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The Effect of Nitrogen and Phosphorous Rates on Fertilizer Use Efficiency in Lentil

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Abstract: Lentil (*Lens culinaris* Medik.) is one of the most important legume crop grown in Iran. The yield of lentil in Iran is very low as compared to other lentil producing countries. One of the most important effective factors is non-application of optimal amounts of nitrogen fertilizer per hectare. The field experiment was arranged in a factorial experiment based on a randomized complete block design with three replications. Factors are includes nitrogen and phosphorous fertilizer. Nitrogen was applied as urea form with three levels (0, 25 and 50 kgha^{-1}) and also phosphorous was applied as triple super phosphate form with three levels (0, 40 and 60 kg ha^{-1}). Each plot comprised 5 rows of 5 m long and spacing was 25 cm between rows and spacing was 3 cm between plants on rows. Plots and blocks were separated by 1.5 m unplanted distances. The result showed marked increased in grain yield (1653 kg/ha) and N uptake in grain (4.21%) of plots received 25 kg N/ha in compared with control but with increasing amount of nitrogen until 50 kg/ha was not observed increment in grain yield. Agronomic efficiency varied from 7 kg per kg of N applied with 50 kg of N to 25 kg per kg of N applied with 25 kg of N. Agronomic efficiency with 25 kg of N was higher and significantly superior to 50 kg of N. Also an increase of about 6 to 15 kg yield per kg of P2O5 was recorded with 40 kg of P compared with 60 kg of P. Therefore based on results of this study, rate of nitrogen and phosphorous should not be more than 25 and 40 kg /ha in dryland condition respectively.

Key words: Dryland · Nutrient use efficiency · Nitrogen · Lentil · Yield

INTRODUCTION

Lentil (*Lense culinaris Medik.*) is one of the most important legume crop grown in Iran. Lentil grain is used for human consumption. This crop has much higher grain protein content than other legumes. The yield of lentil in Iran is very low as compared to other lentil producing countries. One of the most important effective factors is non-application of optimal amounts of nitrogen fertilizer per hectare. Nitrogen is the key element in increasing productivity. It is an integral component of many compounds essential for plant growth processes including chlorophyll and many enzymes. Nitrogen also mediates the utilization of potassium, phosphorous and other elements in plants. The optimum amounts of these elements in the soil cannot be utilized efficiency if nitrogen is deficient in plants. Nitrogen is generally applied as urea form.

Urea hydrolyzes rapidly following its application to soils. Ammonium accumulates in the application zone and pH increases due to the consumption of H+. The resultant pH from urea hydrolysis in most soils ranges from 7.0 to 9.0 [1]. As soil pH rises, the proportion of NH3 over NH4 increases and volatilization can occur when urea is surface applied (Ferguson *et al.*, 1984). Investigations have found that >50% of surface applied urea-N could be lost through NH3 volatilization [2, 3]. Gasser [4] reported that volatilization take place directly after addition of ammonium sulfate. Similar conclusion was reported by Shammas *et al.* [5]. To solve Volatilization problems and enhance urea efficiency, it is essential to slow down urea hydrolysis to avoid both build up and pH increase in soil. Maintaining a low pH in the vicinity of the urea granule reduces urea hydrolysis and volatilization. Addition of H3PO4 reduced volatilization by retarding hydrolysis and by reducing

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the pH increase from urea hydrolysis [6]. Ammonia volatilization could also be decreased by mixing urea with triple super phosphate (TSP) applied to an acid soil [7], or mixing with KCl [8]. The objectives of the present work were studying efficiency of N uptake by lentil in dryland condition and studying the effect of triple super phosphate (TSP) blended Urea fertilizer on plant properties.

MATERIALS AND METHODS

Experimental Site: This experiment was conducted at Agriculture Research Station of Ardabil in 2008. Average rainfall is about 400 mm. Data weathers during growth season and soil characteristics are shown in Table 1 and 2 respectively.

Experimental Design: The field experiment was arranged in a factorial experiment based on a randomized complete block design with three replications. Factors are includes nitrogen and phosphorous fertilizer. Nitrogen was applied as urea form with three levels (0, 25 and 50 kgha^{-1}) and also phosphorous was applied as triple super phosphate form with three levels (0, 40 and 60 kg ha^{-1}). Each plot comprised 5 rows of 5 m long and spacing was 25 cm between rows and spacing was 3 cm between plants on rows. Plots and blocks were separated by 1.5 m unplanted distances.

Preparation of Planting: Before sowing of the crop the field was well prepared by plowing twice with tractor followed planking to make a fine seed bed. Lentil seeds (Genotype, ILL-1236) were planted on the first week of April, 2007. Three seeds were sown per hill and later thinned to one plant per hill. All fertilizer treatments were added at the time planting. Thinning was done at 4-5 leaves stage. All other agronomic operations except those under study were kept normal and uniform for all treatments.

Sampling: Harvest samples were taken of 3 m long from the 3 middle rows at the time of physiological maturity (2nd week of July) for measuring yield and biological yield, then transported to the laboratory, air dried and plants were separated two parts include grain and growing section.

Laboratory Analysis: After determination of dry weight, the grain and growing sections were cut down to thin section, then, then weight and milled. Dry matter was used for chemical analysis. Lentil samples were analyzed for their nitrogen and phosphorous contents using Kejehldal method [6] and spectrophotometer respectively. A composite soil sample (top 30 cm) was collected and analyzed for EC (Electrical conductivity of soil extract was measured usning EC meter), pH (Soil pH was measured potentiometrically using pH meter), organic carbon [9], available phosphorous [10], available K (Flame photometer) and Carbonates [10], soil tex ture by hydrometer [11]. Table 2 showed Soil characteristics in site based on laboratory analysis.

Fertilizer Use Efficiency: The fertilizer use efficiencies or agronomic efficiency (AE) was calculated as follows:

AE = Yield in fertilized plot (kg ha^{-1}) - Yield in control plot (kg ha^{-1}) / Quantity of fertilizer nutrient applied (kg ha^{-1})

Statistical Analysis: Analysis of variance was performed using SAS computer software packages. The main effects and interactions were tested using the Duncan test.

Table 1: Data weathers during growth season

Month	Minimum temperature mean (°C)	Maximum temperature mean (°C)	Precipitation (mm)	Minimum relative humidity (%)	Maximum relative humidity (%)
March	1.35	9.93	2.50	69.67	97.35
April	5.50	17.45	0.85	60.30	92.83
May	10.40	25.29	0.82	58.60	89.38
June	11.96	22.96	0.14	68.00	94.41
July	13.06	27.16	0.14	58.30	88.22

Table 2: Soil characteristics in experiment site

Electrical Conductivity (dSm^{-1})	pH	Saturation Percent (%)	Carbonates (%)	Organic Carbon (%)	Available P (ppm)	Available K (ppm)	Clay (%)	Silt (%)	Sand (%)	Depth (cm)
0.42	7.6	54.9	1.25	0.29	7	584	37.5	20	42.5	0-30

RESULTS AND DISCUSSION

Table 3 indicated mean of squares yield, nitrogen and phosphorous percent in growing portion and grain and fertilizer use efficiency in lentil. Nitrogen had significant effect on all studied traits except nitrogen percent in growing portion of plant. Also Phosphorous had no significant effect on grain yield and fertilizer use efficiency but Phosphorous had significant effect on nitrogen and phosphorous percent in growing portion and grain. Interaction of nitrogen and phosphorous had significant effect on phosphorous percent in growing portion and grain.

Grain Yield: The result of Table 4 showed marked increased in grain yield of plots received 25 kg N/ha in compared with control but with increasing amount of nitrogen until 50 kg/ha was not observed increment in grain yield. It seems that in dry land condition the absorption of further nitrogen could be limited due to water deficit, which results from increasing osmotic potential in root medium.

Data presented in Table 4 showed that the grain yield of lentil was not increased with increasing P level.

Nutrient Accumulation: Grain yield and nitrogen uptake tend increased with N application rate. Levels of 25 kg N/ha resulted in the maximum N uptake in grain (4.21%) and grain yield (1653 kg/ha). Based on Table 4 with increasing rate of N from 25 to 50 kg/ha was not observed significant increment in grain nitrogen percentage. Also Table 4 indicated that between different levels of N are not significant differences on percentage of N in growing portion. Because at final growth stage, 37 to 72% of N of leafs and 12 to 56% of N of stems are transferred to grains [12]. Also Davis *et al.* [13] reported that 62 to 85% of N of grain is obtained from transferring N of growing portion of plant.

Table 4 showed marked increased in percentage of seed nitrogen and nitrogen of growing portion of plots received 40 kg P/ha in compared with control. Because phosphorous provide long time for absorbing nitrogen by plant. Application of P reduces volatilization by retarding hydrolysis and by reducing the pH increase from urea hydrolysis [6]. Ammonia volatilization could also be decreased by mixing urea with triple super phosphate applied to an acid soil [7], or mixing with KCl [8]. But with increasing amount of P until 60 kg/ha was not observed increment in percentage of seed nitrogen and growing portion.

Table 3 showed that the effect of interaction of N and P was significant on growing portion phosphorous and seed phosphorous percentage. Maximum growing portion phosphorous and seed phosphorous percentage was obtained at N_{25} P_{40}.

Table 3: Mean of squares yield, nitrogen and phosphorous percent in growing portion and grain and fertilizer use efficiency

Source of variable	Degree of free	Grain yield	Nitrogen of growing portion (%)	Nitrogen of grain (%)	Nitrogen use efficiency	Phosphorous of growing portion (%)	Phosphorous of grain (%)	Phosphorous use efficiency
Replication	2	0.001^{ns}	0.01^{ns}	0.006^{ns}	0.97^{*}	0.000007^{ns}	0.000003^{ns}	0.016^{*}
Nitrogen (N)	2	0.091^{*}	0.01^{ns}	0.78^{**}	4.24^{**}	0.00016^{**}	0.000087^{*}	0.029^{**}
Phosphorous (P)	2	0.029^{ns}	0.05^{*}	0.29^{**}	0.04^{ns}	0.000069^{**}	0.00026^{**}	0.005^{ns}
N×P	4	0.030^{ns}	0.01^{ns}	0.06^{ns}	1.11^{ns}	0.00033^{**}	0.000108^{**}	0.003^{ns}
Error	16	0.034	0.01	0.03	0.29	0.000004	0.000018	0.002
CV (%)	--	5.98	8.58	4.28	23.91	1.64	2.99	9.68

ns, * and ** is non significantly at probable level 5% and 1%, respectively

Table 4: Mean comparison of effect of nitrogen and phosphorous on studied traits

Treatment	Levels of treatments (kg ha^{-1})	Grain yield (kg ha^{-1})	Nitrogen of growing portion (%)	Nitrogen of grain (%)	Phosphorous of growing portion (%)	Phosphorous of grain (%)	Nitrogen use efficiency (kg/kg)	Phosphorous use efficiency (kg/kg)
Nitrogen	0	1027.9 b	1.39 a	3.74 b	0.126 a	0.141 b	0	0
	25	1653.0 a	1.38 a	4.21 a	0.122 b	0.146 a	25.00 a	15.73 a
	50	1380.9 ab	1.45 a	4.28 a	0.118 c	0.140 b	7.06 b	6.33 b
Phosphorous	0	1184.6 a	1.32 b	3.98 b	0.122 b	0.137 c	0	0
	40	1466.5a	1.45 a	4.29 a	0.125 a	0.148 a	19.56 a	7.04 a
	60	1410.8a	1.45 a	3.97 b	0.119 c	0.142 b	13.59 a	3.77 a

Nutrient Use Efficiency: Agronomic efficiency due to nitrogen (N) fertilization calculated as kg yield per kg of N applied are presented in Table 4. Agronomic efficiency varied from 7 kg per kg of N applied with 50 kg of N to 25 kg per kg of N applied with 25 kg of N. Agronomic efficiency with 25 kg of N was higher and significantly superior to 50 kg of N.

In the case of P use efficiency also, similar trend as the one observed as that of nitrogen. An increase of about 6 to 15 kg yield per kg of P_2O_5 was recorded with 40 kg of P compared with 60 kg of P.

In fact nutrient use efficiency is low at a high nutrient level. fixen [14] suggested that the value of improving nutrient use efficiency is dependent on the effectiveness. Because of maximizing efficiency may not always be advisable or effective. When yield is low, therefore high nutrient use efficiency is not suitable. However, effectiveness cannot be sacrificed for the sake of efficiency.

Fertilizer nutrient applied, but not taken up by the crop, are vulnerable to losses from leaching, erosion and denitrifiction or volatilization in the case of N. Therefore N fertilization is essential for lentil, but it should be affected with respect to dosage in dryland condition.

CONCLUSION

Over-or under – application of fertilizer will result in reduced nutrient use efficiency or losses in yield and crop quality. Nutrient use efficiency is site-specific and can only be determined by studying local targets vulnerable to nutrient impact. Therefore based on results of this study, rate of nitrogen and phosphorous should not be more than 25 and 40 kg /ha in dryland condition respectively.

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