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SULPHUR NUTRITION AND ITS RESPONSE ON THE SEED, OIL AND PROTEIN YIELD OF INDIAN MUSTARD (*BRASSICA JUNCEA* L.) GENOTYPES

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ABSTRACT

This experiment was carried out in factorial complete randomized block design (RCBD) with 3 replications and 12 treatment combinations at the College Research Farm, Banda University, of Agriculture & Technology, Banda (Uttar Pradesh) during the winter season of 2018-19 and 2019-20. The treatments consisted of three genotypes of Indian mustard namely*, 1) 'PM 25', 2) 'NRCHB 101', and 3) 'DRMR 150-35'* and four sulphur levels *i.e. a) No Sulphur* (0), b) 10 kg, c) 20 kg, and d) 30 kg per hectare. The results indicated that marked differences were observed among the Indian mustard's genotypes with regard to yields and crop biomass. The genotypes 'DRMR 150-35' produced the maximum seed yield of 1505 kg and 1560 kg ha^{-1} being a margin of 5.98% & 11.89% and 3.45% & 8.03% over remaining genotypes ('NRCHB 101' and 'PM-25'), respectively though it remained comparable with 'NRCHB 101 but proved distinct advantage over PM 25 during both the years. Similarly, genotype '*NRCHB 101*' produced significantly higher dry matter production plant^{-1}, protein content and protein recovery as compared 'PM 25'. Increasing application of sulphur to the crop correspondingly enhanced a higher dry matter production plant^{-1}, siliquae plant^{-1}, seed yield, stover yield, oil content, oil yield, protein content, protein yield, nutrient (N and S) content and their nutrient uptake.

Keywords: *Brassica juncea,* genotypes, sulphur levels, quantitative traits, qualitative traits.

Introduction

India is the 4th largest oilseed producing economy after China, USA and Brazil contributing 10% of global oilseed production, 6-7% of world vegetable oil production and roughly 7%of protein meal (Nayak *et al.*, 2021). Among the seven edible oilseed crops cultivated in India, rapeseed-mustard rank 3rd after soybean & groundnut and it contributes nearly 28% in the Indian oilseed's economy and 80% of rabi oilseed production. The India has attained the ever highest Rapeseed-mustard productivity by 1420 kg/ha during 2020 despite escalating population of India and state are facing acute shortage of edible oil by 53% and 49% and indeed these short falls in oil requirements have to be fulfilled by importing edible oil and oilseed to meet up the current deficit from other countries on a cost over 70000 crore (a huge amount of foreign exchange). We are importing. As per estimation, the projected per capita edible oil consumption will reach 25 kg by 2030 with an annual per capita consumption growth of 3.1%.

In India, Rapeseed-mustard is largely cultivated in an area of 6.96 million ha with a production of 9.73 million tonnes with 1397 kg ha^{-1} of yield productivity (GOI, 2022) though much shorter against the global average productivity of 2144 kg ha^{-1}. However, In Bundelkhand region of Uttar Pradesh, it occupies comparatively 0.42 Mha of land and produces 0.36 MT with a least productivity of 857 kg ha^{-1} by 39% lesser than the national productivity of the crop as the crop is mostly grown in poor resource-management conditions of marginal and sub marginal areas, either mixed or intercropped under rain fed conditions. Thus, it is the need of the hour to intensify oilseed production through adoption of improved agronomic practices to meet the future requirement. Besides, use of traditional and/or local varieties, intensive agriculture with imbalanced and irrational application of inorganic high analysis S-free fertilizers leading to widespread S deficiency in Indian soils could be other reasons for poor productivity (Rana *et al.*, 2020).

Yield is a complex trait and is greatly influenced by various genetically governed yield-contributing traits such as seed size, primary and secondary branches per plant, and length of siliqua, seeds per siliqua, and the environmental factors. Hence, the selection of superior/improved genotypes is the first and foremost stipulation to increase crop productivity as it plays a key role in producing higher yield due to their genetic enrichments and better synthesis towards oils. By this study, we are in search of the most prominent variety that has a better adoptability to the climatic conditions with higher yielding potential, and also possess high content of good quality oil. The old varieties of the region are poor yielder and are facing unvarying problems and getting infected by the pathogens and pests that coincides. And the newer varieties have the substantial resistance to pest & diseases and have comparatively better yielding potential.

The Sulphur deficiency is aggregating day by day with the amplification of agriculture and the fertilizer-responsive varieties have accelerated the depletion of S reserves from the soil (Dhaliwal *et al.,* 2022). The visual symptoms of S deficiency in oilseed crops are very specific and can be treated by application of inorganic sulphur in the field throughout the growing season. As we all know that mustard crop is very much responsive to sulphur and application of higher amount of inorganic sulphur led to produce the optimum seed and oil yield of Indian mustard (Patel *et al.,* 2011; Kumar *et al.,* 2011; Ray *et al.,* 2015) by increasing oil content and oil quality (Ahmed and Abdin, 2000) and sequestered in the storage proteins cruciferin and napin, and in the secondary metabolite glucosinolate (GSL) sinigrin, gluconapin and progoitrin (Hassan *et al.*, 2007 and Schatzki *et al.*, 2014 and Borpatragohain *et al.*, 2019). Sulphur application largely influenced chlorophyll synthesis, carbohydrate as well as protein metabolism. Therefore, realizing the importance of above fact mentioned, the present study entitled “Sulphur nutrition and its response on the seed, oil and protein yield of Indian mustard (*Brassica juncea* L.) genotypes” was carried out.

Materials and Methods

The field experiment was laid out at College Research Farm, Banda University, of Agriculture & Technology, Banda (Uttar Pradesh) during winter seasons of calendar years of 2018-19 and 2019-20. On an average, the experimental soil of top 20-cm depth was silty loam in nature having pH 7.75 and was moderately fertile-being low in organic carbon (0.35%), available nitrogen (195.5 kg ha^{-1}) and available sulphur (16.1 kg ha^{-1}) and medium in available phosphorus (18.0 kg ha^{-1}) and available potassium (250.1 kg ha^{-1}). The well pulverized and loose seedbed, was prepared with the help of 2 cross ploughing & disk harrowing followed by planking, that enable seeds to get good and uniform germination, and helps newly emerged radicles to establish faster for optimum growth and development. Recommended dose of fertilizers *i.e.* 60 kg ha^{-1} N, 40 kg ha^{-1} P_2O_5 and 30 kg ha^{-1} K_2O were applied. The experimental crop was fertilized as per treatments using neem coated urea, diammonium phosphate (DAP), potassium chloride (MOP), and sulphur (80%WDG). However, basal application of Phosphatic and Potassic fertilizers in full quantities and nitrogenous fertilizers in one-third quantities of the recommended dose were applied to the tested crops and remaining two-third dose of nitrogenous fertilizers were equally top-dressed at 30 DAS (6-7 leaves stage) and at 55 DAS (pre flowering stage). On the contrary, Sulphur nutrition to the crop was supplied by 80%WDG sulphur fertilizers prior to 2 days of sowing as per treatments of the study. The crop was sown in the first week of November at a row spacing of 40 cm and plant to plant distance (15 cm) was maintained by thinning of extra plants within row. All agronomic practices were followed to harvest good crop yield and the crop was adequately protected from insects-pests and diseases. The experiment was arranged in factorial randomized block design with 3 replications involving twelve treatment combinations of three genotypes *i.e.* ‘PM 25’, ‘NRCHB 101’ and ‘DRMR 150-35’ and four sulphur levels *i.e.* 0, 10, 20 and 30kg S ha^{-1}. The all treatment combinations were allocated randomly in each replication. The experimental crop didn’t experience any biotic stress during its growth period.

The sample plants were randomly selected and tagged for recording observations for all the desired parameters individually and were analysed statistically by SAS version 9. The mature crop of the border area was formerly harvested and then bulked it separately. Latterly, harvesting of the net plot area was done and then kept separately in the field for sun drying for three-four days. Thereafter, harvested material from each net plot was carefully bundled and tagged and then brought to the threshing floor. The bundle of harvested produce of each net plot was weighed for recording biological yield. Threshing of harvested produce of each treatment was manually done and then recorded the grains and straw yield after winnowing, cleaning, and sun drying. The obtained seeds and stove yield from each treatment plot was finally converted into kg per hectare (kg/ha).

The oil content was determined from seed by Soxhlet's method (Ganzler *et al.,* 1986). Oil content, oil recovery, protein content, protein recovery and total nitrogen and sulphur uptake by the crop were calculated by using following formulae:

$$\text{Oil content in seed (\%)} = \frac{\{(\text{Weight of oil flask + ether extract}) - (\text{Weight of oil flask})\}}{\text{Substances taken (g)}} \times 100$$

Oil recovery (kg ha^{-1}) = Seed yield (kg ha^{-1}) x Oil content in seed (%)

Protein content in seed (%) = Nitrogen content in seed (%) x 6.25

Protein yield (kg ha^{-1}) = Seed yield (kg ha^{-1}) x Protein content in seed (%)

Nitrogen uptake by crop (kg ha^{-1}) = {Seed yield (kg ha^{-1}) x Nitrogen content in seed (%)+ Stover yield (kg ha^{-1}) x Nitrogen content in stover (%)}

Sulphur uptake by crop (kg ha^{-1}) = {Seed yield (kg ha^{-1}) x Sulphur content in seed (%)+ Stover yield (kg ha^{-1}) x Sulphur content in stover (%)}

Data about the experimental crop were sorted out, tabulated and finally analyzed statistically by applying the standard techniques to draw a valid conclusion. Analysis of variance for factorial randomized block design was worked out as per the standard procedure and the significance was tested by ‘F’ test at $p \leq 0.05$. The interaction effect i.e., additional effects due to the combined influence of two (or more) factors were calculated.

Results and Discussion

The quantitative (dry matter production $plant^{-1}$, siliquae $plant^{-1}$, seed yield, stover yield, oil yield, protein yield, total nitrogen uptake and total sulphur uptake) and qualitative traits (oil content, protein content and nutrient content) of Indian mustard were markedly influenced by different genotypes. The Variety DRMR 150-35 had produced significantly more siliquae $plant^{-1}$, seed yield and protein yield over variety PM-25 though it remained statistically comparable over genotype 'NRCHB 101'. The seed yield is a function of yield attributing characters hence; a significant increase in seed yield of 'DRMR 150-35' may be due to increase in siliquae plant^{-1} as compared to other genotypes. The maximum seed yield (1505 kg ha^{-1} and 1560 kg ha^{-1}) and stover yields (5827 kg ha^{-1} and 5912 kg ha^{-1}) were recorded in 'DRMR 150-35' followed by NRCHB 101 and the least was achieved by the'PM-25', respectively during both the years of experimentation. This rise in yield parameters of genotypes owed due to its genetic potential compared to other genotypes (Kumar *et al.*, 2001 and Sarkar *et al*, 2005).Conversely, genotype 'NRCHB 101' noted higher dry matter production plant^{-1} and protein content and it showed significant superiority over 'PM 25' but it was at par with genotype 'DRMR 150-35'. In addition, 'NRCHB 101' recorded the highest oil content, nutrient (N and S) content in seed as well as in stover and their total uptake but the differences among the genotypes did not touch the level of significance regarding the same. Based on benefit-cost ratio, 'DRMR 150-35'had produced the maximum profit by utilizing per unit cost followed by 'NRCHB 101' and 'PM-25', respectively.

The mustard crop responded significantly up to 30 kg Sha^{-1} in terms of quantitative and qualitative traits during both years of investigation. Dry matter accumulation plant^{-1} and siliquae plant^{-1}were increased due to direct involvement of sulphur in cell division, cell elongation and cell enlargement which promotes higher growth and number of flowers (Ahmed, *et al.,* 1999 and Dongarkar *et al.,* 2005). Application of 30 kg S ha^{-1} to mustard crop recorded the highest seed yield, stover yield, oil content, oil recovery, protein content, protein recovery, nutrient (N and S) content and its uptake and it showed statistically significant advantage over 10 kg S ha^{-1} and no application of sulphur fertilizer to the crop, but it was remained comparable with 20 kg S ha^{-1}. These results were close conformity with results of Prabhakar *et al.* (2016) and Kabdal *et al.* (2018). Seed yield and stover yield increases due to enhanced rate of photosynthesis and carbohydrate metabolism and intumesced by sulphur application. Sulphur augmented the translocation of photosynthates to sink site. Sulphur has been found to bemore efficient in increasing the oil-content and protein content of seeds possibly due to intensive participation in glucoside synthesis and amino acid synthesis (Ghadge *et al.*, 2005a; Shri Krishna *et al.,* 2005 and Piri and Sharma, 2006). Increased nitrogen and sulphur uptake was mainly due to the concentration of nitrogen and sulphur in seed and stover along with increase in yield (Ghadge *et al.*, 2005). Among sulphur levels, benefit-cost ratio increased with increasing sulphur levels up to 20 kg ha^{-1} after that downwards trend was noted (Sardana *et al.,* 2008).

Interaction effect between genotypes and sulphur levels did not confirmed significant response for qualitative and quantitative traits of Indian mustard.

Conclusion

In view of the above results, it may be concluded that mustard genotype 'DRMR 150-35 be fertilized at 30 kg sulphur accompanied with 60 kg N-30 kg P-20 kg K per hectare performed well and produced the better quantitative and qualitative traits under Bundelkand condition of Uttar Pradesh.

Table 1: Dry matter production plant^{-1}, siliquae plant^{-1}, seed yield, stover yield, oil content, oil recovery, protein content and protein recovery of Indian mustard genotypes as affected by sulphur levels

Treatments	Dry matter production plant^{-1} (g)		Siliquae plant^{-1}		Seed yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Oil content (%)		Oil recovery (kg ha^{-1})		Protein content (%)		Protein recovery (kg ha^{-1})	
	18-19	19-20	18-19	19-20	18-19	19-20	18-19	19-20	18-19	19-20	18-19	19-20	18-19	19-20	18-19	19-20
Genotypes																
PM-25	25.7	28.4	156.0	160.8	1255	1344	5727	5732	41.9	41.2	566.2	595.3	21.0	20.6	282	297
NRCHB 101	30.1	32.2	164.7	171.7	1416	1508	5827	5912	42.6	42.7	608.5	643.6	21.7	21.5	309	323
DRMR 150-35	26.0	30.1	169.4	178.6	1530	1590	5781	5865	42.3	41.6	638.6	648.9	21.3	21.1	321	329
S.Em±	0.7	1.4	2.84	2.99	37.6	42	40	68	0.3	0.3	31.2	32.5	0.2	0.3	9	10
CD (P=0.05)	2.1	4.1	8.3	8.8	110	125	NS	NS	NS	NS	NS	NS	0.7	0.9	26	29
Sulphur nutrition (kg ha^{-1})																
0	20.7	21.6	137.0	145.5	1116	1155	5436	5435	40.9	39. 8	456.4	459.8	19.9	19.6	223	225
10	26.7	28.8	155.2	166.2	1325	1455	5725	5760	42.1	41. 1	569.0	598.5	21.1	20.8	288	302
20	29.2	33.6	179.7	180.9	1510	1660	5915	5999	43.1	42. 3	671.3	701.8	22.1	21.9	344	363
30	31.0	35.4	184.7	186.7	1650	1734	6026	6128	43.3	42. 9	720.7	743.0	22.2	22.2	370	385
S.Em±	0.9	1.6	3.3	3.4	42.4	53	56	79	0.3	0.4	35	38	0.26	0.34	11	12
CD (P=0.05)	2.5	4.7	9.6	10.1	124	157	165	232	1.0	1. 1	101.5	112.5	0.8	1.0	32	34

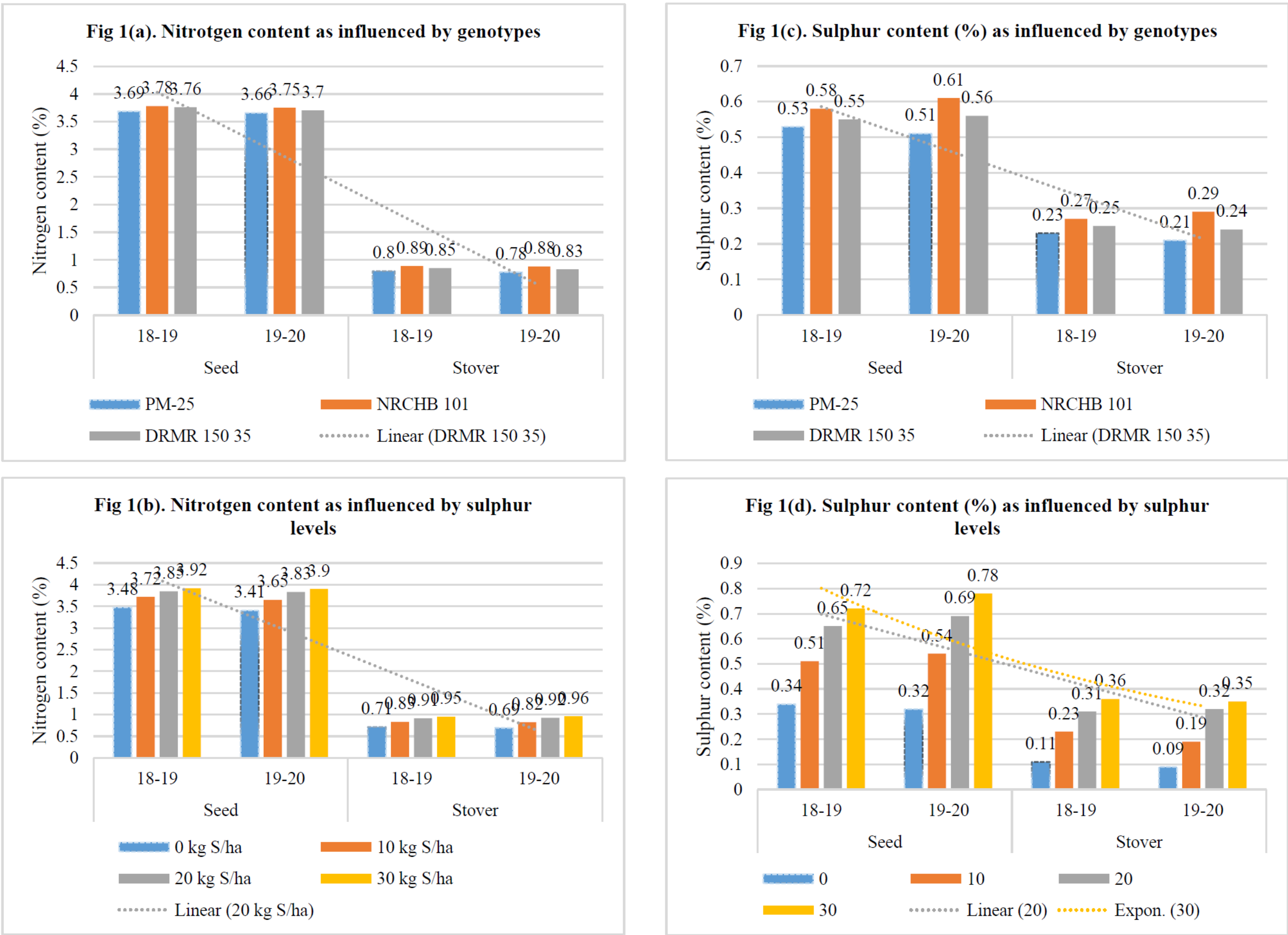

Fig. 1 (a,b,c,d): Response of sulphur levels on nitrogen and sulphur content in seed & stover, and their uptake by Indian mustard genotypes.

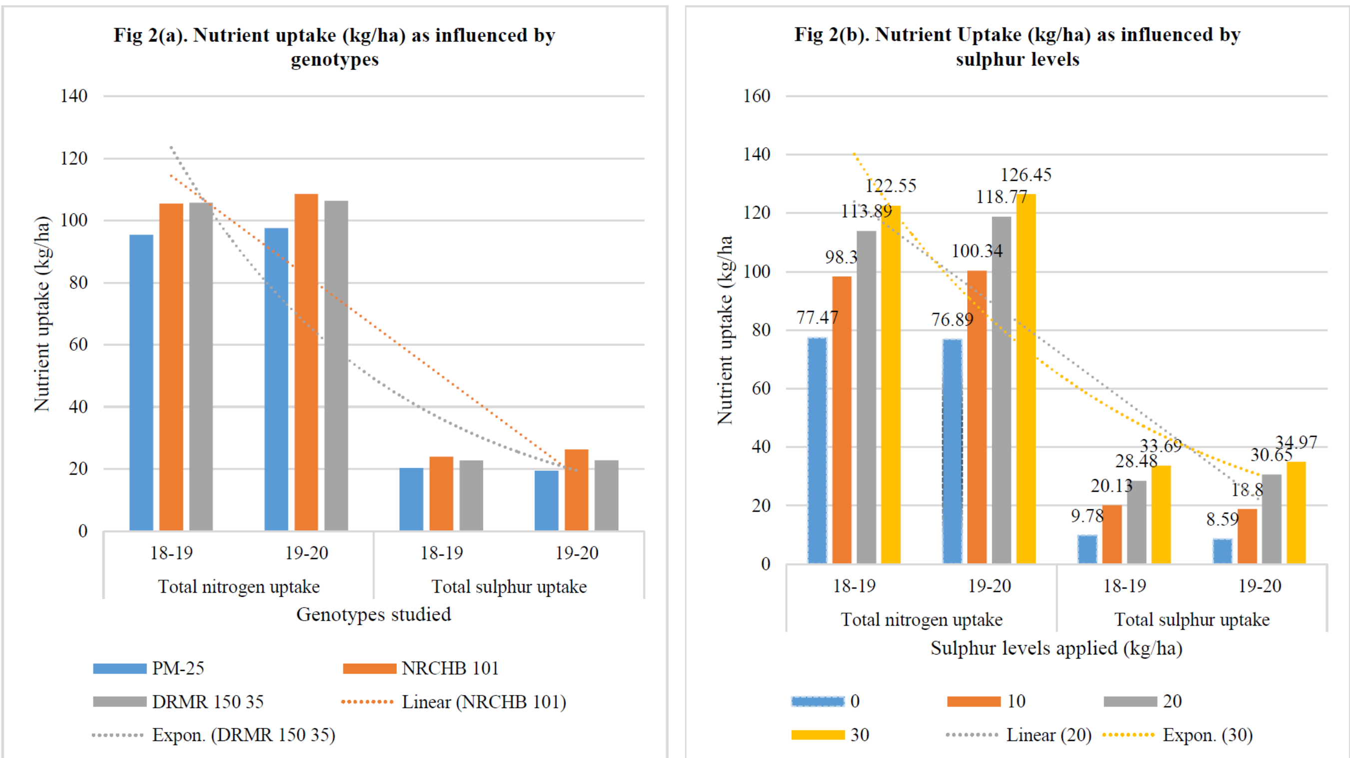

Fig. 2 (a&b): Total nutrient uptake by Indian mustard genotypes as affected by sulphur levels.

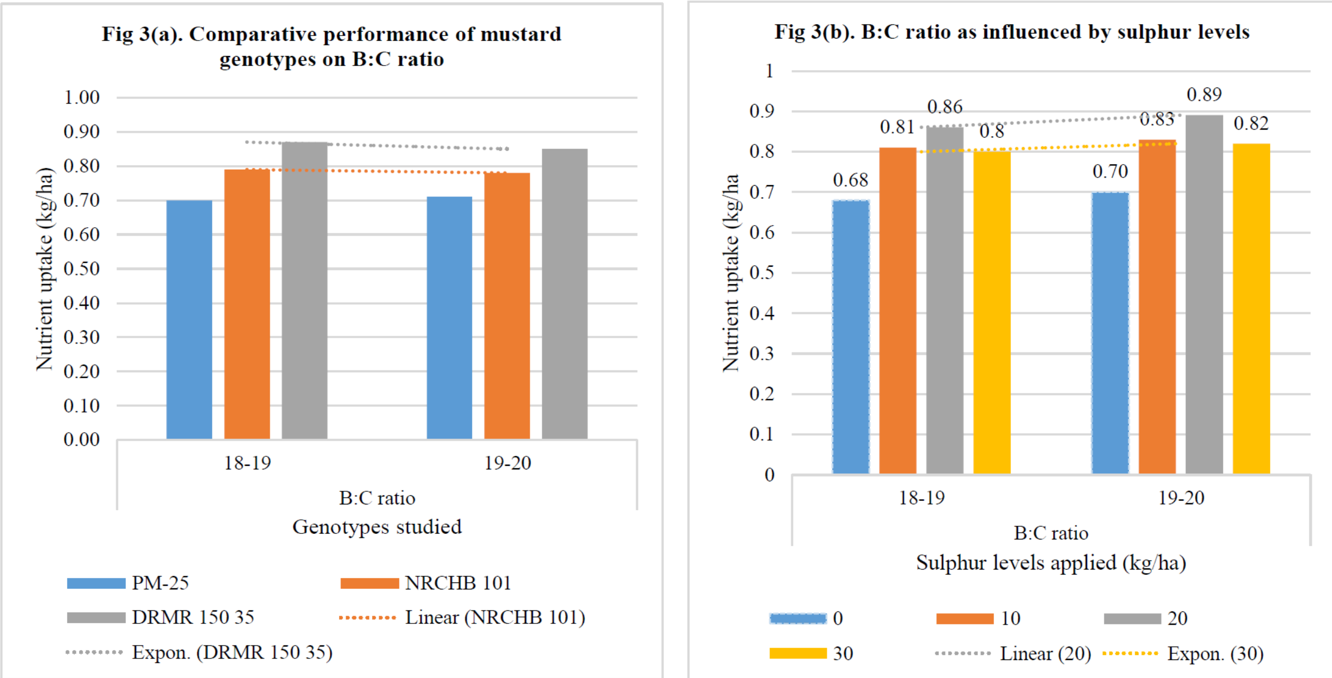

Fig. 3 (a &b): Benefit-cost ratio of Indian mustard genotypes as affected by sulphur levels.

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