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Reducing the deleterious effect of chemical fertilizers by waste into valuable manure and its impact on barnyard millet

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Abstract
To evaluate the effect of integrated organic nutrient sources on yield of barnyard millet, the field experiment was conducted in the farmer's field at Anaikkudam Village, Udaiyarpalayam Taluk, Ariyalur District of Tamil Nadu with eight treatments, thee replications under randomized block design (RBD). The eight treatments were T_1– Control, T_2 –100% RDF, T_3 – CPC + BMP + PG, T_4 – CPC + PG , T_5 – CPC+ BMP , T_6 –T_3 + LBF , T_7 – T_4 + LBF and T_8 – T_5 + LBF. The recommended dose of fertilizers 40: 30: 50 kg N, P_2O_5 and K_2O ha^{-1} were adopted and incorporated. As per the treatment schedule, different organic nutrient sources *viz.,* coir pith compost (CPC), borne meal powder (BMP), panchagavya (PG) were given. Liquid bio-fertilizers (LBF) were also supplied as foliar spray @ 1% on 30 and 60 DAS. The key component of modern waste reduction is reduce-reuse-recycle. The use of animal waste in farming operations can reduce the quantity and hauling costs of commercial fertilizer. The results revealed that application of 100% RDF (T_2) recorded significantly the highest grain yield of 2172 kg ha^{-1}. The next best was found to be with CPC+BMP+PG+LBF (T_6) registered the grain yield of 1923 kg ha$^{-1.}$ The combined application of coir pith compost @ 10 t ha^{-1}, bone meal powder @ 1 t ha^{-1} and panchagavya @3% along with liquid bio-fertilizers @ 1% recorded the favorable effect on soil properties compared to control and chemical fertilizers applied plot.

Keywords: Chemical fertilizers, organic sources, barnyard millet, yield, soil health

Introduction
The deleterious effect of chemical fertilizers will itself start from manufacturing of these chemicals, whose products and by-products are toxic or gases like NH_4, CO_2, CH_4 etc., which will cause air pollution (Sharma and Chetani, 2017) [9]. When the wastes from the industries are disposed off untreated into nearby water bodies it will cause water pollution (Feigin A and J. Halevy. 1989) [5]. When added in soil, its continuous use degrades soil health and quality and cause soil pollution. Consumption of chemical fertilizers in the country will increase to 45 million tonnes by 2025 which will lead to increase in health hazards. Use of fertilizers increased to 25.6 million tonnes in 2014-15 from 1 million tonne in 1960s. Therefore, this is high time to realize that this crop production input is depleting our environment and ecosystem. Excessive use of chemical fertilizers has led to several issues such as serious soil degradation, nitrogen leaching, soil compaction, reduction in soil organic matter and loss of soil carbon. In addition, the efficacy of chemical fertilizers on crop yield has been decreasing over time. The adverse effect of these synthetic chemical fertilizers on human health and environment can only be reduced or eliminated by adopting new agricultural technological practices such as conversion from chemical intensive agriculture into organic agriculture will create a healthy natural environment and ecosystem (Chandini *et al*., 2019) [2]. Manure from different animals has different qualities and requires different application rates when used as fertilizer. For example horses, cattle, sheep, chicken, turkeys, rabbits and quano from seabirds and bats all have different properties. Among all the millets, barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) is hardly and vigorous growing nature can be grown in drought and water logging condition (Raundal *et al.,* 2017) [8]. In Tamil Nadu, nearly 0.2 million tonnes of coir pith are available annually (Parasuraman *et al.,* 2002) [6]. The spongy structure of coir pith facilitates the retention of water in soil and the slow release of nutrients. Bone meal is a mixture of finely and coarsely ground animal bones and slaughter-house waste products. Panchagavya is an organic formulation with a blend of five products obtained from cow i.e. milk, ghee, curd, dung and urine.

Liquid bio-fertilizers fixes atmospheric nitrogen and converts insoluble phosphorous into soluble form and provide to plant.

Material and Methods

The field experiment was conducted to study the impact of different organic nutrient sources on yield and soil health of barnyard millet in the farmer's field at Anaikkudam Village, Udaiyarpalayam Taluk, Ariyalur District of Tamil Nadu. The weather at Anaikkudam village was moderately warm with hot summer. The experimental design adopted in the field experiment was randomized block design (RBD) with eight treatments replicated thrice. The eight treatments were T_1– Control, T_2 –100% RDF, T_3 – CPC + BMP + PG, T_4 – CPC + PG , T_5 – CPC+ BMP , T_6 –T_3 + LBF , T_7 – T_4 + LBF and T_8 – T_5 + LBF . The yield of barnyard millet were measured and recorded from each and every plot.

The recommended dose of fertilizers 40: 30: 50 kg N, P_2O_5 and K_2O ha^{-1} were adopted and incorporated. Nitrogen applied in two splits *viz.,* first half as basal and remaining half at 30 days after planting. The entire dose of P and K were applied basally. The required quantities of N, P_2O_5 and K_2O were supplied through urea, super phosphate and muriate of potash, respectively. The organic nutrient sources *viz.,* coir pith compost and bone meal were applied @ 10 and 1.0 t ha^{-1}, respectively to the respective treatment. Panchagavya also applied as per the treatment as seed treatment, seedling treatment and foliar spray @ 3%. Liquid bio-fertilizer is consortia for nitrogen, phosphorus and potassium were also supplied as foliar spray @ 1% on 30 and 60 DAS.

Soil sampling and analysis

The initial soil samples and post-harvested soil samples were collected from the field experiment. The collected soil samples were air- dried in shade, powdered and sieved to pass through 2mm sieve and stored in polythene bags. These samples were analyzed for their properties based on standard procedures.

Results and Discussion

Initial soil characteristics

The initial soil sample was collected from Anaikkudam Village, Udaiyarpalayam Taluk, Ariyalur District, Tamil Nadu. The soil was analyzed for their various physico-chemical properties and nutrients status. The soil comprised of 31.17 per cent coarse sand, 28.31 per cent find sand, 21.36 per cent silt and 18.64 per cent clay and hence it was classified as sandy loam texture. The soil belonged to series-vayalogam series, Alfisols in order. The taxonomic classification of the soil is *Typic Rhodustalfs*. The bulk density, pore space and water holding capacity of the soil were 1.45 Mg m^{-3}, 46.29 and 21.27 percent, respectively. The soil color was (7.5YR 6/6 (moist) (7.5YR7/8 (dry) based on munsell color chart. The soil registered a pH, electrical conductivity, organic carbon and cation exchange capacity of 6.7, 0.14 dSm^{-1}, 2.74 g kg^{-1} and 17.8 c mol (p$^+$) kg^{-1}, respectively. The initial soil available nitrogen, phosphorus and potassium status were 184, 10.2 and 210 kg ha^{-1}, respectively. The details of physico – chemical properties of the initial soil are presented in table 1.

Effect of organic nutrient sources on barnyard millet production and its soil health

Grain yield (kgha^{-1})

The grain yield of barnyard millet differed significantly due to treatment effects. The highest grain yield (2172 kg ha^{-1}) was obtained in T_2- 100% RDF. The next best grain yield of 1923 and 1412 kg ha^{-1} were found to be with T_6 - CPC+BMP+PG+LBF and T_7-CPC+PG+LBF, respectively. Application of CPC+BMP+LBF (T_8) and CPC+BMP+PG (T_3) were registered the grain yield of 1679 and 1634 kgha^{-1}, respectively. The treatment T_8 was on par with T_3. However, the lowest grain yield (1067 kg ha^{-1}) was recorded in the treatment T_1 (control).

Among the different treatments tried in field experiment, the grain yield of barnyard millet ranged from 1067 to 2172 kg ha^{-1}. Application of 100% RDF (N: P_2O_5: K_2O @ 40:30:50 kg ha^{-1}(T_2) recorded the highest grain yield of 2172 kg ha^{-1}. This was followed by application of coir pith compost, bone meal powder, panchagavya and liquid bio-fertilizer (T_6) (1923 kg ha^{-1}). There were significant difference was noticed between these treatments. This might be due to the positive impact of availability plant nutrients, growth hormones from organic manures and balanced supplement of major nutrients through organic manure could be attributed to adequate supply of nutrients, which in turn, must have improved synthesis and translocation of metabolites to various reproductive structure of the plant. Organic nutrition has significant effect on grain yield of rice was also reported by Shekara *et al.* (2010) [10].

Soil health

Bulk density (Mgm^{-3})

The highest soil bulk density of 1.52 Mg m^{-3} was recorded with control (T_1) and the lowest bulk density of 1.36 Mg m^{-3} was registered with CPC+BMP+PG+LBF (T_6). The reduction of bulk density was observed in the treatments receiving nutrients thorough organic sources may be attributed to the fact that application of organics (coir pith compost, bone meal, panchagavya) might have caused better aggregation thereby increasing soil aeration. Similar findings were also observed by Vora *et al.* (2015) [11].

pH (soil reaction)

The data on soil pH as influenced by different treatments are depicted in table 2. The effect of treatments on pH in the post-harvest soil was statistically non-significant. The highest pH (6.8) noticed with control (T_1) which was followed by T_4 (6.7) and T_7 (6.6) which received CPC+PK and CPC+PG+LBF, respectively. The treatment T_4 was on par with T_7. Application of T_5 – CPC+BMP, T_3 – CPC+BMP+PG and T_8 - CPC+BMP+LBF recorded the pH of 6.6, 6.4 and 6.4, respectively. These treatments were on par with each other. However, the lowest pH of 6.4 was found to be application of CPC+BMP+PG+LBF (T_6). This was due to combined application of organic source of nutrients (Chuwku *et al.*, (2012).

CEC (c mol (p$^+$) kg^{-1})

Application of CPC+BMP+PG+LBF (T_6) registered the highest cation exchange capacity of 22.87 c mol (p$^+$) kg^{-1} against 18.81 c mol (p$^+$) kg^{-1} which was lowest cation exchange capacity recorded in control (T_1). The second best cation exchange capacity of 23.96 c mol (p$^+$) kg^{-1} was found to be T_2, which received 100% RDF. Application of CPC + BMP + LBF (T_8), CPC + BMP + LBF (T_3) and CPC + BMP (T_5) registered the cation exchange capacity of 21.69, 22.01 and 20.97 c mol (p$^+$) kg^{-1}, respectively. There was a non - significant differences observed between these treatments. The increase in CEC was due to improvement in organic

matter content of the soil due to incorporation of organic materials. The lowest CEC was because of lower organic matter content. These results are in conformity with the findings of Patiram and Singh (1993) [7].

Organic carbon (g kg^{-1})

The application of different combinations of organic nutrient sources *viz.*, coir pith compost, bone meal powder, panchagavya and liquid bio-fertilizer significantly increased the organic carbon content in the post-harvest soil of barnyard millet. The highest organic carbon content of 4.9 g kg^{-1} was registered with the application of CPC+BMP+PG+LBF (T_6). Which was followed by 3.6,3.8 and 4.3 g kg^{-1} were found to be with CPC + BMP + LBF (T_8), CPC + BMP + PG (T_3) and 100% RDF (T_2), respectively. This might be due to the use of organics helped in higher concentration of biomass to soil in the form of greater root biomass through crop stubbles and residues. These findings are in line with those of Akhari *et al.* (2011).

The effect due to application of different combinations of organic nutrient sources *viz.*, coir pith compost, bone meal powder, panchagavya and liquid bio-fertilizers on bacterial, fungal and actinomycetes populations in post-harvest soil of barnyard millet were statistically significant are given in table 2.

Microbial population

Bacterial population (CFU×10^{-6})

Among the different treatments, application of CPC+BMP+PG+LBF (T_6) recorded the highest bacterial of (63.81 CFU×10^{-6}). The treatments T_8- CPC+BMP+LBF and CPC+BMP+PG (T_3) registered the bacterial population of 62.81and 61.67, respectively. However, the lowest number of bacterial population was recorded in treatment T_1 (40.35 CFU×10^{-6}).

Fungal population (CFU×10^{-4})

With regard to fungal population, highest value (16.60) was recorded in the treatment T_6 - CPC+BMP+PG+LBF. The treatments T_2, T_3, T_4 and T_5 registered the fungal populations of 16.40, 14.85, 12.49 and 12.84, respectively. However, the lowest fungal population of 10.50 CFU×10^{-4} was recorded in control (T_1).

Actinomycetes population (CFU×10^{-4})

Application of CPC+BMP+PG+LBF (T_6) recorded the highest actinomycetes population (50.32 CFU×10^{-5}), whereas the lowest actinomycetes population (21.05 CFU×10^{-5}) was recorded in control (T_1). Among the different treatments tried, T_8 (43.21 CFU×10^{-5}) on par with T_2 (42.86 CFU×10^{-5}). However, application of CPC+PG (T_4) and CPC+ BMP (T_5) registered the actinomycetes population of 24.24 and 30.08 CFU×10^{-5}, respectively.

The highest bacterial, fungal and actinomycetes population of 63.81 (CFUX10^{-6}), 16.60 (CFUX10^{-4}) and 50.32 (CFUX10^{-5}) were recorded with T_6 – CPC+ BM+ PG+ LBF (T_6) compared to control.

The soil microbial population significantly increased in organically amended plots compared to control plots which might be due to the addition of coir pith compost, bone meal and panchagavya that might have large impact on the activity of microbial population. It was also due to addition of liquid bio-fertlizer in soil creates conducive environment and promoted high microbes and high activities. The enhanced biological activities in the compost treated soil are evidenced by relatively high carbon content and enzyme activities (Elliott and Lynch, 1994) [4].

Table 1: Physico-chemical properties of an initial soil

S. No	Properties	Content
A	**Physical Properties**	
	Mechanical Properties	
1	Coarse sand (%)	31.17
2	Fine sand (%)	28.31
3	Silt (%)	21.36
4	Clay (%)	18.64
5	Texture	Sandy loam
6	Taxonomical classification	*Typic Rhodustalfs*
9	Bulk density (Mg m^{-1})	1.45
10	Particle density(Mg m^{-1})	2.70
11	Pore space (%)	46.29
12	Water holding capacity	21.27
13	Soil colour	
	When wet	7.5 YR 6/6
	When dry	7.5 YR 7/8
B	**Physico –chemical properties**	
1	pH	6.7
2	EC (dSm^{-1})	0.14
3	Organic carbon (g kg $^{-1}$)	2.74
4	CEC (C mol (p^{+}) kg^{-1})	17.86
C	**Available major nurients**	
1	Available nitrogen (kg ha^{-1})	184 (low)
2	Available phosphorus (kg ha^{-1})	10.2(low)
3	Available potassium (kg ha^{-1})	210 (medium)
D	**Available dtpa-extractable micro nutrients**	
1	Fe (mgkg^{-1})	14.68
2	Zn (mgkg^{-1})	4.07
3	Cu (mgkg^{-1})	1.19
4	Mn (mgkg^{-1})	3.75

Table 2: Effect of coir pith compost, bone meal powder, panchagavya and liquid bio-fertilizer on grain yield of barnyard millet and its soil health

Treatment Details	Grain yield (kgha^{-1})	BD (Mgm^{-3})	pH	CEC(cmol (p+) kg^{-1})	OC (gkg^{-1})	Bacterial population (CFU ×10^{-6})	Fungal population (CFU×10^{-4})	Actino mycetes population (CFU×10^{-5})
T_1- Control	1067	1.52	6.8	18.81	2.3	40.35	10.50	21.05
T_2-100% RDF	2172	1.36	6.5	23.96	4.3	57.63	16.40	42.86
T_3 - CPC + BMP + PG	1634	1.42	6.4	22.01	3.8	61.47	14.85	36.55
T_4 - CPC + PG	1239	1.50	6.7	19.65	2.7	47.56	12.49	24.24
T_5 - CPC+ BMP	1438	1.47	6.6	20.97	3.2	49.30	12.84	30.08
T_6 - T_3 + LBF	1923	1.32	6.4	22.87	4.9	63.81	16.60	50.32
T_7 - T_4 + LBF	1412	1.46	6.6	20.51	3.1	61.67	13.90	45.90
T_8 - T_5 + LBF	1679	1.41	6.4	21.69	3.6	62.81	13.65	43.21
SEd	84.22	0.03	0.16	0.67	0.016	0.35	0.09	0.98
CD(p=0.05)	168.4	0.07	NS	1.45	0.032	0.70	0.18	2.10

Conclusion

To reduce different kinds of hazards due to excessive use of fertilizers, judicious and sustainable use of fertilizers should be made. Soil testing and analysis should be done properly and then fertilizer should be given to soil. Therefore to ensure sustainable agricultural production and to safeguard the environment, it can be concluded from this present investigation that though, application of 100% RDF(40:30:50 kg ha^{-1}) (T_2) was found to be effective for boosting growth and yield of barnyard millet, application of coirpith compost@10 t ha^{-1}, bonemeal powder @1 t ha^{-1}, panchagavya@3% along with liquid bio-fertilizer @1% (T_6) significantly improved health of sandy loam soil in terms of bulkdensity, cation exchange capacity, organic carbon content and microbial populations.

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