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EFFECT OF PHOSPHORUS, SULPHUR AND PSB ON GROWTH AND YIELD OF MUSTARD IN SOUTHERN RAJASTHAN

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ABSTRACT

A field experiment was conducted to study the "effect of phosphorus, sulphur and PSB on growth and yield of mustard [Brassica juncea (L) cernj & Cosson], at Chittorgarh, (Rajasthan) during rabi seasons of 2012-13 and 2013-14. The experiment was laid out in randomized block design with four levels of phosphorus and sulphur and two levels of phosphate solubilizing bacteria (control and inoculation) with three replications. The results revealed that each successive increase in level of phosphorus up to 50 kg P_2O_5 ha^{-1} significantly enhanced the plant height, dry matter accumulation $plant^{-1}$ at 60 days and at harvest stage, branches $plant^{-1}$, siliquae $plant^{-1}$, seed $siliqua^{-1}$, test weight as compared to control and 30 kg P_2O_5 ha^{-1}, .This reflect in marked effect on increased mean seed (19.75 q ha^{-1}) as well as stover (50.48q ha^{-1}) yields, net returns (`.Rs. 38531 ha^{-1}) and B:C ratio (1.86) with 40 kg P_2O_5 ha^{-1}. Increasing levels of sulphur up to 40 kg ha^{-1} significantly increased the plant height, dry matter accumulation $plant^{-1}$ at 60 days and at harvest stage, branches $plant^{-1}$, siliquae $plant^{-1}$, seed $siliqua^{-1}$, test weight,mean seed (19.40 q ha^{-1}) and stover (48.14 q ha^{-1}) yields, net returns (Rs.36416 ha^{-1}) and B:C ratio (1.91) over control. Seed inoculation with PSB significantly increased the plant height, dry matter accumulation $plant^{-1}$ at 60 days and at harvest stage, branches $plant^{-1}$, siliquae $plant^{-1}$, seed $siliqua^{-1}$, test weight, seed and straw yield and economic of mustard as compared to control.

Keywords: Phosphorus, sulphur, PSB, mustard, economics, yield.

INTRODUCTION

Mustard is the third important oilseed crop in the world after soybean and palm oil. Indian mustard is cultivated on 5.6 million ha area in India and predominately in Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, Gujarat and West Bengal, Rajasthan alone contributes 45.5% of total area and 48.6% of total production (6.4 mt) in the country.The important reason responsible for poor productivity in Rajasthan inadequate supply of nutrients..Phosphorus is critical in plant metabolism which plays an important role in cellular energy transfer, respiration, photosynthesis. It is a key structural component of nucleic acids, coenzymes, phosphoproteins and phospholipids. It improves seed size, stimulates proper seed filling and increases oil content. Sulphur is now rightly called the fourth major element of the plant next only to N, P and K. In mustard crop apart from N and P, the need for secondary nutrient specially sulphur is frequently felt and a deficiency of thIs nutrient has deleterious effect on plant productivity. It is a constituent of protein and plays an important role in oil synthesis. Besides, performing many physiological functions like synthesis of cysteine, methionine and chlorophyll in oilseed crops, sulphur also plays an important role in the formation of amino acids, synthesis of certain vitamin like biotin, thiamine and protein (Rathore *et al.* 2015).Biofertilizers are known to play a number of vital roles in soil fertility crop productivity and production in agriculture as they are eco-friendly but cannot at any cost replace chemical fertilizers that are indispensable for getting maximum crop yields. They promote seed germination and initial vigor of plant by producing growth promoting substances (Yadav *et al*, 2013). There is a lack of information pertaining to effect of phosphorus, sulphur and PSB on yield of mustard in Southern Rajasthan. Hence, the present investigation was carried out to study the effect of phosphorus, sulphur and PSB levels on the performance of Indian mustard under irrigated condition in Southern Rajasthan.

MATERIALS AND MATHEDS

A field experiment was conducted during winter (*rabi*) seasons of 2012-13 and 2013-14 at Krishi Vigyan Kendra, Chittorgarh (Rajasthan). Chittorgarh situated at $24^0.13'$ to $25^0.13'$ N latitude, $74^0.04'$ to $75^0.53'$ E longitude and at an altitude of 403.20 MSL in the Sub Humid

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Southern Plain and Aravalli Hills zone of Rajasthan. The experimental soil was sandy loam in texture, alkaline in reaction (pH 8.1) normal with respect to salinity (EC 0.79 dSm^{-1}), low in organic carbon (4.5 g kg^{-1}) and available N (246 kg ha^{-1}) and sulphur (9 mg kg^{-1}) and medium in available P (27 kg ha^{-1}) and K (329 kg ha^{-1}). The experiment consisting of four levels each of P (0, 30, 40 and 50 kg P_2O_5 ha^{-1}) and S (0, 30, 40 and 50 S kg ha^{-1}) and two levels of phosphate solubilizing bacteria (no inoculation and inoculation). The treatments were evaluated in randomized block design with three replication. Gypsum (15% sulphur) as a source of sulphur was applied uniformly as per treatments and incorporated in the soil. Phosphorus was applied through diammonium phosphate as per treatments. The crop was fertilized with recommended dose of nitrogen (60 kg N ha^{-1}). Half dose of nitrogen through urea and full dose of P was applied as basal in furrows and remaining half dose of N was applied as top dressing 30 days after sowing. The pure and freshly prepared strains of PSB inoculants were coated with seed uniformly and used for sowing as per treatments. Bio-902 Indian mustard was sown manually using a seed rate of 5 kg ha^{-1} on 12 October, 2012 and 13 October, 2013 at row spacing of 30 cm. Plant population was maintained by thinning 10 days after germination. All the agronomic practices were followed as per recommendation. The observations recorded were plant height, dry matter accumulation $plant^{-1}$ at 60 days and harvest stage, branches $plant^{-1}$, siliquae $plant^{-1}$, seed $siliqua^{-1}$, tests weight, and seed and stover yields were recorded at harvest. The economics of mustard crop was calculated based on the prevailing market prices of inputs and produce.

RESULTS AND DISCUSSION

Effect of phosphorus

Application of 40 kg P_2O_5 ha^{-1} significantly increased the plant height at 60 DAS, and harvest and dry matter accumulation $plant^{-1}$ at 90 DAS and harvest, branches $plant^{-1}$, siliquae $plant^{-1}$, seed $siliqua^{-1}$ and test weight in lmustard over control (Table 1). However, the differences between 40 and 50 kg P_2O_5 ha^{-1} for growth and yield attributes were non-significant. The highest mean of all the growth and yield attributing characters was noted at 50 kg P_2O_5 ha^{-1} which was more as compared to control, 30 and 40 kg P_2O_5 ha^{-1}. Application of 40 kg P_2O_5 ha^{-1} significantly increased siliquae $plant^{-1}$ (363.6) seed $siliqua^{-1}$ (16.2) and test weight (5.9 g) over control (Table 1). The better development of yield attributes with phosphorus fertilizers might be due to its key role in root development, energy translocation and metabolic processes of plant through which increased translocation of photosynthesis towards sink development might have occurred.These results are in close conformity with the finding of Kumar *et al. (*2007) and Khatkar *et al,* (2009). There was significant effect of different P levels on seed and stover yield of mustard during both the years and in pooled as well. Application of 40 kg P_2O_5 ha^{-1} resulted in significant increase in seed yield of 19.33 and 19.44 q ha^{-1} and stover yield of 48.23 and 49.89 q ha^{-1} in 2012-13, 2013-14, respectively. Application of 40 kg P_2O_5 ha^{-1} also produced higher biological yield by 34.9 and 31.4% over control, 30 kg P_2O_5 ha^{-1}, respectively. However, harvest index was not influenced significantly with phosphorus fertilization. This might be due to increased dry matter with higher levels of phosphorus which resulted increased supply of phosphorus to plant for proper growth and metabolic process as well as its resultant positive effect on yield attributes led to enhanced seed yield. The findings corroborate the results of Khatkar *et al.,* (2009) and Gangwal *et al.* (2011). The net returns and benefit: cost ratio obtained from mustered were significantly affected with phosphorus application. Application of 50 kg P_2O_5 ha^{-1} resulted in net returns of Rs. 38531 ha^{-1} with a benefit: cost ratio of 1.8.

Effect of sulphur

The maximum plant height at 60 DAS (160.6 cm) and harvest stage (198.6 cm), dry matter accumulation $plant^{-1}$ at 90 DAS (57.1g $plant^{-1}$) and harvest stage (70.1g $plant^{-1}$) branches $plant^{-1}$ (24.8) ,siliquae $plant^{-1}$ (366.3) , seed siliqua $plant^{-1}$ (16.4) and test weight (5.7g) were recorded with 50 kg S ha^{-1}, but significant increase was recorded only up to 40 kg S ha^{-1} .The increase in growth parameters under sulphur fertilization might be due to improved sulphur availability, which in turn enhanced the plant metabolism and photosynthetic activity resulting in better growth. These results are in the line with the findings of Gangwal *et al*, (2011) and Verma *et al.* (2012). Application of 40 kg S

Table 1: Effect of phosphorus, sulphur and PSB levels on growth and yield attributes of mustard (Pooled data of 2 years)

Treatment	Plant height (cm)		DMA (g plant^{-1})		Branches plant^{-1}	Siliqua plant^{-1}	Seed siliqua^{-1}	Test weight (g)
	60 DAS	At harvest	90 DAS	At harvest				
Phosphorus (kg ha^{-1})								
0	136.4	172.3	45.4	63.2	19.5	343.7	14.5	5.3
30	146.8	180.4	51.0	65.7	21.2	356.9	15.3	5.5
40	158.3	195.5	55.5	68.1	24.1	363.6	16.2	5.6
50	160.5	198.6	57.1	70.2	24.9	366.3	16.4	5.7
S.Em.±	1.20	1.81	0.61	0.76	0.24	1.06	0.09	0.03
C.D. (P=0.05)	3.36	5.07	1.72	2.13	0.67	2.96	0.25	0.08
Sulphur (kg ha^{-1})								
0	140.8	181.0	48.2	61.7	20.1	340.4	14.9	5.3
30	148.8	182.8	51.1	66.3	21.5	357.8	15.6	5.5
40	155.1	189.1	54.5	68.8	23.7	365.8	15.9	5.6
50	157.3	193.9	55.1	70.2	24.3	367.4	16.1	5.7
S.Em.±	1.20	1.81	0.61	0.76	0.24	1.06	0.09	0.03
C.D. (P=0.05)	3.36	5.07	1.72	2.13	0.67	2.96	0.25	0.08
PSB								
No inoculated	146.1	181.6	50.5	64.1	21.7	351.2	15.2	5.5
PSB	154.9	191.7	54.0	69.4	23.1	364.0	15.9	5.6
S.Em.±	0.85	1.28	0.43	0.54	0.17	0.75	0.06	0.02
C.D. (P=0.05)	2.38	3.58	1.21	1.50	0.47	2.09	0.17	0.06

ha^{-1} significantly increased the number of siliquae plant^{-1}, number of seeds siliqua^{-1} and test weight compared to control and 30 kg S ha^{-1} (Table 1). The increase in these characters might be due to the important role of sulphur in energy transformation, activation of enzymes and carbohydrate metabolism. Supply of sulphur in adequate and appropriate amount also helps in flower primordia initiation for its reproductive part, which in turn governs the yield attributes significantly. These results corroborate the findings of Dongarkar *et al.,* (2005) and Jat and Mehra (2007). Application of 50 kg S ha^{-1} resulted in seed yield of 19.25, 19.54 and 19.40 q ha^{-1} and stover yield of 47.32, 48.97 and 48.14q ha^{-1} in 2012-13, 2013-14 and pooled basis, respectively. The application of sulphur might have encouraged yield attributes and total biomass which resulted an increase in seed yield. These results are in close conformity with those of Gangwal *et al.* (2011), Jyoti *et al.* (2012) Verma *et al.* (2012) and Singh *et al.*

Table 2: Effect of phosphorus, sulphur and PSB levels on yields, harvest index, net return and economics of mustard (Pooled data of 2 years)

Treatments	Seed yield (q ha^{-1})			Stover yield (q ha^{-1})			Biological yield (q ha^{-1})	Harvest Index (%)	Net return (Rs.ha^{-1})	B:C ratio
	2012-13	2013-14	Mean	2012-13	2013-14	Mean				
Phosphorus (kg ha^{-1})										
	14.76	14.90	14.80	36.42	38.03	37.23	52.03	28.5	26276	1.4
30	16.78	17.01	16.95	41.51	43.19	42.35	59.30	28.5	31063	1.6
40	19.33	19.44	19.38	48.23	49.89	49.06	68.44	28.4	37920	1.9
50	19.60	19.90	19.75	49.84	51.13	50.48	70.23	28.2	38531	1.8
S.Em.±	0.30	0.26	0.20	0.81	0.79	0.56	0.57	0.36	572	0.03
C.D (P=0.05)	0.84	0.74	0.55	2.28	2.23	1.58	1.59	NS	1602	0.08
Sulphur (kg ha^{-1})										
0	15.06	15.21	15.14	38.97	40.58	39.78	54.92	27.6	26242	1.4
30	17.48	17.65	17.57	43.38	45.00	44.19	61.76	28.5	32961	1.6
40	18.67	18.85	18.76	46.34	47.69	47.02	65.78	28.6	36416	1.8
50	19.25	19.54	19.40	47.32	48.97	48.14	67.54	28.7	38172	1.9
S.Em.±	0.30	0.26	0.20	0.81	0.79	0.56	0.57	0.36	572	0.03
C.D. (P=0.05)	0.84	0.74	0.55	2.28	2.23	1.58	1.59	NS	1602	0.08
PSB										
	17.22	17.35	17.28	41.95	43.08	42.52	59.80	28.9	32102	1.6
PSB	18.01	18.27	18.14	46.05	48.04	47.04	65.18	27.8	34793	1.7
S.Em.±	0.21	0.19	0.14	0.57	0.56	0.40	0.40	0.25	405	0.02
C.D. (P=0.05)	0.59	0.52	0.39	1.61	1.58	1.12	1.13	0.71	1133	0.06

(2015).Similar results were also recorded for stover yield of mustard. However, harvest index was remained comparable with no sulphur fertilization. The levels of sulphur showed vareations in net returns and B:C ratio (Table 2). Application of 50 kg S ha^{-1} gave significantly net returns (Rs 38172 ha^{-1} and B:Cratio 51.9) than other levels of sulphur.

Effect of PSB

The inoculation of seeds with PSB significantly increased plant height at 60 DAS (154.9 cm) and harvest stage (194.7 cm), dry matter accumulation at 90 DAS (54.0 g $plant^{-1}$) and harvest stage (69.4 g $plant^{-1}$) , branches $plant^{-1}$ (23.1), siliquae $plant^{-1}$ (164.0), seed siliqua $plant^{-1}$ (15.9) and test weight (5.8 g) over no inoculation treatment. Seed inoculation with PSB produced significantly higher seed yield of mustard. (18.01 and 18.27 q ha^{-1}) and stover yield (46.05 and 48.04 q ha^{-1}) during 2012-13, 2013-14, respectively over un inoculated with PSB. A marked effect on biological yield (65.2 q ha^{-1}), was recorded with inoculation of seed with PSB over no inoculation. Beneficial effect of PSB could be attributed to the fact that PSB solubilizes the native as well as applied phosphorus and also synthesize growth promoting substances like auxin, indole acetic acid, gibberllins, cytokinin and vitamins which augment the plant growth .Similar beneficial effect of PSB inoculation on yield of mustard was also reported by Kantwa and Meena (2002) and Gangwal *et al*, (2011). The highest net returns (Rs. 34793 ha^{-1}) and B:C ratio (1.7) were obtained with PSB inoculation. This increase in net returns and B:C ratio was due to higher grain and stover yield of mustard.

From the results, it may be concluded that phosphorus and sulphur fertilization are required to harvest higher yield and economic output. Application of 50 kg P_2O_5, 50 kg S ha^{-1} and seed inoculation with PSB was found aptimum for maintaining higher mustard yield and net returns in sandy loam soil of southern Rajasthan.

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