GREEN MANURING IN SUGARCANE - A REVIEW
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ABSTRACT
Green manures play an important role in the nutrition of sugarcane productivity. Intercropping and incorporation of green manure legumes in sugarcane, not only increased the cane productivity, but also improved the soil fertility for sustainable cane production. Growing of green manure crops in between the rows of cane and incorporated at 45 days after sowing will supply nitrogen by adding organic matter and besides increasing the phosphorus availability through release of organic acids during decomposition and increase the nutrient use efficiency. Incorporation of green manure leguminous crops viz., sunhemp, daincha, gur, mung and soybean etc. into the soil have the beneficial effect on cane productivity and soil fertility. Research information on various studies all over India indicate the significant favourable influences on cane productivity and on soil fertility are reviewed in this paper.

Sugarcane (Saccharum officinarum L.) is one of the most important commercial crops in India, cultivated in 4 million hectares with a production of 300 million tonnes of cane. Our country shares about 13.25 per cent of the World and 41.1 per cent of Asian sugar production. Sugar industry being the second largest agro-based industry, plays a dominant role in both agricultural and industrial economy of our nation. It employs over 40 million cane growers and about 3.5 lakhs skilled and unskilled workers (Shahi, 2000). Sugarcane is one of the most exhaustive crops, yielding 125 tonnes of cane per hectare, removes about 83 kg N, 37.2 kg P and 168 kg K from the soil. Sugarcane is widely spaced with slow rate of germination and up to 90 days the canopy does not cover the empty space in between the rows, provides congenial condition for growing green manure legumes as intercrop at its early growth phase.

Intercropping of sugarcane with short structured and short duration leguminous crops could alter the growth of cane favourably. Intercropping of soyabean and daincha did not have any marked influence on cane bud germination (Bawasakar et al., 1977). Similar findings of non-significant influence of pulse intercrops on sugarcane germination were earlier reported by Ethirajan et al. (1981), Yadav et al. (1987), Jayapal (1988) and Mahendran (1994) in different agro-ecological situations.

Tiller production is very important in sugarcane as it is directly related to final millable cane population at harvest. Though the tillering is a genetic character, it could be modified to some extent through environmental and management factors. Tiller production in sugarcane was reduced when intercropped with groundnut, green gram and sunflower (Nasir Ahmed and Singaravelu, 1986). This could be attributed to the shading effect of green manure crop at the base of the sugarcane crop resulting in less tillering. But in contrast, Chauhan and Yadav (1988) reported that green gram intercropping did not influence the number of tillers significantly.

Intercropping of green manure crops resulted in reduced tiller production and sole crop of cane recorded the maximum tiller production and was significantly superior over green manure intercropped canes (Mahendran et al., 1997). Similarly, Nasir Ahmed (1999) stated that raising sunhemp as intercrop in sugarcane reduced tiller production. Similar results were reported by Jayapal et al. (2000) and Remesh (2001) who observed that sole cropping of sugarcane registered higher number of tillers than the daincha intercropped
Effect of green manure on cane productivity

Inclusion of green manures in the cropping system improved the crop yield and sustains the soil fertility. This might be due to addition of organic matter by green manure crop, which on decomposition supplied nitrogen as well as other macro and micronutrients during the course of the crop growth. Green manure residues having wider C: N ratio favoured by immobilizing higher percentage of applied fertilizer nitrogen initially and then slowly releasing the same over a period of time. Contribution of organic matter, which might have helped in utilizing, increased available nitrogen as well as phosphorus on decomposition. The organic acids produced during decomposition also favoured solubilization of native soil phosphorus and retaining more available phosphorus for longer period resulting in higher cane yield. Finally the losses of nitrogen were minimized and phosphorus availability increased by *daincha* green manure incorporation.

According to Dixit and Misra (1991), growing of intercrops in spring planted sugarcane was generally remunerative by recording higher cane productivity. They further added that sugarcane + cluster bean intercropping was the most profitable system as it gave 18 per cent higher cane yield. Nasir Ahmed et al. (1991) reported that the millable cane production was not very much affected due to soybean or black gram intercropping in cane. Sathyavelu et al. (1991) also registered higher number of millable canes when sugarcane was intercropped with legumes.

Sowing of *daincha* in single continuous line and *insitu* incorporation with recommended level of N application produced lengthier cane, higher individual cane weight and cane yield (Kathiresan and Ayyamperumal, 1996 and Kathiresan et al., 1996). Srinivas (1996) observed that *insitu* incorporation of *daincha* at 14 t ha⁻¹ along with 50 per cent N application recorded higher cane girth and cane yield, but the number of internodes were not influenced by *daincha* intercropping.

Similarly, *daincha* intercropping in sugarcane resulted in higher numbers of millable cane with both plant and ratoon crops even with comparatively lower tiller production. Maximum cane yield was obtained in *daincha* intercropping and it was comparable with sunhemp intercropping over sole crop of cane (Mahendran et al., 1997; Jayapaul et al. (2000) and Yadav et al. (2000) reported that sugarcane intercropped with two rows of *daincha* and *insitu* incorporation on 45 DAP registered higher number of millable canes and significantly higher cane yield. From Table 1, it could be inferred that incorporation of *daincha* green manure crop along with the recommended NPK application recorded higher number of millable cane and 4.6 per cent higher cane yield (Ramesh, 2001).

Intercropping and incorporation of sunhemp at 45 DAS might have adequately supplied the plant nutrients to the sugarcane crop resulting in enhanced number of millable canes and cane yield as compared to sole crop of sugarcane (Nasir Ahmed, 1999). Similarly, Mathukia et al. (1999) concluded that the combined application of organic sources like green manure and fertilizers increased the NMC and cane yield as compared to sole application of fertilizer alone. Sunhemp was buried at six weeks, the green pods in french bean and dry pods in cowpea were harvested and residues of plants incorporated *insitu* produced significant improvement in the yield of sugarcane (Shankaraiah et al., 1999). Jayapal et al. (1989) recorded significant increase in cane yield by incorporation of green gram harvested on 45th day and by allowing beyond that stage of intercrop reduced the cane yield considerably.

In contrast, Dhoble and Khuspe
Table 1. Effects of different green manures incorporation on the yield of sugarcane

<table>
<thead>
<tr>
<th>Green manure intercropping in sugarcane</th>
<th>Cane yield (t/ha)</th>
<th>Increase/decrease (t/ha)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without green manure</td>
<td>With green manure</td>
<td>(%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Daincha</strong></td>
<td>111.39</td>
<td>128.26</td>
<td>16.87</td>
</tr>
<tr>
<td></td>
<td>92.60</td>
<td>93.10</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>128.12</td>
<td>143.11</td>
<td>14.99</td>
</tr>
<tr>
<td></td>
<td>115.20</td>
<td>120.74</td>
<td>5.54</td>
</tr>
<tr>
<td><strong>Sunhemp</strong></td>
<td>111.39</td>
<td>123.08</td>
<td>11.69</td>
</tr>
<tr>
<td></td>
<td>92.60</td>
<td>96.30</td>
<td>3.70</td>
</tr>
<tr>
<td></td>
<td>135.3</td>
<td>148.4</td>
<td>13.10</td>
</tr>
<tr>
<td></td>
<td>155.00</td>
<td>181.00</td>
<td>26.00</td>
</tr>
<tr>
<td><strong>Sesbania rostrata</strong></td>
<td>111.39</td>
<td>119.91</td>
<td>8.52</td>
</tr>
<tr>
<td><strong>Cowpea</strong></td>
<td>73.52</td>
<td>72.18</td>
<td>-1.34</td>
</tr>
<tr>
<td></td>
<td>88.64</td>
<td>90.62</td>
<td>1.98</td>
</tr>
<tr>
<td></td>
<td>92.60</td>
<td>106.30</td>
<td>13.70</td>
</tr>
</tbody>
</table>

(1983) stated that the individual cane weight did not differ between intercropped and sole sugarcane. Yadav et al. (1987) reported that though legumes improved the soil fertility, failed to show impact on cane yield enhancement. They attributed that legumes might have caused initial shading during early stage of cane establishment, thus adversely affecting tiller production (Table 2).

Similar findings were reported by Yadav (1987) and Chauhan and Yadav (1988), indicating the unfavourable effect of broad-leaved legumes intercropping on cane productivity. Menhilal et al. (2000) also observed that the intercropping of one or two rows of Lentil did not significantly affect the number of millable cane and cane yield.

Effect of green manure on cane quality

Daincha incorporation through continuous line sowing registered significantly higher sugar yield (Kathiresan and Ayyamperumal, 1996). Mahendran et al. (1997) indicated that intercropping of daincha recorded the maximum commercial cane sugar, followed by sunhemp intercropping over sole crop in both plant and ratoon canes. Mathukia
et al. (1999) stated that the sucrose and CCS per cent of sugarcane were not influenced in individual years; however, in pooled results they were significantly increased with application of either bulky organic manures or along with fertilizer nutrients. Nasir Ahmed (1999) observed that sugar yield was significantly influenced with sunhemp intercropping in sugarcane, the commercial cane sugar did not show significant difference.

In contrast, Lakshmikanthan (1983) reported that intersowing of *Sesbania speciosa* along with cane rows and incorporated after sixth week added 47·kg N ha⁻¹ without significantly affecting the cane yield and juice quality. Similarly, incorporation of *daincha* in sugarcane did not influence the quality parameters like purity per cent, Brix value and recovery per cent (Srinivas, 1996 and Ramesh, 2001). Durai and Ravichandran (1999) concluded that growing of intercrops like cowpea, sunhemp and *daincha* in sugarcane and incorporated did not alter the CCS per cent of cane as compared to sole sugarcane.

Intercropping and incorporation of legumes have established the beneficial effect of increasing the N use efficiency in cane (Shankaraiah et al., 1999). Similarly, Jayapaul et al. (2000) stated that the available plant nutrients like N, P, K and organic carbon content of the soil were in the increasing trend after the harvest of sugarcane when sunhemp was grown as intercrop and ploughed insitu on 45 days after sowing of intercrops. Ramesh (2001) reported that soil available nitrogen was increased when incorporation of *daincha* green manure crop in between the rows of sugarcane.

**Effect of green manure on phosphorus availability**

During decomposition of green manure crops the organic acids produced which have favoured solubilization of native soil phosphorus and retaining more available phosphorus for longer period resulting in higher phosphorus availability and cane yield. *Daincha* was more efficient in mining P from subsurface soil layers and making it available to the succeeding crops (Subbiah and Mannikar, 1964). Talashiltar and Patil (1979) indicated that phenolic and aliphatic acids produced during decomposition of organic matter were responsible for the solubilization of appreciable amount of phosphates, resulting in increased P availability in soil. Ghosh et al. (1981) observed that the application of organic manure significantly reduced the fixation of added P as well as native P, and thus made phosphorus more available to plants.

Crop rotation involving legume crops, both as grain or fodder had lead to an economy in P fertilizer and perhaps of N fertilizer also (Srivastava and Pandit, 1981).

Khind and Maskina (1986) found that *Sesbania aculeata* increased the microbial population of soil and thus enhanced mineralisation of soil and other essential nutrients.

Application of fertilizer phosphorus to green manure at its sowing and insitu incorporation of whole green manure crop increased the available N and P after harvest of sugarcane in cane+ cowpea green manure intercropping system (Jafri and Pandit, 1986). Similarly Yadav and Prasad (1986) observed higher P utilization efficiency of sugarcane with legume intercropping system. Lamare et al. (1987) indicated that green manuring increased the phosphoric acid concentration in soil solution thereby increasing the availability of applied P to the succeeding crop. Similar results were subsequently reported by Yashpal and Milapochand (1993) indicating the P availability for succeeding crops through preceding legumes.

Sundara and Rikkiappan (1994) observed that use of green manure crop along with phosphatic fertilizers increased the availability of phosphorus to cane. Later on
Vijay Kumar et al. (1999) concluded that green manure application slightly increased the available P (6-kg ha⁻¹) and K (144-kg ha⁻¹), probably, sugarcane might have taken up P and K released by the decomposition of organic manures. Similarly, Ramesh (2001) indicated that incorporation of daincha along with recommended level of Rock phosphate increased the available P (4 kg ha⁻¹) compared to without daincha incorporation.

CONCLUSION
To sustain the sugarcane production under intensive cultivation, as practiced in the hot climate of India, the organic carbon content of the soil must be maintained by intercropping and incorporation of green manure crops. Growing of green manure in the inter row spacing and incorporation at appropriate time not only supplement the fertilizer nutrient requirements, but also maintain the soil fertility and sustain the cane yield. Many findings confirmed that there is an indication of saving of N up to 25%, when green manures were raised as intercrop in sugarcane. Intercropping and incorporation of legumes such as French bean, sunhemp, etc., have established the beneficial effect of improving the nitrogen use efficiency, cane yield besides improving the physico-chemical properties of soil. If the yield of sugarcane crop is to be maintained at high level on a long-term basis, it is necessary to evolve a system whereby adequate supplies of organic manures through intercropping and incorporation of green manure crops and chemical fertilizers can be assured without damaging the soil structure and fertility status.

REFERENCES
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