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Effect of integrated nutrient management on forage yield and quality of lucerne (*Medicago sativa* L.)

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Abstract

A field experiment was conducted during 2007-08 to 2009-10 at MPKV, Rahuri, Maharashtra to study the effect of integrated nutrient management on forage yield and quality of perennial Lucerne. Application of recommended dose of fertilizer (20:80:40 kg NPK ha^{-1}), elemental sulphur (30 kg ha^{-1}), sodium molybdenum (1 kg ha^{-1}) and borax (4 kg ha^{-1}) along with FYM (10 t ha^{-1}) to perennial lucerne crop recorded significantly highest growth attributes *viz.,* plant height (79.7 cm) and leaf: stem ratio (1.01), maximum green forage and dry matter yield (4782.0 and 1056.6 q ha^{-1}, respectively), with highest net return (Rs. 330443/- ha^{-1}) and benefit: cost ratio (2.21) from 34 cuts of lucerne as compared to other treatments under study. It registered higher values of soil available nutrients *viz*., Nitrogen, phosphorous, potassium, sulphur, molybdenum and boron over rest of all the treatments. However, it was found at par with application of RDF (20:80:40 kg NPK ha^{-1}), elemental sulphur (30 kg ha^{-1}), sodium molybdenum (1 kg ha^{-1}) and borax (4 kg ha^{-1}) along with FYM (5 t ha^{-1}) in respect of green forage yield (4639.95 q ha^{-1}), dry matter yield (1023.18 q ha^{-1}), net return (Rs. 320539/- ha^{-1}) and benefit : cost ratio (2.21).

Keywords: Boron, Fodder, Lucerne, Molybdenum, Sulphur, Yield

Introduction

Agriculture is the back bone of Indian economy and livestock sector is an integral part of agriculture. Livestock sector contributes 24.72 per cent of the agricultural GDP and 4.36 per cent of total GDP. In spite of having huge livestock population, the milk productivity is very low as compared to the world average. One of the major limitations to efficient livestock population is the lack of adequate level of quality and quantity of forage (Singh, 2009). At present, the deficit in the country is to the tune of 35.6 % green fodder, 10.95 % dry crop residues and 44 % concentrate. (Anonymous, 2013). In order to bridge this gap, efforts are to be intensified to increase the yield per unit area and time with maximum returns per rupee investment.

Lucerne is the most important winter perennial multicut forage crops for dairy industry in India which provides a high tonnage of palatable nutritive protein and energy rich green fodder. Due to its excellent growth habit, quick re-growth after cutting and better nutritive value and high tillering, it is extensively grown in irrigated areas of Maharashtra. As a lucerne crop is grown under irrigated condition and remains in the field upto three years, therefore its nutritional requirement is very high and thereby depletes the more soil nutrients hence, it perform better under adequate nutrition management. Irrigated soils in Maharashtra are intensively cultivated and hence these soils are deficient in major and minor nutrients. The requirement of these nutrients differed in perennial legume crops. Sulphur is an essential element and their applications to the soil not only improve the yield but quality of fodder will also be improved (Aulakh *et al.*, 1976). Sulphur is known for its role in the synthesis of proteins, oils and vitamins. It also promotes nodulation in legumes thereby promoting nitrogen fixation. Molybdenum and boron application in berseem play important role in growth, yield as well as nodulation and nitrogen fixation (Datta and Gurubasava, 1953). Boron is essential for pollen germination and pollen tube growth during fertilization. The efficacy of sulphur, molybdenum and boron especially in forage crops is yet to be fully assessed. Considering the problems associated with the perennial lucerne crop and unique importance of integrated nutrient management in crop production and forage quality, the present investigation was planned.

Material and Methods

An experiment was conducted for three consecutive years of 2007-08 to 2009-10 at All India Coordinated Research Project on Forage Crops, MPKV, Rahuri, Maharashtra.

The experiment was laid out in randomized block design with three replications. The eleven treatments comprised of different levels of recommended dose of chemical fertilizers, farm yard manure and micronutrients *viz*., sulphur, molybdenum and boron are **T_1**- Absolute control, **T_2**- RDF (20: 80: 40 kg NPK ha^{-1}), **T_3**- FYM @ 5 t ha^{-1}, **T_4**- FYM @ 10 t ha^{-1}, **T_5**- RDF + FYM @ 5 t ha^{-1}, **T_6**- RDF + FYM @ 10 t ha^{-1}, **T_7**- RDF + S + Mo + B, **T_8**- FYM @ 5 t ha^{-1} + S + Mo + B, **T_9**- FYM @ 10 t ha^{-1} + S + Mo + B, **T_{10}**- RDF + FYM @ 5 t ha^{-1} + S + Mo + B, **T_{11}**- RDF + FYM @ 10 t ha^{-1} + S + Mo + B. To all the above treatments 100 kg DAP ha^{-1} was applied after harvest of every four cut throughout the experimental period. The soil of the experimental field was clayey in texture with alkaline in reaction (pH-7.86), electrical conductivity (0.26 dSm^{-1}), low in organic carbon (0.34 %) and available nitrogen (207.80 kg ha^{-1}), medium in available phosphorus (13.09 kg ha^{-1}) and high in available potassium (357.40 kg ha^{-1}) and also low in available sulphur, molybdenum and boron (5.57, 0.040 and 0.24 $\mu g g^{-1}$of soil, respectively) as against its critical limits (10, 0.050 and 0.5 $\mu g g^{-1}$of soil, respectively). The micronutrient status observed in applied FYM with respect to sulphur, molybdenum and boron were (997, 20 and 2.1 $\mu g g^{-1}$, respectively). The recommended dose of fertilizer (20:80:40 kg NPK ha^{-1}) was applied as per the treatments. The recommended dose of sulphur was applied in the form of elemental sulphur (30 kg ha^{-1}), molybdenum in the form of sodium molybdenum (1 kg ha^{-1}) and boron in the form of borax (4 kg ha^{-1}) as per the treatments. The line sowing of lucerne variety RL-88 was done on 15.11.2007 at 30 cm apart by using seed rate of 25 kg ha^1 with gross and net plot size of 3 x 3 m^2 and 2.4 x 2.0 m^2, respectively. The recommended packages of practices were followed during the experimental period and total thirty four cuts were taken as per the given details (on **I**-9.1.08, **II**-6.2.08, **III**-29.2.08, **IV**-28.3.08, **V**-24.4.08, **VI**-17.5.08, **VII**-12.6.08, **VIII**-16.7.08, **IX**-14.8.08, **X**-8.9.08, **XI**-4.10.08, **XII**-31.10.08, **XIII**-24.11.08, **XIV**- 20.12.08, **XV**-15.1.09, **XVI**-11.2.09, **XVII**-4.3.09, **XVIII** -25.4.09, **XIX**-19.5.09, **XX**-10.6.09, **XXI**-2.7.09, **XXII**-25.8.09, **XXIII**-17.9.09, **XXIV**-10.10.09, **XXV**-3.11.09, **XXVI**-25.11.09, **XXVII**-24.12.09, **XXVIII**-16.1.10, **XXIX**-10.2.10, **XXX**-6.3.10, **XXXI**-30.3.10, **XXXII**-24.4.10, **XXXIII**-19.5.10 and **XXXIV**-13.6.10) for green forage yield. Cut wise data of green forage were pooled and statistically analyzed. From each plot a representative samples of green forage were collected to estimate the dry matter content and the dry matter yield.

The soil available nitrogen was estimated through alkaline permanganate method given by Subbiah and Asija (1956), available phosphorus through 0.5M. $NaHCO_3$ (pH 8.5) method given by Olsen *et al.* (1954) and available potassium through N$\underline{N}$ NH_4OAc (pH 7.0) method given by Knundsen *et al.* (1982). Soil available sulphur was estimated through Turbidimetric method given by Tondon (2009), molybdenum through Stannous chlorid methods given by Sims (1996) and boron through Azometine-H method given by Gupta and Stewart (1975). Applied FYM was also estimated for determination of sulphur through Barium sulphate method given by Tondon (2009) while, molybdenum and boron were estimated through Atomic absorption spectrophotometry method given by Zoroski and Burau (1977). The standard analytical methods were used for plant analysis for P and K content given by the Jackson (1973), crude protein content by A.O.A.C. (2005).

Results and Discussion

Growth attributes: The growth attributes *viz*., plant height (79.75 cm) and leaf : stem ratio (1.01) of lucerme were significantly higher with application of RDF + FYM @ 10 t ha^{-1} + S + Mo + B (T_{11}) as compared to other treatments and it was found at par with the treatments T_{10}, T_7, T_6, T_5 and T_2 (Table 1). This might be due to the beneficial effect of application of RDF + FYM @ 10 t ha-1 + S + Mo + B associated with higher photosynthetic activity and protein synthesis, which promotes cell division and elongation that in turn accelerates the vegetative growth *viz*., plant height, number of tillers per meter row length and L:S ratio of lucerne. Application of 15 kg borax and 0.45 kg ammonium molybdate increased plant intensity, number of nodule, number of branch shoots and plant height of lucerne (Wang *et al.,* 2003). The minimum values of growth attributes were noticed in control. However, number of tillers per meter row length showed non-significant differences during experimentation.

Yield and quality attributes: The green forage yield, dry matter yield, crude protein yield, crude fiber yield, gross and net returns differed significantly due to different treatments of fertilizer under study. The significantly higher green forage yield (4782.00 q ha^{-1}), dry matter yield (1056.68 q ha^{-1}), crude protein yield (200.03 q ha^{-1}) and crude fiber yield (238.39 q ha^{-1}) was recorded with application of RDF+ FYM @ 10 t ha^{-1} + S + Mo + B (T_{11}) as compared to other treatments except, treatment T_{10} where, it was found at par with green forage, dry matter, crude protein and crude fiber yield (4639.95, 1023.18, 190.52 and 229.81 q ha^{-1}, respectively). The minimum values of all yield and quality attributes were noticed in control (Table 1). The per cent increase in green forage yield, dry matter yield, crude protein yield and crude fibre yield due to

application of RDF + FYM @ 5 t ha^{-1} + S + Mo + B and application of RDF + FYM @ 10 t ha^{-1} + S + Mo + B were 23.29 and 27.07, 28.50 and 32.71, 32.27 and 38.87 and 33.13 and 38.10. per cent, respectively over recommended dose of fertilizer (20:80:40 kg NPK ha^{-1}). The increase nutrient use efficiency was due to organic manure which improve the physical, chemical and biological properties of the soil which in turn increases the nutrient availability. Apart from that, the organic manures also contain most of the essential micro elements in variable quantity which has synergistic effect with other essential elements for their availability. The application of RDF + FYM @ 10 t ha^{-1} + S + Mo + B accelerates the vegetative growth of lucerne. Phosphatic fertilizers enhance the uptake of nutrients, photosynthetic activity and accumulation of the organic constituents in lucerne crop. Potassium increases the translocation of photosynthates from source to vegetative part. The overall effect of all nutrients on yield parameters was positive which resulted in higher green forage yield. The beneficial effect of NPK on the green forage yield may be attributed to the production of superior yield attributes and higher dry matter production. Since application of RDF + FYM @ 10 t ha^{-1} + S + Mo + B produced more herbage yield, accumulation of more dry matter and crude protein content in plants which in turn to increased crude protein yield. Pathan *et al.* (2005) and Pathan *et al.* (2011) reported that application of molybde-num @ 0.5 kg ha^{-1} and boron @ 2.0 kg ha^{-1} was beneficial for the green forage production of lucerne. The reasons for increased response to FYM are generally ascribed to beneficial effect associated with soil productivity (Prasad *et al.*, 1996; Acharya *et al.*, 1988). Farm yard manure directly added an appreciable amount of major micronutrients to the soil, which could contribute to the enhanced yield. The improved physical properties like water holding capacity and moisture retention, provided a desirable soil condition for the root development, enhanced nutrient uptake, crop growth and yield (Naphade *et al.,* 1993).

***Economic studies*:** The significantly highest net returns (Rs. 330443/- ha^{-1}) were registered with treatment T_{11}- (RDF + FYM @ 10 t ha^{-1} + S + Mo + B) and it was found at par with treatment T_{10}- RDF + FYM @ 5 t ha^{-1} + S + Mo + B (Rs. 3,20,539/- ha^{-1}). The maximum benefit: cost ratio (2.21) was similar in both T_{11} and T_{10} treatment. The minimum values of net returns and benefit: cost ratio was noticed in control (Table 1). An increasing net return with treatment T_{10} and T_{11} were 37.83 and 42.09 per cent, respectively over application of RDF (T_2). These findings are in conformity with Pathan *et al.* (2005), Joshi and Bhilare (2006) and Pathan *et al.* (2011).

Soil fertility status: The soil data after completion of experimentation in respect of pH, EC, OC, available N, P,

Table 1. Three years data of mean plant height, number of tillers per meter row length and leaf: stem ratio green forage yield, dry matter yield, crude protein yield and crude fiber yield, net returns and benefit: cost ratio of lucerne as influenced by different treatment during 2007-08 to 2009-10. (Total of 34 cuts).

Treatment	Plant height (cm)	No. of tillers / m row length	L: S ratio	Green forage yield (q ha^{-1})	Dry matter yield (q ha^{-1})	Crude protein yield (q ha^{-1})	Crude fiber yield (q ha^{-1})	Net returns (Rs. ha^{-1})	B : C Ratio
T_1	64.24	109	0.80	2623.23	529.84	93.36	112.22	128385	1.63
T_2	75.16	110	0.92	3763.30	796.23	144.04	172.62	232560	1.98
T_3	65.93	109	0.88	3144.94	650.15	116.18	141.67	173969	1.79
T_4	69.72	109	0.94	3341.01	693.36	123.00	149.21	189324	1.83
T_5	76.66	110	0.95	4034.06	856.26	158.24	191.97	255095	2.03
T_6	77.18	110	1.00	4219.26	910.51	169.45	205.50	268478	2.04
T_7	74.25	110	0.98	4016.94	852.84	155.22	189.76	254993	2.04
T_8	71.09	110	0.94	3495.57	732.18	132.30	158.44	206903	1.90
T_9	73.59	111	0.85	3639.48	793.61	142.69	173.40	216073	1.91
T_{10}	78.47	110	0.93	4639.95	1023.18	190.52	229.81	320539	2.21
T_{11}	79.75	114	1.01	4782.00	1056.68	200.03	238.39	330443	2.21
S.E. ±	2.14	5.86	0.03	130.56	46.33	8.60	10.26	16180	0.06
C.D. at 5 %	6.25	NS	0.08	385.09	138.66	25.35	30.61	47730	0.18

T_1- Absolute control, **T_2**- RDF (20: 80: 40 kg NPK ha^{-1}), **T_3**- FYM @ 5 t ha^{-1}, **T_4**- FYM @ 10 t ha^{-1}, **T_5**- RDF + FYM @ 5 t ha^{-1}, **T_6**- RDF + FYM @ 10 t ha^{-1}, **T_7**- RDF + S + Mo + B, **T_8**- FYM @ 5 t ha^{-1} + S + Mo + B, **T_9**- FYM @ 10 t ha^{-1} + S + Mo + B, **T_{10}**- RDF + FYM @ 5 t ha^{-1} + S + Mo + B, **T_{11}**- RDF + FYM @ 10 t ha^{-1} + S + Mo + B

Year wise selling rate of Lucerne: 2007-08-Rs.120/- q^{-1} **:** 2008-09-Rs.110/- q^{-1} **:** 2009-10-Rs.160/- q^{-1}

K, sulphur, molybdenum and boron content at the harvest of 34th cut of lucerne is presented in (Table 2). Soil pH and EC showed non significant differences. In general, it was found that there was decrease in pH as compared to its initial value (7.86) in all the treatment. The maximum reduction in pH was noticed in the treatment where FYM was applied. However, in respect to EC, there was slight increase in EC values as compared to its initial value (0.26) in most of the treatments. Highest organic carbon (0.45 %) was observed in the treatment T_{11} (RDF + FYM @ 10 t ha^{-1} + S + Mo + B) and was found at par for treatment $T_{6,}$ T_9 and T_{10} in which FYM was added. Lowest organic carbon content was observed with control (0.36%). In general, increase in organic carbon content of soil was observed in all the treatments at the end of experimentation as compared to initial value of 0.34 %. It was partly due to the direct addition of organic manure (FYM) and partly through better root growth and also due to better activity of microorganisms. Higher production of biomass might have increased the organic carbon content (Babhulkar *et al.,* 2000).

The available N, P, K, sulphur, molybdenum and boron content differed significantly due to different treatments at the harvest of last cut of perennial lucerne crop. Significantly higher nitrogen (290.97 kg ha^{-1}), phosphorous (14.42 kg ha^{-1}) and potassium (384.23 kg ha^{-1}) was observed with treatment T_{11} and it was found at par with treatment T_{10} in respect of potassium (382.03 kg ha^{-1}) only.

However, significantly increase in sulphur content (12.20 μgg^{-1}) was observed in treatment T_{11} and it was found at par with treatment T_9 (11.47 μgg^{-1}) as compared to its initial values and critical level (5.57 and 10 μgg^{-1}, respectively). Similarly, molybdenum and boron was also found statistically higher in treatment T_{11} (0.044 μgg^{-1}) and (0.32 mg kg-1). But it was below its initial values and critical levels (0.04 and 0.05 mg kg^{-1}, respectively) and (0.24 and 0.5 μgg^{-1}, respectively) in all treatments under study. This might be because of the added fertilizer has basic residual effects, however the increased organic carbon content was due to addition of increased level of fertilizer along with application of 10 t FYM ha^{-1} $year^{-1}$ which increased the organic matter in soil. Another possibility might be associated with the decaying of old roots of lucerne as well as profuse growth of roots enhanced the organic carbon in soil. The use of FYM was found beneficial in improving the status of soil micronutrients *viz*., S, Mo and B at the end of experimentation as compared to its initial values. It might be due to the application of 10 t FYM ha^{-1} along with sulphur, molybdenum and boron found beneficial as it consisted of all the essential as well as beneficial elements, incorporation of such materials produces the organic acids, organic constituents and ultimately fermentation of humus. Similarly, organic acids and humus act as chelating agent for micronutrients. Therefore, addition of FYM increases the micronutrient status of soil at the end of experimentation. These results are close vicinity with those reported by Pathan *et al.* (2005), Joshi and Bhilare (2006) and Pathan *et al.* (2011).

Table 2. Soil pH, EC, OC, Available N, P, K, sulphur, molybdenum and boron content at harvest of lucerne as influenced by different treatment at the end of experimentation.

Treatment	pH (1:2.5)	EC (dSm^{-1})	OC (%)	Available (N $kgha^{-1}$)	Available (P $kgha^{-1}$)	Available (K kg ha^{-1})	Sulphur (μgg-1)	Molybdenum (μgg^{-1})	Boron (μgg^{-1})
T_1	7.62	0.26	0.36	234.27	13.26	362.33	5.23	0.032	0.19
T_2	7.60	0.27	0.38	266.80	13.90	377.13	6.78	0.033	0.20
T_3	7.57	0.29	0.41	245.33	13.34	368.47	7.22	0.035	0.22
T_4	7.58	0.27	0.43	255.60	13.70	375.17	8.57	0.037	0.25
T_5	7.58	0.26	0.42	278.20	14.17	380.03	8.09	0.036	0.24
T_6	7.57	0.28	0.44	281.83	14.27	380.83	9.56	0.039	0.28
T_7	7.58	0.28	0.39	275.00	14.03	378.30	9.98	0.040	0.26
T_8	7.60	0.28	0.42	252.40	13.53	372.17	10.69	0.041	0.27
T_9	7.60	0.28	0.44	262.70	13.68	376.33	11.47	0.043	0.29
T_{10}	7.61	0.28	0.44	285.97	14.30	382.03	10.39	0.042	0.28
T_{11}	7.58	0.29	0.45	290.97	14.42	384.23	12.20	0.044	0.32
S.E. ±	0.03	0.01	0.003	0.53	0.02	0.89	0.43	0.001	0.005
C.D. at 5 %	N.S.	N.S.	0.007	1.55	0.05	2.62	1.27	0.002	0.014
Initial Values	7.86	0.26	0.34	207.80	13.09	357.40	5.57	0.04	0.24

T_1- Absolute control, **T_2**- RDF (20: 80: 40 kg NPK ha^{-1}), **T_3**- FYM @ 5 t ha^{-1}, **T_4**- FYM @ 10 t ha^{-1}, **T_5**- RDF + FYM @ 5 t ha^{-1}, **T_6**- RDF + FYM @ 10 t ha^{-1}, **T_7**- RDF + S + Mo + B, **T_8**- FYM @ 5 t ha^{-1} + S + Mo + B, **T_9**- FYM @ 10 t ha^{-1} + S + Mo + B, **T_{10}**- RDF + FYM @ 5 t ha^{-1} + S + Mo + B, **T_{11}**- RDF + FYM @ 10 t ha^{-1} + S + Mo + B

Conclusion

It can be concluded that, for growing of perennial lucerne crop in sulphur, molybdenum and boron deficit soils of Maharashtra application of recommended dose of fertilizer (20:80:40 kg NPK $kgha^{-1}$) + 30 kg Elemental Sulphur, 1.0 kg Sodium Molybdate and 4.0 kg Borax along with 5 t FYM ha^{-1} at the time of sowing through soil application and 100 kg DAP ha^{-1} after every four cut is found beneficial to obtain maximum green forage yield, monitory returns and to improve the soil fertility.

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