



Effect of Woven Jute Agro Textile Mulch on Soil Health and Productivity of Banana (*Musa domestica* L.) in New Alluvial Soil

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Authors' contributions

This work was carried out in collaboration among all authors. Author AS collected the data, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author PKT designed the study. Authors PKT and SKD assisted in the analyses of the study and refined the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

To evaluate the effects of jute agro textile mulches on yield and yield attributes, water use efficiency of banana as well as physicochemical and biological properties of soil under banana production. The study was conducted in the experimental farm of Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India for two consecutive years from March to February of 2017-2018 and 2018 - 2019. The experiment was carried out using a randomized block design with four treatments and five replicates taken Banana (variety Singapuri) as a test crop. The treatments (T), composed of different strength of jute agro textile (JAT) used as mulching material. All the data regarding yield, yield attributes, crop water use efficiency and soil properties were recorded accordingly. The response of yield over control was 32.52 t/ha, 38.61 t/ha, 43.05 t/ha in treatments T₂- 500 GSM, T₃ - 800 GSM and T₄ - 1000 GSM respectively where GSM is gram per square meter. Though the best results were obtained in T₄- 1000 GSM, in terms of cost-benefit ratio T₃- 800 GSM proved more beneficial than the other treatments. The average water use efficiency of the crop increased significantly by 96.9% (on an average) over control for using the jute agro

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textile mulch. Among all the treatments, T₃ exhibited the most promising effect on improving yield and other attributes along with maintaining sustainability because it provided the most favourable soil condition compared to other mulches for banana.

Keywords: Banana; jute agro textiles; water use efficiency; mulching; soil physicochemical properties; yield attributes.

1. INTRODUCTION

The growth of the Indian Economy is significantly reliant on the success of the agriculture community. But, traditional methods are limited in their ability to increase yields with the current constraints of restricted space and water supply. Agriculture uses 70% of the world's freshwater drawn from aquifers, streams and lakes [1]. As a result of the growing population, global food production is expected to increase by 70% by 2050, having a direct impact on water resources. In light of the continual pressing issue of food security, Agrotextile utilization has helped the agriculture community in attaining increased yield and enhanced quality in agriculture produce. Amongst its various benefits, agro textiles protect produce from harmful external elements and assist in better soil management [2]. Again, geotextiles or agro textiles mulches, permeable fabrics made from polypropylene or biodegradable materials like jute and other fabrics, are most effective in modifying soil environment, suppressing weed and increasing crop yield [3]. In this context, jute agro textile, made from 100% natural bast fibre has the same potential to improve crop yield as well as soil fertility and productivity status as it contains natural substances for plant growth and releases essential plant nutrients through lignin decomposition [4]. Application of geotextile mulches increased the yield of capsicum and pointed gourd [5] and that of mosumbi and turmeric [6] compared to control where no mulching materials were used.

Banana is the oldest and commonest fruit known to mankind and in India Banana ranks second next to Mango in area and production. Being a long duration crop, the total water-per year requirements are high, varying between 1200 mm in the humid tropics to 2200 mm [1]. So, deficit water supply can lead to the uneven and inadequate production of banana in the country.

So, a field experiment was undertaken to explore, in details, the effects of jute agro textile mulches on growth and productivity of banana, nutrient enrichment and microbial population in

the soil, moisture conservation, weed suppression in the new alluvial soil of West Bengal, India.

2. MATERIALS AND METHODS

2.1 Study Area

The field experiment was conducted from March to February of 2017-2018 and 2018-2019 at Regional Research Station, Bidhan Chandra Krishi Viswavidyalaya, New Alluvial zone, Nadia, West Bengal. The farm is located at 22°58' N L, 88°26' E L, with an altitude at 10.9 m above MSL having an average rainfall of 1500-1600 mm/year with the variation of temperatures between 10°-38°C. The soil of the experimental site is a typical alluvial soil (Typic ustifluent), sandy loam in texture with neutral pH, low in organic carbon and medium in the fertility status [7].

2.2 Sampling Method and Data Analysis

The experiment was carried out using a randomized block design with four treatments and five replicates taken Banana (variety Singapuri) as a test crop. The treatments, composing different strength of jute agro textile (JAT) were as follows: T₁: farmer's practice (control), T₂: 500 GSM, T₃: 800 GSM and T₄: 1000 GSM JAT. The unit plot size was maintained by 24 square meters with an inter-row spacing of 2 meters and 2 meters intra-row spacing. Before transplanting, the soil surface was covered with jute agro textiles along with the basal dose of N-P-K at 20-40-40 kg/ha. Thirty days old healthy seedlings were transplanted on each plot on the first week of March for each year. The recommended cultural practices were adopted for growing the crop. The crop was harvested on 3rd week of February, of 2018 and 2019.

All the data regarding the yield, yield attributes and water use efficiency of the crop were recorded. The moisture content of surface soil samples collected at 7 days interval of the entire growth period was determined by the gravimetric

method. Bulk density and porosity of soil were determined by the method as proposed [8]. The pH, organic carbon (by wet digestion method) [9] and available potassium was measured as described [10]. Available soil nitrogen and phosphorus were estimated by the method as outlined [11] and Bray's no. 1 method [12] respectively. The population of fungi, bacteria and actinomycetes from soil was determined using Martin's agar medium, Thorton's medium and Starch-casein medium respectively as described [13]. All the data of two years are presented as an average value for each parameter of the test under consideration.

The data were subjected to statistical analysis to interpret the effects of treatments as suggested [14]. The level of significance used in the F and t-test was $p = 0.05$. Critical difference values were calculated wherever the F test was significant.

3. RESULTS

3.1 Yield and Yield Attributes of Banana

The results of the effect of different treatments on yield and its attributes of banana are presented in Table 1, where the values were taken for two years as an average basis. The significantly highest ($P < 0.05$) yield (108.98 Tonnes/ha) of banana was observed in treatment T_4 (1000 GSM JAT) along with highest plant height (262 cm), length and diameter of fruit (19.8 cm & 4.3 cm respectively). Response of banana yield over control (T_1) were 32.52 t/ha (49.32%), 38.61 t/ha (58.56%) and 43.05 t/ha (65.30%) respectively in treatments T_2 , T_3 and T_4 respectively. Though all the obtained values were significant with treatment T_1 (control), the increment of yield from treatment T_2 to T_3 was more (6.09 tons/ha) than T_3 to T_4 (4.44 tons/ha). Again the cost-benefit ratio of the crop production was maximum in T_3 (1: 2.26) but the rate was lower in case of T_4 (1:1.99) which was also lower than T_2 (1:2.24).

3.2 Soil Moisture Content and Water Use Efficiency of Banana

The soil moisture content of the surface level (upper 15 cm) at 7 days interval for the entire growing period of the test crop under various treatments has been depicted in Fig. 1. Results revealed that its content was lowest at T_1 (without JAT) compared to other treatments. The moisture content of the surface soil at every stage was higher under each of the treatment in the following order: $T_4 > T_3 > T_2 > T_1$ though it can be seen that the moisture levels in both treatments T_4 and T_3 were almost equal through the entire range of growth.

The water use efficiency (WUE) which is defined as the ratio between total yield and total water use during the growing period of the crop are provided in Fig. 2. Again the data here showed that the average water use efficiencies of the crop increased significantly by 96.9% due to the treatments of jute agro textiles over control. Though the highest of 110.88% increment occurred in treatment T_4 , the increment of WUE was more from treatment T_2 to T_3 (15.7%) than T_3 to T_4 (13.0%).

3.3 Physical and Chemical Properties of Soil

The results of the effects of different amount of jute caddies on the changes in physical and chemical properties of soil are presented in Table 2. Bulk density of soil was decreased by 1.51%, 3.78% and 4.54% with simultaneous increase of porosity by 6.71 (15.65%), 8.84 (20.62%) and 9.6 (22.4%) in treatment T_2 , T_3 and T_4 respectively. The results further indicated that significantly increased availability of nitrogen, phosphorus and potassium. The results also revealed the increment of organic carbon by 32%, 64% and 84% in treatment by 500 GSM, 800 GSM and 1000 GSM jute agro textiles respectively.

Table 1. Effect of different jute agro textiles on yield and yield component of banana

Treatment	Plant height (cm)	Length of fruit (cm)	The diameter of fruit (cm)	Yield (Tonnes/ha)	Cost-benefit ratio
T_1	223	16.9	3.1	65.93	1: 1.62
T_2	245	18.3	3.6	98.45	1: 2.24
T_3	253	18.8	4.1	104.54	1: 2.26
T_4	262	19.8	4.3	108.98	1: 1.99
CD at 5%	17.64	0.266	0.306	0.798	--
SE (m) \pm	5.66	0.085	0.098	2.815	--

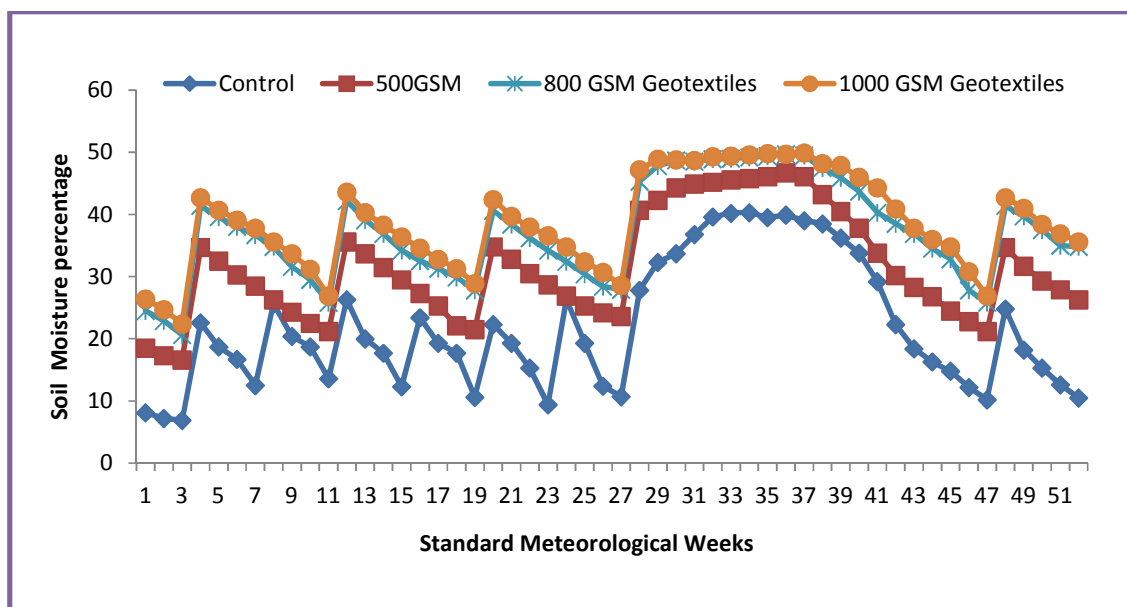


Fig. 1. Effect of various jute agro textiles on changes of soil moisture percentage every week

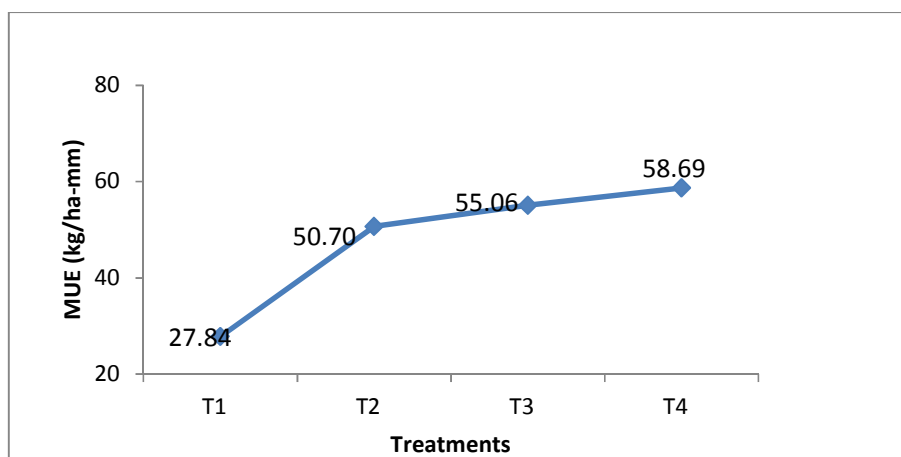


Fig. 2. Moisture use efficiency (kg/ha-mm) of banana under different treatments

Table 2. Effect of different treatments on soil physical and chemical properties

Treatment	Bulk density (g/cc)	Porosity (%)	Organic carbon (%)	Available nitrogen (Kg/ha)	Available phosphorus (Kg/ha)	Available potassium (Kg/ha)
T ₁	1.32	42.86	0.25	31.19	16.26	136.5
T ₂	1.30	49.57	0.33	53.0	19.6	193.0
T ₃	1.27	51.70	0.41	73.6	24.8	219.0
T ₄	1.26	52.46	0.46	79.4	25.0	226.1
SE (m)±	0.01	0.64	0.01	0.61	0.57	0.28
CD at 5%	0.03	2.27	0.05	2.16	2.01	1.01

Table 3. Effect of different treatments on rhizosphere microbial population

Treatment	Bacteria (cfu X 10 ⁶)	Actinomycetes (cfu X 10 ⁵)	Fungi (cfu X 10 ⁴)
T ₁	13.7	27.2	33.7
T ₂	22.5	29.5	39.5
T ₃	24.9	33.7	44.7
T ₄	25.4	33.8	45.3
SE (m)±	0.82	0.56	0.85
CD at 5%	2.89	1.99	3.01

3.4 Effect of JAT on Rhizosphere Microbial Population

Results on the effect of JAT on rhizosphere soil microbial population of the experiment revealed highly significant variation under different treatments imposed (Table 3). For all the treatments, it was observed that bacterial population in soil increased significantly and after harvesting, the highest bacterial count was observed in T₄ treatment (1000 GSM) which was statistically at par with T₃ (800 GSM) and lowest in T₁ (without JAT) treatment.

The highest fungal population (45.3×10^4 cfu) was recorded in T₄ treatment which was, however, statistically close to T₃ (33.7×10^4 cfu). After harvesting, it was observed that the population of actinomycetes under all the treatments was increased over the control plot. The highest population of actinomycetes (33.8×10^5 cfu) was recorded in T₄ which was, however, statistically similar to that of T₃ treatment. The lowest count of actinomycetes population was recorded in the control plot (27.2×10^5 cfu).

4. DISCUSSION

The beneficial effect of biodegradable JAT mulch to increase the yield of banana was due to the beneficial effect of increased moisture conservation, increased organic carbon and nutrient status along with high weed control efficiency. It was evidenced that the highest yield of high-value crops like capsicum (8.2 t ha^{-1}) and pointed gourd (1.4 t ha^{-1}) in geotextile mulched plot compared to control which was due to higher heat and moisture conservation resulted in better root growth and increased microbial activity in the rhizosphere. As a result availability of nutrients through mineralization and subsequent uptake by crops might have increased [15]. Again in another study, the yield of tomato had increased 51.8% over control for the use of jute agro textile as mulching material [16]. The highest cost-benefit ratio was found in 800 GSM JAT due to the higher price of JAT of

1000 GSM than 500 or 800 GSM and proper root growth towards uninterrupted availability of nutrients through continuous supply of moisture and air. The increment of soil moisture content due to the treatments might be attributed to a decrease in evaporation loss due to surface cover and increasing porosity for the increment of organic matter content due to decomposition of jute agro textile. High surface soil moisture due to the increase in organic matter content in soil has been reported [17]. Increase in WUE and crop productivity due to the addition of organic matter or mulching have been reported in many cases [6,18]. Again it can be seen that as the strength of applied JAT increased, soil physical properties improved and nutrient availability increased over the plot not treated with JAT. The changes in soil physicochemical properties due to the addition of organic matter were a highly correlated phenomenon [19]. For soil biological properties, the microbial population increased due to use of jute agro textile mulch and the population of bacteria in JAT mulched soil was higher due to favourable temperature, humidity and anaerobic condition under agro textiles [20]. Again, the population of actinomycetes in soil increased towards maturity stage of soybean crop because of the higher availability of carbon at that stage due to leaf-fall [21,22]. So, the use of jute agro textile as a mulching material for crop production has been proven very beneficial as it improves the soil properties leading to high crop production rate by using all the production factors significantly [23].

5. CONCLUSION

The results of the study exhibited that the use of jute agro textile as the mulching component is beneficial for getting higher productivity of banana over the control as it increased the soil moisture content, organic C, available N, P, K contents and microbial population in the root zone. Decrement of bulk density and increment of porosity occurred due to application of each strength of JAT in general, of which 1000 GSM JAT showed the most prominent effect. Though

in all cases T_4 i.e. 1000 GSM JAT showed the highest result, treatment T_3 -800 GSM showed much more beneficial effect when compared in percentage increase with other treatments and as well as the cost-benefit ratio. The increment from treatment T_2 to T_3 is higher than from T_3 to T_4 which is increment but in decreasing rate. So, the treatment T_3 i.e. 800 GSM thickness of jute agro textile provided the most favourable soil condition compared to other mulches and resulted in highest growth and yield of the crop and subsequent improvement in soil health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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