Biological Forum – An International Journal **14(1): 1370-1375(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of Tillage Practices, Sulphur and Boron Application on Growth, Yield and Economics of Mustard

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(Received 18 November 2021, Accepted 05 February, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Productive profitability of mustard is constrained mainly due to intensive use of nutrients and inappropriate moisture conservation strategies in soil layers. Keeping the issues in view, a field experiment was conducted during *rabi* season 2016-17 and 2017-18 at research farm of Bihar Agricultural College, Sabour, Bhagalpur to assess the response of mustard to tillage, S and B doses. It consisted of main plot having three tillage practices *viz.*, conventional tillage, zero tillage and reduced tillage, while sub plots having three S doses *i.e.*, 0, 20 and 40 kg ha^{-1} and three B doses *i.e.*, 0, 1.0 and 2.0 kg ha^{-1} in sub sub plots laid out in split split plot design replicated thrice. Results indicated that siliqua length, 1000-seed weight and seeds siliqua^{-1} were maximum in conventional tillage. Tillage practices did not cause significant variation in 1000-grain weight. These attributes increased with increasing doses up to 40 kg S ha^{-1} and 1.0 kg B ha^{-1}. S doses caused non significant variation in seeds siliqua^{-1}. Conventional tillage gave significantly highest seed yield (10.42 and 9.61 q ha^{-1}) over zero tillage during both the years. Reduced tillage was significantly superior over zero tillage during 2017-18. Significantly highest seed yield (10.65 and 9.85 q ha^{-1}) was recorded with 40 kg S ha^{-1}; being at par with 20 kg S ha^{-1} during both the years. Significantly highest seed yield (10.59 and 9.75 q ha^{-1}) was recorded with 1.0 kg B ha^{-1}; being at par with 2.0 kg B ha^{-1} during both the years. Conventional tillage achieved highest net returns (₹25383 and 23564 ha^{-1}) and B: C ratio (1.42 and 1.23) during both the years. It increased correspondingly up to 40 kg S and 1.0 kg B ha^{-1}. Significantly maximum B: C ratio (1.53 and 1.32) was noted at 20 kg S ha^{-1}; being at par with 40 kg S ha^{-1} and B:C ratio was noted highest (1.58 and 1.38) with 1.0 kg B ha^{-1} during both the years.

Keywords: Boron, Economics, Mustard, Sulphur, Tillage, Yield, Zero tillage.

INTRODUCTION

Mustard is predominantly dependent upon residual soil moisture from preceding crop. Tillage practices play an important role in enhancing and economizing the mustard productivity. Among different tillage practices, conventional tillage resulted into higher growth and yield of mustard (Poddar and Kundu 2007). Tillage, an important agronomic manipulation, plays vital role in soil moisture conservation in rainfed cultivation. Disturbing the soil too much through tillage operations is not actually required to obtain good yields (Prasad *et al*., 2006), and also a major portion of energy (25-30 %) in agriculture is utilized for either field preparation or crop establishment (Tomar *et al*., 2006) where conventional tillage is mostly followed. Rising fuel cost and availability of package of practices for conservation tillage are now redefining tillage in India in recent. Conservation tillage has been found to be very important in sustaining rainfed farming. Rapeseed and mustard needs highest S amongst the oilseed group. S is taken up by roots as sulphate and transported via xylem to the leaves where it is reduced to cysteine and either converted into methionine or incorporated into proteins (Orlovius and Kirkby 2013). B plays important role in cell differentiation & development, photosynthates translocation from source to sink and growth of pollen grains, thereby marked increase in seed yield. There is still enough scope to increase the productivity of rapeseed and mustard through nutrient supplementation and tillage manipulation in the cultivation practices. Keeping these issues in view, the present investigation was carried out to assess the effect of tillage practices, S and B doses on growth, yield and economics of mustard.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season 2016-17 and 2017-18 at research farm of Bihar Agricultural College, Sabour, Bhagalpur to assess the effect of tillage practices, S and B doses on growth, yield and economics of mustard. The experiment comprised of three tillage practices *viz.*, conventional tillage, zero tillage and reduced tillage in main plot, while three S doses *i.e.*, 0, 20 and 40 kg ha^{-1} in sub plots and three B doses *i.e.*, 0, 1.0 and 2.0 kg ha^{-1} in sub sub plots; laid out in split split plot design with three replications. Conventional tillage was done by one deep ploughing, two harrowing and planking. In reduced and zero tillage, seeds were sown in furrows by opening with desi *Kudal*. Recommended fertilizer dose (40 kg N, 20 kg P_2O_5 and 20 kg K_2O ha^{-1}) was uniformly applied as basal. Sulphur was given through bentonite-S and boron through B-containing fertilizer as basal. Data on growth (LAI**)**, yield attributes (length of siliqua, number of seeds $siliqua^{-1}$ and 1000-seed weight), seed, stover yield, harvest index and economics were recorded. Data were statistically analyzed separately to interpret the results. The mean data for each parameter has been presented. For comparison of 'F' values and for determination of critical difference at 5% level of significance, Fisher (1970) was consulted.

RESULTS AND DISCUSSION

A. Growth parameter

Leaf area index (LAI). LAI increased with advancement in age of mustard irrespective of treatments. Increasing tillage intensity *i.e.,* conventional tillage influenced LAI at most of the growth stages. This supports that fine seed bed is essential for good germination, growth and development of plant. LAI increased up to 60 DAS there after declined. Tillage influenced LAI significantly only at 30 DAS when highest LAI (1.27 and 1.23) was recorded with zero tillage during 2016-17 and 2017-18, respectively (Table 1). These results are in conformity with the findings of Saha *et al*. (2010). 40 kg S ha^{-1} registered highest LAI at all growth stages except at 30 DAS. Highest LAI at 40 kg S ha^{-1} was recorded at 60 and 90 DAS which was significantly higher than rest of S doses during both the years. Verma *et al*. (2012) reported positive effect of S on LAI in mustard. 2.0 kg B ha^{-1} resulted into maximum LAI over control and was at par with 1.0 kg B ha^{-1} at 30 DAS only during both the years. Sharma (2006) observed that B is directly or indirectly involved in several physiological and biochemical processes during plant growth.

B. Yield and yield attributes of mustard

Siliqua length, seeds $siliqua^{-1}$ and 1000-seed weight were markedly higher at higher tillage intensity *i.e*., conventional tillage. Higher tillage intensity provided better growth that is likely to induce greater translocation of photosynthates from leaves *via* stem to sink site *i.e*., siliqua and seeds.

This resulted in bigger siliqua and more seeds $siliqua^{-1}$ which becomes bold with highest test weight. These results are in accordance with the findings of Mondal *et al*. (2008) and Belal (2013).

Length of siliqua. Siliqua length increased with increasing tillage intensity from zero tillage to reduced tillage and conventional tillage during both the years. However, difference between conventional tillage and reduced tillage was statistically at par. 40 kg S ha^{-1} produced significantly highest siliqua length over control and 20 kg S ha^{-1} during 2017-18 only. Highest siliqua length (5.27 cm in 2016-17 and 5.23 cm in 2017-18) was recorded at 40 kg S ha^{-1}. For first year, 40 kg S ha^{-1} was at par with 20 kg S ha^{-1} (Table 2).

Table 1: Effect of tillage, sulphur and boron on leaf area index (LAI) of mustard.

Treatments	30 DAS		60 DAS		90 DAS	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage practices						
T_1-Conventional tillage	1.19	1.14	3.20	3.17	2.13	2.13
T_2- Zero Tillage	1.27	1.23	3.18	3.15	2.12	2.11
T_3- Reduced Tillage	1.14	1.09	3.32	3.29	2.21	2.26
SEm±	0.02	0.02	0.07	0.05	0.10	0.05
CD (P = 0.05)	0.07	0.08	NS	NS	NS	NS
Sulphur Levels (kg ha^{-1})						
S_1-0	1.16	1.11	2.78	2.79	1.75	1.74
S_2-20	1.17	1.12	3.22	3.14	2.12	2.12
S_3-40	1.28	1.23	3.71	3.68	2.59	2.64
SEm±	0.04	0.04	0.11	0.15	0.11	0.14
CD (P = 0.05)	NS	NS	0.33	0.46	0.34	0.42
Boron Levels (kg ha^{-1})						
B_1-0	1.11	1.06	3.09	3.05	2.01	2.01
B_2-1.0	1.24	1.19	3.39	3.35	2.32	2.32
B_3-2.0	1.27	1.22	3.23	3.21	2.14	2.18
SEm±	0.03	0.03	0.16	0.16	0.15	0.16
CD (P = 0.05)	0.08	0.08	NS	NS	NS	NS
Interaction						
T×S	NS	NS	NS	NS	NS	NS
T×B	NS	NS	NS	NS	NS	NS
S×B	NS	NS	NS	NS	NS	NS
T×S×B	NS	NS	NS	NS	NS	NS

Rana and Rana (2003) reported that 40 kg S ha^{-1} also increased yield attributes of mustard.

1.0 kg B ha^{-1} produced significantly highest siliqua length (5.0 and 4.97 cm) over control during 2016-17 and 2017-18, respectively and was at par with 2.0 kg B ha^{-1} during both the years. Saha *et al*. (2003) reported that siliqua length of mustard increased significantly with 1.0 kg B ha^{-1}.

Number of seeds siliqua^{-1}. Maximum seeds siliqua^{-1} was recorded with conventional tillage which was significantly higher than zero tillage during both the years. However, difference between conventional tillage and reduced tillage was statistically at par (Table 2). There was no significant effect on seeds siliqua^{-1} due to S application, however, it was higher with 40 kg S ha^{-1} over its lower doses during both the years. S had significant and positive influence on seeds siliqua^{-1} in mustard as reported by Jat *et al*. (2012) and Rana *et al*. (2005). 1.0 kg B ha^{-1} produced significantly highest seeds siliqua^{-1} (12.69 and 12.59) over control during 2016-17 and 2017-18, respectively and was at par with 2.0 kg B ha^{-1} during both the years. 1.0 kg B ha^{-1} produced significantly highest seeds siliqua^{-1} over control being at par with 2.0 kg B ha^{-1}. These results are in close conformity with those of Tahir *et al*. (2014).

1000-seed weight. Tillage caused non significant variation in 1000-seed weight at harvest stage during both the years. 1000-seed weight was maximum with conventional tillage. Minimum was noted with zero tillage during both the years (Table 2). Highest 1000-seed weight (4.24 and 4.22 g) was recorded at 40 kg S ha^{-1} during 2016-17 and 2017-18, respectively. Sah *et al*. (2013) and Rao *et al*. (2013) reported increased 1000-seed weight due to S which was due to positive role of S in oil synthesis.

1.0 kg B ha^{-1} produced significantly highest 1000-seed weight (4.09 and 4.08 g) during 2016-17 and 2017-18, respectively over control and was found at par with 2.0 kg B ha^{-1} during both the years. Increase in 1000-seed weight due to B was also in agreement with the findings of Saha *et al*. (2003). Rana *et al*. (2005) also reported that 1000-seed weight was increased by B application. B availability is essential at fruit/seed development (Stangoulis *et al*., 2001).

Seed yield. Conventional tillage gave significantly higher seed yield over zero tillage during both the years. Reduced tillage was significantly superior over zero tillage during 2017-18. Highest seed yield (10.42 and 9.61 q ha^{-1}) was recorded with conventional tillage during 2016-17 and 2017-18, respectively which was 4.61 and 10.73 % higher in 2016-17 and 5.37 and 13.99 % higher in 2017-18 over reduced and zero tillage, respectively (Table 3). Increased tillage intensity enhanced the seed and stover yield significantly in conventional tillage. The highest seed yield was recorded under conventional tillage followed by reduced tillage and zero tillage. Higher yield associated with higher tillage intensity were consistently observed because of enhanced growth and yield attributes. Positive response of mustard to conventional tillage was also reported by Saha *et al*. (2010).

Table 2: Effect of tillage, sulphur and boron on yield attributing characters of mustard.

Treatments	Length of siliqua (cm)		Number of seeds siliqua^{-1}		1000-seed weight (g)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage practices						
T_1-Conventional tillage	5.16	5.13	12.76	12.67	4.10	4.07
T_2- Zero Tillage	4.46	4.41	11.31	11.21	3.87	3.89
T_3- Reduced Tillage	4.89	4.85	12.57	12.52	3.98	3.94
SEm±	0.075	0.074	0.24	0.19	0.09	0.07
CD (P = 0.05)	0.29	0.29	0.96	0.77	NS	NS
Sulphur Levels (kg ha^{-1})						
S_1-0	4.36	4.32	11.69	11.69	3.76	3.76
S_2-20	4.88	4.84	12.26	12.17	3.95	3.92
S_3-40	5.27	5.23	12.70	12.54	4.24	4.22
SEm±	0.13	0.12	0.32	0.33	0.071	0.063
CD (P = 0.05)	0.39	0.37	NS	NS	0.22	0.25
Boron Levels (kg ha^{-1})						
B_1-0	4.59	4.55	11.50	11.42	3.79	3.79
B_2-1.0	5.00	4.97	12.69	12.59	4.09	4.08
B_3-2.0	4.91	4.87	12.46	12.39	4.07	4.04
SEm±	0.078	0.082	0.19	0.19	0.079	0.082
CD (P = 0.05)	0.22	0.24	0.55	0.53	0.23	0.24
Interaction						
T×S	NS	NS	NS	NS	NS	NS
T×B	NS	NS	NS	NS	NS	NS
S×B	NS	NS	NS	NS	NS	NS
T×S×B	NS	NS	NS	NS	NS	NS

Table 3: Effect of tillage, sulphur and boron on seed yield, stover yield and harvest index of mustard.

Treatments	Seed yield (q ha^{-1})		Stover yield (q ha^{-1})		Harvest index (%)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage practices						
T_1-Conventional tillage	10.42	9.61	27.42	26.25	28.27	27.14
T_2- Zero Tillage	9.41	8.43	24.15	22.86	27.71	26.92
T_3- Reduced Tillage	9.96	9.12	26.01	25.17	28.10	27.04
SEm±	0.16	0.16	0.60	0.65	0.28	0.57
CD (P = 0.05)	0.63	0.62	2.39	2.57	NS	NS
Sulphur Levels (kg ha^{-1})						
S_1-0	8.69	7.81	21.57	20.40	27.40	26.54
S_2-20	10.45	9.51	27.54	26.59	27.72	26.55
S_3-40	10.65	9.85	28.47	27.29	28.96	28.00
SEm±	0.27	0.29	0.59	0.62	0.54	0.68
CD (P = 0.05)	0.82	0.91	1.84	1.92	NS	NS
Boron Levels (kg ha^{-1})						
B_1-0	8.80	7.98	22.09	21.36	27.51	26.57
B_2-1.0	10.59	9.75	27.86	26.76	28.79	27.54
B_3-2.0	10.40	9.44	27.63	26.16	27.79	26.98
SEm±	0.25	0.24	0.60	0.53	0.70	0.62
CD (P = 0.05)	0.71	0.70	1.73	1.54	NS	NS
Interaction						
T×S	S	S	S	S	NS	NS
T×B	NS	NS	NS	NS	NS	NS
S×B	NS	NS	NS	NS	NS	NS
T×S×B	NS	NS	NS	NS	NS	NS

Significantly highest seed yield (10.65 and 9.85 q ha^{-1}) was recorded with 40 kg S ha^{-1} over control and was at par with 20 kg S ha^{-1} during 2016-17 and 2017-18, respectively. Increase in seed yield due to S levels was mainly due to increased formation of reproductive structure for strengthening sink and boosted photosynthesis and carbohydrate metabolism which led to improved sink *i.e*., siliqua and seeds. Enhancement in seed yield due to S was also reported by Suresh *et al*. (2002) that might be due to photosynthates translocation resulted into higher seed yield. These results are in conformity with Sharma and Singh (2005). Significantly highest seed yield (10.59 and 9.75 q ha^{-1}) was recorded with 1.0 kg B ha^{-1} over control and was at par with 2.0 kg B ha^{-1} during 2016-17 and 2017-18, respectively. This was mainly due to involvement of B in cell division and enzyme activation. With the increment in supply of essential micronutrients to mustard, their availability, acquisition, mobilization and influx into plant tissues increased and thus improved growth, yield attributes and finally yield (Singh and Pal, 2011).

Stover yield. The highest stover yield (27.42 and 26.25 q ha^{-1}) was recorded with conventional tillage during 2016-17 and 2017-18, respectively which was 5.42 and 13.54% higher in 2016-17 and 4.29 and 14.82% higher in 2017-18 over reduced tillage and zero tillage, respectively (Table 3). However, the difference between conventional and reduced tillage was statistically at par. Increase in yield due to increase in intensity of tillage might be attributed due to cumulative effect of increase in dry matter and branches $plant^{-1}$. These results are in conformity with the findings of Belal (2013). Application of 40 kg S ha^{-1} produced significantly highest stover yield (28.47 and 27.29 q ha^{-1}) over control and was at par with 20 kg S ha^{-1} during 2016-17 and 2017-18, respectively. Increase in stover yield due to S use in mustard involved in synthesis of cystine, cysteine and methionine, S-containing amino acids required for protein synthesis. It is also involved in chlorophyll synthesis. 1.0 kg B ha^{-1} produced significantly highest stover yield (27.86 and 26.76 q ha^{-1}) over control and was at par with 2.0 kg B ha^{-1} during 2016-17 and 2017-18, respectively. Improved stover yield with increase in tillage intensity. B enhanced more nutrient uptake, greater photosynthetic/metabolic activity led to more vegetative growth and stover yield (Singh and Pal, 2011).

Harvest index (HI). The effect of tillage on HI was found non-significant at harvest. Maximum HI (28.27 and 27.14) was noted from conventional tillage during 2016-17 and 2017-18, respectively (Table 3). HI increased from zero to conventional tillage. These findings were supported by Mondal *et al*. (2008).

S levels did not cause any significant variation in HI. 40 kg S ha^{-1} exhibited maximum HI (28.96 and 28.00) during 2016-17 and 2017-18, respectively. HI increased gradually with increasing B doses up to 1.0 kg ha^{-1} and at subsequent 2.0 kg B ha^{-1}, it declined during both the years.

C. Economics

Cost of cultivation. Zero tillage resulted in its minimum cost of cultivation (Rs. 16047 and 17255 ha^{-1}) during 2016-17 and 2017-18, respectively. It increased with corresponding increase in S levels from 0 to 40 kg ha^{-1} and B levels from 0 to 2.0 kg ha^{-1} during both the years.

Net returns. Conventional tillage recorded highest net return (Rs. 25383 and 23564 ha^{-1}) which was significantly superior over rest of the tillage practices during 2016-17 and 2017-18, respectively (Table 4). 40 kg S ha^{-1} significantly recorded maximum net return (Rs. 25931 and 24216 ha^{-1}) during 2016-17 and 2017-18, respectively; being at par with 20 kg S ha^{-1}. Among B levels, highest net return (Rs. 26743 and 25025 ha^{-1}) was noted with 1.0 kg B ha^{-1} which was significantly superior over rest of B levels. Differences in net returns under tillage practices, S and B levels were largely due to differences in seed and stover yield while cost of cultivation was also different.

B:C ratio. The highest B:C ratio (1.42 and 1.23) was obtained with conventional tillage which was significantly superior over rest of the tillage practices during 2016-17 and 2017-18, respectively. B: C ratio increased with corresponding increase in S levels up to 20 kg ha^{-1}. Maximum B: C ratio (1.53 and 1.32) was found at 20 kg S ha^{-1} which was significantly superior over control and was at par with 40 kg S ha^{-1} during 2016-17 and 2017-18, respectively. Similarly, highest B: C ratio (1.58 and 1.38) was obtained with 1.0 kg B ha^{-1} during 2016-17 and 2017-18, respectively which was significantly superior over remaining B levels.

Table 4: Effect of tillage, sulphur and boron on cost of cultivation, net return and benefit: cost ratio of mustard.

Treatments	Cost of cultivation (Rs. ha^{-1})		Net return (Rs. ha^{-1})		B:C ratio	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage practices						
T_1- Conventional tillage	17647	18855	25383	23564	1.42	1.23
T_2- Zero Tillage	16047	17255	19938	17603	1.25	1.02
T_3- Reduced Tillage	16847	18055	23788	22266	1.40	1.22
SEm±	-	-	705	661	0.040	0.035
CD (P = 0.05)	-	-	2770	2597	0.16	0.14
Sulphur Levels (kg ha^{-1})						
S_1-0	15736	16944	17505	15329	1.11	0.90
S_2-20	16847	18055	25673	23888	1.53	1.32
S_3-40	17958	19166	25931	24216	1.43	1.25
SEm±	-	-	734	867	0.042	0.047
CD (P = 0.05)	-	-	2262	2671	0.13	0.15
Boron Levels (kg ha^{-1})						
B_1-0	15957	17165	18486	16419	1.15	0.95
B_2-1.0	16847	18055	26743	25025	1.58	1.38
B_3-2.0	17737	18945	23880	21989	1.33	1.15
SEm±	-	-	751	832	0.043	0.044
CD (P = 0.05)	-	-	2155	2387	0.12	0.13
Interaction						
T×S			NS	NS	NS	NS
T×B			NS	NS	NS	NS
S×B			NS	NS	NS	NS
T×S×B			NS	NS	NS	NS

CONCLUSION

Hence it might be concluded that use of 20 kg S ha^{-1} and 1.0 kg B ha^{-1} under conventional tillage recorded highest seed yield and benefit: cost ratio of mustard besides significant improvement in growth and yield attributes in context to S and B nutrition at various tillage practices.

FUTURE SCOPE

Future research strategy may be focused on effect of S & B source of either basal or foliar form on the performance of rainfed mustard in zero tillage practice.

Acknowledgements. The authors are very grateful to Hon'ble Vice Chancellor, Directorate of Research, BAU, Department of Agronomy, Bihar Agricultural College, Sabour for providing financial support and consistent encouragement to carry out the research work.

Conflict of interest. None.

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How to cite this article: Shashank Tyagi*, Vinod Kumar, Sushant and M.K. Singh (2022). Effect of Tillage Practices, Sulphur and Boron Application on Growth, Yield and Economics of Mustard. *Biological Forum – An International Journal, 14*(1): 1370-1375.