indian society of soil science*, 47. (661-665).

Prasad, B. and Rokima, J. (1992). Changes in available nutrient status of calcareous soil as influenced by manures, fertilizers and biofertilizers. J. Indian Soc. Soil Sci., 39(4): 783 - 85.

Singhundhup, R.B. and Rajput, R.K. (1990). Nitrogen uptake by rice as influenced by irrigation regimes and nitrogen in sodic soils. *Journal of Indian society of soil science*, 38 (2), 297-303.

Subbiah, B. and Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soil. *Current Science,* 25, 259 – 260.

Walkley, A. and Black, C.A. (1934). An examination of the digestion methods for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, 34, 29 -38.

RESEARCH ARTICLE

EFFECT OF HOST RAGE AND DATES OF SOWING OF BACTERIAL BLIGHT OF RICE PATHOGEN

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Abstract: Host range study revealed that BLB can produce visible symptoms on Cyperus *rotundas*, *Cynodon dactylon*, *Paspalum scrobiculatum*, *Leersia oryzoides* and *Oryza sativa* and symptoms were not appeared on *Zea mays*, *Sesamum indicum*, *Vigna radiate*, *Vigna mungo* and *Glycin max*. However, five out of ten hosts plant take 48-58 hours to symptoms expression.

Keyword: Bacterial leaf blight, *X. oryzae* pv. *Oryzae,* Host range, Date of sowing

INTRODUCTION

The date of sowing is an important factor that determines disease incidence and severity as well as rice yield. On the basis of pooled data of both the years, the highest yields and low disease severity were observed in first sown crops *i.e.* 24th July followed by second sown *i.e.* 31 July, third sown *i.e.* 7th August, fourth sown *i.e.* 14th August, and lowest grain yield with highest disease severity was recorded in 5th date of sowing *i.e.* 21th August in both the years *i.e.* 2012 and 2013. The results indicate that the first and early sown crops escape the disease severity resulting in highest yield

MATERIAL AND METHOD

Host range of the pathogen

Studied the host-range of bacterial blight of rice pathogen, some of the cultivated plants and wild plants were raised in earthen pots in cage house. One month old plants of 10 plants species presented in Table1 which are belonging to different families were inoculated by bacterial suspension with carborundum abrasion technique. The inoculated plants along with controlled plants were kept under high humidity conditions for 48 hrs and then these were placed in cage house. In control, sterilized distilled water was sprayed. The pathogenicity was proved by following Koch's postulates in those plants which showed infect.

Table 1.

S. No.	Host plants	Scientific name
1.	Maize	*Zea mays* L.
2.	Sesame	*Sesamum indicum* L.
3.	Green gram	*Vigna radiata* L.
4.	Black gram	*Vigna mungo* L.
5.	Rice	*Oryza sativa* L.
6.	Purple nut sedge	*Cyperus rotundus* L.
7.	Bermuda grass	*Cynodon dactylon* L.
8.	Rice grass	*Paspalum scrobiculatum* L.
9.	Rice cutgrass	*Leersia oryzoides* L.
10.	Soybean	*Glycin max* L.

The observations were recorded using standard rating scale for disease severity and depicted as + = sensitive and - = non sensitive.

Table 2. Host range of *X. oryzae* pv. *oryzae* on different plants by using spray inoculation method

Host	Scientific Name	Reaction	Incubation Period (hrs)
Maize	Zea mays	-	-
Sesame	Sesamum indicum	-	-
Green gram	Vigna radiata	-	-
Black gram	Vigna mungo	-	-
Soybean	*Glycin max*	-	-
purple nutsedge	*Cyperus rotundus*	+	51-53
Bermuda grass	*Cynodon dactylon*	+	59-61
Rice grass paspalum	*Paspalum scrobiculatum*	+	54-56

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Rice cutgrass	*Leersia oryzoides*	+	56-58
Rice	*Oryza sativa*	+	48-50

Note: + = Visible symptoms, - = Not visible symptoms

Table 3. Effect of different date of sowing on development of bacterial leaf blight (*X. oryzae* pv. *oryzae*) of rice cv. Ratna, *Kharif*, 2012 and 2013

Date of sowing (2012 & 2013)	Per cent disease index (PDI)			Grain yield (q/ha)		
	2012	2013	Pooled	2012	2013	Pooled
24th July	38.00 (38.05)	35.00 (36.26)	36.50 (37.15)	22.59	23.00	22.80
31st July	44.30 (41.73)	41.50 (40.10)	42.90 (40.91)	20.82	21.84	21.33
7th August	49.10 (44.48)	45.10 (42.19)	47.10 (43.33)	20.17	20.01	20.09
14th August	55.50 (48.16)	51.20 (45.69)	53.35 (46.92)	18.67	19.68	19.17
21st August	65.60 (54.10)	58.90 (50.13)	62.25 (52.12)	16.67	18.50	17.58
SEm±	0.884	0.808	0.518	0.992	1.220	0.681
CD at 5%	2.882	2.634	1.554	3.234	3.978	0.108
CV %	3.38	3.26	3.33	8.68	10.25	9.53

Figures in parentheses are angular transformed values

Dates of sowing

Effect of date of sowing on the appearance of bacterial blight in rice was studied. The experiment was conducted in RBD design with three replications. Spacing was maintained as 25 cm row to row and 25 cm plant to plant with plot size: 3 x 2 m^2. The seed of Ratna, a highly susceptible variety of rice was sown in different dates started from 24 July, 31 July, 7 August, 14 August and 21 August at on intervals of 7 days during Kharif 2012-13 in Southern Rajasthan. Fertilizers @ N 50 kg, P 40 kg and K 25kg /ha were applied as basal dose before sowing the plants were inoculated by spray inoculation method with freshly prepared bacterial suspension ($1x10^8$ ml^{-1}) at one month stage of the plants. Observations recorded separately for the per cent disease index and grain yield was recorded after harvesting of crop from individual plots.

RESULT AND DISCUSSION

Host range of the pathogen

Host range studies in present investigation were done by taking 10 different cultivated and wild plant species, which are being grown in *Kharif* season. The pathogen could produce visible symptoms on *Cyperus rotundas*, *Cynodon dactylon*, *Paspalumscro biculatum*, *Leersia oryzoides* and *Oryza sativa* and symptoms did not appeared on *Zea mays*, *Sesamum indicum*, *Vigna radiata*,*Vigna mungo* and *Glycin max*. This study indicates that sensitive plant species may be collateral hosts of this pathogen. Wind and water may also help spread of *X. oryzae* pv.*oryzae* bacteria pathogen to rice and other weed crops. In non-growing seasons, the pathogen may survive in rice seeds, straw, other living hosts, water and soil. Similar studies were carried out by Srivastava and Rao (1968), Durgapal (1985a), Ou (1985), Gonzalez *et al.*, (1991). Valluvaparidason and Mariappan (1998) reported that some common weeds including *Cyperus rotundus, C. deformis, Paspalum scrobiculatum, Leersia hexandra, Cenchrus cilaris, Echinochola crusgalli, Panicum maximum* and *Brachiaria mutica* have been found susceptible to *X. oryzae pv. oryzae* under artificial inoculations but their role in the perpetuation of the disease has not been demonstrated.

Dates of sowing

To study the effect of date of sowing (24th July, 31st July, 7th August, 14th August and 21st August) on disease severity and yield of rice susceptible variety "Ratana", a field trials were conducted during *kharif* 2012 and 2013 . On the basis of pooled data, the highest yields and low disease severity were observed in first sown crops i.e. 24th July (22.80 q/ha, PDI- 36.50 %), followed by second sown i.e. 31 July (121.33 q/ha, PDI- 42.90 %), third sown *i.e.* 7th August (20.09 q/ha, PDI- 47.10 %), fourth sown *i.e.* 14th August (19.17 q/ha, PDI-53.35%), and lowest grain yield with highest disease severity was recorded in 5^{th} date of sowing *i.e*. 21^{th} August (17.58 q/ha , PDI- 62.25%). The results indicate that the first and early sown crops escape the disease severity resulting in highest yield and the severity of bacterial blight disease increased with delayed sowing. Thus sowing date is an important factor that determines rice yield, disease incidence and severity. The similar result was agreement with the result of Rajan *et al*., (2012) that the highest yields and low disease severity were observed in first sown crops *i.e*. 8 June, in all the four varieties, followed by second sown *i.e*. 23 June and third sown 8 July and the first sown crops escape the disease severity resulting in highest yield.

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REFERENCES

Durgapal, J.C. (1985). High virulence of *Xanthomonas campestris* pv.*oryzae*. A factor in 1980 epiphytotic in nontraditional rice growing regions North West India. *Indian J. agric. Sci*. **55**:133-135.

Srivastava, D.N. and Rao, Y.P. (1968). Epidemiology and prevention of bacterial blight of rice in India. FAO *newsletter*.**27**:33.

Ou, S.H. (1985). Rice disease. 2^{nd} edn. Commonwealth of Mycological Institute, Kew, Surrey, England, 380 pp.

Gonzalez, C., Xu, G., Li. H. and Cosper, J.W. (1991). *Leersia hexandra*, an alternate host for *Xanthomonas campestris* pv. *oryzae* in Texas. *Plant Dis* **75**:159-16.

Valluvaparidason, V. and Mariappan, V. (1998). Control of bacterial leaf blight disease of rice. *Int. Rice Res. Newsl*.**7**:7.

Ranjan, R. K., Rai, B.,Chaudhari, P. K. and Rai, R. C. (2012). Effect of different dates of sowing on bacterial leaf blight of rice disease (*Xanthomonas oryzae* pv. *oryzae*) *Environment and Ecology*, **30** (3) 586-589.

RESEARCH ARTICLE

BALANCE FERTILIZATION FOR HIGH SUSTAINABLE RICE (*ORYZA SATIVA* L.) YIELD AND QUALITY IN CENTRAL ALLUVIAL SOILS OF UTTAR PRADESH

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Abstract: The pot experiment was conducted at soil science laboratory of C. S. Azad University of Agriculture & Technology, Kanpur with 150kg N+ 75kg P2O5+ 75kg K2O ha-1 in rice crop during kharif 2011 . The other treatments included the 125% increased doses of above and sulphur (60 kg ha^{-1}) and zinc (5 kg ha^{-1}) were added since the experimental soil was deficient in these two nutrients. Mustard was grown after rice on the residual nutrients of the same treatments with application of 80 kg N ha^{-1} uniformly. The results revealed that rice yields varied from 49.0 to 73.0 q ha^{-1} and NPK raised by 125% with 60 kg S ha^{-1} and 5kg Zn ha^{-1} gave the highest yields. The starch content varied from 65 to 71%, amylose from 27 to 34% and amylopectin from 66 to 73%. The treatment T_8 (187.5N + 93.75 P_2O_5 + 93.75 K_2O + 60 S + 20 Zn Kg ha^{-1}) gave the best result in terms of yield and crop quality.

Keywords: Balanced fertitilization, Rice yield, Starch, Amylose, Amylopectin

INTRODUCTION

Paddy rice is one of the most important food crops of the world and so also of India. At the national level, it occupies about 45 million hectares of land and share about 43% of total food production. In face of rising population, rice requirement will be about 120-130 million tones. In spite of our best efforts, the rice yields have reached a plateau and there is a dire need of increasing the productivity of rice (Subbaiah et al;2006). Use of high fertilizer responsive varieties and applying high levels of fertilizers in a balanced proportion appears to be a feasible approach for the scale up of rice-productivity to a considerable extent. However, the possibility of residual nutrients in soil, particularly at comparatively higher rates of nutrients cannot be ruled out. Under the circumstance it appears worthwhile to exploit the residual nutrients per se in a succeeding crop of different rooting habit.

For optimum plant growth, nutrients must be available in sufficient and balanced quantities. Soils contain natural reserves of plant nutrients, but these reserves are largely in forms unavailable to plants, and only a minor portion is released each year through biological activity or chemical processes. This release is too slow to compensate for the removal of nutrients by agricultural production and to meet crop requirements. Therefore, fertilizers are designed to supplement the nutrients already present in the soil. The use of chemical fertilizer, organic fertilizer or biofertilizer has its advantages and disadvantages in the context of nutrient supply, crop growth and environmental quality. The advantages need to be integrated in order to make optimum use of each type of fertilizer and achieve balanced nutrient management for crop growth.

With the above objective in view, the present study was planned to examine the effect of direct fertilization of rice by rising the RDF by 125% and 150% and addition of required doses of sulphur and zinc. The sulphur and zinc hold the key to the balanced nutrition of rice.

MATERIAL AND METHOD

The physicochemical properties of soil revealed that it belonged to loam textural class with pH 8.1, EC- 2.6 dSm, organic carbon 0.47%, available N 250 kg ha^{-1}, available P 15 kg ha^{-1}, available K 138 kg ha^{-1}, available S- 8.2 kg ha^{-1} and available Zn 0.30 ppm.

The experiment was conducted in cemented ground pots of 10 kg capacity having 30 cm diameter at the top and 26 cm depth with 9 treatments four replications under randomized block design. Each pot was filled with 10 kg well pulverized homogeneous soil. In kharif season of 2011 using rice variety PHB-78 was transplanted on 8^{th} July 2011. The crop was harvested on 26^{th} October 2011. Fertilizer treatments were T_1. Control, T_2. 60 kg S+5 kg Zn ha^{-1}, T_3. 150 kg N+ 75 kg P_2O_5+75 kg K_2O ha^{-1}, T_4. 187.5 N+93.75 kg P_2O_5+ 93.75 kg K_2O ha^{-1}, T_5. 150 kg N+ 75 kg P_2O_5+75 kg K_2O ha^{-1}+ 60 kg S ha^{-1}, T_6. 150 kg N+ 75 kg P_2O_5+ 75 kg K_2O+60 kg S+ 20 kg Zn ha^{-1}, T_7. 187.5 kg N+93.75 kg P_2O_5+75 kg K_20+ 60 kg S ha^{-1}, T_8. 187.5 kg N+93.75 kg P_2O_5+93.75 kg K_2O+60 kg S+20 kg Zn ha^{-1}, T_9. 225 kg N+112.5 kg P_2O_5+112.5 kg K_2O+60 kg S+20 kg Zn ha^{-1}.

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The fertilizers applied for above nutrients were urea, DAP, Muriate of Potash, elemental sulphur and zinc sulphate. Total amounts of phosphorus potash, sulphur and zinc were applied in the soil before transplanting however nitrogen was applied half as basal and rest half top dressed after 30 days of transporting.The observations were recorded on grain and straw yield, concentration and uptake of NPK, S and Zn in rice and yield.

The standard analytical procedures were adopted for soil and plant analysis. Mechanical analysis of soil was done by international pipette method (Piper, 1966), pH in 1:2:5 soil water ratio, EC was analyzed in above supervision (Jackson, 1973), organic carbon by rapid titration method (Walkley and Black's 1934) , Available N was estimated by alkaline permaganate method of (Subbiah and Asija1956), available P by Olsen's method (Olsen, et al. 1954), available K ammonium acetate extraction method (Jackson 1973), available S by turbidimetric method (Chesnin and Yien 1951) and available Zn was extracted with DTPA and determined using AAS as described by Lindsay and Norvell (1978).

Table 1. Effect of balanced fertilization on grain and straw yields of rice (q ha^{-1})

Treatments	**Grain**	**Straw**
T_1	49.0	62.0
T_2	52.0	66.0
T_3	66.5	85.5
T_4	70.0	89.0
T_5	62.0	75.5
T_6	69.0	88.0
T_7	71.0	90.0
T_8	73.0	94.0
T_9	70.0	91.0
SEm ±	0.95	0.833
C.D (at 5%)	1.949	1.710

Table 2. Effect of balanced fertilization on crop quality

Treatments	**Starch (%)**	**Amylose (%)**	**Amylopectin (%)**
T_1	65	34	66
T_2	66	32	68
T_3	67	33	67
T_4	68	33	67
T_5	66	31	69
T_6	69	28	72
T_7	70	29	71
T_8	71	28	72
T_9	68	27	73
SEm ±	2.18	0.98	2.10
C.D (at 5%)	NS	NS	NS

RESULT AND DISCUSSION

Grain and straw yield

The experimental data of grain yield of rice are presented in table 1. The grain yield varied from 49.0 – 73.0 qha^{-1}. The treatment T_8 (187.5 kg N + 93.75 kg P_20_5 + 93.75 K_20 + 60 kg S + 20 kg Zn) gave the highest grain yield in present investigation. The data clearly shows that all the treatment gave significantly higher yield in comparison to control. The grain yield of rice increased by increasing the nutrient dose but the yield was slightly decreased at T_9 (225 Kg N + 112.5 kg P_20_5 + 112.5 Kg K_20 + 60 kg S + 20 kg Zn) in comparison to T_8 treatment. The data of study clearly indicated that the addition of S and Zn gave only marginal response aver NPK combination in respect of grain yield. It was suggested that the pot soil was poor in nitrogen, phosphorus of added nutrients in terms of straw yield were more or less similar to those of grain yield. The straw yield ranged from 62.0 to 94.0 qha^{-1} and the treatment T_8 was once again found best fertilizer combination. Increased grain straw yield due to addition of nutrients in the form of fertilizers in balanced manner has been reported by several workers Pandey et al. (2004), Darde and Banker (2009), Reddy et al. (2010)

Crop Quality- The maximum starch content in rice grain was observed at T_8(187.5 Kg N + 93.75 Kg P_2O_5 + 93.75 Kg K_2O + 60Kg S + 20Kg Zn) treatment and lowest value was recorded at control. In case of amylose content the highest value was recorded in control treatment and lowest at T_8 treatment. Thus there a negative relationship appeared in between starch and amylose content. However, due to increased yield, the harvest of amylopectin should also be higher in high nutrient treatment. The increase in amylopectin content at the cost of amylost. It ranged from 27 to 34%. The data of present study are in agreement with the findings (Tripathi *et al.* 1997, and Dwevedi et.al.2006)

REFERENCES

Chesnin, L. and Yien (1951). C.H. : Turbidimetric determination of available sulphur. *Proc. Soil Sci. Soc. Amer.*, 14 : 149-151.

Darade, A. B. and Banker, K. B. (2009). Yield attributes and yield of hybrid rice as affuled by placement of urea, DAP briquettes and Zn levels. *Agriculture Update 9(3/4): 226-228.*

Dwivedi, A.P.; Dixit, R.S. and Singh, G.R. (2006). Effect of nitrogen, phosphorus and potassium levels on growth, yield and quality of hybrid rice (*Oryza sativa* L.). *Oryza,* **43** (1) : 64-66.

Jackson, M. L. (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Lindsay, W.L. and Norvell, W.A. (1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal 42, 421-428*.

Olsen, S.R.; Cole, C.V.; Watanable, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *Circ U.S. Deptt. Agric.,* 939.

Pandey, S. B., Pandey, I. P. and Singh, R. S. (2004). Effect of potassium and magnesium on growth yield an uptake of nutrients in wheat. *Annals Plant Soil Res., 3(1):7-78.*

Piper, C.S. (1966). Soil and plant analysis, International Science Publisher University of Adelaide, Australia.

Reddy, B. C. M., Manjunatha, H., Patil, V. C. and Patil, S. N. (2010). Response of transplanted rice to N, P and K levels effect on growth, grin yield and economics. *Asian J. of Soil Science 4(2):298-303.*

Subbaiah, S.V.; Singh, S.P.; Mahendra Kumar, R.; Viraktamath, B.C. and Ilyas Ahmed, M. (2006). *Agrotechniques for hybrid rice cultivation and seed production.* Directorate of Rice Research.

Subhiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in Soil. *Curr. Sci.,* 25 : 259-260.

Tripathi, H.C.; Singh, R.S. and Mishra, S.K. (1997). Effect of S and Zn nutrition on yield and quality of chickpea. *J. Indian Soc. Soil Sci.,* **45** (1) : 123-126.

Walkley, A.J. and Black, I.A. (1934). Estimation of soil organic carbon by chromic acid titration method. *Soil Sci. 37 : 29-38.*

RESEARCH ARTICLE

ESTIMATION OF GENETIC VARIABILITY AND CORRELATION ANALYSIS IN FIELD PEA (*PISUM SATIVUM* L.) GENOTYPES

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Abstract: An experiment was undertaken to study genetic variability and correlation analysis in 20 genotypes of pea (*Pisum sativum* L.) on the experimental field at Department of Genetics and Plant Breeding, Rajasthan College of Agriculture during *Rabi*, 2014. The genotypes were tested under irrigation condition in randomized block design with three replications. Analysis of variance revealed significant differences for six characters studied among the genotypes. The *per se* mean performance of various genotypes exhibited wide range of variation for most of the traits studied. According to mean performance of various traits viz. seed yield per plant, days to maturity and pod per plant, seed per pod was found superior for selection. The highest genotypic coefficient of variation was observed primary branches per plant followed by seed yield per plant, pod per plant, and seed per pod. Heritability estimates (broad sense) were found to be high for days to maturity followed by yield per plant, seed per pod, and pod per plant. High expected genetic advance coupled with high heritability estimates *were* recorded for seed yield per plant and days to maturity. The both genotypic and phenotypic levels for pod per plant and seed per pod were significantly correlated with seed yield/plant., Heritability coupled with high genetic advance and correlation also useful tool in predicting the effect in selection of best genotypes for future hybridization in yield improvement programme of pea.

Keyword: GCV, PCV, Heritability, Genetic advance, Correlation

INTRODUCTION

Field pea (*Pisum sativum* L.) is one of the world's oldest domesticated crops. Its area of origin and initial domestication lies in the Mediterranean, primarily in the Middle East. The pea (*Pisum sativum* L.) is an important vegetable crop due to its high nutritive value. The most important tasks for a pea breeding are development of high yielding varieties with stable productivity, with sufficiently good resistance to disease and unfavorable environmental conditions, increases in protein content essential amino acids and favorable ration among them (Tiwari *et al*., 2001). Its improvement is based mainly on exploiting the natural sources of germplasm by means of selection or hybridization followed by selection. Genetic variability is considered as an important factor which is essential prerequisite for crop improvement program for obtaining high yielding progenies (Tiwari & Lavanya, 2012). The evaluation of genetic variability is important to know the source of genes for a particular trait within the available germplasm. The heritable variances give a clue for possible improvement of the character under study. Heritability is the portion of phenotypic variation which is transmitted from parent to progeny. The higher the heritable variation, the greater will be the possibility of fixing the character by selection methods (Sharma *et al* 2003). The natural selection over years operated towards increasing the potentiality for survival and wider adoption at the cost of yield traits. A great extent of variability has been observed in different agronomic characters of pea with respect to plant height, days to flowering, pod length, and seed weight (Pallavi *et al.*, 2013). The research work in this study aims at studying genetic variability and heritability of some traits in pea (*Pisum sativum*) which may help to select suitable genotypes for future breeding programs. Correlation studies provide an opportunity to study the magnitude and direction of association of one character with another, It is important for a plant breeder to find out which of the characters are correlated with yield to bring about genetic improvement in crop plants. Rathi *et al* (2007) Hence, an experiment was conducted to study the genetic variability, correlation and path coefficients among yield and yield component traits in pea. Character association studies are also helpful while making selection in the field for increasing seed yield. The present investigation was therefore, undertaken to eliminate appropriate plant type for selection so as to improve the seed yield accordingly in view the interrelation between traits and heritability.

Experimental material and method

The experimental material for the present investigation from the Department of Genetics and Plant Breeding, RCA, MPUAT, Udaipur, India. The experiment was conducted in randomized block design at Field Experimentation Centre, Department of Genetics and Plant Breeding, Rajasthan College of Agriculture during *Rabi*, 2014. All recommended agronomic and plant protection practices were followed to raise a good crop. Material consisting of twenty genotypes with one check of pea was sown in four rows per plots of 4 m length with three

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replications. Row-to-row and plant-to-plant distance was maintained at 45 cm and 15 cm respectively. Recommended agronomic practices and plant protection measures were followed to raise a good crop. After eliminating the border plants, observations were recorded on five randomly selected plants from each plot on six quantitative characters *viz*, Days to 50% flowering, Primary branches per plant, pods per plant, seeds per pod, days to maturity and seed yield per plant. The mean, range and standard deviation for each character have been calculated and analysis of variance for each of the character was performed. The mean square (MS) at error and phenotypic variances were estimated as per Johnson *et al*. (1955). Genotypic and phenotypic co-efficient of variation was calculated by the formula suggested by Burton (1952). Broad sense heritability was estimated (defined by Lush 1949) and given the formula, suggested by Hanson *et al.* (1956) and Johnson *et al*. (1955). The expected genetic advance for different characters under selection was estimated using the formula suggested by Lush (1949) and Johnson *et al.* (1955). Genotypic and phenotypic correlation coefficients were measured with the formula suggested by Johnson *et al*. (1955)

RESULT AND DISCUSSION

The success of any breeding programme lies upon the thorough knowledge of genetic variability, heritability and type of gene action involved in the inheritance of improvement of desirable characters. The analysis of variance showed significant differences among the genotypes for different characters were studied, showing the great amount of genetic variability present among the genotypes studied (Table. 1). Thus, success of genetic enhancement is attributed to the magnitude and nature of variability present for a specific character.

Per se mean performance of genotypes

The *per se* mean performance of various genotypes exhibited wide range of variation for most of the traits studied (Table 2). Despite that some traits showed more variation like as days to maturity (120-140days), seed yield per plant (71.50-172.85g), days to 50% flowering (55-79 days), pods/plant (18.26-42.13), primary branches per plant (4.15-11.05) and seed per pod (3.56-5.36) etc. indicates sufficient variation among the genotypes for the traits studied. The mean value for grain yield was found 125.41g with standard error of 10.49. This reflected that there is greater opportunity to improve the yield and its related traits in pea.

Genotypic and phenotypic variance

Phenotypic variance was higher than the genotypic variances for all the characters thus indicating the influence of the environmental factors on these traits. The genotypic and phenotypic variations were obtained for different characters, and they are presented in Table 2. Genotypic and phenotypic coefficients of variation was high in case of seed yield per plant (539.63, 870.06), days to flowering (25.96, 33.03) pod per plant (23.94, 35.60), showing the presence of high amount of variation. Moderate genotypic and phenotypic coefficient of variation were found in primary branches per plant (3.06,4.44) and days to maturity (21.17,29.70) Lowest genotypic and phenotypic coefficient of variation estimate was found in a seed per pod (0.18, 0.27).

Genotypic and Phenotypic Coefficient of Variation

The GCV and PCV provide a measure to compare the variability present in the traits. GCV and PCV were classified as suggested by Burton (1952). Phenotypic coefficient of variation (PCV) was slightly higher in magnitude than the genotypic coefficient of variation (GCV) for all the characters indicating the influence of environmental factors on these traits as revealed in Table 2. PCV and GCV were high for primary branches per plant (23.45, 28.27) followed by seed yield per plant (18.52, 23.52) and pod per plant (18.81, 22.94). Tiwari and Lavanya (2012) also reported High GCV and PCV estimates recorded for seed yield per plant, whereas heritability estimates were found high for days to 50% flowering and for days to maturity and high excepted genetic advance as per cent of mean was recorded for seed yield per plant. The other characters were showing moderate GCV and PCV estimates viz., seed per pod (8.78,10.61) and days to flowering (7.28,8.21). Low values (less than 10%) for days to maturity (3.56, 4.21) Ahmad *et al*. (2014) also gave the high genotypic and phenotypic coefficient of variation for branches /plant, seed yield per plant and pods/plant. Similar results were found by Yadav *et al*. (2009) in field pea where seed yield and pod per plant were showing high and significant positive GCV and PCV. Lavanya *et al*.(2010) also recorded that high GCV and PCV estimates for seed yield per plant. Heritability estimates were ranged lowest from days to maturity (0.62) to highest for days to flowering (0.79).

Table 1. Analysis of variance for quantitative traits in pea genotypes.

S. No.	Characters	Mean sum of squares			CV
		Replication (d.f.= 2)	Treatments (d.f.= 19)	Error (d.f.= 38)	
1	Days to Flowering	0.600	84.947**	7.073	3.799

2	Primary Branches/ Plant	1.544	10.552**	1.385	15.791
3	Pods/ Plant	9.987	83.472**	11.663	13.129
4	Seeds/ Pod	0.151	0.630**	0.084	5.966
5	Days to Maturity	1.850	72.031**	8.534	2.259
6	Seed Yield/ Plant	413.259	1949.332**	330.427	14.494

** 1% level of significant

Table 2. The estimates of mean, range and genetic variability for seed yield and its component in field pea.

Characters	Range	Mean±SEm	Vg	Vp	GCV	PCV	h^2 (Broad sense)	GA	GA as % of mean
Days to Flowering	55.0-79.0	70.00±1.53	25.96	33.03	7.28	8.21	0.79	9.30	13.29
Primary Branches/ Plant	4.15-11.05	7.45±0.67	3.06	4.44	23.45	28.27	0.69	2.99	40.07
Pods/ Plant	18.26-42.13	26.01±1.97	23.94	35.60	18.81	22.94	0.67	8.26	31.77
Seeds/ Pod	3.56-5.36	4.86±0.16	0.18	0.27	8.78	10.61	0.68	0.73	14.95
Days to Maturity	120-140	129.30±1.68	21.17	29.70	3.56	4.21	0.62	8.00	6.19
Seed Yield/ Plant (g)	71.50-172.83	125.41±10.49	539.63	870.06	18.52	23.52	0.71	37.69	30.05

Table 3. Genotypic and phenotypic correlation for quantitative traits in pea.

Character		Days to Flowering	Primary Branches/ Plant	Pods/ Plant	Seeds/ Pod	Days to Maturity	Seed Yield/ Plant
Days to Flowering	G	1.000	0.093	-0.288	0.200	0.709**	-0.105
	P	1.000	0.181	-0.271	0.114	0.436*	-0.129
Primary Branches/ Plant	G		1.000	0.024	-0.072	0.249	0.010
	P		1.000	-0.143	-0.052	0.056	-0.131
Pods/ Plant	G			1.000	-0.114	-0.416*	0.825**
	P			1.000	-0.047	-0.059	0.859**
Seeds/ Pod	G				1.000	0.213	0.478*
	P				1.000	0.211	0.405*
Days to Maturity	G					1.000	-0.233
	P					1.000	0.081
Seed Yield/ Plant (g)	G						1.000
	P						1.000

G-genotypic, P-phenotypic

Vg- Genotypic variance, Vp phenotypic variance, GCV-Genotypic coefficient of variation, PCV-phenotypic correlation coefficients,**h^2**- heritability broad sense, GA – genetic advance

Heritability and genetic advance

The moderate heritability were found in seed yield per plant (0.71), primary branches per plant (0.69), seed per pod (0.68) and pods per plant (0.67). Nawab *et al*. (2008) also shown the high heritability of days to 50% flowering and yield (kg/ha). The highest estimates of heritability shown here is due to a little influence of environment. The highest value of genetic advance were obtained for seed yield per plant (37.69), days to flowering (9.30), pods per plant (8.26) and genetic advance as percentage of mean were found for primary branches per plant (40.07), pods per plant (31.77) and seed yield per plant (30.05). It reveals that these characters were governed by additive genes and selection for improvement in these traits would be beneficial. The minimum value of genetic advance for seed per pod (0.73) and as percent of mean for days to maturity (6.19) shown that this trait was being governed by non additive genes action.

Genotypic and Phenotypic Correlation

The estimates of genotypic and phenotypic correlation coefficients between different characters of pea genotypes are presented in (Table 3.) The genotypic correlation coefficients in most of cases were higher than their phenotypic correlation coefficients indicating the genetic reason of association. In some cases, phenotypic correlation coefficients were higher than genotypic correlation indicating suppressing effect of the environment which modified the expression of the characters at phenotypic level. In present investigation were found significant and highly positive with seed yield per plant at both genotypic and phenotypic levels for pod per plant (0.825**, 0.859**) and seed per pod (0.478**, 0.405**). Rai *et al*. (2006) observed same result that the yield/plant is showing a positive and significant association of with pods/plant. The genotypic and phenotypic character of days to flowering was shown negative correlation with seed yield per plant. The genotypic characters of primary branches per plant shown positive correlation (0.010) but phenotypic negatively correlated (-0.131) with seed yield per plant. In case of days to maturity genotypic was found negatively correlation (-0.233) but phenotypic was found positive correlation (0.081) with seed yield per plant. Tiwari and Lavanya (2012)also reported similar characters like number of branches/ plant, pod length, pods/ plant, seeds/ pod and seed index recorded high positive and significant correlation with seed yield, suggesting their potential use in field pea improvement. In case of correlation coefficients studies for genotypic and phenotypic, the genotypic coefficient values are higher than the phenotypic correlation coefficients value for almost all the characters either it is in positive or negative direction shows that the strong associations between the characters present in (Table 3.). Here the environment played a minor role in the modification of the expression of the genes. Govardhan *et al*. (2013) were also recorded that grain yield/plant is positively correlates with pods/plant and negatively correlated with days to maturity. Parihar *et al*. (2014) also observed that correlation studies exhibited that seed yield had positive significant correlation with most of the traits.

REFERENCES

Burton, G.W. (1952). Quantitative inheritance in grasses. *Proceeding of 6th International Grassland Congress*, **1**: 277-283

Chakraborty, M., Haque, M. F. (2000). Genetic variability and component analy- sis in lentil (*Lens culinaris* Medik). *Journal of Research Birsa Agricultural University*, **12**(2), 199-204.

Govardhan, G., Lal, G. M., Vinoth, R. and Reddy, P. R. (2013). Character association studies in M2 generation of fieldpea (*Pisum sativum var. arvense* L.). *Int J of Appl Bio and Pharm Tech,* **4**(4):161-163.

Hanson, C.H., Robinson, H. P. and Comstock, R. E. (1956). Biometrical studies of yield in segregating populations of Korean Lespedeza. *Agronomy Journal*, **48**, 268- 272.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. (1955). Genotypic and phenotypic correlation in soybeans and their implication in selection. *Agron. J.*, **47**: 477-483.

Lavanya, G. R., Singh, D. and Vinoth, R. (2010). Genetic variability, character association and component analysis in field pea, *Pisum sativum var. arvense*. *Madras Agric J,* **97**(10-12): 329-331.

Lush, J. L. (1949). Intensive correlation and regression of characters. *Proceeding of American Society of Animal Production.*, **33**: 293-301.

Nawab, N. N., Subhani, G.M., Mahmood, K., Shakil, Q. and Saeed, A. (2008). Genetic variability, correlation and path analysis studies in Garden pea (*Pisum sativum,* L). *J.Agric. Res*., **46**(4): 333-340.

Pallavi,Y. Singh, V., Singh, A., Pandey, K. K.and. Awasthi, A. K. (2013). Genetic variability, estimation for various characters in pea (*Pisum Sativum*) for mollisol of Uttarakhand, *International Journal of Plant, Animal and Environmental Sciences,* **3**(4):10-13.

Parihar, A.K., Dixit, G.P., Pathak, V. and Singh, D. (2014). Assessment of the genetic components and trait association in diverse set of fieldpea (*Pisum sativum* L.) genotypes. Bang J Bot, **43**(3):323-330.

Rai, M, Verma, A., Kumar, R. and Vishwanath (2006). Multivariate genetic analysis of pea (*Pea sativum*). Veg Sci, **33**(2): 149-154.

Rathi, R. S. and Dhaka, R.P.S. (2007). Genetic Variability, Correlation and Path Analysis in Pea *(Pisum sativum* L.), *Journal of Plant Genetic Resources,* **20**(2):126-129.

Sharma, A.K., Singh, S. P. and Sarma, M. K. (2003). Genetic variability, heritability and character association in pea (*Pisum sativum* L.). *Crop Research Hisar* **26 (1)**, 135-139

Singh, J.D. Kumar, B. and Singh, J.P. (2007). Genetic variability, heritability and character association in dwarf field pea *{Pisum sativum* L.). *Prog. Agric,* **7**(1/2): 102-104.

Tiwari, S.K., Singh, H.L., Kumar, R. andNigam, H.K. (2001). A postmortem of selec- tion parameters in pea (*Pisum sativum* L.). *Crop Research* **2** (2): 237-242.

Tiwari, G. and Roopa Lavanya, G. (2012). Genetic variability, character association and component analysis in F4 generation of fieldpea (*Pisum sativum* var. *arvense* L.). Karnataka Journal of Agric, Sciences **25**(20): 173-175.

Yadav, R, Srivastava, R. K., Kant, R. and Singh, R. (2009). Studies on genetic variability, heritability and and character association in fieldpea. *Crop Res,* **38(**1):184-188.

SHORT COMMUNICATION

CHARACTERIZATION OF FLY ASH COLLECTED FROM NATIONAL THERMAL POWER PLANT

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Abstract: In this study fly ash collected from the National Thermal Power Corporation (NTPC) Sipat, Bilaspur (C.G.) was characterized for its physical and chemical properties. The fly ash is slightly alkaline in reaction and very low organic carbon content. The presence of various heavy metals elements was in the order of Cr > Pb >Co> Ni. The DTPA extractable micronutrients were in the order of fe>Mn>Zn>Cu where as total N, P, K show the trend as N>K>P. Fly ash used for enhanced crop production depending upon the nature of soil and fly ash.

Keywords: Fly ash, FYM, Macro, Micronutrients

INTRODUCTION

The amount of ash produced annually in India was around 100 million tons during 2005 and is likely to exceed 150 million tons in 2020 and there are few uses for the tonnages produced and the disposal of fly ash has become a significant problem (Ravikumar, *et.al.*, 2008). Fly ash is used in buildings, construction of roads, embankment and cement industries. Its alkaline character and a high concentration of mineral substances have resulted in attempts at using it as fertilizer or amendment to enhance the physico-chemical properties of soil. Apart from necessary nutrients, ashes contain elevated concentration of heavy metals which may disturb the biological properties. Fly ash may either have a positive and negative effect on plant growth and yielding if not used in optimum doses. The effect is determined primarily by chemical composition and the ash dose applied (Kalara *et al.*, 2003).

Fly ash being an amorphous ferro-alumino silicate could be a good amendment for problem soils. Properties of fly ash vary depending on the grade and quality of coal as well as the technology employed in the power station. This study is physical and chemical properties of FYM and fly ash collected from National Thermal Power Plant.

MATERIAL AND METHOD

Fly ash taken from National Thermal Power Corporation (NTPC) Sipat, Bilaspur (C.G.). Fly ash and FYM (Farm Yard Manure) was characterized for various parameters and data are presented in Table 1and 2.

The pH was measured with pH meter using 1:2.5 soil water suspensions (Black, 1965) and EC measurement using conductivity bridge (Black, 1965). N was determined by alkaline permanganate method as described by Subbiah and Asija (1956). P was determined by colorimetric analysis (Jackson, 1978) and K was determined by flame photometer described by Jackson (1978).Available micronutrients Fe, Mn, Cu and Zn and heavy metals (Cr, Ni, Co, Pb) were analyzed using atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

RESULT AND DISCUSSION

Characteristics of fly ash

Physical characteristics

Physical properties of fly ash and FYM presented in table 1. The physical properties of fly-ash vary widely depending on the coal type, boiler type, ash content in coal, combustion method and collector setup. In general fly ash particle are spherical and size distribution with medium. Fly ash generated at NTPC, Sipat, Bilaspur (C.G.) comprise sand, silt and clay are 68%, 28% and 4% (Table 1).its particle and bulk density is density 1.93 and 0.83 (g cm^{-3}).Its low bulk density increases potential for dust formation, which creates the problem of storage and transportation of the fly ash (Sudhir and Naveen, 2006). Water holding capacity (WHC) of fly ash is 49.04 % on weight basis. Fly ash has unusually high surface urea and light texture due to presence of large, porous and carbonaceous particles. Fly ash addition changes physical properties of soil such as texture, bulk density, WHC, hydraulic conductivity and particle size distribution (Sharma.*et.al*., 2002).

Chemical characteristics

The factors influencing the physical properties are also responsible for wide variation of chemical properties of fly-ash. Fly ash collected from NTPC are pH is alkaline 8.1, EC 0.81 (dSm^{-1}), Cation Exchange Capacity (c mol (p+) kg-1) is 9.16 (Table 2).The concentration of various element in fly ash decreased with increasing particle size and its contain considerable amount of macro and micronutrients. The pH of the fly ash varies depending on the parent coal and type of coal used for combustion affects the

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sulphur content of fly ash (Maiti,*et.al.*,1990).Fly ash contain lower amount of macro nutrients (N,P,K) and higher amount of micronutrients(Fe,Mn,Zn,Cu) (Table 2). DTPA extractable heavy metals Ni, Co, Cr and Pb present in fly ash are are 1.4, 4.4, 36.9 and 4.5 ppm. The cementing effects of fly ash could possibly impede root development by creating hard area near the soil. The soluble calcium of fly ash provides congenial atmosphere for the flocculation of highly dispersed alkali soil particle and organic matter content of this ash provides much needed protective action to stabilize physical environment improved by the calcium (Sharma.*et.al*., 2002).

Table 1. Physical characteristics of fly ash and FYM

Particulars		Fly ash	FYM
Texture	Sand%	68	
	Silt%	28	
	Clay%	4	
Bulk Density(g cm^{-3})		0.83	0.55
Particle Density(g cm^{-3})		1.93	-
Water Holding Capacity (%)		49.04	60.56

Table 2. Chemical characteristics of fly ash and FYM

Particulars	Fly ash	FYM
Soil reaction (pH)	8.1	8.2
Electrical conductivity (dSm-1)	0.18	0.20
Cation Exchange Capacity (c mol (p^+) kg^{-1})	9.16	-
Organic carbon (%)	0.26	2.22
Total N (%)	0.02	0.98
Total P (%)	0.01	0.17
Total K (%)	0.10	0.83
Total Fe ($mg.kg^{-1}$)	3340.00	1086.00
Total Mn ($mg.kg^{-1}$)	320.00	255.00
Total Zn ($mg.kg^{-1}$)	33	163.7
Total Cu ($mg.kg^{-1}$)	11.00	36.00
Total Ni ($mg.kg^{-1}$)	1.4	-
Total Co ($mg.kg^{-1}$)	4.4	-
Total Cr ($mg.kg^{-1}$)	36.90	-
Total Pb ($mg.kg^{-1}$)	4.5	-

CONCLUSION

Fly ash vary widely in its physical and chemical composition, therefore the mode of use in agriculture is different and depends on the characteristics of soil type. Fly ash contain various essential and non essential elements therefore its use for as an amendment and source of nutrients which improves physical and chemical properties of soil further improve yield of crops.

REFERENCES

Black, C. A. (1965). Methods of Soil Analysis. Amer. Soc.of Agro. Inc. Publ. Madison, Wisconsin, USA.

Jackson, M.L. (1978). Soil Chemical Analysis. Pentice Hall of India Pvt. Ltd. New Delhi. pp. 498

Kalra, N., Jain, M. C., Choudhary, R., Hari, R. C., Vatsa, B. K., Sharma, S. K. and Kumar, V. (2003). Soil properties and crop productivity as influenced by fly ash in corporation in soil. *Environment Monitoring Assessment*, **87**: 93-109.

Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for zinc,iron, manganese and copper. *Soil Sci. Soc Amer. J.,* **42**: 421-428.

Maiti, S.S., Mukhopadhyay, M., Gupta, S.K. and Banerjee, S.K. (1990). Evaluation of fly ash is useful material in agriculture. *J.Indian Soc.Soil Sci*.,**38**:342-344.

Ravikumar, T. N., Yeledhalli, N. A., Ravi, M. V. and Narayana Rao, K. (2008). Physical, Physico-Chemcial and Enzymes Activities of Vermiash Compost. Karnataka J. Agric. Sci.,21(2) : 222-226.

Sharma, S.K., Kalra, N. and Singh, G.R. (2002). Soil physical and chemical properties as influenced by fly ash addition in soil and yield of wheat. *Journal of Scientific & Industrial Research*, **61**:617-620.

Subbiah B.V. and Asija, G. L. (1956). A rapid procedure for the determination of available nitrogen in soils. *Current Science*, **25**:259-260.

Sudhir, K. Sharma and Naveen, Kalra (2006). Effect of fly ash incorporation on soil properties and productivity of crops: A Review. *Journal of Scientific & Industrial Research*, **65**:383-390.