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Effect of mulch types on soil moisture, soil fertility, growth and yield of pineapple (*Ananas comosus*) in hill zone of Assam

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ABSTRACT

A field experiment was carried out in Hill Zone of Assam from 2017 to 2019 with the objective of identifying mulch types on soil moisture retention, soil physical and chemical properties, growth and yield of pineapple (Ananas comosus) grown in hill slopes under farmers' field condition. The treatments consisting of mulching with black polythene, dhaincha (Sesbania aquleata) as mulch, frequent slashing of weeds, soil mulching (soil mounding) and farmers practice without any mulch as control were evaluated in a randomized block design. Soil moisture content at 0-30cm depth was significantly different among the mulching methods and highest value of 14.2% at 0-30cm depth at harvesting was recorded in black polythene followed by slashing of weeds (13.1) and minimum in farmers practice. Soil texture was not affected by various mulches but there was a decline in bulk density with mulching and minimum value of 1.23 kg m^{-3} was recorded under slashing of weeds. Higher organic carbon (8.8 g kg^{-1}), available nitrogen (341.8 kg ha^{-1}), phosphorus (9.5 kg ha^{-1}) and potassium (100.6 kg ha^{-1}) were recorded in organic mulches i.e. slashing of weeds and dhaincha. The highest yield attributing characters and fruit yield of 38.3t ha^{-1} was recorded in the black polythene treatment followed by dhaincha as mulch (36.5 t ha^{-1}) and frequent slashing of weed (35.6 t ha^{-1}). Soil mulching and farmers practice recorded significantly lower yield than other treatments.

Key words: Dhaincha, hill zone, mulch, slashing, soil moisture

INTRODUCTION

Pineapple (*Ananas comosus)* is one of the most important tropical and subtropical fruit of Bromeliaceae family. Pineapple is one of the largely grown fruit in North Eastern States of India including Assam. The Northeastern region of India produces more than 40 per cent of the total pineapple of the country and almost 90-95 per cent is organic. The area under pineapple cultivation in Assam is 16905 ha with an average productivity of 18.27 t/ha (Statistical Handbook of Assam, 2020). Mulching has been practised in pine apple cultivation as a way of increasing water retention, reduce run off, suppress weeds and improve soil fertility. Mulching with weeds uprooted during cultivation has been a traditional soil and water conservation technique among local farmers to improve yield and it conserve soil moisture, improve soil microclimates and soil lives as well as prevent soil damage from solar radiation and rainfall.

Different mulch materials have different effects on soil environment and crop yield. It has been reported that plastic mulch materials are more effective than the organic materials in controlling soil environment and increase yield, while the organic mulch materials are inexpensive and environment friendly (Kader *et al*., 2017). Plastic is now used in all types of climates, seasons and soils. Plastic mulch enhances soil temperature and moisture retention, accelerates crop growth with increased yield (Kasirajan and Ngouajio, 2012). It also improves crop-water use efficiency, minimises salt build-up in the crop root zone and reduces fertilizer leaching during rainy periods (Almeida *et al*., 2015). Consequently, the use of mulch materials in pineapple production to conserve soil moisture, suppress weed growth, control soil structure and temperature, and influence soil microbial populations has become imperative (Kader *et al*., 2017). The use of crop residue such as straw, palm fronds, leafy organic materials have been shown to be cheap and effective mulching technique in improving yield wheat (Chakraborty *et al*., 2008), groundnut (Ghosh *et al*., 2006) and cassava. Although the studies on the effect of different mulch materials on various crops and soil environment have been reported but none has been reported in pineapple cultivation in hill slopes in north

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eastern hill region of India. Hence, comprehensive field trials with various mulching materials are crucial to monitor their efficiency and cost-effectiveness in this region. Besides, mulching with locally available materials is of paramount significance. Therefore, the objectives of this study were to determine the effects of different mulch materials on the physical and chemical properties of soil under pineapple cultivation as well as the growth and yield performance of the pineapple plants grown in hill slopes under farmers' field condition.

MATERIALS AND METHODS

The study was carried out in Hill Zone of Assam from 2017 to 2019 under technology demonstration component of the project National Innovations on Climate Resilient Agriculture (NICRA). The soils of the experimental sites are with the following characteristics: pH 5.2-5.2, organic carbon 7.2-8.2 g kg^{-1}, available nitrogen 276.2-298.3 kg ha^{-1}, available phosphorus 8.16-12.04 kg ha^{-}1, and available potassium 128.70-138.60 kg ha^{-1}. The soil texture is sandy clay loam with 48.2-50.12% sand, 16.4-19.6% silt and 32.0-34.0% clay with bulk density of 1.24-1.28 Mg m^{-3}. Four different types of mulch materials and farmers existing practice as control were used in the study. The mulch materials were black polythene sheet (50 micron thickness, single layer of 60 cm width in each side), *dhaincha* grown as green manuring crop and incorporated as mulch, frequent slashing of weeds in which vegetation is cut and mulched on site rather than being discarded or burned and soil mulching (20cm mound of 60 cm width in each side). Top soil (30 cm depth) under fallow vegetation was collected for pre-planting physical and chemical soil analyses and these were repeated at harvest. The experiment was conducted in farmers field in three locations as replications and pineapple was planted in double row spacing @90 x 60 x 30 cm. In each plot, five soil cores (each 2.5 cm diameter) were excavated randomly to a depth of 30 cm and mixed to form a composite sample. Soil samples were air dried and sieved through a 0.25 mm sieve determined the physico-chemical properties as per standard procedures (Baruah & Bartahakur, 1999). Soil moisture content was estimated by Gravimetric method. Yield parameters evaluated include number of fruit, fruit length, fruit girth, fruit weight and yield. Data were subjected to analysis of variance (ANOVA) and means significantly different were separated using Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS AND DISCUSSION

Physico-chemical Properties of Soil

Average sand content across the plots reduced from 48.2% to 47.6% in mulched plots while it increased to 50.8 % in farmers practice indicating that the soil is subjected to erosion in unmulched conditions (Table 1). The bulk density showed significant variations among the treatments and farmers practice showed the highest bulk density (1.28 Mg m^{-3}) which was statistically at par with polythene mulch (1.27 Mg m^{-3}) and organic mulched plots showed the lowest value of bulk density (1.14 Mg m^{-3}). The lower values of soil bulk density might be the result of addition of organic matter in organic mulched plots and higher bulk density in polythene mulched plots might be the result of breakdown of organic matter under higher soil temperature and removal of weeds in farmers practice.

Table 1: Effects of mulch materials on soil physical properties after harvest of pineapple (means of two years)

Treatment	Sand (%)	Silt (%)	Clay (%)	Textural class	Bulk density (Mg m^{-3})	Soil Moisture (%)
Black polythene	47.8	19.8	32.4	Sandy Clay Loam	1.27^{a}	14.2^{a}
Dhaincha mulching	51.2	17.2	31.6	Sandy Clay Loam	1.18^{b}	12.2^{b}
Slashing of weeds	47.6	19.9	32.5	Sandy Clay Loam	1.14^{b}	13.1^{ab}
Soil mulching	49.2	20.6	30.2	Sandy Clay Loam	1.23^{a}	11.4^{bc}
Farmers practice	50.8	19.1	30.1	Sandy Clay Loam	1.28^{a}	10.8^{c}
CD (P=0.05)	NS	NS	NS	-	0.06	1.22

**Means followed by same letter in each column are not significantly different at 5% level of significance based on DMRT*

Mulching had a significant effect (Table 2) on the soil moisture content at 30 cm depth at the harvesting stage. Highest soil moisture at the 30cm depth at harvesting in the black polythene mulching (14.2%) was not different from frequent slashing of weeds (13.1%). Farmers practice recorded significantly lower soil moisture (10.8 %). Organic mulched materials evaluated significantly recorded higher soil moisture storage. The soil moisture storage under frequent slashing of weeds as mulch was at par with polythene mulching. Mulching increased the soil water content presumably as a result of reduced evaporation (Cheng *et al.*, 2015). Furthermore, the collection and infiltration pathway, particularly for the plastic film treatments, was likely to have led to more efficient delivery of rainwater to the roots (Xiaomin *et al.* 2017). The significantly lower soil moisture in unweeded plots (farmers practice) might be attributed to the maximum vegetation that increased the evapotranspiration and decreased the soil moisture storage. Polythene mulching prevents soil exposure to solar radiation, and its resistance to the passage of water has decreased soil evaporation. Also, mulches reduce impact of raindrops and splash, thereby preventing soil compaction, reducing surface run-off, and increasing water infiltration. All these were combined to increase the soil moisture content and reduce moisture depletion (Rahmani *et al.*, 2021).

Soil pH changed from average of 5.2 before mulching to a range of 4.8 – 5.3 after mulching, depending on the mulch material. Soil mulched with black polythene gave the highest pH of 5.3 followed by *soil mulching* (5.1), farmers practice (4.9), slashing of weeds (4.9) and dhaincha mulching (4.8). The decrease in pH value in organic mulches could be due to decomposed organic matter producing humic acid, nitric acid and sulfuric acid those increase the H^+ ion in the soil. Rainfall which causes leaching that tends to wash away the basic cations viz. K^+, Mg^{**} and Ca^{**} those are replaced by acidic cations like H^+ making soil acidic (Nierves and Salas, 2015). Frequent slashing of weeds and dhaincha mulching resulted the highest amount of organic carbon content (8.8 g kg^{-1} and 8.3 g kg^{-1} respectively) which was significantly higher than the control (5.3 g kg^{-1}). Soils mulched with polythene sheet and soil mulching was not significantly different (table 3). The lower organic carbon in polythene mulching might be the result of breakdown of organic matter under higher soil temperature lesser weed growth which thereby less addition of plant biomass into the soil. Furthermore, Guo *et al.*(2013) showed a greater decline in soil organic C under polythene film because of a more favorable temperature regime for decomposition, which is consistent with our observation of a lower soil organic C. The soil organic carbon under organic mulch was higher than that of the ploythene mulch and control, mainly because the soil organic C was enhanced due to accumulation of carbonaceous material to the soil upon decomposition (Guan *et al.*, 2014).

Table 2: Effects of mulch materials on soil fertility after harvest of pineapple (means of two years)

Treatment	pH	Organic carbon (g kg^{-1})	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
Black polythene	5.3^a	6.4^a	261.3^a	6.2^a	100.4^a
Dhaincha mulching	4.8^b	8.3^b	320.4^b	8.2^b	104.3^a
Slashing of weeds	4.9^b	8.8^b	341.8^b	9.5^b	100.6^a
Soil mulching	5.1^{ac}	6.8^a	273.5^a	7.6^c	98.4^a
Farmers practice	4.9^b	5.3^c	240.3^c	7.1^{ac}	91.2^b
CD (P=0.05)	0.40	0.76	28.43	0.88	6.82

Soils mulched with slashing of weeds gave the highest available nitrogen N contents (341.8 $kgha^{-1}$) followed by dhaincha mulching (320.4 $kgha^{-1}$) while farmers practice recorded the least N content (240.3 $kgha^{-1}$). Black polythene mulching and soil mulching showed significantly lower available N than organically mulched plots (Table 2). The available P and available K in soils also showed significant variations among the mulch materials (Table 2). The highest available P was recorded in slashing of weeds (9.5$kgha^{-1}$) followed by dhaincha mulching (8.2 $kgha^{-1}$), soil mulching (7.6 $kgha^{-1}$), farmers practice (7.1 $kgha^{-1}$) and lowest in polythene mulching (6.2 $kgha^{-1}$). There was no significant difference in available K content NILIM among polythene mulch and organic mulch, however soil mulching and farmers practice recorded significantly lower available K which may be attributed to leaching as well as loss through surface run off from bare soils under unmulched condition.The favourable changes in the available nutrients due to mulching with organic materials can be attributed to the increased biological activities in the soil, thus, resulting in the mineralization of organic matter leading to increased nutrient content. Besides the higher available N near the soil surface are likely to be the result of reduced water infiltration and flow beneath the mulches, therefore reduced leaching (Xiaomin, 2017).

Table 3: Effects of mulch materials on yield and yield attributes of pineapple plant (means of two years)

Treatment	Fruit girth (cm)	Fruit length (cm)	Fruit weight (kg)	Fruit yield (t ha^{-1})
Black polythene	38.6[a]	14.60[a]	1.56[a]	38.3[a]
Dhaincha mulching	38.2[a]	14.45[a]	1.52[a]	36.5[a]
Slashing of weeds	36.7[a]	14.13[a]	1.48[a]	35.6[a]
Soil mulching	32.4[b]	12.16[b]	1.21[b]	23.5[b]
Farmers practice	28.0[c]	10.42[c]	1.16[b]	21.6[b]
CD (P=0.05)	3.23	1.14	0.22	3.16

Yield and Yield Attributes

The highest fruit girth (38.6 cm), fruit length (14.6 cm), fruit weight (1.56 kg) and fruit yield was recorded in polythene mulch which was statistically at par with dhaincha mulching and slashing of weeds. Soil mulching and farmers practice recorded significantly lower fruit girth, fruit length, fruit weight and fruit yield than polythene and organic mulching (Table 3). The higher values of yield attributes and yield under polythene and organic mulching might be attributed to better availability of moisture during the dry period. Besides, organic mulches act as a nutrient reserve to the soil which upon mineralization adds up to the soil fertility in turn resulting in higher crop yields (Fang *et al.*, 2011). Higher yield in dhaincha mulching and slashing of weeds can be attributed to their high organic matter, soil moisture conservation and nutrient availability arising from their high decomposition rates and better microbiological activities.

It may be concluded that the organic mulch decreased the soil pH but increased organic matter, nitrogen and phosphorus content. The polythene mulch was superior in conservation of soil moisture and suppression of weed than other treatments and farmers practice thereby resulting in corresponding increase in yield attributes and yield. Organic mulching methods were found to improve soil fertility and recorded higher yield which was at par with polythene mulching. Since the climatic condition of this zone is favourable for high weed growth, the study depicted that the farmers who can't afford the plastic polythene, frequent slashing of weeds as well as incorporation of dhaincha after 40 days can be used as alternative means of mulch material for moisture conservation, sustaining soil fertility and increased pine apple production.

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