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Impact of different row spacing and nutrient management practices on growth, yield attributes and yield of rabi Niger (*Guizotia abyssinica*)

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Abstract
A field experiment was carried out during *rabi* season of the year 2021-22 at Niger Research Station, Navsari Agricultural University, Vanarasi to study the effect of different row spacing and nutrient management practices on *rabi* niger. Growth parameters were influenced significantly due to different row spacing. Significantly higher plant height at 30 DAS and number of branches per plant at harvest were recorded with application of 45 cm row spacing (S3) which remained at par with 30 cm row spacing at 30 DAS in case of plant height. While, significantly higher plant height at 60 DAS was observed with 30 cm row spacing (S2) and remained at par with 45 cm row spacing (S3). Plant height at harvest remained unaffected due to different row spacings. All the yield attributes and yield of Niger were influenced significantly by different row spacing. Significantly higher number of capitula per plant, number of seeds per capitula and seed yield was recorded with application of 45 cm row spacing. Among the nutrient management practices, significantly higher number of capitula per plant, number of seeds per capitula and seed yield were recorded with application of RDF + vermicompost @ 1.5 t/ha + biofertilizers (*Azotobacter* +PSB +KSB) and remained at par with vermicompost @ 1.5 t/ha and RDF + vermicompost @ 1.5 t/ha treatments for number of capitula per plant and number of seeds per capitula. While in case of seed yield RDF + vermicompost @ 1.5 t/ha + biofertilizers (*Azotobacter* +PSB +KSB) treatment remained at par with RDF + vermicompost @ 1.5 t/ha treatment. Therefore, on the basis of results, it can be concluded that niger crop (GNNIG-3) should be sown at 45 cm row spacing and nutrient management should be integrated in the manner of RDF (20-20-00 N-P_2O_5-K_2O kg/ha) along with 1.5 t/ha vermicompost (basal application) with or without biofertilizers seed treatment (*Azotobacter* + PSB + KSB) for securing higher seed yield in niger crop.

Keywords: Niger, RDF, Vermicompost, Biofertilizers, *Azotobacter*, PSB, KSB

Introduction
Oilseeds occupy a key place in agriculture and constituting an important group of crops next to cereals. Niger (*Guizotia abyssinica*) belongs to compositae family. The species of the genus *Guizotia* are diploid with 2*n*=30 chromosomes. It is believed to introduce in India by Ethiopian immigrants, probably in the third millennium BC along with other crops such as finger millet. Niger is locally known as *ramtil*, *jagni* or *jatangi* (Hindi), *ramtal* (Gujrati), *karale or khurasani* (Marathi), *Uchellu* (Kannada), *Payellu* (Tamil).

In India, Niger is grown on an area of 2.61 lakh ha. Niger crop is mainly cultivated in the states of Madhya Pradesh, Orissa, Maharashtra, Bihar, Karnataka and Andhra Pradesh, and to some extent in hilly areas of Rajasthan, Uttar Pradesh, Gujarat and Tamil Nadu and some parts of the North-eastern hilly regions of the country. The average yield in India is 3.21 q/ha. In Gujarat, Niger is grown exclusively in tribal and hilly areas of Panchmahal, Navsari, Valsad and Dang districts. Niger seed contains edible oil (38 to 43%), protein (18 to 24%), sugar (12%) and minerals essential for human and animal meals. Niger oil is a substitute for sesame oil for pharmaceutical purposes and can be used for soap-making. The Niger seed mixed with roasted cereals is preferred food for young boys. In Karnataka and Maharastra, Niger seeds are used to make a dry chutney which is used as accompaniment with breads and also used as a spice in some curries. It is well known for dietary fats, rich in linoleic acid prevent cardiovascular

disorder such as coronary heart disease, atherosclerosis and high blood pressure and also serves as structural components of the plasma membrane and as precursor of metabolic regulatory compounds. Niger seed sprouts mixed with garlic and Tej are used to treat coughs. Niger id also called as a "bee plant" as they attract honey bees (Abraham, 1989) [1]

Niger is generally grown in tribal regions of India, with no any specific management practices leading to low yields. Row spacing is important agricultural factor and has great effect on growth and yield components of individual plants. Kose and Ozlem (2017) [2] observed that safflower with 30 or 45 cm row spacing gave the highest number of seed/capitula, test weight and achene yield. Nutrient stress is another important factor for low productivity in Niger. Use of inorganic fertilizers is not only costly but its timely availability is also problem besides causing ill effects on soil health. Use of integrated nutrient management is the better way in increasing the yields as well as protecting the soil degradation. Therefore, this research was formulated with the objective to study the effect of different row spacing and nutrient management practices on yield attributes and yield of *rabi* Niger.

Materials and Methods

The present investigation was carried out in plot-2 during *rabi* season of the year 2021-22 at Niger Research Station, NAU, Vanarasi, Navsari. The experimental plots had good drainage with uniform topography and soil characteristics which is suitable for Niger cultivation. The experiment was laid out in Factorial Randomized block design (FRBD) with three replications with a view to study the effect of different row spacing and nutrient management practices on growth, yield and quality of Niger.

The factors consisted of three level of row spacing (S_1: 20 cm, S_2:30 cm and S_3: 45 cm) and four levels of nutrient management practices [N_1: RDF (20-20-00 NPK kg/ha, N_2: Vermicompost @ 1.5 t/ha, N_3: RDF + Vermicompost @ 1.5 t/ha, N_4: RDF + Vermicompost @ 1.5 t/ha + Biofertilizers (*Azotobacter* + PSB + KSB]. Soil of experimental field was clayey in texture and moderately alkaline in reaction. The soil nutrient status was found medium in available nitrogen, low in available phosphorous and high in available potassium.

Seeds of Niger variety GNNIG-3 were used for sowing. Before sowing, the seeds were treated with thirum @ 3 g/kg of seed. Then, the seeds were dried under the shade and sown at a depth of about 3-4 cm maintaining row spacing as per treatment using seed rate of 5 kg/ha. Spacing and nutrient management were done as per treatment and rest of package of practices were followed as per university recommendations. Urea and SSP were used as source of fertilizers for N & P application, while NAUROJI liquid bio fertilizers *viz*., *Azotobacter*, Phosphorus solubilizing bacteria @ 10 ml/kg seed was used for seed treatment.

Results & Conclusion

Effect of Row Spacing

Growth parameters

Plant height (cm): A perusal of data presented in Table 1 indicated significant differences in plant height of Niger due to different row spacing treatment at 30 DAS and 60 DAS. However, plant height was not influenced by different row spacing treatment at harvest. Plant height at 30 DAS showed significantly taller plants under 45 cm row spacing (14.48cm) and remained at par with 30 cm row spacing. However, at 60 DAS significantly higher plant height was observed with 30 cm row spacing (S_2) (59.68cm) and remained at par with 45 cm row spacing (S_3). Dwarf plants at 30, 60 DAS were recorded with 20 cm row spacing treatment. (S_1) (12.83, 51.27 cm). The increase in plant height under wider spacing may be due to competition free environment prevailing more availability of nutrients, greater light interception, efficient utilization of soil moisture and space under lower degree of inter-plant competition. Similar findings were observed by Rajpurohit *et al*. (2017) [3] in sesame.

No. of branches per plant

The mean data presented in Table 1 indicated that significantly maximum number of branches per plant (6.11) with 45 cm row spacing (S_3). While the lowest number of branches per plant was noted with 20 cm row spacing (S_1) (4.86). The number of branches increased may be due to wider row spacing receiving maximum sun light for the photosynthesis that lead to increased biomass of the plant by producing healthy plant parts and space for growth resulting in more number of branches per plant. Similar results were obtained by Kumar and Singh in sesame (2021) [4].

Yield attributes and yield

No. of capitula per plant

It is evident from the data in Table 1 that the treatment of 45 cm row spacing (S_3) produced significantly highest number of capitula per plant (37.54). Lowest number of capitula per plant was observed under the treatment of 20 cm row spacing (S_1) (28.12). This increase in capitula per plant might be the result of less competition between plants for nutrient, soil moisture, space and solar radiation etc. in wider spacing than closer spacing. Further, wider spacing plants produced a greater number of branches and stimulated the formation of larger number of capitula per branch per plant. While, narrow spacing might have inter or intra plant competition leading to less branches and capitula. Similar trend in number of capsules per plant was reported by Rajpurohit *et al.* in sesame (2017) [3] and Kumar and Singh in sesame (2021) [4] due to increase in row spacing.

Seeds per capitulum

Data furnished in Table 1 indicated that significantly higher number of seeds per capitula was recorded with 45 cm row spacing (S_3) (27.11) and remained at par with 30 cm row spacing (S_2) (26.58). While, significantly the lowest number of seeds per capitula were recorded with 20 cm row spacing (S_1) (20.68). It might be due to optimum plant coverage in the field which facilitated more aeration, greater light interception and more photosynthetic activity resulting in more number of capitula per plant and seed per capitula. The results are in confirmation with finding of Kumar and Singh in sesame (2021) [4].

Test weight (g)

A perusal of data presented in Table 1 revealed that none of the row spacing treatments showed significant variation on test weight of Niger seed.

Seed yield (Kg/ha)

Data furnished in Table 1 indicated that significantly higher seed yield was recorded with 45 cm row spacing (S_3) (512 kg/ha) and was followed by 30 cm row spacing (S_2) (453 kg/ha). While, significantly the lower seed yield was recorded with 20 cm row spacing (S_1) (346 kg/ha). The increase in seed yield in wider row spacings as compared to 20 cm row spacing were in the tone of 30.92% and 47.98% with 30 cm and 45 cm row spacing respectively. The result showed positive effect of row spacing

on *rabi* niger on enhancing growth and yield. Many researchers demonstrated that low to medium densities produced more seed yield but in too narrow plant spacing, yield gets reduced due to increasing competing to uptake water, nutrients and exposure to sunlight. As wider sown crop has less number of plants per unit area, result in more number of leaves, taller plant height and better light interception which cause increase in seed yield by enhanced photosynthesis and assimilation. Similar result observed by Rajpurohit *et al.* in sesame (2017) [3], Kumar and Singh in sesame (2021) [4].

Effect of Nutrient Management Practices

Growth parameters

Plant height (cm)

The data in Table 1 show significant differences in plant height of niger due to different nutrient management practices at 30, 60 DAS and at harvest. The plant height at 30 and 60 DAS were recorded significantly higher with the application of RDF + vermicompost @ 1.5 t/ha (N_3) (14.70, 60.11cm) which remained at par with RDF + vermicompost @ 1.5 t/ha + biofertilizers (*Azotobacter* + PSB + KSB) (N_4). However, at harvest, significant taller plants were seen with RDF + vermicompost @ 1.5 t/ha + biofertilizers (*Azotobacter* + PSB + KSB) (N_4) (77.68 cm) which remained at par with RDF +vermicompost @ 1.5 t/ha (N_3) and vermicompost @ 1.5 t/ha (N_2). Lowest plant height at 30, 60 DAS and at harvest (12.27, 49.63 and 68.49 cm respectively) was recorded with RDF alone (N_1). The increase in plant height might be due to application of nutrients along with organic which increased the availability of nutrients for plant growth and development and better utilization of major nutrient through use of biofertilizers. Similar results observed by Jaishankar and Wahab in sesame (2005) [5].

No. of branches per plant

The results presented in Table 1 demonstrated that significantly higher number of branches per plant at harvest were found with application of RDF + vermicompost @ 1.5 t/ha + biofertilizers (*Azotobacter* + PSB + KSB) (N_4) (5.85) and remained at par with RDF + vermicompost @ 1.5 t/ha (N_3) and vermicompost @ 1.5 t/ha (N_2). The lowest numbers of branches per plant were noted with RDF alone (N_1) (4.71). This may be due to supply of nutrients from diversified sources and prolonged availability of nutrients to the growing plants. The beneficial role of microorganisms as biofertilizers for enhancing plant growth through their ability in nitrogen fixation, phosphorus and potassium solubilizing ability as well as the effect of their metabolites secretion on the crop may also be attributed for the more number of branches. Jaishankar and Wahab in sesame (2005) [5] observed similar results.

Yield attributes and yield

No. of capitula per plant

Data in Table 1 shows that number of capitula per plant of niger was found significant higher with application of RDF + vermicompost @ 1.5 t/ha + biofertilizers (*Azotobacter* + PSB + KSB) (N_4) (35.96) and remained at par with vermicompost @ 1.5 t/ha (N_2) and RDF + vermicompost @ 1.5 t/ha (N_3). The lowest numbers of capitula per plant were recorded at RDF alone (N_1) (29.41). It might be due to application of diversified nutrient management practices in niger resulted in increased plant accessibility to nutrients and number of branches resulting in improved plant growth and development that resulted in increase in total number of capitula per plant. The results are in confirmation with finding of Vedpathak and Chavan in sunflower (2016) [6] and Yadav *et al*. in mustard (2023) [7].

Seeds per capitula

Data in Table 1 shows significantly higher number of seeds per capitulum obtained with RDF + vermicompost @ 1.5 t/ha + biofertilizers (*Azotobacter* + PSB + KSB) (N_4) (27.02) which remained at par with vermicompost @ 1.5 t /ha (N_2) (25.77) and RDF + vermicompost @ 1.5 t/ha (N_3) (25.13). Whereas, significantly the lowest number of seeds per capitulum were recorded with RDF alone (N_1) (21.23). Similar results are observed by Singh *et al.* in mustard (2022) [8] and Yadav *et al.* in mustard (2023) [7].

Test weight (g)

Data given in Table 1revealed that none of the nutrient management practices showed significant variation on test weight of Niger seed. However, numerically higher value of test weight was recorded with application of RDF + vermicompost @ 1.5 t/ha + biofertilizers (*Azotobacter* + PSB + KSB) (N_4) (3.94 g) and the lower value of test weight were recorded with RDF alone (N_1) (3.81 g). whereas, the biofertilizer treated plants are well nourshied. These plants are capable of transporting sufficient quantities of minerals and metabolites to the developing seeds. Hence, the seed weight registered was higher in the biofertilizer treatment.

Seed yield (Kg/ha)

Data in Table 1 revealed that the nutrient management practices showed significant effect on seed yield with RDF + vermicompost @ 1.5 t/ha + biofertilizers (*Azotobacter* + PSB + KSB) (N_4) giving significantly higher seed yield (478 kg/ha) and remained at par with RDF + vermicompost @ 1.5 t/ha (N_3) (456 kg/ha). While minimum seed yield was found at RDF alone (N_1) (373 kg/ha). The increase in seed yield of Niger using N_4 and N_3 treatments as compared with N_1 was in the tone of 28.15% and 22.25%, respectively. The response of integrated nutrient practices was more pronounced in seed yield. Increase in number of capitulum and seeds per capitula could be a result of nitrogen being involved in carbohydrate and protein metabolism that promotes cell division and enlargement resulting in more productive capitula and seed yields. The results indicated that integrated application of chemical fertilizer, organic manure and biofertilizer might have supplied plant nutrients for a longer period. Similar results were also reported by Moitra *et al*. in sunflower (2012) [9] and Vedpathak and Chavan in sunflower (2016) [6].

Interaction effect

The data of plant height and branches per plant were found non-significant under the interactions of row spacing and nutrient management practices (Table 1).

The number of capitula per plant of Niger was significantly influenced by S x N interaction (Table 1). The treatment combination of 45 cm row spacing with RDF + vermicompost @ 1.5 t/ha + biofertilizers (Azotobacter + PSB + KSB) (S3N4) (41.33) gave significantly maximum capitula per plant and found at par with S3N3, S3N2, S2N4. While, significantly the lowest capitula per plant was registered with treatment combination S1N2 (27.46). This might be due to optimum space for better light interception resulted enhanced photosynthetic activity and higher uptake of nutrient from diversified nutrient sources, thereby increased plant dry matter production in the capitula setting phase which might be improve capitula development. Similar results were obtained by Patel *et al*. in

sesame (2018) [10] and Mahapatra and Shah in soybean (2020) [11].

The data of seeds per capitula and test weight were found non-significant due to interactions of different row spacing and nutrient management practices.

Seed yield of *rabi* niger was significantly influenced by S x N interaction (Table 1). The treatment combination of 45cm row spacing with RDF + vermicompost @ 1.5 t/ha + biofertilizers (*Azotobacter* + PSB + KSB) (S_3N_4) gave significantly highest seed yield (571.34 kg/ha). While, significantly the lowest seed yield was registered with treatment combination of 20 cm row spacing with RDF alone (S_1N_1).

These results may be observed due to increasing row spacing resulted in early leaf area development and maximum interception of solar energy condition favoring translocation efficiency of dry matter to the seed resulted to get the highest yield. Further, using diversified sources of nutrient caused beneficial effect to those plants on root proliferation that increased the absorption of plant nutrient from the soil improving the growth of the plant through active protein metabolism, transportation of photosynthates and synthesis of nucleic acid and proteins. Similar results were also reported by Patel *et al.* in sesame (2018) [10], Mahapatra and Shah in soybean (2020) [11].

Table 1: Effect of different row spacing and nutrient management practices on plant height, no. of branches per plant, capitula per plant, seeds per capitula, test weight, seed yield, oil content and protein content of *rabi* niger

Treatment	Plant height (cm)			No. of branches per plant	Capitula per plant	Seeds per capitula	Test weight (g)	Seed yield (kg/ha)
	30 DAS	60 DAS	At harvest					
Row spacing								
S_1: 20 cm	12.83	51.27	72.06	4.86	28.12	20.68	3.75	346
S_2: 30 cm	14.08	59.68	75.32	5.30	34.86	26.58	3.92	453
S_3: 45 cm	14.48	57.50	74.53	6.11	37.54	27.11	3.94	512
SEm (±)	0.25	1.39	1.51	0.14	0.74	0.94	0.06	10.72
CD at 5%	0.73	4.09	NS	0.41	2.18	2.77	NS	31.43
Nutrient management practices								
N_1: RDF (20-20-00 N-P_2O_5-K_2O kg/ha)	12.27	49.63	68.49	4.71	29.41	21.23	3.81	373
N_2: Vermicompost @ 1.5 t/ha	13.67	54.87	73.01	5.53	34.21	25.77	3.84	440
N_3: RDF + Vermicompost @ 1.5 t/ha	14.70	60.11	76.69	5.60	34.44	25.13	3.89	456
N_4: RDF + Vermicompost @ 1.5 t/ha + Biofertilizers (*Azotobacter* + PSB + KSB)	14.56	59.99	77.68	5.85	35.96	27.02	3.94	478
SEm (±)	0.29	1.61	1.74	0.16	0.86	1.09	0.07	12.38
CD at 5%	0.85	4.72	5.12	0.47	2.52	3.20	NS	36.30
Interaction								
SEm (±)	0.50	2.79	3.02	0.28	1.49	1.89	0.13	21.43
CD at 5%	NS	NS	NS	NS	4.36	NS	NS	62.87
CV (%)	6.29	8.6	7.07	8.85	7.68	13.2	5.7	8.49

Conclusions

On the basis of results from one-year field experimentation, it can be concluded that niger crop (GNNIG-3) should be sown at 45 cm row spacing and nutrient management should be integrated in the manner of RDF (20-20-00 N-P_2O_5-K_2O kg/ha) along with 1.5 t/ha vermicompost (basal application) with or without biofertilizers seed treatment (*Azotobacter* + PSB + KSB) for securing higher Seeds per capitula and higher yield.

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