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Influence of potassium and sulphur on quality parameters and nutrient uptake by mustard (*Brassica juncea*) under irrigated condition

BK Atkari, Dr. PC Pagar, RN Jamdade, AR Kadam and RB Kothikar

BK Atkari
M.Sc., Department of Agronomy Section, College of Agriculture, Nagpur, Maharashtra, India

Dr. PC Pagar
Assistant Professor, Department of Agronomy Section, College of Agriculture, Nagpur, Maharashtra, India

RN Jamdade
M.Sc., Department of Agronomy Section, College of Agriculture, Nagpur, Maharashtra, India

AR Kadam
M.Sc., Department of Agronomy Section, College of Agriculture, Nagpur, Maharashtra, India

RB Kothikar
JRA., Department of Agronomy Section, College of Agriculture, Nagpur, Maharashtra, India

Corresponding Author:
BK Atkari
M.Sc., Department of Agronomy Section, College of Agriculture, Nagpur, Maharashtra, India

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 quality parameters and nutrient uptake by 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}). Significantly higher total potassium and sulphur uptake was recorded with application of potassium @ 45 kg 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, application sulphur @ 25 kg ha^{-1} recorded significantly higher total potassium and sulphur uptake over application of sulphur @15 kg ha^{-1} and was found at par with application of 20 kg S ha^{-1} to mustard. Significantly highest available potassium and sulphur content in soil was observed 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 potassium @ 40 kg ha^{-1} to mustard. Similarly application of sulphur @ 25 kg ha^{-1} recorded higher available potassium and sulphur content in soil over application of sulphur @15 kg ha^{-1} and was found at par with application of sulphur @ 20 kg ha^{-1} to mustard. Application of potassium @ 45 kg ha^{-1} showed significantly higher protein and oil content as well as protein and oil yield amongst all other treatments which was found at par with application of 40 kg K ha^{-1} to mustard. Sulphur application @ 25 kg ha^{-1} showed significantly higher protein and oil content as well as protein and oil yield amongst all other treatments which was found at par with application of 20 kg S ha^{-1} (S2) to mustard.

Keywords: Potassium, Sulphur, protein content, oil content

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) [2].

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 these types 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 "Influence of potassium and sulphur on quality parameters and nutrient uptake by 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-108-1 on 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, 25 and 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 treatment 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 are reduced. The pan evaporation ranges between 1.6 to 8.8 mm during crop growth period.The season was fair and slight incidence of pest (Aphids) was observed which was controlled by using systemic insecticide.

Result and Discussion

Effect of potassium and sulphur on total potassium uptake and total sulphur uptake of mustard

Data pertaining to total potassium uptake and total sulphur uptake of mustard as influenced by various treatments are presented in Table-1.

Total potassium uptake

Data presented in Table-1 revealed that mean potassium content in seed and straw was 0.80% and 1.06%, respectively. The total potassium uptake by mustard was significantly influenced by different levels of potassium and sulphur application. Highest total potassium uptake was recorded with application of potassium @ 45 kg ha^{-1} which was superior over 35 kg K ha^{-1} and 30 kg K ha^{-1} and was found at par with application of 40 kg K ha^{-1} to mustard. Application of Sulphur @ 25 kg ha^{-1} recorded significantly higher total potassium uptake over application of sulphur @ 15 kg ha^{-1} but was found at par with application of sulphur @ 20 kg ha^{-1} to mustard. This might be due to increase in level of potassium and sulphur significantly enhance the potassium and sulphur availability and its absorption by crop and thereby its content in seed and straw. These results are in confirmity with the findings of Lakhan *et al*., (2017) [8], Tekchand *et al*., (2017) [13].

Total sulphur uptake

Data revealed that mean sulphur content in seed and straw was 0.89% and 0.30% respectively. The total sulphur uptake by mustard was significantly influenced due to different levels of potassium and sulphur application. Highest total sulphur uptake was recorded with application of potassium @ 45 kg ha^{-1} which was significantly superior over application of potassium @ 35 kg ha^{-1} and 30 kg ha^{-1} and was found at par with 40 kg ha^{-1} potassium application to mustard. Sulphur application @ 25 kg ha^{-1} showed significantly highest total sulphur uptake over application of sulphur @ 15 kg ha^{-1} but was found at par with 20 kg ha^{-1} sulphur application to mustard. This might be due to more availability of sulphur resulting into more sulphur absorption by the crop plant thereby increasing the yield levels and its uptake. These results are in confirmity with the findings of Govahi *et al*., (2006) [4], Sahoo *et al.*, (2018) [10].

Residual soil status of potassium and sulphur

Data presented in Table-2 indicated that average available potassium and sulphur in soil after harvest was 367.89 kg ha^{-1} and 11.12 kg ha^{-1}, respectively. The initial status of available potassium and sulphur in soil was 334.20 kg ha^{-1} and 9.37 kg ha^{-1}, respectively.

Residual soil status of potassium in soil

Data in the table revealed that residual available potassium in soil was increased with each increasing levels of potassium. The highest available potassium in soil was recorded with application of potassium @ 45 kg ha^{-1} and significantly superior over lower levels but found to be at par with potassium applied @ 40 kg ha^{-1}. Similarly, residual available potassium in soil was increased with each increasing levels of sulphur. The highest available potassium content in soil was recorded with application of sulphur @ 25 kg ha^{-1} and significantly superior over lower levels but found to be at par with sulphur applied @ 20 kg ha^{-1}. Increase in available potassium in soil might be due to the increasing levels of potassium and sulphur application. These results are in confirmity with the findings of Gajghane *et al.*, (2015) [3].

Residual soil status of sulphur

Residual available sulphur in soil was increased with each increasing levels of potassium. The highest available sulphur in soil was recorded with application of potassium @ 45 kg ha^{-1} and significantly superior over lower levels but found to be at par with potassium applied @ 40 kg ha^{-1}. Residual available sulphur in soil was increased with each increasing levels of sulphur. The highest available sulphur in soil was recorded with application of sulphur @ 25 kg ha^{-1} and significantly superior over lower level but found to be at par with sulphur application @ 20 kg ha^{-1}. Increase in available sulphur in soil might be due to the increasing levels of sulphur application. These results are in conformity with findings of Gajghane *et al.*, (2015) [3].

Effect of potassium and sulphur on quality parameters of mustard crop

The data pertaining to the protein and protein yield; oil content and oil yield of mustard as influenced by different treatments are presented in Table -3. On an average protein and protein yield in mustard was 20.49% and 159.27 kg ha^{-1}, respectively. Whereas the oil and oil yield in mustard was 39% and 304.71 kg ha^{-1}, respectively.

Protein Content

Protein content of mustard was differed due to different levels of potassium and sulphur. Application of potassium @ 45 kg ha^{-1} and sulphur @ 25 kg ha^{-1} showed highest protein content amongst all other treatments. Lowest protein content was observed in application of potassium at 30 kg ha^{-1} and sulphur at 15 kg ha^{-1}. The increase in protein content owing to potassium addition might be attributed to its involvement in nitrogen metabolism. Potassium promotes conversion of plant metabolism into protein and amino acids, thus providing a sink for the nitrogen fixed. This result is in accordance with the findings of Sharma *et al*., (2020) [11], Chattopaddhyay *et al*., (2012) [1].

Protein Yield

Protein yield of mustard was significantly differed due to different levels of potassium and sulphur. The maximum protein yield (181.78 kg ha^{-1}) was recorded with application of potassium @ 45 kg ha^{-1} which was superior over 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}. In case of sulphur, application of sulphur @ 25 kg ha^{-1} showed highest protein yield (163.32 kg ha^{-1}) which was significantly superior over application of sulphur @ 15 kg ha^{-1} and was found at par with sulphur applied @ 20 kg ha^{-1}. The increase in protein yield of mustard might be due to cumulative effect of increase in protein content and seed yield of mustard crop due to potassium and sulphur application.These results are in confirmity with the findings of Islam *et al*., (2004) [6], Gupta *et al*., (2011) [5].

Oil Content

Oil content of mustard was differed due to different levels of potassium and sulphur. Application of potassium @ 45 kg ha^{-1} and sulphur @ 25 kg ha^{-1} showed highest oil content amongst all other treatments. Lowest oil content was observed in application of potassium @ 30 kg ha^{-1} and sulphur @ 15 kg ha^{-1}. The increase in oil content might be due to supply of sulphur which is integral part of oil. Sulphur play an important role synthesis of essential amino acids like cysteine, methionine, and certain vitamin like biotin, thymine as well as the formation of ferodoxin that act as an electron carrier in the photosynthetic process and chlorophyll which required for the production of oil. These results are in confirmity with the findings of Kumar *et al*., (2018) [7], Tripathi *et al*., (2011) [14].

Oil Yield

Oil yield (kg ha^{-1}) of mustard was significantly differed due to different levels of potassium and sulphur. The maximum oil yield (339.53kg ha^{-1}) was recorded with application of potassium @ 45 kg ha^{-1} which was superior over application of potassium @ 35 kg ha^{-1} and 30 kg ha^{-1} but was found at par with potassium applied @ 40 kg ha^{-1}. Application of sulphur at 25 kg ha^{-1} showed highest oil yield (313.81 kg ha^{-1}) which was significantly superior over application of sulphur @ 15 kg ha^{-1} and was found to be at par with sulphur applied @ 20 kg ha^{-1}. The increase in oil yield of mustard was due to the increase in oil content and seed yield with application of higher levels of potassium and sulphur to mustard.This result is in accordance with the findings of Mozaffari *et al*., (2012) [9], Sahoo *et al*., (2018) [10].

Interaction effect

The interaction effect of potassium and sulphur application on total nutrient uptake, residual soil status and quality parameters of mustard was found to be non-significant.

Table 1: Effect of potassium and sulphur on total potassium uptake and total sulphur uptake of mustard crop

Treatments	Potassium content (%)		Potassium uptake (kg ha^{-1})			Sulphur content (%)		Sulphur uptake (Kg ha^{-1})		
	Seed	Straw	Seed	Straw	Total	Seed	Straw	Seed	Straw	Total
Potassium Levels (K)										
K1 (30 kg ha^{-1})	0.73	0.95	5.19	28.34	33.53	0.77	0.24	5.34	7.13	12.47
K2 (35 kg ha^{-1})	0.78	1.05	6.03	32.33	38.36	0.86	0.28	6.41	8.59	15.00
K3 (40 kg ha^{-1})	0.83	1.11	7.09	36.28	43.37	0.93	0.32	7.71	10.42	18.14
K4 (45 kg ha^{-1})	0.87	1.14	7.40	38.49	45.89	0.98	0.34	8.39	11.62	20.01
S.E. (m) ±	-	-	0.10	0.96	1.01	-	-	0.26	0.37	0.57
C.D. at 5%	-	-	0.34	3.31	3.50	-	-	0.90	1.28	1.96
Sulphur Levels (S)										
S1 (15 kg ha^{-1})	0.78	1.03	6.13	32.28	38.41	0.86	0.28	6.53	8.70	15.23
S2 (20 kg ha^{-1})	0.80	1.06	6.49	33.94	40.44	0.89	0.30	7.04	9.66	16.70
S3 (25 kg ha^{-1})	0.82	1.10	6.66	35.35	42.01	0.91	0.31	7.31	9.97	17.28
S.E. (m) ±	-	-	0.14	0.64	0.65	-	-	0.20	0.31	0.49
C.D. at 5%	-	-	0.41	1.92	1.94	-	-	0.59	0.94	1.46
Interaction (K X S)										
S.E. (m) ±	-	-	0.28	1.28	1.30	-	-	0.39	0.62	0.98
C.D. at 5%	-	-	NS	NS	NS	-	-	NS	NS	NS
G.M.	0.80	1.06	6.43	33.86	40.29	0.89	0.30	6.96	9.44	16.40

Table 2: Residual soil fertility status after harvest of crop

Treatments	Available nutrient status (kg ha^{-1})	
	Available K	Available S
Potassium Levels (K)		
K1 (30 kg ha^{-1})	350.47	10.38
K2 (35 kg ha^{-1})	367.05	10.80
K3 (40 kg ha^{-1})	375.56	11.63
K4 (45 kg ha^{-1})	378.47	11.67
S.E. (m) ±	2.99	0.14

C.D. at 5%	10.36	0.48
Sulphur Levels (S)		
S1 (15 kg ha^{-1})	358.14	10.96
S2 (20 kg ha^{-1})	368.24	11.07
S3 (25 kg ha^{-1})	377.29	11.33
S.E. (m) ±	3.54	0.10
C.D. at 5%	10.61	0.29
Interaction (K X S)		
S.E. (m) ±	7.08	0.19
C.D. at 5%	N.S.	N.S.
G.M.	367.89	11.12
Initial fertility status	334.20	9.37

Table 3: Effect of potassium and sulphur on protein and protein yield; oil and oil yield of mustard crop

Treatments	Protein Content (%)	Protein Yield (Kg Ha^{-1})	Oil Content (%)	Oil Yield (Kg Ha^{-1})
Potassium Levels (K)				
K1 (30 kg ha^{-1})	19.69	132.61	38.21	265.87
K2 (35 kg ha^{-1})	20.19	150.04	38.64	287.14
K3 (40 kg ha^{-1})	20.86	172.66	39.44	326.28
K4 (45 kg ha^{-1})	21.23	181.78	39.69	339.53
S.E. (m) ±	-	5.56	-	7.23
C.D. at 5%	-	19.25	-	25.02
Sulphur Levels (S)				
S1 (15 kg ha^{-1})	19.99	151.51	38.73	293.24
S2 (20 kg ha^{-1})	20.68	162.99	39.01	307.07
S3 (25 kg ha^{-1})	20.81	163.32	39.25	313.81
S.E. (m) ±	-	3.33	-	3.86
C.D. at 5%	-	9.99	-	11.56
Interaction (K X S)				
S.E. (m) ±	-	6.67	-	7.72
C.D. at 5%	-	NS	-	NS
G.M.	20.49	159.27	39.00	304.71

Conclusion

Based on experimental findings, it can be concluded that application of potassium @ 45 kg ha^{-1}recorded maximum total potassium and sulphur uptake, residual soil status of potassium and sulphur as well as quality parameters of mustard and was comparable with application of potassium @ 40 kg ha^{-1} to mustard crop. Similarly, application of sulphur @ 25 kg ha^{-1} recorded maximum total potassium and sulphur uptake, residual soil status of potassium and sulphur as well as quality parameters of mustard and was found at par with 20 kg ha^{-1} sulphur application to mustard crop.

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