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Effect of nitrogen and sulphur nutrition on growth and yield of Indian mustard (*Brassica juncea* L.) in western UP

Mukesh Kumar, PK Singh, KG Yadav, Ashutosh Chaurasiya and Ashok Yadav

Abstract

A field experiment was conducted to study the effect of nitrogen and sulphur nutrition on growth and yield of Indian mustard (*Brassica juncea* L.) in western UP during *Rabi* season of 2016 at Crop Research Centre (Chirori) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). The soil of the experimental field was well drained, sandy loam in texture and slightly alkaline in nature. It was low in organic carbon and nitrogen but medium in available phosphorus and potassium with an electrical conductivity (1:2, soil: water) of 1.65 dS/m. The experiment consisted of twelve treatment combinations with nitrogen and sulphur. The treatment consisted of four nitrogen levels (0, 40, 80 and 120 kg ha^{-1}) and three sulphur levels (0, 20 and 40 kg ha^{-1}) were tested in Factorial Randomized Block Design (RBD) with three replications. The mustard variety Pusa Bold was grown. The growth and yield, nutrient uptake as influenced by different treatments were assessed. Increasing levels of nitrogen from 0 to 120 kg N ha^{-1} caused significant increase in growth and yield attributes (plant height, LAI, branches $plant^{-1}$, siliqua $plant^{-1}$, seeds $siliqua^{-1}$, 1000 seed weight) and yields (biological, seed and oil yield) of mustard crop and found maximum at 120 kg N ha^{-1}. Similarly, application of 40 kg S ha^{-1}gave maximum plant height, leaf area index (LAI), dry matter production, yield attributes, seed, stover yield, oil content and oil yield of mustard crop. The highest net returns of 48,006 and B: C ratio of 2.25 was obtained with the application 120 kg N ha^{-1}than rest of nitrogen levels. With respect to sulphur levels, the highest net returns of 36,454 and B: C ratio of 1.65 was obtained with 40 kg S ha^{-1}. Thus, the application of nitrogen at 120 kg N $ha^{-1}$and sulphur at 40 kg S ha^{-1} found economical in obtaining higher yields with higher net return and B: C ratio.

Keywords: Nitrogen, Sulphur, Mustard

Introduction

Indian mustard (*Brassica juncea* L.) belonging to the family cruciferae is one of the important oilseed crops and currently ranked as the world's third important oil seed crop in terms of production and area. Oil content in rapeseed & mustard varies from 33% to 46% and average oil recovery is around 32% to 38%. After oil extraction, the remaining part of the seed is used to produce rapeseed/ mustard meal, an important component of cattle and poultry feed. In India, the annual production of rapeseed-mustard was about 58.03 lakh tonnes covering an area of about 61.90 lakh hectares with a total productivity of 0.94 tonnes ha^{-1} (Anonymous, 2015) [1]. It is estimated that 58 mt of oil seeds will be required by the year 2020, wherein the share of mustard will be around 24.2mt (Bartaria *et al*., 2001) [2]. Therefore, it becomes imperative to increase the productivity of rapeseed-mustard per unit area and per unit time. Amongst the agronomic factors known to augment crop production, fertilizer stands first and considered one of the most productive inputs in agriculture as a source of nutrient elements particularly nitrogen which is insufficient in most of our Indian soils and plays appreciably an important role in Brassica crops (Singh and Meena, 2004) [8].

Mustard crop responded favorably to nitrogen and sulphur fertilization increases yield by influencing different growth parameters and viz. increasing plant height, number of flowering branches, total plant weight, leaf area index, number and weight of siliquae and seeds per plant. Adequate supply of sulphur to rapeseed-mustard promotes the synthesis of sulphur containing essential amino acids, proteins and oil. Moreover, nitrogen and sulphur are closely related with one another because both of these elements are required for protein synthesis and their amount in plant tissue always maintained at constant ratio. Application of fertilizers containing these two nutrient elements have been recognized to be the 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 cannot be realized regardless of other nutrients applied or adoption of improved crop management practices. Therefore, the present study was conducted to investigate the effects of N and S fertilization on growth and yield of mustard.

Methodology

The field experiment was conducted during *Rabi* season of 2016 at Crop Research Centre (Chirori) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). The experiment was laid out in Factorial Randomized Block Design (RBD) with three replications. The treatment consisted of four nitrogen levels were 0, 40, 80 and 120 kg ha^{-1} and three sulphur levels 0, 20 and 40 kg ha^{-1}thus there were treatment combinations. The soil of the experimental field was well drained, sandy loam in texture and slightly alkaline in nature. It was low in carbon and nitrogen but medium in available phosphorus and potassium with an electrical conductivity (1:2, soil: water) of 1.65 dS/m. The mustard variety Pusa Bold was grown and growth and yield, economics as influenced by different treatments were assessed.

Results and Discussion

Nitrogen application

Nitrogen fertilization contributed to a great extent in influencing the seed yield of mustard on account of its pronounced effect on the growth and yield attributes of the plant, at various stages of the crop growth. The various growth parameters including plant height, number of branches were affected to the great extent with the increase in the rates of nitrogen fertilization. The plant height, leaf area index, branches/plant and dry matter/plant considerably increased at higher doses of nitrogen application (Table-1). These growth parameters increased significantly with increasing levels of nitrogen upto 120 kg N ha^{-1}. Probably 120 kg N ha^{-1} ensured the availability of other nutrient and favorable condition for growth of mustard plant. Nitrogen increase in size of cell, which expressed morphologically increased in plant height, leaf area and branches/plant. Nitrogen provide deep green colour to leaves due to better chlorophyll synthesis which increase the effective area of photosynthesis and resulting in higher dry matter. These results are in conformity with finding of Singh and Kumar, (2014) [10].

The number of siliqua $plant^{-1}$, length of siliqua, and the number of seeds $siliquae^{-1}$ were noticed maximum with the application of 120 kg ha^{-1} (Table-1). Improvement in the growth and yield attributes of Indian mustard due to nitrogen application appeared quite logical. It is well known that nitrogen being the constituent of amino acids, proteins, chlorophyll and protoplast would directly influence the growth and yield attributing characteristics through better utilization of photosynthates. Singh and Kumar, (2014) [10] also reported increase in growth and yield attributes of rapeseed - mustard due to nitrogen application.

The seed and stover yield as well as biological yield increased significantly with the application of nitrogen. The maximum seed, stover and biological yield were recorded with the application of 120 kg N ha^{-1} (Table-2). The increase in yield of mustard due to nitrogen application may be because of the fact that nitrogen played an important role in synthesis of chlorophyll and amino acids, which constitute building of protein blocks. Nitrogen influenced the seed yield through a source-sink relationship and in addition to higher production of photosynthates it leads to increased translocation to reproductive parts. Nitrogen being a most important plant nutrient needed for growth and development of plant and is known to increase the yield of *Brassica* species (Singh *et al.*, 2002) [7].

Oil content in seed increases significantly upto 40 kg N ha^{-1} and decreased thereafter at higher nitrogen rates however, the difference in oil content due to 40 kg N ha^{-1} and higher nitrogen levels was statistically non-significant (Table-2). As per pathway of degradation, carbohydrates are degraded to acetyl Co-A. In case of insufficient supply of nitrogen acetyl Co-A is used for the synthesis of fatty acids by using acetyl carrying proteins (ACP) resulting in higher oil content in seeds. Although nitrogen application resulted in reduce oil percent in seeds. These results confirm with findings of Singh and Meena (2004) [8].

Increasing levels of nitrogen from 0 to 120 kg N ha^{-1} caused significant increase in oil yield of mustard. The oil yield is the function of oil content in seed and seed yield. The oil content in seeds increased with the application of nitrogen up to 40 kg N ha^{-1} and decreased thereafter while seed yield was found maximum at 120 kg N ha^{-1}, the decrease in oil content at higher nitrogen rates was compensated by seed yield and resulted in more oil yield at 120 kg N ha^{-1}. Similar finding was also reported by Singh *et al.*, (1992).

Sulphur application

Sulphur fertilization has been reported to influence the various plant growth, yield and quality parameters significantly in mustard. Application of sulphur fertilization at the rate of 40 kg ha^{-1} gave significantly higher plant height, leaf area index and branches/plant than lower doses of sulphur application (Table-1). The increase in growth parameters may be attributed mainly due to the fact that sulphur application improved the nutritional environment for plant growth at active vegetative stage as a result of improvement in roots growth, cell multiplication, elongation and cell expansion in the plant body which ultimately increased the plant height, leaf area index and branches/plant. Similar finding was also reported by Katiyar *et al*., (2014) [3].

The dry matter accumulation was increased with increase in sulphur application and found maximum at 40 kg S ha^{-1} (Table-1). This might be due to sulphur application improved the growth attributes of mustard and imparts a deep green colour to leaves due to better chlorophyll synthesis which inturn increase the effective area for photosynthesis resulting in higher dry matter accumulation. These results were in agreement with the finding of Singh *et al*., (2002) [7].

Yield attributing characters such as number of siliqua, siliqua length, seeds $siliqua^{-1}$, and 1000 seed weight increased with increasing levels of sulphur up to 40 kg S ha^{-1} (Table-1). Sulphur enhanced primary and secondary branches which are siliqua 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 siliqua $plant^{-1}$. Plant well supplied with sulphur will have relatively larger photosynthesizing area, consequently accumulating higher quantities of photosynthates which will be translocate to sink site i.e. siliqua and seeds with higher quantities being accumulated in the siliqua and seeds and thus increase the size of siliqua, number of seeds $siliqua^{-1}$ and test weight of seeds has increased. Similar finding was also reported by Rao *et al*., (2013) [4].

The seed yield increased with increase in sulphur application from 0 to 40 kg S ha^{-1} and noticed maximum at 40 kg S ha^{-1}

(Table-2). This might be attributed to sum total effect of better growth of plants and increase in yield attributing characters due to sulphur application. Yield attributes viz. increased number of siliqua plant^{-1}, more number of seeds siliqua^{-1}, higher 1000 seed weight and length of siliqua showed their additive effect in influencing the seed yield significantly with sulphur fertilization and the significant increase in all these characters were recorded upto 40 kg S ha^{1}. The increase in these characters as a result of sulphur fertilization resulted in increased in seed yield of mustard. Higher stover, biological yield and harvest index were also recorded at 40 kg S ha^{-1} which may be due to increased supply of sulphur and better translocation of photosynthates to seeds and thus increased to value of harvest index. Similar finding was also reported by Rao *et al.,* (2013) [4].

Oil content of mustard seed and oil yield increased significantly due to sulphur application and found maximum at 40 kg S ha^{-1} (Table-2). Sulphur plays an important role in the formation of more glycosides and glucosinolate and activation of enzymes, which as in biochemical reaction with the plant and on hydrolysis produce higher amount of oil as well as alkyl isothiocyanate, which is responsible for pungency. Oil yield is additive effect of oil content and seed yield which was noticed maximum at 40 kg S ha^{-1} resulted in higher oil yield. The results are in close conformity with the finding of Sah *et al*., (2013) [6].

The total variable cost of cultivation increased slightly with difference sources of fertilizer. The highest net returns (Rs.48006 ha^{-1}) and B: C ratio (3.25) was recorded with the application of 120 kg N ha^{-1} (Table-3). Similarly, application of 40 kgS ha^{-1} gave the maximum net returns (Rs.36454 ha^{-1}) and B: C ratio (2.67). Each increasing level of nitrogen and sulphur increased the economic yield significantly which ultimately resulted in increased net return. Similar trend was also observed by Rathore *et al*. (2014) [5].

From the forgoing discussion it may be concluded that application of 120 kg N ha^{-1} + 40 kg S ha^{-1} gave higher values of growth yield attributes and seed & oil yield of mustard crop. This treatment also gave maximum gross return and benefit cost radio. Thus application of 120 kg N ha^{-1} + 40 kg S ha^{-1} seems to best option for higher yield and monetary return under western UP condition.

Table 1: Growth and yield attributes of mustard as influenced by varying levels of nitrogen and sulphur nutrition.

Treatments	Plant height (cm)	Leaf area index	Branches/ plant	Dry matter accumulation (g/plant)	Siliqua plant^{-1}	Siliqua length (cm)	Seed siliqua^{-1}	1000 seed weight (g)
Nitrogen level (kg ha^{-1})								
0	147.85	1.25	10.60	40.93	216.01	3.31	6.65	4.36
40	154.18	2.86	14.12	48.26	241.51	3.79	7.40	4.64
80	161.14	3.57	17.93	53.06	260.92	4.07	7.87	4.82
120	175.24	4.23	22.29	60.50	265.65	4.58	8.47	5.10
SEm±	3.31	0.07	0.30	1.08	2.34	0.06	0.18	0.05
CD at 5%	9.71	0.23	0.88	3.17	6.88	0.20	0.54	0.16
Sulphur levels (kg ha^{-1})								
0	153.09	2.54	14.77	47.97	325.07	3.78	6.87	4.60
20	161.30	2.91	15.98	50.47	244.41	3.90	7.53	4.75
40	164.41	3.11	17.99	53.62	258.59	4.13	8.39	4.84
SEm±	2.86	0.07	0.26	0.93	2.03	0.06	0.16	0.04
CD at 5%	8.41	0.20	0.76	2.75	5.96	0.17	0.47	0.14

Table 2: Biological, seed, stover and oil yield, harvest index and oil content as influenced by varying levels of nitrogen and sulphur nutrition.

Treatments	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Oil content (%)	Oil yield (kg ha^{-1})
Nitrogen level (kg ha^{-1})						
0	3708	851	2857	22.96	39.23	334.13
40	4804	1155	3649	24.03	39.54	456.63
80	5417	1333	4084	24.60	38.90	518.69
120	6084	1564	4519	25.70	38.68	605.20
SEm±	14	6	13	0.08	0.05	2.54
CD at 5%	42	17	34	0.25	0.17	7.45
Sulphur levels (kg ha^{-1})						
0	4773	1154	3618	24.05	38.99	449.64
20	4959	1215	3744	24.32	39.05	473.63
40	5278	1309	3969	24.60	39.22	512.72
SEm±	12	5	10	0.07	0.05	2.20
CD at 5%	37	15	29	0.22	0.14	6.45

Table 3: Economics of mustard crop as influenced by various nutrient management treatments.

Treatment	Cost of cultivation (Rs.ha^{-1})	Gross return (Rs.ha^{-1})	Net return (Rs.ha^{-1})	Benefit :cost ratio
Nitrogen levels (kg ha^{-1})				
0	19506	38344	18838	1.97
40	20115	51634	31519	2.57
80	207424	59446	38722	2.87
120	21333	69339	48006	3.25
Sulphur levels (kg ha^{-1})				
0	19506	51602	32096	2.65
20	20663	54176	33513	2.62
40	21820	58274	36454	2.67

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