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Effect of sulphydryl bioregulator sprays on yield and economics in lentil (*Lens culinaris*) under vertisols

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ABSTRACT

A field experiment was carried out during winter (*rabi*) seasons 2011-12 and 2012-13 at Agricultural Research Station, Ummedganj, Kota to find out the effective sulhpydryl bioregulator for increasing productivity and profitability of lentil (*Lens culinaris*) under vertisols of south eastern Rajasthan. Foliar spray of thiourea 500 ppm at pod initiation significantly increased the growth, yield attributes, grain yield (1898 kg/ha), net return (₹ 52269/ha) and B: C ratio (4.26) as compared to no spray. The alternately urea 2 % spray at pre flowering + pod initiation had significant effect on growth, yield attributes, grain yield and economics of lentil.

Key words: Lentil, Productivity, Profitability, Thiourea, Urea, Yield

Lentil (*Lens culinaris* Medikus Subsp *culinaris*) is the most important grain legume crop of *rabi* season after chickpea and widely grown in arid and semi-arid parts of the country and contributes significantly to food, feed and sustainable farming systems. It contains high amount of digestible protein (up to 35%), macro and micronutrients, particularly iron and zinc and vitamins, thus provides nutritional security to its consumers. It is the most drought tolerant crop among the grain legumes. In India, it is grown in an area of 1.27 million hectares, mostly confined to Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Rajasthan and Jharkhand with a production of 0.97 million tonnes (Anonymous, 2015-16). The Rajasthan state has a sizeable area 74.5 thousand hectares with annual production of 60.0 thousand tonnes and average productivity was only 859 kg/ha (Anonymous, 2015-16).

The productivity of lentil is low and unstable as most of the area under rainfed, may be ascribed to many reasons but, terminal heat and temperature extremities in the later stages of crop growth during moisture stress especially at pod development stage are the major factors which affect the lentil productivity due to flower drops and unfilled grains in pod. This aberrant weather condition and temperature extremities caused second generation problems in nutrient management 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). Pod and seed development are in part, dependent of carbon and nitrogen accumulated prior to podding (Davies *et al.* 2000) as roots fail to absorb nitrogen from dry vertisol soils if applied at that time. Under such situations, nitrogen supply can be maintained through foliar application at lower concentration. Hence, mitigation of terminal heat and temperature extremities is one of the major abiotic constraints for limiting productivity of lentil. The reasons for low yield are occurrence of various biotic, abiotic and edaphic factors at different growth stages. This has further been compounded by the non-adoption of improved agronomic practices and inadequate availability of quality seeds of suitable improved varieties. To realize the maximum production for existing varieties it is necessary that the chemical reactions takes place in the plants are in balanced and efficient manner which help in formation of quality seed. 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).

Keeping this in view, a field experiment was carried out to find out the effective sulphydryl bioregulator for enhancing productivity and profitability of lentil under vertisols.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* (winter) seasons of 2011-12 and 2012-13 at Agricultural Research Station (Agriculture University), Ummedganj, Kota to find out effective sulphydryl bioregulator for enhancing productivity and profitability of lentil under vertisols. The soil of the experimental field was clay loam, slightly alkaline in reaction (pH 7.5), poor in organic carbon (4.1 g/kg), low in available nitrogen (278.5 kg/ha), phosphorus (20.5 kg/ha), sulphur (16.1 kg/ha) and medium in available potassium (292.5 kg/ha). The experiment was carried out in randomized block design comprised of 13 treatments *viz.*, T_1- no spray (Control), T_2- water spray at PF (45 DAS), T_3- water spray at PI (65 DAS), T_4- water spray at PF+ PI (45 & 65 DAS), T_5- urea 2 % at PF (45 DAS), T_6- urea 2 % at PI (65 DAS), T_7- urea 2 % at PF + PI (45 & 65 DAS), T_8- thiourea 500 at PF (45 DAS), T_9- thiourea 500 at PI (65 DAS), T_{10}- thiourea 500 at PF + PI (45 & 65 DAS) T_{11}- thiourea 1000 at PF (45 DAS), T_{12}- thiourea 1000 at PI (65 DAS)and T_{13}- thiourea 1000 at PF + PI (45 & 65 DAS) with three replications. The

recommended dose of fertilizer (20 kg N, 17.5 kg P, 25 kg K/ ha and 5 kg Zn) was applied through organic and inorganic sources. Organic manure (farm yard manure) was applied two weeks before sowing and chemical fertilizers were drilled into the soil at the time of sowing in earmarked plots. Seeds were treated with rhizobium and phosphate solubilising bacteria (PSB) @ 10 g/kg as per treatment.

A pre-sowing irrigation was applied to all the plots 10 days before sowing. The seed of variety DPL-62 was drilled at 30 cm and 5 cm inter and intra row spacing, respectively by adopting the seed rate of 60 kg/ha. Weeds were managed manually by hand weeding at 30 and 60 days after sowing (DAS). The plant protection measures were taken up as and when required. In each plot five plants were randomly selected and tagged to record biometric observations on growth and yield attributes. Data on number and dry weight of nodules/plant were recorded at 70 DAS by digging five plants from each plot. Number of nodules/plant were counted and then dried to get nodule weight/plant. 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. All data were subjected to analysis of variance.

RESULTS AND DISCUSSION

Nodule count and biomass: The results showed that all the foliar sprays significantly enhanced the number and dry weight of nodules observed at 70 days after sowing (DAS) as compared to no spray (Table 1). Foliar spray of thiourea 500-1000 ppm sprayed at pre flowering (PF), pod initiation (PI) and pre flowering + pod initiation (PF+PI) recorded significantly higher number and dry weight of nodules as compared to no spray, water spray and urea spray at pre flowering (PF), pod initiation (PI) and pre flowering + pod initiation (PF+PI) but thiourea 500-1000 ppm remained statistically on par with each other. It was registered to the tune of 62.6 & 44.4 and 72.4 & 50.2 per cent higher with foliar spray of thiourea 500 ppm and 1000 ppm at pre flowering + pod initiation (PF+PI) over no spray, respectively. The foliar spray of thiourea increased the plant photosynthetic efficiency and canopy photosynthesis due to presence of –SH group as an integral constituent of these thiols might have helped in better nodulation. Thus, improvement in nodulation was also resulting in better root growth and consequently exploited greater soil volume for nodulation. Foliar sprays of 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 findings was reported by Halmann, 1980.

Growth and yield attributes: A perusal of data (Table 1) further revealed that foliar spray of bioregulators (water, urea and thiourea) have significant improvement in plant height, branches/plant, pods/plant and seeds/pod over no spray. Significantly taller plant (56.6 cm), branches/plant (3.5), pods/plant (91.4) and seeds/pod (1.83) was observed in two foliar spray of thiourea 500 pp at pre flowering and pod initiation remained on par with one foliar spray of thiourea at pre flowering or pod initiation, one spray of urea at pre flowering or pod initiation or both and higher concentration of thiourea 1000 ppm one spray at pre flowering or pod initiation or both over no spray and one water spray at pre flowering or pod initiation. Two foliar spray of urea 2 % and thiourea 500 ppm at pre flowering and pod initiation had registered per cent increase of 31.0 and 36.1 in plant height, 41.7 and 45.8 in branches/plant, 30.4 and 41.7 in pods/plant and 48.7 and 48.7 in seeds/pod over no spray, respectively. Foliar spray of bioregulators (water, urea and thiourea) did not influence the test weight

Table 1. Effect of sulphydryl bioregulator on nodule, growth parameters and yield attributes of lentil (Pooled data of 2 years)

Treatment	Nodules (no) /plant at 70 DAS	Nodule dry weight (mg/plant) at 70 DAS	Plant height (cm)	Branches/ plant (Nos)	Pods/ plant (Nos)	Seeds/ pod (Nos)	Test weight (g)
No spray (Control)	12.3	27.5	41.6	2.4	64.5	1.23	28.65
Water spray at PF (45 DAS)	14.7	34.3	47.8	2.8	68.5	1.43	28.72
Water spray at PI (65 DAS)	15.0	34.7	48.7	2.9	70.0	1.53	28.73
Water spray at PF+ PI (45 & 65 DAS)	15.4	35.2	50.4	3.0	73.0	1.60	28.93
Urea 2 % at PF (45 DAS)	17.4	35.3	51.7	3.2	78.3	1.63	29.01
Urea 2 % at PI (65 DAS)	17.4	36.2	53.4	3.3	81.5	1.70	29.23
Urea 2 % at PF + PI (45 & 65 DAS)	17.8	36.8	54.5	3.4	84.1	1.83	29.37
Thiourea 500 at PF (45 DAS)	19.5	37.4	52.3	3.3	84.2	1.67	29.25
Thiourea 500 at PI (65 DAS)	19.6	39.0	54.0	3.5	87.5	1.67	29.33
Thiourea 500 at PF + PI (45 & 65 DAS)	20.0	39.7	56.6	3.5	91.4	1.83	29.37
Thiourea 1000 at PF (45 DAS)	20.3	40.3	52.3	3.5	86.4	1.63	29.27
Thiourea 1000 at PI (65 DAS)	20.5	40.7	54.0	3.5	89.4	1.70	29.36
Thiourea 1000 at PF + PI (45 & 65 DAS)	21.2	41.3	57.0	3.6	94.3	1.80	29.43
SEm $\pm$	0.6	1.4	2.6	0.2	4.1	0.11	0.24
CD (P=0.05)	1.67	4.03	7.7	0.6	11.9	0.32	NS

Table 2. Effect of sulphydryl bioregulator on yield and economics of lentil (Pooled data of 2 years)

Treatment	Yield (kg/ha)			Harvest index (%)	Total cost of cultivation (₹ /ha)	Gross return (₹/ha)	Net return (₹/ha)	B : C ratio
	Grain	Straw	Biological					
No spray (Control)	1420	2459	3879	36.64	11500	48286	36786	3.20
Water spray at PF (45 DAS)	1664	2834	4498	36.96	12000	56570	44570	3.71
Water spray at PI (65 DAS)	1682	2849	4531	37.10	12000	57171	45171	3.76
Water spray at PF+ PI (45 & 65 DAS)	1733	2922	4655	37.21	12500	58911	46411	3.71
Urea 2 % at PF (45 DAS)	1771	3004	4776	37.09	12030	60225	48195	4.01
Urea 2 % at PI (65 DAS)	1811	3042	4853	37.30	12030	61591	49561	4.12
Urea 2 % at PF + PI (45 & 65 DAS)	1855	3106	4961	37.40	12560	63070	50510	4.02
Thiourea 500 at PF (45 DAS)	1874	3142	5017	37.34	12275	63730	51455	4.19
Thiourea 500 at PI (65 DAS)	1898	3197	5096	37.23	12275	64544	52269	4.26
Thiourea 500 at PF + PI (45 & 65 DAS)	1947	3294	5241	37.14	13050	66209	53159	4.07
Thiourea 1000 at PF (45 DAS)	1890	3197	5087	37.14	12550	64254	51704	4.12
Thiourea 1000 at PI (65 DAS)	1916	3251	5167	37.02	12550	65127	52577	4.19
Thiourea 1000 at PF + PI (45 & 65 DAS)	1955	3290	5245	37.27	13600	66459	52859	3.89
SEm $\pm$	82	135	216	0.242	-	-	2786	0.22
CD (P=0.05)	239	394	628	NS	-	-	8114	0.65

significantly over control. The foliar spray of thiourea increased dark fixation of CO_2 in embryonic tissues of chickpea as the –SH group has diverse biological activities. Its beneficial effect in the present study secondly appears to be due to delayed senescence of both vegetative and reproductive organs as thiourea has cytokinin like activity particularly on delaying senescence (Halmann, 1980). Thiourea is also known to increase photosynthetically active leaf surface during grain filling period in cereals (Sahu *et al.* 1993). These findings corroborate the findings of Ram and Punia, 2007 and Bochalia *et al.* 2011in fenugreek.

Yield and economics: Foliar spray of bioregulators showed beneficial effect on grain, straw and biological yields as well as economics as compared to no spray (Table 2). Foliar spray of thiourea 500-1000 ppm at pre flowering, pod initiation and pre flowering + pod initiation and also urea 2% spray at pre flowering, pod initiation and pre flowering + pod initiation had significant influence on yield and economics of lentil. Application of two foliar spray of thiourea 500 ppm at pre flowering + pod initiation recorded significantly higher grain (1947 kg/ha), straw (3294 kg/ha), biological yields (5241 kg/ha), gross return (66209/ha) and net return (53159/ha) remained statistically on par with one foliar spray of thiourea 500 ppm at pre flowering or pod initiation and urea 2% spray at pre flowering or pod initiation or pre flowering + pod initiation over no spray and water spray at pre flowering and pod initiation. Foliar spray of urea 2% at pre flowering+ pod initiation and thiourea 500 ppm at pre flowering + pod initiation had registered 30.6 and 37.1 per cent higher grain yield over no spray. Similarly, maximum net return was fetched thiourea 500 ppm at pre flowering + pod initiation to the tune of 16373/ha followed by urea 2 % spray at pre flowering + pod initiation (13724/ ha) and thiourea 1000 ppm at pre flowering + pod initiation (16073/ha) over no spray. Thiourea is also known to increase photo synthetically active leaf surface during grain filling period in cereals might be increased yield (Sahu *et al.* 1993). Urea 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. Similar mechanism might have resulted in yield increase was found in chickpea (Palta *et al.* 2005).

Highest B:C ratio (4.26) was observed under thiourea 500 ppm at pod initiation which was significantly superior over no spray but remained statistically on par with rest of the treastments. The next best treatment was thiourea 500 ppm at pre flowering (4.19) and thiourea 1000 ppm at pod initiation (4.19). This might be due to that cost of cultivation is less in these treatments and synergistic effect of foliar spray of bioregulator for cumulative enhancement of yield attributes and yield. These results are in close agreement with the findings of Ram and Punia, 2007 and Bochalia *et al.* 2011 in fenugreek.

Thus, two years study suggests that foliar spray of thiourea 500 ppm at pod initiation or pre flowering harvest maximum productivity and profitability of lentil.

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