Integrated Use of Organic and Inorganic Fertilizer on Yield, Uptake and Quality of Sugarcane in Calcareous Soil

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This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

ABSTRACT

The field experiment was conducted to study the integrated use of organic product viz., pressmud + neem cake and seaweed extract along with inorganic fertilisers on yield, uptake and nutrient availability of sugarcane (BO 154) in alluvial soil rich in free calcium carbonate. The plot treated with pressmud + neem cake/seaweed extract either alone or in combination with inorganic fertiliser (100% NPK) significantly increased yield attributes and cane yield over control. The mean data indicated that highest number of tillers (101.44 x10^3 /ha), NMC (76.68 x10^3 /ha), cane length (162.40 cm) and single cane wt. (863.3 g) were recorded in treatment receiving 100 % NPK along with pressmud + neem cake + seaweed extract in combination and lowest in control. The result indicated that integrated use of organic along with inorganic nutrient source was found superior regarding increasing cane yield up to the tune of 21.34% over control. However, juice quality parameters viz., brix, pol and purity coefficient remains unaffected. The mean sugar yield varied (6.71 - 8.23 t/ha) significantly due to application of an inorganic and organic source of nutrients. The uptake of nutrients followed the similar trend as cane yield. However, the effect of various organic products viz., pressmud + neem cake and seaweed extract was found at par. The significant increase in organic carbon and available –N and available phosphorus were recorded in organic treated plots and being highest in treatment receiving pressmud + neem cake + seaweed extract in combination with inorganics over control. Thus, integrated use of RDF (150–85–60 kg N-P2O5–K2O /ha) along with soil application of pressmud + neem cake (9:1@ 1 t/ha) or seaweed extract...
Keywords: Pressmud; neem cake; seaweed extract; sugarcane; productivity.

1. INTRODUCTION

Sugarcane (Saccharum spp. hybrid complex) is an important cash crop grown primarily for sugar production in India in a tropical and subtropical climate. It plays a pivotal role in the agricultural and industrial economy of India. It is cultivated in an area of 5 million hectares with an average productivity of 68 t/ha. The crop is long duration and nutrient exhaustive. The long-term use of inorganic fertiliser without organic supplements damages the physical, chemical, biological properties and causes environmental pollution. Chemical fertilisers play a pivotal role in boosting crop production. Due to the increasing prices, soil health deterioration sustainability and pollution consideration led to renewed interest in the use of organic manures. However, it is not possible to supply all the nutrients through organic manures. The integrated use of organic and inorganic plant nutrient sources recycles not only organic waste but also conserves rich pool of nutrients resources for sustainable crop production. The yield of sugarcane has reached plateau due to decline in factor productivity. The deterioration in soil health and crop productivity is associated with a decline in soil organic carbon under intensive sugarcane farming system. To stop the continuous decline in soil fertility it is important to use organic manure in combination with chemical fertilisers to meet the nutritional requirements of sugarcane crop [1] adequately.

Pressmud is a solid waste bi-product of sugar mill and a rich source of organic carbon, NPK and other micronutrients. Pressmud has a great potential in supplying the nutrients and organic matter. Sugarcane pressmud is reported to be a precious resource of plant nutrients and may, therefore, influence physical, chemical and biological properties of a soil [2,3]. On an average it contains N 2.0 to 5.0 %, P2O5 0.5 to to 1.0%, K 1.0 to 2.0%, Ca 0.5 to 3.0%, Mg 0.3 to 1.0%, S 0.2 to 3.0 and micronutrients in appreciable quantity. It is also rich in both sulphur compounds and bitter limonoids and having pesticidal properties. Seaweed has 60 trace minerals and ready-to-use nutrients including nitrogen, potassium, phosphate, and magnesium. It also contains hormones to encourage plant growth.

In recent years, the use of seaweed extract have gained in popularity due to their potential use in organic and sustainable agriculture [4], especially in rainfed crops as a means to avoid excessive fertilizer application and to improve mineral nutrition unlike fertilizer, extract derived from seaweed are biodegradable, non-toxic, non-polluting and non-hazardous to human and animals [5]. Devi and Mani [6] observed increased yield, yield attributes and juice quality of sugarcane due to foliar application of seaweed extract. Sea weed extract contains major and minor nutrients, amino acids, vitamins, cytokinin, auxin and ascorbic acid like growth promoting substances [7] and have reported to stimulate the growth and yield of crop [8] and increased nutrient uptake from soil [9]. In the present experiment, an attempt has been made to study the effect of various organics in a combination of inorganic fertiliser on the productivity of sugarcane in calcareous soil.

2. MATERIALS AND METHODS

The field experiment was conducted on spring sugarcane (BO 154) at Crop Research Farm, RPCAU, Pusa, Samastipur; Bihar (India) under technology testing experiment on organic products. The farm is situated at 25° 98’ N latitude, 85° 67’ E longitude and at an altitude of 52.0 m above mean sea level. The climate of the study area was sub-tropical. The experimental soil was sandy -loam in texture rich in free calcium carbonate. The factors under study comprised of RDF (150–85–60 kg N–P2O5–K2O /ha) with or without organic products Viz., mixture of pressmud cake (PMC) + Neem cake (NC) in the ratio of 9:1 @ 10 q/ha and seaweed extract (SWE) @ 1 kg/ha. The experiment was laid out

(@ 1 kg/ha) was found favourable for improving yield and soil fertility status of sugarcane. It would be better to apply inorganic fertiliser with organics to sustain the productivity of sugarcane in calcareous soil.

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in RBD with five replication. The treatment consists of T<sub>1</sub>: RDF through inorganic fertilizers (Control), T<sub>2</sub>: RDF + PMC + Neem cake 10 q/ha, T<sub>3</sub>: RDF + Seaweed extract 1 kg/ha, T<sub>4</sub>: RDF + PMC + Neem cake 10 q/ha + Seaweed extract 1 kg/ha. The pressmud + neem cake and seaweed extract powder were obtained from M/S Durga Agro Care, Samastipur under technology testing programme and tested at two sites during the year 2016 and mean data has been presented. The recommended dose of fertiliser was applied through urea, DAP and MOP respectively. The half dose of the nitrogen and full dose of phosphorus and potassium were applied as basal and remaining half dose in two equal splits. The pressmud and neem cake were applied in-furrow. The seaweed extract powder with bentonite mixture in 9:1 @ 10 kg/ha was applied in soil at planting. Soil samples were collected before planting and after harvest of the crop. The processed surface soil samples (0-30 cm) were collected and analysed. The soil sample was analysed for pH and EC in 1:2 soils: water ratios [10]. The organic carbon was estimated by chromic acid digestion method [11]. The available N was estimated using alkaline permanganate method [12], available P by double beam spectrophotometer [13] and available K was determined flame photometrically [10]. The whole plant was digested and analysed for NPK content using standard procedure and their uptake was calculated. The cane juice quality viz. brix, pol and purity were determined as per method is given by Spencer and Meade [14]. The data were analysed statistically.

3. RESULTS AND DISCUSSIONS

3.1 Yield Attributes and Yield

The application of organic fertiliser in combination with inorganics significantly increased all the growth parameters of sugarcane (Table 1). The plot treated with pressmud + neem cake/seaweed extract either alone or in combination with inorganic fertiliser (100% NPK) significantly increased yield attributes and cane yield over control. The mean data indicated that highest number of tillers (101.44 x10<sup>3</sup>/ha), NMC (76.68 x10<sup>3</sup>/ha), cane length (162.40 cm) and single cane wt. (863.3 g) were recorded in treatment receiving 100% NPK along with pressmud + neem cake + seaweed extract (T<sub>4</sub>) and lowest in control (T<sub>1</sub>). The application of seaweed extract (T<sub>2</sub>) significantly increased germination of cane over control. However, the effect of treatments on cane length was non-significant. In sugarcane production, yield attributes viz., cane length, number of millable cane (NMC) and cane wt assume practical significance as they are directly related to cane yield. It is a fact that increase in tillering capacity of sugarcane plant leads to the sizable increase in the NMC thus boosting the productivity of sugarcane. The result indicated that all organic with inorganic nutrient sources showed their superiority over T<sub>1</sub> (RDF). The cane yield increased up to the tune of 21.34% in T<sub>4</sub> over control. The increased growth of sugarcane crop may be due to the presence of some growth promoting substances present in seaweed extract (Bludne, 1991). Also, the growth-enhancing the potential of organic fertiliser might be due to the presence of macro and micronutrients. The improved productivity and soil fertility of sugarcane due use of organic manure in combination with inorganic fertilisers has been also reported by Bokhtiar et al. [15].

3.2 Juice Quality and Sugar Yield

The juice quality parameters viz., brix, pol and purity coefficient were remained unaffected due to various treatments (Table 2). The mean sugar yield varied (6.71- 8.23 t/ha) significantly due to the application of inorganic and organic nutrient sources. However, the effect of various organic products viz., pressmud + neem cake and seaweed extract was found at par. The data indicated that application of 100% NPK along with pressmud + neem cake + seaweed extract (T<sub>4</sub>) recorded highest sugar yield (8.23 t/ha), followed by application of sea weed extract in T<sub>3</sub> (7.86 t/ha) and lowest in control T<sub>1</sub> (6.71 t/ha). The sugar yield increased by 22.65% in organic treated plots (T<sub>4</sub>) over control (T<sub>1</sub>). The data indicated that integrated use of nutrients from organic and inorganic sources improved sugar yield. Sugar yield increased due to increase in cane yield and exhibited similar trends as cane yield.

3.3 Soil Properties

The data revealed that (Table 3) integrated use of organic and inorganic fertiliser has no any significant effect on pH and EC of soil, however, organic carbon and available nutrient of soil increased significantly in organic treated plots. The effect of seaweed extract (T<sub>2</sub>) on soil organic carbon was non-significant. The mean value for N (232.8-243.1 Kg/ha), P<sub>2</sub>O<sub>5</sub> (16.90-19.90 Kg/ha) and K<sub>2</sub>O (64.45-68.36 Kg/ha) varied significantly.
Table 1. Effect of organic and inorganic fertilizer on growth and yield of sugarcane

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Germination (%)</th>
<th>Tiller (000/ha)</th>
<th>Cane length (cm)</th>
<th>NMC (000/ha)</th>
<th>Single Cane wt (g)</th>
<th>Yield (t/ha)</th>
<th>Increase in yield over control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁ - RDF (Control)</td>
<td>36.48</td>
<td>89.52</td>
<td>156.12</td>
<td>69.51</td>
<td>784.2</td>
<td>54.49</td>
<td>-</td>
</tr>
<tr>
<td>T₂ - RDF + PMC+NC (9:1)</td>
<td>39.31</td>
<td>97.46</td>
<td>162.88</td>
<td>74.71</td>
<td>848.0</td>
<td>63.37</td>
<td>16.29</td>
</tr>
<tr>
<td>T₃ - RDF + SWE</td>
<td>41.08</td>
<td>97.43</td>
<td>158.68</td>
<td>75.15</td>
<td>836.5</td>
<td>62.97</td>
<td>15.56</td>
</tr>
<tr>
<td>T₄ - RDF+ PMC+NC (9:1) + SWE</td>
<td>39.05</td>
<td>101.44</td>
<td>162.40</td>
<td>76.68</td>
<td>863.3</td>
<td>66.12</td>
<td>21.34</td>
</tr>
<tr>
<td>SE ±m (P=0.05)</td>
<td>4.48</td>
<td>7.20</td>
<td>3.98</td>
<td>1.25</td>
<td>8.71</td>
<td>1.29</td>
<td></td>
</tr>
</tbody>
</table>

RDF- 150–85–60 kg N-P₂O₅-K₂O/ha ; PMC- pressmud cake , NC- Neem cake mixture @ 10 q/ha ; SWE- sea weed extract @ 1 kg/ha

Table 2. Effect of organic and inorganic fertilizer on juice quality and sugar yield

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Juice quality (%)</th>
<th>Sugar yield t/ha</th>
<th>Increase in sugar yield over control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brix</td>
<td>Pol</td>
<td>Purity coefficient</td>
</tr>
<tr>
<td>T₁ - RDF (Control)</td>
<td>20.03</td>
<td>17.82</td>
<td>88.98</td>
</tr>
<tr>
<td>T₂ - RDF + PMC+NC (9:1)</td>
<td>20.16</td>
<td>17.94</td>
<td>88.98</td>
</tr>
<tr>
<td>T₃ - RDF + SWE</td>
<td>20.10</td>
<td>17.84</td>
<td>88.76</td>
</tr>
<tr>
<td>T₄ - RDF+ PMC+NC (9:1) + SWE</td>
<td>20.08</td>
<td>17.91</td>
<td>89.21</td>
</tr>
<tr>
<td>SE ±m (P=0.05)</td>
<td>0.24</td>
<td>0.22</td>
<td>0.15</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

RDF- 150–85–60 kg N-P₂O₅-K₂O/ha ; PMC- pressmud cake , NC- Neem cake mixture @ 10 q/ha ; SWE- sea weed extract @ 1 kg/ha

Table 3. Effect of organic and inorganic fertilizer on soil properties after harvest of sugarcane

<table>
<thead>
<tr>
<th>Treatments</th>
<th>pH</th>
<th>EC (dS/m)</th>
<th>Organic carbon (%)</th>
<th>Available nutrients (Kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>T₁ - RDF (Control)</td>
<td>8.20</td>
<td>0.20</td>
<td>0.52</td>
<td>232.8</td>
</tr>
<tr>
<td>T₂ - RDF + PMC+NC (9:1)</td>
<td>8.19</td>
<td>0.22</td>
<td>0.58</td>
<td>242.9</td>
</tr>
<tr>
<td>T₃ - RDF + SWE</td>
<td>8.17</td>
<td>0.20</td>
<td>0.54</td>
<td>234.5</td>
</tr>
<tr>
<td>T₄ - RDF+ PMC+NC (9:1) + SWE</td>
<td>8.18</td>
<td>0.20</td>
<td>0.58</td>
<td>243.1</td>
</tr>
<tr>
<td>SE ±m (P=0.05)</td>
<td>0.05</td>
<td>0.02</td>
<td>0.02</td>
<td>1.43</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>NS</td>
<td>NS</td>
<td>0.04</td>
<td>4.27</td>
</tr>
<tr>
<td>Initial soil</td>
<td>8.22</td>
<td>0.23</td>
<td>0.49</td>
<td>230.8</td>
</tr>
</tbody>
</table>

RDF- 150–85–60 kg N-P₂O₅-K₂O/ha ; PMC- pressmud cake , NC- Neem cake mixture @ 10 q/ha ; SWE- Sea weed extract @ 1 kg/ha
Fig. 1. Effect of organic and inorganic fertilizer on uptake of nutrients by sugarcane at harvest stage

RDF- 150–85–60 kg N–P<sub>2</sub>O<sub>5</sub>–K<sub>2</sub>O/ha; PMC- pressmud cake, NC- Neem cake (9:1) mixture @ 10 q/ha; SWE- sea weed extract @ 1 kg/ha

<table>
<thead>
<tr>
<th></th>
<th>Nutrient uptake (Kg/ha)</th>
<th>T1 - RDF</th>
<th>T2 - RDF + PMC+NC</th>
<th>T3 - RDF + SWE</th>
<th>T4-RDF+ PMC+NC+SWE</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td></td>
<td>173.6</td>
<td>186.2</td>
<td>185.8</td>
<td>190.2</td>
</tr>
<tr>
<td>P</td>
<td></td>
<td>19.5</td>
<td>21.8</td>
<td>21.2</td>
<td>23.4</td>
</tr>
<tr>
<td>K</td>
<td></td>
<td>171.2</td>
<td>181.8</td>
<td>187.6</td>
<td>192.2</td>
</tr>
</tbody>
</table>
due to the combined application of organic and inorganic fertiliser. The maximum amount of organic carbon and available nutrient was recorded in treatment T₄ receiving pressmud + neem cake + seaweed extract in combination with mineral fertiliser (100% NPK) over control. The mean organic carbon content of soil increased maximum by 11.53% in T₄. However, treatments T₂, T₃ and T₄ were found at par on soil organic carbon and available nutrients. The improvement in available nutrient status and organic carbon was observed in organic treated plots over initial soil values indicating the positive balance of nutrient in the soil after the sugarcane harvest. The overall data indicated that improvement in the fertility status of land in organic treated plots. Such an increase in organic carbon and soil available nutrients resulted due to decomposition and mineralisation of added organics having low C: N ratio. The concentrate organic manure neem cake has an adequate quantity of macro and micronutrients for plant growth. It is a nitrification inhibitor and prolongs the availability of nitrogen to crops. Soil fertility could be maintained with the use of organic manure in combination with chemical fertilisers to meet the nutritional requirements of sugarcane crop [1] adequately. Soil organic matter forms complexes and thereby increases nutrient mobility and/or plant availability. Thakur et al. [16] reported similar findings.

3.4 Nutrient Uptake

The use of organics increased significantly NPK uptake by sugarcane plant at harvest stage (Fig. 1) and recorded highest in T₄ receiving 100% RDF along with PMC + NC+ Seaweed extract in combination. The mean uptake of N (173.6-190.2 Kg/ha), P (19.5-23.4 Kg/ha) and K (171.2-192.2Kg/ha) varied significantly. The increased nutrient concentration in plant treated with organics might be due to increased efficiency of inorganic fertiliser and mineralisation of organics viz., pressmud cake, neem cake and seaweed extract resulted in higher nutrient uptake. Also, the presence of biostimulants in seaweed extract enhance the effectiveness of fertiliser as well as nutrient utilisation from soil [17]. The seaweed extract contains bioactive substances which stimulate uptake efficiency of in treated plots [18] and yield and nutrient uptake by sugarcane [6]. Further, the addition of organic matter in calcareous soils brings significant change in soil environment and prevents fixation and increased solubilization of native and applied nutrients. Bokhtiar et al. [15] reported similar findings.

4. CONCLUSION

Thus, our study reflects that integrated use of RDF (150–85–60 kg N–P₂O₅–K₂O /ha) along with pressmud + neem cake (9:1 @ 10 q/ha) or seaweed extract (@ 1 kg/ha) was found favourable for improving yield and soil fertility status of sugarcane. It would be better to apply inorganic fertiliser with organics to sustain productivity of sugarcane in calcareous soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES


