RESEARCH ARTICLE

EFFECT OF NITROGEN (N) AND SULPHUR (S) ON THE GROWTH AND YIELD OF MUSTARD

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Abstract: An experiment was conducted in the experimental field of SAGE University, Indore, Madhya Pradesh during the period from 2019-2020 to "Effect of Nitrogen and Sulphur on Growth and Yield of Mustard at Institute of Agriculture Sciences, SAGE University, Indore (M.P.) nutrient content and their uptake by mustard plants. The experiment consisted of two factors. Factor A: Nitrogen (4 levels) i.e. 0 kg N ha^{-1} (N_0), 40 kg N ha^{-1} (N_1), 80 kg N ha^{-1} (N_2) and 120 kg N ha^{-1} (N_3); Factor B: Sulphur (4 levels) i.e. 0 kg S ha^{-1} (S_0), 8 kg S ha^{-1} (S_1), 16 kg S ha^{-1} (S_2), 24 kg S ha^{-1} (S_3) On indian Hybrid Mustard NRCHB-101 is mustard (Brassica juncea L. Czern & Coss) There were 16 treatments combinations. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. After emergence of mustard seedlings, various intercultural operations were accomplished for better growth. Data were collected in respect of the plant growth characters and content and uptake by seed, strove, plant and available nutrients in soil for different levels of nitrogen and sulphur. The yield attributes like no.of siliqua per plant ,No. of seed per plant,test weight of seed,and as well as stover yield significantly increased with the application of 120 kg Nitrogen ha^{-1} and 24 kg Sulpher ha^{-1} .The interaction effects of nitrogen and Sulphur (N_2S_3) gave the best results. For application of nitrogen 120 kg N ha^{-1} and Sulphur 24 kg S ha^{-1} gave the best result showed is most effective combination in respect on Growth and Yield of mustard.

Keywords: Nitrogen, Sulpher, Nutrient content, Yield, Oil content

INTRODUCTION

The oilseeds have an important place in Indian agriculture next to cereals crops. Oilseed crops form the second major group among agricultural crops after cereals in the country. Mustard seed has high nutritive value with protein content of 28-36%. Mustard a winter (*Rabi*) season crop that requires relatively cool temperature, a fair supply of soil moisture during the growing season and a dry harvest period (Budzynski *et al.*, 2019), India, total area under mustard crop is 6671 thousand ha with production 7120 thousand ton. (Anonymous, 2018-19) but the average yield of rapeseed-mustard in India is only 1150 kg ha^{-1} (Economic survey, 2019) due to the lack of optimum use of nutrients particularly sculpture which is one of the important factors responsible for its low yield. Application of sculpture was reported to increase yield attributes and yield of Indian mustard. The first position in area and second position in Production after China (Anonymous, 2019), The quality of the oil in the rapeseeds and mustard possess a adequate amount of erucic acid 40-60% together with Linolinic up to 4.5 to 13%.The oleic acid and linoleic acid which have a higher nutritive value together constituent only about 25-30%.It is desirable to increase the quality of oleic acid and linoleic acid by reducing the linolinic and erucicacid, a lower proportion of erucic acid will make the oil more palatable, nutritive, besides reducing metabolic disorders. The oil content in mustard about 35-40% and a protein content range from 25-30%.But the presence of toxic glucosinolate in mustard render it unavailable as a source of human protein and are present used as manures and an animal feed. Although it has been know the effect nitrogen and sulphur in mustard production is beneficial, yet pieces information regarding the effect of these nutrients on production, crop quality and other nutrients effects in plants is partically lacking. Therefore, to gain the information regards various aspects pertaining its quality, yield and other nutrients effect is imperative in the proper use of nitrogen and sulphur.

The nitrogen is a major nutrient element that provides lush green color in crop (due to increase in chlorophyll) and its deficiency in arid and semi-arid regions is considerable because the amount of organic matters, which are the main nitrogen reserves, is very low in these regions and even if they were found, they would be quickly decomposed. Nitrogen increases the vegetative growth and delayed maturity of plants. Excessive use of this element may produce too much of vegetative growth, thus fruit production may be impaired. 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. 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. Mustard a cruciferous crop, responds remarkably to sulphur application. Adequate supply of sulphur to mustard promotes the synthesis of sulphur containing essential amino acids, proteins and oil. 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

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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. 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. In addition, the fertilizer requirement for maximum growth and yield of newly developed mustard variety NRCHB-101 is not much investigated.

MATERIALS AND METHODS

The experiment was conducted at the Research farm of Institute of Agriculture Science Sage University Indore (M.P.) during 2019-020 to examine the effect of nitrogen (N) and sulphur (S) on the growth and yield of NRCHB-101 mustard.The study was carried out in Indore. The area has almost uniform topography with medium black soils, formed from basaltic parent material. Institute of Agriculture Sciences, SAGE University, Indore (M.P.) The dominating soils of the study area are shallow, medium black soil with dark brown coloration. The analysis was done for organic carbon, available N, P & K, soil pH and electrical conductivity. The data obtained were analyzed statistically by the analysis of variance method . The data were estimated for N,P,K ,Organic Carbon,Soil pH and Ec by Alkaline permanganate method (Subbaiah and Asija, 1956), Olsen's procedure (Olsen et al. 1954), Walkey and Black's rapid titration method, Olsen's procedure (Olsen et al. 1954), Flame Photometer (Black 1965), Walkey and Black method (1934) ,Glass electrode pH meter and Solubridgemethod (Jackson, 1973) respectively.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Fertilizer treatments consisted of 4 levels of N (0, 40, 80 and 120 kg N ha^{-1} designated as N_0, N_1, N_2 and N_3 respectively) and 4 levels of S (0, 8, 16 and 24 kg S ha^{-1} designated as S_0, S_1, S_2 and S_3 respectively). There were 16 treatment combinations. Fertilizer treatment were randomly distributed in each block. Each block consisted of 16 plots and individual plot was 2.5m * 2m i.e 5 sq. m in size. Seeds of NRCHB-101 variety of mustard were sown continuously @5 kg ha^{-1} on 8 November 2019 by hand as uniform as possible in the 30 cm apart lines. A strip of the same crop was established around the experimental field as border crop. Plant population was kept about 180-200 per plot. After sowing the seeds were covered with soil and slightly pressed by laddering. The P and K fertilizer were applied at the rate of 20 and 50 kg ha^{-1} One third (1/3) of whole amount of Urea and full amount of MP and TSP were applied at the time of final land preparation. The remaining Urea was top dressed in two equal installments at 25 days after sowing (DAS) and 40 DAS respectively.

RESULTS AND DISCUSSION

Effect of Nitrogen, sulphur and their Interaction effect of on yield contributing characters.

Siliqua $plant^{-1}$ and seed $siliqua^{-1}$ of mustard showed a statistically significant variation for different nitrogen level. The number of siliquae $plant^{-1}$ and seed $siliqua^{-1}$ enhanced with increasing the doses of N and the greatest significant number was obtained with N_2 (80 kg N ha^{-1}) followed by N_3 (120 kg N ha^{-1}). The minimum number of siliquae $plant^{-1}$ and seed $siliqua^{-1}$ was recorded from the N_0 treatment. Further increase in N level, failed to increase the number significantly (Table 1). Mondal and Gaffer (1983), Gaffer and Razzaque (1983) also reported the similar findings from their experiment. They reported that different levels of nitrogen significantly increased siliqua per plant of mustard ensuring proper growth of plant. Sharawat *et al.* (2002) recorded maximum number of siliquae $plant^{-1}$ with 120 kg N ha^{-1}. These results indicated that higher dose of nitrogen favored higher number of siliqua formation in mustard.

Different level of sulphur showed statistically significant differences for siliqua $plant^{-1}$ and seed $siliqua^{-1}$. The maximum number of siliqua $plant^{-1}$ and seed $siliqua^{-1}$ was observed from S_3 treatment followed by S_2 Treatment (Table 1). On the other hand the minimum number of siliqua $plant^{-1}$ was recorded from the S_0 treatment. Nitrogen and sulphur showed a significant interaction effect for number of siliqua $plant^{-1}$ and seed $siliqua^{-1}$. The maximum number of siliqua $plant^{-1}$ (193) was recorded from the treatment combination N_2S_3 (80 kg N ha^{-1} + 24 kg S ha^{-1}). The increase sulphur may be ascribed to its role growth and yield attributes with application of nitrogen and sulphur may have helped in improvement in yield attributes of Indian mustard. These results the findings by Meena J *et al.*, (2018), the similar results were also reported by (Dongarkar *et al.*, 2015 and Kumar A *et al.*, 2016).

Effect of Nitrogen, sulphur and their Interaction effect on yield characters

Nitrogen showed statistically significant differences for test weight, Seed yield and Stover yield of mustard under the present trial. The test weight of seed, Seed yield and Stover yield increased with increasing levels of N upto N_2 (80 kg N ha^{-1})followed by N_3 (120 kg N ha^{-1}). The minimum number of test weight, Seed yield and Stover yield was recorded from the N_0 treatment. (Table 1). Sharawat *et al.*, (2002), Mudhokar and Ahlawat (1981) also reported the similar results from their experiment.

Different level of sulphur exhibited statistically significant variation for test weight ,Seed yield and Stover yield. It increased significantly with higher levels of S with the highest at S_3 treatment followed by S_2 Treatment (Table 1). On the other hand the minimum number of test weight, Seed yield and Stover yield was recorded from the S_0 treatment.

Interaction effect of nitrogen and sulphur showed a significant variation for test weight ,Seed yield and Stover yield under the present experiment. The highest test weight of seed ,Seed yield and Stover yield was recorded from the treatment combination N_2S_3 comprising of 80 kg N ha^{-1} + 24 kg S ha^{-1} and the lowest (3.46 g) was recorded from N_0S_0 where no nitrogen and sulphur were applied (Table 1). Chhata *et al*.(2017) also suggested that Treatment module comprising of seed treatment with *Trichoderma viride*@8g/kg seed +foliar spray of Azadirachtin @3ml/lit.at 5-10DAS+Neem oil spray@2% at 10-20DAS+NSKE spray@5% at 30-40 DAS+cow urine spray@10% at 50-60DAS+milk whey spray @10% at 60-75 DAS was found significantly superior over control and gave maximum seed yield of mustard 13.65q/ha. in comparison to control.

These results are in conformity with that of Tomer *et al.* (1996), Singh and Rathi (1984), Narang and Singh (1985) who have observed increased seed yield of mustard by increasing rate of nitrogen. Banueles *et al.* (1990) recorded significant differences for different level of sulphur application. It is also observed by C.K. Verma *et al.,(*2009) Results reveals that fertilizer 120 N + 45 S kg ha^{-1} gave significantly results.

Table 1. Effect of Nitrogen, sulphur and their Interaction effect of on yield contributing characters and Yield of Mustard crop.

Treatments	Siliqua plant^{-1} (No.)	Seed siliqua^{-1} (No.)	test weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Main Effect of Nitrogen					
N_0 0,	106	11.54	3.25	918	1605
N_1 = 40 kg N ha^{-1}	126	13.12	3.83	1108	1843
N_2 = 80 kg N ha^{-1}	180	16.34	4.03	1545	2752
N_3 =120 kg N ha^{-1}	168	16.31	3.86	1441	2728
LSD(0.05)		1.050	0.0344	18.094	26.22
Main Effect of Sulpher					
S_0 = 0, kg S ha^{-1}	117	12.67	3.55	1088	1593
S_1 = 8, kg S ha^{-1}	143	12.94	3.79	1171	1831
S_2 = 16 kg S ha^{-1}	164	15.56	3.93	1350	2716
S_3 == 24 kg S ha^{-1}	185	16.05	4.15	1404	2718
LSD(0.05)	1.940	1.050	0.0344	18.094	26.22
Interaction effect of nitrogen and sulphur					
N_0S_0=**Control**(No N and S application)	97	11.21	3.46	860	1233.24
N_0S_1 = 0 kg N ha^{-1} +8 kg S ha^{-1}	103	13.03	3.61	892	1279.128
N_0S_2 = 0 kg N ha^{-1} +16 kg S ha^{-1}	105	14.22	3.71	956	1370.904
N_0S_3= 0 kg N ha^{-1} +24 kg S ha^{-1}	118	16.20	3.78	964	1382.376
N_1S_0= 40 kg N ha^{-1} +0 kg S ha^{-1}	124	12.21	3.81	1048	1502.832
N_1S_1= 40 kg N ha^{-1} +8 kg S ha^{-1}	147	12.23	3.83	972	1393.848
N_1S_2= 40 kg N ha^{-1} +16 kg S ha^{-1}	138	13.33	3.52	1248	1789.632
N_1S_3= 40 kg N ha^{-1} +24 kg S ha^{-1}	135	14.22	3.99	1164	1669.176
N_2S_0 =80 kg N ha^{-1} +0 kg S ha^{-1}	153	12.03	3.94	1272	1824.048
N_2S_1 = 80 kg N ha^{-1} +8 kg S ha^{-1}	180	13.24	4.04	1510	2165.34
N_2S_2 = 80 kg N ha^{-1} +16 kg S ha^{-1}	186	15.23	4.12	1650	2366.1
N_2S_3 = 80 kg N ha^{-1} +24 kg S ha^{-1}	193	16.21	4.23	1748	2506.632
N_3S_0 = 120 kg N ha^{-1} +0 kg S ha^{-1}	170	13.22	3.46	1171	1679.214

N_3S_1 = 120 kg N ha^{-1} +8 kg S ha^{-1}	185	13.13	3.53	1310	1878.54
N_3S_2 = 120 kg N/ha+16 kg S/ha	186	14.03	3.97	1544	2214.096
N_3S_3 =120 kg N ha^{-1} +24 kg S ha^{-1}	174	16.28	4.07	1738	2492.292
SEm±	4.331	2.017	0.138	36.33	42.61
CD at 5%	6.731	5.775	7.565	5.94	8.68

Effect of Nitrogen, sulphur and their Interaction effect on nitrogen, sulphur, phosphorus and potassium content by seed of mustard

Nutrient such as nitrogen, sulphur, phosphorus and potassium content in seed was estimated for different level of nitrogen and sulphur application and also their different combination.The effect of nitrogen and Sulpher showed a statistically significant variation for nitrogen content in seed of mustard under the present trial. The highest nitrogen ans sulpher content in seed was recorded from N_3 treatment and S_2 treatment followed by N_2 treatment and S_3 treatment and the lowest nitrogen content was recorded from N_0 treatment i.e. control (Table 2). Highest application of nitrogen accelerated nitrogen uptake by plant resulting the highest nitrogen content in seed. Mahajan *et al.,* (1994) also recorded the similar results from their experiment.

The effect of nitrogen and Sulpher showed a statistically significant variation for Sulpher, phosphorus and potassium content in seed of mustard under the present trial. The highest nitrogen ans sulpher content in seed was recorded from N_2 treatment and S_3 treatment followed by N_3 treatment and S_2 treatment and the lowest nitrogen content was recorded from N_0 treatment i.e. control (Table 2). Significant interaction effect was also recorded between nitrogen and sulphur for nitrogen ,sulphur ,phosphorus and potassium content in seed under the present trial. The highest Nitrogen, sulphur ,phosphorus and potassium content in seed were recorded from the treatment combination N_2S_3 (80 kg N ha^{-1} + 24 kg S ha^{-1}) and the lowest was recorded from N_0S_0 (Table 2). The similar results were also reported by (Dongarkar *et al.,* 2015 and Kumar A *et al.,* 2016). Each increasing nitrogen and sulphur increased the Nutrient content in seed significantly which ultimately resulted in increased Nutrient content. Similar trend was also observed by Rathore *et al.,* (2014) and Kumar M *et al.,* (2017)

Effect of Nitogen, sulphur and their Interaction on nitrogen, sulphur, phosphorus and potassium uptake by seed of mustard-

Nutrient such as nitrogen, sulphur and Phosphorus, potassium uptake by mustard seed was estimated for different level of nitrogen and sulphur application and also their different combination in the present experiment.Effect of nitrogen and sulpher showed a statistically significant difference for nitrogen sulphur and Phosphorus, potassium uptake by seed of mustard. The maximum nitrogen sulphur and Phosphorus, potassium uptake by seed were recorded from N_2 treatment (80 kg N ha^{-1}) and S_2 treatment which was significantly higher than that obtained from N_3 treatment and S_3 treatment the minimum nitrogen uptake by seed (29.28 kg ha^{-1}) was recorded from N_0 treatment (Table 2). Mahajan *et al.,* (1994) reported that sulphur increased nitrogen uptake in mustard seed.

A significant interaction effect was observed between nitrogen and sulphur for nitrogen, sulphur and Phosphorus, potassium uptake by seed. The maximum nitrogen, sulphur and Phosphorus, potassium uptake by mustard seed were recorded from the treatment combination N_2S_3 (80 kg N ha^{-1} + 24 kg S ha^{-1}) and the minimum uptake by seed were recorded from N_0S_0 (Table 2). The findings are in close harmony with the result of Chaudhary (2012), Sharma (2013) and Sharma V *et al.,* (2013).

Table 2. Effect of Nitrogen, sulphur and their Interaction effect on nitrogen, sulphur, phosphorus and potassium content by seed and Uptake by seed of mustard.

Treatments	Content in seed (%)				Uptake by seed (kg ha^{-1})			
	N	S	P	K	N	S	P	K
Main Effect of Nitrogen								
N_0 0,	3.19	1.36	0.57	0.877	29.2842	12.4848	5.2326	8.05086
N_1 = 40 kg N ha^{-1}	3.63	1.53	0.59	0.889	40.2204	16.9524	6.5372	9.85012
N_2 = 80 kg N ha^{-1}	3.91	1.49	0.71	0.889	60.4095	23.0205	10.9695	13.73505
N_3 =120 kg N ha^{-1}	3.92	1.43	0.61	0.892	56.4872	20.6063	8.7901	12.85372

LSD(0.05)	0.079	0.056	0.036	0.009	1.222	0.543	0.362	0.256
Main Effect of Sulpher								
S_0 = 0, kg S ha^{-1}	3.45	1.25	0.59	0.886	37.536	13.60	6.419	9.639
S_1 = 8, kg S ha^{-1}	3.58	1.41	0.61	0.881	41.921	16.511	7.143	10.316
S_2 = 16 kg S ha^{-1}	3.84	1.54	0.63	0.888	51.84	20.79	8.505	11.988
S_3 == 24 kg S ha^{-1}	3.77	1.59	0.65	0.891	51.667	21.340	8.283	11.667
LSD(0.05)	0.079	0.056	0.036	0.009	1.222	0.543	0.362	0.256
Interaction effect of nitrogen and sulphur								
N_0S_0=**Control**(No N and S application)	3.03	0.96	0.53	0.862	26.058	8.256	4.558	7.4132
N_0S_1 = 0 kg N ha^{-1} +8 kg S ha^{-1}	3.15	1.16	0.55	0.869	28.098	10.3472	4.906	7.75148
N_0S_2 = 0 kg N ha^{-1} +16 kg S ha^{-1}	3.16	1.27	0.65	0.887	30.2096	12.1412	6.214	8.47972
N_0S_3= 0 kg N ha^{-1} +24 kg S ha^{-1}	3.18	1.38	0.64	0.892	30.6552	13.3032	6.1696	8.59888
N_1S_0= 40 kg N ha^{-1} +0 kg S ha^{-1}	3.23	1.17	0.58	0.904	33.8504	12.2616	6.0784	9.47392
N_1S_1= 40 kg N ha^{-1} +8 kg S ha^{-1}	3.34	1.33	0.61	0.904	32.4648	12.9276	5.9292	8.78688
N_1S_2= 40 kg N ha^{-1} +16 kg S ha^{-1}	3.78	1.38	0.62	0.903	47.1744	17.2224	7.7376	11.26944
N_1S_3= 40 kg N ha^{-1} +24 kg S ha^{-1}	3.88	1.43	0.69	0.910	45.1632	16.6452	8.0316	10.5924
N_2S_0 =80 kg N ha^{-1} +0 kg S ha^{-1}	3.53	1.08	0.72	0.909	44.9016	13.7376	9.1584	11.56248
N_2S_1 = 80 kg N ha^{-1} +8 kg S ha^{-1}	3.58	1.18	0.73	0.912	54.058	17.818	11.023	13.7712
N_2S_2 = 80 kg N ha^{-1} +16 kg S ha^{-1}	4.03	1.36	0.74	0.915	66.495	22.44	12.21	15.0975
N_2S_3 = 80 kg N ha^{-1} +24 kg S ha^{-1}	4.18	1.68	0.75	0.935	73.0664	29.3664	13.11	16.3438
N_3S_0 = 120 kg N ha^{-1} +0 kg S ha^{-1}	3.73	1.09	0.68	0.907	43.6783	12.7639	7.9628	10.62097
N_3S_1 = 120 kg N ha^{-1} +8 kg S ha^{-1}	3.98	1.28	0.66	0.911	52.138	16.768	8.646	11.9341
N_3S_2 = 120 kg N/ha+16 kg S/ha	4.09	1.46	0.65	0.907	63.1496	22.5424	10.036	14.00408
N_3S_3 =120 kg N ha^{-1} +24 kg S ha^{-1}	3.58	1.18	0.62	0.921	62.2204	20.5084	10.7756	16.00698
LSD(0.05)	0.16	0.109	0.063	0.0201	3.238	1.156	0.693	0.6476
CV (%)	7.76	5.43	6.65	5.607	4.286	4.822	6.395	5.244

CONCLUSION

The experiment levels of Nitrogen is 0 kg N ha^{-1} (N_0), 40 kg N ha^{-1} (N_1), 80 kg N ha^{-1} (N_2) and 120 kg N ha^{-1} (N_3) and Sulphur levels is 0 kg S ha^{-1} (S_0), 8 kg S ha^{-1} (S_1), 16 kg S ha^{-1} (S_2), 24 kg S ha^{-1} (S_3). There were 16 treatments combinations from the present study, it may be concluded is best level of nitrogen (N_3) gave the best results. Application of 120 kg N ha^{-1} gave the best result and the best level of Sulphur (S_3) gave the best results. Application of 24 kg S ha^{-1} gave the best result. The interaction effects of nitrogen and Sulphur (N_2S_3) gave the best results. For application of nitrogen 120 kg N ha^{-1} and Sulphur 24 kg S ha^{-1} gave the best result showed is most effective combination in respect on Growth and Yield of mustard.The results need for further of farmers it may be concluded is best level of nitrogen (N_3) and level of Sulphur (S_3) gave the best results. The interaction effects of nitrogen and Sulphur (N_2S_3) gave the best results. For application of nitrogen 120 kg N ha^{-1} and Sulphur 24 kg S ha^{-1} gave the best result showed is most effective combination in respect on Growth and Yield of mustard in farmer filed in further.

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