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Influence of nitrogen and Sulphur application on growth, yield attributes, yield and quality of mustard (*Brassica junco* L) in Bundelkhand region

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Abstract
Field experiment was carried out during 2013- 14 and 2014-15 at research farm of Institute of Agricultural Sciences, Bundelkhand University, Jhansi to study the influence of nitrogen and sulphur application on growth parameters, yield attributes, yield and quality of mustard. The present study comprised four nitrogen levels (control, 40, 80 and 120 kg ha^{-1}) and four sulphur levels (control, 15, 30 and 45 kg ha^{-1}) tested and replicated three times. It was recorded that plant height, no. of branches per plant (primary, secondary and total), length of silique, no. of silique per plant, no. of seeds per silique, 1000 seed weight, seed yield per plant, seed yield ha^{-1}, oil content (%) and protein content (%) increased significantly with every increasing levels of nitrogen and sulphur application. The maximum values were recorded at 120 kg/ha Nitrogen and 45 kg/ha sulphur application over control. However difference in harvest index and protein content at 15, 30 and 40 kg/ha sulphur was found to be non-significant.

Keywords: Indian mustard, sulphur, nitrogen, yield, quality, growth

Introduction
Mustard belongs to the family cruciferae popularly known as rai and is an important rabi season oilseed crop of northern India. Mustard is second most important edible oilseed crop after groundnut, accounts nearly 30% of the total oilseeds produced in India. India is one of the largest rapeseed-mustard growing countries in the world, occupying the first rank in area and second in production next to China. Total area under rapeseed and mustard in India is 5.92 milllion hectares with a production of 6.78 million tonnes and productivity of 1145 kg ha^{-1}.The oilseed crop plays a very significant role in agricultural economy of our country because of oil and fats apart from forming on India pensile part of human diet. Rapeseed, mustard, groundnut, linseed, castor, safflower and Niger, all put together account for 13% of the annual cropped area. In India, rapeseed, mustard occupied 6.33 million hectare area with a production 6.69 million tones and productivity of 1075 kg/ha during 2011-12. In UP, rapeseeds, mustard is a oilseed crop, accounting for 18.81% area (0.85 million ha) and 19.39% total production (0.76 million tonnes) of the country during 2013-14 to 2014-15 with on average yield 895 kg/Ha which is quite low. Amongst the agronomic factors known to augment crop production, fertilizer stands first and considered one of the most productive input in agriculture as a source of nutrient elements particularly nitrogen which is insufficient in most of our Indian soil and plays appreciable an important role in mustard crop. Under present soil fertility status in India, sulphur is now recognized as the fourth nutrient element after nitrogen, phosphorus and potassium which are limiting the crop yield. On an average crop absorb as much sulphur as they absorb phosphorous and field scale deficiencies of sulphur in soil and plant are becoming increasingly important. Based on the impact of sulphur application on the yield and oil content of oilseed, it has been reported that each unit of sulphur added to sulphur deficient soil can augment the supply of edible oil 3-3.5 units. Mustard a cruciferous crop, respond remarkably to sulphur application. Adequate supply of sulphur to rapeseed mustard promotes the synthesis of sulphur containing essential amino acids, protein and oil. Applications of fertilizers containing these two nutrient elements have been recognized to be most important constraints and often inadequate application of nitrogen and sulphur at farmer's field reduce the yield levels of mustard. Under sulphur deficient soils, the full yield potential of mustard can't be realized regardless of other nutrients applied or adoption of improved crop management practices.

Material and Methods

A field experiment was conducted during 2013-14 and 2014-15 in rabi session at the agriculture research farm, Institute of Agricultural Sciences, Bundelkhand University, Jhansi. The soil was sandy loam (Parwa) in texture. The physiological properties of soil are given in table no. 1.

Climate and Weather

Jhansi district city is situated in subtropical zone between 25° 34'' to 26° 57" N latitude and 77.90° to 78.12° E longitude. It is situated in the south west part of UP and its altitude from sea level is about 251 meter. The winter months are cold and summer is very hot and dry, May and June are hottest months with maximum day temp. Jhansi has subtropical climate with hot days during summer and cold in winters. The mean maximum temp of 45° C to 49° C is not uncommon during summer while very low temp (3° C) accompanied in January. The total rainfall as well as its distribution in this region is subjected to very large variation. About 80 to 90% of it is received during July to September. Few showers of cyclonic rains are also received during December to January of late spring.

Table 1: Physico-chemical properties of experimental soil

S. No.	Particulars	Value	Method employed
1.	Soil texture Sand Silt Clay	42.0% 38% 20% Sandly loam	Deshpandey *et al*. (1971)
2.	Organic carbon (%)	0.48	Walkley and Black method (Jackson 1973)
3.	Available nitrogen (Kg/ha)	212.0	Alkaline $KMnO_4$ method (Jackson 1973)
4.	Available P (Kg/ha)	14.0	Olsen's method (Jackson 1973)
5.	Available K (Kg/ha)	185.0	1 N neutral ammonium acetate method (Jackson 1973)
6.	pH (1:2.5 soil water suspension)	7.4	Glass electrode pH meter (Jackson 1973)

The experimental soil was sandyloam in texture. The treatment comprising 4 levels of nitrogen (control, 40, 80, 120 kg ha^{-1}) and 4 levels of sulphur (control, 15, 30, 45 kg ha^{-1}) were laid out in factorial randomized block design with 3 replications. The mustard variety Rohini was shown on 12 Oct 2013 in first year. During the second year mustard crop shown on 14 Oct 2014. The treatmental doses of nitrogen, sulphur and the recommended doses of phosphorous and potassium were applied at the time of showing in both the experimental year. The sources of nitrogen, phosphorous, sulphur and potassium are applied through urea, DAP, elemental sulphur and murate of potash in all the plots at the time of showing. Remaining dose of nitrogen was top dressed after first irrigation. The package of practices were followed as per zonal recommendations. The mustard crop was grown in conserved moisture and two irrigations were applied at flowering and pod formation stage. The observations were recorded as plant height, no. of branches per plant, no. of silique per plant, length of silique, no. of seeds per silique, 1000 seed weight, seed weight per plant, total biological yield, seed yield kg/ha, harvest index (it is the ratio of grain and biological yield which was calculated as = Grain yield x 100/Biological yield), oil content and protein content were recorded at harvest from each net plot size (4 x 1.8m). Seed samples were analyzed for their nitrogen, phosphorous, potassium and sulphur by adopting standard procedures (Jackson 1973). The soxhlet method was adopted for the estimation of oil content in seeds (AOAC 1960). The soil sample was collected before showing and after the harvesting of mustard crop from 0- 20 cm depth. The processed sample was analyzed from following standard procedures. The available nitrogen analyzed by automatic nitrogen analyzer, available phosphorous by olsons method (1954), available K by flame photometer. The protein content were analyzed and calculated by multiplying with constant factor with nitrogen 6.25 and expressed in %. As per procedure outlined by Jackson (2005)

Result and Discussion

Growth Studies

Table 2 revealed that plant height, no. of branches per plant (primary, secondary and total) increased significantly with increasing levels of nitrogen and sulphur application. The maximum values of above characters are observed at 120 kg/ha nitrogen and 45 kg/ha sulphur application over control. Plant height was found to be 194.1 cm, primary-9.2, secondary- 18.9 and total 27.5 at 120 kg/ha nitrogen application and 183 cm, primary- 7.9, secondary- 15.7 and total 22.9 cm at 45 kg/ha sulphur application. The all growth parameters were increased significantly with increasing levels of nitrogen and sulphur application over control. The vegetative growth and vigorous vegetative growth may be due to greater cell division and more mesitamatic activity increased photosynthesis for branches formation. It is well known that nitrogen being constituent of amino acid, protein, chlorophyll, and chloroplast would directly increased growth parameters through better utilization of photosynthesis. The similar trends were also reported by Hussian *et al* (2004) and Chauhan *et al* (2002), Joshi *et al* (2012), Kachroo *et al* (1997), Chaube *et al* (2011), Rana and rana (2003), Singh and Meena (2011), and Patel *et al* (2010.) [3, 6, 7, 1, 9].

Yield Attributes

Table 3 indicate that no. of silique per plant, length of silique, no. of seeds per plant & 1000 seed weight (gm) increased significantly with every increasing levels of nitrogen and 45 kg/ha sulphur application. The maximum value of such parameters were recorded at 120 kg/ha nitrogen (485.4, 51, 10.7, 5 & 421.0, 4.8, 10.3 and 5.1 respectively). Biological yield & harvest index may be due to increased supply of sulphur and better translocation of nutrients. However the difference in 1000 seed weight with 30 kg/ha and 45 kg/ha sulphur application was found to be non-significant. In the case of seed yield per plant was recorded with 15 kg and 30 kg/ha sulphur remains at par. It is due to increased supply of sulphur and better translocation of nutrients for photosynthesis to seed leading caused by more nutrient accumulation in seed. The similar trends were also reported by Hussian *et al* (2004) Kachroo *et al* (1997) and Chaube *et al* (2011) [7, 1].

Yield Studies

Table no. 3 revealed that seed yield per plant, seed yield kg/ha, biological yield kg/ha, harvest index of mustard seed increased significantly with increasing levels of nitrogen and sulphur application. The maximum value of such parameters was recorded at 120 kg/ha nitrogen (23.8 gm, 2104 kg/ha, 8967 Kg/ha & 23.4 %) and 45 kg/ha sulphur application (19.3 gm, 1869 kg/ha, 8724 kg/ha & 21.3%)**.** The similar trends were also reported by Chaudhary *et al* (1992), Joshi *et al* (2011) Kachroo *et al* (1997) and Chaube *et al* (2011) [7, 1, 2].

Quality Studies

Table 3 indicates that the oil content (%) and protein content (%) of mustard seed increasing trends was observed with increasing levels of nitrogen and sulphur application. The maximum figures are recorded at 120 kg/ha nitrogen application (41.4 % and 22.5 %). The maximum value of oil & protein content at 45 kg/ha sulphur applications (43% and 20.2 %) were recorded. However the difference in protein content at 15, 30 and 45 kg/ha sulphur application were found be non-significant. The increasement in oil and protein content may be due to the nitrogen is the basic constituent of protein & sulphur application improved the nutritional environment and more nutrient uptake. The similar trends were also reported by Jain *et al* (1996) [5].

Table 2: Influence of nitrogen and sulphur fertilization on growth parameters of mustard as plant height, primary, secondary and total branches per plant (Data pooled over two years 2013-14 and 201415)

Treatment	Plant height		Branches per plant		
	60 days	At Harvest	Primary	Secondary	Total
Nitrogen level (Kg/ha)					
Control	73.7	166.0	5.0	7.9	13.1
40	84.6	177.5	6.7	12.7	19.3
80	89.9	183.0	7.8	17.0	24.6
120	91.0	194.1	9.2	18.9	27.5
SEm±	2.7	1.8	0.2	0.4	0.4
CD at 5%	5.4	3.7	0.4	0.8	0.8
Sulphur level (Kg/ha)					
Control	82.1	177.9	6.3	13.1	19.5
40	84.1	178.0	7.0	13.6	20.5
80	85.2	181.3	7.3	14.5	21.4
120	87.8	183.3	7.9	15.5	22.9
SEm±	2.7	1.8	0.2	0.4	0.4
CD at 5%	NS	3.7	0.4	0.8	0.8

Table 3: Influence of nitrogen and sulphur fertilization on yield attributes, yield, and quality of mustard crop (Data pooled over two years 2013-14 and 2014-15)

Treatment	Yield attributes				Yield Studies				Quality Studies	
	No. of silique / plant	Length of silique (cm)	No. of seeds/ silique	1000 seed weight (g)	Seed yield/ plant (g)	Total yield (Kg/ha)	Total yield (Kg/ha)	Harvest Index (%)	Oil content (%)	Protein content (%)
Nitrogen level (Kg/ha)										Nitrogen level (Kg/ha)
Control	258.6	4.0	8.4	4.0	11.4	1194	5887	20.7	37.5	16.6
40	322.9	4.6	8.9	4.9	15.2	1773	7781	22.0	30.4	19.6
80	403.3	4.8	10.5	4.9	19.0	1945	8867	21.9	39.9	21.1
120	485.4	5.1	10.7	5.0	23.8	2104	8967	23.4	41.4	22.5
SEm±	6.3	0.1	0.1	0.2	0.4	35	15	0.6	0.8	0.5
CD at 5%	12.7	0.2	0.2	0.4	0.8	71	320	1.2	1.7	1.0
Sulphur level (Kg/ha)										
Control	309.4	4.4	9.7	4.3	15.4	1618	7206	22.3	36.5	19.5
40	364.0	4.5	9.6	4.7	17.0	1697	7347	23.4	38.5	19.9
80	375.7	4.8	9.9	4.9	17.6	1793	8163	21.6	40.2	20.2
120	421.0	4.8	10.3	5.1	19.3	1869	8724	21.3	43.0	20.2
SEm±	6.3	0.1	0.1	0.2	0.4	35	156	0.6	0.8	0.5
CD at 5%	12.7	0.2	0.2	0.4	0.8	71	320	1.2	1.7	NS

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