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Growth Comparison between Three *Brassica species* in Response to Nutrient Management and Iron Sulphide Nanoparticles

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ABSTRACT: The aim of present study to determine the suitable doses of nano iron sulphide along with nutrient management on three *Brassica species*. Experiment conducted at Agricultural Research Farm, BHU Varanasi which comprised 24 treatment combination involving three genotype (*Brassica juncea, Brassica carinata, Brassica napus*) as main plot, nutrient level (100% RDF and 75% RDF with 25% nitrogen FYM)as sub plot treatment and three iron sulphide nanoparticles levels (0, 4, 8 and 12 ppm) as sub-sub plot treatment in split-split plot design replicated thrice during *Rabi* seasonof 2017–18 and 2018–19.Result disclosed that nanoparticles particle have capacity to replace chemical fertilizer and boosted the photosynthesis, net assimilation and plant relative growth. Statistical analysis of the experiment revealed that application of foliar spray of 8 ppm iron sulphide nanoparticles with application of 75% RDF with 25% nitrogen FYM in *Brassica juncea* significantly enhanced the LAI, CGR and RGR compared to other combination. However the lowest value of all growth attributes was recorded in *Brassica napus* treated with 100% RDF with water spray in both year of investigation.

Keywords: *Brassica,* LAI, CGR,FYM, RDF,RGR.

INTRODUCTION

Brassica species commonly refereed as rapeseed-mustard is the one of the economically important in world agricultural as third largest source of oil next to soybean and palm (Bassegio and Zanotto, 2020). In India, rapeseed- mustard is second most important oilseed crop after soybean but its production was quite low in the country (1349 kg ha^{-1}) against the world average productivity (1,974 kg ha^{-1}) in world (GOI, 2021). India is the fourth largest rapeseed-mustard growing country in the world, occupying the fourth position in area and production (8.6 mt) after Canada (20.5 mt), China (13.8 mt) and European Union (17.2 mt) (USDA, 2021).

Brassica has been grown extensively in India, though its productivity (1176 kg/ha) is much lower than the world average (1850 kg/ha) (DRMR Bharatpur India, 2013). Further there is a huge gap between its demand and production so a significant amount of foreign currency has been used to import the oil (Singh *et al.*, 2021). The major factor responsible for the lower yield of rapeseed and mustard in India are poor marginal land, low rate of fertilizer application and lack of irrigation facility. One of the most important agronomical practice to boost the yield is nutrient management (Kumar *et al*., 2021). Chemical fertilizer are mostly water soluble and rapidly available to plants. But its continuous and excessive use of inorganic fertilizer has led to soil degradation and declining its productivity as well as increases the cost of production. While organic manure is complete source of nutrient which is gradually enrich the soil labile pool depends on the nature of decomposition (Singh *et al.*, 2019). FYM is most popular and easily accessible amendment which can be used along with inorganic nutrient to improve soil physiochemical properties without compromising the yield of *Brassica.*

It is well established that the genetic yield potential and balanced nutrient application are another two important factors responsible for boosting production and productivity of *Brassica species.* However, nutrient requirement and response of *Brassica* varies with species, varieties, seasons and growth stages. Excessive

fertiliser and pesticide use has distorted soil composition, fertility, and integrity, resulting in unfavourable environmental and ecological outcomes (Karuku *et al.*, 2017). To address all of these issues, nanotechnology offers a promising solution that can help to ensure long-term soil health and agricultural productivity. (Lal, 2008). Nanoparticles have unique physico-chemical properties having size less than 100 nm and the potential to boost the plant.

The current study was designed to access the effect nutrient management and foliar spray of iron sulphide nanoparticles on growth attributes of *Brassica species.*

MATERIAL METHOD

A. Site and soil conditions

The field experiment was carried out at Agricultural Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the *Rabi* season of 207-18 and 2018-19. The experiment land was situated in high topographical area of Indo-Gangetic plain, which was characterized by sandy clay loam. The experimental land have well drained soil with homogeneous fertility having pH 7.76, organic carbon 0.46%, available nitrogen 211.40 kg/ha, available phosphorus P 12.02 kg/ha and exchangeable K 200.9 kg/ha.

B. Experimental treatments and design

The treatments included in the experiment were three genotype (*Brassica carinata* cv 'PC-6' *Brassica napus* cv 'GSC 7'and *Brassica juncea* cv 'Giriraj'), two integrated nitrogen management (100% RDF and 75% RDF with 25% through nitrogen FYM) and four iron sulphide nanoparticles (water spray, 4, 8 and 12 ppm). The experiment was laid out in split-split design with three replication. The plants were planted at 45cm × 10cm spacing in both growing seasons.

C. Cultural practices

The experimental plots were ploughed and prepared for sowing. Well-decomposed FYM was applied as per treatments at the time of land preparation. As per treatment specification, the plots of *Brassica juncea*, *Brassica napus* and *Brassica carinata* species was fertilized with the recommended dose of fertilizers (RDF) *viz.*, 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} separately. Full doses of phosphorus and potash, and 50 per cent of nitrogen was applied at the time of sowing, and the remaining 50 per cent of nitrogen was top dressed at 35 DAS in the form of urea, DAP and MOP. The iron sulphide nanoparticles was sprayed at 35 DAS. Irrigation and plant protection measures were taken as per package recommended in rapeseed mustard.

D. Measurement of plant growth indices

Leaf Area Index. Automatic leaf area meter was used to record the area of the leaf at 30^{th}, 60^{th} and 90^{th} days after sowing of the crop. Following formula was used for the calculation of the leaf area index. Leaf area mainly area of photosynthetic surface produced by the per unit plant surface over a period.

Leaf area index (LAI) = leaf area/ ground area

Crop growth rate (g/m^2/day). Crop growth rate refers to the dry matter production of a crop per unit of land-covered area during a given period. The crop growth rate was calculated for period 30-60, 60-90 DAT and 90 DAT to at harvest with the help of following formula

$$\text{CGR}\ (\text{g m}^2\text{day}^{-1}) = \frac{w_2 w_1}{(t_2 - t_1)S}$$

Where, w_2 and w_1 are the total dry weight of plant at the time t_2 and t_1, respectively

S is land area (m^2) over which dry matter was recorded.

Relative growth rate (RGR). Relative growth rate signifies the dry matter production at 30 DAS and it was worked out with the help of following formula

$$\text{Relative growth rate}\ (\text{g g}^{-1}\ \text{day}^{-1}) = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

Where, $\ln W_1$ and $\ln W_2$ are the natural logarithm of total dry weight of plant at the time interval $t_2$and t_1, respectively

All the acquired data were statistically analysed by using analysis of variance ANOVA for split-split design and the LSD test was used to detect the difference between treatment means with a 5% probability.

RESULT AND DISCUSSION

Leaf area index (LAI). At various crop growth stages, observations pertaining to leaf area index (LAI) was represented on Table 1. In both of the year, LAI varied significantly and recorded abrupt increase in LAI from 30 to 60 DAS, later on rate of increment was declined. The highest leaf area was recorded at 90 DAS across all the seasons.

Among genotype, *Brassica juncea* exhibited significantly higher LAI in all stages followed by *Brassica carinata* and lowest LAI was received with *Brassica napus* in both consecutive years. The crop, which received 75% RDF + 25% nitrogen through FYM resulted maximum increase in LAI which was significantly more than inorganic treatment in both the season. Similar finding was reported by Iqbal *et al.* (2008) who reported that *Brassica juncea* documented higher LAI over *Brassica napus* due to their genetic difference. The difference in integrated use of inorganic and organic was insignificant at 30 DAS over 100% inorganic. However LAI increased with advancement of age and found in plots received 75% RDF with 25% nitrogen through FYM compared to 100% RDF. Similar finding was reported at 90 DAS, but LAI of F_{75} was at par with F_{100}. Leaf area index has important role in supplying the energy for photosynthesis. The result corroborated with the finding of Harish *et al*. (2017) who documented that integrated nutrient management (50% RDF through inorganic sources + 50% RDF through FYM and rock phosphate) enhanced the leaf area index in rice.

Table 1: Leaf area index of *Brassica* genotype at different growth stage as influenced by nutrient management and iron sulphide nanoparticles.

Treatments		30 DAS		60 DAS		90 DAS	
		2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Genotype							
G1	*Brassica carinata*	0.34	0.35	1.85	1.89	1.92	1.93
G2	*Brassica napus*	0.25	0.26	1.56	1.57	1.59	1.61
G3	*Brassica juncea*	0.50	0.51	2.27	2.32	2.35	2.37
Sem		0.01	0.01	0.04	0.03	0.04	0.04
CD (P=0.05)		0.04	0.04	0.15	0.12	0.14	0.14
Fertility							
F_{100}	100% RDF	0.36	0.37	1.88	1.90	1.92	1.95
F_{75}	75% RDF + 25% N through FYM	0.36	0.37	1.91	1.96	1.97	1.98
Sem		0.00	0.01	0.03	0.01	0.02	0.01
CD (P=0.05)		NS	NS	0.12	0.04	0.06	0.03
Nano FeS_2 (ppm)							
N_0	Water spray	0.36	0.36	1.82	1.80	1.86	1.88
N_4	4 ppm	0.36	0.37	1.83	1.89	1.92	1.93
N_8	8 ppm	0.37	0.38	2.03	2.07	2.06	2.07
N_{12}	12 ppm	0.37	0.38	1.89	1.96	1.98	1.99
Sem		0.01	0.01	0.07	0.05	0.05	0.05
CD (P=0.05)		NS	NS	0.19	0.14	0.14	0.14

The LAI increased significantly with successive increase in concentration of iron sulphide nanoparticles and lowest was marked in water spray. However, a non-significant difference was observed in 60 DAS among 4, 8 and 12 ppm of iron sulphide nanoparticles, however, it was significantly superior over water spray. Upto 90 DAS, 8 ppm provided a highest LAI which was at par with 12 ppm and significantly superior over 4 ppm and water spray during the both years.foliar application of nano Fe had magnetic and chemical properties which influence the enzyme involved in photosynthesis as well as absorption water and nitrogen. The results are in close conformity with the findings of a Bakhtiari *et al*. (2015) in wheat.

Crop growth rate (CGR). Data on crop growth rate (Table 2) of different genotypes of *Brassica* with respect to time under various treatments showed a significant trend and followed a lag phase upto 30 to 60 DAS in both the year, when plants acquire dry matter at very slow rate. However, among them, *Brassica juncea* had the highest value of CGR (8.59 and 8.78) and lowest with *Brassica napus* (7.01 and 7.03) during 2017-18 and 2018-19 respectively. *Brassica juncea* cultivar 'Giriraj' followed a log phase in between 60 to 90 DAS with peak value of 12.40 and 13.30 for the first and second year respectively and then successively declined after 90 DAS. The rest of the genotype followed a uniform trend up to 90 DAS and a non-significant difference was observed in between *Brassica carinata* and *Brassica napus* upto this stage. *Brassica carinata* followed a grand growth phase after 90 DAS and attained a peak 18.64 and 18.74 during the 2017-18 and 2018-19 respectively while *Brassica juncea* and *Brassica napus* are at par with each other in this stage. *Brassica napus* showed a consistent and significant increase in the dry matter at all stages of the crop.

Table 2: Crop growth rate (g m^2day^{-1}) of *Brassica* genotype at different growth stage as influenced by nutrient management and iron sulphide nanoparticles.

Treatments		30-60 DAS		60-90 DAS		90 DAS-Harvest	
		2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Genotype							
G1	*Brassica carinata*	7.10	7.13	5.49	6.15	18.64	18.73
G2	*Brassica napus*	5.74	5.92	6.07	7.96	7.94	8.59
G3	*Brassica juncea*	8.68	8.79	12.40	13.30	8.08	8.11
Sem		0.17	0.16	0.08	0.31	0.42	0.42
CD (P=0.05)		0.65	0.61	0.33	1.22	1.64	1.63
Fertility							
F_{100}	100% RDF	6.88	6.75	7.99	8.69	10.94	11.19
F_{75}	75% RDF + 25% N through FYM	7.46	7.81	7.98	9.59	12.18	12.43
Sem		0.23	0.31	0.17	0.18	0.25	0.16
CD (P=0.05)		NS	NS	NS	0.62	0.87	0.56
Nano FeS_2 (ppm)							
N_0	Water spray	5.61	5.46	5.82	7.02	10.01	10.14
N_4	4 ppm	7.12	7.19	7.04	8.97	11.80	11.84
N_8	8 ppm	8.62	8.64	10.03	11.01	13.29	13.35
N_{12}	12 ppm	7.35	7.82	9.05	9.54	11.12	11.92
Sem		0.30	0.30	0.25	0.30	0.30	0.36
CD (P=0.05)		0.85	0.86	0.71	0.85	0.87	1.02

Nutrient application either inorganic or integrated recorded a significant variation in crop growth rate, among *Brassica* genotype in all the years except 30-90 DAS in 2017-18 and 30 to 60 DAS in 2018-19. The combined use of 75% RDF with 25% nitrogen FYM significantly improved the CGR value of crops in each successive stage of growth during both years over 100% RDF. The highest peak in CGR was recorded after 90 DAS and F_2 was 18.61% and 11.08% higher in the first and second years compared to F_1. Similar finding was observed in bySahoo *et al.* (2018) fromUdaipur, Rajasthan that 75% RDF + FYM @ 5 t/ha + Zn @ 5 kg/ha + Azotobacter had ability to give higher dry matter over RDF alone.

Different concentrations of iron sulphide nanoparticles remarkably influenced the CGR of *Brassica species* in each growth stage. The successive addition of iron sulphide nano particles significantly improved the CGR value over water spray. Among all the doses of nano iron sulphide, 8 ppm listed maximum CGR in all growth stages followed by 12 ppm which wasat par with 4 ppm. Almost similar results were obtained by Afshar *et al*. (2013) that foliar spray of nano iron (1.5 mg/l) on cowpea improved growth attributes due to more photosynthesis and greater assimilates production.

Relative growth rate. There was significant variation in relative growth rate (Fig. 1) of *Brassica species* was recorded which was significantly influenced by nanoparticles and nutrient sources at different growth stages. At 30–60 DAS, the highest RGR was found in *Brassica juncea* cv 'Giriraj', which was followed by *Brassica carinata* cv'PC-6' and then *Brassica napus* cv 'GSC-7' in both years. However in second year the RGR value of *Brassica juncea* was no able to produce and statical differences. At 60- 90 DAS similar pattern was observed and *Brassica juncea* again provide significantly higher RGR value (0.029 and 0.03 g/g/day) which was 31.81% and 42.85% moreover *Brassica carinata* and 61.11% and 57.11% higher compared to *Brassica napus*. But In the second year, the RGR value of *Brassica napus* had no statistical difference with *Brassica carinata* at this stage. With the further advancement of age, a significant reverse trend was observed among genotypes at 90 DAS to harvest stage. In this growth period maximum RGR value was noted in *Brassica carinata* (0.030 and 0.029 g/g/day) which was significantly superior over rest two genotypes. The next best genotype was *Brassica napus* which gave77.7% (in 1st year) and 70% (in 2nd year) additional RGR value compared to *Brassica juncea.* The variation in dry matter accumulation of *Brassica* genotype was due to genetic heterogeneity (Amanullah *et al*., 2011).

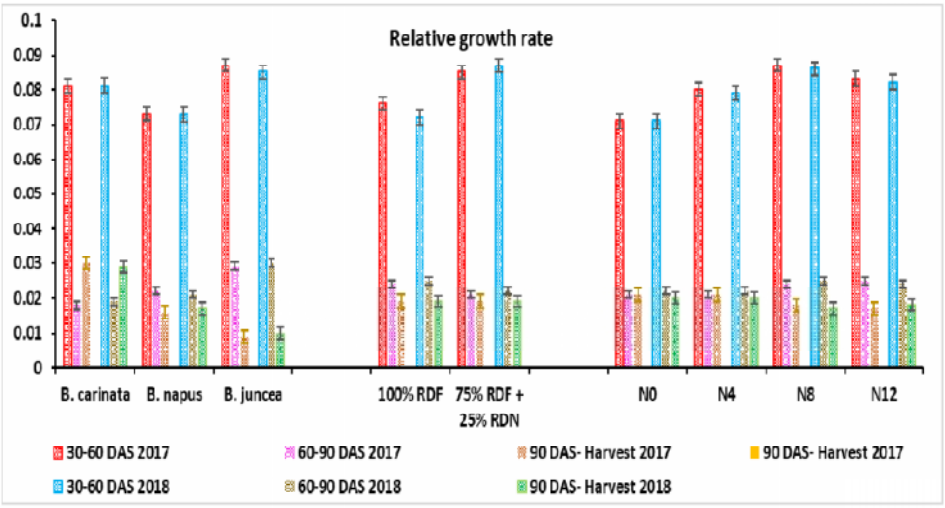

Fig. 1. Relative growth rate (g/g/day) of *Brassica* genotype at different growth stage as influenced by nutrient management and iron sulphide nanoparticles.

In between nutrient sources, the partial replacement of inorganic fertilizer with organic source of nutrient was able to create a significant variation in RGR. At 30–60 DAS, the highest RGR was found from F2 which was followed by F1. However with further advancement of age, the RGR value between two was non-significant in all growing season except at 60 to 90 DAS in second season where 100% RDF gave 13.6% additional rise in RGR value compared with 75% RDF with 25% nitrogen through FYM. Similar finding was documented by Yadav *et al.* (2017) who found that 75% RDF through synthetic fertilizers + 25% RDN through FYM gave the higher value of growth attributes compared to 100% RDF.

The different doses of iron sulphide nanoparticles were failed to mark any noteworthy variation in RGR value of *Brassica species* except at 30-60 DAS for the first year where foliar spray of 8 ppm iron sulphide nanoparticles gave maximum value of RGR but it was at par 8 ppm and further it was at par 4 ppm. However, all iron sulphide nanoparticles doses are significantly superior over water sprayed treated plots. The above result are in close harmony with the results of Valadkhan, (2015) which elaborated that the nano iron (size < 100nm) had potential to increase chick pea yield upto 65% as iron is component of ferredoxin and electron transport system of chloroplast which helped in photosynthesis resulting in enhancement of dry matter.

Fig. 2. Effective photograph of field experiments.

CONCLUSION

Based on the finding during the two years of investigation it could be inferred that *Brassica juncea* gave highest value of LAI followed by *Brassica carinata* and *Brassica napus* in all stages. Similar trend was observed in CGR and RGR value upto 90 DAS. However, it was at par with *Brassica carinata* at later stages. Upto harvest the trend was reversed and *Brassica carinata* acquired highest CGR and RGR value in both years of investigation.

Among nitrogen management 75% RDF with 25% nitrogen through FYM gave higher value of LAI, CGR and RGR value during both years. Increasing concentration of iron sulphide nanoparticles brought significant increment in growth traits in comparison to water spray during both the years of experimentation. 8 ppm spray of iron sulphide nanoparticles was more efficient in producing significant changes in growth attributes followed by 12 ppm and later was at par with 4 ppm.

Overall the foliar spray of 8 ppm iron sulphide nanoparticles with application of 75% RDF with 25% nitrogen FYM in *Brassica juncea* significantly enhanced the LAI, CGR and RGR compared to other combination.

FUTURE SCOPE

Though iron sulphide nanoparticles with integrated nutrient management practice (75% RDF with 25% nitrogen FYM) enhanced the growth attributes of *Brassica species* in all growth parameters. Still, further research is needed to assess the impact of nanoparticles on human and soil health, as well as how to extend their shelf life for its commercialisation.

Conflict of Interest. None.

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