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Effect of potassium and sulphur on growth, yield and economics of mustard (*Brassica juncea.*) under irrigated condition

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Abstract
A field experiment was conducted at Agronomy Farm, College of Agriculture, Nagpur during *rabi* season 2020-21 to study the effect of potassium and sulphur on growth yield and economics of mustard under irrigated condition. The experiment was laid out in factorial randomized block design (FRBD) with 12 treatments and three replications. The treatments comprised of four potassium levels (30, 35, 40, 45 kg ha^{-1}) and three sulphur levels (15, 20, 25 kg ha^{-1}) to mustard. The growth and yield attributes *viz*. plant height, number of branches plant^{-1}, dry matter accumulation plant^{-1}, number of siliqua plant^{-1} and seed yield plant^{-1} were significantly maximum with application of potassium @ 45 kg ha^{-1} as compared to application of potassium @ 35 kg ha^{-1} and 30 kg ha^{-1} but was found at par with the application of potassium @ 40 kg ha^{-1}. These growth and yield attributes were also found significantly higher with application of sulphur @ 25 kg ha^{-1} as compared to application of sulphur @ 15 kg ha^{-1} but was found at par with application of sulphur @ 20 kg S ha^{-1} of mustard. Significantly higher seed yield (855 kg ha^{-1}) and stover yield (3368 kg ha^{-1}) were recorded with application of potassium @ 45 kg ha^{-1} which was found at par with 40 kg ha^{-1} potassium application to mustard. In case of sulphur application, significantly higher seed yield (798 kg ha^{-1}) and stover yield (3210 kg ha^{-1}) was recorded with application of 25 kg sulphur ha^{-1}, which was found at par with application of 20 kg S ha^{-1} to mustard. Relative economic analysis of mustard crop indicated that the maximum gross monetary returns (Rs.43105 ha^{-1}), net monetary returns (Rs.27060 ha^{-1}) were recorded with application of potassium @ 45 kg ha^{-1} as compared to application of potassium @ 35 kg ha^{-1} and 30 kg ha^{-1} but was found at par with application of 40 kg K ha^{-1} to mustard. Application of sulphur @ 25 kg ha^{-1} gave significantly higher gross monetary returns (Rs .40319 ha^{-1}), net monetary returns (Rs. 24504 ha^{-1}) which was found at par with application of 20 kg S ha^{-1} to mustard.

Keywords: Potassium, sulphur, yield, economics

Introduction
India is suffering from a great shortage of edible oils and the gap between production and consumption is more. In Maharashtra, the productivity of mustard is very low because of deficiency of essential plant nutrients. The declined soil fertility is the main cause of low productivity of the cultivated lands. It has been estimated that less than 15% of nutrients absorbed by the oilseeds are contributed by fertilizers while the remaining are obtained from soil resources, organic manures, biological sources and residues as well as wastes (Davari and Mirzakhani, 2009) [3].
Potassium is one of the essential nutrients which is needed for the growth and development of plants. Potassium nutrition is associated with seed quality, including protein content and also stimulates the transport of nitrogenous compounds to developing fruits and thereby increasing seed yield. Sulphur is a master element of oilseed crop for protein and oil synthesis. It is a component of amino acids like cysteine, cystine, Methionine and required for chlorophyll and protein synthesis. Sulphur is also involved in the synthesis of oil in oilseeds. Glucosinolates and Thioglucosides are very much affected by the deficiency of sulphur in plants. Sulphur deficiency can reduce the crop yield to the extent of 10-34%.
As low soil K status is an important limiting factor responsible for poor yields of the crops, it is imperative to evaluate the response of K nutrition on mustard productivity. Also in case of 2:1 type of clay in vertisols the availability of potassium is low though soils are rich in potassium due to potassium fixation in this type of clays. Leaching and erosion losses also contribute to nutrient deficiencies. Decline in crop yield due to lack of K supply was reported even in K rich soils like Vertisols (Singh and Wanjari, 2012) [12].

Limited study has investigated the requirement of K & S in mustard. Therefore, keeping in view the importance of K & S in affecting quantitative and qualitative parameters of mustard, the present investigation was planned to study the "Effect of potassium and sulphur on growth, yield and economics of mustard under irrigated condition''.

Materials and Methods

An experiment was conducted at Agronomy Farm, College of agriculture, Nagpur during *rabi* 2020-21. The experimental site was located at elevation of 321 meter above mean sea level and at latitude 21^0 10' North and longitude at $79^0$19' East, having tropical climate. The soil of the experimental plot was clayey in texture, low in available nitrogen and medium in available phosphorous and very high in available potash. Organic carbon content was medium and soil reaction was slightly alkaline. The soil was deficient in Sulphur as the available Sulphur is lower than critical level. Sowing of seed was done by using variety TAM-108-1on 13^{th} November 2020 at an optimum soil moisture level and harvested on 26^{th} Feb. 2021. The crop was sown in rows 45 cm apart. The total rainfall received during crop growth period was 104.8 mm. The experiment was laid out in F.R.B.D. with four levels of potassium (30, 35, 40, and 45 kg ha^{-1}) as one factor and three levels of Sulphur (15, 20 and 25 kg ha^{-1}) as another factor with twelve treatment combinations replicated three times. Potassium and sulphur was supplied through MOP and Bensulf, respectively. As per treatments half dose of nitrogen and full dose of P, K and S was applied at the time of sowing and the remaining half dose of nitrogen as top dressing. As there is less cool period the yield levels were reduced. The pan evaporation ranges between 1.6 to 8.8 mm during crop growth period. The season was fair with slight incidence of pest (Aphids) which was controlled by using systemic insecticide. The growth and yield attributes were recorded at different crop growth stages and maturity, respectively.

Result and Discussion

Effect of potassium and sulphur on growth parameters of mustard

Data pertaining to growth attributes of mustard as influenced by various treatments are presented in Table-1. The various levels of potassium and sulphur has significantly influenced the growth attributes of mustard. Application of potassium @ 45 kg ha^{-1} recorded significantly higher plant height (188.02 cm) as compared to the application of potassium @ 35 kg ha^{-1} and 30 kg ha^{-1} but was found at par with application of potassium at 40 kg ha^{-1}. Application of sulphur @ 25 kg ha^{-1} recorded significantly higher plant height (184.57 cm) as compared to he application of sulphur @ 15 kg ha^{-1} and was found at par with application of sulphur @ 20 kg ha^{-1} to mustard. The increase in plant height of mustard might be due to increase availability of nutrients i.e. K and S to mustard which leads to vigorous root growth, enhance metabolic rate and cell division, cell enlargement, as well as cell elongation thereby increasing formation of chlorophyll that resulted in higher photosynthetic activity. These results are in confirmity with the findings of Cheema *et al*., (2012) [2], Upadhyay *et al*., (2018) [15].

Significantly higher number of branches $plant^{-1}$ was recorded with application of potassium at 45 kg ha^{-1} to mustard as compared to application of potassium at 35 kg ha^{-1} and 30 kg ha^{-1} which was found at par with application of potassium at 40 kg ha^{-1}. Application of sulphur @ 25 kg ha^{-1} recorded significantly higher number of branches $plant^{-1}$ as compared to application of sulphur @ 15 kg ha^{-1} and was found at par with application of sulphur @ 20 kg ha^{-1} to mustard. The increase in number of branches plant $^{-1}$ might be due to increased availability of K and S to plant which increased activities of meristematic tissues of plant as well as vigour of the plant during vegetative stage that contributed towards the higher production of branches at different growth stages. The above results are in conformity with the results of Gautam *et al*., (2020) [4], Kumar *et al*., (2018) [6].

Application of potassium @ 45 kg ha^{-1} to mustard recorded significantly higher dry matter production $plant^{-1}$ amongst the other treatments and was found at par with application of potassium @ 40 kg ha^{-1}. Application of sulphur @ 25 kg ha^{-1} to mustard significantly influenced dry matter production $plant^{-1}$ and was found at par with application of sulphur @ 20 kg ha^{-1} to mustard. This might be due to increased availability of nutrients in soil and their higher uptake which leads to increase in height that induces more number of branches thereby increasing the dry matter accumulation in the plant. These results are found to be similar with the results reported by Amanullah (2016) [1], Upadhyay (2012) [14].

Effect of potassium and sulphur on yield and yield attributes of mustard

Data pertaining to growth attributes of mustard as influenced by various treatments are presented in Table-1. The various levels of potassium and sulphur have significantly influenced the yield and yield attributes of mustard.

Application of potassium @ 45 kg ha^{-1} recorded significantly higher number of siliqua $plant^{-1}$ and grain yield $plant^{-1}$ as compared to application of potassium @ 35 kg ha^{-1} and 30 kg ha^{-1} but was found at par with application of potassium @ 40 kg ha^{-1}. Application of sulphur @ 25 kg ha^{-1} to mustard recorded significantly higher number of silique $plant^{-1}$ and grain yield $plant^{-1}$ over application of sulphur @ 15 kg ha^{-1} and was found at par with application of 20 kg S ha^{-1} to mustard. Higher seed yield $plant^{-1}$ is the net result of more number of branches at harvest and more number of siliqua $plant^{-1}$ with more seeds $siliqua^{-1}$ and better growth at different stages due to increased nutrient availability. These results are in accordance with the findings of Mohiuddin *et al.*, (2011) [8]. Paliwal *et al.*, (2014) [9], Dhruw *et al*., (2017).

Seed and straw yield of mustard was significantly influenced by various treatments. Significantly higher seed (855 kg ha^{-1}) and straw yield (3368 kg ha^{-1}) was recorded with application of potassium @ 45 kg ha^{-1} as compared to other treatments and was found at par with application of potassium @ 40 kg ha^{-1} to mustard. Application of 25 kg sulphur ha^{-1} recorded significantly higher seed yield (798 kg ha^{-1}) and straw yield (3210 kg ha^{-1}) over application of sulphur @ 15 kg ha^{-1} and was found at par with application of sulphur @ 20 kg ha^{-1} to mustard. The increase in seed yield might be due to combined effect of higher number of siliqua $plant^{-1}$, higher 1000 seed weight and seed weight $plant^{-1}$ which was result of better translocation of photosynthates from source to sink. The highest straw yield might be due to the fact that sulphur encourages above ground vegetative growth due to increased synthesis of amino acid and fatty acids and meristematic activity that enhance higher dry matter accumulation resulting into highest straw yield. These results are in accordance with the findings of Malhi *et al*., (2007) [7], Govahi *et al*., (2006) [5]

Effect of potassium and sulphur on economics of mustard

Application of potassium @ 45 kg ha^{-1} recorded significantly higher gross monetary returns (Rs 43105 ha^{-1}) and net monetary returns (Rs 27060 ha^{-1}) as compared to other treatments but was found at par with application of potassium @ 40 kg ha^{-1} to mustard. In case of sulphur application, significantly higher gross monetary returns (Rs 40319 ha^{-1}) and net monetary returns (Rs 24504 ha^{-1}) were recorded with application of sulphur @ 25 kg ha^{-1} over application of sulphur @15 kg ha^{-1} but was found at par with 20 kg sulphur ha^{-1} to mustard. It may be due to increase in grain and straw yield resulted in increase in gross monetary returns and net monetary returns with application of higher levels of sulphur as well as potassium to mustard crop. Similar findings were associated with Kumar *et al*., (2018) [6], Sharma *et al*., (2020) [11].

Highest benefit cost ratio of (2.69) was observed with application of potassium @ 45 kg ha^{-1} followed by application of 40 kg potassium ha^{-1} (2.61). In case of sulphur application, highest benefit cost ratio of (2.55) was observed with application of sulphur at 25 kg ha^{-1} followed by application of 20 kg sulphur ha^{-1} (2.53). It may be due to increase in grain and straw yield that resulted in increase in gross monetary returns there by increase in B:C ratio. Similar findings were associated with Tripathi *et al.*, (2011) [13].

Interaction effect

The interaction effect of potassium and sulphur application on growth attributes, yield attributes and economics of mustard was found to be non-significant.

Table 1: Influence of potassium and sulphur on growth and yield attributes and yield of mustard

Treatments	Plant height (cm)	No. of branches $plant^{-1}$	Dry matter $plant^{-1}$	No. of siliqua $plant^{-1}$	Seed yield $plant^{-1}$ (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Potassium Levels (K)							
K1 (30 kg ha^{-1})	176.43	11.20	28.53	151.62	6.64	696	2984
K2 (35 kg ha^{-1})	181.16	12.06	29.58	158.22	6.95	744	3067
K3 (40 kg ha^{-1})	186.39	13.11	31.59	167.37	7.56	828	3257
K4 (45 kg ha^{-1})	188.02	14.07	32.57	170.10	7.71	855	3368
S.E. (m) ±	0.84	0.50	0.46	1.49	0.08	11	58
C.D. at 5%	2.89	1.72	1.59	5.16	0.27	39	201
Sulphur Levels (S)							
S1 (15 kg ha^{-1})	180.86	11.70	29.43	158.62	7.07	757	3114
S2 (20 kg ha^{-1})	183.58	12.75	30.93	162.84	7.25	787	3184
S3 (25 kg ha^{-1})	184.57	13.38	31.35	164.03	7.33	798	3210
S.E. (m) ±	0.65	0.33	0.47	1.35	0.06	8	25
C.D. at 5%	1.96	0.99	1.41	4.05	0.19	25	75
Interaction (K X S)							
S.E. (m) ±	1.31	0.66	0.94	2.70	0.12	17	50
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
G.M.	183.00	12.61	30.57	161.83	7.22	780	3169

Table 2: Cost of cultivation, gross monetary returns, net monetary returns (Rs ha^{-1}) and B:C ratio of mustard as influenced by various treatments

Treatments	Gross monetary returns (Rs ha^{-1})	Net monetary returns (Rs ha^{-1})	B:C Ratio
Factor – A Potassium Levels (K)			
K1 (30 kg ha^{-1})	35342	19582	2.24
K2 (35 kg ha^{-1})	37593	21738	2.37
K3 (40 kg ha^{-1})	41644	25694	2.61
K4 (45 kg ha^{-1})	43105	27060	2.69
S.E. (m) ±	644	644	-
C.D. at 5%	2230	2230	-
Factor – B Sulphur Levels (S)			
S1 (15 kg ha^{-1})	38211	22555	2.44
S2 (20 kg ha^{-1})	39734	24044	2.53
S3 (25 kg ha^{-1})	40319	24504	2.55
S.E. (m) ±	443	443	-
C.D. at 5%	1329	1329	-
Interaction (A X B)			
S.E. (m) ±	887	887	-
C.D. at 5%	2657	2657	-
G.M.	39421	23597	2.49

Conclusion

Based on experimental findings, it can be concluded that application of potassium @ 45 kg ha^{-1}recorded highest growth, yield attributes, seed yield (855 kg ha^{-1}), straw yield (3368 kg ha^{-1}) and maximum monetary returns of mustard crop and was comparable with application of 40 kg K ha^{-1} to mustard crop. Similarly, application of sulphur @ 25 kg ha^{-1} recorded maximum growth, yield attributes, seed yield (798 kg ha^{-1}), straw yield (3210 kg ha^{-1}) and maximum monetary returns of mustard crop and was found at par with 20 kg S ha^{-1} application to mustard crop.

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