Indian Journal of Agronomy **51** (3) : 242–244 (September 2006)

Effect of phosphorus and potassium on growth characters, forage yield, nutrient uptake and quality of lucerne *(Medicago sativa)*

P.C. PATEL AND A.V. KOTECHA

Main Forage Research Station, Anand Agricultural University, Anand, Gujarat 388110

Received : October, 2005

ABSTRACT

A field experiment was conducted on well-drained sandy loam soils during the winter, summer and rainy *(kharif)* seasons of 2003-04 to study the nutritional requirement of major nutrients (P, K) for lucerne (*Medicago sativa* L.) crop. Application of 300 kg K_2O/ha significantly increased the green-forage, dry-matter and crude-protein yields by 17.2, 13.3 and 17.6%, respectively over the control (50 kg K_2O/ha), whereas the application of 150 kg K_2O/ha significantly increased the green-forage yield only compared with the control in cumulative yield of 12 cuts. Both the lucerne varieties ('GAUL 1', 'AL 3') were more responsive to higher levels of potassium. Application of 75 kg P_2O_5/ha along with 300 kg K_2O/ha to lucerne variety 'AL 3' recorded significantly highest dry-matter yield and maximum uptake of N, P and K, whereas the highest crude-protein yield and the maximum uptake of N and K were obtained with combined application of 75 kg P_2O_5/ha and 300 kg K_2O/ha to variety 'GAUL 1'. Application of 50 kg P_2O_5 + 300 kg K_2O/ha to 'GAUL 1' showed the maximum net return and net incremental cost: benefit ratio, followed by application of 75 kg P_2O_5/ha + 300 kg K_2O/ha to variety 'AL 3'.

Key words : Lucerne varieties, Fodder yield, Quality, Major nutrients (P, K)

Lucerne *(Medicago sativa)* is the most important fodder crop of the world, grown in a wide range of climatic conditions. It is grown in almost every state in India and provides green fodder for livestock. It is grown in Gujarat state in 0.8 to 0.9 lakh ha. In agronomic techniques, fertilizer management is the most important aspect. It includes proper application of macro- and micronutrients to get maximum quality forage in nutrient-deficient soils. Phosphorus and potassium nutrients are associated with shoot regrowth, quality and persistence of lucerne (Li *et al.*, 1997; Sheyuto, 1997). However, only limited information is available in India on the forage yield and quality of lucerne. Hence the present investigation was undertaken.

MATERIALS AND METHODS

The experiment was conducted at Main Forage Research Station farm, Anand Agricultural University, Anand during the winter, rainy *(kharif)* and summer seasons of 2003-04. The soil was sandy loam, having pH 7.8, electrical conductivity (EC) 0.38 dS/m. It was low in organic carbon (0.33%), high in available phosphorus (83.5 kg/ha) and medium in available potassium (176.9 kg/ha).

The experiment was laid out in factorial randomized block design with 12 treatment combinations of two varieties of lucerne ('GAUL 1', 'AL 3'), two levels of phosphorus (50 and 75 kg P_2O_5/ha, as P_{50} and P_{75} respectively) and three levels of potassium (50, 150 and 300 kg K_2O/ha, as K_{50}, K_{150} and K_{300} respectively) with four replications. The entire quantity of N and P_2O_5 along with half the K_2O (as per treatment) were applied basal at the time of sowing. The remaining quantity of K_2O was top-dressed in two equal splits, at the beginning of summer and *kharif.* The nutrient sources used were urea, single superphosphate and muriate of potash. A blanket application of zinc sulphate @ 12.5 kg $ZnSO_4$/ha, ferrous sulphate @ 25.0 kg $FeSO_4$/ha and gypsum @ 12.0 kg/ha was made to all the experimental plots. The plot size was 4.0 m × 3.0 m with spacing of 25 cm between two rows. Lucerne was sown in the second week of December 2003. All the other crop-management practices were followed as per recommendation. The first cut of lucerne was taken 2 months after sowing and subsequently at an interval of 25 to 30 days. The last cut was taken during the third week of December 2004. Fresh weight of green forage from each plot was recorded immediately after each cut and the dry matter was worked out. The plant samples were first air-dried and then heated in an oven at 75° C to constant weight at atmospheric pressure. The loss of weight is considered as moisture and the residue as dry matter. The dried samples were finely powdered and digested. Crude protein in the plant was computed from the N content multiplied by 6.25. Dry-matter and crude-protein yields were calculated by multiplying dry-matter conent to green-fodder yield and protein content to dry-mater yield respectively.

The variety 'GAUL 1' was released in 1975 and it has tall plants, erect type, crown above the ground, vigorous growing with broad, round light green leaves. Flowers are purple and large. It is widely adapted in Gujarat, Madhya Pradesh, Rajasthan, Maharashtra, Andhra Pradesh and Tamil Nadu. It gave 40 to 65% higher green-forage yield than 'T 9'. It has fast growth and higher forage production with better quality. The variety 'AL 3' released in 2000 is perennial type, having good regeneration capacity compared with the check 'GAUL 1' and 'RL 88'. The productivity and economics were calculated on the basis of prevailing market prices.

RESULTS AND DISCUSSION

Effect of P and K

Growth attributes: Growth-attributing characters, viz. plant height and plant population after 12 cuts, increased significantly with application of different levels of potassium compared with the control (Table 1). Application of 300 kg K_2O/ha showed significantly the highest plant population after 12 cuts than 50 and 150 kg K_2O/ha. It indicated that potassium nutrient is associated with shoot regrowth and persistence. These results are in conformity with the finding of Li *et al.* (1997), Shelyuto (1997) and Berg *et al.*(2003). 'AL 3' showed significantly higher plant population than 'GAUL 1' after 12 cuts (Table 1), indicating its higher regeneration capacity.

Yield : Both the lucerne varieties gave equal performance for forage yield in 12 cuts (Table 1). Its forage yield did not differ significantly due to phosphorus levels, because of sufficient availability of this element in the soil. Maximum green-forage yield (986 q/ha) recorded under individual application of potassium @ 300 kg K_2O/ha that was 17.2 and 11.2% more than under 50 kg and 150 kg K_2O/ha respectively (Table 1). Similarly, the maximum dry-matter yield (210.7 q/ha) obtained with 300 kg K_2O/ha was 13.3 and 8.8% higher than that obtained with 50 and 150 kg K_2O/ha respectively. The increase in green as well as dry matter yields owing to the application of potassium might be attributed to increase in plant height and plant population (Table 1). These findings are in accordance with those of Patel *et al.* (1990), Berg *et al.* (2003, 2005) and Mahale *et al.* (2004). Application of potassium @ 300 kg K_2O/ha resulted in significantly higher crude protein yield than other treatments. The magnitude of increase was 17.6 and 12.8% higher over 50 and 150 kg K_2O/ha respectively. The higher crude protein yield may be an effect of more dry-matter yield (Table 1).

Nutrient uptake : The P uptake was 8.7% more with the lucerne variety 'AL 3' than 'GAUL 1' (Table 1). P uptake increased significantly with the increase in P application over 50 kg P_2O_5/ha (Table 1). This may be attributed to higher dry matter yield and higher P content in lucerne plants. Application of 300 kg K_2O/ha significantly increased the N uptake (694.5 kg/ha) over 50 kg and 150 kg K_2O/ha (Table 1), i.e. 17.7, and 13.2%. This may be attributed to greater dry-matter production as a result of potassium application (Table 1). The uptake followed the yield pattern; as the yield was higher, so was the uptake. The P uptake increased significantly with the increasing levels of potassium from 50 to 150 and 300 kg K_2O/ha. Similarly, K uptake increased significantly with the increase in potassium application from 50 to 150 and 300 kg K_2O/ha, i.e. 29.8 and 15.8%. This may be due to greater dry matter production as a result of potassium application (Table 1). The results are in agreement with the

Table 1. Effect of phosphorus and potassium on forage yield, growth attributes and nutrient uptake by lucerne (total of 12 cuts)

Treatment	Yield (q/ha)			Crude-protein content* (%)	Plant height* (cm)	Plant population after 12 cuts/m²	Nutrient uptake (kg/ha)		
	Green forage	Dry matter	Crude protein				N	P	K
Variety									
'GAUL 1'	898	198.1	39.83	22.97	63.2	17.86	639.1	138.3	204.7
'AL3'	910	195.5	39.08	21.04	64.1	23.84	626.4	150.4	196.9
CD (P=0.05)	NS	NS	NS	NS	NS	2.41	NS	1.1	NS
Phosphorus (kg P_2O_5/ha)									
50 (P_{50})	894	195.0	38.83	22.11	64.1	20.69	622.4	140.1	198.3
75 (P_{75})	915	198.6	40.08	21.90	63.3	21.01	643.1	148.6	203.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	1.1	NS
Potassium (kg K_2O/ha)									
50 (K_{50})	841	186.0	36.78	22.71	62.0	17.34	590.3	140.6	176.2
150 (K_{150})	887	193.6	38.35	21.39	63.3	20.58	613.5	142.8	197.5
300 (K_{300})	986	210.7	43.24	21.93	65.8	24.62	694.5	149.6	228.7
CD (P=0.05)	41	8.7	1.74	NS	1.6	2.95	27.8	1.4	8.9

*Average of 12 cuts

Table 2. Effect of interaction of variety, phosphorus and potassium levels on dry-matter and crude-proein yields, nutrient uptake and economics of lucerne (total of 12 cuts)

Interaction	DMY (q/ha)	Crude-protein yield (q/ha)	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Total K uptake (kg/ha)	Net return (Rs/ha)	Net ICBR
*V_1 x P_1 x K_1	183.0	35.03	568.9	129.0	175.4	-	-
V_1 x P_1 x K_2	189.4	35.97	577.9	139.9	193.5	832	-
V_1 x P_1 x K_3	214.0	44.26	708.9	146.2	241.4	10,666	1:2.59
V_1 x P_2 x K_1	192.2	39.18	625.8	127.8	179.1	2,227	1:0.22
V_1 x P_2 x K_2	195.5	39.38	631.9	143.1	202.6	3,019	1:0.22
V_1 x P_2 x K_3	214.7	45.17	721.2	143.6	235.9	10,477	1:2.02
V_2 x P_1 x K_1	188.8	37.96	606.3	147.4	176.4	-	-
V_2 x P_1 x K_2	201.4	40.08	638.4	128.7	201.1	3,560	1:0.79
V_2 x P_1 x K_3	193.4	39.67	634.0	149.2	201.8	–950	-
V_2 x P_2 x K_1	180.1	34.94	560.1	158.3	173.7	-	-
V_2 x P_2 x K_2	188.1	37.97	605.7	159.5	192.8	-	-
V_2 x P_2 x K_3	220.9	43.86	714.0	159.2	235.6	10,653	1:2.073
CD (P=0.05)	17.5	3.47	55.6	2.7	17.7		

*Present recommended dose of fertilizer for lucerne; Cost : single superphosphate @ Rs 318/q, muriate of potash, Rs 440/q, DMY @ Rs 565/q; Calculated as lucerne having 22.0% dry-matter content; V_1 = 'GAUL 1', V_2 = 'AL 3'

findings of Berrala and Westfull (2005).

Interaction effects and economics

The interaction of variety x phosphorus levels x potassium levels reveals that combined application of phosphorus @ 75 kg P_2O_5/ha+300 kg K_2O/ha to 'AL 3', remaining at par with phosphorus @ 50 or 75 kg P_2O_5/ha + 300 kg K_2O/ha to 'GAUL 1, resulted in significantly higher dry-matter yield (220.9 q/ha) of lucerne over the rest of the combinations of veriety, phosphorus and potassium (Table 2). The maximum crud-protein yield (45.17 q/ha) was obtained by combined application of phosphorus @ 75 kg P_2O_5/ha+300 kg K_2O/ha to 'GAUL 1', but it was on a par with that @ 50 kg P_2O_5/ha+300 kg K_2O/ha to 'GAUL 1' and 75 kg P_2O_5/ha+300 kg K_2O/ha to 'AL 3' in cumulative yield of 12 cuts. Treatment combination of 50 or 75 kg P_2O_5/ha+300 kg K_2O/ha to 'GAUL1' and 75 kg P_2O_5/ ha+300 kg K_2O/ha to 'AL 3' showed equal uptake of N and K. Application of 75 kg P_2O_5/ha+300 kg K_2O/ha to 'AL 3' showed the maximum P uptake. Economic analysis revealed that application of 50 kg P_2O_5 along with 300 kg K_2O/ha to 'GAUL 1' showed the maximum net return and net incremental cost : benefit ratio, followed by application of 75 kg P_2O_5/ha + 300 kg K_2O/ha to 'AL 3' (Table 2). Conti *et al.* (1997) also reported beneficial interaction effect of phosphorus and potassium.

It was concluded that lucerne variety 'AL 3' is more responsive for dry-matter and crude-protein yields (20.7 and 25.2% respectively) to higher levels of phosphorus and potassium (75 kg P_2O_5/ha+300 kg K_2O/ha) when compared with 50 kg P_2O_5/ha+50 kg K_2O/ha to 'GAUL 1'. However, the maximum net return and net incremental cost : benefit ratio was recorded by combined application of phosphorus @ 75 kg P_2O_5/ha+300 kg K_2O/ha to 'GAUL 1'. The present recommended dose of fertilizer @ 50 kg P_2O_5 and 50 kg K_2O/ha is not sufficient for obtaining higher forage yield and quality to both the lucerne varieties in harvesting 12 cuts in a year.

REFERENCES

Berg, W. K., Cunningham, S.M., Brouder, S.M., Joern, B.C., Johnson, K.D., Santini, J. and Volence, J.J. 2003. Enhancing alfalfa production through improved potassium management. *Better Crops with Plant Food* **87** (1) : 8–11.

Berg, W. K., Cunningham, S. M., Brouder, S.M., Joern, B.C., Johnson, K. K., Santini, J. and Volence, J.J. 2005. Influence of phosphorus and potassium on lucerne yield and yield components. *Crops Science* **45** (1) : 297–304.

Berrala, A. and Westfull, D.G. 2005. Irrigated alfalfa response to phosphorus and potassium in calcareous soil. *Communication in Soil Science and Plant Analysis* **36** (9-10): 1213–1227.

Conti, M. E., Horra, A.M., Arrigo, N.M. and Marchi, A. 1997. Fertilization and potassium-phosphorus interaction on lucerne yield in Typic Haplustolf (semiarid area, Argentina). *Ciencia del suelo* **15** : 51–52.

Li, R., Volenec, J. J., Joern, B.C. and Cunningham, S.M. 1997. Potassium and nitrogen effects on carbohydrate and protein metabolism in alfalfa roots. *Journal of Plant Nutrition* **20** (4-5) : 511–529.

Mahale, B.B., Nevase, V. B., Thorat, S.T. and Jambhale, A.S. 1997. Response of lucerne varieties to levels of phosphorus and poatssium. *Research on Crops* **5** (2-3) : 197–200.

Pael, J.R., Patel, P.C., Sadhu, A.C. and Patel, B.G. 1990. Response of lucerne genotypes to phosphorus and potash. *Indian Journal of Agronomy* **5** (3) : 307–308.

Shelyuto, A.A. 1997. Characteristics of the root growth of lucerne compared with that of clover grown on the sod podzol soils of the northern zone of Belarus. *Agricultural Academy, Minsk, Belarus.*