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Impact of phosphorus and sulphur on yield and quality of mustard: A review

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Abstract
Mustard is most important oil seed crop after cereals and pulses. The various factors like soil, biotic and abiotic factor lose the productivity and quality of mustard. The nutrients are one of the most important factors to increase the productivity in mustard. The phosphorus and sulphur are essential for all quality and yield attributes of mustard crop. Optimum fertilizer dose is used for better quality and yield of mustard. Phosphorus and sulphur supports to improve height of plants, number of major and minor branches/plant, no. of foliage/plant, no. of siliqua/plant, number of seeds/siliqua, siliqua length, number of seeds, oil concentration, oil content and quality, yield and growth parameters. Both phosphorus and sulphur are very important for root formation, plant growth and various quality parameters like amino acids, proteins and oil content respectively.

Keywords: Mustard, sulphur, phosphorus, oil seeds, yield

Introduction
In world there are various oil seed crops are present. Across from soybean and groundnut, mustard is also a most significant oil seed crop. It is *Rabi* season crop, mainly grown in North India. It is used for various purposes i.e. for oil purpose, cattle feed. The oil is used for edible purpose, soap making, frying, the seed is used for pickles, curries, vegetables. The stem and leaves are used for fodder and fuel purposes Prasad *et al*. 2018 [12]. Rapeseed-mustard grown under 36.5 m ha area, 71.4 m ton production, 1980 kg/ha productivity in 2018-19 (Directorate of rapeseed-mustard research). Mustard is 11% of total world production and fourth rank of seed contribution (USDA). In India, Uttar Pradesh and Rajasthan are leading states and Uttar Pradesh contribute 60%, Rajasthan contribute 43% mustard seed production Survey report 2014-15.

The nutrient is in important factor to increase the yield and quality of crops. The nutrients play different role in every crop production. Phosphorus is second most important nutrient after nitrogen. Higher requirement of phosphorus needed to brassica species for successful for production. The effect of phosphorus on yield is more than nitrogen and potassium. The phosphorus is constituent of DNA, RNA and responsible for hereditary characters Mishra *et al*. 2010 [10]. It is constituent of enzymes, nucleic acid, ATP, NADPH, GTP and helps in quick establish of seedlings moreover enhance the nodulation and nitrogen fixation by legumes, promote seed along fruit formation and stimulate early root growth. In case of deficiency of phosphorus seed formation delayed, visual purplish pigmentation on leaves, stunted stem at young stage, early shedding of leaves. The major sources of phosphorus are SSP, DSP, TSP, ammonium phosphate, di-calcium phosphate, basic slag, calcium meta-phosphate, rock phosphate, bone meal etc.

In secondary source of macronutrient sulphur ranked fourth after nitrogen, phosphorus, potassium and 13 important earth crust element Mishra *et al*. 2010 [10]. Sulphur is essential element for oil synthesis in oil seed crops. It is constituent of cystine, cystiene, methionine, chlorophyll Singh *et al*. 2018 [19, 20, 22]. Sulphur is important source for activation of enzymes, formation of chlorophyll, glucosinolate content in mustard, additionally it is also play role in increasing yield parameters of mustard and remarkable effect on oil content, fatty acid and glucosinolate in mustard Ray *et al*. 2015. Sulphur is constituent of coenzyme A, ferridoxin, vitamin thiamine and biotin. It is essential for stabilizing the structure of protein and responsible for pungent odour of mustard, onion, garlic due to presence of S containing volatile compounds. Whereas, young leaves turn yellow, slow growth with slender stalks on deficiency of S. The SSP, ammonium sulphate gypsum used as a source of sulphur in crops.

Table 1: Sources of phosphorus and sulphur and nutrient%

Nutrient	Source name	Nutrient%
Phosphorus	SSP	16%
	DSP	32%
	TSP	46-48%
	Ammonium phosphate	20%
	Dicalcium phosphate	14%
	Basic slag	20%
	Calcium metaphosphate	60-64%
	Rock phosphate	20-30%
	Bone meal	21-25%
Sulphur	SSP	12%
	Ammonium sulphate	24%
	Gypsum	16%
	Pyrites	20%
	Potassium sulphate	18%

Table 2: Effect of Different doses of phosphorus and sulphur on mustard

			Phosphorus				
	Siliqua per plant	**Seed per siliqua**	**1000-seed (g)**	**Biomass (q/ha)**	**Seed yield (q/ha)**	**H.I (%)**	**Oil (%)**
P_0	209.9	10.5	3.8	32.5	8.9	27.4	38.6
P_{30}	222.2	11	4.1	35.4	9.8	27.4	39.8
P_{60}	239.1	11.7	4.4	38.2	10.5	27.5	39.9
			Sulphur				
S_0	214.5	10.7	3.9	32.8	9	27.4	38.6
S_{20}	225.4	11.2	4.1	36.2	9.9	24.4	39
S_{40}	233.1	11.4	4.2	37.2	10.3	27.4	39

Source: Satyban *et al.* 2018

Reviews on Impact of phosphorus and sulphur on quality and yield of mustard:

Joshi *et al*. 1973 [4] concerned that in mustard, yield and nutrient uptake was higher on use of 50 kg P/ha but on application of both sulphur and phosphorus, the uptake level of nutrients was decreased at Rajasthan.

Jaggi *et al*. 1998 [5] observed that on combination of both 90 kg S/ha and 26.2 kg P/ha seed yield and straw yield, oil content was higher but by increasing dose of sulphur without phosphorus oil content was decreased at Palampur in mustard crop.

Meena *et al*. 2002 [8] observed that at Rajasthan the dry matter of mustard increase with application of 80 kg S/ha and plant height, primary and secondary branches/plant increased by 60 kg S/ha.

Joshi *et al*. 2008 [6] revealed that linoleic and linolenic acid was maximum (16.8 and 8.73%) with 40 kg S/ha as along higher oil content was recorded in mustard by 40 kg S/ha.

Singh *et al*. 2008 [15] determined that with 60 kg/ha phosphorus higher plant height, number of leaves, siliqua/plant, seed yield, stover yield and all growth and yield parameters increased with supply of 45kg S/ha in mustard.

Khatkar *et al*. 2009 [7] reported that better vegetative growth, taller plant height, number of foliage/plant, number of prime and secondary branches, dry weight, seed yield, straw yield, length of siliqua, siliqua/plant, test weight was improved with supply of 60 kg P2O5/ha and 30kg S/ha in mustard crop at Allahabad.

Mir *et al*. 2010 noticed that 60 kg P_2O_5/ha enhanced the number of siliqua/plant, number of branches/plant, number of grain/pod, grain yield, oil content at Srinagar in mustard crop as compare to other doses and control.

Mishra *et al*. 2010 [10] recorded that in mustard, the optimum dose of phosphorus and sulphur gave better production of mustard but 30 kg/ha phosphorus gave better oil content at New Delhi.

Bharose *et al*. 2011 [1] revealed that 11.90 q/ha yield recorded on application of 25 kg P/ha and 12.30 q/ha yield obtained on application of 50 kg P/ha in toria at Allahabad and on supplying of 0-20 kg S/ha yield showed increase from 11.8 to 15.8 q/ha on another hand with high doses of sulphur yield got decreased,

Trivedi *et al*. 2012 [24] observed that the higher seed and stover yield recorded with use of ammonium sulphate as compared to gypsum, pyrite and SSP application in mustard.

Rao *et al*. 2013 remarked that the more plant height of kernels, 1000 seed weight, seed size apply at rate of 45 kg sulphur/ha in groundnut.

Yadav *et al*. 2014 [26] revealed that higher dry weight/plant 16.9 g, plant height 100.3 cm, number of siliqua/plant 570.5, seed yield 15.4 q/ha, net return 32892.6/ha, oil content 39.6% with supply of 60 kg P_2O_5/ha in addition, higher dry weight/plant 17 g, plant height 101 cm, number of siliqua/plant 566.5, seed yield 15.5 q/ha, net return 32892.6/ha, oil content 39.4% with apply of 45kg S/ha in mustard crop at Uttar Pradesh.

Neha *et al*. 2014 observed that in mustard seed, 5% oil content at a supply of 20 kg S/ha and 8.7% oil content at a supply of 40 kg S/ha.

Ray *et al*. 2015 examined that the 60 kg sulphur/ha increase the yield and yield attributes and 45 kg S/ha improve the oil quality, sulphur uptake, percentage of oil, yield in mustard.

Singh *et al*. 2015 [16] observed that in Indian mustard increase grain yield from 7.97-9.23 and 7.97-10.45 with use of 30 and 60 kg P and S/ha.

Singh *et al*. 2016 [17] revealed at Uttar Pradesh the application of phosphorus 60 kg/ha and sulphur 40kg/ha observe the higher yield, economic parameters, oil attributes in mustard.

Solanki *et al*. 2016 [18] observed that at Rajasthan on supply of 40 kg P/ha apply in mustard increase the seed yield, stover yield, B:C ratio 19.6 q/ha, 50.5 q/ha, 1.85 respectively and application of 50 kg P/ha increase the plant height, dry matter,

siliqua/plant, branches/plant, seed/siliqua and apply 40 kg S/ha increase the test weight, seed yield, stover yield, branches/plant, siliqua/plant, B:C ratio 1.92.

Nath *et al*. 2018 [11] observed that the supply of 75 kg P2O5/ha and 30 kg S/ha increase in plant height, branches number/ plant, siliqua number per plant, seed number per siliqua, grain yield, the stover yield, siliqua length than application of low dose 50 kg P/ha and 20 kg S/ha a in mustard.

Singh *et al*. 2018 [19, 20, 22] reported that the highest nitrogen efficiency and uptake by mustard crop at 30 and 60 day after sowing increase with 75 kg phosphorus/ha and 60 kg sulphur/ha.

Solanki *et al*. 2018 [21] concluded that with 50kg/ha P2O5 the highest seed yield (19.7 q/ha) and stover yield was (50.4 q/ha) and high grain yield with use of phosphorus, sulphur and phosphorus solublizing bacteria at Rajasthan in mustard crop.

Upadhyay *et al*. 2018 [25] concerned that the taller plant height, siliqua no. Per plant, dry matter per plant, no. of siliqua per plant, stover yield and seed yield with application of 50 kg P/ha and 40 kg S/ha than lower doses or no doses at Uttar Pradesh in Indian mustard.

Singh *et al*. 2019 [23] revealed that the 90 kg phosphorus/ ha increase the plant height, 1000 seed weight, seed yield, length of siliqua, siliqua/seed in mustard.

Chauhan *et al*. 2020 [2] revealed that the higher yield, higher nutrient concentration, nutrient uptake and high nutrient available at supply of 50 kg P_2O_5/ha and 40 kg S/ha in mustard as compare to other levels of P_2O_5 and sulphur.

Conclusion

It is observed in above reviews that all the nutrients are essential for plant growth and yield attributes. Similarly, the phosphorus and sulphur play a crucial role in growth, quality and yield parameters in mustard. The plant height, primary and secondary branches/plant, foliage/plant, siliqua number per plant, seed number per siliqua, length of siliqua, grain yield, yield of stover, oil% and oil quality are higher when 60 kg P/ha and 45 kg S/ha are applied. Sulphur and phosphorus are essential nutrients for enhanced growth and yield parameters.

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