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Effect of phosphorus and sulphur on yield attributes, yield and economics of mustard [*Brassica juncea* (L.) Czern & Coss] in loamy sand

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Abstract
A field experiment was conducted during *rabi* season 2014-15 to study the effect of phosphorus and sulphur on yield attributes, yield and economics of mustard [*Brassica juncea* (L.) Czern & Coss] at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Mustard variety GM 3 was used as a test crop. The results of the present investigation revealed that application of 75 kg P_2O_5/ha (P_3) gave significantly the highest plant height at harvest, number of branches/plant, number of siliquae/plant and number of seeds/siliqua, seed and stover yields of mustard over its lower levels of phosphorus (25 kg and 50 kg P_2O_5/ha). Significantly higher length of siliqua was recorded under 75 kg P_2O_5/ha (P_3) being at par with 50 kg P_2O_5/ha as compared to P_1 level of phosphorus. Application of 30 kg S/ha (S_3) being at par with 20 kg S/ha (S_2) significantly improved the number of branches/plant, number of siliquae/plant, length of siliqua, number of seeds/siliqua. Significantly the highest plant height at harvest, seed and stover yields were recorded with application of 30 kg S/ha over its lower levels of sulphur. The treatment combination of P_3S_3 (75 kg P_2O_5 and 30 kg S/ha) gave maximum net return and BCR value as compared to other treatment combinations.

Keywords: Phosphorus, sulphur, yield attributes, economics, mustard, *Brassica juncea* (L.) Czern & Coss, loamy sand

Introduction
The oilseed crops play an important role in agriculture and industrial economy of our country. Worldwide, India is the fourth largest mustard producer. Its cultivation is mainly confined to Uttar Pradesh, Rajasthan, Madhya Pradesh, Haryana, Punjab, Orissa, Assam, Bihar, Gujarat and West Bengal. Gujarat is on the fifth rank in the production of mustard. Its area is about 2.14 lakh hectares with 3.30 lakh tonnes of total production with productivity of 1577 kg/ha (Anon., 2014) [1]. Among the primary nutrients, phosphorus is the most important constraint for increasing oilseed production because of the nutrients requirement of oilseeds, in general is high. The P compounds (ADP and ATP) in fact as energy currency within the plant. It plays a vital role in plant metabolism. Thus, phosphorus influences the vigour of plants and root growth. It also encourages the development of nitrogen fixing bacteria, pod formation and hastens the maturity of pods (Tisdale *et al.* 1984) [11]. Oilseeds in general need more S as compared to other crops due to its pivotal role in synthesis of oil. Sulphur is now recognized as the fourth major plant nutrient. Sulphur is constituent of three S containing amino acids (cystine, cysteine and methionine) which are building blocks of protein. Sulphur deficiency is becoming more critical with each passing year which is severely restricting crop yield, produce quality and nutrient use efficiency. Patel *et al.* (2001) [8] reported that the S deficiency in soils of various districts of Gujarat was ranging from 15 to 56 per cent with an average of 37 per cent. In order to study the effect of phosphorus and sulphur on yield attributes, yield and economics of mustard during *rabi* season of 2014-15 in loamy sand soils of North Gujarat.

Material and methods
A field experiment was conducted at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *rabi* seasons of 2014-15. The soil of the experimental field was loamy sand in texture, alkaline in reaction and soluble salt content under safe limit. It was low in organic carbon (0.19 %), available N (168 kg/ha) and S (8.17 mg/kg); medium in available P_2O_5 (43.9 kg/ha), K_2O (261.6 kg/ha) and DTPA-extractable Fe and Zn and having sufficient DTPA-extractable Mn and Cu status. Nine treatment combinations comprising of three levels of phosphorus *viz.*, P_1 = 25 kg P_2O_5/ha, P_2 = 50 kg P_2O_5/ha and P_3 = 75 kg P_2O_5/ha and three levels of sulphur *viz.*,

S_1 = 10 kg S/ha, S_2 = 20 kg S/ha, S_3 = 30 kg S/ha were tried in randomized block design with factorial concept with four replications. Mustard variety GM 3 was used as a test crop. The crop was sown at a row distance of 45 cm and 15 cm plant to plant within row with a seed rate 4 kg/ha. A uniform half dose of nitrogen (25 kg/ha) through urea and full dose of phosphorus as well as sulphur as per treatments were applied manually in the form of diammonium phosphate and gypsum, respectively in soil just before sowing of seeds in previously opened furrows. Remaining dose of N was applied after 30 days of sowing. Observation in respect of yield attributing characters was recorded at harvest on randomly selected five plants. The seed and stover yields were recorded net/plot and converted into kg/ha.

Results and discussion

Effect of phosphorus

Application of P_2O_5 @ 75 kg/ha (P_3) recorded significantly the highest plant height, number of branches/plant, number of siliquae/plant and number of seeds/siliqua over its lower levels of phosphorus (25 kg and 50 kg P_2O_5/ha). Significantly higher length of siliqua was recorded under 75 kg P_2O_5/ha (P_3) as compared to P_1 level of phosphorus but former treatment was being at par with 50 kg P_2O_5/ha.

The seed and stover yields of mustard increased significantly due to 75 kg P_2O_5/ha (P_3) over its lower level of phosphorus. The per cent increase in seed yield was 31.2 with P_3 level of phosphorus over P_1 level whereas the corresponding value for increase in stover yield was 12.6 per cent.

The supply of phosphorus to soil might have accelerated cell division and enlargement, carbohydrate, fat metabolism and respiration in plant. These results are in agreement with the findings of Rana *et al*. (2005) [9] in mustard; Sune *et al*. (2006) [10] in linseed; Kumar and Yadav (2007) [6] in mustard; Devi *et al*. (2012) [3] and Dhage *et al.* (2014) [4] in soybean.

Effect of sulphur

Crop fertilized with of 30 kg S/ha (S_3) significantly improved the growth and yield atteributes such as plant height at harvest, number of branches/plant, number of siliquae/plant, length of siliqua and number of seeds/siliqua over rest of the levels of sulphur, it remained at par with treatment receiving 20 kg S/ha (S_2) except plant height at harvest.

An application of S @ 30 kg/ha (S_3) produced significantly the highest seed and stover yields over rest of the levels of sulphur. The increased in seed and stover yield due to application of S @ 30 kg/ha (S_3) was to the tune of 22.7 and 13.2 per cent, respectively over S_1 level (10 kg S/ha) of sulphur. Beneficial effect of S application on growth and yield attributes have also been reported by Chaudhary *et al.* (2007) [2], Kumar and Yadav (2007) [6], Mishra *et al.* (2010) [7] in mustard and Dhage *et al.* (2014) [4] in soybean.

Economics

The maximum net realization of ₹55,860/ha with BCR value of 4.33 was secured from the treatment combination of P_3S_3 (75 kg P_2O_5 and 30 kg S/ha) followed by treatment combination P_2S_3 (50 kg P_2O_5 and 20 kg/ha) which gave net realization of ₹ 51,588/ha with BCR value of 4.32. The lowest net realization of ₹33,059/ha with BCR value of 3.35 obtained under treatment combination of P_1S_1.

Table 1: Effect of different levels of phosphorus and sulphur on growth, yield attributes and yield of mustard.

Treatments	Plant height (cm) at harvest	Number of branches/plant	Number of siliquae/plant	Length of siliqua (cm)	Number of seeds/siliqua	1000-seeds weight (g)	Yield (kg/ha)	
							Seed	Stover
Levels of phosphorus (P)								
P_1: 25 kg P_2O_5/ha	162.4	17.20	317	4.11	12.04	4.67	1513	3739
P_2: 50 kg P_2O_5/ha	171.5	18.04	342	4.54	13.12	4.98	1844	3915
P_3: 75 kg P_2O_5/ha	178.5	19.87	355	5.00	14.42	5.17	1985	4212
SEm ±	1.03	0.29	4.32	0.20	0.34	0.21	20	21
CD (P=0.05)	3.03	0.86	12.70	0.60	1.02	NS	57	61
Levels of sulphur (S)								
S_1: 10 kg S/ha	168.8	16.74	315	4.14	11.40	4.81	1601	3677
S_2: 20 kg S/ha	170.2	18.92	345	4.61	13.77	4.99	1777	4026
S_3: 30 kg S/ha	173.4	19.44	353	4.90	14.40	5.02	1965	4163
SEm ±	1.03	0.29	4.32	0.20	0.34	0.21	20	21
CD (P=0.05)	3.03	0.86	12.70	0.60	1.02	NS	57	61
Interaction (P×S)								
SEm ±	1.79	0.50	7.49	0.35	0.603	0.380	34	36
CD (P=0.05)	NS	1.49	NS	NS	NS	NS	99	106
CV%	5.78	6.79	6.78	7.79	7.03	6.49	11.84	12.78

Table 2: Effect of different treatment combinations on economics of mustard.

Treatment combinations	Net return (₹/ha)	BCR
P_1S_1	33059	3.35
P_1S_2	33804	3.39
P_1S_3	43749	4.06
P_2S_1	39333	3.58
P_2S_2	48781	4.17
P_2S_3	51588	4.32
P_3S_1	43484	3.64
P_3S_2	50478	4.04
P_3S_3	55860	4.33

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