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Research Paper

Nitrogen management through organics on the basis of soil test values (STV) in sorghum (*Sorghum bicolor*)–lucerne (*Medicago sativa*) cropping system

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ABSTRACT

A field experiment was conducted at Centre for Research on Integrated Farming Systems, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during 2017–18 to 2020–21 with effect of nitrogen management through organics on the basis of soil test value (STV) in sorghum (*Sorghum bicolor*) - lucerne (*Medicago sativa*) cropping system. Total six treatments were evaluated based on equivalent yield, fodder profitability and possible viability. Result revealed that application of 50% RDN through FYM (9,615 kg/ha to sorghum and 2,404 kg/ha to lucerne) and 50% RDN through vermicompost (3,333 kg/ha to sorghum and 833 kg/ha to lucerne) or 50% RDN through FYM (9,615 kg/ha to sorghum and 2,404 kg/ha to lucerne) + 25% RDN through VC (1,667 kg/ha to sorghum and 417 kg/ha to lucerne) + 25% RDN through castor cake (658 kg/ha to sorghum and 164 kg/ha to lucerne) or 1/3 RDN each through FYM (6,410 kg/ha to sorghum and 1,603 kg/ha to lucerne), vermicompost (2,222 kg/ha to sorghum and 556 kg/ha to lucerne) and castor cake (877 kg/ha to sorghum and 219 kg/ha to lucerne) based on low STV to both the crops for obtaining higher sorghum dry fodder equivalent yield, fodder quality and improving soil fertility.

Key words: Castor cake, Equivalent yield, Farm yard manure, Soil test value, Vermi compost

India caters to approximately 20% of the world's livestock population and about 17.5% ofthe human population on just 2.3% of the world's land area. The human population is increasing at a pace of 1.6% per annum, while the livestock population is increasing at a rate of 0.66% per year. Theses increasing human and animal populations are fighting tooth and nail for land resources for food and fodder production, respectively. As a result, cultivated fodders occupy only 4% of the entire cultivable land in the country. Presently, the country faces a net shortfall of 35.6% green fodder, 10.5% dry crop leftovers, and 44% concentrate feed ingredients. The option for increasing land area under fodder cultivation is very limited. Hence, it is big challenge in front of us to utilize the available meagre land wisely with its fullest potential to produce the fodders for the animals which could be achieved by adopting suitable cropping systems, incorporation of fodder crops in food and other cash crop-based cropping systems on rotational basis, production of fodder on degraded lands by adopting fodder-based cropping systems. The cropping system with forage crops provides a potential alternative to overcome the fodder problem as it utilizes the resources more efficiently (Singh *et al.* 2022). Fodder crops are cultivated or harvested for feeding the animals in the form of forage (cut green and fed fresh), silage (preserved under anaerobic conditions) and hay (dehydrated/dried green). Sorghum (2.6 M ha) and *Trifolium alexandrinum* (1.9 M ha) account for roughly 54% of the total cultivated fodder area in the kharif and rabi seasons, respectively (Dagar, 2017). India ranks first among the major livestock holding countries having about 15% of the world's livestock population. However, milk production has shown an average compound annual growth rate of almost 4.5% thus it is very essential to maximize quality forage production per unit area and time. In animal feed supply, cereals have major role and four major cereals viz. maize, barley, sorghum and pearl millet account for about 44% of the total cereals fodder production. Cropping sequences including fodder crops in cropping systems viz., fodder sorghum – lucerne ensure a year-round supply of green fodder to animal. Also, the continuous use of high levels of chemical fertilizer is adversely affecting the

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sustainability of agricultural production and causing environmental pollution. Nitrogen is an important essential nutrient and the most limiting one in modern crop production. It plays an important role in the production of amino acids, proteins, and pigments, e.g., chlorophyll. Depending on soil properties, plants absorb two chemical forms of N from the soil, viz., nitrate (NO_3^-) and ammonium (NH_4^+). However, in well-aerated soils, NO_3^- is the most abundant and available form of N for plants, and NH_4^+ tends to be the predominant form in non-cultivated soils. Conversely, when both forms of N are available, NO_3^- tends to be the preferred form absorbed by plants (Ostmeyer *et al.* 2022). Therefore, emphasis should be to reduce the use of inorganic fertilizer. Due to limited scientific information about the effect of organic manures on fodder sorghum– lucerne crop sequence, current study is planned with objectives to indentify the best organic sources combinations for enhancing fodder productivity of fodder sorghum-lucerne cropping system.

MATERIALS AND METHODS

A field experiment was conducted at Centre for Research on Integrated Farming Systems, S. D. Agricultural University, Sardarkrushinagar, Gujarat, India, during *kharif-rabi* season of 2017-18 to 2020-21, to find out a nitrogen management through organics on the basis of STV (Already mentioned in title) in sorghum (*Sorghum bicolor*) - lucerne (*Medicago sativa*) cropping system. The experiment was conducted for seven years during 2014–15 to 2020–21, among three years of conversion period and four year taken as research result findings with statistical approach. The experimental soil was loamy sand in texture, alkaline in reaction (pH 7.22), low in organic carbon (0.21 %), available nitrogen (141 kg/ha) and 30.85 kg/ha P_2O_5 and 216 kg/ha K_2O. Plant population at harvest was counted from one-meter row length of five randomly locations in each net plot area. Average plant population per meter row length was calculated and recorded accordingly in both crops. At harvest, height of plant was measured from randomly selected tagged plant in each plot with the help of scale measured in centimeters from ground level to the tip of main axis. Mean values were worked out for all the treatments and recorded in both crops. Leaf: stem ratio calculated on the basis of samples of five fresh plants was taken from each treatment and all leafy portions of the plant were stripped off the plant. The leaf portion and stem portion were weighed in gram and the ratio of leaf to stem was worked out based on green leaf weight to green stem weight of sample at each cut in both crops..Total six treatments with different nutrient source namely viz. T_1, 100% RDN through FYM; T_2, 50% RDN through FYM + 50% RDN through VC; T_3, 50% RDN through FYM + 50% RDN through CC; T_4, 50% RDN through FYM + 25% RDN through VC + 25% RDN through CC; T_5, 1/3 RDN each through FYM + VC+ CC; T_6, RDF (Urea and DAP sources); were tested in randomized block design with four replications. *Kharif* sorghum (variety GFS 5) 60 kg seeds treated with *Azotobactor* and *rabi* lucerne (Variety Guj Anand lucerne 2) 15 kg seed treated with *Rhizobium* @ 5 ml/kg seed. Experiment was conducted on fixed site. The application of manures was done before 10 days before sowing of both the crops as per soil test value. Initial composite soil sample was drawn from 0–15 cm soil depth before application of fertilizers and sowing of the crop from different spots of experimental site. All soil samples collected for chemical analysis were used to determine available N, available P_2O_5, available K_2O and organic carbon. The cost of cultivation was worked out considering the cost of all the operations and input involved right from the preparation of land to the harvesting of the crop. The gross returns in term of rupees were calculated from the income received from grain and straw yield for each treatment at the prevailing market price during the course of investigation. The net returns were worked out by subtracting the total cost of cultivation from the gross returns per hectare for each.

The nitrogen content (%) was estimated from the powder of representative oven dried samples using Kjeldhal's method (Jackson, 1973). Crude protein content (%) was calculated by multiplying the percentage of nitrogen with the factor 6.25.

RESULTS AND DISCUSSION

Effect on sorghum

Plant population (metre row length) of fodder sorghum have non-significant effect of nitrogen management through different organics.

In Table 2, application of 100% RDF through urea and DAP recorded significantly higher plant height (158.7 cm), which was statistically at par with 50% RDN through FYM + 50% RDN through VC (157.2 cm), 50% RDN through FYM + 50% RDN through CC (147.3 cm), 50% RDN through FYM + 25% RDN through VC + 25% RDN through CC (148.1cm) and 1/3 RDN each through FYM

Table 1. Nutrient content of FYM, vermi compost and castor cake (on dry weight basis)

Nutrients	FYM (%) content	Vermi compost (%) content	Castor cake (%) content
N	0.52	1.50	3.80
P_2O_5	0.21	0.60	1.55
K_2O	0.46	0.80	1.10

Table 2. Effect of nitrogen management through organics on growth, yield and quality parameters in sorghum (pooled of 4 years)

Treatment	Fodder sorghum				
	Plant population at initial (metre row length)	Plant height (cm) at harvest	Leaf: stem ratio	Crude protein (%)	Dry weight/ plant (g)
T_1, 100 % RDN through FYM	24.50	131.4	0.27	5.03	19.54
T_2, 50% RDN through FYM + 50% RDN through VC	25.14	157.2	0.31	5.47	24.18
T_3, 50% RDN through FYM + 50% RDN through CC	24.49	147.3	0.28	5.16	23.54
T_4, 50% RDN through FYM+ 25% RDN through VC +25% RDN through CC	24.92	148.1	0.29	5.35	23.89
T_5, 1/3 RDN each through FYM + VC+ CC	25.23	151.7	0.29	5.55	24.41
T_6, RDF (outside the organic farming block)	25.41	158.7	0.32	5.50	25.34
SEm±	0.39	4.03	0.01	0.09	0.58
CD (P=0.05)	NS	12.14	0.02	0.25	1.63

+ VC + CC (151.7 cm) in pooled result. Concerning to the leaf: stem ratio, application of 100% RDF through urea and DAP (out side the plot) recorded significantly higher leaf: stem ratio (0.32) in pooled result. The increase in plant height with increase in successive level of nitrogen is ascribed to more supply of nitrogen to crop resulting in rapid synthesis of carbohydrates and consequently converted into protoplasm and thereby smaller portion available for cell wall formation. The results are in conformity with the findings of Shashikala *et al*. (2017), Mishra *et al*. (2015) and Meena *et al*. (2023). (above 3 line rean already mentioned.

With regard to quality in pooled result, the application of nitrogen at 1/3 of each through FYM, CC and VC recorded significantly higher crude protein content (5.55%), which was at par with T_2 (50% RDN through FYM + 50% RDN through VC) (5.47%) and T_6 (RDF) (5.50%).

Among the different treatments, treatment T_6 recorded significantly higher dry weight/plant (25.34 g) and dry fodder yield (8.398 t/ha), which was at par with T_2 (24.18 g and 7.442 t/ha) and T_4 (24.41 g and 7.492 t/ha), respectively. Significantly lowest dry weight/plant and dry fodder yield of sorghum recorded with T_1 in which 100 % nitrogen was applied through FYM in pooled results.

T_6 RDF (outside the organic farming block) recorded significantly higher green forage yield (29.205 t/ha), which was at par with T_2 (25.838 t/ha), T_4 (24.831 t/ha) and T_5 (26.229 t/ha), respectively. The lowest green forage yield of sorghum was recorded with T_1 in which 100% nitrogen was applied through FYM in pooled results (19.038, t/ha).

Among different organic and inorganic treatments, Treatment T_6 recorded significantly higher economics nutrient use efficiency (5.97 kg/) than rest of the treatments.

Effect on lucerne

The findings presented in Table 4, the plant population (metre row length) have non-significant effect of nitrogen management through different organics in lucerne.

Pooled data showed that, the significantly higher plant height of lucerne was recorded in the treatment T_6 (44.8, 45.2 and 45.4 cm) during 1st, 2nd and 3rd cuts, respectively, which was at par with T_2 (44.1 cm, 44.9 and 45.2 cm, respective cuts) T_4 (42.9,43.8 and 43.4 cm respective cuts) and T_5(43.6, 44.1 and 43.8 cm, respective cuts) in which 100% RDF was given through inorganic, while it was significantly higher under T_2 during 4th cut (45.7 cm) and 5th cut (43.7 cm), which lowest plant height (39.2, 38.8, 37.3, 37.0, and 35.0 cm, respective cuts). Significantly lowest plant height of lucerne recorded with T_1 in which 100% nitrogen was applied through FYM in pooled results.

Data showed that the crude protein content in lucerne fails to exert its significant effects due to nitrogen management through different organics in in pooled result. Treatment T_6 recorded significantly higher green forage yield (55.510 t/ha), which was at par with T_2 (52.837 t/ha), T_4 (49.988 t/ha) and T_5 (49.945 t/ha), respectively. Significantly the lowest green forage yield of lucerne recorded with T_1 in which 100% nitrogen was applied through

Table 3. Effect of nitrogen management through organics on green forage and dry fodder yield of sorghum and Economics nutrient use efficiency of system (pooled of 4 years)

Treatment	Sorghum green forage yield (t/ha)	Sorghum dry fodder yield (t/ha) (t/ha)	Economics nutrient use efficiency (kg/ha)
T_1, 100 % RDN through FYM	19.038	5.473	1.48
T_2, 50% RDN through FYM + 50% RDN through VC	25.838	7.442	0.89
T_3, 50% RDN through FYM + 50% RDN through CC	24.316	7.177	1.29
T_4, 50% RDN through FYM+25% RDN through VC +25% RDN through CC	24.831	7.276	1.04
T_5, 1/3 RDN each through FYM + VC+ CC	26.229	7.492	0.91
T_6, RDF (outside the organic farming block)	29.205	8.398	5.97
SEm±	1.529	0.372	0.06
CD (P=0.05)	4.607	1.120	0.16

Table 4. Effect of nitrogen management through organics on growth, yield and quality parameters in lucerne (pooled of 4 years)

Treatment	Fodder lucerne				
	Number of tillers (metre row length)	Crude protein (%)	Dry weight / plant (g)	Total green forage yield (t/ha)	Total dry fodder yield (t/ha)
T_1, 100% RDN through FYM	81.71	15.97	8.046	39.792	5.03
T_2, 50% RDN through FYM + 50% RDN through VC	83.56	17.01	10.894	52.837	5.47
T_3, 50% RDN through FYM + 50% RDN through CC	82.46	16.40	9.542	46.910	5.16
T_4, 50% RDN through FYM+25% RDN through VC +25% RDN through CC	84.24	16.10	10.302	49.988	5.35
T_5, 1/3 RDN each through FYM + VC+ CC	83.21	16.88	10.587	49.945	5.55
T_6, RDF (outside the organic farming block)	86.45	16.96	11.410	55.510	5.50
SEm±	1.10	0.45	0.528	2.494	0.09
CD (P=0.05)	NS	NS	1.590	7.516	0.25

FYM in pooled results (39.792 t/ha).

It is apparent from the data indicated same trend as in green forage yield of lucerne and found significant effect of nitrogen management through different organics on dry fodder yield of lucerne. In pooled result, treatment T_6 recorded significantly higher dry fodder yield (11.410 t/ha), which was at par with T_2 (10.894 t/ha), T_4 (10.302 t/ha) and T_5 (10.587 t/ha), respectively. Significantly lowest green forage yield of lucerne recorded with T_1 in which 100 % nitrogen was applied through FYM in pooled results (8.046, t/ha).

The significant effect of nitrogen management through different organics found on sorghum dry forage equivalent yield of sorghum-lucerne crop sequence. In pooled result, treatment T_6 recorded significantly higher sorghum dry forage equivalent yield (30.602 t/ha), which was at par with T_2 (28.576 t/ha) and T_4 (27.470 t/ha). Significantly lowest sorghum dry forage equivalent yield of lucerne recorded with T_1 in which 100% nitrogen was applied through FYM in pooled results (21.389 t/ha). As discussed earlier a better growth of plant always helps to increase the dry-matter production. Hence, this might be due to physiological activation of plants and acceleration of photosynthetic activity with availability of adequate moisture during active growth period as the same trend was also obtained in the green forage yield. Similar results were reported by Shashikala *et al*. 2017, Mishra *et al*. 2015, and Meena, *et al*, 2023.

It is evident from the data presented in Table 6, that end the end of 7 years there was improvement in soil organic carbon, available nitrogen, available phosphorus, slightly reduction in *p*H, EC and BD, while increase in sol porosity over its initial value. The soil organic carbon and percent porosity were significantly higher under treatment T_1, which was at par with treatment T_2, T_3, T_4 and T_5, while reduction in pH, EC and BD with the application of 100 % RDN through FYM among the different organic sources. The bulk density was decreased with 100%

Table 5. Effect of nitrogen management through organics on Sorghum dry forage equivalent yield and economics of system (pooled of 4 years)

Treatment	Sorghum dry forage equivalent yield (t/ha)	Gross return (₹ × 10^3/ha)	Cost of cultivation (10^3 ₹/ha)	Net returns (10^3 ₹/ha)	Benefit cost ratio
T_1, 100 % RDN through FYM	21.39	106.95	90.23	16.72	1.19
T_2, 50% RDN through FYM + 50% RDN through VC	28.58	142.88	108.02	34.87	1.32
T_3, 50% RDN through FYM + 50% RDN through CC	25.94	129.70	95.85	33.86	1.35
T_4, 50% RDN through FYM+25% RDN through VC + 25% RDN through CC	27.27	136.36	101.93	34.43	1.34
T_5, 1/3 RDN each through FYM + VC+ CC	27.47	137.35	105.83	31.52	1.30
T_6, RDF (outside the organic farming block)	30.60	153.01	80.93	72.08	1.89
SEm±	1.28	6.42	-	6.42	-
CD (P=0.05)	3.87	19.36	-	19.36	-

Table 6. Effect of nitrogen management through different organic on soil properties at the end of crop sequence (after 7 years)

Treatment	SOC (%)	Available nutrients (kg/ha)			pH	EC (dS/m)	BD (g/cc)	Porosity (%)
		N	P_2O_5	K_2O				
T_1, 100% RDN through FYM	0.360	157.2	42.00	235	7.20	0.138	1.470	44.53
T_2, 50% RDN through FYM + 50% RDN through VC	0.353	158.0	41.36	232	7.23	0.142	1.473	44.42
T_3, 50% RDN through FYM + 50% RDN through CC	0.346	153.3	41.68	235	7.35	0.145	1.484	44.00
T_4, 50% RDN through FYM+25% RDN through VC +25% RDN through CC	0.342	155.6	41.68	225	7.28	0.146	1.482	44.08
T_5, 1/3 RDN each through FYM + VC+ CC	0.335	154.8	41.36	228	7.33	0.146	1.486	43.92
T_6, RDF (outside the organic farming block)	0.249	148.6	42.64	218	7.25	0.148	1.522	42.57
SEm±	0.01	3.4	1.88	6.0	0.07	0.003	0.008	0.29
CD (P=0.05)	0.03	NS	NS	NS	NS	NS	0.024	0.88
CV %	5.18	4.38	8.99	5.2	1.86	4.45	1.05	1.34
Initial status	0.21	141.00	30.85	216	7.22	0.15	1.540	41.89

RDN through FYM or 50% FYM with 50% vermicompost, but application of 50% RDN through CC with FYM or Vermicompost, there was slightly increased in BD and reduction in porosity. No any review paper related to this crop and concern. The treatment T_6 RDF (outside the organic farming block) registered significantly highest economic nutrient use efficiency (6.07, 5.97, 5.59 6.26 and 5.97 kg/). Among the nitrogen management through different organics, application of 100% RDN through FYM registered highest economic nutrient use efficiency.

The data indicated that during the 2017–18 and 2018–19, treatment T_6 registered significantly higher gross profit (Rs. 155.61 and 153.01 × 10^3/ha, respectively), in 2019–20 and 2020–21 treatment T_2 registered significantly highest gross profit of system (150.00 and 164.94 × 10^3/ha, respectively). Based on pooled results, treatment T_5 (153.01 × 10^3 /ha) registered significantly higher gross profit which was at par with T_2 (142.88 × 10^3 /ha) in which 50% RDN through FYM + 50% RDN through VC was applied and T_5 (137.35 × 103/ha) in which 1/3 RDN applied through each of FYM, VC and CC. In case of net profit of system (Table 5), treatment T_6 in which 100% RDF was applied through inorganic sources outside the plot registered significantly highest net profit (74.68, 72.08, 62.20, 79.36 and 72.08 × 10^3 /ha) during all the years after conversion period and also in pooled results with highest BCR (1.89).

It can be concluded that 100 % RDF through chemical fertilizers to both crops (sorghum and lucerne) recorded significantly higher growth parameters, sorghum dry fodder equivalent yield, net return and B:C ratio as per soil test value. In organic fodder production, apply 50% RDN through FYM and 50% RDN through vermicompost or 50% RDN through FYM + 25% RDN through VC + 25% RDN through castor cake or 1/3 RDN each through FYM, vermicompost and castor cake based on low Soil Test Value to both the crops for obtaining higher sorghum dry fodder equivalent yield, fodder quality and improving soil fertility.

REFERENCES

Dagar, J.C. 2017. Potentials for fodder production in degraded lands. In P.K. Ghosh, S.K. Mohanta, J.B. Singh, D. Vijay, R.V. Kumar, V.K. Yadav and S. Kumar (Eds.), Approaches towards fodder security in India (pp. 333–364). Studera Press, New Delhi.

Layek J., Shivakumar B.G., Rana D.S., Munda S., Lakshman K. 2015. Effect of nitrogen fertilization on yield, intercropping indices and produce quality of different soybean (Glycine max) + cereal intercropping systems. *Indian Journal of Agronomy* **60**(2): 230–235.

Meena, L. Meena, S.L. Kumar, L. Pillai, N.S. and Ram, T 2023. Evaluation of food and fodder based cropping systems for sustaining productivity, resource use efficiency and profitability in western plain zone of Uttar Pradesh. *Indian Journal of Agronomy* **68**(4): 398–403.

Mishra, J.S., Ravindrachary, G., and Patil, J.V. 2012. An overview of agronomic research in sorghum (*Sorghum bicolor*) in India. *Indian Journal of Agronomy* **57**(3): 38–44.

Ostmeyer, T.J., Bahuguna, R.N., Kirkham, M.B., Bean, S. and Jagadish, S.V.K. 2022. Enhancing Sorghum Yield Through Efficient Use of Nitrogen – Challenges and Opportunities. *Front. Plant Science* **13**: 845,443.

Shashikala, T., Susheela, R., Naaiik, R.B., Shanti, M., Devi, K.B.S., Chandrika, V. and Murali, B. 2017. Forage resources of telangana state and research technology for enhancing fodder production. *International Journal of Economic Plants* **4**(4): 162–169.

Singh, D.N., Bohra J.S., Tyagi, V., Singh, T., Banjara, T.R. and Gupta, G. 2022. A review of India's fodder production status and opportunities. *Grass and Forage Science* 1–10.