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Growth and nutrient uptake of indian mustard [*Brassica juncea* (L.) Czern and Coss.] genotypes as influenced by nitrogen and sulphur fertilization under irrigated condition

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2016-17 at Banaras Hindu University (Varanasi) in a split plot design having three nitrogen levels (90,120 and 150 kg N ha^{-1}) and two genotypes (Pusa Bold and RH- 749) in main plots and three sulphur levels (0, 25 and 50 kg S ha^{-1}) in sub plots with three replications to study the effect of nitrogen and sulphur levels on growth and nutrient uptake of Indian mustard (*Brassica juncea* L.) genotypes. Results revealed that application of 150 kg N and 50 kg S ha^{-1} improved all the growth attributing characters *viz.* plant height, primary and secondary branches and shoot dry weight, nutrient (N, P, K and S) content and uptake as compared to lower levels of nutrients applied. Application of 50 kg S ha^{-1} improved plant height, shoot dry weight, primary and secondary branches by 3.96%, 9.66%, 8.75% and 14.29%, respectively over the control. Among genotypes, 'RH- 749' showed distinct superiority with respect to growth parameters (plant height and shoot dry weight) and nutrient uptake over 'Pusa Bold'. Combined application of 150 kg N and 25 kg S ha^{-1} to Indian mustard genotype 'RH- 749' was found more remunerative.

Key words: *Genotype, Growth, Indian mustard, Nitrogen and Sulphur*

Introduction

Oilseeds hold a supreme position in Indian agriculture due to its vital role in bolstering the economy of the country. India is the 4th largest oilseed producing country in the world accounting for about 32.10 MT after USA, China and Brazil (DVVOF, 2017). In India, consumption of oil and fats is continuously increasing due to rising demand of the ever-growing population which is mushrooming at a rate of 1.1% annually. Increasing income, urbanization, changing food habits and deeper penetration of processed food are the key drivers of consumption growth of edible oil in the country. Based on an estimation, per capita consumption of edible oil was 18.13 kg during 2016-17, which is projected to increase up to 24 kg by 2025 (FAO, 2016). Keeping in view this huge gap in demand and production, there is an urgent need for adoption of improved agronomic practices for improving edible oilseed productivity.

Among the oilseeds, Indian mustard is the principal winter edible oilseed crop, mainly grown under arid and semi-arid conditions of India occupy-

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ing an area of 6.0 Million ha with a production of 7.98 Million ton and at an average productivity of 1324 kg ha^{-1} (Anonymous, 2018). However, there is no distinguishable enhancement in the productivity of Indian mustard in recent years in the country and is much below than the world average yield (2144 kg ha^{-1}). Suboptimal or imbalanced use of fertilizers, cultivation of traditional or local varieties are among the major causes of low average yield.

Production potential of mustard can be fully exploited by cultivating high yielding varieties under suitable agronomic practices. It is known that a specific genotype may not elicit the same or superior phenotypic characteristics in all environmental conditions. Therefore, after prolonged cultivation of any variety in a specific agro climatic condition, it needs to be replaced with a promising new variety developed for the proper agronomic evaluation.

Among various plant nutrients, the role of nitrogen and sulphur is functionally confluent, as addition of one nutrient not only promotes growth and yield but also regulates the activity of the other. A strong synergistic influence exists between nitrogen and sulphur as both of them involved in enhancing metabolic activity, growth, yield, nutrient uptake, chlorophyll, protein and oil synthesis. Presence of metabolic coupling between nitrogen-sulphur metabolism, creates nitrogen deficiency in plants as a result of sulphur deficiency (Akmal *et al.,* 2014). Thus, the combined application of nitrogen and sulphur had the largest effect on the concentration and uptake of nitrogen and sulphur on growth parameters as well as uptake of the nutrients in Indian mustard (*Brassica juncea* L.). Hence, the present investigation was initiated to access the effect of varying levels of nitrogen and sulphur fertilization on growth and nutrient uptake of Indian mustard genotypes.

Materials and Methods

An experimental trial was carried out during winter (*rabi*) season of 2016-17 at the IFS Block of Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (25°18´ N latitude, 83°36´ E longitude and an altitude of 80.71 meters from mean sea level in the centre of North-Gangetic Alluvial Plain) under subtropical climate. The soil of experimental field was Gangetic alluvial, having sandy clay loam texture with *p*H 7.8. It was moderately fertile, being low in organic carbon (0.38%), available nitrogen (138.48 kg ha^{-1}), medium in available phosphorus (23.31 kg ha^{-1}) and potassium (172.10 kg ha^{-1}). The experiment was carried out in split-plot design and replicated thrice. Combination of three nitrogen levels (90, 120 and 150 kg N ha^{-1}) and two varieties (Pusa Bold and RH- 749) comprised the main plot treatments, whereas three sulphur doses (0, 25 and 50 kg S ha^{-1}) were allocated to subplots.

A pre-sowing irrigation was given and when the soil reached proper moisture condition seedbed was prepared. Seeds of Indian mustard genotypes (Pusa Bold and RH- 749) in accordance with treatments were sown at 5 kg ha^{-1} in the second week of November with 40 cm × 15 cm spacing. The amount of different fertilizer required to supply essential plant nutrient was calculated on per plot basis. Half of the nitrogen (N) along with full amount of phosphorus (P) and potassium (K) were applied basal at the time of sowing. The remaining nitrogen was top-dressed through urea after irrigation at pre-flowering stage. The entire quantity of sulphur as per treatments was incorporated uniformly into the soil before sowing. The source of nitrogen, phosphorus, potassium and sulphur were urea, DAP, MOP and elemental sulphur, respectively. One gap filling was done after 22 days to maintain optimum plant population. All other agronomic packages were kept normal and invariable for all the treatments. Plant protection measures were adopted to keep the crop free from insect-pests, weeds and diseases. For recording observation on various growth and yield parameters four plants were randomly selected and labelled from each net plot. Plant height, number of primary and secondary branch plant^{-1}, shoot dry weight plant^{-1} were recorded at full maturity of crop *i.e.* at harvest. Standard procedures were adopted for these biometric observations. After harvest, analysis for nutrient content in grain and stover was accomplished by following the standard alkaline permanganate, vanadomolybdate phosphoric acid yellow colour, flame photometer and turbidimetry method for nitrogen, phosphorus, potassium and sulphur analysis, respectively. The experimental data were analysed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test the significance of overall treatments by the F test and conclusion were drawn at 5 % probability level.

Results and Discussion

Growth parameters

Growth attributing characters *viz.* plant height, no. of primary and secondary branch and shoot dry weight were affected positively with the application of nitrogen (Table 1). Increasing rate of nitrogen from 90 to 150 kg ha^{-1} improved all these growth parameters at maturity stage. Nevertheless, the difference between 120 and 150 kg N ha^{-1} were found insignificant in case of plant height and secondary branches $plant^{-1}$. It is evident that adequate supply of nitrogen at higher dose favours greater absorption of nutrients which in turn helps in rapid expansion of foliage, subsequent increase in plant height through cell elongation and cell division, better accumulation of photosynthates and eventually resulting in improved plant growth and dry matter accumulation. These results are in close congruity with the findings of Premi and Kumar (2004) and Sah *et al.* (2006)

The genotype 'RH-749' produced distinctly superior plant height and shoot dry weight $plant^{-1}$ over 'Pusa Bold' whereas, non significant responses were noticed between the two cultivars for primary and secondary branches $plant^{-1}$. This may be ascribed to the differential genetic potential of the two genotypes which showed greater photosynthetic efficiency and its translocation to growing points which results faster growth and development. Similar findings were also reported by Pachauri and Trivedi (2012).

Increase doses of sulphur from 0 to 50 kg ha^{-1} resulted in lucid improvement in the growth parameters *viz.* plant height, no. of primary and secondary branch and shoot dry weight. Application of 50 kg S ha^{-1} improved shoot dry weight, primary and secondary branches by 9.66%, 8.75% and 14.29%, respectively over the control. Similarly, it showed an increase in plant height to the tune of 3.96% over no sulphur application, while the two higher levels, *i.e.* 25 and 50 kg S ha^{-1}, were found to be at par. Improved crop growth with higher level of sulphur application is attributed to enhanced metabolic processes in plants with sulphur application which seems to have fostered meristematic activities at active vegetative stage leading to higher apical growth and expansion of photosynthetic area. The findings are in corroboration with Singh and Dhiman (2005) and Makeen *et al.* (2008).

Nutrient content and uptake

Data presented in the Table 2 revealed that N, P, K and S content in seed and stover were found to improve with increasing levels of N application recording maximum at highest level of N application *i.e.* 150 kg N ha^{-1}. Notwithstanding, the difference were not significant with respect to N, P, K and S contents of stover. Likewise, the nutrient contents of seed remained at par between 120 and 150 kg N ha^{-1}. This could be assigned to the dilution effect of

Table 1. Effect of nitrogen and sulphur levels on growth of Indian mustard genotypes

Treatment	Plant height (cm)	Shoot dry weight (g)	Primary branches $plant^{-1}$	Secondary branches $plant^{-1}$
Nitrogen level (kg N ha^{-1})				
90	187.2	61.1	7.3	8.5
120	193.0	68.7	7.7	10.1
150	199.0	73.3	7.9	10.9
SE m±	2.46	1.13	0.13	0.33
CD 5%	7.77	3.55	0.42	1.05
Genotypes				
Pusa Bold	186.3	64.5	7.5	9.9
RH- 749	199.8	70.8	7.7	9.8
SE m±	2.01	0.92	0.11	0.27
CD 5%	6.34	2.89	NS	N.S.
Sulphur levels (kg S ha^{-1})				
0	189.2	64.5	7.3	9.0
25	193.0	67.1	7.5	9.9
50	197.0	71.4	8.0	10.5
SE m±	1.61	0.80	0.16	0.19
CD 5%	4.70	2.33	0.45	0.57

nutrients due to greater biomass production at higher rates of N application. In general, higher nutrient concentrations were observed in seed than straw suggesting productive translocation of nutrients to the sink *i.e.* seed.

Nitrogen at higher rate assured great accessibility of nutrients (N, P, K and S) in adequate amount for the plant uptake. Hence, at 150 kg N ha^{-1}, taller and healthier plant along with better nutrient contents brought about higher nutrient uptake by seed and stover over the lower levels (Table 3). The increase in uptake of N, P, K and S appeared due to cumulative effect of increased seed and stover yield and better contents of N, P, K and S both in seed and stover. These findings are in line with those noted by Parmar *et al.* (2011) and Rajput (2017).

Varietal difference, though recorded slight increase in nutrient contents (N, P and K) of Indian mustard var. 'RH- 749' over 'Pusa Bold', the differences failed to touch the level of significance in seed

Table 2. Effect of nitrogen and sulphur levels on nutrient (N, P, K and S) content (%) of Indian mustard genotypes

Treatment	N content (%)		P content (%)		K content (%)		S content (%)	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
Nitrogen level (kg N ha^{-1})								
90	2.80	0.57	0.447	0.052	0.554	0.81	0.99	0.48
120	2.95	0.61	0.471	0.059	0.594	0.83	1.08	0.49
150	3.03	0.64	0.483	0.058	0.614	0.86	1.13	0.50
SE m±	0.04	0.02	0.008	0.002	0.013	0.01	0.03	0.01
CD 5%	0.12	N.S.	0.027	N.S.	0.042	N.S.	0.10	N.S.
Genotypes								
Pusa Bold	2.89	0.62	0.468	0.056	0.573	0.83	1.09	0.49
RH- 749	2.97	0.59	0.467	0.056	0.602	0.84	1.03	0.49
SE m±	0.03	0.01	0.007	0.002	0.011	0.01	0.03	0.01
CD 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	NS	NS
Sulphur levels (kg S ha^{-1})								
0	2.84	0.59	0.458	0.054	0.559	0.82	1.01	0.45
25	2.93	0.61	0.467	0.055	0.590	0.84	1.06	0.49
50	3.02	0.63	0.476	0.059	0.614	0.85	1.12	0.54
SE m±	0.03	0.02	0.005	0.002	0.011	0.01	0.02	0.03
CD 5%	0.09	N.S.	0.014	N.S.	0.031	N.S.	0.06	NS

Table 3. Effect of nitrogen and sulphur levels on nutrient (N, P, K and S) uptake (kg ha^{-1}) of Indian mustard genotypes

Treatment	N uptake (kg ha^{-1})		P uptake(kg ha^{-1})		K uptake(kg ha^{-1})		S uptake(kg ha^{-1})	
	Seed	stover	Seed	stover	Seed	stover	Seed	stover
Nitrogen level (kg N ha^{-1})								
90	41.86	29.7	6.66	2.69	8.28	42.23	14.63	24.89
120	46.67	34.4	7.44	3.31	9.37	47.17	16.93	27.64
150	51.63	38.6	8.20	3.50	10.47	52.10	19.20	30.55
SE m ±	1.66	0.92	0.23	0.14	0.26	1.24	0.56	0.48
CD 5%	5.23	2.90	0.73	0.45	0.83	3.92	1.75	1.51
Genotypes								
Pusa Bold	42.91	34.2	6.95	3.06	8.53	45.82	16.25	26.81
RH- 749	50.52	34.3	7.92	3.27	10.22	48.52	17.60	28.58
SE m ±	1.36	0.75	0.19	0.12	0.21	1.02	0.45	0.39
CD 5%	4.27	N.S.	0.60	N.S.	0.68	N.S.	1.43	1.23
Sulphur levels (kg S ha^{-1})								
0	43.46	31.5	7.01	2.91	8.55	43.82	15.44	24.00
25	47.48	34.5	7.55	3.13	9.55	47.69	17.05	27.58
50	49.21	36.7	7.75	3.46	10.02	50.00	18.28	31.50
SE m±	0.60	1.57	0.10	0.11	0.21	1.08	0.39	0.66
CD 5%	1.74	4.59	0.29	0.31	0.61	3.16	1.13	1.92

as well as stover between the two genotypes. Since, the genotypes had similar pattern of absorption of nutrients from the soil, the nutrient content between the two cultivars did not differ significantly. Conversely, mustard genotypes exerted marked influence on nutrient uptake in seed. The variety 'RH-749' recorded significantly higher seed N, P, K and S uptake as compared to 'Pusa Bold' whereas, non-significant differences were found in nutrient uptake by stover except for S uptake. Higher seed yield and efficient nutrient use in RH- 749' resulted in greater nutrient uptake by seed than 'Pusa Bold'. Variation in genetic makeup in different varieties could be another reason for differential nutrient uptake which is well reported in the literature (Neha *et al.* 2014).

Sulphur application improved the N, P, K and S contents in seed as well as stover with increasing levels of sulphur applications from 0 to 50 kg S ha^{-1}. However, the differences were significant with respect to nutrient contents of seed only between 50 kg S ha^{-1} and control and the difference between 25 and 50 kg S ha^{-1} was remained comparable with respect to P and K content (Table 2). Similarly, increasing levels of sulphur up to 50 kg S ha^{-1} enhanced the nutrient uptake (N, P, K and S) by seed and stover which is attributed to higher seed and stover yield and efficient utilization of sulphur by test crop. It seemed that seed and stover yields were the major deciding factors for uptake of these nutrients. The significant increase in content and uptake of nutrients might be due to profuse vegetative as well as root growth and enhanced availability of nutrients at maximum dose of sulphur which in turn increased nutrient concentration due to greater absorption. The results are in close conformity with Verma *et al.* (2012).

Thus, recently released Indian mustard genotype 'RH- 749' was found more remunerative and recorded maximum growth, nutrient content as well as uptake as compared to traditionally grown 'Pusa Bold' when fertilized with 150 kg N and 25 kg S ha^{-1}.

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