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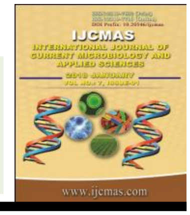

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Yield and Economics of Mustard (*Brassica compestris* L.) as Influenced by Sowing Methods and Levels of Sulphur and Boron

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A B S T R A C T

A field experiment was conducted during the winter season of 2013-14 at the Crop Research Farm, Department of Agronomy, Allahabad School of Agriculture, SHUATS, Allahabad (U.P.) to study the "Effect of sowing methods and levels of sulphur and boron on yield and economics of mustard (*Brassica compestris* L.) *cv.* Peela Sona.". The experiment was laid out in RBD with twelve treatments and replicated thrice. The plot consisted of three levels of sulphur (15, 30 and 45 kg ha^{-1}), two levels of boron (1 and 2 kg ha^{-1}) with two sowing methods (line sowing and broadcasting) along with NPK each at 80:40:40 kg ha^{-1} respectively, the results revealed that the maximum no. of siliquae plant^{-1} (144.86), no. of seeds siliqua^{-1} (41.60), test weight (3.18 g), seed yield (1.74 t ha^{-1}), harvest index (41.90%) and oil content (44.21%) in the treatment T_5 (sulphur 30 kg ha^{-1} and boron 2 kg ha^{-1} with line sowing). The maximum total cost of cultivation (34300.68 Rs ha^{-1}) in the treatment T_6 and T_{12} (sulphur 45 kg ha^{-1} and boron 2 kg ha^{-1} with line sowing) and (sulphur 45 kg ha^{-1} and boron 2 kg ha^{-1} with broadcasting), respectively. The maximum grass return (53860 Rs ha^{-1}) obtained in the treatment T_5 (sulphur 30 kg ha^{-1} and boron 2 kg ha^{-1} with line sowing). The maximum stover yield (2.70 t ha^{-1}), net return (22899.32 Rs ha^{-1}) and benefit cost ratio (1.82) obtained in the treatment T_7 (sulphur 15 kg ha^{-1} and boron 1 kg ha^{-1} with broadcasting).

Introduction

Mustard (*Brassica compestris* L.) is important oilseed crop of family *cruciferae* and occupies a prominent place among oilseed crops being next to groundnut in important. The present area, production and yield of nine oilseeds in India is around 26.48 mha, 30.94 mt and 1168 kg ha^{-1} respectively, and rapeseed mustard sown area in India is 6.36 mha which has a production of 8.03 mt. The average productivity of rapeseed mustard in India is 1262 kg ha^{-1} (Directorate of Economics and Statistics, Department of Agriculture and Cooperation, 2012-13). The average productivity of rapeseed-mustard in India is only 1145 kg ha^{-1}, which needs to be enhanced up to 2562 kg ha^{-1} by 2030 for ensuring edible oil self-reliance (DRMR, 2011). The country shares about 23% of the world production of rapeseed and mustard. These crops are of particular significance of Rajasthan and Uttar Pradesh, which shares about 80% of area and production of entire country. The oil content of the mustard seeds ranges from 35-48 % and 37-42 % protein in cake (NIIR, Board; Nagaraj, 1995). Sowing technique depends upon land resources, soil condition, and level of management and thus broadcast, line sowing, ridge and furrow method and broad bed and furrow method are common sowing techniques. At higher soil moisture regimes, broadcasting followed by light planking gives early emergence and growth. Under normal and conserved moisture regime, seed placement in moist horizon under line sowing becomes beneficial. It is well known that sulphur is only next to nitrogen in the nutrition of *Brassica* crops. Sulphur requirement is higher than any other crops because the synthesis of thioglucosides and other related compounds present to the extent of about 3% of plant dry weight. After N, P and K, S is the fourth nutrient, whose deficiency is wide spread in India (Sarkees, 2013). Among the nutrients, sulphur plays an important role in the biosynthesis of some metabolites, such as chlorophyll, amino acids and essential oils (Morris, 2006). Sulphur plays an important role in metabolism of rapeseed-mustard plant as a component of proteins and formation of flavouring compounds known as glucosinolates (Orlovius and Kirkby, 2013). Sulphur plays a very important role in higher protein and oil production (Jamal *et al.,* 2006). It is an element that is not easily translocated in plant, and its deficiency may cause a significant decrease in seed yield (Jat *et al.*, 2017; Malhi and Leach, 2002). Reports from 12 Indian state cooperative studies of TSI, FAI and IFA at national centers revealed that an average 30-35% of cropped soils were deficit in S and another 35% potentially deficient indicating widespread soil S hunger (NIIR, Board). Recent advances in B research have greatly improved an understanding for B uptake and transport processes (Frommer and Von Wiren, 2002), and roles of B in cell wall formation (O'Neill *et al.,* 2004), cellular membrane functions (Goldbach *et al.,* 2001), and anti-oxidative defense systems. Reproductive growth, especially flowering, fruit and seed set is more sensitive to boron (B) deficiency than vegetative growth (Dear and Lipsett, 1987). Thus, B fertilization is necessary for improvement of crop yield as well as nutritional quality. There are numerous reports on the positive response of mustard to B fertilization (Hossain *et al.,* 2011; Islam, 2005; Saha *et al.,* 2003). Hence an attempt was made to study the effect of sowing method, S and B on yield attributes, seed yield and economics of mustard under irrigated conditions.

Materials and Methods

The experiment was carried out during winter season 2013-14 at Crop Research Farm, Department of Agronomy, Allahabad School of Agriculture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P.). Which is located at 25° 24' 42" N latitude, 81° 50' 56" E longitude and 98 m altitude above the mean sea level. This area is situated on the right side of the river Yamuna and Allahabad Rewa Road about 5 km away from Allahabad city. The soil was sandy loam, pH of soil was 7.4 with 0.39% organic C, having available N, P, K (185.5, 36 and 98 kg ha^{-1} respectively). The experiment was laid out in randomized block design (factorial) with three replications, having three factors are sowing methods (line sowing and broadcasting), sulphur levels (15, 30 and 45 kg ha^{-1}) and boron levels (1 and 2 kg ha^{-1}). Half dose of nitrogen (40 kg ha^{-1}) and full dose of phosphorus and potash each 40 kg ha^{-1} was applied basal and remaining half dose of nitrogen (40 kg ha^{-1}) was applied after the first irrigation. There were total 12 treatment combinations in all. The net subplot size was 3 m x 3m. All other agronomic practices i.e. thinning, hoeing, eradication of weeds and irrigation was kept same for all treatments. Mustard variety 'Peela Sona' was sown. The line sowing was done at a spacing of 30 × 10 cm. Economics of different treatments was worked out on the basis of results of siliquae and seed yield of mustard in terms of gross and net returns ha^{-1} and B:C ratio considering the prevailing market price of produce and cost of cultivation.

Results and Discussion

Yield attributing traits

Yield attributing characters branches $plant^{-1}$, siliquae $plant^{-1}$, seeds $siliquae^{-1}$, test weight, seed yield, oil yield, oil content percentage, stover yield and harvest index of mustard under sowing methods, sulphur and boron levels has been tabulated in the table 1. The maximum number of branches $plant^{-1}$ was 9.93 and siliquae $plant^{-1}$ were 144.16recorded in the treatment T_5 (sulphur 30 kg ha^{-1}+boron 2 kg ha^{-1} with line sowing). Branching and siliquae are basically a genetic character but environmental conditions and different sowing method may also influence the number of branches per plant and play an important role in enhancing seed yield. The 30 kg S ha^{-1} would accelerate phenological development and improve seed quality of mustard as well as the yield contributing characters increased significantly with the increased rate of boron application up to 1.5 kg B ha^{-1} (Hassan and Malhi, 2011; Malhi and Leach, 2002). The maximum number of seeds $siliqua^{-1}$ was 41.60 and test weight was 3.18g were recorded in the treatment T_5 (sulphur 30 kg ha^{-1}+boron 2 kg ha^{-1} with line sowing). Number of seeds per siliquae is considered an important factor that directly imparts in exploiting potential yield recovery in mustard crops. The results and probable reasons for such results are in conformity with the findings (Malhi and Leach, 2002) reported that filled grains per pod were highest with 1.5 kg B ha^{-1}, which was identical to 2.0 kg B ha^{-1}. The sulphur application up to 30 kg ha^{-1} significantly improved the yield attributes (Kumar *et al.*, 2012). The application of 30 kg S ha^{-1} enhanced the 1000 grain weight of beans (Kumar *et al.*, 2012; Jat *et al.*, 2017).

The maximum seed yield was 1.74 tha^{-1} recorded in the treatment T_5 (sulphur 30 kg ha^{-1} + boron 2 kg ha^{-1} with line sowing). Dry matter production and its transformation into economic yield is the ultimate outcome of various physiological, biochemical, phenological and morphological events occurring in the plant system. Seed yield of a variety is the result of interplay of its genetic makeup and environmental factors in which plant grow. The results and probable reasons for such results are in conformity (Pavani *et al.*, 2013) and application of 30 kg S ha^{-1} recorded highest seed yield over 0 and 15 kg S ha^{-1}. The increase in seed yield of Indian mustard was significant only up to 25 kg P_2O_5 ha^{-1} and 20 kg S ha^{-1} and B: C ratio was the highest with 25 kg P_2O_5 and 20 kg S ha^{-1} (Rana *et al.*, 2004). The response of Indian mustard to four levels of S 0, 15, 30 and 45 kg S ha^{-1} (Verma *et al.*, 2011).

Among the S level, 45 kg S ha^{-1} being at par with 30 kg S ha^{-1} gave significantly higher seed yield. The maximum stover yield was 2.70t ha^{-1} recorded in the treatment T_7 (sulphur 30 kg ha^{-1}+boron 1 kg ha^{-1} with broadcasting). The effect of B application on the stover yield of mustard was not significant. However, Boron control treatment produced the lowest stover yield and application of 1 kg B ha^{-1} got the highest (Hossain *et al.*, 2011). The maximum oil yieldwas755.50 kg ha^{-1}recorded in the treatment T_5 (sulphur 30 kg ha^{-1} + boron 2 kg ha^{-1} with line sowing). The sulphur application upto 30 kg ha^{-1} significantly improves the oil yield (Tomar and Singh, 2007). The drill-row sowing method produced seed and oil yields more than broadcasting method (Sarkees, 2013). The application of 1.0 kg B ha^{-1} significantly increased oil yields over the control (Verma *et al.*, 2012). The maximum oil content (44.21 %) was recorded in the treatment T_6 (sulphur 45 kg ha^{-1}+boron 2 kg ha^{-1} with line sowing).

Table.1 Yield attributing traits of mustard in sowing methods and levels of sulphur and boron

Treatments	No. of branches plant^{-1}	Siliquae plant $^{-1}$	Seeds siliquae^{-1}	Test Weight (g)	Seed yield (t /ha)	Oil Yield kg ha^{-1}	Oil content (%)	Stover yield (t /ha)	Harvest Index (%)
T_1	9.20	142.26	38.80	2.98	1.59	681.63	42.87	2.50	37.66
T_2	9.40	143.60	38.90	2.90	1.67	721.60	43.21	2.45	39.80
T_3	9.46	142.73	40.46	2.95	1.63	711.33	43.64	2.33	39.95
T_4	9.33	140.26	39.80	2.86	1.64	706.67	43.09	2.49	38.97
T_5	9.93	144.86	41.60	3.18	1.74	755.50	43.42	2.26	41.90
T_6	9.80	138.06	37.66	3.10	1.65	729.46	44.21	2.29	40.98
T_7	9.26	137.93	40.60	2.70	1.60	658.56	41.16	2.70	36.77
T_8	9.26	137.20	38.26	2.75	1.53	642.60	42.00	2.67	36.43
T_9	9.40	139.93	38.66	2.76	1.64	691.91	42.19	2.64	37.88
T_{10}	9.00	137.00	37.46	2.72	1.57	949.66	41.38	2.68	36.94
T_{11}	9.06	142.73	39.60	2.80	1.62	689.14	42.54	2.63	37.53
T_{12}	9.00	139.80	38.06	2.84	1.60	683.04	42.69	2.63	37.68
F test	NS	NS	NS	NS	NS	NS	NS	NS	S
SEd (±)	0.51	3.68	1.95	0.24	0.18	0.42	1.11	0.26	0.01
CD(p±0.05)	-	-	-	-	-	-	-	-	0.037

Table.2 Economic traits of mustard in sowing methods and levels of sulphur and boron

Treatments	Total cost (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B: C Ratio
T_1	27800.68	50200	22239.32	1.80
T_2	30050.68	52550	22499.32	1.74
T_3	32300.68	51230	18929.32	1.58
T_4	29800.68	51690	21889.32	1.73
T_5	32050.68	53860	21809.32	1.68
T_6	34300.68	51790	17489.32	1.50
T_7	27800.68	50700	22899.32	1.82
T_8	30050.68	48570	18519.32	1.61
T_9	32300.68	51840	19539.32	1.60
T_{10}	29800.68	49780	19979.32	1.67
T_{11}	32050.68	51230	19179.32	1.59
T_{12}	34300.68	50630	16329.32	1.47

Economic traits

Economics *viz.*, cost of cultivation, gross return, net return and benefit cost ratio of mustard under sowing methods, sulphur and boron levels have been tabulated in table 2. Returns were calculated from the market price of seeds Rs 3000 q^{-1} and stover Rs 100 kg^{-1} of Mustard. The variable cost was calculated from the fertilizer application cost which worked out to be Rs 120 kg^{-1} S and Rs 400 kg^{-1} boron.

Among the treatments T_6 (45 kg sulphur and 2 kg boron ha^{-1} with line sowing) and T_{12} (45 kg sulphur and 2 kg boron ha^{-1} with broadcasting) maximum total cost of cultivation (34300₹ha^{-1}) were recorded, whereas gross return was highest (53860₹ ha^{-1}) with treatment T_5 (30 kg sulphur and 2 kg boron ha^{-1} with line sowing). However, maximum net returns (22499.32 ₹ha^{-1}) and highest B: C ratio (1.82) was recorded with treatment T_2 (30 kg sulphur and 1 kg boron ha^{-1} with line sowing) and T_7 (15 kg sulphur and 1 kg boron ha^{-1} with broadcasting), respectively. Boron application was superior to the control for net returns and B: C ratio. Such behaviour of economic parameters due to S and B levels was due to changes in marginal seed yield of the crop with successive increase in fertilizer nutrient and relative costs of inputs in relation to output. The application of 60 kg S ha^{-1} and 1.0 kg B ha^{-1} significantly increased seed yield, economics and oil yield over the control (Verma *et al.,* 2012). The cost effective economically optimum dose of sulphur for sunflower cultivation was found to be 36.70 kg S ha^{-1} under its full availability (Sheoran *et al.,* 2013).

The application of Sulphur at 30 kg ha^{-1} and Boron at 2 kg ha^{-1} along with recommended dose of nutrients (N at 80, P_2O_5 at 40 and K_2O at 40 kg ha^{-1}) with line sowing recorded highest yield with Non-significant results. Since the data is based on the study concluded in one season, the experiment may be repeated to confirm the findings.

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