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EFFECT OF DIFFERENT NUTRIENT SOURCES ON FODDER YIELD, QUALITY AND SOIL FERTILITY STATUS OF LUCERNE GROWN SOIL

K. SATHIYA BAMA*

Department of Agronomy
Tamil Nadu Agricultural University,
Coimbatore (Tamil Nadu), India
**(e-mail : kssoilscience@gmail.com)*

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SUMMARY

An experiment was carried out during 2009-12 to study the impact of different nutrient sources on yield and quality of lucerne (CO 1). The mean of three years data showed that poultry manure (PM) applied @ 2.1 t/ha+398 kg rock phosphate+2 kg rhizobium+2 kg phosphobacteria recorded statistically higher green fodder yield of 60.5 t/ha/year. Highest crude protein yield (3.46 t/ha) was observed in PM treatment, but the FYM recorded higher crude protein content (24.3%). The higher nutrient uptake was recorded in organics applied treatment rather than inorganics. The INM applied soil recorded higher SOC of 0.80 per cent. The same treatment recorded higher available N, P and K content. Though inorganics recorded higher net returns, among the organics the PM applied plot recorded net returns of Rs. 95,865 with high B/C ratio of 3.7.

Key words : Lucerne, FYM, poultry manure, fodder yield, crude protein, soil nutrients

Lucerne, the "Queen of Forages", has not only a very high yield potential, but is also most palatable, nutritious and has highest feeding value. It is the major forage legume grown in approximately 45 million hectares worldwide. It is the oldest plant grown solely for forage with livestock feeding dating back to more than 3,300 years ago. Environmentally friendly, lucerne improves soil health and allows sustainable animal production (Lowe, 1994). Its nutritional value as a source of protein (22-24% crude protein) has long been recognized. It is grown in a almost every state in India and provides green fodder for livestock. In Tamil Nadu, Coimbatore and Erode districts are the major lucerne growing areas. Alfalfa is also known as kuthirai masal in Tamil.

It is a heavy user of plant nutrients. As a legume, alfalfa is expected to meet its N requirements from the atmosphere. Some of the soil laboratories are recommending application of P and K at their removal rate by alfalfa to established stands even in the fields of high or very high to excessive in P and K persistence and maximum yield in alfalfa has shown that highest yield of alfalfa was obtained when macro (N, P, K and S) and micronutrients were applied together (Sahota, 2007).

A well planned fertilizer programme is necessary for alfalfa production. The fertilizer programme for alfalfa should achieve main goals viz., providing levels of nutrients that result in maximum yield and quality of forage and environment in which Rhizobium bacteria can efficiently fix nitrogen. This eliminates the need for nitrogen fertilizer and also ensures forage of high protein content. During establishment and before the bacterial symbiosis develops, a small amount of nitrogen (20 to 40 lb N/ acre) is beneficial. Applications of larger amounts of nitrogen during establishment inhibit bacterial growth. Lucerne can fix up to approximately 250 kg N/ha/year when taking both above and below ground production into account. This fixation will increase soil N content which can be used by following crops. Lucerne has a high P and K requirement. The application of organic nitrogen to lucerne has showed greater capacity to overcome the depressive effect of water deficiency stress with regard to forage productivity, dry root mass and nitrogen in yield (Vasileva and Kostov, 2002).

Its wide usage and importance recognized in livestock sector forced to study the quality aspect of lucerne. The quality of lucerne will vary according to the kind of nutrient source. Organic alfalfa is in high demand by the organic livestock industry, alfalfa also serves as a critical transitional and soil-building crop

(Guerena and Sullivan, 2003).

Now-a-days organic milk production is getting popularity, hence the organic way of producing fodder is also gaining momentum. Since there is a large demand for organic items in the market, scientists and policy planners are reassessing agricultural practices which rely more on biological inputs rather than heavy usage of chemical fertilizers and pesticides. It was reported that the organic production system maintained and improved the soil health though production system maintained and improved the soil health through stimulating the activity of soil organism. Azotobacter/rhizobium naturally fixes atmospheric nitrogen, while the use of phosphate solubilizing bacteria (PSB) is helpful in increasing the availability of fixed phosphorus in soil.

The different nutrient sources have their own effect. The nutrient concentrations of animal manures vary greatly, creating challenges to using them effectively. Hence, to study the impact of different nutrient sources (organics, inorganics INM) on yield and quality of lucerne, the present investigation was undertaken.

MATERIALS AND METHODS

An experiment was carried out during 2009-12 to study the impact of different nutrient sources (organics, inorganics integrated nutrient management (INM)) on yield and quality of lucerne (variety CO 1). The nutrient sources viz., farm yard manure (FYM) 5 t/ha+398 kg rock phosphate+2 kg rhizobium+2 kg phosphobacteria and poultry manure (PM) 2.1 t/ha+398 kg rock phosphate+2 kg rhizobium+2 kg phosphobacteria on N equivalent basis, INM (25 : 124 : 40 kg N, P and K along with 25 t FYM and inorganics (25 : 124 : 40 kg N, P and K) were tried in this experiment. The nutrient contents of the manures analyzed are given in Table 1. For all treatments, cultivation practices were followed as per schedule. For organic treatment, minimum external requirement of N met through FYM, PM sources, P supplied by rock phosphate source, since that is an approved organic source for organic crop production.

The soil analysis report before the commencement of experiment revealed that the soil reaction was slightly alkaline (7.8) and free from excessive salts (0.12 dS/m). It was medium in organic carbon (0.65%) and low in available N (165 kg/ha), medium in available P (15 kg/ha) and high in available K (510 kg/ha). The green fodder yield recorded as such in the field. The dry fodder yield was recorded by keeping the samples in electric oven at 65ºC. The organic carbon was estimated by Walkley and Black (1934). The available N in soil was estimated by alkaline potassium permanganate method (Subbiah and Asija, 1956), available P by Olsen's method (Olsen *et al.*, 1954), available K by flame photometer method (Stanford and English, 1949), and micronutrients by DTPA extraction (Jackson, 1973). The plant samples were analyzed at cutting stage for N, P, K, S, Ca, Mg, S and micronutrients by acid digestion technique (Piper,1966). The fodder quality parameters viz., crude protein, crude fibre and crude fat contents were estimated by the procedure outlined by Van Soest and Moore (1965). The data were analyzed statistically by using simple RBD.

TABLE 1
Chemical composition of manures

Properties	FYM	Poultry manure
Organic carbon (%)	28.0	47.1
N (%)	0.52	1.21
P (%)	0.3	0.4
K (%)	0.53	0.45
Ca (%)	0.18	0.72
Mg (%)	0.32	0.40
S (%)	0.21	0.32
Zn (ppm)	270	260
Fe (ppm)	820	570
Cu (ppm)	17	32
Mn (ppm)	220	120

RESULTS AND DISCUSSION

Fodder Yield

The first year data of this experiment showed that among the different sources of nutrients tried to improve the green fodder yield**,** the inorganics/INM recorded statistically higher green fodder yield of 62 and 61.7 t/ha/year, respectively, followed by PM (58.2 t/ha/year) and FYM (55.4 t/ha/year) (Table 2). During the second year, the INM recorded statistically higher green fodder yield (63.7 t/ha/year) followed by PM (62.12 t/ha/year) and FYM (54.4 t/ha/year). During third year, though INM recorded higher green fodder yield (63.4 t/ha/year) which was on par with inorganics (62.3 t/ha/year) and PM treatment (61.2 t/ha/year). The mean of three years data showed that the results corroborated the findings of Kumar *et al.* (2004). The INM and inorganics recorded higher dry fodder yield of 17.4 and 17.48 t/ha/

TABLE 2
Effect of source of nutrients on fodder yield and quality of lucerne

Treatment	Green fodder yield (t/ha/year)				Crude protein yield (t/ha/year)			Quality (%)		
	I year	II year	III year	Mean	I year	II year	III year	Crude protein	Crude fibre	Crude fat
S_1–FYM	54.4	55.4	56.2	55.3	3.41	3.21	3.85	24.3	21.9	3.7
S_2–PM	62.1	58.2	61.2	60.5	3.46	3.65	3.95	22.9	22.0	3.8
S_3–INM	63.7	61.7	63.4	62.9	3.18	3.47	4.08	22.8	21.7	3.5
S_4–Inorganics	58.3	62.0	62.3	60.9	3.11	3.06	3.58	20.4	23.1	3.6
C. D. (P=0.05)	2.01	5.30	4.22		0.34	0.34	0.30	NS	NS	NS

NS–Not Significant.

year, respectively, followed by poultry manure (16.4 t/ha/year) and FYM treatment (15.6 t/ha/year). Same trend of results was observed during second and third years also. The higher yield in INM might be due to increased plant height, population than organic alone. Also INM practice for lucerne included 25 t FYM/ha may be one of the reasons.

Quality Parameters

The important fodder quality parameters viz., crude protein, crude fibre and crude fat contents were analyzed in the lucerne for the application of different nutrient sources. Among the treatments, the FYM recorded higher crude protein content in lucerne (24.3%) which was statistically on par with PM applied plot. Bama *et al*. (2013) reported that poultry manure application @18.8 t/ha+2 kg azospirillum+2 kg phosphobacteria recorded 167.6 t green fodder yield/ha/year in fodder sorghum. In the crude fibre and crude fat analytical data, there was no significant difference observed among the treatments (Table 2).

Nutrient Uptake

Higher N uptake was observed in INM treatment (959 kg/ha) which was on par with PM applied plot of 938 kg/ha and FYM plot (879 kg/ha) (Table 3). Integrated nutrient management proved to be very effective in enhancing crop yields reported by Dongale *et al.* (1987). It has the ability to accumulate significantly more nitrogen in its biomass than other legumes due to its deeper root system (Jarvis, 2005). Researchers evaluated alfalfa yield and protein responses to nitrogen fertilization, and very few showed any positive effects. In studies where yield responses to nitrogen were obtained, the response was relatively small and inconsistent. Nitrogen in the dry mass of lucerne grown for seed under conditions of water-deficiency stress increased by 33 and 38 per cent for organic fertilizer (Vasileva and Kostov, 2002). The increased N uptake in INM might be due to increased fodder yield.

The highest P uptake was recorded in the INM plot (191 kg/ha) which was on par with PM plot (188 kg/ha). The FYM and inorganic plot recorded similar P uptake (168 kg/ha). Timing the application of

TABLE 3
Effect of source of nutrients on nutrient uptake (kg/ha) of lucerne

Treatment	Nutrient uptake (kg/ha)									
	N	P	K	Ca	Mg	S	Fe	Zn	Mn	Cu
S_1–FYM	879	168	427	426	59	45	11.9	1.76	6.9	2.26
S_2–PM	938	188	461	407	72	51	13.5	2.00	7.8	2.56
S_3–INM	959	191	450	386	66	52	13.8	2.05	8.1	2.63
S_4–Inorganics	774	168	391	373	62	47	12.5	1.85	7.3	2.37
C. D. (P=0.05)	87	21	51	46	8	6	1.5	NS	0.7	NS

phosphorus fertilizer or manure will provide more time for the phosphorus to react with the soil and for plant uptake. Historically, phosphorus has been the nutrient needed in largest quantities for alfalfa production. The higher fodder yield in INM might be the reason for higher P uptake.

Higher K uptake was observed in PM treatment (361 kg/ha) which was on par with INM applied plot of 350 kg/ha and FYM plot (327 kg/ha). The lowest K uptake was recorded in the inorganics alone plot of 391 kg/ha. An adequate supply of available potassium will stimulate nitrogen fixation in alfalfa. Research showed that on sandy loam soils, both the yield and protein content of the forage increased with increasing rates of potassium (K_2O) applied. Potassium enhanced winter hardiness and early spring growth of the plants. The increased K uptake in INM might be due to increased fodder yield. These results are in conformity with the findings of Kumar *et al.* (2011).

The higher Ca uptake was recorded in the FYM plot (426 kg/ha) which was on par with PM plot (407 kg/ha) and INM plot (386 kg/ha). The lowest Ca uptake was recorded (373 kg/ha). Highest Mg uptake was observed in PM treatment (72 kg/ha) which was on par with INM applied plot (66 kg/ha) followed by inorganics (62 kg/ha) and FYM plot (59 kg/ha). Higher S uptake was observed in INM treatment (52 kg/ha) which was on par with PM applied plot (51 kg/ha) and inorganics plot (47 kg/ha). Alfalfa crop has a higher demand for sulphur than annual crops such as cereals and flax. Sulphur is important in the production of protein by legume crops.

Higher Fe uptake was recorded in the INM plot (13.8 kg/ha) which was on par with PM plot (13.5 kg/ha) and INM plot (12.5 kg/ha). The lowest Fe uptake was recorded in FYM plot (11.9 kg/ha). Highest Mn uptake was observed in INM treatment (8.1 kg/ha) which was on par with PM applied plot (7.8 kg/ha) followed by inorganics (7.3 kg/ha) and FYM plot (6.9 kg/ha). The improved uptake might be due to increased fodder yield. Non-significant response was observed for Zn and Cu uptake.

Soil Fertility

The higher SOC content (0.80%) was recorded in INM applied treatment followed by FYM (0.75%) and poultry manure (0.73%) (Table 4). Since the INM received 25 t of FYM/ha might have contributed both directly and indirectly. Alfalfa also contributed positively to soil structure, biodiversity and carbon sequestration (Lowe, 1994). Alfalfa removed large quantities of nutrients from soil. Since lucerne is a legume crop, N application through organics is low. The INM treatment recorded higher available N content (177 kg/ha) which was on par with inorganics alone treatment (175 kg/ha). Rhizobium inoculated alfalfa converts atmospheric nitrogen (N) into forms that can be used by subsequent crops. The same trend of results was observed in the available P status. Higher available P content was recorded in INM (17.2 kg/ha) which was on par with inorganics and FYM applied treatment (15.2 kg/ha). Phosphorus movement in soil is very limited; therefore, phosphorus was placed deep into the root zone by applying and incorporating fertilizer prior to establishing a new stand of alfalfa.

Higher available K was recorded in the INM (535 kg/ha) which was on par with inorganics (528 kg/ha). Alfalfa removes large amounts of potassium from soil. Since a need for potassium has been identified, annual applications be necessary to maintain soil test potassium and high yields. Multi-year applications of

TABLE 4
Effect of source of nutrients on soil nutrient status of lucerne grown soil

Treatment	SOC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Ex Ca (cmolp (+)/kg)	Ex Mg (cmolp (+)/kg)	DTPA Fe (ppm)	DTPA Zn (ppm)	DTPA Mn (ppm)	DTPA Cu (ppm)
S_1	0.75	162	15.2	515	14.5	6.3	7.6	6.4	4.0	6.3
S_2	0.73	165	14.1	503	14.2	6.1	7.5	6.0	3.8	6.1
S_3	0.80	177	17.2	535	14.5	5.8	7.5	5.8	4.5	5.8
S_4	0.70	175	15.2	528	13.5	5.7	7.2	5.7	3.7	5.7
C. D. (P=0.05)	0.09	13	0.8	12	NS	NS	NS	NS	NS	NS

NS–Not Significant.

potassium are not recommended since alfalfa will absorb more potassium than needed for maximum growth. This trait is referred to as *luxury consumption* and results in the harvest of hay containing high concentrations of potassium (Rich Koenig *et al.*, 1999). The increased availability of soil nutrients might be due to integrated application of N, P, K with FYM+biofertilizers by reducing the nutrient losses and increased activity of microbes.

The exchangeable Ca and Mg, DTPA Mn, Zn and Cu content recorded non-significant value. Calcium is a macronutrient that is absorbed in relatively large amounts by alfalfa. However, due to ample soil reserves, these deficiencies are rare. There is promotion of Ca fertilizer use claiming that exchangeable Ca reserves are not readily available. However, at present, Ca fertilization is not recommended for alfalfa production. Magnesium (Mg) is another macronutrient required for alfalfa growth. Like calcium, magnesium deficiencies are rare.

Nutrient deficiencies can significantly reduce alfalfa yield. Decomposition of the alfalfa root system typically contributes about 100 lb/acre N to the soil after one year, and an additional 50 lb/acre N in the second and third years (Lowe,1994). Singh *et al.* (2006) also reported similar results.

Soil Nutrient Balance

The balance sheet computed reveals that actual gain was negative for all the treatments The nutrient uptake pattern reveals that the N and K were heavily removed from the soil (Table 5). Actual gain of N, P and K in lucerne was observed in poultry manure applied plots. Since lucerne is a high protein containing crop, it removes large volume of nitrogen from the soil. But the N might have met from N fixation process. Alfalfa is capable of obtaining N from the atmosphere and does not require supplemental N sources. The remaining nutrients, however, must come from soil reserves or fertilizer sources. The present recommendation of P is sufficient to the crop. Since the lucerne is leguminous crop the N requirement may be satisfied by N fixation by nodules. The lucerne removes large amount of potassium from the soil so K recommendation has to be taken care if lucerne is recommended for cultivation in future. Lowe (1994) reported that each tonne of dairy quality (pre-bloom) alfalfa hay contained approximately 80 lbs of nitrogen (N), 60 lbs of potash (K_2O), 15 lbs of phosphate (P_2O_5), 5 lbs of sulfur (S), 0.05 lb each of zinc (Zn), iron (Fe), manganese (Mn) and boron (B), 0.1 lb copper (Cu) and 0.006 lb molybdenum (Mo).

In general, forage crops have a high demand for phosphorus and potassium. Thus, it is critical that soil levels of these nutrients be built up in preparation for growing forage crops. Phosphorus and potassium are relatively immobile in the soil. Phosphorus moves less

TABLE 5
Effect of source of nutrients on soil nutrient balance of lucerne grown soil

Treatment	Nitrogen					
	Initial (a)	Applied (b)	Uptake (c)	Post-harvest (d)	Actual grain (e) (d-a)	N balance (c+e-b)
S_1	165	25	879	162	-3	-851
S_2	165	25	938	165	0	-913
S_3	165	25	959	177	+12	-946
S_4	165	‘25	774	175	+10	-759
Phosphorus						
S_1	15	134	168	15.2	+0.2	-34.2
S_2	15	134	188	14.1	-0.9	-53.1
S_3	15	124	191	17.2	+2.2	-69.2
S_4	15	174	168	15.2	+-0.2	5.8
Potassium						
S_1	510	25	427	515	+5	-407
S_2	510	8	461	503	-7	-446
S_3	510	40	450	535	+25	-435
S_4	510	65	391	528	+18	-344

than one-eighth of an inch a year in soil. To bring the rooting zone of a soil into the optimum level for crops, the phosphorus and potassium must be thoroughly mixed with the soil. Therefore, it is very important that the soil levels be built up before the perennial forage crop is established, because once the crop is established there is no way to effectively mix the phosphorus and potassium with the soil in the rooting zone.

Calcium and magnesium are essential secondary nutrients required by crops. Legumes in particular have a high demand for calcium and magnesium. On farms with livestock, the manure applied to alfalfa may be major contributor to meeting the phosphorus and potassium goals at establishment. When manure is applied to alfalfa to meet nitrogen needs, excess phosphorus and potassium are also applied. This excess phosphorus and potassium builds soil levels, often into the high range, and can be used by a forage crop later in the rotation. When manure is not available, fertilizer must be applied to replace the nutrients removed in the alfalfa crop and if necessary to build the soil levels into the optimum to high range before forage establishment.

Effect of Source of Nutrients on Economics of Fodder Cultivation

Data pertaining to influence of inorganic and organic source of nutrients on economics of lucerne cultivation are presented in Table 6. The results showed that though inorganics recorded higher net returns (Rs.102669) with B/C ratio of 3.7 among the organics the PM applied plot recorded net returns of Rs. 95,865/ with B/C ratio of 3.7.

TABLE 6

Effect of source of nutrients on monetary benefits of lucerne

Treatment	Lucerne			
	CC	GR	NR	B/C
S_1–FYM	36120	81600	45480	2.2
S_2–PM	35085	130950	95865	3.7
S_3–INM	46831	138825	91994	2.9
S_4	36831	139500	102669	3.7

CC–Cost of cultivation (Rs.), GR–Gross returns (Rs.), NR–Net returns (Rs.) and B/C–Benefit : cost ratio.

CONCLUSION

The research paper on lucerne crop highlights that to get higher green fodder yield, the INM (25 kg N/ha+124 kg P/ha+40 kg K/ha with 25 t FYM/ha) can be recommended. From the soil fertility point of view and economics the INM practice will be the best option. But for the interest of organic farmers in terms of fodder quality, PM applied @ 2.1 t/ha+398 kg rock phosphate+2 kg rhizobium+2 kg phosphobacteria can be recommended to avoid deleterious effect of inorganic fertilizers.

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