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# SOIL FERTILITY OF RICE- BLACKGRAM CROPPING SEQUENCE AS INFLUENCED BY DIFFERENT ORGANIC SOURCES OF NUTRIENTS

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## Abstract

Residual effects of organic manures on rice-blackgram cropping sequence, during 2017 and 2018 at Thoppur, Thirupparankundram, Madurai were studied at field levels. Twelve treatment combinations comprising various sources of nutrients (Green manure @ 6.25 t/ha, neem cake@250 kg/ha, Enriched FYM @1.0 t/ha, tamarind seed powder @ 100 kg/ha, vermicompost @ 4 t/ha, *Panchagavya* @ 3%, Multi varietal seed technique, herbal pest repellant spray @ 10%, state recommendation) in a Randomized Block Design with three replications laid out for rice, were used for rice fallow blackgram. The mean soil available N (345 kg/ha), phosphorous (33 kg $ha^{-1}$) and potassium (310 kg/ha) of 2 cropping cycles were significantly superior with the application of green manure @ 6.25 t/ha along with split application of vermicompost in four equal splits @ 4 t/ha as basal, at active tillering, panicle initiation and flowering stages + *Panchagavya* @ 3 per cent as foliar spray twice at active tillering and panicle initiation stages. A similar trend was also observed with respect to soil chemical and biological properties *viz*., soil pH, organic carbon, fungi, bacteria and actinomycetes population in the same treatment. The results of present study confirm the benefits of organic sources of manures on the nutrient retention characteristic of soil and will be conducive to improve the soil fertility for achieving sustainable soil health.

## Introduction

Rice is the most important grain crop in Tamil Nadu, covering 1.45 million hectares, or 11.13 per cent of the state's total area, with an average yield of 3.42 t/ha. Rice based cropping is an integral part of agriculture in Tamil Nadu. Raising a pulse crop in rice fallows on residual fertility and moisture is a common practice in Cauvery delta Zone and other delta regions of Tamil Nadu. Black gram (*Vigna mungo* L.) is one of the most ancient crops among cultivated pulses. It is a multipurpose crop grown for pulse and forage purposes. It is one of the major sources of protein (21%) in southern states of India and mostly confined to the peninsular region. Tamil Nadu records a production of 1.21 lakh tonnes from an area of 3.41 lakh hectares which accounts for nearly 11 and 8.64 per cent in terms of both area and production in the country, respectively.

The productivity and sustainability of rice-based systems are threatened because of (1) the inefficient use of inputs (fertilizer, water, labour); (2) increasing scarcity of resources, especially water and labour; (3) changing climate; (4) the emerging energy crisis and rising fuel prices; (5) the rising cost of cultivation; and (6) emerging socioeconomic changes such as urbanization, migration of labour, preference of non-agricultural work and concern about farm-related pollution (Ladha *et al.* 2009). Reduced partial crop productivity and factor productivity resulted from the deterioration in soil quality (Jat *et al.* 2012). Rice-rice-blackgram cropping sequence plays a significant role in food security of India and particularly in Tamil Nadu. Nutrient-related stress is becoming a source of concern due to a lack of organic manures and widespread usage of high-

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analysis fertilizers. Soil health may be preserved by using organic sources and maintaining a balance between soil microorganisms and organic matter, which in turn serve to improve soil qualities. So, suitable organic farming practices have to be evaluated for rice based cropping to assess the stability in production. Therefore, this experiment was planned to throw light on the utilization of organic sources on rice, as well as the residual effect on subsequent blackgram.

**Metarials and Methods**

Field experiments were conducted at farmer's holding at Thoppur village, Thirupparank-undram block of Madurai district during summer seasons of 2017 and 2018. The geographical location of the field has the reference to 9.9°N latitude and $78^0$E longitude at an altitude of 101 m above MSL. Rice-blackgram cropping system was tested for two years. Rice (CO 51) was sown with the onset of north east monsoon in the first week of October. Blackgram (VBN 6) was sown on zero tilled plots immediately after the harvest of rice crop during the first fortnight of February.

The experiment was conducted in fixed plot with 12 treatments and replicated thrice. The experiment was laid out in randomized block design with the plot size of 20 $m^2$ (5 m x 4 m). The treatments comprised: $T_1$ : Green manure (*Tephrosia purpurea*) @ 6.25 t/ha + neem cake@250 kg/ha, $T_2$:Enriched FYM (EFYM) @1.0 t/ha, $T_3$: Green manure @ 6.25 t/ha + tamarind seed powder @ 100 kg/ha + neem cake @ 250 kg/ha, $T_4$: EFYM @ 1.0 t/ha + tamarind seed powder @ 100 kg/ha+ neem cake @ 250 kg/ha, $T_5$: Split application of vermicompost @ 4 t/ha(as basal, AT, PI and F)+ neem cake @ 250 kg/ha, $T_6$:$T_3$ + *Panchagavya* (blend of cow's milk, ghee, curd, cow urine, dung) @ 3 per cent as foliar spray twice at (PI & F), $T_7$ : $T_4$ + *Panchagavya* @ 3 per cent as foliar spray twice (PI & F), $T_8$ :$T_5$ + *Panchagavya* @ 3 per cent as foliar spray twice (PI & F), $T_9$ : Green manure @ 6.25t $ha^{-1}$+ split application of vermicompost in four equal splits @ 4 t/ha (as basal, AT, PI & F) +*Panchagavya* @ 3 per cent as foliar spray twice at AT& PI, $T_{10}$: Organic farmers practice (Multi varietal seed technique + herbal pest repellant spray @ 10%), $T_{11}$: Absolute Control (FYM 12.5 t/ha) and $T_{12}$: Control – State recommendation (FYM @ 12.5 t $ha^{-1}$+ Recommended NPK – 150:50:50).

The soil samples (0-20 cm) were collected during the each cropping cycle of Rice-Blackgram cropping system for the analysis of soil physiochemical and biological properties by adopting standard analytical methods. Soil pH, electrical conductivity (EC) and mineral N (Jackson 1973), organic carbon (Walkley and Black 1934), phosphorous (Olsen *et al*. 1954), potassium (Stanford and English 1949) and microbial population (Pramer and Schemidt 1965) were estimated. Statistical analysis was done using SPSS 12.0 for windows package.

**Results and Discussion**

After the harvest of blackgram in rice-blackgram sequence, the soil pH, EC (dS/m) and organic carbon (%) contents were estimated in different treatments during both the years of experimentation (Table 1). In general, there was a marginal decrease in pH levels in all the treatments. However, the soil pH and EC studied after every rice-blackgram sequence did not vary due to the varied sources of nutrients applied.

Whereas the organic carbon content showed variation, but build up due to the application of different organic manures. The green manure applied @ 6.25 t/ha recorded the highest OC% (0.52 and 0.56, respectively) during 2017 and 2018 as compared to other treatments. However, there exists no significant difference between the organic nutrient sources with respect to organic carbon content, even though there is a gradual increase in soil organic carbon.

**Table 1. Effect of organic manures on chemical and nutrient status of post harvest soil of rice-blackgram cropping sequence (2 years).**

| Treatments | pH | | EC (dS/m) | | Organic carbon (%) | | Available N (kg/ha) | | Available P (kg/ha) | | Available K (kg/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| $T_1$ | 7.19 | 7.16 | 0.32 | 0.36 | 0.48 | 0.46 | 340 | 330 | 21.2 | 29.6 | 274 | 282 |
| $T_2$ | 7.31 | 7.28 | 0.35 | 0.31 | 0.49 | 0.47 | 324 | 308 | 19.0 | 22.1 | 224 | 233 |
| $T_3$ | 7.14 | 7.11 | 0.28 | 0.27 | 0.49 | 0.51 | 342 | 332 | 22.9 | 30.4 | 290 | 295 |
| $T_4$ | 7.18 | 7.16 | 0.33 | 0.36 | 0.46 | 0.48 | 327 | 319 | 19.8 | 25.4 | 236 | 251 |
| $T_5$ | 7.18 | 7.14 | 0.28 | 0.31 | 0.48 | 0.50 | 336 | 325 | 21.4 | 26.5 | 271 | 278 |
| $T_6$ | 7.14 | 7.12 | 0.26 | 0.22 | 0.50 | 0.52 | 344 | 335 | 27.9 | 31.9 | 292 | 308 |
| $T_7$ | 7.27 | 7.25 | 0.36 | 0.28 | 0.49 | 0.46 | 329 | 318 | 20.5 | 23.1 | 260 | 262 |
| $T_8$ | 7.26 | 7.33 | 0.39 | 0.48 | 0.51 | 0.50 | 332 | 320 | 20.7 | 23.7 | 262 | 268 |
| $T_9$ | 7.12 | 7.07 | 0.22 | 0.25 | 0.52 | 0.56 | 348 | 342 | 30.9 | 35.6 | 315 | 304 |
| $T_{10}$ | 7.31 | 7.25 | 0.41 | 0.46 | 0.47 | 0.47 | 325 | 310 | 18.6 | 17.1 | 219 | 216 |
| $T_{11}$ | 7.28 | 7.24 | 0.41 | 0.47 | 0.44 | 0.46 | 292 | 279 | 15.8 | 16.1 | 192 | 198 |
| $T_{12}$ | 7.40 | 7.35 | 0.36 | 0.51 | 0.50 | 0.54 | 346 | 339 | 29.5 | 32.3 | 281 | 290 |
| SEd | 0.11 | 0.09 | 0.02 | 0.03 | 0.04 | 0.03 | 14 | 12 | 2.1 | 2.6 | 23 | 25 |
| CD (P=0.05) | NS | NS | NS | NS | 0.08 | 0.06 | 28 | 25 | 4.4 | 5.3 | 48 | 52 |

Results on soil available N showed the significant influence of treatments in sustaining nutrient availability (Table 1). The soil available nitrogen in the post-harvest soil extended from 292 to 348 kg/ha during 2016-17 cropping sequence; 279 to 342 kg/ha during 2017-18 cropping sequence. In both the cropping sequences, $T_9$ registered higher soil available N (348 and 342 kg/ha, respectively), which was comparable with $T_1$, $T_3$, $T_5$, $T_6$ and $T_{12.}$ The treatment $T_{11}$ (absolute control) recorded the least availability of soil available N (292 and 279 kg/ha) during both the years of experiments.

The treatment ($T_9$) improved the soil available N over absolute control ($T_{11}$) by 16.1 and 18.4 per cent in the post-harvest soil at the end of 2016-2017 and 2017-2018 cropping sequence, respectively. The incorporation of N fixing legume (blackgram) into the soil increased the plant-available nitrate-N and released more mineral N from legume residues. Thus, inclusion of legumes in cereal cropping rotations can theoretically increase soil N concentration and, at least, control the decline of soil N fertility associated with the cropping system.

The soil available P status was also influenced owing to the addition of organic manures and recommended NPK fertilizer (Table 1). Higher soil available P (30.9 and 35.6 kg/ha, respectively) was recorded in $T_9$ in the post-harvest soil of the both the cropping sequence. Lower soil available P was registered by absolute control treatment ($T_{11}$) (15.8 and 16.1 kg/ha) during both the years of study.

After harvest of crop there was appreciable build up in available P status in post-harvest soil due to the application of organic manures during both the years, which is largely attributed to minimization of P fixation. The superior treatment ($T_9$) increased available P by 48.9 and 38.6 per cent compared to control ($T_{11}$) in the post-harvest soil at the end of 2016-2017 and 2017-2018 cropping sequence, respectively. This might be due to the fact that during the mineralization of enriched organics, a number of organic acids, especially the hydroxyl ones (product of microbial metabolism) are produced, which released the P through chelation or by removal of metal ions from the insoluble metal phosphates. The influence of organic manure in increasing the labile P through complexing of cations like $Ca^{2+}$ and $Mg^{2+}$ responsible for P fixation has been reported by Balaguravaiah *et al.* (2005).

The superior treatment ($T_9$) registered higher amount of soil available K (315 and 304 kg $ha^{-1}$ respectively) in the post-harvest soil of the both the cropping sequence (Table 1). However, it was comparable with $T_{12}$ during both the years. The lowest soil available K was observed in absolute control ($T_{11}$) (192 and 198 kg/ha) during both the years of study. The same treatment ($T_9$) improved soil available K over control ($T_{11}$) was 39.0 and 34.9 per cent at the end of 2016-2017 and 2017-2018 cropping sequence, respectively. This might be attributed to the reduction in K fixation and release of K due to interaction of soil organic matter. This observation is in agreement with the findings of Agbede *et al.* (2008).

The application of organic manures and state recommended NPK in the first and second cropping system of green manure-rice-blackgram altered the soil available nitrogen reserve. During first cropping cycle 2016 - 2017, the net gain in respect of available N was the maximum with the treatment ($T_9$) (42 kg/ha), State recommendation (FYM @ 12.5 t/ha Fertillisers ($T_{12}$) (40 kg/ha), $T_6$ (38 kg/ha). The net loss of soil available N was observed (-14 kg/ha), when N was not applied through recommended N fertilizer (absolute control) as in $T_{11}$ (Table 2).

Application of organic manures increased soil available N balance. The balance was positive, indicating a net gain, when, rice crops received organic manures. Among the organic treatments, higher positive N balance of 42 kg/ha was recorded in $T_9$ during 2016-2017. The higher net gain in available N might be due to addition of higher amount of organic matter. Even after the completion of growing period mineralization of N could be continued to the soil pool (Tejada

**Table 2. Effect of organic manures on soil available N balance (kg ha$^{-1}$) in the cropping system 2016 – 2017.**

| Treatments | Initial soil N | N applied | | | N added through residues | | | Total quantity of N added | N removal | | Total quantity of N removal | Computed balance | Actual balance (Post harvest soil available) | Net gain or loss |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Green Manure | Rice | Total | Rice | Black-gram | Total | | Rice | Black gram | | | | |
| $T_1$ | 306 | 72.1 | 232 | 304 | 13.1 | 37.4 | 50.5 | 354 | 79.9 | 39.2 | 119 | 235 | 340 | 34 |
| $T_2$ | 306 | 72.1 | 25 | 97 | 10.8 | 21.3 | 32.0 | 129 | 74.7 | 23.9 | 99 | 31 | 324 | 18 |
| $T_3$ | 306 | 72.1 | 239 | 311 | 14.2 | 38.6 | 52.8 | 364 | 87.4 | 41.1 | 129 | 235 | 342 | 36 |
| $T_4$ | 306 | 72.1 | 45 | 117 | 11.0 | 26.2 | 37.3 | 154 | 76.4 | 28.2 | 105 | 50 | 327 | 21 |
| $T_5$ | 306 | 72.1 | 73 | 145 | 11.9 | 32.0 | 43.9 | 189 | 82.9 | 34.8 | 118 | 71 | 336 | 30 |
| $T_6$ | 306 | 72.1 | 239 | 311 | 14.4 | 33.2 | 47.6 | 358 | 88.9 | 35.6 | 125 | 234 | 344 | 38 |
| $T_7$ | 306 | 72.1 | 45 | 117 | 10.8 | 28.0 | 38.8 | 156 | 78.8 | 30.6 | 109 | 47 | 329 | 23 |
| T8 | 306 | 72.1 | 73 | 145 | 11.3 | 30.3 | 41.6 | 187 | 79.4 | 32.8 | 112 | 74 | 332 | 26 |
| T9 | 306 | 72.1 | 279 | 351 | 17.2 | 41.2 | 58.4 | 409 | 96.5 | 43.5 | 140 | 269 | 348 | 42 |
| T10 | 306 | 72.1 | 65 | 137 | 9.9 | 19.1 | 28.9 | 166 | 71.2 | 20.4 | 92 | 74 | 322 | 16 |
| T11 | 306 | 72.1 | 63 | 135 | 8.0 | 16.0 | 24.1 | 159 | 64.2 | 17.8 | 82 | 77 | 292 | -14 |
| T12 | 306 | 72.1 | 150 | 222 | 14.4 | 45.7 | 60.1 | 282 | 91.1 | 47.4 | 138 | 144 | 346 | 40 |

*Data are not statistically analysed.

**Table 3. Effect of organic manures on soil available N balance (kg $ha^{-1}$) in the cropping system 2017 – 2018.**

| Treat-ments | Initial soil N | N applied | | | N added through residues | | | Total quantity of N added | N removal | | Total quantity of N removal | Computed balance | Actual balance (Post harvest soil available) | Net gain or loss |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Green Manure | Rice | Total | Rice | Black-gram | Total | | Rice | Black-gram | | | | |
| $T_1$ | 340 | 74.1 | 232 | 306 | 12.1 | 31.7 | 43.8 | 350 | 76.7 | 35.2 | 111.9 | 238 | 330 | -10 |
| $T_2$ | 324 | 74.1 | 25 | 99 | 10.4 | 20.9 | 31.3 | 130 | 67.6 | 23.9 | 91.5 | 39 | 315 | -9 |
| $T_3$ | 342 | 74.1 | 239 | 313 | 13.3 | 34.7 | 48.0 | 361 | 82.1 | 37.8 | 119.9 | 241 | 332 | -10 |
| $T_4$ | 327 | 74.1 | 45 | 119 | 10.9 | 23.8 | 34.7 | 154 | 70.6 | 28.0 | 98.6 | 55 | 319 | -8 |
| $T_5$ | 336 | 74.1 | 73 | 147 | 11.5 | 29.1 | 40.6 | 188 | 76.3 | 31.7 | 108.0 | 80 | 325 | -11 |
| $T_6$ | 344 | 74.1 | 239 | 313 | 13.3 | 36.2 | 49.5 | 362 | 81.6 | 39.0 | 120.6 | 242 | 335 | -9 |
| $T_7$ | 329 | 74.1 | 45 | 119 | 10.7 | 24.5 | 35.2 | 154 | 70.8 | 28.2 | 99.0 | 55 | 318 | -11 |
| T8 | 332 | 74.1 | 73 | 147 | 11.0 | 25.6 | 36.6 | 184 | 72.5 | 29.6 | 102.1 | 82 | 320 | -12 |
| T9 | 348 | 74.1 | 279 | 353 | 16.2 | 38.6 | 54.8 | 408 | 89.7 | 41.2 | 130.9 | 277 | 342 | -6 |
| T10 | 322 | 74.1 | 65 | 139 | 9.6 | 16.7 | 26.3 | 165 | 65.0 | 20.0 | 85.0 | 80 | 310 | -12 |
| T11 | 292 | 74.1 | 63 | 137 | 7.2 | 13.7 | 20.9 | 158 | 59.8 | 17.5 | 77.3 | 80 | 279 | -13 |
| T12 | 346 | 74.1 | 150 | 224 | 13.3 | 41.2 | 54.5 | 279 | 87.2 | 44.9 | 132.1 | 147 | 339 | -7 |

*Data are not statistically analyzed.

*et al*. 2006). This might have helped in maintaining the soil available N, in spite of depletion by the crops. This was well pronounced with the application of green manure and vermicompost to rice crop.

In the second cropping cycle 2017-2018, soil available N balance ranged from 279 to 342 kg/ha (Table 3). The treatment ($T_9$) recorded a net loss of 6 kg N/ha whereas a net loss of -13 kg $ha^{-1}$ (absolute control) was recorded in $T_{11}$. This might be due to the application of organic manures to preceding rice was not sufficient to meet the needs of the succeeding crop and resulted in the sharp depletion of the soil available N status in the second cropping cycle in almost all the treatments.

The soil microbes *viz.*, bacteria and fungi were estimated from the post harvest soil samples after rice-blackgram cropping system (Table 4). The residual effect of green manure + vermicompost + *Panchagavya* ($T_9$) improved the microbial population in post-harvest soil (16.48 x $10^3$, 43.7 x $10^6$ and 18.6 x $10^4$ CFU/g of soil fungi, bacteria and actinomycetes respectively, during summer 2017) and (15.13, 45.4 16.2 and during summer 2018). However, it was comparable with $T_1$, $T_6$ and $T_3$. The lower fungal, bacteria and actinomycetes population were recorded with absolute control ($T_{11}$) which registered least a population of 7.70, 27.8 and 7.6 in summer 2017 and 8.38, 24.7 and 6.0 in summer 2018 which was comparable with $T_{10}$ and $T_2$ during both the years of study.

**Table 4. Effect of organic manures on soil enzyme activity at post harvest soil of rice- blackgram cropping sequence (2 years).**

| Treatments | Fungal population (x $10^3$ CFU/g of soil) | | Bacterial population (x $10^6$ CFU/g of soil) | | Actinomycetes population (x $10^4$ CFU/g of soil) | |
|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| $T_1$ | 15.11 | 13.53 | 35.8 | 35.9 | 16.6 | 13.9 |
| $T_2$ | 10.75 | 11.80 | 29.2 | 26.3 | 12.0 | 11.5 |
| $T_3$ | 12.94 | 12.99 | 39.7 | 36.6 | 17.1 | 14.2 |
| $T_4$ | 11.69 | 12.28 | 30.1 | 27.3 | 13.3 | 12.1 |
| $T_5$ | 12.53 | 12.90 | 33.8 | 33.6 | 15.9 | 13.5 |
| $T_6$ | 15.18 | 13.97 | 37.9 | 38.0 | 17.5 | 14.4 |
| $T_7$ | 11.96 | 12.47 | 32.4 | 27.4 | 14.1 | 12.4 |
| T8 | 12.02 | 12.62 | 33.7 | 32.8 | 15.5 | 12.8 |
| T9 | 16.48 | 15.13 | 43.7 | 45.4 | 18.6 | 16.2 |
| T10 | 10.63 | 11.74 | 29.1 | 25.9 | 8.7 | 11.0 |
| T11 | 7.70 | 8.38 | 27.8 | 24.7 | 7.6 | 6.0 |
| T12 | 15.48 | 13.88 | 43.6 | 43.7 | 18.2 | 15.8 |
| SEd | 1.60 | 0.60 | 5.1 | 5.5 | 1.46 | 1.14 |
| CD (P=0.05) | 3.31 | 1.25 | 10.6 | 11.4 | 3.03 | 2.36 |

The treatment ($T_9$) had higher influence on the population of bacteria, fungi and actinomycetes as compared to absolute control ($T_{11}$). This might be due to incorporation of organic manures provide a conducive environment for microbial proliferation due to increased organic carbon, mineral N and total N content of soils. It is, therefore, apparent that the addition of organic manure to soils enhances soil organic C status and microbial activity/diversity, which subsequently enhance soil enzyme synthesis and accumulation (Tejada *et al.* 2008). This in turn would boost the soil's capability to provide nutrients for crop growth.

The different organic nutrient management practices exerted variable influence on all the soil properties evaluated. The treatmental influence was exactly similar with respect to each of the parameter, during both the years of study, though, differing only in magnitude. However, from the present study, it may be concluded that the green manure @ 6.25 t/ha + split application of vermicompost in four equal splits @ 4 t/ha as basal, at active tillering, panicle initiation and flowering stages + *Panchagavya* @ 3% as foliar spray twice at active tillering and panicle initiation stages to rice-blackgram cropping system resulted in improved soil health.

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