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Response of mustard (*Brassica juncea* L.) to clay mixing and irrigation under sulphur nutrition

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ABSTRACT

A field experiment on response of mustard (Brassica- juncea L.) to clay mixing and irrigation under sulphur nutrition was conducted at farmers field, Jobner (Rajasthan) during Rabi seasons 2016-17 and 2017-18. The experiment consisted of 3 levels of clay mixing (0, 1 and 2 %), 3 levels of irrigation [1 irrigation at flowering stage, 2 irrigations at flowering and pod filling stages and 3 irrigations at branching, flowering and pod filling stages] as main plot treatments and 4 levels of sulphur (0, 30, 60 and 90 kg S ha^{-1}) as sub plot treatments was laid out in split plot design with three replications. The results indicated that application of 2 per cent clay gave significantly higher growth, yield attributes and yield over control and 1 per cent clay. The increase in seed and stover yield due to 2 % clay addition were 33.0 and 32.0 %, respectively over control (no clay addition). Application of 3 irrigations resulted in significantly higher growth, yield attributes and yield but remained at par with 2 irrigations in siliqua per plant, seed and stover yield over the control. The mean seed (1809 kg ha^{-1}) and stover (4761 kg ha^{-1}) yields with three irrigations were 38.0 and 36.6 % higher than the one irrigation. The application of 60 S kg ha^{-1} gave significantly higher growth; yields attributes and yield over control. Application of 60 kg S ha^{-1} resulted in 32.3 % higher seed yield (1727 kg ha^{-1}) over the yield obtained in control (1169 kg ha^{-1}). Similar increase in stover yield was recorded with 60 kg S ha^{-1} by 31.2 % over control. The content of protein and oil also improved with clay, three irrigations and sulphur application. The uptake of nutrients (N, P and K) by seed and stover of mustard increased significantly with increasing levels of clay and irrigation. The maximum uptake of nutrients was recorded with 60 kg S ha^{-1}.

Key words: Clay, irrigation, mustard, sulphur, yield

INTRODUCTION

Indian mustard (*Brassica- juncea* L.) is the most important edible oilseed crop after groundnut and soybean. It plays an important role in the oilseed economy of the country. There is great scope for increasing the production of mustard by bringing more area under cultivation and increasing its productivity by balanced fertilization, scheduling irrigation at most critical growth stages and maintaining soil fertility status as well as soil moisture conservation. Barriers such as asphalt and bentonite clay were used successfully to control the movement of water and to increase the yield of vegetable crops. A reduction in the permeability can also be brought about by mixing locally available heavy textured soil (claying) into sandy soil which increases moisture storage and nutrient retention capacity of sandy soil besides, improving crop production (Kumawat *et al.,* 2011). Irrigation influences the crop growth directly as almost all physiological processes in plant take place in aqueous media. Crops need water in large quantities and at specific and at specific intervals. Improper scheduling and over irrigation often led to reduction in crop yields. In recent years water resources have become scarce due to expansion in cultivated area and poor recharge of ground water table especially in the arid and semi-arid areas of Rajasthan. In such areas instead of intensive irrigation over a limited area, the right approach would be to serve maximum area with reduced irrigation intensive in order to increase the overall production and the irrigation water use efficiency per unit amount of water which can be ensured by irrigating the crop at such phenological stages of growth which are very critical in their demand for water so that crop growth and quality do not suffer seriously. However, so far it is not very clear that which stages are most critical from irrigation point of view at which the crop must receive irrigation. The soils of this region are light textured and deficient in sulphur. Sulphur plays a multiple role in nutrition. Sulphur uptake and assimilation in rapeseed mustard are crucial for determining yield, oil, quality and resistance to various

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stresses. Among the oilseed crops, rapeseed-mustard has the highest requirement of S. Sulphur plays an important role in the formation of S-containing amino acid like cystine, cysteine and methionine which act as building blocks in the synthesis of proteins. Hence, the present investigation was undertaken to explore the possibilities of improving moisture storage capacity and sulphur utilization besides improving the yield of mustard in sandy soils through soil management practices like mixing of clay or claying.

MATERIALS AND METHODS

A field experiment was conductedfor two consecutive years during *rabi* season of 2016-17 and 2017-18, at farmers field, Jobner (Rajasthan). The soil was loamy sand in texture, alkaline in reaction (pH 7.8), low in organic carbon (3.4 g kg^{-1}), available nitrogen (154 kg ha^{-1}), available phosphorus (19.7 kg P_2O_5 ha^{-1}) and medium in potassium (152 kg K_2O ha^{-1}) and available sulphur (17.2 kg ha^{-1}) content. The experiment comprised of 36 treatment combinations having three levels of clay mixing (0, 1 and 2 % clay in the form of heavy textured soil on the basis of per hectare furrow slice), three levels of irrigation on the basis of deletion of irrigation at phenological stages of crop (1 irrigation at flowering stage, 2 irrigations at flowering and pod filling stages and 3 irrigations at branching, flowering and pod filling stages)as main plot treatments and four levels of sulphur (0, 30, 60 and 90 kg S ha^{-1} through gypsum) as sub plot treatments in split plot design. Fertilizers were applied as per treatment through DAP and urea at the time of sowing as basal dose. Seeds of mustard Bio-902 were sown using seed rate of 4 kg ha^{-1} in rows spaced at 30 cm apart with the help of bullock drawn 'deshi' plough. One spray of methyl parathion @ 2 per cent was done to protect the crop from insects as per schedule during both the years. Intercultural operations *viz.*, thinning, hoeing and weeding were followed after 20 days of sowing to maintain recommended spacing and weed control. Growth and yield attributes were recorded at maturity. Seed and stover yields of mustard were recorded at harvest. The seed and stover samples were analyzed for their N, P and S contents by adopting standard procedures (Jackson, 1973). The protein content was obtained by multiplying N content with a constant factor of 6.25. The uptake of nutrients was computed from their content values with yield data. The oil content in seeds of mustard was determined by Soxhlets extraction method. The data thus obtained were analyzed statistically using analysis of variance technique for various parameters at 5 % level of significance.

RESULTS AND DISCUSSION

Growth attributes

Application of 2 per cent clay gave significantly higher plant height and number of branches over no clay addition (Table 1). The incorporation of clay increased the total pore space and capillary pore space because of improvement in soil texture and thereby reduced the percolation losses consequently leading to higher water. Thus, the increased availability of moisture and nutrients to the plant under the influence of applied clay might have helped the plant in greater absorption and their efficient utilization in vegetative growth. These findings corroborate with the results of Kumawat *et al.* (2011). The plant height and number of branches were significantly higher with the application of three irrigations over rest of the treatments (Table 1). During linear phase of development at the time of sufficient moisture availability, enough assimilates might have produced that used up by the plant in the growth and development and thus the excess diverted towards storage compounds. These findings are in agreement with the results of Mehta *et al.*(2010). Application of 60 kg S ha^{-1} gave significantly higher plant height and number of branches over control (Table 1). This increase may be due to involvement of S in biosynthesis of indole-3 acetic acid. Similar results were reported by Singh *et al.* (2020).

Yield attributes and yield

Incorporation of 2 % clay to soil resulted in significantly maximum number of siliquae per plant (203.6), seeds per siliquae (12.90), test weight (4.96) of mustard and minimum values of these characters were noted under no clay addition (Table 1). This increase in yield attributes may be attributed to greater moisture absorption by the plant under the influence of clay. Kumawat *et al.* (2011) also reported similar

Table 1: Effect of clay mixing, irrigation and sulphur levels on growth, yield attributes and yield of mustard (Pooled over 2 years)

Treatments	Plant height (cm)	Branches plant^{-1}		Siliquae plant^{-1}	Seeds siliqua^{-1}	Test weight (g)	Yield (kg ha^{-1})	
		Primary	Secondary				Seed	Stover
Clay levels (%)								
0	132.5	4.11	10.01	124.9	10.06	4.22	1209	3231
1	179.3	5.83	11.88	186.9	11.97	4.68	1569	4151
2	191.8	6.39	12.47	203.6	12.90	4.96	1805	4758
SEm±	3.0	0.13	0.13	2.3	0.17	0.05	20	53
CD (P=0.05)	8.6	0.38	0.38	6.6	0.50	0.14	58	154
Irrigation levels								
I_1	138.3	4.51	10.44	125.9	10.43	4.23	1121	3014
I_2	169.3	5.23	11.25	191.4	11.79	4.69	1653	4365
I_3	196.1	6.59	12.67	198.1	12.71	4.95	1809	4761
SEm±	3.0	0.13	0.13	2.3	0.17	0.05	20	53
CD (P=0.05)	8.6	0.38	0.38	6.6	0.50	0.14	58	154
Sulphur (kg ha^{-1})								
0	133.8	4.27	10.27	135.7	9.63	4.19	1169	3128
30	166.2	5.01	11.01	163.4	10.91	4.57	1454	3856
60	183.6	6.18	12.20	191.7	12.72	4.81	1727	4553
90	187.9	6.31	12.35	196.3	13.31	4.92	1761	4649
SEm±	2.3	0.12	0.13	1.82	0.16	0.04	13	35
CD (P=0.05)	6.3	0.35	0.36	5.11	0.46	0.11	37	99

results. The seed and stover yield of mustard increased significantly with levels of clay (Table 1).The mean yield of seed and stover increased by 33.0 and 32.0 % with 2 % clay over no clay addition, respectively. This increase may be attributed to increased availability of nutrients and moisture to plants which results in increased growth and development of reproductive parts. Similar results were reported by Kumawat *et al.*(2011). The yield attributes were significantly higher with three irrigations over one irrigation. This increase in yield attributes may be ascribed to increased moisture which might have increased the yield attributes, (Mehta *et al.*2010). The highest seed and stover yields were recorded with three irrigations which registered 38.0 and 36.6 % higher yield over one irrigation, respectively. The increase in yield owing to irrigation may be ascribed to improved growth and yield attributes and yield is directly related to these attributes. These findings are in agreement with those of Mehta *et al.* (2010). The application of 60 kg S ha^{-1} had significantly higher number of siliquae per plant, seed and stover yield over control and 30 kg S ha^{-1} but remained at par with 90 kg S ha^{-1}. The increase in seed yield due to 60 and 90 kg S ha^{-1} over control were 32.3 and 33.6%, respectively. The corresponding increase in stover yield was 31.2 and 32 7%, respectively. The sulphur promotethe carbohydrate metabolism and translocated in reproductive structures as reflected through improvement in yield attributes and yield. With increasing supply of sulphur, the process of tissue differentiation from somatic to reproductive, meristematic activity and developmental of floral primordial might have increased, resulting in more flowers, pods and higher seed yield as reported by Basumatary *et al.*(2019). Singh *et al.* (2020) also reported an increase in growth and yield characters of mustard by increasing levels of sulphur.

Nutrient uptake and quality

The N, P and S uptake by mustard seed and stover increased significantly with increased clay incorporation (Table 2). This increase in N, P and S uptake by mustard could be attributed to increased moisture and nutrient availability in the rhizosphere due to improvement in moisture retention and availability of nutrient and consequently reduction in infiltration rate, non-capillary pore space and increase in capillary pore space under mixing of clay. Thus, these beneficial effects coupled with sulphur fertilization improved overall nutritional environment in the rhizosphere thereby leading to higher uptake of nutrients in general and S in particular by the plants for their efficient vegetative and reproductive growth and ultimately enhanced the uptake of N, P and S in both seed and straw of mustard. These results are in conformity with those of Piri *et al.*(2019) who had reported that N and S uptake by seed and straw of groundnut was increased significantly by mixing of clay in sandy soil. The protein content, being the function of N content and seed yield increased significantly with the increasing N content in seed. The increase in oil content was higher under mixing of 2 % clay over no clay and 1 % clay.

Table 2: Effect of clay mixing, irrigation and sulphur levels on nutrient uptake by mustard (Pooled over 2 years)

Treatments	Protein content in seed	Oil content (%) in seed	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		S uptake (kg ha^{-1})	
			Seed	Stover	Seed	Stover	Seed	Stover
Clay levels (%)								
0	17.20	33.37	33.6	17.9	6.2	7.5	8.5	12.3
1	18.05	34.91	45.8	24.3	8.6	10.8	12.0	17.3
2	18.59	36.21	54.3	27.9	10.2	13.3	14.2	20.8
SEm±	0.09	0.26	0.79	0.40	0.15	0.26	0.18	0.32
CD (P=0.05)	0.25	0.74	2.27	1.14	0.43	0.74	0.53	0.93
Irrigation levels								
I_1	17.19	34.51	31.2	16.8	5.8	7.0	8.0	11.5
I_2	18.04	34.95	48.2	25.4	9.1	11.4	12.6	18.3
I_3	18.61	35.03	54.3	27.9	10.2	13.1	14.1	20.6
SEm±	0.09	0.26	0.79	0.40	0.15	0.26	0.18	0.32
CD (P=0.05)	0.25	NS	2.27	1.14	0.43	0.74	0.53	0.93
Sulphur (kg ha^{-1})								
0	16.95	32.82	32.1	17.2	6.0	7.1	8.3	11.7
30	17.91	34.12	42.1	22.3	7.9	9.8	10.9	15.8
60	18.39	36.03	51.3	26.9	9.6	12.4	13.4	19.6
90	18.53	36.35	52.7	27.0	9.9	12.8	13.8	20.2
SEm±	0.06	0.31	0.46	0.24	0.08	0.15	0.11	0.19
CD (P=0.05)	0.16	0.88	1.28	0.67	0.24	0.42	0.30	0.54

Significant increase in N, P and S uptake by mustard seed and stover as well as protein content in seed was observed with successive increase in number of irrigations (Table 2). The increased N, P and S uptake by crop and protein content might be due to more availability of moisture in soil which solubilized the nutrients and ultimately the plant extracted more N, P and S from soil through their extensive root growth and photosynthetic rate which resulted in more absorption and translocation of these nutrients to seed and straw. It might be due to the fact that under sufficient moisture conditions, the transpirational flux gets increased due to full stomata opening which leads to higher content and uptake of these nutrients. The increase in N, P and S uptake by crop appears to be due to the cumulative effect of increased seed and straw yield as well as their increased concentration. Similar findings were also reported by Piri *et al.* (2019) and Rana *et al.* (2019).

The N, P and S uptake by seed and stover as well as protein and oil content in seed increased significantly with an increase in the level of applied sulphur. This was mainly due to the fact that better nutrient utilization by more healthy and vigorous plants under application of sulphur resulting in more biomass production and yield, which ultimately increased the nutrient content and uptake by plant. The increased availability of nutrient coupled with higher root activity might have resulted in greater extraction of nutrients from the soil and increased photosynthesis and better translocation of photosynthates from source to various plant parts, might have resulted into increased content of nutrient in both seed and stover. The significant improvement in uptake of N, P and S in both seed and stover could be ascribed to increased seed and stover yield and their higher N, P and S content under influence of higher available nutrients status of soil. Since, uptake of nutrients being the function of nutrient content increased with increase in seed and straw yield significantly. The increase in N and S uptake of fenugreek with increasing levels of S had also been reported by Rana *et al.*(2019). Significant increase in protein content of mustard due to sulphur application as compared to that obtained under no sulphur may be attributed to the increased availability of sulphur as well as nitrogen, as both promote protein synthesis. The beneficial effect may be because of the fact that sulphur is a constituent of some amino acid in protein and also participates in several biochemical reactions. Oil content increased significantly as a result of sulphur application. Sulphur is an integral part of mustard oil and might have favourably affected the synthesis of essential metabolites responsible for higher oil content (Singh *et al.* 2020).

From the results, it may be concluded that the mustard crop irrigated three times at various growth stages with incorporation of clay and S produced consistent seed and stover yield and uptake of nutrients by the crop. It may be recommended that mustard growers should adopt the practice of clay mixing and three irrigations with 60 kg S ha^{-1} to obtain higher yield and quality of produce.

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