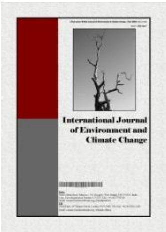

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Effect of Nitrogen and Sulphur in the Production of the Mustard Crop [*Brassica juncea* (L.)]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Crop production largely depends on need based application of nutrients and for maximizing the yield of mustard, it is essential that mustard should not suffer due to inadequate supply of mineral nutrition. In this regard, a field experiment was conducted at Research Farm, Vivekananda Global University, Jaipur during *Rabi* season of 2018-19, to study the effect of nitrogen and sulphur on yield and economics of mustard [*Brassica juncea* (L.)]. The experiment was laid out according to randomized block design with three replications. The treatments consisting of nine treatment combinations *viz.,* 125% RDN + Sulphur 10 kg ha^{-1} (T_1), 125% RDN + Sulphur 20 kg ha^{-1} (T_2), 125% RDN + Sulphur 30 kg ha^{-1} (T_3), 100% RDN + Sulphur 10 kg ha^{-1} (T_4), 100% RDN + Sulphur 20 kg ha^{-1} (T_5), 100% RDN + Sulphur 20 kg ha^{-1} (T_5) 100% RDN + Sulphur 30 kg ha^{-1} (T_6), 75% RDN + Sulphur 10 kg ha^{-1} (T_7), 75% RDN + Sulphur 20 kg ha^{-1} (T_8) and 75% RDN + Sulphur 30 kg ha^{-1} (T_9) were applied to the mustard *var*. Laxmi (RH-8812). Results showed that the yield attributes (number of siliquae plant^{-1} and number of seeds silique^{-1}), yield (seed, stover and biological yield) and economics (net returns and B: C ratio) of mustard was significantly increased due to different nitrogen and sulphur treatments. The maximum number of siliquae plant^{-1}, number of seeds silique^{-1}, seed yield, stover yield and biological yield of mustard was obtained with the application of 125% recommended dose of nitrogen + 30 kg sulphur ha^{-1} (T_3). Similarly, the same treatment also produced maximum net returns and benefit: cost ratio of mustard. So, this treatment was recommended for obtaining maximum yield with increased monetary returns.

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Keywords: Economics; India; mustard; nitrogen; sulphur and yield.

1. INTRODUCTION

In 'Rape seed and Mustard' group of oil seeds, Indian mustard (*Brassica juncea*) occupies the prime position in India. Mustard is a Rabi season crop that requires relatively cool temperature, a fair supply of soil moisture during its growing season and a dry period during harvest. The mustard seeds contain 40 to 42% oil content and 30 to 45% protein content with a high nutritive value. It is also used in the preparation of hair oils, medicines, soap and mixed with mineral oils for lubrication and in manufacture of grease. The seed is also used as condiment in the preparation of pickles and in vegetables for flavoring curries. After the recovery of oil from mustard seed, the residual meal is the rape or mustard cake. The oil cake contains 25 - 30% crude protein, 5% nitrogen, 1.8 - 2.0% phosphorus and 1.0 - 1.2% potassium content. The oil cakes is used as a cattle feed and manure. India is the third largest mustard producer in the world after Canada and China. Mustard accounts for nearly one-third of the oil produced in India, making it the country's key edible oilseed crop. In India, it is grown on 9.12 million tonnes from an area of 6.78 mha with an average productivity of 1345 kg ha^{-1} [1]. Rajasthan is one of the major mustard producing states in the country, holds first ranks both in area and production of mustard in the country with an annual production of 2.95 mha with production of 4.22 million tonnes. The average productivity of Rajasthan is 1431 kg ha^{-1} [1].

Crop production largely depends on cultivation of high yielding cultivars and need based application of nutrients. Thus, for maximizing the yield, it is essential that mustard should not suffer due to inadequate moisture supply and mineral nutrition especially nitrogen. Nitrogen (N) is the most important nutrient, and being a constituent of protoplasm and protein, it is involved in several metabolic processes that strongly influence growth, productivity and quality of crops [2]. The deficiency of soil sulphur in the agriculture soils has been reported frequently over the past several years [3,4]. Sulphur (S) is one of the six macronutrients needed for proper plant development. The reduced sulphur incorporated in cysteine and methionine amino acid plays essential roles in catalytic centers and disulfide bridges of proteins [5]. Additionally, sulphur is also necessary for the synthesis of amino acids, protein and various other cellular components, including thiol compounds and the so- called secondary sulphur compounds, which have a significant bearing on protection of plant against stress and pests. Although, yield of mustard in Rajasthan is more than its national average, but we are still lagging behind as compared to the world's productivity. Taking cognizance of all the above-mentioned facts, the present investigation was conducted to determine the effect of nitrogen and sulphur on growth, yield and quality of mustard [*Brassica juncea* (L.)].

2. MATERIALS AND METHODS

Experimental site: The field experiment was carried out during *Rabi* season of 2018-19 at Research Farm, Vivekananda Global University, Jaipur. Geographically, the study area is located at 075°88'99" E longitude and 26°81'17" N latitude and this region falls under agro-climatic zone III A of Rajasthan (Semi-arid Eastern Plain Zone). The region's climate is classified as semi-arid with characterized by aridity of the atmosphere and extremity of temperature both in summer (45.5ºC) and winter (4ºC) with annual rainfall of 500-700 mm. The soil of experimental field was loamy sand in texture, slightly alkaline in reaction.

Experimentation and crop husbandry: The experiment was laid out in Randomized Block Design with three replications. The treatments consisting of nine treatment combinations *viz.,* 125% RDN + Sulphur 10 kg ha^{-1} (T_1), 125% RDN + Sulphur 20 kg ha^{-1} (T_2), 125% RDN + Sulphur 30 kg ha^{-1} (T_3), 100% RDN + Sulphur 10 kg ha^{-1} (T_4), 100% RDN + Sulphur 20 kg ha^{-1} (T_5), 100% RDN + Sulphur 20 kg ha^{-1} (T_5) 100% RDN + Sulphur 30 kg ha^{-1} (T_6), 75% RDN + Sulphur 10 kg ha^{-1} (T_7), 75% RDN + Sulphur 20 kg ha^{-1} (T_8) and 75% RDN + Sulphur 30 kg ha^{-1} (T_9) were applied to the mustard *var*. Laxmi (RH-8812). The gross plot size was 4.0 m x 3.0 m (12.0 m^2) and total experimental area was 324 m^2. Standard crop production practice and methods were followed for thinning, weeding, fertilizer application and crop protection management to grow the crop. Thinning was done at 20 DAS to maintain proper plant population by keeping the intra row spacing at 30 cm. One hoeing and weeding was done manually at 30 DAS to facilitate aeration and removing the weeds.

Data Collection: Five plants were selected randomly from net plot and tagged for measurement of number of silique plant^{-1}, number of seeds siliqua^{-1}, test weight, seed yield, stover yield, biological yield and harvest index of mustard. Total numbers of siliquae of the five plants selected from the net plot were counted and mean value for number of siliquae plant^{-1} was calculated. Ten siliquae were randomly selected from each plants and numbers of seeds siliquae^{-1} were counted and mean value of seeds siliquae^{-1} was calculated. 1000 seeds were counted from seed sample taken from seed yield of each plot separately and weighed on electric balance. The weight was recorded as test weight of respective treatment. The dry weight of crop biomass (biological yield) including above-ground shoot with siliquae, stem and foliage was recorded. The harvested plants in the net plot (excluding the border rows) were threshed, dried and cleaned to record the seed yield. The net plot yield was converted to kg per hectare. Stover yield was obtained by subtracting the seed yield (q ha^{-1}) from biological yield. The harvest index is the ratio of seed yield to biological yield and expressed in percentage. Economics of different treatments were worked out by considering the cost of inputs and income obtained from output based on the prevailing market price.

Statistical Analysis: The experimental data were subjected to statistical analysis by adopting appropriate method (randomized block design) of analysis of variance assuming homogeneity, analysis of the data was carried out to establish the trend of treatments applied as per Gomez and Gomez [6]. Wherever, the F values were found significant at 5% level of probability, the critical difference (CD) values were computed for making comparison among the treatment means.

3. RESULTS AND DISCUSSION

Yield attributes and yield: Data revealed that all nitrogen and sulphur treatment exhibited significant impact on yield attributes and yield of mustard. The application of 125% recommended dose of nitrogen + 30 kg sulphur ha^{-1} (T_3) significantly increased the number of silique plant^{-1} (192.2), number of seeds siliqua^{-1} (9.9), seed yield (2150 kg ha^{-1}), stover yield (4796 kg ha^{-1}) and biological yield (6945 kg ha^{-1}) of mustard (Table 1) which was closely followed by 125% RDN + Sulphur 10 kg ha^{-1} and 125% RDN + Sulphur 20 kg ha^{-1} and found significantly higher than 100% RDN + Sulphur 10 kg ha^{-1}, 100% RDN + Sulphur 20 kg ha^{-1}, 100% RDN + Sulphur 20 kg ha^{-1}, 100% RDN + Sulphur 30 kg ha^{-1}, 75% RDN + Sulphur 10 kg ha^{-1}, 75% RDN + Sulphur 20 kg ha^{-1} and 75% RDN + Sulphur 30 kg ha^{-1}. While, the test weight and harvest index of mustard were not influenced by nitrogen and sulphur application and remained unchanged among all the treatments. The increase in siliquae plant^{-1} and number of seeds siliqua^{-1} may be explained due increase in plant height, number of branches plant^{-1} and dry matter accumulation under high nitrogen and sulphur levels. With the application of higher levels of nitrogen and sulphur, the tissue differentiations (from the somatic to reproductive), meristematic activity and the development of floral primordial might have been enhanced causing greater production of flowers which latter developed to siliqua. Such a positive effect of nitrogen and sulphur application observed, might be due to this nutrition which enhances cell multiplication, elongation, expansion and imparts a deep green colour to leaves due to better chlorophyll synthesis, which in turn increases the effective area for photosynthesis, resulting in relatively greater amount of photosynthates accumulation in plant and their translocation, which reflect in terms of increased yield attributes and finally increased the yield of crop. The favourable effect of higher dose of nitrogen and sulphur on sink component could be attributed to better development of the plants in terms of plant height and dry biomass production leading to increased bearing capacity due to optimum growth on account of increased in nitrogen and sulphur dose. Higher yield with increasing rate of nitrogen was also reported by [7-14].

Economics: Summary of the data on net returns and B: C ratio of mustard revealed that all the treatments had significant impact on net returns and B: C ratio of mustard. The significantly maximum net return (₹ 67566 ha^{-1}) and B: C ratio (3.62) was obtained with the application of 125% recommended dose of nitrogen + sulphur 10 kg ha^{-1} which was closely followed by treatment 125% recommended dose of nitrogen + sulphur 20 kg ha^{-1} (₹ 66882 ha^{-1}) and 125% recommended dose of nitrogen + sulphur 30 kg ha^{-1} (₹ 66318 ha^{-1}) but superior to all other treatments (Table 2). Application of 125% recommended dose of nitrogen + sulphur 10 kg ha^{-1} provided the additional net returns of ₹ 15717, ₹ 16537, ₹ 17769 and ₹ 32514 ha^{-1}, ₹ 31812 ha^{-1} and ₹ 32692 ha^{-1} in comparison to T_4, T_5, T_6, T_7, T_8 and T_9, respectively. In modern

Table 1. Effect of nitrogen and sulphur on yield attributes and yield of mustard

Treatments	Yield attributes			Yield (kg ha^{-1})			Harvest index (%)
	Number of silique plant^{-1}	Number of seeds silique^{-1}	Test weight	Seed yield	Stover yield	Biological yield	
T_1	188.49	9.77	6.61	2102	4647	6750	31.16
T_2	190.71	9.85	6.67	2125	4708	6833	31.09
T_3	192.20	9.92	6.74	2150	4796	6945	31.01
T_4	157.04	7.93	6.39	1744	3803	5547	31.46
T_5	160.09	8.08	6.48	1763	3869	5633	31.37
T_6	162.20	8.16	6.54	1773	3917	5690	31.22
T_7	127.62	6.35	6.14	1360	2945	4305	31.63
T_8	128.06	6.39	6.26	1398	3045	4444	31.57
T_9	129.69	6.48	6.31	1433	3111	4544	31.52
SEm$\pm$	8.31	0.42	0.39	88	201	225	1.54
CD	24.92	1.27	NS	265	603	673	NS

Table 2. Effect of nitrogen and sulphur on economics of mustard

Treatment	Treatment cost	Total cost	Gross return	Net return	B:C ratio
T_1	3181	25826	93392	67566	3.62
T_2	4895	27540	94423	66882	3.43
T_3	6609	29254	95573	66318	3.27
T_4	2888	25533	77382	51849	3.03
T_5	4602	27247	78276	51029	2.87
T_6	6316	28961	78758	49797	2.72
T_7	2594	25239	60290	35051	2.39
T_8	4308	26953	62024	35071	2.30
T_9	6022	28667	63541	34874	2.22
SEm±	-	-	-	3586	0.13
CD	-	-	-	10750	0.39

Common cost of cultivation – 22645

agriculture, crop production is taken as business. Therefore, based on the experimental results, the practices giving maximum net returns under particular set of condition can only be recommended to the farmers. Under present investigation large variations were noticed for gross returns and cost of cultivation under different nitrogen and sulphur levels. As far as the economic analysis of nitrogen and sulphur application on the mustard is concerned, the differences in net returns under various nitrogen and sulphur levels were mainly due to the differences in seed and stover yield. The maximum gross return, net return and benefit: cost ratio with higher dose of nitrogen and sulphur were also reported by [12, 15,16].

4. CONCLUSION

The impact of nitrogen and sulphur application on enhancing productivity and monetary returns was highly significant in mustard. The present study found consistent evidence that the application of nitrogen and sulphur offers substantial agronomic and economic advantages. Based on the results of one-year experimentation it may be concluded that for higher profitability and productivity, the mustard crop should be supplied 125% recommended dose of nitrogen + 30 kg sulphur ha^{-1} as it provides the maximum values of number of siliquae, number of seeds, seed yield, stover yield, biological yield, net returns and B: C ratio so 125% recommended dose of nitrogen + 30 kg sulphur ha^{-1} was found suitable for farmer practices on the basis of higher productivity and monetary returns of this treatment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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