Study of Non-woven Jute Agrotextile Mulches on Soil Water, Temperature and Nutrient Status in Root Zone in Broccoli (*Brassica oleracea* L.) Cultivation

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ABSTRACT

The field studies were conducted during the middle of November to end of February for the season of 2015–2016 and 2016–2017 respectively in the red lateritic soil of Bahadurpur village of Bolpur, Birbhum, West Bengal, India which lies between 23°39’47.69” N latitude and 87°37’36.91” E longitude with an average altitude of 58.9 m above the mean sea level under sub-humid semiarid region of West Bengal, Eastern India to evaluate the performance of different types of non-woven jute agro-textile mulches (NJATM) in comparison to other mulches on soil temperature, soil moisture, soil physical properties and yield of broccoli (*Brassica oleracea* L.). The highest pooled yield (8.50 t ha⁻¹) of broccoli was recorded in 350 gsm NJATM treatment. Minimum temperature fluctuation (1−3°C) was observed in case non-woven jute agro textile mulches and it was lowest in 350 gsm NJATM treatment followed by 400 gsm NJATM. In case of soil physical properties, the maximum mean value of hydraulic conductivity (0.54 cm hr⁻¹) was observed in 400 gsm NJATM. However, the lowest pooled Bulk Density was recorded in 400 gsm NJATM treatment (1.37 g cm⁻³) which was, however, statistically at par with 350 gsm NJATM treatment (1.38 g cm⁻³). The soil moisture was conserved in all treatments compared to control showing highest moisture content in 400 gsm NJATM treatment. Organic carbon content of soil was increased in all mulch treated plots compared to control, and their initial value and their highest value (0.64%) was recorded in 350 gsm NJATM treatment The NJATM of 350 gsm thickness was very effective compared to other mulches as a result of the soil management practices and productivity.

KEYWORDS: Broccoli, bulk density, hydraulic conductivity, NJATM, soil temperature, yield
1. INTRODUCTION

Mulches are known to regulate the soil temperature which is an important factor in seed germination (Dwyer et al., 1990), root growth (Kaspar and Bland, 1992), root respiration (Burton et al., 1998) and water and nutrient uptake by plants (Kaspar and Bland, 1992). It directly and indirectly affects soil physical processes like infiltration (Singh, 1992), hydraulic conductivity (Ren et al., 2014) and movement of nutrients and chemicals (solute movement) in soil profiles (Grundmann et al., 1995; Vigil and Kissel, 1995). Soil temperature influences the solute movements in soils (Merdun, 2012), controls dissolved organic carbon export (Haei et al., 2010), its residence time in soils (Euskirchen, 2006; Oquist and Laudon, 2008), rates of mineralization (Haei et al., 2013; Rustad et al., 2001), global warming, precipitation pattern (Jungqvist et al., 2014) and decomposition of soil organic matter (Davidson and Janssens, 2006; Domisch et al., 2001; Melillo et al., 2002) as well as forest productivity (Stromgren and Linder, 2002). There is direct relationship between decomposition of organic matter and soil respiration (Leiros et al., 1999). Considering its significant contribution in soil weathering process, soil temperature regime has been included as classification criteria in the Soil Taxonomy (Gislason et al., 2009; Soil Survey Staff, 1999). As the measurement of soil temperature is limited in spatio-temporal scale, air temperature has often been used to estimate soil temperature by several researchers; Zheng et al., 1993). Although soil temperature is often difficult to monitor in spatio-temporal levels as installation of soil temperature measuring equipment in soil profile not only a costly affair but also tedious. Mulches restricts weed growth (Ossom et al., 2001), conserve soil moisture, promote crop development, early harvest, and increase yields (Manna et al., 2018). The use of nonwoven agrotextiles help in extending the growing season by maintaining enough soil humidity and increasing the soil temperature, protecting seeds and plants against storm, cold spells and hail damage (Marasovic, 2019) and increase crop yield (Bhavani et al., 2017). Non-woven jute agro-textile mulch (NJATM) made of natural jute fibres having high porosity high permeability, high carbon to nitrogen (C:N) ratio, high water absorbing power (~500%) composed of 83% cellulose, 12.5% lignin, 1.1% fat and wax and 1.8% nitrogenous matter show higher efficacy compared to others (Manna et al., 2018). The extent of impact of mulch on hydro-physical properties depends on the quantity and quality of mulch, soil properties and soil environment (Lal, 1995). Rate of application of mulch has no significant effect on saturated hydraulic conductivity between soil layers of 0 to 50 cm depth (Lal, 2000). However, Kahlon et al. (2013) attributed improved saturated hydraulic conductivity, reduction in bulk density and improvement in soil moisture status to mulching. Bulk density is dependent on organic matter content, texture and porosity (Dornier et al., 2010); and this is confirmed by Majaliwa et al. (2010) who reported lower bulk density in natural forest compared to tea and eucalyptus land uses. Dec et al. (2008) opined that mulching eases water flow and retention because it ensures pore continuity which influences higher saturated hydraulic conductivity. Blanco-Canqui and Lal (2007) reported significantly lower surface soil bulk density and higher saturated hydraulic conductivity under straw mulch than under non-mulched treatment.

Comprehensive information on effect of different NJATMs on soil physico-chemical properties like soil temperature, soil moisture, hydraulic conductivity, bulk density, nutrient status and broccoli yield is not available for the light textured, acidic, nutrient poor, low productive lateritic soils of West Bengal, India. Keeping in view of above, an experiment was designed and conducted for the first time in a farmer’s field with the following objectives: (1) To assess the impact of different thickness non-woven jute agro-textile mulches (NJATMs) in comparison to other mulching treatments on soil hydro-thermal and nutrient status (2) To understand the yield contributing factors and identify economically viable and environment friendly mulching options in broccoli crop in rain fed area.

2. MATERIALS AND METHODS

2.1. Study area, design and treatments of the experiment
An experiment was conducted on Broccoli in the farmer’s field conducted during the middle of November to end of February for the season of 2015–2016 and 2016–2017 respectively in the red lateritic soil of Bahadurpur village of Bolpur, Birbhum, West Bengal, India which lies between 23°39'47.69'' N latitude and 87°37'36.91'' E longitude with an average altitude of 58.9 m above the mean sea level under sub humid semi-arid region of West Bengal. The soil of the experimental site was a typical lateritic soil (Typicchaquept), sandy loam in texture with acidic pH, low in organic carbon, available N, available P and available K content. The weather data pertaining to the cropping seasons of 2015–16 and 2016–17 recorded at Meteorological Observatory Office, Dept. of Meteorology, Govt. of India, Sriniketan, Birbhum, West Bengal revealed that maximum temperature during the cropping period ranged from 36.65°C to 25.30°C in 2015–16 and 36.85°C to 23.98°C in 2016–17. The average annual rainfall was 1453 mm (Table 1 and 2).

The experiment was laid in randomized block design (RBD) with six treatments viz., T₁ (control, i.e. no mulching), T₂ (300 gsm NJATM), T₃ (350 gsm NJATM), T₄ (400 gsm NJATM), T₅ (rice straw; 10 t ha⁻¹) and T₆ (black polythene mulch of 50 μm) and four replications. Twenty days old
healthy broccoli seedlings were transplanted in the holes on the mulches of each of the experimental plot of 3.0×6.0 m² with row to row and plant to plant spacing were 1.0 and 0.5 m respectively in middle of November and the crop was harvested at the end of February. Supplementary nutrients were applied at the rate of 150, 100, 100 kg ha⁻¹ N, P and K respectively in the form of urea, single super phosphate (SSP), muriate of potash (MOP) respectively.

The entire amount of farm yard manure (5 t ha⁻¹), full SSP and MOP and 1/4th of urea were applied as basal dose and were thoroughly mixed with the soil during final land preparation. Soils were top dressed with rest amount of urea through application in three equal instalments at 15, 30 and 45 days after planting (DAP).

2.2. Physico-chemical analysis of mulching materials

The chemical constituents (Table 4) like lignin, hemicellulose, fat and wax (alcohol-benzene extract) and ash of mulching materials were estimated by TAPPI Standard Method (1971), the α-cellulose content by Sarkar et al., 1948 (Table 4), the Apparent Opening Size \( (O_{95}) \) in micron (ASTM D4751-16, 2016) and the thickness of NJATM was (Table 3) measured by ASTM D5199-16, 2016.

2.3. Irrigation

For establishment of plants 1st irrigation was applied at 1 DAP and there after irrigation was applied at 15 days interval up to 91 DAP (i.e., total seven numbers of irrigation was applied at 1 DAP, 16 DAP, 31 DAP, 46 DAP, 61 DAP, 76 DAP and 91 DAP). Irrigation water requirement was estimated through FAO method (Anonymous, 2020). Supplementary irrigation was provided through drip irrigation system.

2.4. Observation on growth and yield of broccoli

During the crop growth and development periodic data on plant height (cm), numbers of leaves, weight of curds (g) and curd yield of broccoli (t ha⁻¹) were recorded. Three randomly selected plants at harvest from each replication were selected for recording of growth and yield of broccoli.

2.5. Observation on soil temperature

Soil temperature at 10 cm depth was measured with stainless steel Fisher brand bi-metal dial thermometers at 3 DAP, 30 DAP, 60 DAP, 90 DAP in broccoli field at 8.00, 12.00 and 16.00 h for all the replications of each treatment according to Ramakrishna et al. (2006).

2.6. Soil moisture analysis

The moisture content of soil samples collected at 15, 30, 60 and 90 days after planting (DAP) were determined by gravimetric method.
Table 4: Chemical properties of non-woven jute agrotextile mulch (NJATM) material

<table>
<thead>
<tr>
<th>Component</th>
<th>Mulching materials</th>
<th>Non-woven jute agro-textile mulch (NJATM)</th>
<th>Rice straw</th>
<th>Black polythene</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\infty) Cellulose</td>
<td></td>
<td>59.91%</td>
<td>36.80%</td>
<td></td>
</tr>
<tr>
<td>Hemicellulose</td>
<td></td>
<td>23.45%</td>
<td>25.60%</td>
<td></td>
</tr>
<tr>
<td>Lignin</td>
<td></td>
<td>12.56%</td>
<td>10.30%</td>
<td></td>
</tr>
<tr>
<td>Fat and wax</td>
<td></td>
<td>1.10%</td>
<td>5.42%</td>
<td></td>
</tr>
<tr>
<td>Nitrogenous matter</td>
<td></td>
<td>1.80%</td>
<td>1.00%</td>
<td></td>
</tr>
<tr>
<td>Ash content</td>
<td></td>
<td>0.70%</td>
<td>7.20%</td>
<td></td>
</tr>
</tbody>
</table>

(Manna et al., 2018)

2.7. Observation on Soil bulk density and hydraulic Conductivity

The soil bulk density (g cm\(^{-3}\)) was determined by Core Method (Dastane, 1972) and hydraulic conductivity (cm hr\(^{-1}\)) was determined by Constant head method (Mohanty et al. 1994).

2.8. Chemical analysis of soil (0–15 cm)

The initial and post harvest soil pH (1:2.5; soil: water), soil organic carbon (%), Available soil nitrogen (N) content, available phosphorus (P) content and available potassium (K) were measured by standard method (Jackson, 1973; Walkley and Black, 1934; Subbaiah and Asija, 1956; Bray and Kurtz, 1945).

2.9. Statistical analysis

The data collected from the experiment were statistically analyzed following the procedures as described by Gomez and Gomez (1983). The level of significance used in “F” and “t” test was \(p=0.05\). Critical difference values were calculated wherever the “F” test was significant.

3. RESULTS AND DISCUSSION

All the results have been presented as pooled data during the middle of November to end of February for the season of 2015–2016 and 2016–2017 for this field studies.

3.1. Effect on growth and yield of broccoli

The effect of different mulching on the plant height of broccoli at harvest during the middle of November to end of February for the season of 2015–2016 and 2016–2017 respectively is presented in Table 5. Mulching affected the plant height significantly in winter broccoli during both the years (Table 5). The highest plant height was recorded in \(T_1\) (350 gsm NJATM) followed by \(T_4\) (400 gsm NJATM) during both years. NJATM of all the thicknesses showed higher plant height than rice straw, black polythene mulch and control. However, the lowest average plant height was observed in \(T_1\) (control). Highest average number of leaves per plant of broccoli was recorded in \(T_1\) treatment i.e., in plot treated with 350 gsm NJATM during both the years (Table 5). However, lowest average number of leaves was recorded in \(T_1\) treatment (no mulch) which was, however, statistically at par with \(T_4\) and \(T_5\) treatment i.e., in plot treated with rice straw and black polythene respectively. Highest average curd weight of broccoli was recorded in \(T_2\) treatment i.e., in plot treated with 350 gsm non-woven jute agrotextile mulch (NJATM) (Table 5). However, lowest average curd weight of broccoli was recorded in \(T_1\) treatment (no mulch). Data on curd yield of broccoli as influenced by the mulching have been presented in Table 5. Mulching significantly influenced the pooled curd yield of broccoli. The highest curd yield of 8.5 t ha\(^{-1}\) was obtained under 350 gsm NJATM treatment \((T_1)\) which was, however, statistically equal with \(T_4\) (400 gsm NJATM). However, all mulched treatments recorded significant higher curd yield compared to control. A perusal of pooled data of curd yield of broccoli recorded that mulching significantly influenced the curd yield of broccoli. However, all NJATM treatments were significantly superior over rice straw mulch \((T_1)\) and black polythene mulch \((T_4)\). The superiority of bio-degradable 350 gsm NJATM over other thickness
of NJATM and rice straw, polythene mulch or no mulch in the experiment might be due to the beneficial effect of increased moisture conservation, increased organic carbon and nutrient status along with high weed control efficiency (Manna et al., 2018; Sarkar et al., 2019).

3.2. Effect of different mulches on soil temperature
The non-woven jute agro-textile mulches (NJATM) and other mulch treated soil had significantly higher temperature at 10 cm soil depth during winter season (Table 6) compared to control. It was observed that black polythene mulched soil recorded highest soil temperature at 10 cm soil depth compared to bare soil and other mulched soil in 3, 30, 60 and 90 DAP. The pooled highest soil temperatures at 10 cm soil depth at 3 DAP recorded during 8.00 h, 12.00 h and 16.00 h were 22.35°C (recorded in 400 gsm NJATM), 27.65°C (recorded in black polythene mulch) and 26.16°C (recorded in again in black polythene mulch) respectively. However, the lowest pooled soil temperatures were always recorded in control or bare soil. Again, different NJATM showed little variations of soil temperatures in the range of 23.36°C to 23.83°C. The soil temperatures at 30 DAP at different day time recorded almost similar trends. At 60 DAP at 8.00h the highest soil temperature (19.5°C) was recorded in 400 gsm NJATM and lowest soil temperature (18.63°C) was recorded by bare soil. However, the black polythene mulch and rice straw mulch recorded soil temperature 19.5°C and 18.83°C at 8.00 h. The soil temperature in bare soil at 10 cm

Table 6: Effect of different mulches on soil temperature (°C) at 10 cm depth at 3 DAP, 30 DAP, 60 DAP and 90 DAP

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Soil temperature (°C) at 10 cm depth at 3 DAP</th>
<th>Soil temperature (°C) at 10 cm depth at 30 DAP</th>
<th>Soil temperature (°C) at 10 cm depth at 60 DAP</th>
<th>Soil temperature (°C) at 10 cm depth at 90 DAP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At 8.00 h At 12.00 h At 16.00 h</td>
<td>At 8.00 h At 12.00 h At 16.00 h</td>
<td>At 8.00 h At 12.00 h At 16.00 h</td>
<td>At 8.00 h At 12.00 h At 16.00 h</td>
</tr>
<tr>
<td>T3</td>
<td>22.04 24.58 23.36</td>
<td>21.29 23.16 22.33</td>
<td>19.36 23.70 22.83</td>
<td>22.00 23.34 22.54</td>
</tr>
<tr>
<td>T4</td>
<td>22.35 24.66 23.60</td>
<td>21.73 23.65 22.78</td>
<td>19.59 23.86 23.35</td>
<td>22.20 23.60 22.75</td>
</tr>
<tr>
<td>T6</td>
<td>22.01 27.65 26.16</td>
<td>20.01 28.44 26.99</td>
<td>19.50 27.34 25.89</td>
<td>21.51 26.94 25.91</td>
</tr>
<tr>
<td>SEm²</td>
<td>0.10 0.12 0.06</td>
<td>0.07 0.07 0.07</td>
<td>0.06 0.07 0.09</td>
<td>0.08 0.09 0.06</td>
</tr>
<tr>
<td>CD</td>
<td>0.28” 0.33” 0.16”</td>
<td>0.20” 0.19” 0.21</td>
<td>0.18” 0.20” 0.27”</td>
<td>0.23” 0.25” 0.18”</td>
</tr>
</tbody>
</table>

T1: No mulch; T2: 300 gsm NJATM; T3: 350 gsm NJATM; T4: 400 gsm NJATM; T5: Rice straw; T6: Black polythene; NJATM: Non-woven jute agro-textile mulch; **: Indicates F value is significant at (p=0.01) level of significance

depth at 60 DAP at 16.00 h was not increased so much and it was recorded lowest (20.96°C) among all the treatment, whereas the highest pooled soil temperature (24.04°C) was recorded in black polythene mulch followed by straw mulch. At 90 DAP at 8.00 h the highest pooled soil temperature (22.20°C) was recorded in 400 gsm NJATM followed by 350 gsm NJATM and lowest soil temperature (20.48°C) was recorded in control i.e., in bare soil. The NJATM recorded temperature in the range of 23.39–22.75°C and black polythene mulch recorded highest soil temperature (25.91°C) followed by straw mulch (24.14°C) at 16.00 h at 90DAP. Results showed the minimum variation of soil temperature in 350 gsm followed by 400 gsm NJATM. The NJATM kept the soil warm in cool season in better way in comparison to bare soil and others. Black polythene mulch recorded higher temperature at 16.00 h than control and NJATM mulch which might be because of its absorption of more solar radiation compared to others and cooling down slowly. It is observed (Table 6) that black polythene mulch increased the soil temperature both day and night period. Rice straw and NJATM also increased the soil temperature and reduced soil temperature when atmospheric temperature was high. But due to proper aeration and increased soil moisture NJATM stabilized the soil temperature more effectively. The optimum soil temperature 20–25°C (Oswal, 1993) for winter broccoli was achieved by 350 gsm NJATM followed by 400 gsm NJATM. The high soil temperatures of mulched plots (straw and polythene) observed in this investigation were in good agreement with the results of Choi and Chung (1997) recording increase in soil temperatures by 2.8–9.48°C and 0.9–7.38°C due to placement of thermostats placed at surface soil. Increased soil temperatures observed in the mulched plots compared with the unmulched plots also agreed with the findings of Park et al. (1993) recording an increase in average soil temperature by 2.48°C at 15 cm
depth under transparent film while that of 0.88°C increase in soil temperature under black film mulch. There was an increase of 2.9–3.38°C in soil temperatures with application of transparent photodegradable polythene film mulching as reported by Duhr and Dubas (1990). The lower minimum and maximum soil temperatures was observed in plot treated non-woven jute agrotextile and rice straw mulch compared to polythene mulch and it might be due to the fact that the black polythene absorbed more solar radiation compared to straw mulch (Kumar et al., 2011). Byun et al., 1991 inferred that temperature of surface soil (0–10 cm) was always higher with polythene mulches compared to straw mulch or no mulch. The results show that different mulching materials have varying effects on soil temperature.

3.3. Effect of mulches on soil moisture content

Soil moisture is an important parameter influencing nutrient dynamics and the activity of microorganisms in the rhizosphere and growth of broccoli. Soil moisture content was lowest at T₁ (no mulch) in comparison to other NJATM and other mulch treatments at 15, 30, 60 and 90 DAP (Table 7). The bare soil of T₁ was exposed to heat and wind and lost more moisture through evapo-transpiration due to higher weed population density. Data also revealed that moisture content was lowest at 15 DAP and increased in the order 90 DAP < 60 DAP < 30 DAP in all the treatments compared. Soil moisture content in 15, 30, 60 and 90 DAP was found to be highest in T₅ (400 gsm NJATM) treatment followed by T₄ (350 gsm NJATM) > T₃ (300 gsm NJATM) > T₂ (Black Polythene) > T₁ (No Mulch) treatment respectively in decreasing order. Higher soil moisture content was observed in mulch treated plots compared to control because of increased water retention capacity in the soil, conservation of moisture due to surface cover and reduced weed population density. Increased moisture content data in mulched plots are in agreement with the reports of several other studies on effect of mulches on soil moisture status (Ramakrishna et al., 2006; Jordan et al., 2010; Manna et al., 2018). The moisture use efficiency of the crop, was increased significantly by 70.27% in Non-woven jute agro-textile mulch due to the treatments over control (Sarkar et al., 2018).

3.4. Post harvest soil properties

3.4.1. Effect on pH, EC and organic carbon content of post harvest soil

Highly significant variation in soil properties after harvest of Broccoli in respect of initial value was observed after statistical analysis of the pooled data except soil pH and EC under different treatments (Table 8). After analysis of pooled data, it was observed that the percentage of organic carbon increased significantly over control and its value was highest (0.64%) in 350 gsm NJATM mulched plot (Table 8). The soil organic carbon content increased with mulching treatments in spite of reduction in weed population density in mulched treated plots compared to control. It may be attributed to higher broccoli yield and its contribution to organic C through incorporation of roots and crop residues in the soil. Moreover, nutrient immobilization and organic matter accumulation was favoured by application of NJATM with higher C:N ratio and lignin content (12.56%) leading to addition of organic material with exhausted mulch in the soil. The result was in agreement with the report of other researchers who showed mulching affected SOM content and soil moisture.

Table 7: Effect of different mulching materials on soil moisture content

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Moisture content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At 15 DAP</td>
</tr>
<tr>
<td>T₁ (No mulch)</td>
<td>6.59</td>
</tr>
<tr>
<td>T₂</td>
<td>8.94</td>
</tr>
<tr>
<td>T₃</td>
<td>11.11</td>
</tr>
<tr>
<td>T₄</td>
<td>12.71</td>
</tr>
<tr>
<td>T₅</td>
<td>7.41</td>
</tr>
<tr>
<td>T₆</td>
<td>8.38</td>
</tr>
<tr>
<td>SEm±</td>
<td>0.10</td>
</tr>
<tr>
<td>CD (p=0.05)</td>
<td>0.28²</td>
</tr>
</tbody>
</table>

Table 8: Effect of different mulches pH, EC and organic carbon of post-harvest soil

<table>
<thead>
<tr>
<th>Treatments</th>
<th>pH</th>
<th>EC (mhos cm⁻¹)</th>
<th>Organic carbon (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁ (No mulch)</td>
<td>4.91</td>
<td>0.08</td>
<td>0.38</td>
</tr>
<tr>
<td>T₂</td>
<td>4.90</td>
<td>0.08</td>
<td>0.47</td>
</tr>
<tr>
<td>T₃</td>
<td>4.98</td>
<td>0.08</td>
<td>0.64</td>
</tr>
<tr>
<td>T₄</td>
<td>4.98</td>
<td>0.09</td>
<td>0.62</td>
</tr>
<tr>
<td>T₅</td>
<td>4.91</td>
<td>0.09</td>
<td>0.42</td>
</tr>
<tr>
<td>T₆</td>
<td>4.90</td>
<td>0.08</td>
<td>0.45</td>
</tr>
<tr>
<td>SEm±</td>
<td>0.036</td>
<td>0.002</td>
<td>0.006</td>
</tr>
<tr>
<td>CD (p=0.05)</td>
<td>NS</td>
<td>NS</td>
<td>0.017²</td>
</tr>
</tbody>
</table>

T₁: No mulch; T₂: 300 gsm NJATM; T₃: 350 gsm NJATM; T₄: 400 gsm NJATM; T₅: Rice straw; T₆: Black polythene; NJATM: Non-woven jute agro-textile mulch; “**: Indicates F value is significant at (p=0.01) level of significance.
conservation (Youkhana and Idol, 2009). Chaparro et al., 2012 opined that, organic mulches with good amount of organic matter might improve soil properties and activities of soil microbes after its incorporation in the soil.

3.4.2. Effect on hydraulic conductivity and bulk density of soil

The data pertaining to the effect of different mulches on saturated hydraulic conductivity of soil after harvest of broccoli crop are presented in Table 9. Pooled data showed that mulch had significant effect on saturated hydraulic conductivity of soil. The initial saturated hydraulic conductivity of the experimental field was 0.20 cm hr\(^{-1}\). The mean maximum value of 0.54 cm hr\(^{-1}\) hydraulic conductivity was observed in T\(_4\) followed by T\(_3\) (0.46 cm hr\(^{-1}\)) and minimum of 0.20 cm hr\(^{-1}\) was noted in control. However, straw mulch and polythene mulch showed higher mean hydraulic conductivity value over control or no mulching. Mulching increases the soil porosity which in turn led to significant improvement in the saturated hydraulic conductivity. The larger the soil pores, the more water is easily transmitted through the soil. These finding are in good agreement with Dec et al. (2008).

Bulk density (BD) of experimental soil was significantly influenced by different mulching materials (Table 9). Pooled data of BD of post harvest soil revealed that the highest BD was observed in control i.e., T\(_1\) (1.41 g cm\(^{-3}\)) which was, however, statistically at par with T\(_4\) (300 gsm NJATM), T\(_5\) (Rice Straw) and T\(_6\) (Black Polythene). However, the lowest pooled BD was recorded in T\(_4\) (1.37 g cm\(^{-3}\)) which was, however, statistically at par with T\(_3\) (1.38 g cm\(^{-3}\)). Such decrease in BD of soil might be due to increased soil moisture, organic matter contents which in turn created favourable environment for penetration of plant roots. After decomposition of non-woven jute agro-textile mulches improve the physical, chemical and biological properties of the soil by enriching soil both with organic matter and plant nutrients increasing crop yield. And as a result of that aeration and soil microbial activities were enhanced due to lose and friable soil and resulted decrease in BD of post harvest soil. The similar result of decrease in BD as compared to control due to addition of mulches like coir pith @ 20 t ha\(^{-1}\), press mud @ 10 t ha\(^{-1}\) was also reported by Mayalagu (1983) in heavy black soil. Efficient use of jute agro textile as soil conditioner by decreasing the bulk density and increases tomato productivity was reported by Adhikari et al., 2018. The decrease in bulk density under straw mulch (1.42 g cm\(^{-3}\)) compared to bare soil (1.50 g cm\(^{-3}\)) was noted by Lal et al. (1996). Mulching increased soil moisture, and organic matter contents leading to the decrease in bulk density.

4. CONCLUSION

Considering the impact of different mulching materials, NJATM plot recorded significantly higher productivity (8.5 t ha\(^{-1}\)) of broccoli over rice straw and black polythene. In order to achieve good mulching impact through improved hydrothermal condition, reduced soil compaction and enriched nutrient status required for optimal broccoli yield; mulching with 350 gsm NJATM is recommended to the farmers for dry red and lateritic soil of West Bengal.

5. REFERENCES


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Table 9: Effect of different mulches on hydraulic conductivity and bulk density of soil

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Hydraulic conductivity (cm hr(^{-1}))</th>
<th>Bulk density (g cm(^{-3}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>T(_1)</td>
<td>0.20</td>
<td>1.41</td>
</tr>
<tr>
<td>T(_2)</td>
<td>0.41</td>
<td>1.40</td>
</tr>
<tr>
<td>T(_3)</td>
<td>0.46</td>
<td>1.38</td>
</tr>
<tr>
<td>T(_4)</td>
<td>0.54</td>
<td>1.37</td>
</tr>
<tr>
<td>T(_5)</td>
<td>0.33</td>
<td>1.40</td>
</tr>
<tr>
<td>T(_6)</td>
<td>0.31</td>
<td>1.40</td>
</tr>
<tr>
<td>SEm(_{\pm})</td>
<td>0.007</td>
<td>0.007</td>
</tr>
</tbody>
</table>

CD (p=0.05)

T\(_1\): No mulch; T\(_2\): 300 gsm NJATM; T\(_3\): 350 gsm NJATM; T\(_4\): 400 gsm NJATM; T\(_5\): Rice straw; T\(_6\): Black polythene; NJATM: Non-woven jute agro-textile mulch; *: Indicates F value is significant at (p=0.01) level of significance.


Lal, R., 1995. The role of residues management in sustainable agricultural systems. Journal of Sustainable Agriculture 5(4), 51–78. DOI: 10.1300/J064v05n04_06


