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Effect of planting geometry and fertilizer management on growth and yield of Niger [*Guizotia abyssinica* (L.f.) Cass.] under Konkan region

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Abstract
The growing need for wholesome food and sustainable resources by the world's population calls for modern agricultural strategies that balance production and environmental responsibility. Considering these factors, the presented study "Effect of planting geometry and fertilizer management on growth and yield of niger [*Guizotia abyssinica* (L.f.) Cass.] under konkan region" was conducted at Agronomy Farm, College of Agriculture, Dapoli, Ratnagiri (M. S.) during kharif, 2022. The experiment was designed in Factorial Randomized Block Design with 14 treatments having two factors and replicated thrice. First factor spacing consisted two treatments *i.e.*, S_1: 30 cm x 15 cm and S_2: 45 cm x 15 cm whereas second factor fertilizer levels consisted seven treatments *i.e.*, F_0: Absolute control, F_1: 75% RDF, F_2: 100% RDF, F_3: 125% RDF, F_4: 75% RDF (75% N in two splits, at sowing and 30 DAS + 75% P_2O_5 at sowing), F_5: 100% RDF (100% N in two splits, at sowing and 30 DAS + 100% P_2O_5 at sowing) and F_6: 125% RDF (125% N in two splits, at sowing and 30 DAS + 125% P_2O_5 at sowing). Results revealed that higher seed yield (230.45 kg ha^{-1}), straw yield (1661 kg ha^{-1}) and biological yield (1891.85 kg ha^{-1}) of niger and higher nutrient content and uptake (N, P and K) by seed and straw of niger was recorded with the treatment of spacing 30 cm x 15 cm and fertilizer level of 125% RDF (125% N in two splits, at sowing and 30 DAS + 125% P_2O_5 at sowing).

Keywords: Niger, split application, spacing, nutrient content, yield etc.

1. Introduction
The importance of oilseeds in the nation is equal to that of pulses. India has diverse agro-ecological conditions favorable for growing of nine oilseed crops which includes seven edible and two non-edible oilseeds- groundnut, rapeseed-mustard, soybean, sunflower, castor, sunflower, sesame, niger and linseed. Niger is a significant oilseed crop grown primarily in tribal regions of India. More than 50% of the world's niger crop production and area is cultivated in India, a significant niger crop producer country. The niger crop is produced on 21.848 million hectares in India, with an output of 7.019 million tonnes and an average yield of 321 kg ha^{-1} (Anonymous, 2022a) [2]. In 2019–20, niger seed produced 0.042 million tonnes of oilseeds and 0.012 million tonnes of oil. In Maharashtra area under this crop is 13000 ha with production of 2070 tonnes and average productivity of 159 kg ha^{-1} (Anonymous, 2022b) [3]. In Konkan region, area under niger is 625 ha with total production of 70 tonnes and average productivity of 112 kg ha^{-1} (Anonymous, 2021) [1]. The niger seed contains 37-40 percent oil, which is pale yellow in colour, nutty-tasting, and has a pleasant aroma. According to reports, Indian niger oil contains more oleic acid (25%) and less linoleic acid (55%).
Niger (*Guizotia abyssinica*) stands out among all crops as a valuable oilseed plant that has attracted more interest because of its potential to support both nutrition and economic development. As successful crop management systems are built on the complex interaction between planting geometry, which determines the spatial arrangement of crops, and fertilizer levels, which control nutrient availability. It's crucial to comprehend the dynamic interaction between these variables in order to optimize niger productivity and quality as well as to promote a resilient and ecologically responsible agricultural paradigm.
As a result, a crucial area of research is the investigation of how planting geometry and fertilizer amounts affect niger cultivation. The impact of planting configuration and fertilizer supplies on crop performance is needs to be examined, which digs into the many complexities of niger production.

2. Materials and Methods

The present investigation was carried out on "Effect of planting geometry and fertilizer management on growth and yield of niger [*Guizotia abyssinica* (L.f.) Cass.] under Konkan region" was conducted at Agronomy farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during kharif, 2022. The analytical work was done at research laboratory of department of Agronomy. Geographically, experimental plot at Agronomy farm, College of Agriculture, Dapoli is situated in the subtropical region at 17º45'55" N latitude and 73º10'26" E longitude having elevation of about 157.8 m above mean sea level. The climate is sub-tropical which is characterized by warm and humid atmosphere which is very much favorable for a crop like niger during kharif season.

The soil of experimental plot was analyzed initially to study various physio-chemical properties, which showed that it was sandy clay loam in texture, with high organic carbon (11.30 g kg^{-1}) and slightly acidic in reaction (pH 5.88) and low in available nitrogen (245.03 kg ha^{-1}) and potassium (270.14 kg ha^{-1}) and medium in available phosphorous (11.11 kg ha^{-1}). The experiment was designed according to factorial randomized block design with fourteen treatments consisting two factors (spacing and fertilizer levels) and three replications. Niger variety RTNN-1 was used for experiment purpose. The gross plot size was 4.50 m × 2.10 m while the net plot size were 4.20 m × 1.80 m and 4.05 m x 1.80 m respectively. Split application of fertilizers was given at sowing and 30 DAS. All the recommended agronomic practices were carried out uniformly for all the treatments as and when required. All together the experiment consist of 42 plots and the treatment details are given in Table 1.

Yield parameters [number of capsules $plant^{-1}$, weight of capsules $plant^{-1}$ (g), number of seeds $capsule^{-1}$, weight of seeds $plant^{-1}$ (g) and 1000 grain weight] were recorded at harvest from randomly selected five sample hills in each plot. The seed and straw yields and harvest index (HI) was recorded from each net plot area. Plant samples were oven dried, ground, sieved and analyzed for total N by micro-Kjeldahl method (Tandon, 1993) [12], P by ammonium molybdate method (Tandon, 1993) [12] K by flame photometry (Tandon, 1993) [12]. Nutrient uptake was estimated by multiplying the N, P and K concentrations of grains and straw with their respective yield (kg ha^{-1}) and summing up the two values. The significance of the treatment difference was tested by variance ratio test (f value), critical difference (C.D.) at 5 percent level of probability and was worked out for comparison and statistical interpretation of significance between treatments mean.

Table 1: Treatments details along with symbols used

Treatment Details	Symbols
A] Factor: Spacing	
30 cm x 15 cm	S_1
45 cm x 15 cm	S_2
B] Factor: Fertilizer levels	
Absolute control	F_0
75% recommended fertilizer dose (RDF)	F_1
100% recommended fertilizer dose (RDF)	F_2
125% recommended fertilizer dose (RDF)	F_3
75% RDF; N in two splits *i.e.,* at sowing and 30 DAS + 75% P_2O_5 at sowing	F_4
100% RDF; N in two splits *i.e.,* at sowing and 30 DAS + 100% P_2O_5 at sowing	F_5
125% RDF; N in two splits *i.e.,* at sowing and 30 DAS + 125% P_2O_5 at sowing	F_6

3. Result and Discussion

3.1 Effect on yield attributes

Effect of different treatments on yield attributes and yield was recorded after harvest of niger and the recorded data has been presented below.

3.1.1 Number of capsules $plant^{-1}$

The data presented in the Table 2 implies that, different spacing significantly influenced the number of capsules $plant^{-1}$. The maximum number of capsules was observed at 45 cm x 15 cm *i.e.,* 79.84 and found to be superior over spacing of 30 cm x 15 cm. Similar result was observed by Kivadasannavar *et al.* (2006) [8]. As fertilizer levels were concerned, the maximum number of capsules $plant^{-1}$ was recorded with the treatment F_6 (125% RDF, 2 split applications of N at sowing and 30 DAS + 125% P_2O_5 at sowing) *i.e.,* 89.03 and the treatment F_5 (100% RDF, 2 split applications of N at sowing and 30 DAS + 100% P_2O_5 at sowing) was found to be at par with treatment F_6 *i.e.,* 86.40. Whereas the lowest number of capsules $plant^{-1}$ was observed with treatment F_0 (Absolute control) *i.e.,* 62.90. These findings are in conformity with those reported by Yadav (2006) [14]. However, the mean number of capsules $plant^{-1}$ was not influenced significantly by interaction effect of spacing and fertilizer levels.

3.1.2 Weight of capsules $plant^{-1}$ (g)

The data presented in the Table 2 indicates that, the different spacing significantly influenced the weight of capsules $plant^{-1}$. The maximum weight of capsules $plant^{-1}$ was observed at 45 cm x 15 cm *i.e.,* 6.09 g and found to be significantly superior over the spacing of 30 cm x 15 cm. Similar results were observed by Bhusari *et al.* (2020) [5]. As far as for fertilizer levels, maximum weight of capsules $plant^{-1}$ was observed with the treatment F_6 (125% RDF, 2 split applications of N at sowing and 30 DAS + 125% P_2O_5 at sowing) *i.e.,* 7.01 g and the treatment F_5 (100% RDF, 2 split applications of N at sowing and 30 DAS + 100% P_2O_5 at sowing) was found to be at par with treatment F_6 *i.e.,* 6.55 g. This result is confirmed with the findings of Kasle *et al.* (2020) [5]. However, the mean weight of capsules $plant^{-1}$ did not differ significantly by the interaction effect of spacing and fertilizer levels.

3.1.3 Number of seeds $capsule^{-1}$

The data presented in the Table 2 implies that, different spacing significantly influenced the number of seeds $capsule^{-1}$. The maximum number of seeds $capsule^{-1}$ was observed at 45 cm x 15 cm *i.e.,* 17.27 and was found to be superior over spacing of 30 cm x 15 cm. Similar trend was observed by Bhusari *et al.* (2020) [5] and Kivadasannavar *et al.* (2006) [8].

Similarly, different fertilizer levels significantly influenced the number of seeds capsule^{-1}. The maximum number of seeds capsule^{-1} was observed with the treatment F_6 (125% RDF, 2 split applications of N at sowing and 30 DAS + 125% P_2O_5 at sowing) *i.e.,* 18.63 and the treatment F_5 (100% RDF, 2 split applications of N at sowing and 30 DAS + 100% P_2O_5 at sowing) was found to be at par with treatment *i.e.,* 18.20. Whereas lowest number of seeds capsule^{-1} was observed in the treatment F_0 (Absolute control) *i.e.,* 12.00. These results are in conformity with those found by Yadav (2006) [14] and Ukale (2014) [13]. However, the mean number of seeds capsule^{-1} was not influenced significantly by interaction effect of spacing and fertilizer levels.

3.1.4 Weight of seeds plant^{-1} (g)

The data presented in the Table 2 indicated that, different spacing significantly influenced the weight of seeds plant^{-1}. The maximum weight of seeds plant^{-1} was observed at 45 cm x 15 cm *i.e.,* 1.81 g and was found to be superior over spacing of 30 cm x 15 cm. Similar trend was observed by Bhamdare *et al.* (2020). For different fertilizer levels, the maximum weight of seeds plant^{-1} was observed with the treatment F_6 (125% RDF, 2 split applications of N at sowing and 30 DAS + 125% P_2O_5 at sowing) *i.e.*, 1.78 g and the treatment F_5 (100% RDF, 2 split applications of N at sowing and 30 DAS + 100% P_2O_5 at sowing) was found to be at par *i.e.*, 1.73 g with F_6 treatment. Whereas minimum weight of seeds plant^{-1} was observed with the treatment F_0 (Absolute control) *i.e.*, 1.38 g. Similar trend was Ukale (2014) [13] and Gaikwad *et al.* (2020) [5].

3.1.5 Test weight (g)

The data presented in Table 2 shows that there is no significant effect in test weight (1000 seeds weight) due to different spacing. Numerically higher test weight was recorded in spacing 45 cm x 15 cm. Similarly, there was no significant effect in test weight (1000 seeds weight) due to different fertilizer levels. But numerically higher test weight was recorded in treatment F_6 (100% RDF, 2 split applications of N at sowing and 30 DAS + 100% P_2O_5 at sowing) followed by treatment F_5 (100% RDF, 2 split applications of N at sowing and 30 DAS + 100% P_2O_5 at sowing). Whereas lowest test weight was recorded in treatment F_0 (Absolute control). No significant difference was observed in test weight due to interaction effect of spacing and fertilizer levels.

3.2 Effect on yield

Higher yield was influenced mainly by yield attributing characteristics *viz*., number of capsules plant^{-1}, number of seeds capsule^{-1}, weight of capsules plant^{-1} and weight of seeds plant^{-1} etc. Thus, significantly higher seed yield (230.45 kg ha^{-1}), straw yield (1661.85 kg ha^{-1}), biological yield (1891.85 kg ha^{-1}), harvest index (12.13%) was recorded with spacing of 30 cm x 15 cm. Though, higher seed yield plant^{-1} was obtained from the spacing of 45 cm x 15 cm because of increased photosynthetic activity, the overall seed yield net plot^{-1} and seed yield (kg ha^{-1}) increased eventually because of overall increase in number of plants in the spacing of 30 cm x 15 cm. The yield loss plant^{-1} due to competition in closer spacing was compensated by the higher number of plants ha^{-1} and thus increase in yield ha^{-1}. Similar results were obtained for straw yield and total biological yield. Similar results were observed by Kivadasannavar *et al.* (2007) [8], Sandeep and Kusbad (2020) [11], Nadeem *at al.* (2015) [9] and Kasle *et al.* (2020) [5].

As for fertilizer levels are concerned, significantly higher seed yield (250.07 kg ha^{-1}), straw yield (1703.51 kg ha^{-1}), biological yield (1953.58 kg ha^{-1}), harvest index (12.79%) was recorded with treatment F_6 (100% RDF, 2 split applications of N at sowing and 30 DAS + 100% P_2O_5 at sowing) with treatment F_5 (100% RDF, 2 split applications of N at sowing and 30 DAS + 100% P_2O_5 at sowing) at par to it. Whereas lower seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), total biological yield (kg ha^{-1}) and harvest index (%) was recorded with the treatment F_0 (Absolute control). Application of 125% recommended dose of fertilizers (RDF) recorded significantly higher seed yield as compared to other treatments, the possible reason for increase in seed yield might be the production of higher number of branches plant^{-1}, higher number seeds capsule^{-1}, higher weight of seeds plant^{-1} and 1000 seed weight which could be because of split application of nitrogen at two different growth stages as nitrogen is believed to help in cell division and expansion, strengths sink capacity and acquired more photosynthates. These findings are in confirmation with those by Yadav (2006) [14], Kasle (2020) [5], Ukale (2014) [13] and Sandeep and Kusbad (2020) [11]. However, seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), total biological yield (kg ha^{-1}) and harvest index (%) was not influenced due to interaction effect of spacing and fertilizer levels.

3.3 Nutrient content and uptake

Among different spacing levels, highest nitrogen content (Seed 3.04% and straw 0.91%), phosphorous content (Seed 0.68% and straw 0.14%) and potassium content (Seed 0.36% and straw 0.40%) was observed with the spacing of 30 cm x 15 cm. Similar trend was followed for total uptake of nitrogen (22.22 kg ha^{-1}), phosphorous (3.96 kg ha^{-1}) and potassium (7.58 kg ha^{-1}). The higher biomass or dry matter harvested from the spacing of 30 cm x 15 cm has resulted significantly higher nutrients content in the seed, straw and its total uptake by the niger crop. Similar results were observed by Sandeep and Kusbad (2020) [11].

For different fertilizer levels, highest nitrogen content (Seed 3.16% and straw 1.02%), phosphorous content (Seed 0.70% and straw 0.16%) and potassium content (Seed 0.38% and straw 0.44%) was observed with the treatment F_6(100% RDF, 2 split applications of N at sowing and 30 DAS + 100% P_2O_5 at sowing) with treatment F_5 (100% RDF, 2 split applications of N at sowing and 30 DAS + 100% P_2O_5 at sowing) at par to it. Similar trend was followed for total uptake of nitrogen (25.27 kg ha^{-1}), phosphorous (4.52 kg ha^{-1}) and potassium (8.67 kg ha^{-1}). Whereas, treatment F_0 (Absolute control) recorded lower values of nutrient content and total uptake. The higher biomass or dry matter accumulation created under F_6 and F_5 has resulted significantly higher nutrient content in the seed, straw and its total uptake by the niger crop. The split application of nitrogenous fertilizers has resulted in improved nutrient use efficiency by niger crop thus increasing the nutrient content and uptake by crop. This finding is in agreement with the results reported by Sandeep and Kusbad (2020) [11].

Table 2: Yield attributing characters of niger as influenced by different treatments

Treatments	Number of capsules plant^{-1}	Weight of capsules plant^{-1} (g)	Number of seeds capsules^{-1}	Weight of seeds plant^{-1} (g)	Test weight (g)	Seed yield kg ha^{-1}	Straw yield kg ha^{-1}	Biological yield kg ha^{-1}	Harvest Index (%)
A] Spacing									
S_1: 30 cm x 15 cm	74.44	5.13	15.09	1.44	3.24	230.45	1661.40	1891.85	12.13
S_2: 45 cm X 15 cm	79.84	6.09	17.27	1.81	3.31	204.79	1629.53	1833.32	11.14
SE ±	1.323	0.147	0.279	0.02	0.102	1.874	6.469	6.628	-
C.D. at 5%	3.844	0.426	0.811	0.05	N.S.	5.448	18.803	19.264	-
B] Fertilizer levels									
F_0: Absolute control	62.90	3.89	12.00	1.38	2.83	167.05	1472.12	1639.17	10.19
F_1: 75% RDF	68.93	4.67	14.93	1.55	3.03	201.89	1643.89	1845.78	10.93
F_2: 100% RDF (25:25:00 kg NPK ha^{-1})	80.63	6.27	16.87	1.64	3.21	217.95	1672.87	1890.82	11.52
F_3: 125% RDF	81.48	6.08	17.23	1.71	3.27	234.57	1669.97	1904.54	12.30
F_4: 75% RDF (N in two splits, at sowing and 30 DAS + 75% P_2O_5 at sowing)	70.60	4.73	15.37	1.59	3.10	209.79	1657.45	1867.24	11.23
F_5: 100% RDF (N in two splits, at sowing and 30 DAS + 100% P_2O_5 at sowing)	86.40	6.55	18.20	1.73	3.47	242.00	1694.95	1936.95	12.50
F_6: 125% RDF (N in two splits, at sowing and 30 DAS + 125% P_2O_5 at sowing)	89.03	6.90	18.63	1.78	3.53	250.07	1703.51	1953.58	12.79
SE ±	2.474	0.275	0.522	0.03	0.190	3.507	12.103	12.400	-
C.D. at 5%	7.192	0.798	1.516	0.10	N.S.	10.192	35.177	36.040	-
C] Interaction									
SE ±	3.499	0.388	0.738	0.05	0.269	4.959	17.116	17.536	-
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	-
General mean	77.14	5.61	16.18	1.63	3.28	217.62	1644.97	1862.58	11.64

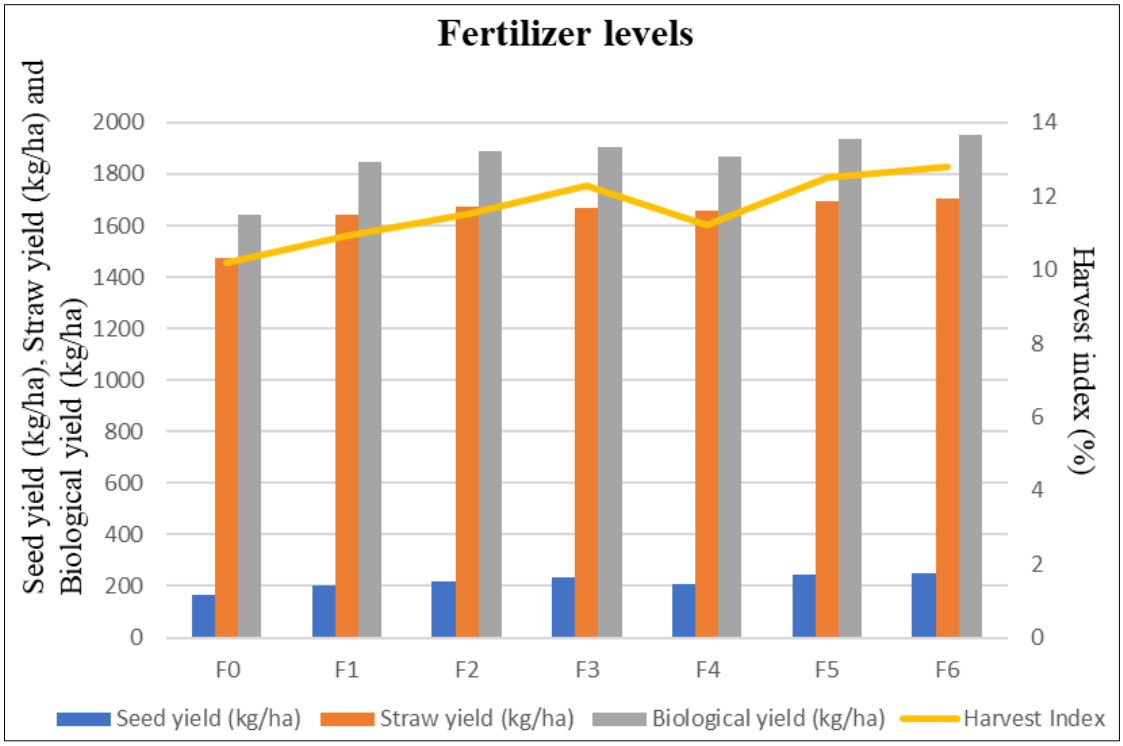

Fig 1: Seed yield, straw yield, biological yield (kg ha^{-1}) and harvest index (%) of niger as influenced by different spacings and fertilizer levels

Table 3: Nutrient uptake and total uptake by seed and straw of niger as influenced by different treatments

Treatments	N content (%)		Total N uptake (kg ha^{-1})	P content (%)		Total P uptake (kg ha^{-1})	K content (%)		Total K uptake (kg ha^{-1})
	Seed	Straw		Seed	Straw		Seed	Straw	
A] Spacing									
S_1: 30 cm x 15 cm	3.04	0.91	22.219	0.68	0.14	3.96	0.36	0.40	7.58
S_2: 45 cm X 15 cm	2.96	0.74	18.23	0.66	0.11	3.19	0.34	0.38	6.05
SE ±	0.011	0.009	0.183	0.001	0.010	0.083	0.001	0.0002	0.009
C.D. at 5%	0.033	0.028	0.549	0.003	0.031	0.251	0.002	0.001	0.025
B] Fertilizer levels									
F_0: Absolute control	2.63	0.60	13.30	0.60	0.09	2.37	0.32	0.27	4.63
F_1: 75% RDF	2.99	0.70	17.61	0.65	0.10	3.04	0.33	0.31	5.73
F_2: 100% RDF (25:25:00 kg NPK ha^{-1})	3.05	0.81	20.21	0.67	0.12	3.51	0.35	0.35	6.66
F_3: 125% RDF	3.06	0.92	22.66	0.69	0.14	4.04	0.36	0.41	7.63
F_4: 75% RDF (N in two splits, at sowing and 30 DAS + 75% P_2O_5 at sowing)	3.01	0.75	18.76	0.67	0.11	3.28	0.34	0.33	6.17
F_5: 100% RDF (N in two splits, at sowing and 30 DAS + 100% P_2O_5 at sowing)	3.15	0.96	23.91	0.69	0.15	4.25	0.37	0.44	8.62
F_6: 125% RDF (N in two splits, at sowing and 30 DAS + 125% P_2O_5 at sowing)	3.16	1.02	25.27	0.70	0.16	4.52	0.38	0.442	8.67
SE ±	0.004	0.022	0.460	0.002	0.001	0.095	0.002	0.001	0.016
C.D. at 5%	0.013	0.067	1.380	0.005	0.004	0.287	0.007	0.002	0.047
C] Interaction									
SE ±	0.002	0.011	0.048	0.002	0.002	0.023	0.001	0.001	0.023
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	3.00	0.82	20.21	0.67	0.13	3.57	0.34	0.37	6.81

4. Conclusion

This leads to conclusion that, RTNN-1 niger variety can perform better when sown at spacing of 30 cm x 15 cm with the application of 125% RDF (RDF 25:25:00 kg ha^{-1}), N in two splits, at sowing and 30 DAS + 125% P_2O_5 at sowing for obtaining higher yield. Additionally, it also improves nutrient content and uptake by seed and straw of niger crop.

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