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Interaction effect of varying level of nitrogen and sulphur fertilizers on growth and yield of Indian mustard (*Brassica juncea* L.) under Northern hill zone of Chhattisgarh

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Abstract
The field experiment entitled "Interaction effect of varying level of nitrogen and sulphur fertilizers on growth and yield of Indian mustard (*Brassica juncea* L.) Under Northern hill zone of Chhattisgarh." was conducted during the *rabi* season of 2019-20 at Research farm of Ambikapur (CG). The field experiment was conducted in factorial randomized completely block design constituted of sixteen treatment combinations consisting four levels of nitrogen fertilizer (30, 60, 90 and 120 kg ha^{-1}) and four levels of sulphur fertilizer (0, 20, 30 and 40 kg ha^{-1}) and replicated trice. The result shows that growth and yield attributes, seed yield, oil yield and biological yield were influenced significantly by impose of different levels of nitrogen and sulphur fertilizers simultaneously. Significantly the maximum values of above mentioned parameters were recorded with 120 kg N+ 40Kg S ha^{-1}. However 120 kg N+ 30Kg S ha^{-1} recorded highest net return (63384.27 ₹ ha^{-1}) with the B: C ratio of 1.51. with the view of results obtained, it can be advocated to the farmers of northern hill zone of Chhattisgarh for optimizing the yield, quality and economics of Indian mustard, it should be applied with 90 kg N ha and 30 kg S ha^{-1} simultaneously.

Keywords: Indian mustard, interactions, factorial RBD

1. Introduction
Indian mustard [*Brassica juncea* (L.) Czern & Cosson.] is an most important oilseed crop, next to sunflower. Mustard (*Brassica juncea*) is commonly known as rai. Its oil and its oil meal may contain anti-nutritional factors like, goitrogens (thioglucosides or glucosinolates), pectins and oligosaccharides, erucic acid, tannic acid, sinapine (cholinester). Mustard also stimulates digestion and salivary secretion.

Mustar and rapeseed are used in various ways. The oil and seed are used as condiments in the preparation of vegetables, curries, pickles so also as the used as, hair oil, in medicines and manufacturing of grease. The mustard oil cake is considered as the best animals feed and organic manures. The leaves are consumed as green vegetables. In the leather industries-mustard oil is used for softening of leather.

Seeds of mustard have high energy content with 28-32% oil and relatively high (28-36%) protein content. The amino acid composition of protein in mustard is well balanced; it is also rich in essential amino acids. Mustard oil contains 20-28% oleic acid, 10- 20% linoleic and 30-40% erucic acid [8].

In India, mustard is grown over an area of 5.96 million ha and production of 8.32 M tonnes with the productivity of 1397 kg ha^{-1} (Department of Agriculture, Cooperation and Farmers Welfare Ministry of Agriculture and Farmers Welfare Government of India). In Chhattisgarh state productivity is 564 kg ha^{-1} (Directorate of Agriculture, Government of Chhattisgarh).

The nutrients management is the key technology in maintaining and sustaining the production potential of mustard. One of the most important factors which is responsible for low yield of mustard is inadequate supply of plant nutrients, especially nitrogen and sulphur. The importance of nitrogen fertilization to achieve the higher production potential in mustard is well recognized, it is the basic constituent of plant life.

Sulphur is involved in various metabolic processes in the plants. It is imperative for synthesis of essential amino acids like cysteine, cystine and methionine. The SH-sulphydryl linkages provide the source of pungency in oils. It is involved in the formation of glycosides or glucosinolates. It plays a vital role in chlorophyll formation [5].

2. Materials and Methods

The investigation was carried out during *Rabi* season of the year 2019-20 at the Research farm of RMD College of Agriculture & Research Station, Ambikapur which is situated at $23^0$18' N latitude and $83^0$15' longitude and at altitude of 611 meter above MSL and represents the northern hills agro-climatic zone of Chhattisgarh. The experimental soil was sandy loam in texture, acidic in reaction (pH 5.7), medium in organic carbon (0.56), available nitrogen (234 kg ha^{-1}), available phosphorus (8.4 kg ha^{-1}) and available potassium (268 kg ha^{-1}). The experiment was carried out in factorial randomized completely block design (FRCBD) with 3 repetations. The treatments contained of sixteen treatment combinations. The treatment comprised of two factors having four levels each, ie. Factor 1 was nitrogen levels (30, 60, 90 and 120 kg ha^{-1}) and factor 2 was sulphur levels (0, 20, 30 and 40 kg ha^{-1}). Sowing of the crop was done manually at the end of November, 'Chhattisgarh Sarson-1' mustard cultivar was used. In each experimental plot full dose of P_2O_5, K_2O, S and 50% dose of N (as per treatment) were applied in furrow. Remaining nitrogen was top dressed (as per treatment) 26 DAS. Mustard was sown at spacing of 30 cm with plant to plant distance of 10 cm. by using 5 kg seeds ha^{-1}. Five plants were randomly selected in each plot to record growth parameters of mustard *viz.*, plant height, number of leaves $plant^{-1}$, number of branches $plant^{-1}$ and dry matter accumulation at various growth stages i.e. 30, 60, 90 DAS and at harvest. Five plants were randomly selected at the time of harvesting from each net plot for determination of yield attributes *viz*., number of siliqua $plant^{-1}$, length of siliqua, seeds $siliqua^{-1}$ and test weight of seeds. After cleaning and proper drying the seed yield of each net plot was recorded and after that stover weight was taken. The cost of cultivation of different treatments was worked out separately. Labour and requirement of mechanical power for different operations such as land preparation, planting and harvesting was calculated as per local market rate. Benefit cost (B: C) ratio was calculated by dividing cost of cultivation by net return. All data obtained in the experiment was analyzed statistically by using *F*- test, critical difference (CD) values at *P*= 0.05 were used to determine the significance of mean differences of treatments.

3. Result and Discussion

3.1 Growth Parameters

A significant variation in growth parameters such as plant height, number of leaves $plant^{-1}$ and dry matter accumulation was observed with interactions of various levels of nitrogen and sulphur (Table l).

Tallest plants were recorded from the plot integrated with 120 kg N+40 Kg S ha^{-1} (172.3 cm) followed by 120 kg N+30 Kg S ha^{-1} (171.0 cm), 90 kg N+ 40 Kg S ha^{-1} (170.6 cm) and 90 kg N+ 30 Kg S ha^{-1} (170.6 cm) and were found statistically superior over rest of the treatments and the smallest plants were recorded in plot treated with 30 kg N+0 Kg S ha^{-1} (145.7 cm). Similar results were also recorded by [3].

Maximum number of leaves $plant^{-1}$ at 60 DAS (38.96) were obtained with the treatment supplied with 120 kg N+40 kg S ha^{-1}, found to be in parity with 120 kg N+30 kg S ha^{-1} (37.32), 90 kg N+40 kg S ha^{-1} (37.21) and 90 kg N+30 kg S ha^{-1} (36.78) but significantly higher than other combinations of N and S, while significantly minimum number of leaves $plant^{-1}$ (26.22) were recorded with 30 kg N + 0 kg S ha^{-1}. Number of leaves $plant^{-1}$ gradually increased up to 60 DAS and there after fall-down trend was observed. Least number of leaves were recorded at harvest.

Analysis of variance showed that the treatment 120 kg N + 40 kg S ha^{-1} exhibited maximum effect on number of branches $plant^{-1}$ of mustard, gave the value of 24.30 branches $plant^{-1}$ and was found to be on par with 120 kg N+ 30 kg S ha^{-1} (23.64), 90 kg N + 40 kg S ha^{-1} (23.42) and 90 kg N + 30 kg S ha^{-1} (23.0).

Crop fertilized with 120 kg N + 40 kg S ha^{-1} accumulated significantly more dry matter $plant^{-1}$ (76.10 g) followed by 120 kg N + 30 kg S ha^{-1} (76.10 g), 90 kg N + 40 kg S ha^{-1} (75.34 g) and 90 kg N + 30 kg S ha^{-1} (75.84 g). Application of 30 kg N+ 0 kg S ha^{-1} resulted into significantly lowest dry matter accumulation $plant^{-1}$ (60.32 g). Dry matter production successively increased with maturity due to favorable effect of sulphur probably because of involvement of deeper and intensive root system higher uptake, quick physiological process resulting in greater dry matter production of plant [5]. These results are in the line of [1].

3.2 Yield attributes

Number of siliqua $plant^{-1}$, length of siliqua, seeds $siliqua^{-1}$ and test weight varied significantly due to nitrogen and sulphur levels (Table 2). Application of 120 kg N + 40 kg S ha^{-1} resulted in highest number of siliqua $plant^{-1}$ (346.20), length of siliqua (5.19 cm), number of seeds $siliqua^{-1}$ (15.22) and test weight (4.13g) which were on par with the results obtained from application of 120 kg N + 30 kg S ha^{-1}, 90 kg N + 40 kg S ha^{-1} and 90 kg N + 30 kg S ha^{-1} but significantly superior over the other treatment combinations. While significantly lower number of siliqua $plant^{-1}$ (145.00), length of siliqua (4.67 cm), number of seeds $siliqua^{-1}$ (11.95) and test weight (2.88 g) were observed with 30 kg N + 0 kg S ha^{-1}. The findings are in conformity with the findings obtained by [6] and [2].

3.3 Yields

A significant increase in seed yield and biological yield were noted with increasing levels of N and S fertilizers (Table 3). The maximum seed yield (1827.16 kg ha^{-1}) and biological yield (6862.51 kg ha^{-1}) were obtained with the application of 120 kg N + 40 kg S ha^{-1}, which was at par with 120 kg N + 30 kg S ha^{-1} (1823.00 and 6825.27 kg ha^{-1} seed and biological yield respectively), 90 kg N + 40 kg S ha^{-1} (1799.67 kg ha^{-1} and 6714.67 kg ha^{-1} seed and biological yield respectively) and 90 kg N + 30 kg S ha^{-1} (1788.33 and 6701.03 kg ha^{-1} seed and biological yield respectively). 30 kg N + 0 kg S ha^{-1} recorded lowest seed yield (1121.03 kg ha^{-1}) and biological yield (4431.77 kg ha^{-1}).

A significant increase in seed yield of mustard with high N and S application might be because of the better availability of the nutrients for production of more siliquae $plant^{-1}$ and seeds $siliqua^{-1}$ [4]. These results are in agreement with the findings of [4].

3.4 Economics

Economics were worked out for mustard by taking into consideration of the input cost and market price of the crop produce. Significant variations in economic parameters were

observed due to different nitrogen and sulphur levels (Table 3). The maximum net return (Rs.63384.27 ha^{-1}) was accrued with 120 kg N+30 Kg S ha^{-1} followed by 120 kg N+ 40 Kg S ha^{-1}, 90 kg N+30 Kg S ha^{-1} and 90 kg N+ 40 Kg S ha^{-1} resulted Rs. 62757.53, 61778.63 and 61515.47 ha^{-1} net return respectively. The findings are within the close vicinity of those reported by Singh *et al.* (2010) [7]. Significantly the highest B:C ratio (1.51) was obtained from the treatment applied 120 kg N+30 Kg S ha^{-1}, closely followed by 90 kg N +30 Kg S ha^{-1} (1.49), 120 kg N + 40 Kg S ha^{-1} (1.47) and 90 kg N + 40 Kg S ha^{-1} (1.45). Application of 60 kg N + 20 Kg S ha^{-1}, recorded significantly the lowest (0.68) B:C ratio. The findings are alike with those reported [7].

Table 1: Interaction effect varying levels of nitrogen and sulphur fertilization on growth attributes of mustard

Treatments	**Plant height (cm)**				**Number of leaves plant^{-1} 60DAS**			
S levels (kg ha^{-1})	**N levels (kg ha^{-1})**							
	30	**60**	**90**	**120**	**30**	**60**	**90**	**120**
0	145.7	146.0	162.4	162.6	26.22	25.23	32.17	30.70
20	148.5	150.1	163.5	163.1	27.23	28.50	32.33	32.43
30	154.0	160.8	170.6	171.0	28.30	29.63	36.78	37.32
40	158.6	161.0	170.6	172.3	29.75	30.60	37.21	38.96
S.Em±	2.490				1.496			
CD (P=0.05)	7.303				4.389			
Treatments	Number of branches plant^{-1}				Dry matter accumulation plant^{-1} (gm)			
N levels (kg ha^{-1})	S levels (kg ha^{-1})							
	30	60	90	120	30	60	90	120
0	15.89	17.38	18.89	20.23	60.32	60.86	67.25	68.87
20	16.07	17.67	19.45	20.52	60.33	61.33	69.86	69.33
30	17.43	18.21	23.00	23.64	63.47	63.47	74.84	76.00
40	18.40	18.43	23.42	24.30	64.70	64.79	75.34	76.10
S.Em±	0.712				0.665			
CD (P=0.05)	2.088				1.950			

Table 2: Interaction effect varying levels of nitrogen and sulphur fertilization on yield attributes of mustard

Treatments	**Number of siliqua Plant^{-1}**				**Length of siliqua(cm)**			
S levels (kg ha^{-1})	**N levels (kg ha^{-1})**							
	30	**60**	**90**	**120**	**30**	**60**	**90**	**120**
0	145.00	156.67	232.07	264.33	4.67	4.69	4.75	4.78
20	161.00	182.90	245.33	287.00	4.68	4.72	4.76	4.79
30	172.67	206.71	291.24	310.18	4.70	4.74	5.15	5.18
40	179.37	222.43	309.40	346.20	4.72	4.74	5.17	5.19
S.Em±	18.151				0.021			
CD (P=0.05)	53.230				0.759			
Treatments	Number of seeds siliqua^{-1}				Test weight (gm)			
N levels (kg ha^{-1})	S levels (kg ha^{-1})							
	30	60	90	120	30	60	90	120
0	11.95	11.97	12.60	12.65	2.88	2.96	3.14	3.15
20	12.04	12.50	12.79	12.83	2.91	2.98	3.15	3.16
30	12.13	12.60	15.04	15.19	2.93	3.05	3.94	4.08
40	12.27	12.68	15.08	15.22	2.96	3.07	4.06	4.13
S.Em±	0.236				0.059			
CD (P=0.05)	0.694				0.174			

Table 3: Interaction effect varying levels of nitrogen and sulphur fertilization on yield and economics of mustard

Treatments	**Seed yield (kg ha^{-1})**				**Biological yield (kg ha^{-1})**			
S levels (kg ha^{-1})	**N levels (kg ha^{-1})**							
	30	**60**	**90**	**120**	**30**	**60**	**90**	**120**
0	1121.03	1152.20	1445.30	1446.30	4431.77	4464.07	5284.96	5295.55
20	1155.37	1194.76	1487.67	1480.90	4500.90	4545.99	5383.32	5398.20
30	1208.87	1244.63	1788.33	1823.00	4850.04	4935.73	6701.03	6825.27
40	1227.90	1270.96	1799.67	1827.16	4886.90	5035.84	6714.67	6862.51
S.Em±	36.81				71.37			
CD (P=0.05)	107.97				209.31			
Treatments	Net return (Rs ha^{-1})				B: C ratio			
N levels (kg ha^{-1})	S levels (kg ha^{-1})							
	30	60	90	120	30	60	90	120
0	26922.37	28247.47	46504.98	43793.72	0.71	0.73	1.20	1.12
20	27068.30	33253.38	45113.72	43372.78	0.68	0.83	1.11	1.06
30	29417.63	31044.13	61778.63	63384.27	0.72	0.76	1.49	1.51
40	29593.50	31677.26	61515.47	62757.53	0.71	0.75	1.45	1.47
S.Em±	2176.97				0.05			
CD (P=0.05)	6384.26				0.15			

4. Conclusions

The interaction effect of nitrogen and sulphur (120 kg N ha^{-1} + 30 kg S ha^{-1}) was recorded highest net return (63384.27 ₹ ha^{-1}) with B:C ratio of 1.51. According to the findings of one year experimentation, it can be advocated to the farmers of northern hill zone of Chhattisgarh for optimizing the yield, quality and economics of Indian mustard, it should be applied with 90 kg N ha^{-1} and 30 kg S ha^{-1} simultaneously.

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