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Effect of Moisture Conservation Practices and Nutrient Management on Growth, Yield and Oil Content of Mustard

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ABSTRACT: A field experiment was conducted during *rabi* season of 2016-17 and 2017-18 at Bihar Agricultural University research farm, Sabour, Bhagalpur with objective to find out the effect of moisture conservation practices and nutrient management on growth, yield and oil content of mustard. The experiment comprised of three tillage practices (conventional tillage, zero tillage and reduced tillage) in main plot while three S doses (0, 20 and 40 kg ha^{-1}) in sub plots and three B doses (0, 1.0 and 2.0 kg ha^{-1}) in sub sub plots were laid out in split split plot design with three replications. Results indicated that conventional tillage recorded significantly maximum number of siliqua plant^{-1} (293.81) and seed yield (10.02 q ha^{-1}). Significantly highest number of siliqua plant^{-1} (301.63) and seed yield (10.25 q ha^{-1}) was recorded at 40 kg S ha^{-1}. The highest number of siliqua plant^{-1} (298.09) and seed yield (10.17 q ha^{-1}) was recorded with 1.0 kg B ha^{-1} which was at par with 2.0 kg B ha^{-1}. T_1B_3 was the best in terms of highest number of siliqua plant^{-1} (319.06); being at par with T_1B_2 and T_3B_2. $T_1B_2S_3$ was the best in terms of highest number of siliqua plant^{-1} (365.17); being at par with $T_1B_3S_3$ and $T_1B_3S_2$. $T_1S_3B_2$ and $T_2S_3B_2$ was the best in terms of highest oil content in seed (43.55%) which were at par with $T_1S_3B_3$ and $T_3S_3B_2$.

Keywords: Boron, Conventional tillage, Mustard, Reduced tillage, Sulphur, Zero tillage.

INTRODUCTION

Indian mustard is cultivated as rainfed during winter (*rabi*) season using profile-stored soil moisture. However, productivity of rainfed mustard is too low which may be largely due to lack of inadequate soil and water management with reference to water shortage in soil profile. Among them, tillage practices play an important role in enhancing and economizing the mustard productivity. Among different tillage practices, conventional tillage resulted into higher growth parameters and yield of mustard (Poddar and Kundu 2007). Tillage is an important agronomic practice and plays vital role in soil moisture conservation at different depths in rainfed cultivation. It also improves soil condition by altering mechanical impedance to root penetration, hydraulic conductivity and water holding capacity, which in turn affects plant growth.

Rapeseed and mustard has the highest requirement of sulphur among all the oilseed crops. Response of mustard to S is determined by moisture availability, soil S status and yield level. S is involved in oil synthesis and physiological functions like amino acid synthesis, component of vitamin A and activates enzyme system in plant (Havlin et al., 2004). Boron is required in lesser quantities by most of the field crops, but it affects the crop yield to greater extent. There are numerous reports on the positive response of mustard to B fertilization (Islam, 2005). Seed yield is greatly influenced by boron particularly, where soil is deficient in B. They reported that B increased number of siliqua and yield of mustard. Keeping these issues in view, the present investigation was undertaken to find out effect of moisture conservation practices and nutrient management on growth, yield attributes, yield and oil content 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 at latitude of 25°15'40″N and longitude 87°2'42″E with an altitude of 37.46 meters above mean sea level to find out effect of moisture conservation practices and nutrient management on growth, yield attributes, yield and oil content of mustard. The experimental plot was sandy loam in texture, low in available nitrogen (230.35 kg ha^{-1}) and phosphorus (23.9 kg ha^{-1}) and medium in available potassium (143.4 kg ha^{-1}), medium in available sulphur (13.26 ppm) and low in available boron (0.44 ppm). The experiment consisted of twenty seven treatment combinations comprising three tillage practices *viz.*, conventional tillage, zero tillage and reduced tillage place in main plot, whereas three doses of sulphur *i.e.* 0, 20 and 40 kg ha^{-1} in sub plots and three doses of boron *i.e.* 0, 1.0 and 2.0 kg ha^{-1} in sub sub plots. The experiment was laid out in split split plot design with three replications.

Conventional tillage system was required thorough field preparation before sowing that was accomplished by one deep ploughing with cultivator, two harrowing and planking. In reduced and zero tillage system, seeds were sown in rows with the help of hand operated narrow blade (*Kudal*) by opening furrow. Recommended dose of NPK *viz.*, 40 kg N, 20 kg P_2O_5 and 20 kg K_2O ha^{-1} was applied uniformly. Full dose of nitrogen and full dose of phosphorus and potassium was applied as basal dressing as basal. Sulphur was applied through bentonite sulphur and boron through boron fertilizer as per treatment as basal.

Data on growth (plant height**)**, yield attributes (number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$ and number of siliqua $plant^{-1}$), seed yield and oil content 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. The data of two years 2016-17 and 2017-18 were pooled and analysed.

RESULTS AND DISCUSSION

Growth parameters of mustard

Plant height. Plant height increased progressively with the advancement in the age of mustard irrespective of treatments. Tillage practices influenced the height significantly at harvest. Highest height was recorded with conventional tillage which was significantly higher than rest of the tillage practices except reduced tillage (Table 1). The increasing the intensity of tillage operations markedly influenced the plant height. All the growth parameters improved with conventional tillage at most of the growth stages during the experimentation. This supports the well-established fact that a fine seed bed is very much essential for good germination, growth and development of plant for getting better yield. Conventional tillage produced highest plant height at 90 days after sowing and at harvest over other methods of tillage practices. These results are in conformity with the findings of Saha *et al.* (2010); Belal (2013).

Application of 40 kg S ha^{-1} increased the plant height significantly caused an increase of 3.59 and 3.32 cm over control, respectively at 60 and 90 DAS though the difference between 20 and 40 kg S ha^{-1} was not significant. Increasing levels of B up to 1.0 kg ha^{-1} significantly increased the height at 60 and 90 DAS registered an increase of 3.25 and 4.14 cm over control, respectively. However, the difference between 1.0 and 2.0 kg B ha^{-1} was not significant.

Maximum plant height was recorded at 40 kg S ha^{-1}. The rate of increase in plant height was more with higher dose of S application perhaps due to increased metabolic processes in plant with sulphur application which seems to have promoted meristematic activities resulting in higher apical growth and expansion of photosynthetic surface (Piri *et al.*, 2011). Increase in plant height with an increase in dose of sulphur application has also been reported by Rana *et al*. (2005). These results are also in close conformity with the results of Verma *et al.* (2012). The rate of increase in plant height was more at 60 kg S ha^{-1} due to better nutritional environment for plant growth at active vegetative stages as a result of improvement in root growth, cell multiplication, elongation and cell expression in the plant body (Kumar and Yadav 2007) which ultimately increased the plant height.

The maximum plant height was recorded with 1.0 kg B ha^{-1} as compared to control (no boron). Verma et al. (2012) also found significant effect of boron application on plant height in mustard. This might be due to role of B in cell elongation, photosynthesis and translocation of photosynthates (Stangoulis *et al.*, 2001).

Table 1: Effect of tillage, sulphur and boron on plant height (cm) of mustard (Pooled mean over two years)

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
Tillage practices				
T_1-Conventional tillage	44.67	138.30	162.66	168.62
T_2- Zero Tillage	46.73	140.65	160.38	166.50
T_3- Reduced Tillage	46.53	140.36	161.44	168.21
SEm±	0.67	0.46	0.50	0.48
CD (P = 0.05)	NS	1.51	1.64	1.58
Sulphur levels (kg ha^{-1})				
S_1-0	44.40	137.51	159.54	165.51
S_2-20	46.52	140.69	162.08	168.51
S_3-40	47.01	141.10	162.86	169.32
SEm±	0.76	0.83	0.77	1.12
CD (P = 0.05)	NS	2.44	2.24	NS
Boron levels (kg ha^{-1})				
B_1-0	44.24	137.67	158.83	165.25
B_2-1.0	46.97	140.92	162.97	169.12
B_3-2.0	46.72	140.71	162.67	168.96
SEm±	0.65	0.69	0.85	0.89
CD (P = 0.05)	1.82	1.93	2.39	2.52
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

Yield and yield attributes of mustard. Yield attributing characters viz., number of primary branches plant^{-1}, number of secondary branches plant^{-1} and number of siliqua plant^{-1} were markedly higher at higher intensity of tillage.

Number of primary branches plant^{-1}. The effect of tillage practices on primary branches plant^{-1} was found non significant at harvest. Primary branches plant^{-1} were observed maximum (6.19) from conventional tillage (Table 2). Application of 40 kg S ha^{-1} produced significantly highest primary branches plant^{-1} (6.54). Different B levels caused significant variation in primary branches plant^{-1}. Application of 1.0 kg B ha^{-1} exhibited maximum primary branches plant^{-1} (6.26) which was at par with 2.0 kg B ha^{-1}.

Table 2: Effect of tillage, sulphur and boron on yield attributing characters and seed yield of mustard (Pooled mean over two years)

Treatments	Yield attributing characters			Seed yield (q ha^{-1})
	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Number of siliqua plant^{-1}	
Tillage practices				
T_1-Conventional tillage	6.19	26.95	293.81	10.02
T_2- Zero Tillage	5.92	25.53	262.83	8.92
T_3- Reduced Tillage	6.12	26.78	276.74	9.54
SEm±	0.11	0.57	3.23	0.11
CD (P = 0.05)	NS	NS	10.55	0.37
Sulphur levels (kg ha^{-1})				
S_1-0	5.76	25.84	257.43	8.25
S_2-20	5.94	26.39	274.33	9.98
S_3-40	6.54	27.02	301.63	10.25
SEm±	0.14	0.40	7.81	0.37
CD (P = 0.05)	0.42	NS	22.78	1.08
Boron levels (kg ha^{-1})				
B_1-0	5.76	25.38	250.26	8.39
B_2-1.0	6.26	27.06	298.09	10.17
B_3-2.0	6.21	26.82	285.04	9.92
SEm±	0.07	0.39	5.00	0.17
CD (P = 0.05)	0.19	1.10	14.10	0.49
Interaction				
T×S	S	NS	NS	NS
T×B	S	NS	S	NS
S×B	NS	NS	NS	NS
T×S×B	NS	NS	S	NS

Table 3: Effect of tillage and sulphur on number of primary branches plant^{-1} of mustard (Pooled mean over two years)

Tillage practices / Sulphur levels (kg ha^{-1})	S_1-0	S_2-20	S_3-40
T_1-Conventional tillage	5.81	5.65	7.10
T_2- Zero Tillage	5.76	5.50	6.51
T_3- Reduced Tillage	5.70	6.67	6.00
SEm±	0.25		
CD (P=0.05)	0.73		

Table 4: Effect of tillage and boron on number of primary branches plant^{-1} of mustard (Pooled mean over two years)

Tillage practices / Boron levels (kg ha^{-1})	B_1-0	B_2-20	B_3-40
T_1-Conventional tillage	6.16	6.23	6.17
T_2- Zero Tillage	5.30	6.30	6.17
T_3- Reduced Tillage	5.83	6.24	6.30
SEm±	0.12		
CD (P=0.05)	0.33		

Treatment combination of T_3S_2 was found the best in terms of highest primary branches plant^{-1} (6.67) which was at par with T_2S_3 and T_3S_3 as depicted in Table 3. Treatment combination of T_2B_2 and T_3B_3 was found significantly the best in terms of highest primary branches plant^{-1} (6.30) as presented in Table 4.

Number of secondary branches plant^{-1}. Effect of tillage and S levels on number of secondary branches plant^{-1} was not significant at harvest. However, maximum number of secondary branches plant^{-1} (26.95 and 27.02) was recorded from conventional tillage and 40 kg S ha^{-1}, respectively (Table 2). Application of 1.0

kg B ha^{-1} exhibited highest secondary branches plant^{-1} (27.06) at harvest which was at par with 2.0 kg B ha^{-1}. Conventional tillage produced highest number of branches i.e. both primary and secondary branches as compared to reduced and zero tillage. The number of branches plant^{-1} declined with the intensity of tillage from conventional to zero tillage that might be because of the reason that better soil characteristics had promoted better root growth, shoot growth and higher number of branches. These results are in conformity with the findings of Belal (2013); Mondal *et al*. (2008).

Number of siliqua plant^{-1}

Yield attributing character like number of siliqua plant^{-1} was found to be significantly highest under conventional tillage (Table 2). Increasing the intensity of tillage from zero to reduced tillage and conventional tillage progressively increased number of siliqua plant^{-1} up to level of significant resulted into maximum siliqua (293.81) under conventional tillage. Significantly highest number of siliqua plant^{-1} (301.63) was recorded at 40 kg S ha^{-1}. The highest number of siliqua plant^{-1} (298.09) was recorded with 1.0 kg B ha^{-1} which was at par with 2.0 kg B ha^{-1}.

Table 5: Effect of tillage and boron on number of siliqua plant^{-1} of mustard (Pooled mean over two years)

Boron levels (kg ha^{-1}) / Tillage practices	B_1-0	B_2-20	B_3-40
T_1-Conventional tillage	252.50	309.89	319.06
T_2- Zero Tillage	246.78	278.72	263.00
T_3- Reduced Tillage	251.50	305.67	273.06
SEm±	8.66		
CD (P=0.05)	24.43		

Table 6: Interaction effect of tillage, sulphur and boron on number of siliqua plant^{-1} of mustard (Pooled mean over two years)

Tillage practices	T_1-CT			T_2-ZT			T_3-RT		
S levels (kg ha^{-1}) / B levels (kg ha^{-1})	S_1-0	S_2-20	S_3-40	S_1-0	S_2-20	S_3-40	S_1-0	S_2-20	S_3-40
B_1-0	262.67	235.33	259.50	252.83	251.67	235.83	186.17	276.33	292.00
B_2-1.0	282.67	281.83	365.17	281.50	272.50	282.17	292.67	311.50	312.83
B_3-2.0	250.17	342.50	364.50	226.17	240.33	322.50	282.00	257.00	280.17
SEm±	15.01								
CD (P=0.05)	42.31								

Treatment combination of T_1B_3 was found the best in terms of highest number of siliqua plant^{-1} (319.06); being at par with T_1B_2 and T_3B_2 as depicted in Table 5. Treatment combination of $T_1B_2S_3$ was found the best in terms of highest number of siliqua plant^{-1} (365.17); being at par with $T_1B_3S_3$ and $T_1B_3S_2$ as presented in Table 6.

The higher number of siliqua at main shoot at conventional tillage is attributed due to taller plant and thereby longer central axis at higher intensity of tillage operations due to better growth condition. The increase in number of siliqua plant^{-1} may be explained due to increase in number of branches plant^{-1} under higher tillage levels. With conventional tillage due to better vegetative growth and initial establishment, the tissue differentiations from somatic to reproductive, meristematic activity and development of flowers occurred which later developed into siliqua. These results are in accordance with the findings of Mondal *et al.* (2008) ; Belal (2013).

Seed yield of mustard. Increasing the intensity of tillage from zero to reduced tillage and conventional tillage progressively increased the seed yield of mustard up to the level of significance resulted into maximum seed yield (10.02 q ha^{-1}) under conventional tillage. Significantly highest seed yield (10.25 q ha^{-1}) was recorded at 40 kg S ha^{-1}. However, in case of boron application; the highest seed yield (10.17 q ha^{-1}) was recorded with 1.0 kg B ha^{-1} which was at par with 2.0 kg B ha^{-1}.

Conventional tillage gave significantly higher seed yield over zero tillage. Reduced tillage was significantly superior over zero tillage. Highest seed yield (10.02 q ha^{-1}) was recorded in conventional tillage that was 5.03 and 12.33 % higher over reduced and zero tillage, respectively (Table 2). Increased tillage intensity enhanced seed yield significantly in conventional tillage. Highest seed yield was recorded in conventional tillage followed by reduced and zero tillage. Higher yield associated with higher tillage intensity was because of enhanced growth and yield attributes. Positive response of mustard to conventional tillage was reported by Saha et al. (2010).

Significantly highest seed yield (10.25 q ha^{-1}) was recorded with 40 kg S ha^{-1} over control and was found at par with 20 kg S ha^{-1}. 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 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 (10.17 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}. 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).

Oil content in seed. Interaction between tillage, sulphur and boron (T×S×B) was significant for oil content in seed (Table 7). Treatment combinations of $T_1S_3B_2$ and $T_2S_3B_2$ were found the best in terms of highest oil content (43.55 %) in seed which were found at par with $T_1S_3B_3$ and $T_3S_3B_2$. Similar results were also reported by Houx *et al*. (2014); Gaweda *et al*. (2016).

Table 7: Interaction effect of tillage, sulphur and boron on oil content (%) in seed of mustard (Pooled mean over two years)

Tillage practices	T_1-CT			T_2-ZT			T_3-RT		
S levels (kg ha^{-1}) / B levels (kg ha^{-1})	S_1-0	S_2-20	S_3-40	S_1-0	S_2-20	S_3-40	S_1-0	S_2-20	S_3-40
B_1-0	36.73	37.08	38.98	39.15	37.25	39.08	36.98	39.15	38.25
B_2-1.0	40.12	41.55	43.55	41.05	41.12	43.55	40.55	41.05	42.12
B_3-2.0	39.35	39.98	43.52	40.12	40.35	41.98	39.52	40.45	41.18
SEm±	0.54								
CD (P=0.05)	1.51								

Oil content in seed of mustard was significantly increased with increase in levels of sulphur during both the years which was probably due to beneficial role of sulphur in fatty acid biosynthesis. The oil content was maximum due to higher concentration of S. Many researchers described the positive effect of sulphur on oil content of mustard as reported by Dash and Ghosh (2012); Piri and Sharma (2006); Kumar and Yadav (2007). Application of 1.0 kg B ha^{-1} produced significantly highest oil content over control and 2.0 kg B ha^{-1}. Similar results were also observed by Dinesh and Sudkep (2009) who reported that increase in oil content and other quality parameters with combined application of B and S. Mallick and Raj (2015) noticed that seed oil content was significantly enhanced with S and B application up to 20 kg S ha^{-1} and 1.0 kg B ha^{-1}, respectively.

CONCLUSIONS

Thus, it might be concluded that application of 20 kg S ha^{-1}, 1.0 kg B ha^{-1} and conventional tillage practice enhanced highest seed yield and oil content of mustard apart from improving growth and yield attributes of the crop.

FUTURE SCOPE

Future research options must be focused on response of zero tilled mustard to local as well as improved varieties and application of micronutrient mixture in order to get balanced nutrition and better yield advantages

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