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Effect of foliar nutrition and hydrogel on soil moisture, growth, yield and economics of lentil under vertisols

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ABSTRACT

A field experiment was carried out during three consecutive winter (*rabi*) seasons (2015-16 to 2017-18) at Agricultural Research Station (Agriculture University), Kota to find out effective dose of foliar nutrition and hydrogel on soil moisture, productivity and profitability of lentil (*Lens culinaris*) under vertisols of south eastern Rajasthan. The experiment was laid out in thrice replicated split plot design comprising of 3 hydrogel levels (i.e. 0, 2.5 kg/ha & 5.0 kg/ha) in main plots and 5 levels of foliar nutrition (i.e. water spray, urea 2 %, thiourea @ 500 ppm, salicylic acid @ 75 ppm & NPK (19:19:19) @ 0.5 %) in sub plots. It revealed that soil application of hydrogel 5.0 kg/ha before sowing recorded significantly higher pods/plant (67.2), grain yield (1325 kg/ha) and net return (₹ 33390/ha) over control and 2.5 kg/ha, respectively while, maximum B: C ratio (1.72) was fetched with hydrogel 2.5 kg/ha (being on par with hydrogel 5.0 kg/ha over no hydrogel). Foliar application of NPK (19:19:19) @ 0.5% at flower initiation & pod development stages recorded significantly higher pods/plant (63.7), grain yield (1224 kg/ha), net return (31748/ha) and B: C ratio (1.72) (being on par with salicylic acid @ 75 ppm) over water spray and urea 2%.

Key words: Economics, Foliar nutrition, Hydrogel, Salicylic acid, Thiourea, Yield

Lentil (*Lens culinaris* Medikus Subsp *culinaris*) is the major *rabi* pulse crop after chickpea in Rajasthan and mostly cultivated under arid and semi arid regions with traditional methods where shortage of water during the crop growth period has become the major impediments for its cultivation. It contains high amount of digestible protein (up to 35 %), macro and micronutrients, particularly iron, zinc and vitamins thus contributes significantly to food for nutritional security to consumers, feed for animals and sustainable farming systems. In India, it is grown in an area of 1.49 mh with annual production of 1.61 mt and average productivity 1006 kg/ha (Anonymous 2017). It is mainly grown in south and south eastern plain zones of Rajasthan and covers sizeable area 30.7 thousand hectares with annual production of 43.2 thousand tones and average productivity was only 1408 kg/ha (Anonymous 2017). The stress crunch of inefficient use of rain & irrigation water by rainfed crops is the most important problem in semiarid and arid regions. The low productivity and unstable production of lentil under rainfed may be ascribed due to terminal heat and temperature extremities in the later stages of crop growth especially at pod development stage occurrence due to moisture stress thus led to flower drops and unfilled grain in pod. Aberrant weather condition and extremities of temperature causes second generation nutrient management problems under rainfed condition although photosynthesis gets reduced due to depletion of nitrogen in leaves and may lead to acceleration of senescence of leaves (Leport *et al*. 1998). While, pod and seed development are mainly dependent of carbon and nitrogen accumulated prior to podding (Davis *et al.* 2000) as root fails to absorb nitrogen from dry vertisol soils due to degeneration of nodules after pod formation or if applied nitrogen at the time of sowing. Hence, mitigation of terminal heat at the time of pod formation and temperature extremities by the exogenous application of chemical and foliar nutrition to maximize the lentil productivity.

Application of water-saving super absorbent polymers i.e. hydrogel into the soil could be an effective way to increase both water and nutrient use efficiency in crops (Lentz *et al.* 1998). Hydrogel is drilled in the soil before sowing the crop, it is presumed that hydrogel retain large quantities of water and nutrients, which are released as & when required by the plant and it might be that plant growth could be improved with limited water and nutrient supply (Gehring and Lewis 1980). Under such situations, nitrogen supply can be maintained through foliar application at lower concentration by the bioregulators act as chemical catalyst in plants and improve physiological and reproductive efficiency in the plant. These bioregulators possibly improve the gene expression for efficient sucrose transport and increase dry matter partitioning for grain production (Werdan *et al.* 1975). Nutrient management (Major & Minor) is the main component for sustainable lentil production along with foliar application of water soluble fertilizers at appropriate stages of growth i.e. flower initiation and pod development may also ameliorate the nutrient deficiency as well as mitigate the heat stress. Keeping these facts in view, a field experiment was carried out to find out the effective dose of hydrogel in conjunction with suitable foliar nutrition for enhancing yield and economics of lentil under vertisols.

MATERIALS AND METHODS

A field experiment was conducted during three consecutive winter *rabi* seasons (2015-16 to 2017-18) at Agricultural Research Station (Agriculture University), Kota to find out effective dose of hydrogel in conjunction with suitable foliar nutrition for enhancing yield and economics of lentil under vertisols. The soil of the experimental field was clay loam, slightly alkaline in reaction (pH 7.6), poor in organic carbon (4.1 g/kg), low in available N (278.5 kg/ha), available P (8.94 kg/ha) & sulphur (16.1 kg/ha) and medium in available potash (292.8 kg/ha). The experiment comprised of 3 hydrogel levels (i.e. 0.0, 2.5 kg/ha & 5.0 kg/ha) were kept in main plots and 5 levels of foliar nutrition (i.e. water spray, 2 % urea, thiourea 500 ppm, salicylic acid 75 ppm & NPK (19:19:19) @ 0.5 %) in sub plots. The experiment was laid out in split plot design and replicated three times. Hydrogel was drilled in soil before lentil sowing in earmarked main plot strips and foliar nutrition for spray were prepared in water on w/v basis and applied at critical stages i.e. flower initiation and pod development. The recommended dose of fertilizer (20 kg N, 17.5 kg P, 16 kg K, 20 kg S and 5 kg Zn/ha) were drilled in the soil at the time of last land preparation before sowing and seeds were treated with *rhizobium* and *phosphate solubilising bacteria* each @ 10 g/kg.

A pre sown irrigation was applied to the experimental plots before sowing. The lentil variety "IPL 316" was used for experimental purpose and sown at 30 cm and 5 cm inter and intra row spacing on November 26, 16 & 11 in the year 2015, 2016 & 2017, respectively by adopting the recommended seed rate of 60 kg/ha. Weeds were managed by application of preemergence herbicide i.e. pendimethalin 30 EC @ 1.0 kg/ha before seed germination. The plant protection measures were taken up as and when required. Soil moisture content was recorded at the time of sowing, 30, 60, 90 days after sowing and at harvest. In each plot five plants were randomly selected and tagged to record biometric observations on growth and yield attributes. At maturity data on plant height, branches/plant, pods/plant, seeds/pod, 1000-seed weight, biological yield and grain yield were recorded. Harvest index was calculated by dividing economical yield by total biomass production. Net returns as well as B:C ratios were also worked out based on prevailing market prices. All data were subjected to analysis of variance. Results of three years were analyzed statistically and pooled analysis was carried out.

RESULTS AND DISCUSSION

Soil moisture content: The pooled data (Table 1) showed that initial soil moisture was 25.6 & 24.0 and 29.3 & 26.8% in upper soil layer 0-15 cm & 15-30 cm recorded at the time of sowing and 30 days after sowing, respectively. It was further reduced in soil moisture content with advancement of vegetative and reproductive growth of lentil significantly where no hydrogel was drilled in the soil compared to hydrogel drilled @ 2.5 and 5.0 kg/ha. Maximum and significantly higher soil moisture content was recorded with application of 5.0 kg/ha hydrogel in the manner of 22.2 & 24.7, 18.8 & 21.4 and 15.7 & 18.3 % being on par with 2.5 kg/ha hydrogel as compared to no hydrogel in upper soil layer 0-15 cm & 15-30 cm at 60, 90 DAS and at harvest, respectively. Soil moisture content in lower layer (15-30 cm) also reduced at a slower pace than upper soil layer (0-15 cm). This might be due to higher evaporation losses from upper soil layer. Foliar sprays of salicylic acid @ 75 ppm, NPK (19:19:19) @ 0.5 % and thiourea @ 500 ppm sprayed at flower initiation and pod development stages of lentil observed significantly lesser soil moisture depletion from upper soil layer 0-15 cm and 15-30 cm in comparison to water spray recorded at 60, 90 DAS and at harvest, respectively. Significantly higher values of soil moisture content was recorded with foliar spray of salicylic acid @ 75 ppm in the manner of 20.9 & 23.4, 18.5 & 20.9 and 15.2 & 18.1 % being statistically on par with NPK (19:19:19) @0.5% and thiourea @ 500 ppm as compared to water spray in upper soil layer 0-15 cm & 15-30 cm at 60, 90 DAS and at harvest, respectively. This might be possible mechanism of salicylic acid in enhancing plant responses to abiotic stress is that salicylic acid participates in the development of stress symptoms, but it is also needed for the acclimation process and induction of stress tolerance (Horvath *et al.*

Table 1. Effect of hydrogel and foliar nutrition on soil moisture content (%) at different soil depth and growing season of lentil (Pooled data of 3 years)

Treatment	Soil moisture content (%) at different soil depth & lentil growing season									
	At sowing		30 DAS		60 DAS		90 DAS		At harvest	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Hydrogel (kg/ha)										
0	25.5	29.1	23.3	26.0	18.5	20.4	17.5	19.2	14.1	16.2
2.5	25.6	29.2	24.2	26.9	21.2	23.6	18.2	20.4	15.0	17.5
5.0	25.8	29.5	24.5	27.5	22.2	24.7	18.8	21.4	15.7	18.3
SEm (+/–)	0.14	0.16	0.27	0.30	0.29	0.32	0.13	0.15	0.21	0.25
CD (P=0.05)	NS	NS	NS	NS	1.13	1.26	0.53	0.60	0.83	0.96
Foliar nutrition spray (FI & PD)										
Water spray	25.6	29.2	23.9	26.7	20.2	22.2	17.6	19.4	14.4	16.6
Urea 2 %	25.9	29.5	24.1	26.9	20.3	22.7	18.0	20.2	14.8	17.1
Thiourea 500 ppm	25.4	29.0	23.9	26.8	20.6	23.0	18.1	20.4	15.0	17.3
Salicylic acid 75 ppm	25.7	29.3	24.2	27.0	20.9	23.4	18.5	20.9	15.2	18.1
NPK (19:19:19) 0.5 %	25.7	29.4	23.9	26.7	21.1	23.2	18.7	20.6	15.3	17.7
SEm (+/–)	0.32	0.35	0.78	0.30	0.22	0.24	0.25	0.28	0.19	0.21
CD (P=0.05)	NS	NS	NS	NS	0.63	0.70	0.71	0.81	0.54	0.63

2007). Similarly, thiourea might have enabled the plant to produce proliferated roots having greater physiological activity as a result of presence of-SH group in these chemicals, as metabolic role of -SH group in root physiology is well recognized. Thus, plant treated with these thiols appears to have greater power for nutrient absorption as well as for their utilization in efficient way (Solanki 2003). Similar finding was reported by Ram *et al.* (2018) in lentil.

Growth and yield attributes: A perusal of pooled data (Table 2) revealed that drilling of hydrogel had positive effect on crop maturity duration, plant growth and yield attributes as compared to no hydrogel drilling in the soil. Drilling of hydrogel 5.0 kg/ha and 2.5 kg/ha before sowing of lentil hasten the maturity period 9 and 5 days in comparison to no hydrogel (control) thus led higher growth, yield attributes and grain yield of lentil. It might be due to hydrogel adsorb and hold more moisture in the root zone at reproductive to maturity phase of lentil crop helps in enhancing the maturity period and overcome the abiotic stress. Drilling of hydrogel 5.0 kg/ha before sowing recorded maximum and significantly tallest plant (60.1 cm), number of branches/plant (2.1) and number of pods/plant (67.2) over control and 2.5 kg/ha, respectively. It was registered 13.6, 39.6 and 36.1 per cent higher over control, respectively. This might be due to water conservation by hydrogel creates a buffered environment being effectiveness in short term drought tension and losses reduction in early establishment phase in the lentil plant. Hence, super absorbent polymers (hydrogel) causes improvement in plant growth by increasing water holding capacity in soils (Boatright *et al.* 1997) and delaying the duration to wilting point in drought stress (Gehring and Lewis 1980). Therefore, totally proficiency in water consumption and dry matter production are positive plant reactions by the super absorbent application (Woodhouse and Johnson 1991). Similarly, application of SAPs improved physical properties of soil, water use efficiency, reduced infiltration rate, increased water holding capacity and decreased evaporation losses (Choudhary *et al.* 1995; Shooshtarian *et al.* 2012) thus ultimately enhanced growth and yield attributes to increased grain yield of lentil under water scarce condition.

Foliar application of nutrients at flower initiation and pod development stages had positive effect on increasing growth parameters and yield attributes of lentil. Pooled data further revealed that foliar application of NPK (19:19:19) @0.5% at flower initiation & pod development stages recorded significantly tallest plant (59.7 cm), higher number of branches/plant (1.97), number of pods/plant (63.7) and number of grains/pod (1.6) being on par with salicylic acid @ 75 ppm and thiourea @ 500 ppm over water spray and urea 2 %, respectively. The per cent increase to the tune of 14.1, 28.8, 21.4 and 16.1 in respect of plant height, branches/ plant, pods/plant and seeds/pod over water spray, respectively. This might be help by foliar spray of NPK (19:19:19) @ 0.5 %, salicylic acid 75 ppm and thiourea 500 ppm increased dark fixation of CO_2 in embryonic tissues of plant has diverse biological activities. Its beneficial effect might be appears due to delayed senescence of both vegetative and reproductive organs as thiourea has cytokinin like activity particularly on delaying senescence (Halmann 1980). These regulators are also known to increase photosynthetically active leaf surface during grain filling period in cereals (Sahu *et al.* 1993). Drilling of hydrogel and foliar spray of bioregulators (thiourea, salicylic acid and multi grade nutrients) did not influenced the test weight significantly over control. These findings corroborate the findings of Ram *et al.* (2018) in lentil and Bochalia *et al.* (2011) in fenugreek.

Yield and economics: Soil drilling of hydrogel 5.0 kg/ha before lentil sowing in ear marked plots was recorded maximum and significantly higher grain yield (1325 kg/ha) over control and 2.5 kg/ha while net return (33390/ha) being on par with 2.5 kg/ha (31604/ha) over control only (Table 3). It was registered 45.6 and 56.1 per cent higher over control, respectively. Whereas, maximum and significantly higher B: C ratio (1.72) was fetched with hydrogel 2.5 kg/ha being on par with hydrogel 5.0 kg/ha (1.60) over no

Table 2. Effect of hydrogel and foliar nutrition on growth and yield attributes of lentil (Pooled data of 3 years)

Treatment	Days to maturity	Plant height (cm)	Branches/ plant	Pods/ plant	Seeds/ pod	Test weight (g)
Hydrogel (kg/ha)						
0	102	52.87	1.49	49.35	1.40	26.33
2.5	107	56.86	1.80	59.43	1.52	26.57
5.0	111	60.07	2.08	67.15	1.52	26.73
SEm (+/-)	-	1.01	0.04	1.41	0.05	0.60
CD (P=0.05)	-	3.11	0.11	4.33	0.16	NS
Foliar nutrition spray (FI & PD)						
Water spray	107	52.30	1.53	52.44	1.37	26.20
Urea 2 %	107	55.08	1.72	56.90	1.41	26.37
Thiourea 500 ppm	107	57.22	1.83	59.31	1.49	26.55
Salicylic acid 75 ppm	107	58.69	1.90	60.91	1.55	26.72
NPK (19:19:19) 0.5 %	107	59.69	1.97	63.66	1.59	26.88
SEm (+/-)	-	0.94	0.08	1.42	0.06	0.41
CD (P=0.05)	-	2.66	0.23	4.00	0.17	NS

Table 3. Effect of hydrogel and foliar nutrition on yield and economics of lentil (Pooled data of 3 years)

Treatment	Grain yield (kg/ha)	Harvest Index (%)	Net return (₹/ha)	B: C ratio
Hydrogel (kg/ha)				
0	910	30.44	21390	1.35
2.5	1220	30.57	31604	1.72
5.0	1325	30.96	33390	1.60
SEm (+/-)	22.83	0.15	935	0.05
CD (P=0.05)	70.34	0.47	2880	0.15
Foliar nutrition spray (FI & PD)				
Water spray	1046	30.43	24627	1.34
Urea 2 %	1127	30.72	27864	1.51
Thiourea 500 ppm	1168	30.69	29574	1.61
Salicylic acid 75 ppm	1191	30.70	30162	1.60
NPK (19:19:19) 0.5 %	1224	30.75	31748	1.72
SEm (+/-)	19.12	0.21	783	0.04
CD (P=0.05)	53.90	NS	2207	0.12

hydrogel. It may be due to application of super absorbent polymers (hydrogel) improves plant growth by increasing water holding capacity in soils (Boatright *et al.* 1997) and delaying the duration to wilting point in drought stress (Gehring and Lewis 1980) thus enhanced growth and yield attributes eventually for harvest higher grain yield of lentil.

Foliar application of nutrients at flower initiation and pod development stages had positive effect on grain yield and economics of lentil. A perusal of pooled data (Table 3) further revealed that foliar application of NPK (19:19:19) @ 0.5 % at flower initiation & pod development stages recorded maximum and significantly higher grain yield (1224 kg/ha), net return (31748/ha) and B:C ratio (1.72) also being on par with salicylic acid @ 75 ppm over water spray, urea 2 % and thiourea 500 ppm, respectively. The per cent increase in grain yield of lentil was to the tune of 17.0, 8.6 and 4.8 over water spray, urea 2 % and thiourea 500 ppm, respectively. This might be probably spray of NPK (19:19:19) @ 0.5 % and salicylic acid @ 75 ppm spray improved nitrogen supply to leaf by foliar absorption might have delayed the senescence of leaves and allowed greater soil total assimilation and carbon remobilization to the seeds of additional pods reported by Palta *et al.* 2005.

Thus, three years consecutive study suggests that soil drilling of hydrogel 2.5-5.0 kg/ha before lentil sowing and subsequently foliar spray of either NPK (19:19:19) @ 0.5 % or salicylic acid @ 75 ppm at flower initiation and pod development was found effective for increasing grain yield and economics of lentil. Hence, hydrogel 5.0 kg/ha along with foliar application of either NPK (19:19:19) @ 0.5 % or salicylic acid @ 75 ppm may become a practically convenient and economically feasible and viable option in water-stressed areas for increasing productivity of lentil with environmental sustainability.

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