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Effect of organic sources of nitrogen on growth, yield attributes and yield of linseed (*Linum usitatissimum* L.) under irrigated condition

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Abstract
A field experiment was conducted at Agronomy Farm, B. A. College of Agriculture, AAU, Anand, Gujarat, during *rabi* 2019-20 to study the "Nitrogen management through organic sources in linseed (*Linum usitatissimum* L.) under irrigated condition". The experiment was laid out in a randomized block design with ten treatments of organic sources of nitrogen *viz*., 100% RDF (60-30-0 NPK kg/ha) (T_1), N equivalent to 60 kg/ha through FYM (T_2), N equivalent to 60 kg/ha through vermicompost (T_3), N equivalent to 60 kg/ha through castor cake (T_4), N equivalent to 45 kg/ha through FYM + NPK consortium as seed treatment (T_5), N equivalent to 45 kg/ha through vermicompost + NPK consortium as seed treatment (T_6), N equivalent to 45 kg/ha through castor cake + NPK consortium as seed treatment (T_7), N equivalent to 45 kg/ha through FYM + NPK consortium as soil application (T_8), N equivalent to 45 kg/ha through vermicompost + NPK consortium as soil application (T_9) and N equivalent to 45 kg/ha through castor cake + NPK consortium as soil application (T_{10}). The result indicated that growth and yield attributing character of linseed *viz*., plant height at 60 DAS and at harvest, number of branches/plant at 60 DAS and at harvest, dry matter accumulation (g/plant) at 60 DAS and at harvest, root length (cm) at 60 DAS and at harvest, root dry biomass (g/plant) at 60 DAS and at harvest, number of capsules/plant, test weight (g), seed yield (kg/ha) and straw yield (kg/ha) were recorded significantly higher under treatment T_3 (N equivalent to 60 kg/ha through vermicompost).

Keywords: linseed, organic, nitrogen, vermicompost, FYM, higher yield

1. Introduction

Linseed (*Linum usitassimum* L.) also referred as flax, is a member of plant genus *Linum* within the family Linaceae (Burako, 2010; Bremer *et al*., 2009) [5, 3]. It is the only species in Linaceae family which have economic values (Tadesse *et al*., 2010) [25]. Linseed is grown on about 32.23 lakh ha around the world, with annual productivity and production of 951.8 kg/ha and 30.68 lakh tonnes, respectively. India is the second largest linseed growing country in the world after Canada and production wise it ranks fourth in the world after Canada, China and USA. Among the *rabi* oil seed crops in India, linseed occupies the second position *i.e*., next to rapeseed-mustard in production as well as in area. In India, Linseed is grown on about 1.72 lakh ha with annual production and productivity is 0.99 lakh tonnes and 573.6 kg/ha respectively. Rajasthan has the highest productivity (1012 kg/ha), followed by Bihar (800 kg/ha), Jammu and Kashmir (630 kg/ha), Uttar Pradesh (615 kg/ha) and Assam (600 kg/ha) (Anonymous, 2019a) [1].

Commercially, any portion of the linseed plant is used, either directly or after processing. Linseed has a protein content of 20-24%, oil content of 37-42%, carbohydrates of 15-29%, crude fibre of 5-9% and ash content of 2-4% in the seed. Linseed oil used in industries in various forms such as boiled oil, borated oil, eposidized oil, aluminated oil, isomerized oil and urethane oil etc. (Khan *et al.*, 2010) [14]. Linseed oil is high in omega-3 fatty acids (58%), especially alpha-linoleic acid, which has been shown to reduce the risk of heart disease, inflammatory disease, arthritis and a number of other health problems. It also contained lignins, which helps prevent cancer. (Hasler, 2001; Vaisey-Genser and Morris, 2003; Singh *et al.*, 2018; Matheson, 1976) [11, 26, 17]. Vermicompost provides a high amount of available nutrients and have lot of outstanding biological properties. (Werner and Cuevas, 1996) [27]. Vermicomposts had significantly higher populations of fungi (22.7 x 10^4), bacteria (5.7 x 10^7) and actinomycetes (17.7 x 10^6) than the conventional composts (Nair *et al.*, 1997) [19].

NPK consortium was used as liquid biofertilizer which contained nitrogen fixing (*Azotobacter chroococcum*, *Azospirillum lipoferum*), phosphate solubilizing and potash mobilizing native bacteria (*Bacillus spp*). It is used as seed treatment (3-5 ml/kg seed), soil application (1 L/ha), seedling treatment (3-5 ml/L) and with drip irrigation (1 L/ha) (Anonymous, 2019b). On national scale, linseed (34.60%) has the highest yield advantage over farmers practice, followed by safflower (33.89%), sesame (31.71%), castor (29.63%), soybean (29.32%), mustard (29.04%), groundnut (23.93%), sunflower (22.56%) and niger (19.68%). This was due to appropriate technological interventions and farmers skilling (Anonymous, 2020). Castor oil cake is quick-acting organic manure which content 4.3% N, 1.8% P_2O_5 and 1.3% K_2O and it becomes available to the plants in about ten days. (Mondal and Das, 2019) [18]. According to Parihar *et al*., 2012 [20], well decomposed farmyard manure contains nitrogen (0.53%), phosphorous (0.22%), potassium (0.59%), iron (2100 mg/kg), zinc (61 mg/kg), boron (2.2 mg/kg) and molybdenum (0.75 mg/kg). FYM improves the physio-chemical properties of the soil as well as the direct release of macro and micronutrients, resulting in increased crop yields.

The excessive use of fertilizers and pesticides over the last 50 years has helped make good progress earlier, but in recent decades the decline in the growth and stagnation in crop yields, creating big problems and the chain of many problems, has been addressed. A number of deleterious effects on the soil, water and air have been caused by the indiscriminately used fertilizers and pesticides. This has declined soil productivity by deteriorating soil health as regards soil fertility and microbial activity (Collins *et al*., 1992) [9].

2. Materials and Methods

2.1. Description of the study area

The experiment was conducted during *rabi* 2019-20 at Agronomy farm, B. A. College of Agriculture, Anand Agricultural University Anand, (Gujarat). Geographically, Anand is located on 22˚35' N latitude and 72˚55' E longitude, with an elevation of 45.1 m above the mean sea level. Climate of this region is typical sub-tropical climate with dry and hot summer, fairly cold and dry winter and moderately humid monsoon. The maximum temperature ranged between 22.5 ºC to 33.2 ºC and minimum temperature ranged from 9.7 ºC to 23.7 ºC during the crop season of the year 2019-20. The average humidity was ranged between 42.5 to 78% during *rabi* 2019-20. The other weather parameters were normal during the year of experimentation. In general, the weather conditions were congenial during crop season. The soil was representative of the soil of the region, locally known as *Goradu* soil. The texture of the soil was loamy sand. It is alluvial in origin, light brown in colour, well drained, fairly retentive of moisture, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potash. The soil is free from any kind of salinity and sodicity and responded well to manuring.

2.2. Experimental details

The experiment was laid out in a randomized block design with 10 treatments and 4 replications. The recommended dose of fertilizers *i.e.,* 60:40:00 kg/ha N, P_2O_5 and K_2O, respectively, were applied according to treatments. FYM (0.32:0.18:0.40% NPK), vermicompost (1.21:1.01:0.80% NPK) and castor cake (3.24:1.5:1.3% NPK) are applied as organic sources of nutrient. The experiment included treatments of organic sources of nitrogen 100% RDF (60-30-0 NPK kg/ha) (T_1), N equivalent to 60 kg/ha through FYM (T_2), N equivalent to 60 kg/ha through vermicompost (T_3), N equivalent to 60 kg/ha through castor cake (T_4), N equivalent to 45 kg/ha through FYM + NPK consortium as seed treatment (T_5), N equivalent to 45 kg/ha through vermicompost + NPK consortium as seed treatment (T_6), N equivalent to 45 kg/ha through castor cake + NPK consortium as seed treatment (T_7), N equivalent to 45 kg/ha through FYM + NPK consortium as soil application (T_8), N equivalent to 45 kg/ha through vermicompost + NPK consortium as soil application (T_9) and N equivalent to 45 kg/ha through castor cake + NPK consortium as soil application (T_{10}). The seed was sown manually on 5 November, 2019 at a depth of 4-5 cm. Thinning was done after 25 days after sowing maintaining row to row distance 30 cm. In order to minimize weed competition, spraying pre-emergence herbicide pendimethalin (stomp 30 EC @ 3.3 L/ha) with one inter cultivations (at 25 DAS) and two hand weeding at 25 DAS and 50 DAS. Five irrigations were given to the crop according to critical growth stage of crop. Growth, yield attributes and yield were recorded and statistically analysed. The crop was harvested during second week of March. The growth parameters *viz.:* plant population/meter row length at 25 DAS and at harvest, periodical plant height (cm) at 30, 60 DAS and at harvest, numbers of branches/plant at harvest, dry matter accumulation (g/plant) at 60 DAS and at harvest, root length (cm) at 60 DAS and at harvest and dry root biomass (g/plant) at 60 DAS and at harvest, whereas yield parameters were observed after harvesting of the crop with following procedures:

The height of the five tagged plants was recorded from the ground level to the tip of the plant. Then, average height was computed.

The primary branches, which is arising from the main shoot were recorded from the five tagged plants in each experimental plot and expressed on per plant basis.

Five plants were randomly selected then removed border rows of experimental plot. Root length was measured after those plants were dried in sun and also in an oven at 65°C temperature. The dry weight of plant and root was recorded according to experimental treatments on weighing balance.

At harvest, the total number of capsules of five tagged plants from each plot was counted and average number of capsules/plant was recorded.

Randomly selected ten capsules from five tagged plants were split open and the number of seeds was counted and the mean was expressed.

A representative seed sample was drawn randomly from the bulk produce of each net plot after winnowing and one thousand seeds were counted by seed counter and their weight was recorded as test weight for each treatment.

The total biomass harvested from each net plot was threshed, cleaned and dried. Seeds thus obtained were weighed (kg/plot) and then converted into seed yield (kg/ha) by multiplying with appropriate factor.

Straw yield was calculated by subtracting seed yield from biological yield.

The harvest index for each treatment was worked out by using the formula given by Donald and Hamblin, 1976.

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \text{ X } 100$$

The data was subjected to analysis of variance as per the procedure described by Cochran and Cox (1967) [8].

3. Results and Discussion

3.1 Growth parameter

3.1.1 Plant population (per meter row length)

The data clearly showed that different organic sources of nitrogen remained akin to plant population (Table 1) and they had no any significant influence on plant population recorded at 25 DAS as well as at harvest.

3.1.2 Periodical plant height (cm)

The table 1 showed that there was no significant difference in plant height at 30 DAS. The treatment T_3 (N equivalent to 60 kg/ha through vermicompost) recorded significantly higher plant height of 55.00 and 71.50 cm at 60 DAS and at harvest, respectively as compared to other treatments. However, it was remained at par with treatment T_1, T_2, T_4 and T_6 at 60 DAS and at harvest. Significantly lower plant height was recorded in treatment T_8. Increase in plant height in treatment T_3 (N equivalent to 60 kg/ha through vermicompost) might be due to basal application of vermicompost supply macro as well as micro nutrients through organic source, which improve soil physical and biological properties and increase the availability of nutrients and solubilizing them. Thus, favourable influence of nutrients to produce larger cells with thinner cell walls and its contribution in cell division and cell elongation which improved vegetative growth and ultimately increased the plant height. These are in conformity with the results of Choubey *et al.* (2002) [7], Parihar *et al.* (2014) [21], Chaudhary (2016) [6], Patil (2017) [22] and Makkar *et al.* (2018) [16].

3.1.3 Number of branches/plant

It was find out from data (Table 1) that treatment T_3 (N equivalent to 60 kg/ha through vermicompost) registered significantly the higher number of branches/plant (11.81) at harvest in linseed and it was remained at par with treatment T_1, T_2, T_4 and T_6, while minimum value was secured with treatment T_8. The increase in the number of branches/plant could be attributed to the presence of growth hormones in vermicompost, which are responsible for activation of cell division and cell elongation in axillary buds. These results are in concurrence with the findings of Choubey *et al.* (2002) [7], Singh *et al.* (2013), Chaudhary (2016) [6] and Makkar *et al.* (2018) [16].

3.1.4 Dry matter accumulation (g/plant)

The table 1 showed that the treatment T_3 (N equivalent to 60 kg/ha through vermicompost) recorded significantly higher plant dry matter accumulation of 7.31 g/plant and 18.31 g/plant at 60 DAS and at harvest, respectively as compared to other treatments. However, it was remained at par with treatment T_1, T_2, T_4 and T_6 at 60 DAS and at harvest. Significantly lower dry matter accumulation was recorded under the treatment T_8. Increase in dry matter accumulation in treatment T_3 (N equivalent to 60 kg/ha through vermicompost) might be due to application of vermicompost supplied all essential nutrients, growth hormones and enzymes to plant, which favours rapid cell division and elongation and ultimately results into more development of plant and higher dry matter accumulation. These results are in concurrence with the findings of Chaudhary (2016) [6], Kamdi *et al.* (2014) [12] and Kaushal & Umrao (2019).

3.1.5 Root length (cm)

The table 1 showed that the treatment T_3 (N equivalent to 60 kg/ha through vermicompost) recorded significantly higher root length of 12.13 and 17.60 cm at 60 DAS and at harvest, respectively as compared to other treatments. However, it was remained at par with treatment T_2, T_4 and T_6 at 60 DAS and at harvest. Significantly lower root length was observed under the treatment T_8. The higher root length might be due to significant increase in organic matter content in the soil with the application of organic manure which improved the favourable effect on modifying the soil environment physically and hold more water and nutrients, better aeration and enhanced microbial activities, resulting ultimately into higher root length. These results are in concurrence with the findings of Makkar *et al.* (2018) [16].

3.1.6 Dry root biomass (g/plant)

The appraisal of result (Table 1) revealed that treatment T_3 (N equivalent to 60 kg/ha through vermicompost) registered significantly higher dry root biomass of 0.75 and 2.08 g/plant at 60 DAS and at harvest, respectively. However, it was remained at par with treatment T_2, and T_6. While lower values of dry root biomass were obtained with treatment $T_{8.}$ The probable reason behind that application of vermicompost was cytokine synthesis and rapid conversion of synthesized carbohydrates into protein, consequent to increase in the number and size of growing cells. It improved the favourable effect on modifying the soil environment to hold more water and nutrients, better aeration and enhanced microbial activities resulting into more number of root and higher dry root biomass. These results are in concurrence with the findings of Chaudhary (2016) [6] and Kamdi *et al.* (2014) [12].

3.2 Yield parameter

3.2.1 Number of capsules/plant

The results summarized in Table 2 revealed that treatment T_3 (N equivalent to 60 kg/ha through vermicompost) obtained significantly higher number of capsules/plant (49.99). It was also remained at par with treatment T_1, T_2, T_4 and T_6 in linseed. While minimum value was secured with treatment $T_{8.}$ These results are in conformity to those reported by Choubey *et al.* (2002) [7], Chaudhary (2016) [6], Patil (2017) [22].

3.2.2 Number of seeds/capsule

The statistically analyzed data presented in Table 2 indicated that application of various treatments had no any significant influence on number of seeds/capsules recorded at harvest in linseed. It might be due to genetic characters responsible for number of seeds/capsule.

3.2.3 Test weight (g)

The data showed in Table 2 revealed that treatment T_3 (N equivalent to 60 kg/ha through vermicompost) recorded significantly higher test weight of 7.79 g as compared to other treatments. However, it was remained at par with treatment T_2 and T_6. Significantly lower test weight of was observed under the treatment T_8. Increase in test weight in treatment T_3 (N equivalent to 60 kg/ha through vermicompost) might be due to application of vermicompost delayed leaf senescence and this might be the reason for increased seed weight. These results are in close accordance with those reported by Choubey *et al.* (2002) [7] and Kaushal & Umrao (2019).

3.2.4 Seed and straw yield (kg/ha)
The appraisal of result (Table 2) revealed that treatment T_3 (N equivalent to 60 kg/ha through vermicompost) registered significantly higher seed yield (1648 kg/ha) and straw yield (4819 kg/ha). However, it was remained at par with treatment T_1, T_2, T_4 and T_6. The lower value of seed and straw yield were obtained under treatment T_8. Vermicompost application might have increased activities of N fixing bacteria and increased rate of humification. Humic acid in vermicompost might have enhanced the availability of both added and native nutrients in soil and as a result improved growth, yield attributes and yield of the crop significantly. These results are in close accordance with those reported by Choubey *et al.* (2002) [7], Singh *et al.* (2013), Parihar *et al.* (2014) [21], Chaudhary, 2016) [6], Kumar (2017), Patil (2017) [22] and Kaushal & Umrao (2019) [13]

3.2.5 Harvest Index (%)
The data clearly showed that different organic sources of nitrogen remained akin to harvest index (Table 2) and they had no any significant influence on harvest index.

Table 1: Influence of nitrogen management through various organic sources on plant population, plant height (cm), branches/plant, dry matter accumulation (DMA)/plant (g), root length (cm) and root dry biomass (g/plant) of linseed.

Treat.	Plant population		Plant height (cm)			Branches/ plant	DMA/plant (g)		Root length (cm)		Dry root biomass (g/plant)	
	25 DAS	At Harvest	30 DAS	60 DAS	At harvest		60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest
T_1	24.90	20.33	16.63	49.44	64.88	11.42	7.16	15.76	10.11	14.81	0.63	1.81
T_2	25.05	20.85	15.95	52.53	68.65	10.66	7.17	16.32	12.05	17.36	0.70	1.96
T_3	25.40	20.99	16.70	55.00	71.50	11.81	7.31	16.86	12.13	17.60	0.75	2.08
T_4	24.90	20.98	14.80	52.66	67.49	11.33	6.62	15.21	11.48	16.11	0.67	1.90
T_5	24.80	20.50	14.60	45.34	59.11	10.22	6.22	14.84	10.50	15.21	0.62	1.85
T_6	24.55	20.33	15.15	49.78	61.49	10.55	7.03	15.56	11.64	16.66	0.70	1.94
T_7	24.25	20.68	15.00	46.10	59.74	10.31	6.13	14.75	10.30	14.71	0.66	1.74
T_8	23.60	20.30	14.20	43.28	56.19	9.43	5.63	13.43	10.09	14.17	0.59	1.69
T_9	24.80	20.88	15.85	45.94	59.45	9.55	6.14	14.84	10.52	14.98	0.66	1.86
T_{10}	24.15	20.70	14.90	45.55	56.99	10.30	5.99	14.34	10.20	15.24	0.64	1.79
SEm ±	0.65	0.52	0.65	2.57	3.50	0.50	0.36	0.64	0.51	0.76	0.03	0.07
CD at 5%	NS	NS	NS	7.47	10.14	1.46	1.05	1.84	1.49	2.21	0.08	0.21
CV%	5.29	5.05	8.41	10.60	11.18	9.54	11.07	8.37	9.40	9.72	8.79	7.89

Table 2: Effect of nitrogen management through various organic sources on no. of capsules/plant, no. of seeds/capsule, test weight (g), straw yield (kg/ha) and harvest index (%) of linseed

Treat.	No. of capsules/plant	No. of seeds/capsule	Test weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
T_1	48.57	6.63	6.69	1420	4155	25.47
T_2	44.29	6.83	7.30	1509	4374	25.68
T_3	49.99	6.88	7.79	1648	4819	25.39
T_4	47.36	6.87	6.54	1537	4667	24.81
T_5	40.05	6.65	6.87	1278	3769	25.34
T_6	44.60	6.80	7.13	1481	4192	26.03
T_7	41.24	6.68	6.83	1364	3960	25.64
T_8	38.02	6.60	6.40	1188	3765	24.29
T_9	40.95	6.81	6.92	1374	4078	25.26
T_{10}	38.64	6.75	6.81	1290	3875	25.22
SEm ±	2.42	0.11	0.24	82.20	229.6	1.26
CD at 5%	7.01	NS	0.69	239	666	NS
CV%	11.05	3.2	6.89	11.67	11.03	9.95

4. Conclusion
Based on the results of one year experimentation, it can be concluded that the application of 60 kg N/ha through vermicompost (T_3) produced higher growth, yield attributes and yield of linseed crop.

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