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COMBINED EFFECT OF MINIMUM TILLAGE, MULCHING AND VERMICOM POST APPLICATION ON JUTE

H. K. TARAFDER*, P. K. MANI[1] AND M. RAY[2]
*Regional Research Station, Hill Zone, Uttar Banga Krishi Viswavidyalaya, Kalimpong - 734 301, WB
[1]Department of Agricultural Chemistry and Soil Science,
[2]Department of Agronomy,
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur - 741 252, Nadia, WB
e-mail: hridaykamalt25@gmail.com

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***Corresponding author**

ABSTRACT

A field experiment was conducted at AICRP on IFS at the Central Research Farm, Gayeshpur, BCKV, during 2011-12 on jute with an objective to determine the physico-chemical soil quality under minimum tillage and mulching condition (straw mulch@5 tha^{-1}) with 8 treatments which replicated thrice in RBD. The treatments were., T1M1F1- minimum tillage (1ploughing+1planking)+ no mulch + 100% RDF (N:P:K::80:40:40); T1M1F2- minimum tillage (1ploughing+1planking)+ no mulch + 75% RDF and 25% N through vermicompost; T1M2F1- minimum tillage (1ploughing+1planking)+ mulch + RDF; T1M2F2- minimum tillage (1ploughing+1planking)+ mulch + 75% RDF and 25% N through vermicompost; T2M1F1- conventional tillage (3ploughing+1planking)+ no mulch + RDF (N:P:K::80:40:40); T2M1F2- conventional tillage (3ploughing+1planking)+ no mulch+ 75% RDF and 25% N through vermicompost; T2M2F1- conventional tillage (3ploughing+1planking)+ mulch + RDF (N:P:K: 80:40:40); T2M2F2- conventional tillage (3ploughing+1planking)+ no mulch + % RDF and 25%N through vermicompost. It was found in treatment T1M2F2 significantly influence soil pH(7.30), organic carbon (0.84%), available nitrogen (309 kgha^{-1}), available phosphorus (64 kgha^{-1}), available potassium (305 kgha^{-1}), WHC (45.68%) MWD (0.99 mm) and thereby influence production of jute (5.2 t/ha). The combination of minimum tillage, mulching as well as 25% substitution of RDF was found the best combination with respect to soil health and crop yield.

INTRODUCTION

Over a decade, research on minimum tillage and mulching has been more identified and popularized by different group of researchers throughout the world for improving sustainable productivity. The practice of mulching protects the soil against the direct impact of raindrop and surface crust formation & reduces evaporation losses, check weed infestation, increase water infiltration rate, improve soil fertility and also improve plant growth. Minimum tillage involves considerable soil disturbance, though to a much lesser extent than that associated with convention tillage. Minimum tillage aimed at reducing tillage to the minimum necessary for ensuring a good seedbed, rapid germination, a satisfactory stand and favorable growing condition and increased soil organic matter and reduced operation costs (Lal *et al*., 1994; Malicki *et al*., 1997). The minimum tillage systems can have considerable impact on the environment through its influences on soil structure which substantially affect water quality, nutrients, sediments, pesticides and air quality and greenhouse effect (Holland, 2004; Hobbs, 2007).

Many researchers (Six *et al*., 2000; Bhattacharyya *et al*., 2009, Kumar et al., 2016) were worked on different tillage practices and many other researchers (Singh *et al*., 2004; Sharma *et al*., 2011; Vijay Kumar, 2014) were worked on different mulching techniques. So, the combination of tillage-mulch practices with cropping systems may have synergistic effects on the chemical and physical properties of the soil and research on refinement of combinations is still lacking. Adoption of the more appropriate tillage-mulch-crop combination for the soil is essential in the zone. Moreover, interactions among soil conditions, management practices and crops are influenced by variability within a system (Pikul *et al*., 2007). Therefore, the present investigation was framed to determine the chemical and physical quality under minimum tillage and mulching condition (straw mulch@5 tha^{-1}) in jute.

MATERIALS AND METHODS

The field experiment was conducted in jute during 2011-2012. The location of the experimental site was in the hot, humid subtropics under AICRP on IFS at the Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. Gayeshpur is situated in the in New Alluvial zone of West Bengal at 23° North latitude and 89° East longitude at an altitude of 9.75 m above the mean sea level (Agro-ecological zone- 15.1). The experimental site receives an average annual rainfall of approximately 1576mm and experiences mean annual minimum and maximum temperature of 12.5°C and 36.2°C, respectively. The soil is hyperthermic and clay loam in texture (*Aeric Haplaquepts*, US Soil Taxonomy).

The experiment was laid out in randomised block design with eight treatments and three replication in the plot size of 5 m ×

4 m. The treatment combinations were- T1M1F1- minimum tillage (1ploughing+1planking)+ no mulch + recommended dose of fertilizer (N:P:K:: 80:40:40); T1M1F2- minimum tillage (1ploughing+1planking)+ no mulch + 75% RDF and 25% N through vermicompost; T1M2F1- minimum tillage (1ploughing+1planking)+ mulch + recommended dose of fertilizer; T1M2F2- minimum tillage (1ploughing+1planking)+ mulch + 75% RDF and 25% N through vermicom post; T2M1F1- conventional tillage (3ploughing+1 planking)+ no mulch + recommended dose of fertilizer (N:P:K: 80:40:40); T2M1F2- conventional tillage (3ploughing+1planking)+ no mulch+ 75% RDF and 25% N through vermicompost; T2M2F1- conventional tillage (3ploughing+1planking)+ mulch + recommended dose of fertilizer (N:P:K:: 80:40:40); T2M2F2- conventional tillage (3ploughing+1planking)+ no mulch + 75% RDF and 25% N through vermicompost.

Jute (JRO- 50) was grown in line sowing (45 × 10 cm) under irrigated pre-kharf season. Mulching was done with dry paddy straw @ 5 t ha^{-1} (0.43 % nitrogen and C:N ratio= 90:1) after 5 days of germination. Half the nitrogen and full P and K fertilizer was applied as basal dose and remaining nitrogen was applied in two equal splits in top dressing.

Three representative field moist samples were collected from each of the treatments in each replication from 0-15cm depth with a bucket auger and were dried under shade. The air-dried sub sample of each sample were then hand crushed, passed through 2 mm sieve and were stored for determination of various physical and chemical properties.

The chemical parameters like soil pH, electrical conductivity, available nitrogen, potassium and phosphorus (Jackson, 1973), oxidizable organic carbon (Walkley and Black, 1934), the physical parameters such as (Blake and Hartge (1986) was determined. Particle size soil moisture distributions of the, soils were determined following the Boyoucous hydrometer method (Gee and Bouder, 1986). Water stable aggregates and their distribution in each soil layer under different treatments were determined by wet sieving method as described by Yoder (1936).

After correction of sand content, the amount of aggregates remaining in each size fraction was used to calculate the mean weight diameter (MWD) of the water stable aggregates following van Bavel (1949) as:

$$\text{Mean weight diameter (mm)} = \frac{\sum_{i=1}^{n} x_{iWi}}{\sum_{i=1}^{n} W_i}$$

Where n is the number of fractions (0.1-0.25, 0.25-0.50, 0.50-1.0, 1.0-2.0, >2.0 mm), X_i is the mean diameter (mm) of the sieve size class (0.175, 0.375, 0.75, 1.5 and 2mm) and W_i is the weight of soil (g) retained on each sieve.

Geometric mean diameter (GMD), an exponential index of aggregate stability was expressed as:

$$\text{Geometric mean diameter} = \exp[\frac{\sum_{i=1}^{n} W_i \log x_i}{\sum_{i=1}^{n} W_i}$$

Where n is the number of fractions (0.1-0.25, 0.25-0.50, 0.50-1.0, 1.0-2.0, >2.0 mm), X_i is the mean diameter (mm) of the sieve size class (0.175, 0.375, 0.75, 1.5 and 2 mm) and W_i is the weight of soil (g) retained on each sieve.

The index percent aggregate stability or degree of aggregation (AS) of soil was calculated as

$$(\frac{\text{Percent Sp} > 0.25\text{mm} - \text{Percent Pp} > 0.25\text{mm}}{\text{Percent Pp} < 0.25\text{mm}}) \text{X } 100$$

Where

Sp and Pp represents the soil particle and the primary particle, respectively.

The data was analysed as a randomised block design and significance was evaluated by *F*-test, (Gomez and Gomez, 1984). Standard error of mean and least significant difference ($p<0.05$) values were calculated whenever needed.

RESULTS AND DISCUSSION

Effect of tillage, mulch and fertilizer on chemical properties of the soil

The data on the pH of the soil samples was presented in the Table 1. Result showed that there was significant response of tillage mulch and vermicompost on pH of the soil. However results showed that a significant decrease in pH (7.30) were associated with T1M2F2 (treatment receiving mulch and 75% recommended dose of fertilizer and 25% N through Vermicompost). This may be due to organic acid production which buffered the soils against major swings in pH ether by taking up or releasing H^+ ion into the soil solution making the concentration of soil solution H^+ ion more constant resulting into a stable pH near neutrality (Brady and Weil, 2002; Malhi *et al.* 2011). The decrease in soil pH follows the order T1M2F2> T2M2F2> T1M1F2> T1M2F1> T2M1F2> T2M2F1> T1M1F1> T2M1F1.

Organic carbon content of soil acts as proxy indicator of soil structure, stability, nutrient retention and soil erosion (Carter, 2002). Results showed a significantly higher organic carbon content (0.84%) in the soil under Minimum tillage, mulching and vermicompost application (T1M2F2) impacts soil organic carbon stock by reducing disturbance which favours the formation of soil aggregates and protects soil organic carbon encapsulated inside these stable aggregates from rapid oxidation (Six *et al.*, 2000). The highest value was recorded T1M2F2 (0.84%) followed by T2M2F2 (0.83%) > T1M1F2 (0.81%)>T1M2F1 (0.80%)> T2M1F2 (0.78%)> T2M2F1 (0.75%)> T1M1F1 (0.74%) and T2M2F1 (0.75%). Higher the content of lignin, polyphenol in paddy straw led to the formation of stable complexes with protein origin and thus made the paddy straw carbon more resistant to decomposition.

It is evident from the results a significantly higher available nitrogen content (309 $kgha^{-1}$) in the treatment receiving minimum tillage, mulching and vermicompost application i.e. treatment T1M2F2. The highest value was recorded T1M2F2 (309 $kgha^{-1}$) followed by T2M2F2 (308 $kgha^{-1}$) > T1M1F2 (293 $kgha^{-1}$)> T1M2F1 (293 $kgha^{-1}$)> T2M1F2 (282 $kgha^{-1}$) > T2M2F1 (277 $kgha^{-1}$) > T1M1F1 (276 $kgha^{-1}$) and T2M1F1 (272 $kgha^{-1}$). Beside this decomposition of vermicompost some organic ligands which helps to increase its availability to plants and at the same time due to mineralization of such organics,

Table 1: Effect of combination of tillage, mulch and fertilizer on chemical properties of the soil

Treatments	pH	EC (dSm^{-1})	Org C (%)	Avail N ($kgha^{-1}$)	Avail P($kgha^{-1}$)	Avail K($kgha^{-1}$)	Fe ($mgkg^{-1}$)	Mn ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)	Zn ($mgkg^{-1}$)
T1M1F1	7.40	0.69	0.74	276	45.3	260	81.10	21.21	12.60	2.14
T1M1F2	7.33	0.71	0.81	293	58.0	289	100.53	24.41	13.88	2.35
T1M2F1	7.37	0.84	0.80	293	55.6	272	98.81	23.63	13.58	2.32
T1M2F2	7.30	0.75	0.84	309	64.6	305	125.53	25.13	16.98	2.58
T2M1F1	7.47	0.81	0.75	272	44.0	259	89.50	20.71	11.61	2.02
T2M1F2	7.37	0.71	0.78	282	52.3	269	97.46	22.76	12.80	2.20
T2M2F1	7.37	0.85	0.75	277	49.0	261	85.20	21.41	12.33	2.13
T2M2F2	7.32	0.81	0.83	308	59.0	289	117.23	24.65	14.45	2.39
S.E. m.(±)	0.01535	0.0073	0.01475	0.1109	0.0484	0.1074	0.0649	0.03184	0.0245	0.0099
CD (5%)	0.29	0.03	0.03	11.54	2.21	10.84	4.97	0.95	0.57	0.12

T1-minimum tillage; T2-conventional tillage; M1-non mulch; M2-mulch; F1-100% RDF; F2-75% RDF + 25% N through vermicompost

nitrogen is released in the soil (Ghorai, A.K., 2004).

From the perusal data it was observed that a significantly higher available phosphorus content ($kgha^{-1}$) in the treatment receiving minimum tillage, mulching and vermicompost application. The highest value was recorded T1M2F2 (64.6 $kgha^{-1}$) followed by T2M2F2 (59.0 $kgha^{-1}$) > T1M1F2 (58.0 $kgha^{-1}$) > T1M2F1 (55.6 $kgha^{-1}$) T2M1F1 (52.3 $kgha^{-1}$) > T2M2F1 (49.0 $kgha^{-1}$) > T1M1F1 (45.3 $kgha^{-1}$) and T2M1F1 (44.0 $kgha^{-1}$). Results thus indicated that application of balanced fertilizer with partial substitution of inorganic nitrogen with vermicompost could be effective to increase the availability of phosphorus in soil over the application of only inorganic fertilizer. Similar view was also reported by Park *et al.*, 2004, Chaudhury *et al.,* 2005 and by Pal *et al.*, 2015. Organic amendments on decomposition released organic acids which increased the P availability by blocking P adsorption sites on soils or through anion exchange phenomenon (Nambiar, 2002). Besides this, the organic acid produced could cause dissolution of P bearing minerals in soil and thus cause an increase in P availability.

From the perusal data it was observed that a significantly higher available potassium content (305 $kgha^{-1}$) in the treatment receiving minimum tillage, mulching and vermicompost application (T1M2F2) followed by T2M2F2 (289 $kgha^{-1}$) > T1M1F2 (289 $kgha^{-1}$) > T1M2F1 (272 $kgha^{-1}$) > T2M1F2 (269 $kgha^{-1}$) > T2M2F1 (261 $kgha^{-1}$) > T1M1F1 (260 $kgha^{-1}$) and T2M1F1 (259 $kgha^{-1}$). Lower the K content in T2M1F1 might be due to higher uptake by jute and also possibly due to decrease in exchangeable basic cations like K^+ by its leaching, runoff losses (Bellakki *et al.*, 1998). Results also revealed that application of 75% RDF (recommended dose of fertilizer) & 25% N through vermicompost significantly increased the available potassium (Singh *et al.,* 2002). This might be due to application of vermicompost along with 75% RDF increase the cumulative non exchangeable potassium release and could maintain large amount of potassium in soil solution and on exchange sites be re-establishing the equilibrium among different forms of potassium.

Effect of tillage, mulch and fertilizer on soil micronutrients avaiabilty was also studied. Results revealed that showed a higher available Fe (125.23 $\mu g\ gm^{-1}$), Mn (25.13 $\mu g\ gm^{-1}$), Cu (16.98 $\mu g\ gm^{-1}$), Zn (2.58 $\mu g\ gm^{-1}$) in the soil under minimum tillage, mulching and vermicompost application (T1M2F2). This is might be due to chelation of that micronutrient by the decomposing organics that reduced its vulnerability to fixation (Choudhury *et al.*, 2005).The maximum increases in available Mn (25.13 $\mu g\ gm^{-1}$) content in soil due to reduced state of the soil under T1M2F2 treatment helped in reduction of Mn^{4+} to Mn^{2+} due to greater soil moisture and thereby enhances the solubility and increases the concentration of water soluble manganese. The decreases in available Cu content in soil under conventional tillage might be due to insoluble precipitation of Cu as hydroxide, carbonates and sulphide under during cultivation of jute.

Effect of tillage, mulch and fertilizer on physical properties of the soil

The effect on soil physical properties has been presented in Table 2. The results revealed that a significant decrease bulk density (1.46 gm cc^{-1}) under minimum tillage, mulching and vermicompost application (T1M2F2) is possibly due to the addition of organic matter which lowered the bulk density.

The mean weight diameter is an important index for characterizing the structure of whole soil by integrating the aggregate class size distribution into one number. Increase in mean weight diameter (MWD) has been observed in minimum tillage system mulch and vermicompost application combination system i.e. T1M2F2 (0.99 mm) followed by T2M2F2 (0.89 mm) > T1M1F2 (0.89 mm) > T1M2F1 (0.83 mm) > T2M1F2 (0.78 mm) > T2M2F1 (0.75 mm) > T1M1F1 (0.69 mm) and T2M1F1 (0.62 mm). The possible reason for increasing MWD by mulched and reduced tillage condition had been found to induce a loss of C-rich macroaggregates and gain of C-depleted micro aggregates as observed by Six *et al*, 2000. This is mainly due to the presence of lignin and other organic materials in paddy straw which were resistant to rapid degradation and form persistant aggregates.

The lower aggregate stability (21.10) in conventional tillage, without mulching and vermicompost application i.e. in T2M1F1 was due to fact that soil disturbances from tillage operations and no mulch caused of reduction in the number and stability of the soil aggregates (Bandopadhyay *et al.,* 2010; Six *et al.*, 2000). On the other hand mulching, minimum tillage and vermicompost application (T1M2F2) significantly increase the aggregate stability (34.38 %) compared to tillage, without mulching and vermicompost application *i.e.* in T2M1F1 (21.10).

Table 2: Effect of minimum tillage, mulch and fertilizer on soil physical properties.

Treatments	BD (gm/cc)	WHC (%)	MWD (cm)	AS (%)	AR	GMD (mm)	Yield (kg/ha)
T1M1F1	1.53	41.92	0.69	24.95	0.41	0.64	4485
T1M1F2	1.49	44.32	0.89	31.04	0.61	0.84	4620
T1M2F1	1.48	41.58	0.83	28.07	0.57	0.78	4521
T1M2F2	1.46	45.68	0.99	34.38	0.68	0.96	5211
T2M1F1	1.54	40.11	0.62	21.10	0.39	0.61	3996
T2M1F2	1.52	41.92	0.78	26.61	0.48	0.74	4485
T2M2F1	1.51	41.20	0.75	25.07	0.45	0.68	5024
T2M2F2	1.46	45.26	0.89	32.93	0.67	0.85	5153
S.E. m.(±)	0.0078	0.0422	0.0059	0.0347	0.0048	0.0058	0.4541
CD (5%)	0.06	1.68	0.03	1.15	0.02	0.03	193.85

T1-minimum tillage; T2-conventional tillage; M1-non mulch; M2-mulch; F1-100% RDF; F2-75% RDF + 25% N through vermicompost

Aggregate ratio is nothing but to the ratio between macro and micro aggregates. Increasing in the aggregate ratio was related with the better aggregation. The decreases in aggregate ratio (0.39) in soil under conventional tillage, without mulching and vermicompost application i.e. in T2M1F1 caused destruction of water stable macro aggregates and increases proportion of micro aggregates which in turn reduce the aggregate ratio. On the other hand organics promotes higher aggregate ratio in T1M2F2 (0.68) due to the fact that organic matters act as a chelating agent to bind the soil particle thus help in the soil aggregation and increases proportion of water stable macro aggregates. The results thus indicated the cultivation without organics led to poor aggregate ratio because of lack of chelating agents to bind soil particle into aggregates.

It was found a significant highest yield in T1M2F2 (5211 kg ha^{-1}) followed by T2M2F2 (5153 kg ha^{-1} > T2M2F1 (5024 kg ha^{-1}) > T1M1F2 (4620 kg ha^{-1}) > T1M2F1 (4521 kg ha^{-1}) > T2M1F2 (4485 kg ha^{-1}) > T1M1F1 (4485 kg ha^{-1}) and T2M1F1 (3996 kg ha^{-1}).

It can be safely concluded that combination of minimum tillage, mulching as well as 25 percent substitution of recommended dose of fertilizer significantly influence soil pH, organic carbon, available nitrogen, phosphorus, potassium, DTPA extractable micronutrients (Fe, Mn, Cu and Zn), bulk density and soil aggregation and thereby influence production of jute. So, we need to shift from conventional practice to combined resource conservation practice as far soil health and economic yield is concern.

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APPLICATION FORM

NATIONAL ENVIRONMENTALISTS ASSOCIATION (N.E.A.)

To,
The Secretary,
National Environmentalists Association,
D-13, H.H.Colony,
Ranchi - 834 002, Jharkhand, India

Sir,
I wish to become an Annual / Life member and Fellow* of the association and will abide by the rules and regulations of the association

Name ____________________

Mailing Address ____________________

____

Official Address ____________________

____

E-mail ____________________ Ph. No.__________(R)__________(O)

Date of Birth ____________________ Mobile No. ____________________

Qualification ____________________

Field of specialization & research ____________________

Extension work (if done) ____________________

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Please find enclosed a D/D of Rs... No. .... Dated .... as an *Annual / Life membership fee*.

*Attach **Bio-data and some recent publications along with the application form when applying for the Fellowship of the association.**

Correspondance for membership and/ or Fellowship should be done on the following address :

SECRETARY,
National Environmentalists Association,
D-13, H.H.Colony,
Ranchi - 834002
Jharkhand, India
E-mails : m_psinha@yahoo.com Cell : 9431360645
dr.mp.sinha@gmail.com Ph. : 0651-2244071