International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 1896-1899

Received: 07-03-2018
Accepted: 10-04-2018

Dujeshwer
Research Scholar, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Ram Kumar Singh
Professor, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India.

Correspondence
Dujeshwer
Research Scholar, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Effect of hydrogel and *Trichoderma* on growth and quality of linseed varieties under rainfed condition

Dujeshwer and Ram Kumar Singh

Abstract
Field experiments were conducted during *Rabi* seasons of 2015 and 2016 at the Agricultural Research Farm, Institute of Agricultural Sciences, and Banaras Hindu University. Aim of this present study was to see the effect of super absorbent polymer (hydrogel) and *Trichoderma* fungus on growth and quality of linseed varieties. Hydrogel and *Trichoderma* and its combination found effective to improving growth, yield and quality attributes of linseed. Results of the study found that Furrow application of hydrogel @ 5 kg ha^{-1} with *Trichoderma* treated seed @ 10 g kg^{-1} significantly improves the plant height, plant biomass, number of branches, seed yield, protein content, protein yield and oil yield. Highest protein content was recorded with variety Garima but oil content was found maximum with variety Deepika. Protein and oil yield was maximum with variety RLC-92.

Keywords: Hydrogel, *Trichoderma*, quality, yield, growth

Introduction
India is one of the leading oilseeds growing country in the world and fourth largest vegetable oil economy next only to USA, China and Brazil. Currently, India accounts for about 12-15 percent of world's oilseed area, 7-8 percent of world's oilseed output and 10 percent of world's edible oils consumption. The diverse agro-ecological conditions in the country are favorable for growing oilseeds. They occupy an area of 27.86 million ha with 27.98 million tons of production registering a productivity level of 10.10 q/ha. Oilseeds play the second important role in the Indian agricultural economy, next only to food grains in terms of area and production.

Linseed (*Linum usitatissimum* L.) is an important oilseed and fiber crop in the world. Linseed has different industrial value and is produced mostly in India, Canada, China, USA, Argentina and Russia. Linseed is one of the most important industrial oilseed crops of India and stands next to rapeseed-mustard in *Rabi* oilseeds in area and production. India is the second largest producer of linseed, next to Canada in the world with an area of 5.25 lakh ha, total production of 2.11 lakh tones per annum and productivity of 403 kg/ha. India has 18.8 percent of worlds recorded linseed area but produces less than 10% of total world production. Linseed is generally grown in rainfed/dry land areas where the residual moisture of previous crop is only source of water, thereby crop many time suffers from the water stress conditions results in drastic decrease in productivity of crop.

FAO (2009) [5] points out that one major challenge towards global agriculture includes production of 70% more food crop for an extra 2.3 billion people by 2050 worldwide. Drought is a major stress limiting the increase in the demand for food crops. Global climate change has been witnessed over the past decades and is anticipated to continue in the future (IPCC, 2007) [8]. Rainfall patterns cannot be foretold with much assurance and therefore, extreme weather conditions are becoming common. In that, some regions are experiencing overflows while others are affected by deficiency of precipitation (Chepsergon *et al.*, 2012) [3]. Drought and high temperature are especially considered as key stress factors with high potential impact on crop yield (Kurrey *et al.*, 2016) [11]. It is therefore necessary that irrigated agriculture produces more food while consuming less water without deteriorating the environment (Kefa *et al.*, 2013) [10]. Development of micro-irrigation systems have considerably reduced the water requirement of the crops; moreover the performance of superabsorbent polymers that absorb and retain huge amount of water and release it as per the need also demands attention. It absorbs water a minimum of 350 times of its dry weight and gradually releases it to growing plants. Use of hydrogel increased the amount of available moisture in the root zone, resulting in longer intervals between irrigations (Jain *et al.,* 2017) [9].

On the other hand, *Trichoderma spp*. is acosmopolitan fungi found in agricultural, forest, desert soils. Also, they colonize roots of various plants found in different ecosystems. They have been defined as plant symbionts opportunistic avirulent organisms, able to colonize plant roots and to produce compounds that stimulate growth and plant defense mechanisms under suboptimal conditions (Harman *et al.*, 2004) [6]. For the past many years, *Trichoderma spp.* has been mostly used as biocontrol agents. However, in the recent years, they have become popular as plant growth promoter (Hermosa *et al.,* 2012) [7]. In this present study we tried the evaluate the combined effect of hydrogel and *Trichoderma* on growth, protein and oil yield of linseed varieties under rainfed conditions of Eastern Uttar Pradesh.

Materials and Method

A field experiment was conducted to evaluate the effect of hydrogel and *Trichoderma* on crop growth and quality attributes in linseed varieties at Research farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) during *Kharif* 2015 and 2016. The experiment was laid out in Split Plot Design comprises three replications with four rice varieties *i.e.* Kartika, Deepika, Garima, RLC-92 and six hydrogel and *Trichoderma* treatments *i.e.* Control, Seed soaking in hydrogel @ 5 kg ha^{-1}, Seed treatment with *Trichoderma* @ 10 g per kg seed, Seed soaking in hydrogel @ 5 kg ha^{-1} followed by seed treatment with *Trichoderma* @ 10 g per kg seed, Furrow application of hydrogel @ 5 kg ha^{-1} and Furrow application of hydrogel @ 5 kg ha^{-1} followed by sowing of *Trichoderma* treated seed. Soaking with hydrogel was done by mixing of required hydrogel with same amount of water and seed for 12 hrs before sowing. Seed was treated with *Trichoderma* @10 g per kg seed just before sowing of seed. Furrow application of hydrogel was done just before of direct seeding of seeds. Although, hydrogel is not soluble in water but it makes semi-translucent material with seed. A uniform dose of 40 kg N ha^{-1}, 20 kg P_2O_5 ha^{-1}, and 20 kg K_2O ha^{-1} were applied for both years of experiment. The weekly mean maximum temperature ranged from 19.0 to 41.4°C with an average of 29.40°C during experimentation 2015 and 20.1 to 40.1°C with an average of 28.99°C during experimentation 2016.The cumulative rainfall received during the period of experiment was 45.5 mm and 1.0 mm during 2015 and 2016, respectively. The plant height of five tagged plant was measured with the help of metre scale from the base. Number of branches plant^{-1} at the tagged plants were counted and expressed as average number of branches plant^{-1}. Plants were cut close to the ground portion to remove the root part to record dry matter accumulation. After shad drying plant sample put in oven at killing temperature (105ºC for 1 hour) at which all metabolic process of plant were stopped after that temperature of oven was maintained at 65ºC until the weight of plant become constant. Yield was recorded at harvest.

For determination of protein content in seeds, chemical analysis for nitrogen content was done by Micro-Kjeldahl method, and the values thus obtained were multiplied by a factor 6.25. Protein content in seed sample of each treatment was multiplied by corresponding seed yield (kg ha^{-1}) to get the protein yield (kg ha^{-1}). Oil percentage was determined by the Soxhlet's apparatus using petroleum ether as extractant. Oil content in seed sample of each treatment was multiplied by corresponding seed yield (kg ha^{-1}) to get the oil yield (kg ha^{-1}).

Results and Discussion

Effect on growth attributes

The growth attributes like plant height, number of branches plant^{-1} and dry matter accumulation (g plant^{-1}) was taken at maximum growth stage at 90 DAS. The different varieties as well as different hydrogel and *Trichoderma* treatments and its combination have significant variation on growth attributes (Table 1). The pooled data revealed that among the varieties, RLC-92 recorded significantly higher plant height (71.9 cm) and dry matter accumulation (8.50 g) over the other varieties. Number of branches plant^{-1} (5.56) was highest with variety Garima and was found statistically similar to variety Deepika (5.22) during the experimentation. Among the hydrogel and *Trichoderma* treatment, Furrow application of hydrogel @ 5 kg ha^{-1} followed by sowing of *Trichoderma* treated seed recorded statistically highest plant height (62.9 cm), branches plant^{-1} (5.47) and dry matter accumulation (8.25 g) and found comparable with Seed soaking in hydrogel @ 5 kg ha^{-1} followed by seed treatment with *Trichoderma* @ 10 g kg^{-1} during the experiment. *Trichoderma* increase availability of nutrients like macro (N, P, K) as well as micronutrient (Mo, Zn and Mn) to the roots of crop which helps in turns to increase in photosynthetic activity of plants that later enhances the vegetative growth thus the number of leaves per plant, number of branches, plant height and root length (Sharma *et al.,* 2014 and Sureshrao *et al.*, 2016) [13, 15]. Hydrogel have been reported to increase the activity of cell division, cell expansion and cell elongation, ultimately leading to an increased plant height, number of leaves, numbers of branches, leaf area index, plant biomass and root growth. Similar results have been reported by Al-Harbi *et al*. (1996) [1] in cucumber.

Table 1: Effect of varieties, hydrogel and *Trichoderma* on growth attributes of linseed

Treatments	Plant height (cm)		Pooled	Number of branches plant^{-1}		Pooled	Dry matter accumulation g plant^{-1}		Pooled	Seed yield (kg ha^{-1})		Pooled
	2015	2016		2015	2016		2015	2016		2015	2016	
Varieties												
V_1: Kartika	57.4	55.4	56.4	4.73	4.70	4.71	7.17	6.73	6.95	1328.5	1294.9	1311.7
V_2: Deepika	54.5	50.9	52.7	5.15	5.29	5.22	7.64	7.27	7.45	1376.0	1333.2	1354.6
V_3: Garima	62.2	60.1	61.1	5.60	5.51	5.56	8.07	7.51	7.79	1423.8	1352.7	1388.2
V_4: RLC-92	73.2	70.5	71.9	4.19	4.44	4.32	8.88	8.13	8.50	1484.1	1433.8	1458.9
SEm±	0.88	0.77	0.71	0.15	0.14	0.12	0.22	0.19	0.13	25.3	24.1	19.7
CD (P=0.05)	3.05	2.65	2.45	0.50	0.49	0.41	0.75	0.65	0.49	87.3	83.3	67.9
Hydrogel and *Trichoderma* treatments												

H_1: Control	58.7	56.6	57.6	4.41	4.22	4.31	7.26	6.50	6.88	1263.4	1253.9	1258.6
H_2: Seed soaking in hydrogel @ 5 kg ha^{-1}	60.4	57.9	59.2	4.75	4.76	4.76	7.92	7.13	7.52	1348.9	1339.8	1344.3
H_3: Seed treatment with *Trichoderma* @ 10 g ha^{-1}	62.9	59.9	61.7	4.93	5.22	5.07	7.78	7.51	7.65	1430.0	1367.4	1398.7
H_4: Seed soaking in hydrogel @ 5 kg ha^{-1} followed by seed treatment with *Trichoderma* @ 10 g ha^{-1}	62.8	60.5	61.5	5.10	5.29	5.20	8.39	7.73	8.07	1456.4	1404.9	1430.6
H_5: Furrow application of hydrogel @ 5 kg ha^{-1}	61.5	59.2	60.6	4.90	4.89	4.90	7.87	7.47	7.67	1411.9	1357.1	1384.5
H_6: Furrow application of hydrogel @ 5 kg ha^{-1} followed by sowing of *Trichoderma* treated seed.	64.5	61.2	62.9	5.41	5.53	5.47	8.42	8.11	8.25	1508.0	1428.7	1468.3
SEm±	0.79	0.75	0.47	0.11	0.13	0.10	0.18	0.14	0.11	23.7	21.5	17.2
CD (P=0.05)	2.85	2.13	1.35	0.31	0.36	0.28	0.51	0.39	0.31	67.5	61.5	46.7
Interaction (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS= Not significant, NA= Not analyzed

Effect on yield

The pooled data (Table 1) showed that variety has shown significant variation on seed yield (kg ha^{-1}) and data reveals that RLC-92 (1458.9) recorded significantly higher seed yield over, Garima (1388.2) Deepika (1354.6) and Kartika (1311.7) and was remain at par with and during the investigation. Variety RLC-92 recorded 11.22 per cent higher seed yield over Kartika. The significant maximum grain yield (kg ha^{-1}) was recorded under Furrow application of hydrogel @ 5 kg ha^{-1} followed by sowing of *Trichoderma* treated seed (1468.3) which was found on par with Seed soaking in hydrogel @ 5 kg ha^{-1} followed by seed treatment with *Trichoderma* @ 10 g kg^{-1} (1430.6). The lowest grain yield was recorded under Control (1258.6 kg) which was 16.6 per cent lower than the best treatment. An increase in yield and yield related attributes could be because of sufficient availability of water and indirectly nutrients supplied by the SAP to the plants under water stress condition, which in turn lead to better translocation of water, nutrients and photosynthates and finally better plant stand and yield (El-Hardy *et al.*, 2009). Bal and Altintas (2006) reported that various species of *Trichoderma* are also effective in the promotion of growth and yield in various crops.

Effect on quality parameters

Pooled data revealed that qualitative parameters like protein content (%), protein yield (kg ha^{-1}), oil content (%) and oil yield (kg ha^{-1}) was significantly affected by different varieties and treatments (Table 2). Among the varieties, protein content (22.23 %) recorded statistically higher under Garima over other variety and found at par with RLC-92 (21.47 %). However, oil content was found significantly higher under Deepika (42.19 %) over other three varieties but protein yield (313.6 kg) and oil yield (592.9 kg) was found maximum under variety RLC-92. Oil yield was remained at par with Deepika (571.8 kg). Among the treatments, Furrow application of hydrogel @ 5 kg ha^{-1} followed by sowing of *Trichoderma* treated seed recorded significantly maximum protein content (21.91 %), protein yield (322.2 kg), oil yield (603.7 kg) and found on par with Seed soaking in hydrogel @ 5 Kg ha^{-1} followed by seed treatment with *Trichoderma* @ 10 g kg^{-1} (H_4) during the investigation. Oil content was not found significant under different treatments. Increase in oil recovery and oil content had positive correlation with availability of water for longer duration. Hydrogel applied in water deficit stress conditions certainly improved moisture conditions and increased sink capacity in the plant that facilitated longer period which provided enough time to prepare unsaturated fatty acids from the saturated fatty acids (Tohidi Moghadam *et al.*, 2011). Hydrogel also helped to increase the chlorophyll and protein content as amount of polymer increased in soil (Singh *et al.*, 2017).

Table 2: Effect of varieties, hydrogel and *Trichoderma* on quality attributes of linseed

Treatments	Protein content (%)		Pooled	Protein yield (kg ha^{-1})		Pooled	Oil content (%)		Pooled	Oil yield (kg ha^{-1})		Pooled
	2015	2016		2015	2016		2015	2016		2015	2016	
Varieties												
V_1: Kartika	20.20	20.08	20.14	268.4	260.3	264.4	41.49	41.01	41.25	551.4	531.3	541.3
V_2: Deepika	20.77	20.58	20.67	286.3	274.4	280.4	42.28	42.11	42.19	582.1	561.5	571.8
V_3: Garima	22.36	22.09	22.23	318.5	299.1	308.8	39.55	39.17	39.36	563.2	529.7	546.5
V_4: RLC-92	21.52	21.42	21.47	319.0	308.2	313.6	40.50	40.20	40.35	601.2	584.6	592.9
SEm±	0.25	0.20	0.17	7.51	6.11	5.16	0.18	0.22	0.16	9.65	9.24	7.26
CD (P=0.05)	0.85	0.69	0.58	25.9	21.0	17.8	0.62	0.76	0.55	33.3	31.9	25.0
Hydrogel and *Trichoderma* treatments												
H_1: Control	20.58	20.22	20.40	260.0	253.7	256.9	40.54	40.27	40.40	512.0	504.9	508.5
H_2: Seed soaking in hydrogel @ 5 kg ha^{-1}	20.93	20.57	20.75	282.5	275.9	279.2	41.18	40.82	40.58	555.3	545.1	545.2
H_3: Seed treatment with *Trichoderma* @ 10 g ha^{-1}	21.02	21.03	21.02	301.0	287.6	294.3	41.06	40.72	40.89	586.7	556.5	571.6
H_4: Seed soaking in hydrogel @ 5 kg ha^{-1} followed by seed treatment with *Trichoderma* @ 10 g ha^{-1}	21.53	21.41	21.45	319.3	301.1	310.2	40.84	40.32	41.00	595.4	565.1	586.2
H_5: Furrow application of hydrogel @ 5 kg ha^{-1}	21.19	21.04	21.11	299.9	285.9	292.9	40.88	40.44	40.73	576.9	549.3	563.6
H_6: Furrow application of hydrogel @ 5 kg ha^{-1} followed by sowing of *Trichoderma* treated seed.	22.24	21.58	21.91	335.7	308.7	322.2	40.24	40.03	40.13	609.5	575.9	603.7
SEm±	0.25	0.19	0.15	6.85	5.65	4.83	0.11	0.12	0.09	9.21	9.11	6.91
CD (P=0.05)	0.71	0.54	0.43	19.5	16.1	13.8	NS	NS	NS	26.3	25.9	18.8
Interaction (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS= Not significant, NA= Not analyzed

Conclusion

Trichoderma spp. is a cosmopolitan fungal organism that has been utilized not only in bio-control of plant pathogens but also in enhancing plant growth even under suboptimal plant growth conditions. *Trichoderma* promote the growth of plant by releasing various growth promoting substance to the host plant, like phyto-hormones, enzymes, amino acids and organic acids. Lone *et al.* (2005) reported that phytohormones are the chief constituent of protein levels and oil structure and improve the yield and quality of oilseed crops. Hydrogel increases the availability of water and indirectly nutrients. Increased supply of water and nutrient increase the biosynthesis of amino acids and stimulate the accumulation of protein in the seed.

Acknowledgement

The authors would like to express their sincere gratitude to the Institute of Agricultural Sciences, BHU, Varanasi (Uttar Pradesh) and University Grant Commission (UGC) for providing necessary facilities and funds for conducting the investigation.

References

1. Al-Harbi AR, Al-Omran AM, Shalaby AA, Choudhary MI. Efficacy of a hydrophilic polymer declines with time in house experiments. Horticulture Science. 1996; 34:223-224.
2. Bal U, Altintas S. A positive side effect from *Trichoderma harzianum*, the biological control agent: Increased yield in vegetable crops. Journal of Environmental Protection and Ecology. 2006; 7:383-387.
3. Chepsergon J, Mwamburi L, Kassim MK. Mechanism of drought tolerance in plants using *Trichoderma* spp. International Journal of Science and Research. 2012; 3(11):1592-1595.
4. El-Hardy OA, El-Kader AA, Shafi AM. Physio-bio-chemical properties of the sandy soil conditioned with acrylamide hydrogels after cucumber plantation. Australian Journal of Basic Applied Sciences. 2009; 3:3145-3151.
5. FAO. Declaration of the World Summit on Food Security, WSFS 2009/2, 2009.
6. Harman GE, Howell CR, Viterbo A, Chet I, Lorito M. *Trichoderma* species-opportunistic, avirulent plant symbionts. Nature Reviews Microbiology. 2004; 2(1):43-56.
7. Hermosa R, Viterbo A, Chet I, Monte E. Plant-beneficial effects of *Trichoderma* and of its genes. Microbiology. 2012; 158(1):17-25.
8. IPCC. Climate Change Synthesis Report, A Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R. K. and Reisinger, A. (eds.)], IPCC. Geneva, Switzerland, 2007.
9. Jain NK, Meena HN, Bhaduri D. Improvement in productivity, water-use efficiency, and soil nutrient dynamics of summer peanut (*Arachis hypogaea L.*) through use of polythene mulch, hydrogel, and nutrient management. Communications in Soil Science and Plant Analysis. 2017; 48(5):549–564.
10. Kefa CC, Kipkorir EC, Kwonyike J, Kubowon PC, Ndambiri HK. Comparison of water use savings and crop yields for clay pot and furrow irrigation methods in lake Bogoria. Kenya Journal of Natural Sciences Research. 2013; 3(8):34-39.
11. Kurrey D, Ahmad MA, Saxena RPN, Singh RK. Challenges to food grain production in the current climate change scenario for ensuring food security in India: A strategic review. Bioscience Biotechnology Research Communication. 2016; 9(1):1-5.
12. Lone NA, Mir MR, Khan NA. Effect of gibberellic acid on physiological attributes and yield of mustard (*Brassica juncea* L.). Applied Biological Research. 2005; 7:24-26.
13. Sharma A, Jadeja KB, Kataria GK, Anamika M, Dhakad JK. Plant growth promoting effect of *Trichoderma* on groundnut. AGRES-An International e-Journal. 2014; 3(4):342-352.
14. Singh A, Singh AK, Aswin C. Effect of hydrogel and thiourea on yield, quality and nutrient uptake of Indian mustard under moisture stress condition. Research on crops. 2017; 18(1):42-48.
15. Sureshrao KS, Pradeeprao KT, Dyanobarao GS, Agrawal T and Kotasthane AS. Root growth stimulation in rice (*Oryza sativa* L.) by seed biopriming with *Trichoderma* sp. Applied Biological Research. 2016; 18(1):30-38.
16. Tohidi Moghadam HR, Zahedi H and Ghooshchi F. Oil quality of canola cultivars in response to water stress and super absorbent polymer application. Pesquisa Agropecuária Tropical. 2011; 41(4):579-86.