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Response of Bio-fertilizers and Hydrogel on Yield and Yield Attribute of Linseed Crop (*Linum usitatissimum* L.) under Rainfed Condition

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ABSTRACT: To investigate the effects of hydrogel and bio-fertilizers on cultivars of linseed's yield attribute, the experiment was carried out during the rabi season of 2020–2022. The experiment, which was set up in RBD, included three doses of fertilizer with combinations of Bio-Fertilizers, namely N1 (100% RDF), N2 (75% RDF + Azotobacter), and N3 (50% RDF + Azotobacter + PSB), as well as three moisture conservation practices, namely M1 (Dust mulch), M2 (Hydrogel @2.5kg/ha), and M3 (Hydrogel @5. In times of water constraint, hydrogel may show to be a realistically effective and environmentally benign solution for achieving the aim of agricultural output. Different field, ornamental, and food crops have been observed to produce better yields after applying hydrogel to the soil. Analysis of the response dosages of nutrient management with moisture conservation techniques was done on the growth traits, plant population, flowering, yield attribute, and yield of the linseed crop. The greater seed production in nutrient management was attained at a rate of 75% RDF + Azotobacter of 13.02 q/ha and 13.32 q/ha in the first and second years, respectively. The higher seed yield was attained with hydrogel@5kg/ha in the first and second years, at 13.55 q/ha and 14.17 q/ha, respectively. This is similar to moisture conservation measures. The experiment's two years of data showed that the lowest seed yields were 9.25 q/ha and 9.64 q/ha of dust mulch. In India, a very low application rate of fertilizer is necessary for nearly all crop kinds due to the country climate types.

Keywords: Biofertilizer, Hydrogel, Ornamental, Moisture conservation, Growth traits.

INTRODUCTION

Linseed (*Linum usitatissimum* L.) is a self-pollinated plant that is also known as tisi, Linum, and linen, among other names. In the world, it is mostly grown for the multifunctional oil and fiber it contains (Kajla *et al*., 2015). Farmers often fail to plant linseed on time, which causes late-sown linseed to have a shorter development period accessible to it. This, combined with high temperatures and hot winds during the reproductive growth phase, resulting in forced maturity and a poor grain yield. Numerous data show that the linseed sowing dates have a considerable impact on the growth and yield-attributing features (Al-Doori, 2012; Maurya *et al.,* 2017; Jana *et al*., 2018; Ganvit *et al.,* 2019). About 60% of the net cultivated area is in poor condition, and much more than 30% of that area struggles with insufficient rainfall. Some techniques used to increase the water-use effectiveness in agricultural systems include the use of chemicals like anti-transparent and hydrogel. A synthetic polymer used to amend soil is called hydrogel. The goal of agricultural output in the face of water scarcity, hydrogel may prove to be a practically realistic and financially viable choice. It is simple to apply directly to the soil for planting field crops, as well as to the growing medium for nursery plantations. According to the soil type and climate in India, the low application rate (2.5-5.0 kg/ha) of hydrogel is effective for practically all crops. Application of hydrogel has been observed to improve the growth and yield attributing attributes and yield of several agricultural, ornamental, and vegetable crops (Kalhapure *et al.,* 2016). Numerous rhizospheric microorganisms have colonized the roots, and many of these are known to positively influence plant development and exert a synergistic effect on Rhizobium effectiveness. The productivity of crops, particularly legumes, can be increased through the use of naturally occurring organisms with diverse growth-promoting properties. Although seed bacterization with the proper rhizobia at sowing is advised, recent research suggests that a combination of N_2 -fixers, including phosphorus-solubilizing bacteria (PSB), may be more efficient than a single organism at providing a more balanced diet, especially in the case of low nutrient inputs (Ahmad *et al.,* 2006). The use of synergistically interacting microorganisms is an effort to change the microbiological balance in favour of greater plant growth and productivity, and is therefore likely to assist in maintaining the productivity in many agricultural systems.

MATERIALS AND METHODS

The experiment was carried out at the Chandra Shekher Azad University of Agriculture and Technology's Soil Conservation and Water Management Farm during the rabi seasons of 2020–21 and 2021–22. (U.P.). It is located at a height of 125.9 meters above sea level in the alluvial tract of the Indo-Gangetic plains, Zone V of the agro climatic classification applies to this area (Central region). Three replications and 27 treatments were used in the experiment's Randomized Block Design. The treatments consist of a mixture of three doses of nutrient management (biofertilizer + fertilizer), 100% RDF, 75% RDF + Azotobacter, 50% RDF + Azotobacter + PSB, and the application of three moisture conservation techniques (dust mulch), Hydrogel@5kg/ha, and M3 hydrogel @2.5kg/ha. The potential uses of super absorbent polymers (SAPs) in the agricultural sector have drawn more attention and have been researched to address issues including water stress conditions. White flowers and dark green foliage characterize this type of linseed (50–60 cm). In 120–140 days, this cultivar reaches maturity. Oil yield (kg/ha^{-1}) is 450–500, whereas stover yield (q/ha^{-1}) is 26–30, with a potential production of 12–14 q ha^{-1}. Oil content is 35–37%.

RESULT AND DISCUSSIONS

A. Yield attributes

Number of capsules/plant. Significantly, the treatment group (5kg/ha of hydrogel) recorded the highest number of capsules/plant (50.85). This may have been because crops were exposed to favorable weather and available moisture throughout the whole growing cycle, which allowed distinct crop phases to be finished at the proper times. The nutritional management of 75%RDF + Azotobacter (47.95), which led to the development of more capsules/plant and more sites for reproductive structures, *i.e.,* the number of capsules/plant, finally resulted in the production of more capsules/plant. Additionally, this supports the findings of (Ganga *et al.*, 2015) with three replications and 27 treatments, the experiment used a randomized block design. Using three doses of nutrient management (biofertilizer plus fertilizer), 100% RDF, 75% RDF + Azotobacter, and 50% RDF + Azotobacter + PSB, along with three moisture conservation techniques, sand mulch), Hydrogel @ 5 kg/ha, M3 Hydrogel @ 2.5 kg/ha.

Seeds/capsule. Significantly more seeds and capsules were produced using hydrogel at 5 kg/ha (7.64). This may have happened due to a hospitable environment, especially the temperature that prevailed during the growth phase as well as the vegetative and reproductive stages. Significant differences in moisture conservation and nutrient management strategies were found after data analysis. The maximal seed per capsule nutrition management strategy was developed for 75% RDF + Azotobacter. This might be because fertilizer use causes the linseed crop to receive the right amount of nutrients, leading to greater growth and development of the crop. Tanwar *et al.* (2011) conclusions are supported by the results; crop may have received the appropriate amount of nutrients in the ideal and balanced ratio needed for greater growth and development.

Test weight. The results demonstrated the grain test weight's significant development over the course of the two years in all treatments. The maximum test weight increase in terms of nutrient management was observed in 75%RDF+Azotobacter both years, followed by 100% RDF, while the lowest results were recorded in 50% RDF + Azotobacter + PSB both years. The application of Hydrogel @5 kg/ha will undoubtedly result in the greatest conservation practices test weight, followed by Hydrogel @2.5 kg/ha in both years, while the lowest test weight will be recorded in dust mulch in both years.

B. Yield characters

Grain yield q/ha. The plant noticed more nutrients and moisture, which allowed it to produce more photosynthesis accumulate there. Significant differences in moisture conservation and nutrient management strategies were found after data analysis. The 75% RDF + Azotobacter and 100% RDF nutrient management treatments were the first to introduce a maximum seed per capsule. The lowest value determined by 50% RDF + PSB of the trial. In comparison to other treatments in moisture conservation techniques, the application of Hydrogel@5kg/ha increased grain production, which was followed by Hydrogel@2.5kg/ha. The least effective treatment was Dust Mulch.

Stover yield (q/ha). The treatment in Table 2 provides information about stover yield as influenced by various methods. Maximum stover yields of 4.764 q/ha and 5.06 q/ha, respectively, were recorded by 75% RDF + Azotobacter in the first year of the experiment and 50% RDF + Azotobacter + PSB in the second year, respectively. In the first year of the experiment, 100% RDF and 50% RDF + Azotobacter + PSB had the next highest stover yields (4.15 q/ha), and 50%RDF+Azotobacter The amount of stover produced per hectare varied significantly depending on moisture conservation techniques. The maximum stover yield was greatly increased when Hydrogel @5 kg/ha was used, and was significantly followed by Hydrogel @2.5 kg/ha, with dust mulch stover yield coming in at the minimum.

Harvesting Index. A harvest index measures the biological yield of grains. Table 2 contains data related to harvest index. It shows that all treatments have a significant impact on the harvest index when compared to all subsequent treatment combinations. With 75%

RDF + Azotobacter and Hydrogel @5kg/ha, the greatest grain yield will be achieved**.** I recorded the highest harvesting index grain yield in 75%RDF + Azotobacter in both years (31.91%, 32.11%), followed by the 31.66% and 31.86% in 100% RDF. In both years, minimums of 30.99% and 31.19% were observed. Hydrogel @5 kg/ha had the highest harvesting index following the application of moisture conservation techniques (31.97% and 32.18%), with Hydrogel @2.5 kg/ha coming in second (31.66% and 31.86%). Both years of the trial, when dust mulch was being used, had the lowest harvest index value (30.93% and 31.13%). The combined effect of the two therapies was determined to be insignificant.

Table 1: Effect of biofertilizer and hydrogel on yield attributes of linseed.

Treatments		Number of capsule/plant		Number of seed/ capsule		Test weight(g)	
		2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022
Nutrient management:							
N_1	100%RDF(60kg N +30kg p+ 30 kg K /ha)	43.30	45.273	7.35	7.45	7.22	7.32
N_2	75%RDF+ Azotobacter	46.77	49.129	7.58	7.71	7.45	7.58
N_3	50%RDF+Azotobacter+PSB	37.65	39.367	6.96	7.06	6.85	6.95
Moisture conservation practices:							
M_1	Dust mulch	33.71	35.250	6.89	6.99	6.78	6.87
M_2	Hydrogel @2.5 kg/ha	44.57	46.607	7.03	7.41	7.18	7.28
M_3	Hydrogel @5 kg/ha	49.44	51.912	7.69	7.82	7.56	7.69
	SE(d)	3.26	3.83	0.18	0.22	0.20	0.23
	CD (P = 0.05)	N.S	N.S	N.S	N.S	N.S	N.S

Table 2: Effect of biofertilizer and hydrogel on yield characters of linseed.

Treatments		Grain yield q/ha		Stover yield q/ha		Harvesting Index	
		2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022
Nutrient management:							
N_1	100%RDF(60kg N +30kg p+ 30 kg K /ha)	11.87	12.25	2 5.48	26.05	31.66	31.86
N_2	75%RDF+ Azotobacter	13.02	13.23	27.60	27.96	31.91	32.11
N_3	50%RDF+Azotobacter+PSB	10.33	10.86	23.05	23.89	30.99	31.19
Moisture conservation practices:							
M_1	Dust mulch	9.25	9.64	20.55	21.28	30.93	31.13
M_2	Hydrogel @2.5 kg/ha	12.22	12.62	26.25	26.86	31.66	31.86
M_3	Hydrogel @5 kg/ha	13.75	14.17	29.33	29.75	31.97	32.18
	SE(d)	1.34	1.48	2.00	2.16	0.24	0.27
	CD (P = 0.05)	N.S	N.S	N.S	N.S	N.S	N.S

CONCLUSIONS

The dual inoculation of Azotobacter and PSB resulted in noticeably superior yield attributes, such as the number of capsules per plant and seed weight per plant, although statistically, this was no different from PSB seed inoculation. This may be because plants in dual-inoculation and PSB alone plots accumulate dry matter more efficiently than those in single-inoculation plots. Biofertilizers also considerably affected the seed and stover production of linseed. With the simultaneous inoculation of PSB and Azotobacter, a higher seed production was observed. Azotobacter has been found promising to improve nitrogen status of soil and crop yield due to their capacity to fix atmospheric nitrogen. By boosting the supply or availability of primary nutrients to the host plant, the biofertilizers encourage development. It raises agricultural yield production, soil quality, and fertility. To increase photosynthetic efficiency, assimilate partitioning, and boost crop growth and yield, hydrogel treatment may be a viable choice**.** In the current experiment, the hydrogel @5 $kgha^{-1}$ with 75% RDF + Azotobacter showed higher growth characteristics. Therefore, the aforementioned dose can be suggested to the farmer in order to increase the yield of linseed under rainfed conditions. Agricultural hydrogels are environmentally beneficial since they biodegrade over time without leaving any residue on the soil.

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Conflict of Interest. None.

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