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Soil nutrient balance under influence of different organic manures and fertilizers in fodder maize

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Abstract
Soil nutrient balance and soil health is mostly affected by application of different sources of nutrients. A faulty nutrient management technique to the crops results in an imbalance in the soil nutrient status which could have a long term negative impact on crop production. Therefore, the present study was conducted to assess the effect of different nutrient management strategies on nutrient balance of soil. Nutrient management strategies included organic manure application (M1: No manure, M2: Farm Yard Manure (25 t ha^{-1}), M3: Vermicompost (12 t ha^{-1}) and M4: Poultry Manure (12 t ha^{-1}) in Main plots and inorganic fertilizer application (F1:Control, F2: 125% RDF, F3: 100% RDF and F4: 75% RDF) in sub plots. The recommended dose of fertilizer applied for fodder maize was 60:40:20 kg NPK ha^{-1}. The organic manures were applied as per the N equivalent basis to inorganic nutrient recommendation. Nutrient balance was calculated by using following formula: Apparent gain or loss of nutrient = Final status of nutrient in soil - (Initial status of nutrient in soil + nutrient applied - nutrient uptake by crop) Net gain or loss of nutrient = final status of nutrient in soil - Initial status of nutrient in soil. The results revealed that apparent gain of Nitrogen (51.7 Kg) was found higher in application of poultry manure along with 75% RDF to fodder maize followed by control. The actual loss of nitrogen (-19.0 Kg) is low in application of poultry manure along with 125% RDF. Apparent gain of P was low in control (-0.94 Kg)followed by application of poultry manure along with 75% RDF (-17.57 Kg) and apparent gain of K (-2.15 Kg) was low in the same treatment. But actual loss of P and K was high in control plots. Therefore, basal application of poultry manure with 125% RDF followed by poultry manure with 100% RDF can minimize nutrient losses from soil in turn fodder maize utilized the applied nutrients effectively.

Keywords: Fodder maize, organic manure, fertilizer, nutrient balance

Introduction
Green fodder is the important source of feed in the livestock sector. It contains carbohydrates, proteins, vitamins, minerals and other nutrients which help in keeping the animals healthy and increases the animal productivity which in turns reduces the feeding cost spent for concentrate feed (Santhosh Kumar *et al.* 2015) [11].

In India, as the livestock population is increasing every yea underscores the urgent need for efficient fodder management strategies to meet out the demand. Area available under fodder cultivation is diminishing due to the expansion of area under commercial crops cultivation. Hence, farmers are using crop residues as a major feed for livestock. Continuous feeding of crop residues leads to reduction in the milk production and also affects the animal health. Green fodder production can be increased by growing of high yielding fodder varieties.

In this context, maize is one of the non-leguminous fodder which is cultivated in varied agro climatic conditions. It has short duration, high bio mass production, high palatability, suitable for silage making and absence of anti-nutritional factors. As fodder for livestock, maize is excellent, highly nutritive and sustainable crop (Iqbal *et al.* 2006) [4]. Its quality is much better than sorghum and pearl millet, since both sorghum as well as pearl millet possess anti nutritional components such as hydrocyanic acid and oxalate, respectively.

Fertilizers are crucial elements for all the crops, which supply essential nutrients for its growth and development. In India, decrease in yield has been observed in many crops due to depletion of nutrients, imbalances in use of nutrient sources and sub-optimal addition of organic and inorganic fertilizers to soil (Singh *et al.* 2009) [12]. Maize is an exhaustive crop; it requires more quantity of fertilizers for bio mass production and grain yield.

There are many nutrient supplying sources are available in which organic sources are sustainable and further enhance soil fertility.

In addition, integration of inorganic with organic manures will not only sustain the crop production but will also be effective in improving soil health and enhancing the nutrient use efficiency (Verma *et al.* 2005) [14]. The studies on cultivation of fodder maize by use of organic manures are limited. Considering the above points, the present study was undertaken to investigate the soil nutrient balance by use of integrated nutrient supplying sources in fodder maize.

Materials and Methods

The present study was conducted at the Department of Agronomy, Madras Veterinary College, Chennai, Tamil Nadu. The experiment was laid out in a factorial randomized block design with three replications. Nutrient management strategies included organic manure application (M_1: No manure, M_2: Farm Yard Manure (25 t ha^{-1}), M_3: Vermicompost

(12 t ha^{-1}) and M_4: Poultry Manure (12 t ha^{-1}) in Main plots and inorganic fertilizer application (F_1: Control, F_2: 125% RDF, F_3: 100% RDF and F_4: 75% RDF) in sub plots. The recommended dose of fertilizer (RDF) for fodder maize was 60: 40: 20 Kg NPK ha^{-1}, respectively. The organic manures were used as per the N equivalent basis to the inorganic nutrient recommendation. The nutrient status of the soil was low in available Nitrogen (128.5 kg ha^{-1}), medium in available Phosphorus (25.3 kg ha^{-1}), and medium in available potassium (226.3 kg ha^{-1}). Fodder maize variety African tall was used for the study.

Random samples of FYM, Vermicompost, and poultry manure were collected from the bulks separately, air-dried, ground, sieved and analyzed before the start of the experiment *viz.,* total organic C, total N, total P, total K and C:N ratio (Chapman and Pratt, 1961) [1] and applied in pots as per the treatments. Composition of organic manures used in the experiment is given in the Table 1.

In the experimental field, fodder maize seeds were sown with the spacing of 30 x 15 cm. The quantities of organic and inorganic fertilizers were calculated based on the nutrient availability in their nutrient sources. All the organic manures were applied as basal and inorganic fertilizers were applied in the form of Urea (46% N), Single super phosphate (16% P2O5) and Muriate of potash (60% K2O) in all pots. Nitrogen was applied in two splits *viz*., 50: 50 percent as basal and on 30 DAS, respectively. The entire dose of Phosphorus and potassium was applied basally.

The soil samples were collected at 0-15 cm depth from each treatment plot randomly and these soil samples were analyzed for available N, P and K contents after harvesting of maize. Available N, P and K in soil was analyzed using alkaline KMnO4 (Subbiah and Asija, 1956) [13], Olsen's extraction method (Olsen *et al.,* 1954) and flame emission spectrometry method (Jackson, 1973) [5]. Nutrient balance was calculated by using following formula: Apparent gain or loss of nutrient = Final status of nutrient in soil - (Initial status of nutrient in soil + nutrient applied - nutrient uptake by crop) Net gain or loss of nutrient = final status of nutrient in soil - Initial status of nutrient in soil Data on various parameters were analyzed as described by Gomez and Gomez (1984) [3] at 5% level of significance for factorial randomized block design. To compare differential fertilizer placement with and without K split application and farmers practice 'student t' test was used at 5% significance level as per the methods explained by Rangaswamy (2006) [10].

Results and Discussion

Soil Nitrogen Balance

The actual gain or loss in soil available N was negative in all treatment combinations (Table 2). Lower actual N loss was (-19 kg ha^{-1}) under the treatment combination of poultry manure along with 125% RDF(M_4F_2) followed by the combination of poultry manure along with 100% RDF (-24.2 kg ha^{-1}). Increase in nutrient dose from 100 to 125% recommended level reduced actual N loss in soil. The difference in actual N gain between 100 and 125% NPK dose was 5.2 kg ha^{-1}. The maximum actual loss was recorded under the fodder maize grown in control plots (-57.9 kg ha $^{-1}$) (M_1F_1) followed by treatment combination of no manure along with 75% RDF (-56.1 Kg ha^{-1}). Significantly lower N uptake from soil with no nitrogen application under control treatment and low available N status of soil under control plots resulting into more negative actual gain or loss in N balance in this treatment. The findings of Kumar (2009) [6] also confirm these results.

The results showed that the apparent gain or loss in soil available N was higher (51.7 kg ha^{-1}) under the treatment combination of poultry manure along with 75% RDF (M_4F_4) which is followed by poultry manure with 100% RDF (34.8 Kg ha^{-1}). The high N uptake by crop and low level of added nitrogen and high soil available nitrogen in the soil resulted in high apparent gain of N. Among the different organic and inorganic nutrients, farm yard manure along with control had maximum apparent N loss from soil (-32.9 kg ha^{-1}) followed by no manure with 125% recommended NPK dose recorded the maximum N loss (-32.3 kg ha^{-1}).

Apparent loss and actual loss of nitrogen was high both in farm yard manure + no fertilizer (M_2F_1) and no manure+75%RDF (M_1F_4) treatments, respectively. The apparent loss was higher by 19.9 kg ha^{-1} under M_2F_1 over M_4F_4 and actual loss was higher by37.1 kg ha^{-1} under M_1F_4 over M_4F_2. These findings are in line with Deepak Pandey *et al.* (2019) [2].

Soil Phosphorus Balance

The results showed that the apparent and actual gain P balance in soil remained negative in all the treatment combinations. The minimum actual P loss was (- 9.8 kg ha^{-1}) under the treatment combination of poultry manure along with 100%RDF to fodder maize followed by combination of poultry manure along with 75%RDF (-11.8 kg ha^{-1}) (Table 3). The recommended level of fertilizer along with organic source of nutrients reduced actual P loss in soil. More P uptake by fodder maize and high available P in soil helped in increasing actual P balancer in soil. The findings of Rahul Morya *et al.* (2024) [9] also confirm these results. The maximum actual P loss was recorded under the control plots (no manure and no fertilizer) to fodder maize (-17.6 kg ha^{-1}). The reason might be no addition of P, low P uptake by crop and low soil available P.

With regard to apparent gain, maximum apparent gain was exhibited in control plots (-0.94 kg ha^{-1}) followed by poultry manure with 75% RDF to fodder maize (-17.57 kg ha^{-1}). The treatment combination of 125% RDF without manure application recorded maximum apparent loss (-48.61 Kg ha^{-1}).

Soil Potassium Balance

Negative balance for apparent K gain and actual K loss was observed in soil under all the treatments. The minimum actual K loss was (- 107.7 kg ha^{-1}) under the treatment combination of poultry manure along with 100% RDF to fodder maize (M_4F_3) followed by poultry manure along with 75% RDF (M_4 F_4) (-110.8 kg ha $^{-1}$) (Table 4). The results showed that in all the treatments, nutrients were effectively utilized by the crop and leaves high nutrient loss in soil. This could be addressed by adding more K nutrient to the soil to maintain soil K status and prevent k loss (Mahapatra *et al.* 2007) [7].

The maximum actual K loss was recorded under the control treatments without manure and fertilizer application to fodder maize (-151.6 kg ha^{-1}).

In all the treatments there was a negative apparent balance of K in soil ranged from -2.15 kg ha^{-1} in (M_4 F_4) to -76.61kg ha^{-1}in (M_1 F_4) treatment. The apparent K gain and the actual K loss in soil were found negative in all the nutrient doses suggesting high soil fertility exhaustion under these treatments. Different sources of nutrients with manures and fertilizers had more apparent and actual gains of K than control treatments. Without application of manures and fertilizers exhibited more actual loss of K from soil.

Table 1: Composition of organic manures used in the experiment

Nutrient source	Total organic carbon (%)	C:N ratio	Total Nitrogen (%)	Total Phosphorus (%)	Total Potassium (%)
Farm Yard Manure	16.7	19.0	1.17	0.40	0.69
Vermicompost	19.4	18.0	1.75	0.59	0.95
Poultry manure	21.3	20.0	1.85	0.68	1.12

Table 2: Effect of organic and inorganic sources of nutrients in balance sheet of N

Treatment	Initial N (A)	Added N (B)	Crop N uptake by Maize (C)	Expected balance (D) (A+B)-C	Soil available N (E)	Apparent gain (E-D / loss (D-E)	Actual gain(E-A) / loss (A-E)
M_1F_1	128.5	-	83.7	44.8	70.6	25.8	-57.9
M_1F_2	128.5	75	90.5	113	80.7	-32.3	-47.8
M_1F_3	128.5	60	88.2	100.3	78.7	-21.6	-49.8
M_1F_4	128.5	45	84.2	89.3	72.4	-16.9	-56.1
M_2F_1	128.5	75	86.5	117	84.1	-32.9	-44.4
M_2F_2	128.5	60	105.4	83.1	91.3	8.2	-37.2
M_2F_3	128.5	45	108.5	65	89.7	24.7	-38.8
M_2F_4	128.5	75	110.5	93	85.5	-7.5	-43
M_3F_1	128.5	60	86.8	101.7	83.6	-18.1	-44.9
M_3F_2	128.5	45	95.8	77.7	100.5	22.8	-28
M_3F_3	128.5	75	98.5	105	97.6	-7.4	-30.9
M_3F_4	128.5	60	102.5	86	94.6	8.6	-33.9
M_4F_1	128.5	45	92.5	81	80.7	-0.3	-47.8
M_4F_2	128.5	75	114.8	88.7	109.5	20.8	-19
M_4F_3	128.5	60	119	69.5	104.3	34.8	-24.2
M_4F_4	128.5	45	122.5	51	102.7	51.7	-25.8

Table 3: Effect of organic and inorganic sources of nutrients in balance sheet of P

Treatment	Initial P (A)	Added P (B)	Crop P uptake by Maize (C)	Expected balance (D) (A+B)-C	Soil available P (E)	Apparent gain (E-D / loss (D-E)	Actual gain(E-A) / loss (A-E)
M_1F_1	25.3	-	16.66	8.64	7.7	-0.94	-17.6
M_1F_2	25.3	50	17.69	57.61	9	-48.61	-16.3
M_1F_3	25.3	40	17.46	47.84	8.9	-38.94	-16.4
M_1F_4	25.3	30	16.82	38.48	8.2	-30.28	-17.1
M_2F_1	25.3	50	17.35	57.95	9.6	-48.35	-15.7
M_2F_2	25.3	40	18.24	47.06	10.9	-36.16	-14.4
M_2F_3	25.3	30	18.28	37.02	10.1	-26.92	-15.2
M_2F_4	25.3	50	18.34	56.96	9.9	-47.06	-15.4
M_3F_1	25.3	40	17.28	48.02	9.3	-38.72	-16
M_3F_2	25.3	30	18.06	37.24	12.5	-24.74	-16
M_3F_3	25.3	50	18.14	57.16	12	-45.16	-12.8
M_3F_4	25.3	40	18.21	47.09	11	-36.09	-13.3
M_4F_1	25.3	30	17.99	37.31	9	-28.31	-14.3
M_4F_2	25.3	50	18.39	56.91	15.5	-41.41	-16.3
M_4F_3	25.3	40	18.46	46.84	13.5	-33.34	-9.8
M_4F_4	25.3	30	22.23	33.07	15.5	-17.57	-11.8

Table 4: Effect of organic and inorganic sources of nutrients in balance sheet of K

Treatment	Initial K (A)	Added K (B)	Crop K uptake by Maize (C)	Expected balance (D) (A+B)-C	Soil available K (E)	Apparent gain (E-D / loss (D-E)	Actual gain(E-A) / loss (A-E)
M_1F_1	226.3	-	83.16	143.14	74.7	-68.44	-151.6
M_1F_2	226.3	25	95.78	155.52	85.5	-70.02	-140.8
M_1F_3	226.3	20	93.25	153.05	83.7	-69.35	-142.6
M_1F_4	226.3	15	84.79	156.51	79.9	-76.61	-146.4
M_2F_1	226.3	25	90.48	160.82	91.5	-69.32	-134.8
M_2F_2	226.3	20	110.44	135.86	98.7	-37.16	-127.6
M_2F_3	226.3	15	111.84	129.46	95.6	-33.86	-130.7
M_2F_4	226.3	25	115.46	135.84	92.5	-43.34	-133.8
M_3F_1	226.3	20	88.3	158	90.6	-67.4	-135.7
M_3F_2	226.3	15	100.19	141.11	107.9	-33.21	-135.7
M_3F_3	226.3	25	103.24	148.06	104.7	-43.36	-118.4
M_3F_4	226.3	20	105.46	140.84	100.8	-40.04	-121.6
M_4F_1	226.3	15	98.69	142.61	85.5	-57.11	-125.5
M_4F_2	226.3	25	119.45	131.85	118.6	-13.25	-140.8
M_4F_3	226.3	20	124.36	121.94	115.5	-6.44	-107.7
M_4F_4	226.3	15	128.45	112.85	110.7	-2.15	-110.8

Conclusion

Application of poultry manure along with 125% RDF to fodder maizecan lower the nitrogen losses from soil followed by the combination of poultry manure along with 100% RDF. The treatment combination of poultry manure along with 100% RDF to fodder maize will minimize the phosphorus and potassium loss from soil. The combined application of manures and fertilizers can minimize the nutrient reduction in soil and maintain the soil fertility. Without application of manures and fertilizers (control) to fodder maize leaves the soil in poor fertility status.

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