Original Research Article

Nutrient availability from an organic fertilizer produced by chemical decomposition of solid wastes in relation to dry matter production in banana

ABSTRACT

An investigation was carried out at the College of Agriculture, Trivandrum, Kerala, India to evaluate the suitability of an organic fertilizer produced by rapid chemical decomposition of organic waste as a substitute for farmyard manure for banana cultivation with reference to its effects on soil properties, nutrient availability and dry matter production. A field experiment for 11 months duration was conducted in banana (*Musa* spp. variety Nendran) in Randomized Block Design with eight treatments with three replications. The treatments were selected to compare conventional farmyard manure based and soil test based fertilizer recommendations with those of the newly produced rapid organic fertilizer. Treatments to study the combined effect were also included. Fertilizers were applied basally and in six split doses in accordance with the recommended package of practices. The fresh weight of the pseudostem, leaves, fruits and rhizome were recorded at harvest and dry matter production computed after oven drying the samples. The study revealed that the substitution of farmyard manure with rapid organic fertilizer imparted a better buffering action to soil with only 51.43% decline in pH, without significant changes in electrical conductivity and ensured a steady supply of major nutrients during the active growth stages of the crop. Total and fruit dry matter production also differed significantly. Hence it can be inferred that the organic fertilizer produced by rapid thermochemical decomposition of solid wastes can substitute farmyard manure for banana cultivation.

Keywords: Organic fertilizer; chemical decomposition; rapid processing; degradable solid waste; dry matter production; nutrient availability

1. INTRODUCTION

In India, the most commonly used organic manure is farmyard manure [1], but there is a wide gap between demand and availability that is currently filled by the application of composts. The most attractive method for recycling organic wastes is composting because the waste materials are converted into environmentally benign products [2]. Although composting is a popular practice, the scarcity of land and the long time required pose serious limitations to large-scale production. However, extensive dumping of solid waste for long periods creates environmental and human health hazards. As an alternative to conventional composting practices, Sudharmaidevi et al. [3] reported on the thermochemical treatment of degradable solid wastes to rapidly produce organic fertilizer (Fig. 1). The method is scientific, efficient and capable of providing a rapid and sustainable solution for hygienic waste disposal and the production of organic fertilizer. Processing waste at the point of its generation avoids the need for transportation to centralized processing yards, and since the waste can be processed on the day of generation, dumping is avoided, which prevents other environmental problems. Banana is a popular fruit crop that is cultivated all over the world, but because it is an annual crop with a duration of 10 months, large quantities of organic fertilizers are required. However, in the context of scarce availability of farmyard manure, organic fertilizer that is rapidly produced by chemical decomposition of degradable solid wastes can be a good substitute. Hence, this study was conducted to evaluate the suitability of such organic fertilizer as a substitute for farmyard manure and its effects on soil properties, nutrient availability and dry matter production in banana.

Fig.1. Waste processing machine (modified model) used for the rapid processing of degradable solid waste to organic fertilizer (A), rapid organic fertilizer produced by thermochemical conversion (B)

2. MATERIALS AND METHODS

2.1. Experimental Site

A field experiment involving banana (*Musa* spp. variety Nendran) was conducted from October 2014 to August 2015 at the College of Agriculture, Trivandrum, Kerala, India, located at 8° 25'46.94"N latitude and 76° 59'1.12"E longitude at an altitude of 23.8 m above MSL. The mean annual temperature ranged from 21.56℃ to 32.74℃, and the relative humidity ranged from 78.25 to 87% during the crop growth period. The total rainfall during the study was 1634 mm, which ranged from 0 to 406 mm in different months. The soil in the experimental site was clayey, kaolinitic, isohyperthermic, Typic Kandiustult. The physico- chemical properties of the experimental site is presented in Table1.

Table 1. Soil fertility parameters of experimental site

Fertility parameters	Content	Status*
pH	5.45 ± 0.05	Moderately acidic (5.5 -6.0)
OC %	1.69 ± 0.3	High (> 1.51)
N (kg ha^{-1})	539 ± 13	Medium (280-560)
P (kg ha^{-1})	180 ± 23	High (>24)
K (kg ha^{-1})	358 ± 26	High (>275)
Ca (mg kg^{-1})	448 ± 40.1	Sufficient (>300)
Mg (mg kg^{-1})	78.6 ± 4.4	Deficient (< 120)
S (mg kg^{-1})	13.5 ± 5.4	Sufficient (5-10)
Fe (mg kg^{-1})	193.9 ± 55.6	Sufficient (>5)
Mn (mg kg^{-1})	3.0 ± 1.1	Sufficient (>1)

Zn (mg kg $^{-1}$)	12.60 ± 0.85	Sufficient (>1)
Cu (mg kg $^{-1}$)	1.07 ± 0.21	Sufficient (>1)
B (mg kg $^{-1}$)	0.08 ± 0.01	Deficient (< 0.5)

* Soil fertility parameters classified as per Package of Practices Recommendations of Kerala Agricultural University [4]

2.2. Experimental Design and Treatments

The experiment had a randomized block design with 8 treatments and 3 replications and with Nendran variety of banana with 10 months duration. The treatments were selected to compare conventional farmyard manure (FYM) based and soil test based fertilizer recommendations with those for newly produced rapid organic fertilizer (ROF). The treatments were (1) CR: conventional recommendation followed in the state ($FYM_{10kg}+N_{190g}+P_{115g}+K_{300g}$), (2) ST:CR modified on the basis of soil test data ($FYM_{10kg}+lime_{100g}+N_{135g}+P_{30g}+K_{75g}$), (3) STSM:ST with secondary nutrients and micronutrients ($ST+MgSO_{4(50g)}+B_{4g}$), (4) STSM(F): STSM with foliar-applied micronutrients, (5) FSTSM:STSM with ROF_{1kg} as topdressing, (6) FSTSM(F):FSTSM with foliar-applied micronutrients, (7) FSTSMP:FSTSM with $PGPR_{2\%}$, and (8) OFSTSM:FSTSM, in which basal farmyard manure was replaced with ROF_{1kg}. The FYM was basally applied. Inorganic fertilizers, except P, were applied in 6 equal top dressing applications at 1-month intervals, and P was applied in two split doses at one and two months after planting. The FYM used for the study was obtained from the College Farm and contained organic carbon (20.5%), N (0.78%), P (0.44%) and K (0.73%). ROF was produced from degradable solid wastes by rapid thermochemical processing, as reported by Sudharmaidevi *et al.* [3]. PGPR was obtained from the Department of Microbiology. The ROF was neutral in reaction and contained organic carbon (23.6%), N (2.31%), P (1.01%) and K (1.37%).

2.3. Dry Matter Production

The fresh weight of the pseudostem, leaves, fruits and rhizome were recorded at harvest. Samples of these parts were separately oven dried at 65°C to a constant weight to determine the dry weight, and the total dry weight was computed and expressed in kg ha^{-1}. Weight of the bunch including the portion of the peduncle up to the first scar (exposed outside the plant) was recorded in kg.

2.4. Soil Analysis

For soil analysis, samples from 0-15 cm in depth were collected prior to the start of the experiment, at monthly intervals up to the last top dressing and at harvest. The standard procedures as described by Hesse [5] were followed in the chemical analysis of soil. The pH and electrical conductivity were determined in a 1:2.5 (w/v) soil/water extract using a pH meter (Cyber Scan PC 510, Eu Tech Instruments, Singapore) and an EC-TDS Analyser (CM183, Elico, India), respectively. Other parameters were determined as follows: soil organic C by $K_2Cr_2O_7$ oxidation; available N by distillation (Kelplus KEL VAC, Pelican Equipments, India); Bray No.1-extractable P by spectrophotometry (Double Beam UV-VIS Spectrophotometer 2201, Systronics) and available (neutral 1*N* ammonium acetate-extractable) K (by flame photometry).

2.5. Statistical Analysis

The data from the field experiment were statistically analyzed by analysis of variance. The F values for the treatments were compared with the table values, and if the effects were significant, critical differences were determined at the 5% level of significance by a means comparison. The software Web Agri Stat Package (WASP) ver. 2.0 was used for data analysis.

3. RESULTS AND DISCUSSION

3.1. Soil pH and Electrical Conductivity

It was revealed in Table 2 that at the harvest stage, soil reaction was rendered more acidic than the initial level in all the treatments. A decrease of 0.53 to 1.57 units in different treatments was observed. Acidification of tropical soils due to the release of organic acids from applied organic manures especially FYM has been reported by Wakene et al. [6]. The treatments FSTSMP and OFSTSM maintained a similar trend which was statistically on par at all stages. However, the lowest decrease of 0.57 units was recorded in OFSTSM where ROF was applied basally. This is because ROF, besides having a neutral pH, was enriched with lime which would have provided a buffering effect. Composts release alkaline substances and cations such as Ca^{2+}, Mg^{2+}, K^{+} [7] which increase pH and counteract soil acidification.

In contrast to pH, soil EC (Table 3) showed an increasing trend up to 4 months and then decreased. The decrease was gentle in CR and OFSTSM. Soil EC is a measure of soluble nutrients in soil. The increase in EC observed is due to the release of nutrients from inorganic and organic fertilizers. EC gives an indication of the rate of mineralization of organic matter. Mineralization of organic manures produce cationic and anionic nutrients [8] contributing to soil electrical conductivity. Significant increase in EC with application of different types of organic manures had been reported [9]. The trend observed in the present study corresponded well with the release pattern of N, K, Mg and S, in different treatments.

Table 2. Soil pH as affected by farmyard manure and rapid organic fertilizer based treatments

Treatments	1 M	2 M	3 M	4 M	5 M	6 M	H
CR	6.52 ^{a}	5.42 ^{bc}	5.17 ^{e}	5.26 ^{cd}	5.18 ^{e}	5 ^{ef}	4.95 ^{a}
ST	6.15 ^{b}	5.92 ^{a}	5.79 ^{abc}	5.76 ^{a}	5.72 ^{bcd}	5.69 ^{a}	4.7 ^{abc}
STSM	5.6 ^{d}	5.58 ^{b}	5.32 ^{de}	5.27 ^{cd}	5.21 ^{e}	5.17 ^{de}	4.4 ^{d}
STSM(F)	5.88 ^{c}	5.58 ^{b}	5.54 ^{cd}	5.02 ^{d}	5.43 ^{de}	5.54 ^{ab}	4.82 ^{ab}
FSTSM	5.31 ^{e}	5.22 ^{c}	5.88 ^{ab}	5.92 ^{a}	5.99 ^{ab}	5.04 ^{de}	4.6 ^{bcd}
FSTSM(F)	5.52 ^{d}	5.47 ^{bc}	6.04 ^{a}	5.41 ^{bc}	5.57 ^{cd}	4.85 ^{f}	4.51 ^{cd}
FSTSMP	5.47 ^{de}	5.28 ^{bc}	5.58 ^{cd}	5.69 ^{ab}	5.82 ^{bc}	5.2 ^{cd}	4.94 ^{a}
OFSTSM	5.48 ^{de}	5.54 ^{bc}	5.7 ^{bc}	5.82 ^{a}	6.15 ^{a}	5.38 ^{bc}	4.91 ^{a}
SEm (±)	0.097	0.154	0.136	0.143	0.147	0.086	0.136
CD (0.05)	0.207	0.331	0.292	0.307	0.316	0.185	0.291

Means in a column followed by the same letter do not differ significantly at 5% level.
CR: Conventional recommendation, ST: CR modified on the basis of soil test data, STSM: ST with secondary and micronutrients, STSM(F): STSM with micronutrients as foliar, FSTSM: STSM with rapid organic fertilizer for top dressing, FSTSM(F): FSTSM with micronutrients as foliar, FSTSMP: FSTSM with PGPR and OFSTSM: In FSTSM basal farmyard manure replaced with rapid organic fertilizer, M: months, H: harvest stage

Table 3. Effect of farmyard manure and rapid organic fertilizer on electrical conductivity

Treatments	1 M	2 M	3 M	4 M	5 M	6 M	H
CR	0.09 ^{a}	0.100 ^{b}	0.154 ^{abc}	0.206 ^{c}	0.184 ^{bc}	0.169 ^{a}	0.101 ^{abc}
ST	0.107 ^{a}	0.128 ^{ab}	0.193 ^{a}	0.274 ^{ab}	0.238 ^{a}	0.102 ^{bc}	0.073 ^{c}
STSM	0.049 ^{b}	0.051 ^{c}	0.193 ^{a}	0.317 ^{a}	0.169 ^{cd}	0.08 ^{c}	0.122 ^{ab}
STSM(F)	0.111 ^{a}	0.132 ^{ab}	0.193 ^{a}	0.271 ^{ab}	0.204 ^{b}	0.109 ^{b}	0.135 ^{a}

FSTSM	0.088 ^{a}	0.111 ^{b}	0.174 ^{ab}	0.221 ^{bc}	0.168 ^{cd}	0.0942 ^{bc}	0.086 ^{bc}
FSTSM(F)	0.085 ^{a}	0.165 ^{a}	0.147 ^{bc}	0.134 ^{d}	0.117 ^{e}	0.0891 ^{bc}	0.105 ^{abc}
FSTSMP	0.114 ^{a}	0.117 ^{b}	0.149 ^{abc}	0.184 ^{cd}	0.139 ^{de}	0.08 ^{c}	0.115 ^{ab}
OFSTSM	0.086 ^{a}	0.101 ^{b}	0.115 ^{c}	0.221 ^{bc}	0.203 ^{b}	0.185 ^{a}	0.107 ^{abc}
SEm (±)	0.015	0.018	0.021	0.028	0.015	0.012	0.018
CD (0.05)	0.033	0.038	0.045	0.059	0.032	0.026	0.038

Means in a column followed by the same letter do not differ significantly at 5% level.
CR: Conventional recommendation, ST: CR modified on the basis of soil test data, STSM: ST with secondary and micronutrients, STSM(F): STSM with micronutrients as foliar, FSTSM: STSM with rapid organic fertilizer for top dressing, FSTSM(F): FSTSM with micronutrients as foliar, FSTSMP: FSTSM with PGPR and OFSTSM: In FSTSM basal farmyard manure replaced with rapid organic fertilizer , M: months, H: harvest stage

3.2. Soil Availability of Plant Nutrients

At 4 month's stage, the lowest availability of N was recorded in treatments ST and FSTSMP and the highest by OFSTSM (Table 4). The increase in availability of N in OFSTSM was 44.4% over ST and FSTSMP at the 4 month stage. But all the treatments except OFSTSM registered an increase in available N content at the end of the experiment compared to 4 month stage. Decline in available N might be due to plant uptake, since high quantity of N is required for vegetative growth of banana. Agele et al. [10] reported that in Ultisols under combined application of organic and inorganic fertilizers, the NO_3 –N availability was at its lowest at 120 days after planting. The foliar concentration of ST showed that the released N was absorbed by the plants. Low availability in FSTSMP might be due to the utilization of N by the PGPR in this treatment in addition to plant uptake. High content of organic matter in OFSTSM at this stage led to highest availability. Soil N is highly correlated with the amount of soil organic matter [11]. Organic manures with high N content and low C:N ratio mineralize N in sufficient quantities for plant use [12]. Moreover, the release of N from organic manures is decided mainly by its chemical composition and the nature of soil microorganisms. Organic manures with high N content and low C:N ratio mineralize N in sufficient quantities for plant use. Nutrient content could vary in composts made from the same source depending upon the technology used for production of compost [13]. A high N availability after a period of one year in plots applied with organic amendments as reported by Kowaljow et al. [14] supports the increased N availability at the end of the experiment. Mineral N release from organic waste composts from 12 weeks to 49 weeks is significantly correlated with the properties of functional groups [12]. However the status in all the treatments were well below that of initial level. The treatments CR, FSTSM and FSTSMP exhibited same pattern throughout the crop growth period. Although the pattern was similar,

Table 4. Temporal variation in soil available Nitrogen as affected by farmyard manure and rapid organic fertilizer based treatments

Treatments	1 M	2 M	3 M	4 M	5 M	6 M	H
CR	273.62 ^{c}	250.88 ^{c}	246.30 ^{bc}	238.34 ^{cd}	264.73 ^{c}	301.06 ^{b}	275.97 ^{e}
ST	364.95 ^{a}	439.04 ^{a}	294.50 ^{a}	225.79 ^{d}	283.61 ^{b}	351.23 ^{a}	326.14 ^{ab}
STSM	206.73 ^{f}	225.79 ^{d}	253.41 ^{bc}	288.51 ^{b}	281.46 ^{bc}	275.97 ^{c}	288.51 ^{de}
STSM(F)	219.27 ^{ef}	225.79 ^{d}	247.62 ^{bc}	275.97 ^{b}	287.39 ^{b}	301.06 ^{b}	338.69 ^{a}
FSTSM	239.58 ^{d}	263.42 ^{c}	258.42 ^{b}	250.88 ^{c}	263.29 ^{c}	250.88 ^{d}	301.06 ^{cd}
FSTSM(F)	337.86 ^{b}	351.23 ^{b}	310.43 ^{a}	288.51 ^{b}	280.48 ^{bc}	275.97 ^{c}	288.51 ^{de}

FSTSMP	244.81^{d}	250.88^{c}	238.75^{c}	225.79^{d}	263.47^{c}	301.06^{b}	313.60^{bc}
OFSTSM	237.53^{de}	263.42^{c}	297.61^{a}	326.14^{a}	342.96^{a}	351.23^{a}	288.51^{de}
SEm (±)	9.106	10.510	7.910	8.558	8.591	9.972	9.988
CD (0.05)	19.533	22.543	16.967	18.357	18.427	21.389	21.425

Means in a column followed by the same letter do not differ significantly at 5% level.
CR: Conventional recommendation, ST: CR modified on the basis of soil test data, STSM: ST with secondary and micronutrients, STSM(F): STSM with micronutrients as foliar, FSTSM: STSM with rapid organic fertilizer for top dressing, FSTSM(F): FSTSM with micronutrients as foliar, FSTSMP: FSTSM with PGPR and OFSTSM: In FSTSM basal farmyard manure replaced with rapid organic fertilizer, M: months, H: harvest stage

actual N availability was low initially and high in later growth stages registering an increase of 28% at harvest in FSTSMP. This treatment was enriched with PGPR in addition to the essential nutrients. Initial low availability might be due to the utilization of N by the PGPR in this treatment for its growth and once they flourished, released nutrients to the rhizosphere. N fixing microorganisms which are components in PGPR, also might have contributed to increase in later stages. The two treatments receiving micronutrients through foliar spray exhibited contrasting patterns of N availability. The treatment STSM(F) which did not receive ROF as top dressing showed an increasing trend of up to 54.5% at harvest whereas FSTSM(F) which received ROF in addition to FYM, exhibited a decreasing trend of up to 14.6 % at harvest from the beginning. This could be attributed to the increased absorption of N in FSTSM(F) which was used for dry matter production, as evidenced by a higher dry matter content. The lowest availability was in CR. This is because in all others N was applied on soil test basis.

P availability increased in all the treatments (Table 5). The farmyard manure applied plots recorded a higher content of available P compared to organic fertilizer treated plots. This is because the treatment recorded a lower pH compared to others. Soil pH has a direct bearing on P availability. P availability is inversely proportional to soil pH [11]. The availability of P from added MSW compost is low initially but increases within 3 months to make it sufficiently available for plants. The increased availability may be attributed to the P release from Fe and Al compounds by the chelating action of organic anions. In banana P is applied at the initial growth period. The soil of the experimental site was having a high status of P but at the same time a high P fixation capacity (>90%). Maximum P sorption by the plants take place at the early growth period since P is required for root formation. Since there was no addition of external P after 2 months, the balance after plant uptake might have been fixed by the Fe and Al compounds present in the soil as

Table 5. Effect of farmyard manure and rapid organic fertilizer on Phosphorus availability in soil

Treatments	1 M	2 M	3 M	4 M	5 M	6 M	H
CR	69.22^{a}	71.76^{ab}	74.89	80.97	81.78^{bc}	69.19^{e}	81.80^{d}
ST	46.78^{c}	49.53^{de}	63.22	71.43	83.56^{a}	98.81^{a}	108.52^{b}
STSM	58.44^{b}	60.25^{bcd}	62.19	62.49	64.33^{e}	91.51^{b}	92.09^{c}
STSM(F)	67.56^{a}	69.03^{abc}	68.11	67.78	82.44^{abc}	99.89^{a}	117.48^{a}
FSTSM	56.38^{b}	58.29^{cd}	59.87	61.46	63.44^{e}	87.86^{c}	81.80^{d}
FSTSM(F)	68.67^{a}	72.84^{a}	74.67	80.64	81.11^{c}	81.97^{d}	91.43^{c}
FSTSMP	47.00^{c}	49.53^{de}	57.78	65.62	74.89^{d}	85.45^{c}	57.49^{e}
OFSTSM	36.33^{d}	43.80^{e}	58.67	72.26	82.89^{ab}	91.92^{b}	91.92^{c}
SEm (±)	4.057	5.681	3.109	8.475	0.774	1.274	0.558

CD (0.05)	8.702	12.185	NS	NS	1.660	2.732	1.197

Means in a column followed by the same letter do not differ significantly at 5% level.
CR: Conventional recommendation, ST: CR modified on the basis of soil test data, STSM: ST with secondary and micronutrients, STSM(F): STSM with micronutrients as foliar, FSTSM: STSM with rapid organic fertilizer for top dressing, FSTSM(F): FSTSM with micronutrients as foliar, FSTSMP: FSTSM with PGPR and OFSTSM: In FSTSM basal farmyard manure replaced with rapid organic fertilizer, M: months, H: harvest stage, NS: Not significant

reported by Bolan et al. [15] for weathered soils. High content of available P in the farmyard manure applied plots as compared to organic fertilizer treated plots is attributable to differences in P sorption by these sources. Release of available P from bio solids composts where P is bound to Fe and Al was lower than farmyard manure where P is bound by Ca phosphates [16]. Increased P availability from farmyard manure is related to the decrease in orthophosphate sorption. In banana the fertilizers are applied up to 6 months which coincide with stages of active uptake and as a result after 6 months even if the P availability in soil is high, it will not be properly utilized by the plant.

K availability in all the treatments increased up to 2 months and continued to increase up to 4 months except in FSTSM(F) and FSTSMP (Table 6). In ST and OFSTSM the status remained high up to 6 months. While ST recorded a 46.9% increase at 6 months, OFSTSM recorded an increase of 59.4% at the 6 months stage. However the values at harvest stage were lower than the initial in all treatments except in CR and STSM. The release of K from the organic and inorganic fertilizers together with the high initial availability in the soil gave an enhanced K availability. Application of organic manures as well as combined application of organic and inorganic fertilizers increased K availability in soil [17]. Even at low rates of application MSW compost is able to increase soil K concentrations [18]. However the values at harvest stage were lower than the initial in all treatments. The uptake pattern of K showed that the nutrient was absorbed by plants resulting in a shortage in soil.

Table 6. Effect of farmyard manure and rapid organic fertilizer based treatments on soil available Potassium

Treatments	1 M	2 M	3 M	4 M	5 M	6 M	H
CR	407.11 ^{c}	439.04 ^{f}	523.12 ^{b}	589.12 ^{a}	462.08^{bc}	323.56 ^{e}	416.64 ^{b}
ST	314.08 ^{e}	356.16 ^{g}	394.12 ^{d}	420.03 ^{c}	438.12 ^{c}	461.44 ^{b}	340.48 ^{c}
STSM	421.08 ^{c}	478.24 ^{e}	518.12 ^{b}	563.36 ^{a}	472.28 ^{b}	398.72 ^{c}	448.00 ^{a}
STSM(F)	498.29 ^{b}	549.92 ^{c}	559.13 ^{a}	573.55 ^{a}	458.26 ^{bc}	332.64 ^{e}	342.72 ^{c}
FSTSM	506.19 ^{b}	592.48 ^{b}	579.31 ^{a}	570.08 ^{a}	476 .30^{b}	368.48 ^{d}	238.56 ^{e}
FSTSM(F)	542.25 ^{a}	624.96 ^{a}	564.14 ^{a}	515.20 ^{b}	438.28 ^{c}	331.52^{e}	334.88 ^{c}
FSTSMP	482.12 ^{b}	516.32 ^{d}	423.21 ^{c}	273.28 ^{d}	283.11 ^{d}	288.96 ^{f}	295.68 ^{d}
OFSTSM	352.10 ^{d}	455.84 ^{f}	509.21 ^{b}	567.84^{a}	563.31 ^{a}	561.12 ^{a}	318.08 ^{cd}
SEm (±)	15.061	10.000	11.181	13.007	11.651	12.944	12.109
CD (0.05)	32.306	21.451	23.984	27.900	24.992	27.765	25.973

Means in a column followed by the same letter do not differ significantly at 5% level.
CR: Conventional recommendation, ST: CR modified on the basis of soil test data, STSM: ST with secondary and micronutrients, STSM(F): STSM with micronutrients as foliar, FSTSM: STSM with rapid organic fertilizer for top dressing, FSTSM(F): FSTSM with micronutrients as foliar, FSTSMP:

FSTSM with PGPR and OFSTSM: In FSTSM basal farmyard manure replaced with rapid organic fertilizer, M: months, H: harvest stage

2.4. Dry Matter Production in Banana

The dry matter content at harvest stage (Table 7) differed significantly. Total, leaf, rhizome and fruit dry matter production were significantly superior in OFSTSM and STSM. The values were significantly lower in FSTSM, FSTSMP and FSTSM (F). The lowest value was recorded by STSM(F) which received farmyard manure as basal and micronutrients through foliar application. All the parameters were significantly lower in STSM(F) and FSTSM (F) indicating that soil application is better in the case of micronutrients. The treatments with farmyard manure produced more pseudostem dry matter when compared to treatments which received rapid organic fertilizer. The highest pseudostem weight was recorded in CR followed by ST, STSM and FSTSM. The lowest rhizome dry matter was also recorded in CR. In ROF based treatments allocation to fruit dry matter was more compared to farmyard manure based treatments. Use of agricultural wastes either alone or in combination with N, P, K fertilizers is reported to enhance the growth and yield characters of maize [10].

Table 7. Effect of farmyard manure and rapid organic fertilizer based treatments on dry matter production in banana

Treatments	Leaf (kg ha^{-1})	Pseudostem (kg ha^{-1})	Rhizome (kg ha^{-1})	Fruit (kg ha^{-1})	Total (kg ha^{-1})
CR	1574.93 ^{bc}	4301.54 ^{a}	1217.12 ^{d}	2535.11 ^{cd}	9628.77 ^{c}
ST	1924.22 ^{b}	3350.00 ^{a}	2376.48 ^{ab}	2535.71 ^{cd}	10186 .41 ^{bc}
STSM	2082.06 ^{b}	3975.41 ^{a}	2838.67 ^{a}	2966.43 ^{b}	11862.55 ^{ab}
STSM(F)	1620.00 ^{bc}	1682.00 ^{b}	1533.63 ^{cd}	2372.56 ^{d}	7208.20^{d}
FSTSM	844.72 ^{c}	1953.33 ^{b}	1896.83 ^{bcd}	2546.50 ^{cd}	7241.39 ^{d}
FSTSM(F)	1835.04 ^{b}	1443.74 ^{b}	2034.75 ^{bc}	2555.35 ^{cd}	7868.88 ^{d}
FSTSMP	1604.35 ^{bc}	1610.49 ^{b}	1451.18 ^{cd}	2875.06 ^{bc}	7541.07 ^{d}
OFSTSM	2995.83 ^{a}	3511.61 ^{a}	2840.98 ^{a}	3519.80 ^{a}	12868.21 ^{a}
SEm (±)	391.14	632.28	327.18	163.49	1263.64
CD (0.05)	839.006	1356.242	701.81	350.685	2710.50

Means in a column followed by the same letter do not differ significantly at 5% level.
CR: Conventional recommendation, ST: CR modified on the basis of soil test data, STSM: ST with secondary and micronutrients, STSM(F): STSM with micronutrients as foliar, FSTSM: STSM with rapid organic fertilizer for top dressing, FSTSM(F): FSTSM with micronutrients as foliar, FSTSMP: FSTSM with PGPR and OFSTSM: In FSTSM basal farmyard manure replaced with rapid organic fertilizer, M: months, H: harvest stage

4. CONCLUSION

Substitution of farmyard manure with rapid organic fertilizer imparted a better buffering action to soil, ensured a steady supply of major nutrients during the active growth stages of the crop and resulted in higher dry matter production in banana.

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