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Impact of nitrogen and sulphur levels on growth and yield of Indian mustard (*Brassica juncea* L.) in the Prayagraj region

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Abstract
A field experiment was conducted during *Rabi* season of 2023-24 at the Crop Research Farm. Department of Agriculture and Allied Science, United University, Rawatpur, Jhalwa, Prayagraj (UP) to study about "Influence of Nitrogen and Sulphur level on growth and yield of Indian mustard (*Brassica juncea* L.)'' of Prayagraj, U.P. The experiment was carried out to find the performance of Indian Mustard, which laid out in Randomized Block Design (RBD) & replicated thrice. Among the various treatments, treatment T_8 provided the highest net return of Rs. 81920 ha^{-1} that excelled rest of the treatments. Treatment T_9 was observed as the next superior and best treatment by fetching the net returns of Rs. 78620 ha^{-1}. However, the control plot treatment showed lowest net returns of Rs.42120 ha^{-1}. The highest mean B: C ratio of 2.95 was recorded with the application of over other treatments for mustard cultivation.

Keywords: Economics, nitrogen, sulphur, growth parameter and yield

Introduction
Mustard (*Brassica juncea* L.) belongs to the family of "Cruciferae" and popularly used in Indian cooking. It has also been reported that mustard crop had cultivated in Channhu-daro of Harrapan ancient civilization during 2300-1750 BC. There is ambiguity in the history as the origin of *B. juncea* is concerned. It had been believed that center of origin for *B. juncea* is Middle-East, where putative parents i.e. *B. nigra* and *B. rapa* would have crossed with each other. Later on, it had been disseminated to other parts of the world such as Europe, Asia, and Africa etc. Brassicaceae occupies about 23% area and 14.6% production in *India.* Rajasthan leads in mustard cultivation with 46.06 per cent, followed by Haryana with 12.60 per cent, Madhya Pradesh with 11.38 per cent, Uttar Pradesh with 10.49 per cent and West Bengal with 7.81 per cent. Mustard seeds production is expected to increase to 49.50 lakh tones during the *Rabi* season of 2021-22 as against 35 lakh tones in the previous year. In Uttar Pradesh, the production is projected to increase from 13.5 lakh tones to 15 lakh tones. Mustard (*Brassica juncea*) is predominantly cultivated in the states of Rajasthan. Uttar Pradesh, Madhya Pradesh. Haryana, Gujarat, Punjab and Bihar (AICRP, 2020-2021). Rajasthan is the state having the largest area of 2550.92 hectare and highest production of 1466 kg/ha as compared to Uttar Pradesh having an area of 694.66 hectare and production of 1290 kg/ha, respectively (Government of India Ministry of Agriculture and Farmers Welfare Department of Agriculture, 2020-2021).
Which is considered low. The role of different nutrients in growth and yield of various oilseeds is well established. Nitrogen is an important component of many essential structural, genetic and metabolic compounds in plant cells. It is also an elementary constituent of numerous important organic compounds including amino acids, proteins, nucleic acids, enzymes, and the chlorophyll molecule. Nitrogen is the nutrient which normally produces the greatest yield response in crop plants, promoting rapid vegetative growth and giving the plant a healthy green color. Sulphur is essential role of increasing oil content (%) and oil yield Sulphur application greatly influenced chlorophyll synthesis, carbohydrate as well as protein metabolism.

Since last few decades, the growth, development and productivity of brassicas have been hampered due to a number of factors including the in balance and use of Sub-optimum dose of nutrients in soil. In fact, the extra pressure on the limited land resources and use of high yielding varieties to feed rapidly increasing production have led to the present scenario of shortage of important plant mineral nutrient in major soils on the globe. The deficiency of soil S in the agriculture soils has been reported frequently in mustard crop found significant interaction between N and Son height of plant, number of pods per plant, number of seeds per pod, 1000 seed weight, seed yield and oil percentage reported that grain yield was significantly higher at the highest levels of both the nutrients applied while oil contents decreased with increase in level of Sulphur to 90 kg ha-1 (43/19%) and nitrogen to level of 120 kg ha-1 (42%). However meagre information is available with regards to response of nitrogen and sulphur level on mustard under central plain zone of U.P, there is therefore, an urgent need to find out the optimum dose of nitrogen and sulphur level for obtaining higher grain yield as well as oil yield under central plain zone of U.P.

Materials and Methods

Geographical location of the experimental site

The experiment was conducted during the Rabi season of 2023-24 at the Crop Research Farm, faculty of agriculture and allied sciences United University Rawatpur Jhalwa, Prayagraj (U.P.) The Crop Research Farm is situated at 25.57o N latitude, 87.19o E longitude and at an altitude of 98 m above mean sea level. This area is situated about 12 km from the city. All the facilities required for crop cultivation were available.

Climatic conditions of the experimental area

The area of Prayagraj comes under humid sub-tropical climate, which experiences warm humid monsoon, hot dry summer and cold dry winter. The annual mean temperature is 26.1 ºC while monthly mean temperatures are 18-29 ºC. The daily average maximum temperature is about 22 ºC and the minimum temperature is 9 ºC. The average annual rainfall received is 1042.2 mm. At this location, the temperature reaches upto 46-48 ºC and the minimum temperature recorded is 4-5 ºC. The relative humidity ranges in this location ranges between 20-94%.

Experimental details

Table 1: Treatment Combinations

Treatment No.	Treatment Combinations
T_1	Nitrogen - RDF 50% + Sulphur- 30 kg/ha
T_2	Nitrogen - RDF 50% + Sulphur- 40 kg/ha
T_3	Nitrogen - RDF 50% + Sulphur- 50 kg/ha
T_4	Nitrogen - RDF 75% + Sulphur- 30 kg/ha
T_5	Nitrogen - RDF 75% + Sulphur- 40kg/h
T_6	Nitrogen - RDF 75% + Sulphur- 50 kg/ha
T_7	Nitrogen - RDF 100% + Sulphur- 30 kg/ha
T_8	Nitrogen - RDF 100% + Sulphur- 40 kg/ha
T_9	Nitrogen - RDF 100% + Sulphur- 50 kg/ha
T_{10}	100 RDF (Control)

Results and Discussion

Vegetative Growth Parameter

At harvest significantly higher plant height was recorded with the application of Nitrogen- RDF 100% + Sulphur- 50 kg/ha (205.86 cm). However, treatment with Nitrogen- RDF 100% + Sulphur- 40 kg/ha (202.80 cm) were statistically at par with Nitrogen- RDF 100% + Sulphur- 30 kg/ha. Sulphur is one of the responsible nutrient for plant growth also helps in cell elongation, photosynthesis and translocation of photosynthates by Simta *et al.* (2020). The possibility in increase in plant height due to widest (increased) plant spacing might be due to the fact that the increased spacing between plants resulted in enhanced space, sunlight, nutrients and soil moisture for increased photosynthesis, metabolic activities, growth and development.

The higher dry weight at harvest was recorded with the application of Nitrogen RDF 100% + Sulphur- 50 kg/ha (130.53g/plant). However, treatment with Nitrogen- RDF 100% + Sulphur- 40 kg/ha (127.47 g/plant were statistically at par with Nitrogen- RDF 100% + Sulphur- 30 kg/ha. Reported higher dry matter accumulation at higher doses of nutrient as compared to lower doses at different growth stages except at maturity Parminder *et al.*, (2012). In case of dry matter accumulation Sulphur helps in formation of deep green colour due to synthesis of chlorophyll which in turn provide the larger area for photosynthesis by Simta *et al.*, (2020).

Table 2: Influence of Nitrogen and Sulphur level on growth parameters of Indian mustard.

S. No.	Treatments	Plant height (cm)	Dry weight (g)	No. of siliqua/plant	No of Seed per siliqua
1	Nitrogen- RDF 50% + Sulphur- 30 kg/ha	190.86	115.53	222.82	11.66
2	Nitrogen- RDF 50% + Sulphur- 40 kg/ha	191.69	116.36	248.76	11.86
3	Nitrogen- RDF 50% + Sulphur- 50 kg/ha	193.48	118.15	311.54	12.23
4	Nitrogen- RDF 75% + Sulphur- 30 kg/ha	194.35	119.02	251.51	12.39
5	Nitrogen- RDF 75% + Sulphur- 40kg/h	195.30	119.97	253.23	12.68
6	Nitrogen- RDF 75% + Sulphur- 50 kg/ha	196.61	121.28	271.31	13.72
7	Nitrogen- RDF 100% + Sulphur- 30 kg/ha	200.13	124.80	276.33	14.19
8	Nitrogen- RDF 100% + Sulphur- 40 kg/ha	202.80	127.47	369.03	14.76
9	Nitrogen- RDF 100% + Sulphur- 50 kg/ha	205.86	130.53	309.85	15.28
10	100% RDF (Control	189.17	113.84	190.57	10.49
F test		S	S	S	S
Sem(+)		3.36	3.36	31.76	0.93
CD (5%)		9.98	9.98	94.38	2.77

Post-harvest observations of mustard

The number of siliqua per plant was significantly influenced due to different treatment combinations. Number of siliqua per plant was recorded significantly higher (376.33) with the application of Nitrogen- RDF 100% + Sulphur- 30 kg/ha, which was statistically at par with Nitrogen- RDF 100% + Sulphur- 40 kg/ha (369.03). Sulphur enhance the primary and secondary branches which are silique bearing organs as flowers are borne at the terminals of the branches. Therefore with increased number of branches, there was increase in the number of silique per plant. Mounika *et al.* (2021) [9].

The number of seeds per siliqua was significantly influenced due

to different treatment combinations. Number of pods per plant was recorded significantly higher (15.28) with the application of Nitrogen- RDF 100% + Sulphur- 50 kg/ha. Sulphur promotes the pollen producing capacity of anthers and hence might have produced higher number of seeds per siliqua. It also had a positive effect on the photosynthetic performance of plants by influencing phosphorylation process, reducing the quantity of assimilates consumed by respiration to obtain energy and accelerating the removal of products of photosynthesis. Ranvir *et al.* (2017).

The test weight was significantly influenced due to different treatment combinations. The higher test weight (5.79g) was recorded in treatment with Nitrogen- RDF 100% + Sulphur- 40 kg/ha and the lowest (3.98 g) was obtained with treatment with Nitrogen- RDF 100% + Sulphur- 4/ha. The maximum TSW recorded from plants at widest spacing may be result of active photosynthetic machinery for longer period of time as plants did not face any competition for moisture or nutrients. Hassan *et al.* (2012) [8].

The seed yield was significantly influenced due to difference among the treatments. Seed yield was recorded significantly higher (2.58 t/ha) in treatment with the application of Nitrogen- RDF 100% + Sulphur- 50 kg/ha, which was statistically at par with Nitrogen- RDF 100% + Sulphur- 40 kg/ha (2.30 t/ha).

The beneficial effect of Sulphur on yield attributes may be due to its role in flower development, pollen grain formation, pollen viability, pollen tube growth for proper pollination and seed development. Yadav *et al.* (2016) [24].

The higher seed yield was observed because such an optimum plant density facilitated maximum utilization of nutrients and increased dry matter production which ultimately resulted in higher seed yield ha. Cheema *et al.* (2001) [11].

The significantly higher (5.48 t/ha) Stover yield was observed in treatment with the application of Nitrogen- RDF 100% + Sulphur- 50 kg/ha, which was statistically at par with Nitrogen- RDF 100% + Sulphur-40 t/ha (5.43 t/ha). Application of Sulphur enhanced more uptakes of major nutrients resulting greater photosynthetic activities and led to greater vegetative growth of plants. Ultimately this accelerated growth due to proper metabolic activities produced higher stover yield in mustard. Mounika *et al.* (2021) [9].

The harvest index was significantly influenced due to difference among the treatments. The higher (74.82%) harvest index was recorded in treatment with the application of Nitrogen- RDF 50% + Sulphur- 50 kg/ha and the lowest (66.25%) was obtained in treatment with the application of Nitrogen- RDF 100 + Sulphur 50 kg/ha

Table 3: Post-harvest observation of mustard.

S. No.	Treatments	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1	Nitrogen- RDF 50% + Sulphur- 30 kg/ha	3.90	1.39	3.44	71.16
2	Nitrogen- RDF 50% + Sulphur- 40 kg/ha	4.20	1.41	3.55	71.84
3	Nitrogen- RDF 50% + Sulphur- 50 kg/ha	4.49	1.43	4.17	74.82
4	Nitrogen- RDF 75% + Sulphur- 30 kg/ha	4.65	1.80	4.44	71.55
5	Nitrogen- RDF 75% + Sulphur- 40kg/h	4.83	1.92	4.54	70.22
6	Nitrogen- RDF 75% + Sulphur- 50 kg/ha	5.15	1.93	4.91	72.47
7	Nitrogen- RDF 100% + Sulphur- 30 kg/ha	5.50	2.06	5.17	71.79
8	Nitrogen- RDF 100% + Sulphur- 40 kg/ha	5.79	2.30	5.43	70.45
9	Nitrogen- RDF 100% + Sulphur- 50 kg/haz	5.51	2.58	5.48	66.25
10	100% RDF (Control	3.41	1.32	3.07	69.92
F test		NS	S	S	NS
SEm(+)		0.52	0.24	0.51	2.55
CD (5%)		1.55	0.71	1.51	7.59

Among the various treatments, treatment T8 provided the highest net return of Rs. 81920 ha^{-1} that excelled rest of the treatments. Treatment T_9 was observed as the next superior and best treatment by fetching the net returns of Rs. 78620 ha^{-1}. However, the control plot treatment showed lowest net returns of Rs.42120 ha^{-1}. The highest mean B: C ratio of 2.95 was recorded with the application of over other treatments for mustard cultivation.

Conclusion

Findings of the above results, it was concluded that application NITROGEN- RDF 100% + S- 40 kg/ha (T_8) had performed better in growth and yield parameters and was economically viable. Since the findings are based on one season, further trails are needed to confirm the results hence being recommended for mustard cultivation.

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