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The effect of irrigation and foliar spray of nutrients and growth hormones on nutrient uptake and water use efficiency of lentil

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Abstract

The field experiment was conducted during *Rabi* season of 2017-18 at the Research cum Instructional Farm, under all India Coordinated Research Project on MULLaRP, Department of Agronomy, College of Agriculture, I.G.K.V. Raipur (CG.) on 'The effect of irrigation and foliar spray of nutrients and growth hormones on nutrient uptake and water use efficiency of lentil'. The experiment was laid out in Strip Plot Design having the combination of fourteen treatments and three replications. The treatment consisted of seven foliar nutrients spray and two irrigation levels. The experiment was comprised of factor A. Horizontal plot (Irrigation level-2) I₁-One irrigation (35 DAS), I₂-Two irrigation (35 and 65 DAS) B. Vertical plot (Foliar Spray-7) F₁-Water Spray, F₂-Nitrobenzene @ 0.3%, F₃-N: P: K:: 19:19:19 @ 1% solution, F₄-Multi micro nutrient (Fe, Mn, Zn, B, Cu, Mo) @ 0.1%, F₅-Plant growth hormones mixture (Cytokinins and Enzymes) @ 0.15%, F₆-N: P: K:: 19:19:19 @ 1% + Multi micro nutrient (Fe, Mn, Zn, B, Cu, Mo) @ 0.1%, F₇-N: P: K: 19:19:19 + Multi micro nutrients + Plant growth hormones. Significantly maximum N, P and K uptake in seed, stover as well as in total was recorded with I₂-Two irrigations followed by I₁-One irrigation. As regards to foliar spray, significantly higher N, P and K uptake in seed, stover and in total was noted under F₇-N: P: K: 19:19:19 + MMN + PGHM as compared to others, however, it was at par to treatments F₆-N: P: K: 19:19:19 + MMN, F₃-N: P: K: 19:19:19 @ 1% and F₄-Multi Micro Nutrients. Between the irrigation levels, significantly higher water use efficiency (86.79 kg ha⁻¹cm) was recorded with I₁-One irrigation as compared to I₂-Two irrigation (66.06 kg ha⁻¹cm). As regards to the foliar spray of micronutrients and growth hormones, maximum water use efficiency (89.56 kg ha⁻¹cm) was recorded with F₇-N: P: K: 19:19:19 + MMN + PGHM. However, it was at par to treatment F₆-N: P: K: 19:19:19 + MMN (82.13 kg ha⁻¹). The minimum water use efficiency (58.03 kg ha⁻¹cm) was observed with F₁- Control (water spray).

Keywords: Lentil, irrigation, growth hormones, nutrient uptake, water use efficiency

Introduction

India is one of the major lentil growing countries in the world. In India, it is grown over an area of 1.27 m ha with an annual production of 0.976 mt and an average productivity of 765 kg ha⁻¹ (Anonymous, 2016-17) [2]. Lentil is mainly cultivated in Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Jharkhand, Bihar and West Bengal. It is generally grown as rainfed crop during *Rabi* season after rice, maize, pearl millet. Chhattisgarh state has good agro-ecological situation for lentil production. In state it is grown over an area of 17.5 thousand hectare with an annual production of 5.7 thousand tonnes and an average productivity of 331 kg ha⁻¹ (Anonymous, 2016) [1]. Foliar application of micronutrients and growth hormones to the standing crop in the form of spray for quick recovery from the deficiency. It avoids fixation of nutrients in the soil. Therefore it becomes an important aspect of research. Foliar application of micronutrients is more beneficial than soil application. Since application rates are lesser as compared to soil application, same application could be obtained easily and crop reacts to nutrient application immediately (Zayed *et al.*, 2011) [10]. Insufficient water supply during the growing period may reduce crop production and quality (Debaeke and Aboudrare, 2004) [3], while excess irrigation not only wastes water and increases nutrient leaching (Pang *et al.*, 1997) [5], but can also reduce crop yield (Sezen *et al.*, 2006) [7]. These reasons emphasis on developing methods of irrigation that minimize water use or maximize the water use efficiency. Low and variable seed yield is a major problem limiting the production and rapid expansion of grain legumes including lentil in tropic. The serious problem of flower drop and poor seed setting need serious attentions.

Materials and methods

The experiment was comprised of horizontal and vertical factor against effect of irrigation and foliar spray of nutrients and growth hormones on growth, yield attributes and yield of lentil.

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The treatment consisted of seven foliar nutrients spray and two irrigation levels. The experiment was laid out in Strip Plot Design having the combination of fourteen treatments and three replications. The treatment was carried out during *Rabi* season of 2017-18 at Instructional cum Research Farm, I.G.K.V., Raipur, Chhattisgarh. The soil of the experimental field was *Vertisols* with low, medium and high in N, P and K, respectively and neutral in reaction. The climate of the region is sub-humid to semi-arid.

Observation recorded

During crop growth period various growth attributing characters of lentil such as plant population (m^{-2}), plant height (cm), number of branches $plant^{-1}$, leaf area $plant^{-1}(cm^2)$, leaf area index, dry matter accumulation ($g\ plant^{-1}$), crop growth rate ($g\ day^{-1}\ plant^{-1}$), relative growth rate ($g\ g^{-1}\ day^{-1}$), number of nodules $plant^{-1}$ and dry weight of nodules ($g\ plant^{-1}$), yield attributing characters seed yield and stover yield, nutrient uptake, water use efficiency were taken as per schedule and requirement of investigation.

Result and discussion

Nutrient content (%) in lentil

After harvesting of lentil crop, plant samples were analyzed for nitrogen, phosphorus and potassium content and data are embodied in Table 1. The results revealed that N, P and K content in seed and stover did not differ significantly with different irrigation levels and foliar spray of micronutrients and growth hormones. However, between the irrigation levels, the maximum N, P and K content in seed and stover was observed with I_2 -Two irrigations and minimum was noted under I_1 -One irrigation. Nutrient content i.e. N,P,K content in seed and stover remain unaffected due to different foliar spray of micronutrients and growth hormones. In general, maximum N and P content in seed and stover and K content in seed was noted with treatment F_7 - N: P: K:: 19:19:19 + MMN + PGHM. Whereas, the minimum N and P content in seed and stover and K content in seed was observed with F_1 -Control (water spray), but F_6 -N: P: K:: 19:19:19: + MMN recorded minimum K content in stover. The differences in nutrient content of lentil due to interaction between irrigation levels and foliar spray of micronutrients and growth hormones was found non- significant.

Nutrient uptake by lentil

Data related with N, P and K uptake in seed and stover are presented in Table 2. Irrigation levels significantly influenced the N, P and K uptake in seed, stover. Significantly maximum nitrogen uptake in seed ($45.93\ kg\ ha^{-1}$) and stover ($25.71\ kg\ ha^{-1}$) was recorded with I_2 -Two irrigations and minimum was noted with I_1 -One irrigation. As regard to different foliar spray of micronutrients and growth hormones, treatment F_7 -N: P: K:: 19:19:19 + MMN + PGHM produced significantly maximum nitrogen uptake in seed ($52.54\ kg\ ha^{-1}$), stover ($27.78\ kg\ ha^{-1}$). However, it was at par to treatments F_3 - N: P: K:: 19:19:19 @ 1% and F_6 - N: P: K:: 19:19:19: + MMN in case of seed, stover and treatment F_4 - Multi Micro Nutrients in case of seed and stover. The lowest nitrogen uptake in seed ($32.85\ kg\ ha^{-1}$), stover ($18.13\ kg\ ha^{-1}$) was recorded with F_1 -Control (water spray). Higher uptake of nitrogen during growth period which increased photosynthesis, synthesis of protoplasm and protein for higher rate of mitosis. The higher protein content was found with application of enriched sap which might be due to foliar nutrition of macro elements with hormones, could improve the photosynthetic activity and enzymes carbohydrate transformation (Doss *et al.*,2013) [4].

Phosphorus uptake in grain, stover was observed significant due to different irrigation levels and foliar spray of micronutrients and growth hormones. Significantly maximum phosphorus uptake in seed ($3.14\ kg\ ha^{-1}$), stover ($3.05\ kg\ ha^{-1}$) was recorded with treatment I_2 -Two irrigations and minimum was noted with I_1 -One irrigation. As regards to foliar spray of micronutrients and growth hormones, treatment F_7 -N: P: K:: 19:19:19 + MMN + PGHM produced significantly maximum phosphorus uptake in seed ($3.63\ kg\ ha^{-1}$), stover ($3.58\ kg\ ha^{-1}$), but it was at par to treatments F_3 - N: P: K:: 19:19:19 @ 1% and F_6 -N: P: K:: 19:19:19: + MMN. The lowest phosphorus uptake in seed ($2.08\ kg\ ha^{-1}$), stover ($1.60\ kg\ ha^{-1}$) and in total ($3.68\ kg\ ha^{-1}$) was recorded with F_1 -Control (water spray). Potassium uptake in seeds, stover were observed significant due to different irrigation levels and foliar spray of micronutrients and growth hormones. Between the irrigation levels, significantly maximum potassium uptake in seed ($15.04\ kg\ ha^{-1}$) and stover ($65.74\ kg\ ha^{-1}$) was recorded with I_2 -Two irrigations and minimum value was noted with I_1 -One irrigation. In case of foliar spray of micronutrients and growth hormones, treatment F_7 -N: P: K:: 19:19:19 + MMN + PGHM produced significantly maximum potassium uptake in seeds (17.30) and stover (70.71) However, it was at par to treatment F_6 - N: P: K:: 19:19:19: + MMN in case of seed, stover, treatment F_3 -N: P: K:: 19:19:19 @ 1% in case of stover and treatment F_4 -Multi Micro Nutrients (MMN) in case of stover. The lowest potassium uptake in seed ($9.89\ kg\ ha^{-1}$) and stover ($44.80\ kg\ ha^{-1}$) was recorded with F_1 -Control (water spray).

Water use efficiency ($kg\ ha^{-1}\ cm$)

The data on water use efficiency are presented in Table 3 and 4. The results revealed that water use efficiency differ significantly with different irrigation levels and foliar spray of micronutrients and growth hormones. Between the irrigation levels, significantly higher water use efficiency ($86.79\ kg\ ha^{-1}\ cm$) was recorded with I_1 -One irrigation as compared to I_2 -Two irrigation ($66.06\ kg\ ha^{-1}\ cm$). As regards to foliar spray of micronutrients and growth hormones, maximum water use efficiency ($89.56\ kg\ ha^{-1}\ cm$) was recorded with F_7 - N: P: K:: 19:19:19 + MMN + PGHM. However, it was at par to treatment F_6 -N: P: K: 19:19:19 + MMN ($82.13\ kg\ ha^{-1}$). The minimum water use efficiency ($58.03\ kg\ ha^{-1}\ cm$) was observed with F_1 - Control (water spray). The differences in water use efficiency of lentil due to interaction effect of irrigation levels and foliar spray of micronutrients and growth hormones was found non- significant. Ray *et al.*, (2001) [6] and Singh *et al.* (2004) [8] also noted similar findings.

Seed yield ($kg\ ha^{-1}$)

Data related to seed yield are presented in Table 5 and 6 respectively. Irrigation levels significantly influenced the seed yield ($kg\ ha^{-1}$) of lentil. Between the irrigation levels, significantly higher seed yield ($1189.05\ kg\ ha^{-1}$) was observed under the I_2 -Two irrigations as compared to I_1 -One irrigation due to optimum plant population and superior growth and yield attributes. As regards to foliar spray of micronutrients and growth hormones, treatment F_7 -N: P: K:: 19:19:19 + MMN + PGHM produced significantly higher seed yield ($1320.0\ kg\ ha^{-1}$) as compared to others. However, it was at par to treatment F_6 -N: P: K: 19:19:19: + MMN ($1194.17\ kg\ ha^{-1}$). The lowest seed yield ($868.33\ kg\ ha^{-1}$) was observed with F_1 -Control (water spray). The seed yield is the resultant of growth and yield attributing characters of a crop. The superiority of growth characters *viz.* number of nodules,

branches, dry matter accumulation and yield attributes i.e. pods plant⁻¹ and seeds pod⁻¹ as discussed earlier could be accounted for the production of higher yield under F7- N: P: K:: 19:19:19 + MMN + PGHM. The differences in seed yield of lentil due to interaction effect of irrigation levels and foliar spray of micronutrients and growth hormones was found non-significant.

Stover yield (kg ha⁻¹)

Data related to stover yield are presented in Table 6. Between the irrigation levels, significantly higher stover yield (1955.52 kg ha⁻¹) was observed under I₂-Two irrigations as compared to I₁-One irrigation (1595.10 kg ha⁻¹) due to optimum plant population and superior growth and yield attributes. As regards to foliar spray of micronutrients and growth hormones, treatment F7- N: P: K: 19:19:19 + MMN + PGHM produced significantly higher stover yield of (2109.17 kg ha⁻¹) as compared to others. However, it was at par to treatment F6- N: P: K: 19:19:19 + MMN (1986.50 kg ha⁻¹). The lowest stover yield (1327.83 kg ha⁻¹) was observed with F1-Control (water spray). The higher values of growth characteristics viz. plant height, branches and dry matter accumulation of F7-N: P: K: 19:19:19 + MMN + PGHM gave higher stover yield under this foliar spray of micronutrients and growth hormones. The differences in stover yield of lentil due to interaction between irrigation levels and foliar spray of micronutrients and growth hormone was found non-significant.

Harvest index (%)

The data on harvest index are presented in Table 4.1 and 4.1.1. Non-significant variations are observed in harvest index due to different irrigation levels and foliar spray of micronutrients and growth hormones. Similarly, interaction effect was also noted to be non-significant. However, between the irrigation levels, I₁-One irrigation recorded maximum harvest index (39.46 %) and minimum was noted under I₂-Two irrigation (38.0). With respect to foliar spray of micronutrients and growth hormones, treatment F5-Plant Growth Hormones Mixture (PGHM) @ 0.15% recorded maximum harvest index (39.32%) and the minimum harvest index (37.67%) was recorded with F6- N: P: K:: 19:19:19 + MMN.

Conclusion

The available N, P and K in soil after harvest of lentil, N, P, K content in seed and stover, protein content in lentil as well as harvest index did not influence significantly due to different irrigation levels and foliar spray of micronutrients and growth hormones. Under irrigation levels, I₁-One irrigations at 35 DAS and in foliar spray of micronutrients and growth hormones, F₇-N: P: K: 19:19:19 + MMN + PGHM followed by F₆- N:P:K::19:19:19 + MMN recorded more water use efficiency. Nutrient uptake recorded more under irrigation levels, I₂-Two irrigations at 35 and 65 DAS and in foliar spray of micronutrients and growth hormones, F₇-N: P: K:: 19:19:19 + MMN + PGHM followed by F₆- N:P:K::19:19:19 + MMN.

Table 1: Nutrient content in lentil as affected by irrigation levels and foliar spray of micronutrients and growth hormones

Treatment		Nutrient content (%)					
		N		P		K	
		Seed	Stover	Seed	Stover	Seed	Stover
Irrigation levels							
I ₁ -	One irrigation (35 DAS)	3.80	1.23	0.25	0.14	1.19	3.35
I ₂ -	Two irrigations (35 and 65 DAS)	3.86	1.31	0.26	0.16	1.26	3.44
	SEm±	0.10	0.05	0.01	0.01	0.02	0.07
	CD (P=0.05)	NS	NS	NS	NS	NS	NS
Foliar spray							
F ₁ -	Water Spray	3.74	1.21	0.23	0.12	1.14	3.41
F ₂ -	Nitrobenzene @ 0.3%	3.77	1.26	0.24	0.14	1.17	3.46
F ₃ -	N: P: K:: 19:19:19 @ 1%	3.86	1.29	0.27	0.17	1.27	3.45
F ₄ -	Multi Micro Nutrients(MMN)	3.84	1.27	0.26	0.15	1.23	3.38
F ₅ -	Plant Growth Hormones Mixture (PGHM) @ 0.15%	3.76	1.24	0.24	0.14	1.17	3.38
F ₆ -	N: P: K:: 19:19:19 + MMN	3.89	1.30	0.27	0.16	1.27	3.34
F ₇ -	N: P: K:: 19:19:19 + MMN + PGHM	3.92	1.31	0.27	0.17	1.30	3.35
	SEm±	0.28	0.09	0.02	0.01	0.04	0.15
	CD (P=0.05)	NS	NS	NS	NS	NS	NS
	Interaction I×F	NS	NS	NS	NS	NS	NS

Table 2: Nutrient uptake in lentil as affected by irrigation levels and foliar spray of micronutrients and growth hormones

Treatment		Nutrient uptake (kg ha ⁻¹)					
		N		P		K	
		Seed	Stover	Seed	Stover	Seed	Stover
Irrigation levels							
I ₁ -	One irrigation (35 DAS)	40.02	20.43	2.64	2.39	12.41	54.87
I ₂ -	Two irrigations (35 and 65 DAS)	45.93	25.71	3.14	3.05	15.04	65.74
	SEm±	0.85	0.41	0.06	0.05	0.31	1.17
	CD (P=0.05)	5.15	2.47	0.34	0.31	1.88	7.12
Foliar spray							
F ₁ -	Water Spray	32.85	18.13	2.08	1.60	9.89	44.80
F ₂ -	Nitrobenzene @ 0.3%	39.93	20.66	2.57	2.14	12.39	53.66
F ₃ -	N: P: K:: 19:19:19 @ 1%	45.40	25.86	3.17	3.33	14.84	69.71
F ₄ -	Multi Micro Nutrients	43.67	22.77	2.97	2.76	13.98	61.15
F ₅ -	Plant Growth Hormones Mixture (PGHM) @ 0.15%	39.71	20.31	2.60	2.35	12.52	55.71
F ₆ -	N: P: K:: 19:19:19 + MMN	46.73	26.02	3.19	3.28	15.16	66.41
F ₇ -	N: P: K:: 19:19:19 + MMN + PGHM	52.54	27.78	3.63	3.58	17.30	70.71
	SEm±	3.21	1.64	0.19	0.21	0.71	3.14
	CD (P=0.05)	9.89	5.06	0.60	0.64	2.17	9.68
	Interaction I×F	NS	NS	NS	NS	NS	NS

Table 3: Water use efficiency of lentil as affected by irrigation levels and foliar spray of micronutrients and growth hormones

Treatment		WUE (kg ha ⁻¹ cm)
Irrigation levels		
I ₁	One irrigation (35 DAS)	86.79
I ₂	Two irrigation (35 and 65 DAS)	66.06
SEm±		1.65
CD (P=0.05)		10.02
Foliar spray		
F ₁	Water Spray	58.03
F ₂	Nitrobenzene @ 0.3%	72.55
F ₃	N: P: K:: 19:19:19 @ 1%	81.32
F ₄	Multi micro nutrients (MMN)	77.18
F ₅	Plant Growth Hormones Mixture (PGHM) @ 0.15%	74.19
F ₆	N: P: K:: 19:19:19: + MMN	82.13
F ₇	N: P: K:: 19:19:19 + MMN + PGHM	89.56
SEm±		3.60
CD (P=0.05)		11.08
Interaction I×F		NS

Table 4: Interaction table on water use efficiency of lentil as affected by irrigation and foliar spray of micronutrients and growth hormones.

A×B	I ₁	I ₂	Total	Mean
F ₁	58.75	57.31	116.06	58.032
F ₂	83.06	62.04	145.09	72.546
F ₃	97.64	65.00	162.64	81.319
F ₄	86.67	67.69	154.35	77.176
F ₅	89.31	59.07	148.38	74.190
F ₆	94.72	69.54	164.26	82.130
F ₇	97.36	81.76	179.12	89.560
Total	607.50	462.41		
Mean	86.79	66.06		

Table 5: Yield and harvest index of lentil as affected by irrigation levels and foliar spray of micronutrients and growth hormones

Treatment		Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index (%)
Irrigation levels				
I ₁	One irrigation (35 DAS)	1041.43	1595.10	39.46
I ₂	Two irrigations(35 and 65 DAS)	1189.05	1955.52	38.0
SEm±		22.44	22.85	0.41
CD (P=0.05)		136.55	139.05	NS
Foliar spray				
F ₁	Water Spray	868.33	1327.83	39.14
F ₂	Nitrobenzene @ 0.3%	1056.67	1686.67	39.07
F ₃	N: P: K:: 19:19:19 @ 1%	1170.83	1883.67	38.38
F ₄	Multi Micro Nutrients (MMN)	1129.17	1782.50	39.20
F ₅	Plant Growth Hormones Mixture (PGHM) @ 0.15%	1067.50	1650.83	39.32
F ₆	N: P: K:: 19:19:19: + MMN	1194.17	1986.50	37.67
F ₇	N: P: K:: 19:19:19 + MMN + PGHM	1320.0	2109.17	38.34
SEm±		47.29	51.31	0.98
CD (P=0.05)		145.71	158.11	NS
Interaction I×F		NS	NS	NS

Table 6: Interaction table on seed yield of lentil as affected by irrigation and foliar spray of micronutrients and growth hormones

A×B	I ₁	I ₂	Total	Mean
F ₁	705	1032	1737	868
F ₂	997	1117	2113	1057
F ₃	1172	1170	2342	1171
F ₄	1040	1218	2258	1129
F ₅	1072	1063	2135	1068
F ₆	1137	1252	2388	1194
F ₇	1168	1472	2640	1320
Total	7290	8323		
Mean	1041	1189		

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