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EFFECT OF FOLIAR AND SOIL APPLICATION OF NITROGEN, PHOSPHORUS AND POTASSIUM ON YIELD COMPONENTS OF LENTIL

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Abstract

Lentil is an important food supplement bearing potential nutrients. An experiment was conducted to evaluate the effect of foliar and soil application of nitrogen, phosphorus and potassium (NPK) on yield component of lentil (*Lens culinaris* Medic). In general, best results were recorded from the plants treated with NPK through both soil and foliage. Optimal concentration of NPK for the various yield parameters was found to be 0.17% N, 0.21% P and 0.33% K for foliar and 0.35% N, 0.32% P and 0.50% K for soil application at pH 7.0. Timing of fertilizer application also affected different yield components. Multiple application of both soil and foliar application of NPK gave better results as compared to single application of NPK. Soil application produce slightly improved results compared to foliar application when applied unaided. The foliar application of nitrogen alone was more effective than NPK in producing higher number of seeds per pod.

Introduction

With growing population of the world in general and the developing countries in particular, demands are overwhelmed for enhanced food production. Besides emphasizing on main crops and vegetables, various pulses also play an important role to satisfy the growing human food demands. Among many others, lentil is an important food source for the people especially in the subcontinent.

Lentils (locally called masur) are grown as a post-rainy season crop in the rain-fed areas. It is a vital component of rain-fed (barani) cropping systems, providing an alternative to cereal grains. It is grown as a sole crop and may be inter-cropped with wheat, mustard and chickpea (Quraishi & Zia, 1997). The seeds of lentil approximately contain 11.2% water, 25% protein, 10% fat, 55.8% carbohydrates, 3.7% fiber, and 3.3% ash (Purseglove, 1968; Wang *et al*., 2009). On the global basis, Pakistan is the second largest producer of lentil after India. In Pakistan, lentil was cultivated on 47 thousands hectares in the year 2005-06 with an annual production of 37.1 thousands metric tons and an average yield of 593 kg per hectare. These estimates show a slight decrease in the total area under lentil cultivation, which was 69.5 thousands hectares during 1996-97 (Anon., 1998).

To get higher production from the available scarce cultivable land resources, feasible conditions for cultivation are key factors. The importance of nutrients in plant growth and yield was known from time immemorial. The nutrients applied in the agricultural fields in the form of dung manure and ash is still in practice in least developing countries. However, crop physiologists have recently developed the technique of foliar application to the agricultural crops (Kochhar & Krishnamoorthy, 1988; Smolen & Sady, 2008; Smolen & Sady, 2009). Foliar application is regarded as a preferred solution when the quick supply of nutrients is hindered or the soil conditions are not conducive for the absorption of nutrients (Salisbury & Ross, 1985). The nature of soil plays a very vital role in the availability of Mn, Cu, Zn, and Fe, which are precipitated in insoluble form in alkaline soils. Most of the absorption by the young leaf takes place through the cuticle and hairs (trichomes) while some absorption might take place through stomata (Salisbury & Ross, 1985).

The most efficient way to apply fertilizer is by soil. Foliar application of fertilizer should be viewed as temporary or emergency solution only but still it showed excellent results in some crops. The foliar method of fertilizer application is usually preferred because very small amounts of fertilizers are applied per hectare. It also reduces the number of passes of the applicant, thereby reducing problem of soil compactness. Foliar application is also less likely to result in ground water pollution. The adverse effect of the application of combined nitrogen to soil on biological nitrogen fixation is known. It is interesting to determine the impact of foliar application of nitrogen on natural ability of plants to fix atmospheric nitrogen. The atmospheric nitrogen is fixed in the root nodules by certain bacteria e.g., *Rhizobium lens*. The main objective of the present investigation was to see the effect of both foliar and soil application of NPK on different yield parameters of *Lens culinaris* Medic.

Materials and Methods

A field experiment was set up in replicated trials at Quaid-i-Azam University Islamabad, during 2003. Lentil seeds of an approved variety Masur-93 were procured from the Pulses Program, National Agriculture Research Centre, Islamabad.

Clay pots (27.75cm height and 25.62cm diameter) were used in the experiment. Each pot was filled with 10.5 kg of sandy-loam soil. Healthy seeds with uniform size were randomly selected for experimental work. Their viability was tested by germinating in Petri dishes in an incubator at 20ºC. Initially six seeds per pot were sown. 50% germination was achieved at 8^{th} day of sowing. The plants were then thinned to three seedlings per pot.

Solutions of required concentration of K_2HPO_4 and KH_2PO_4 were prepared and mixed to form potassium-phosphate buffer. NH_4NO_3 was then added. A pH of 7.0 was maintained for fertilizers throughout the course of study. NH_4NO_3 was used as nitrogen source, K_2HPO_4 and KH_2PO_4 was used as Phosphorus and Potassium source.

The following fertilizer concentrations were used during the experiment

Foliar application of NPK

- 1st concentration (C_1): 0.17%N, 0.21%P and 0.33%K
- 2^{nd} concentration (C_2): 0.35%N, 0.32%P and 0.50%K
- 3rd concentration (C_3): 0.52%N, 0.43%P and 0.66%K
- Soil application of NPK: 2nd concentration (C_2): 0.35%N, 0.32%P and 0.50%K.
- Foliar application of N: 2nd concentration (C_2): 0.35% N.

Strategy for foliar and soil application of NPK: Foliar application of NPK was carried out at 40 days, 65 days and 89 days from mean germination, respectively. The soil application of NPK was done after 25 days, 55 days and 88 days from mean germination. For foliar application, 20 ml of fertilizer solution was sprayed on the leaves of plants per pot while for soil application 100 ml of fertilizer solution was added to each pot in each dose application.

Soil analysis: A representative random sample was analyzed for physical and chemical analysis at Land Resources Research Institute, NARC. Soil texture was determined by Bouycous hydrometer method (Bouycous, 1962). The nitrogen was analyzed through Macro-Kjeldahl method (Paul & Berry, 1921).

Ammonium bicarbonate- Diethylen triamin penta acetic acid (AB-DTPA) method was used to analyze both phosphorus and potassium (Soltanpour & Woekman, 1979). Soil analysis report has been given in Table 1.

Results and Discussion

Experimental data and its statistical analysis have shown a significant effect of NPK application under different modes, concentration and timings of application on different yield parameters. The maximum number of pods per plant has been observed when NPK was supplied to plants both through foliage and soil (Table 2) while minimum number of pods per plant was noted in the plants with mixed NPK. There were not much differences between the number of pods per plant in the plants provided with both foliar and soil application and plants where only soil application of NPK was carried out. Changes in the concentrations of nutrient within a given limit did not cause any significant difference in number of pods. These results clearly indicate that application of fertilizer resulted in an increase in number of pods per plant. Growada & Growada (1980) observed similar results and concluded that the number of pods per plant was increased with NPK application. Shabir (1982) also found that application of 60 kg phosphorus per hectare significantly increased the number of pods per plant while Lateef *et al.*, (1998) and Ghildiyal (1992) found that foliar application increased number of pods per plant. Soil application of NPK showed second best results for number of pods per plant. Singh & Kamath (1989) observed that foliar application was not superior to basal application.

Maximum total pod weight per plant (6.83 gm/plant) was recorded when NPK was supplied both through foliar as well as soil application in the form of single dose (T3C1.2t_1) (Table 2). Minimum total pods weight was recorded in plant where NPK was supplied mixed with commercial detergent through foliar application. NPK in these plants was supplied in the form of three doses during the life cycle of plants (T1dC1t_3). The results were very close to the maximum results when number of fertilizer doses were changed in both foliar and soil application (T3C2.2t_3, T3C1.2t_2, and T3C1.2t_3).

There appears to be no significant difference in the average number of seeds per pod under different concentrations, modes of application and timings of application of fertilizers to the plants (Table 3). It is evident from the results that the number of seeds per pod was not influenced by any of the parameter relating to the nutrient application. However, the mean number of seeds per pod marginally increased in treatments, which were only sprayed with nitrogen, followed simultaneously by soil applied NPK treatments (T2) and both soil plus foliar applied NPK treatments (T3). It appeared that nitrogen was more effective than phosphorus in terms of producing higher number of seeds per pod. It was reported that foliar application of nitrogen increased seed number per pod (Hamid, 1991). However, Jain & Tiwari (1997) reported that NPK application gave the highest number of seed per pod.

Table 1. Chemical analysis of soil samples showing the mount of NPK in mg Kg^{-1} of soil.

No.	pH	ECe (dSm^{-1})	K	NO_3-N	P	Soil texture
1	7.32	0.93	70	0.68	0.84	Sandy-loam
2	7.33	1.39	64	0.76	0.84	Sandy-loam

Table 2. Mean values for number of pods per plant and pod weight per plant as affected by different modes of fertilizer application, fertilizer concentration and number of fertilizer doses applied.

Treatment	Con.	No. of pods/plant			Pod weight/plant (gm)		
		t_1	t_2	t_3	t_1	t_2	t_3
T0	C0	55.16	55.16	55.16	4.1	4.1	4.1
T1	C1	67.83	107.5	94	4.66	5.33	4.93
T1	C2	56.83	74.66	82	3.91	5.16	4.83
T1	C3	76.5	72.83	77.33	4.96	4.91	4.1
T2	C2	80.66	85.33	88.66	4.08	5.16	6.15
T3	C1.2	121	95.83	92.33	6.83	6.66	6.16
T3	C2.2	89.16	92.83	110	5.43	5.83	6.71
T3	C3.2	67	91.83	68.83	3.58	4.91	5.51
T4	C2	74.33	80.16	64	4.66	5.06	4.41

Con. stands for concentration, T0 for control, T1 for foliar application of NPK, T2 for soil application, T3 for both foliar and soil application, T4 for foliar application of N, C1.2 for 1st foliar application con. and 2nd soil applied conc., C2.2 for 2nd NPK conc. applied through foliage and soil, C3.2= 3rd conc. for foliar and 2nd conc. of soil applied NPK, t_1 single fertilizer dose applied at first growth stage, t_2 for fertilizer dose applied at 1st and 2nd growth stage each and t_3 for fertilizer dose applied at three different times.

Table 3. Mean values for number of seeds per pod (gm) and 1000 seed weight (gm) as affected by different modes of fertilizer application, fertilizer concentration and number of fertilizer doses applied.

Treatment	Con.	No. of seeds/pod			1000 seed weight (gm)		
		t_1	t_2	t_3	t_1	t_2	t_3
T0	C0	1.15	1.15	1.15	25.7	25.7	25.7
T1	C1	1.3	1.167	1.4	25.9	27.1	30.7
T1	C2	1.167	1.25	1.35	26.3	31.5	33.2
T1	C3	1.25	1.45	1.25	31.5	30.7	28
T2	C2	1.3	1.3	1.35	26.6	29.4	32.5
T3	C1.2	1.25	1.25	1.3	35	34.8	30.5
T3	C2.2	1.25	1.3	1.45	38.8	29	30.4
T3	C3.2	1.3	1.4	1.35	30	32.6	37.1
T4	C2	1.5	1.3	1.45	29	29.8	35.5

Table 4. Mean values for seed yield per plant (gm) as affected by different modes of fertilizer application, fertilizer concentration and number of fertilizer doses applied.

Treatment	Concentration	Seed yield/plant		
		t_1	t_2	t_3
T0	C0	3.15	3.15	3.15
T1	C1	3.71	4.38	3.98
T1	C2	2.96	4.21	3.88
T1	C3	4.1	3.96	3.15
T2	C2	3.13	4.21	5.2
T3	C1.2	5.9	5.71	5.21
T3	C2.2	4.48	4.9	5.8
T3	C3.2	2.63	3.96	4.6
T4	C2	3.71	4.11	3.46

The results showed that 1000 seed weight was significantly affected by the fertilizer application (Table 3). When NPK was supplied to the plants both through soil and foliar applications, maximum thousand seed weight was recorded. The results did not differ much when number of NPK dose was increased to three. In control plants, where no fertilizers were applied, the thousand seed weight was equal to 25.7 gm. The T3 treatments showed the maximum thousand seed weight because they received NPK through both foliar and soil application. Jain & Tiwari (1997) reported that application of NPK in lentil produced maximum seed weight. Shabir (1982) also recorded that application of 60 kg phosphate per hectare significantly increased thousand seed weight.

Maximum seed yield of 5.9 gm/plant was recorded in plants in which soil and foliar application was provided in the form of single dose T3C1.2t_1 (Table 4). Foliar application in these were carried out in the form of three doses (T1dC1t_3). Variations in the concentrations of various fertilizers within the limits of experimental design gave the results almost similar to the maximum (T3C2.2t_3, T3C1.2t_2, and T3C1.2t_3). In control plants, where no nutrient was applied, seed yield per plant was 3.15gm. Maximum seed yield per plant were obtained in treatments, which received NPK through both soil and foliage. Pandrangi *et al.*, (1991) observed that seed yield in mung beans were highest with soil plus foliar application of phosphorus followed by soil-applied phosphorus and foliar applied phosphorus. Hamayun & Chaudhary (2004) and Raghuwanshi et al., (1993), also observed similar results. T2 treatments showed better results than T1 treatments, which clearly revealed that soil application of NPK was superior to foliar application of NPK. Similarly, Singh & Kamath (1989) reported that foliar application of phosphorus was not superior to basal application.

Conclusion

Soil application of fertilizers combined with foliar application, marginally improved yield in lentil. The results do not justify the foliar application of NPK under conditions where physio-chemical properties of soil are good enough for the uptake of nutrients from soil. However, under conditions where nutrients supply to plants become a limiting factor because of soil properties, foliar spray can serve a useful purpose in by passing the soil to ensure optimal supply of nutrients to plants. Thus to enhance food production and elevating the nutritional aspects of lentil, such green agricultural practice be adopted. However, further research work needs to be undertaken to clarify the role foliar application and nutritional aspects of ancient lentil.

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