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Effect of nutrient sources on productivity of fodder cropping systems in Punjab

C.S. AULAKH[1], M.S. GILL[2], R.K. MAHEY[3], S.S. WALIA[4], AND GURMINDER SINGH[5]

Punjab Agricultural University, Ludhiana, Punjab 141 004

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ABSTRACT

A field study was conducted to investigate the effect of nutrient sources on green fodder productivity of different fodders in cropping system mode at Ludhiana on a sandy loam soil in split plot design. The main plots consisted of four fodder cropping systems i.e. sorghum [*Sorghum bicolor* (L.) Moench]-berseem (*Trifolium alexandrinum* L.), maize (*Zea mays* L.)-berseem-pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz], maize-berseem-maize + cowpea [*Vigna unguiculata* (L.) Walp] and sorghum + clusterbean [*Cyamopsis tetragonoloba* (L.) Taub]-oat (*Avena sativa* L.)-cowpea and three nutrient management systems viz. organic, chemical and integrated in sub-plots with three replications. The highest maize equivalent green fodder yield (83.3 t/ha) was obtained in maize-berseem-pearlmillet fodder cropping system, which was significantly higher than sorghum-berseem, but statistically at par with the sorghum + clusterbean-oat-cowpea and maize-berseem-maize + cowpea cropping systems. Pearlmillet (64.2 t/ha) in summer, sorghum (34.6 t/ha) in *kharif* and berseem (62.7 t/ha) in *rabi* season gave the highest green fodder yield. The organic nutrient management produced significantly higher total system green fodder productivity (125.8 t/ha) and maize equivalent green fodder yield (85.4 t/ha) than the integrated and chemical fertilizer system. The organic carbon status of the soil increased by 24 and 11% over its initial status with the adoption of organic and integrated nutrient management systems, respectively. The available nitrogen, phosphorus and potassium status in soil were also higher in organic and integrated nutrient management as compared to chemical fertilizer application.

Key words **:** Fodder cropping systems, Nutrient sources, Productivity, Soil health

India, with 2.2% of the world's geographical area, supports nearly 20% of the world's livestock and 17% human population. Heavy livestock pressure on limited land resources in the country demands increased fodder production for a healthy livestock. The area under fodder crops in the country is 8.47 million ha but the country faces a net deficit of 61.1% green fodder (IGFRI, 2011). There is a little possibility of any tangible increase in fodder area due to competition from other economically competitive agricultural crops and preferential need for food crops. Therefore, there is need to increase forage production, within the existing farming systems, by developing intensive fodder production systems to get year round forage and economize livestock feeding management.

Continuous cereal after cereal cropping has led to a decline in the productivity of crops and has adversely affected the physical and chemical properties of soil causing multi nutrient deficiencies in soil and farm products. Inclusion of legumes in cropping systems and use of farmyard manure (FYM) can minimize the use of chemical fertilizers, improve soil health and sustain the desired yield levels. Inclusion of legumes in cropping systems also improves fertility status of soil and helps in increasing the yield of succeeding cereal crops (Balyan, 1997). Interest in the use of organic manures is growing due to health awareness of stakeholders, reports of toxic residues in human food chain and chemical poisoning of animals through contaminated fodders. The recycling of crop residues and use of organic manures have been given more consideration for ensuring sustainable land use and agricultural production. These developments have led to the growing interest of people in organic food and milk. The global area under organic management has increased to 37.2 M ha and with 54.9 billion US $ sales of organic products (Yadav, 2011). The demand for organic milk is likely to promote the concept of organic dairy. Hence, organic fodder production can play a vital role in organic dairy farming system. The integration of organic and inorganic sources may help in minimizing the cost of chemical fertilizers, improve crop performance and soil fertility

[1]**Corresponding author Email:** csaulakh@rediffmail.com
[1,4]Agronomist, [5]Research Fellow, Department of Agronomy, [2]Director of Extension Education; [3]Registrar, Punjab Agricultural University, Ludhiana.

(Swarup, 1998). Organic manures supply the nutrients in a sustained manner during the crop growth period and this becomes more important in fodder crops because of their multi-cut nature. Organic and integrated nutrient management in forage production systems, therefore deserve investigation. The present study was undertaken to evaluate the response of different fodder cropping systems to organic and integrated nutrient management (INM) in comparison to chemical fertilizers.

MATERIALS AND METHODS

A field experiment was conducted to investigate the effect of organic, chemical fertilizer and integrated nutrient management (INM) on green fodder production of various fodder cropping systems at the Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana from 2005-06 to 2006-07 on a sandy loam soil in a split plot design. The experimental site had sub-tropical and semi-arid type of climate and was situated at a height of 247 m above the mean sea level at 30º-54´ N latitude and 75 º-48´ E longitudes. The soil of experiment site was medium in organic carbon (0.54%) having 244.4, 41.9 and 143.7 kg/ha available (alkaline permanganate oxidisable) nitrogen, phosphorus (0.5 M $NaHCO_3$ extractable) and potassium (1 M ammonium acetate exchangeable), respectively. The experiment was laid out in split plot design with four fodder cropping systems i.e. sorghum (*kharif*)-berseem (*rabi*) [SB], maize (*kharif*)-berseem (*rabi*)-pearlmillet (summer) [MBP], maize (*kharif*)-berseem (*rabi*)-maize + cowpea (summer) [MBMC] and sorghum + clusterbean (*kharif*)-oat (*rabi*)-cowpea (summer) [SCbOC] in main plots and three nutrient management practices i.e. organic, chemical fertilizer and integrated (INM) as sub-plots with three replications. The details regarding agronomic practices followed and fertilizers used for raising the crops, as per the management systems, are given in Table1. The nutritional requirement of crops in organic system was fulfilled by application of farmyard manure (FYM) to each crop by taking into consideration the nitrogen content of FYM (1.04 and 1.01% N in first and second year, respectively) on dry weight basis. The quantity of FYM to each crop was based on the nitrogen requirement of crops given in Table 1. In integrated system, the 50% of recommended nitrogen was supplied through FYM taking N as base and the remaining 50% through chemical fertilizers. In chemical fertilizer, the whole nutrition was supplied through chemical fertilizers. The fodder cropping systems and nutrient management systems were evaluated for seasonal and total green fodder productivity and their effect on soil health. Maize equivalent fodder yields of different cropping systems were calculated by taking into account the sale price of different fodders. The formula for calculating the maize equivalent fodder yield is given below:

$$\text{Maize equivalent fodder yield (t/ha)} = \frac{\text{Green fodder yield (t/ha)} \times \text{Price of fodder}}{\text{Price of maize fodder}}$$

The data on different crop and soil parameters for individual years were pooled and statistically analyzed by using statistical methods described by Gomez and Gomez (1984) and the software used was CPCS1 developed by the Department of Statistics, Punjab Agricultural University, Ludhiana.

RESULTS AND DISCUSSION

Seasonal green fodder yield

Pearlmillet gave significantly higher green fodder yield than maize + cowpea or cowpea alone during summer season; 74 and 96% more than maize + cowpea and cowpea alone, respectively. Maize + cowpea also gave significantly higher green fodder yield than cowpea alone. Hence, pearlmillet proved a better option to get green fodder during the lean periods of hot summers from June onwards. Although maize + cowpea and cowpea alone gave low fodder yields, but have significance from animal nutrition and soil fertility point of view particularly under organic farming situations. Among various nutrient management practices, use of organic manure yielded significantly higher green fodder yield than chemical fertilizer alone or integrated nutrient management (INM). The INM was also significantly better than chemical fertilizer alone (Table 2). The application of organic manure resulted in better growth of fodder crops as compared to chemical fertilizer alone. Application of farmyard manure along with chemical fertilizers is recommended to most of the fodder crops in Punjab (PAU, 2010). Sorghum produced significantly higher green fodder yield than maize, but it was statistically at par with sorghum + clusterbean during *kharif* season (Table 2). The organic manure and INM in these fodders were at par and significantly superior to the application of fertilizer alone. These results are in line with the findings of Jayanthi *et al.* (2002).

During *rabi* season, berseem is the predominant green fodder extensively grown under Punjab (India) conditions and it gives four to five cuttings. Berseem gave the highest green fodder under maize-berseem-pearlmillet cropping system which was significantly higher than that produced by oat in sorghum + clusterbean-oat-cowpea system but was statistically at par with berseem in sorghum-berseem and maize-berseem-maize + cowpea system. The higher yield of berseem than oat was due to more number of cuttings. Organic manure gave significantly more berseem green fodder yield than chemical fertilizer and INM.

Table 1. Production practices followed in the experiment for raising different crops

Cropping system/ crop	Sowing time	Variety	Seed rate (kg/ha)	Spacing (cm)	Nutrients supplied (kg/ha) N - P	Stage at harvest
			Sorghum-berseem (SB)			
Sorghum	2nd week June	'SL 44'	50	22	100 - 20	Milk ripe stage to dough stage of grain development i.e. 50-60 days after sowing (DAS)
Berseem	1st week September	'BL 10'	20	-	25 - 75	First cutting 50 DAS and subsequent cuttings at 40 days interval
			Maize-berseem-pearlmillet (MBP)			
Maize	2nd week August	'J 1006'	75	30	87.5 - 30	Boot to milk stage i.e. 65-80 DAS
Berseem	1st week September	'BL 10'	20	-	25 - 75	First cutting 50 DAS and subsequent cuttings at 40 days interval
Pearlmillet	2nd week June	'PCB 164'	20	22	50 - 0	Ear emergence stage i.e. at 45-55 DAS
			Maize-berseem-maize + cowpea (MBMC)			
Maize	2nd week August	'J 1006'	75	30	87.5 - 30	Boot to milk stage i.e. 65-80 DAS
Berseem	1st week September	'BL 10'	20	-	25 - 75	First cutting 50 DAS and subsequent cuttings at 40 days interval
Maize + Cowpea	2nd week June	'J 1006' + 'Cowpea 88'	37.5 + 37.5	30	87.5 - 30	Boot to milk stage i.e. 65-80 DAS
			Sorghum + clusterbean-oat-cowpea (SCbOC)			
Sorghum+Clusterbean	2nd week June	'SL 44' + *'Guara* 80'	25 + 25	22	100 - 20	Milk ripening stage to dough stage of grain development i.e. 50-60 DAS when its 1/3rd ears had emerged
Oat	3rd week October	'OL 9'	62.5	20	75 - 20	Boot to milk stage
Cowpea	1st week April	'Cowpea 88'	50	30	Residual fertility	Pre-flowering stage i.e. at 55-65 DAS

INM was also significantly better than chemical fertilizer alone.

Total green fodder yield

The maize-berseem-pearlmillet cropping system gave the highest total green fodder yield, which was significantly more than sorghum-berseem, sorghum + clusterbean-oat-cowpea and maize-berseem-maize + cowpea cropping systems (Table 3). The sorghum + clusterbean-oat-cowpea and maize-berseem-maize + cowpea cropping systems were statistically at par with each other, but were significantly better than sorghum-berseem system. The better performance of maize-berseem-pearlmillet system may be attributed to the higher green fodder yield by pearlmillet and the poor performance of sorghum-berseem due to less cropping intensity in this cropping system. Similar findings were also reported by Bhilare *et al.* (2002). The application of organic manure produced significantly more total green fodder yield than INM and chemical fertilizer alone. INM also enabled the crops to produce significantly more green fodder yields than the chemical fertilizer alone. This was due to better response of fodder crops to organic manure than chemical fertilizer. The better performance of crops with application of organic manure than with chemical fertilizers in the very first year was due to more responsiveness of fodder crops to organic manure. The application of farmyard manure is recommended to most of the fodder crops in Punjab (PAU, 2010). Kumar *et al.* (2005) also reported that application of 50% recommended dose of nitrogen and phosphorus through fertilizers and 50% through FYM recorded significantly higher forage yield than the 100% recommended dose of nitrogen and phosphorus through chemical fertilizers.

Maize green fodder equivalent yield

The summer fodder crop of maize + cowpea gave significantly higher maize equivalent green fodder yield than summer fodder of cowpea alone. However, it was statistically at par with pearlmillet (Table 3). Maize + cowpea fodder although gave poor yield than pearlmillet , but could compete with pearlmillet in respect of maize fodder

equivalent yield due to its higher market price as it is nutritionally better than pearlmillet. Maize + cowpea could also prove better than pearlmillet under organic farming systems particularly when the availability of organic manures is limited. The sorghum and sorghum + clusterbean during *kharif* season were statistically at par with each other, but produced significantly more maize equivalent green fodder yields than maize. The maize yields were statistically at par in maize-berseem-pearlmillet and maize-berseem-maize + cowpea cropping systems. The berseem during *rabi* season, irrespective of the cropping systems, produced significantly higher maize equivalent green fodder yield than oat in sorghum + clusterbean-oat-cowpea system. This was due to higher green fodder yield of berseem than oat. The maize equivalent green fodder yields of berseem did not differ significantly among themselves in different berseem based cropping systems. The maximum total maize equivalent green fodder productivity was recorded in maize-berseem-pearlmillet system, which was statistically at par with maize-berseem-maize + cowpea, but was significantly better than sorghum-berseem and sorghum + clusterbean-oat-cowpea cropping systems. The maize-berseem-maize + cowpea system was statistically at par with sorghum + clusterbean-oat-cowpea system, but both were significantly better than sorghum-berseem system. Singh (2008) reported significantly higher berseem forage equivalent yield in sorghum-berseem-maize + cowpea sequence.

The application of organic manure gave significantly more maize equivalent green fodder yields than INM and chemical fertilizer alone in seasonal and total system maize equivalent green fodder yields. In general, integrated nutrient management (INM) gave significantly more total maize equivalent green fodder yields than the

Table 2. Green fodder yield of various fodder crops as influenced by cropping system and nutrient management

Treatment	Summer fodder yield (t/ha)			*Kharif* fodder yield (t/ha)			*Rabi* fodder yield (t/ha)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Cropping system									
SB	-	-	-	32.3	37.1	34.6	60.2	61.0	60.6
MBP	75.1	53.5	64.2	9.6	12.0	10.8	57.4	68.0	62.7
MBMC	40.6	33.0	36.9	8.9	10.4	9.6	56.9	65.5	61.2
SCbOC	31.2	34.3	32.8	28.3	37.0	32.7	49.0	48.1	48.6
SEm±	0.6	0.3	0.4	0.7	0.4	2.1	0.6	2.4	1.7
CD (P=0.05)	2.4	1.0	1.4	2.3	1.4	7.3	2.0	8.4	5.7
Nutrient management									
Organic	53.3	41.8	47.8	24.4	26.0	25.2	64.7	64.7	64.7
Chemical	45.0	38.3	41.5	13.6	20.9	17.2	45.9	55.8	50.9
Integrated	48.7	40.7	44.6	21.3	25.5	23.4	57.0	61.4	59.3
SEm±	0.4	0.6	0.5	0.4	0.4	1.1	0.3	1.1	0.9
CD(P=0.05)	1.2	1.8	1.4	1.2	1.1	3.2	0.9	3.4	2.7

SB- Sorghum-berseem; MBP- Maize-berseem-pearlmillet; MBMC- Maize-berseem-maize + cowpea; SCbOC- Sorghum + clusterbean-oat-cowpea

Table 3. Total green fodder yield and maize equivalent green fodder yield of different cropping systems as affected by system of nutrient management

Treatment	Total green fodder yield (t/ha)			Maize equivalent green fodder yield (t/ha)			
	1st year	2nd year	Pooled	Summer	*Kharif*	*Rabi*	Total
Cropping system							
SB	92.5	98.0	95.2	-	32.2	34.6	66.8
MBP	142.1	133.5	137.7	36.7	10.8	35.8	83.3
MBMC	106.4	108.9	107.8	36.9	9.6	35.0	81.5
SCbOC	108.5	119.4	114.0	18.7	30.3	27.8	76.8
SEm±	1.0	1.7	2.4	2.1	0.8	0.9	1.8
CD (P=0.05)	3.5	5.9	8.4	8.3	2.9	3.2	6.1
Nutrient management							
Organic	129.6	122.1	125.8	32.8	23.8	37.0	85.4
Chemical	93.0	105.4	99.17	28.7	16.3	29.1	66.9
Integrated	114.7	117.4	116.1	30.8	22.1	33.9	79.1
SEm±	0.6	1.0	1.5	0.3	0.5	0.5	1.1
CD(P=0.05)	1.8	3.1	4.6	0.8	1.6	1.6	3.2

chemical fertilizer alone. The higher maize equivalent green fodder yields with organic manure and INM were due to higher green fodder yields with application of organic manure. These results are in accord with those reported by Skekinah (2004) and Kumar and Gautam (2004). The major advantage with organic manure is its capacity to supply potassium and most of the secondary and micronutrients. This was partly met by organic manure component of INM. As a contrast in chemical fertilizer treatment only N and P were applied.

Soil health

The pH of soil decreased slightly under organic and INM, but remained unchanged when chemical fertilizer alone was applied. The organic carbon content increased by 24 and 11% over its initial status in organic and INM, respectively (Fig. 1). An increase of 14-15% in organic carbon with the use of organic manures has also been observed by Kumar *et al.* (2005). However, available nitrogen and potassium content did not differ significantly with different nutrient management practices (Table 4). The available phosphorus status was significantly higher under organic manure than chemical fertilizer alone but was statistically at par with INM.

The different cropping systems did not differ significantly in respect of soil pH, organic carbon, available nitrogen and potassium. However, the phosphorus build up was significantly lower under sorghum + clusterbean-oat-cowpea (IV) than other cropping systems which were statistically at par among themselves. This could be due to growing of cowpea on residual soil fertility only. The soil organic carbon improved under all the cropping systems from its initial values. Application of nutrients through organic and integrated sources improved the available nitrogen, phosphorus and potassium status as compared with the chemical fertilizers (Kumar *et al.* 2005). The improvement in soil fertility with combined application of chemical fertilizers and organic manures was also reported by Choubey *et al.* (2002).

Economics

The maize-berseem-pearlmillet cropping system gave the highest net returns and were almost similar to that obtained with sorghum + clusterbean-oat-cowpea cropping system. Sorghum-berseem gave the lowest net returns because of less cropping intensity of the system as compared to other systems. The benefit cost ratio was highest in sorghum + clusterbean-oat-cowpea cropping system due to lower cost of cultivation of this system and was lowest in maize-berseem-maize + cowpea system due to its higher cost of cultivation. The highest net returns were obtained with application of organic manure and were followed by

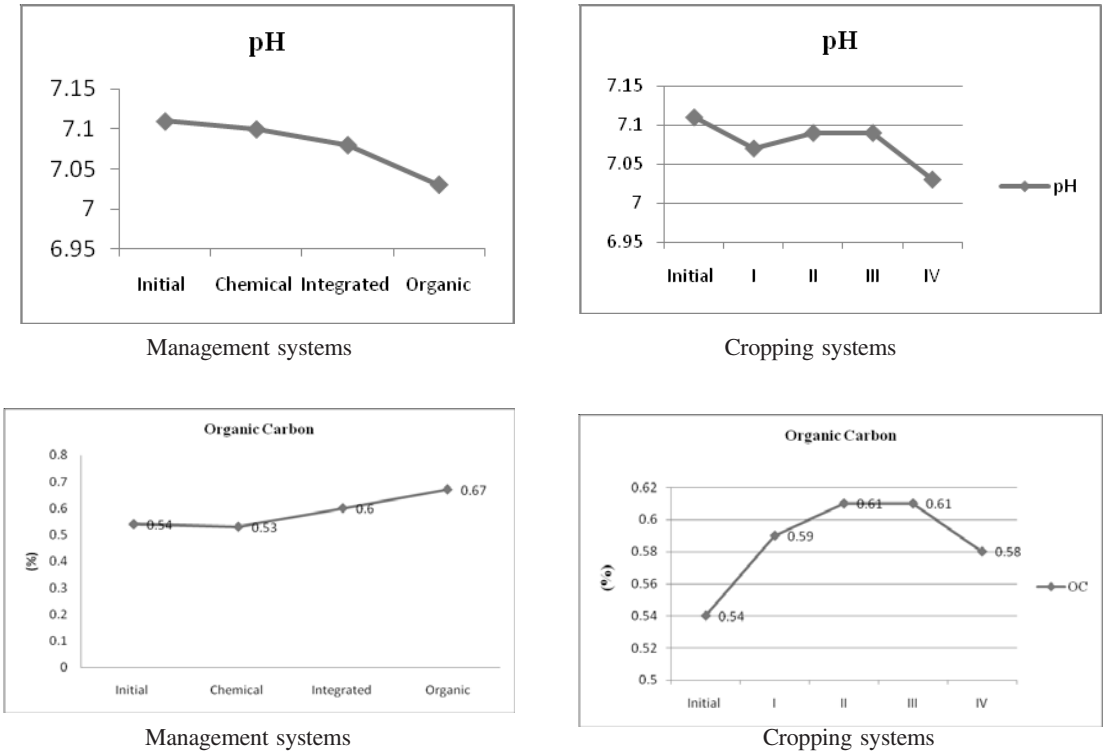

Fig 1. Changes in soil organic carbon under different managemant and cropping systems (I-SB, II-MBP, III-MBMC, IV-SCbOC)

Table 4. Economics of production and available nutrient status of soil after two years as affected by nutrient management system

Treatment	Cost of cultivation (×10³₹/ha)	Gross returns (×10³₹/ha)	Net returns (×10³₹/ha)	B : C ratio	Available nutrients (kg/ha)		
					N	P	K
Cropping system							
SB	14.7	46.75	32.06	3.18	226	67	148
MBP	18.08	58.34	40.25	3.23	314	71	136
MBMC	19.47	57.08	37.61	2.93	238	64	129
SCbOC	14.38	53.77	39.39	3.74	261	53	122
SEm±	-	-	-	-	35	3	12
CD (P=0.05)	-	-	-	-	NS	10	NS
Nutrient management							
Organic	17.19	59.79	42.60	3.48	258	71	135
Chemical	16.13	46.81	30.68	2.90	243	56	126
Integrated	16.66	55.36	38.70	3.32	277	64	141
SEm±	-	-	-	-	29	4	10
CD (P=0.05)	-	-	-	-	NS	12	NS
Initial value	-	-	-	-	244	42	144

INM and chemical fertilizer alone. This was due to more green fodder production with organic manure in organic and INM treatments as the fodder crops responded better to application of organic manure as compared to chemical fertilizer alone.

Based on the study, maize-berseem-pearlmillet fodder system was found more productive and organic sources of nutrients outyielded other sources of nutrients.

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