Productivity, Nutrient Uptake and Profitability of Sweet Sorghum -Mustard Cropping System under Different Levels of Nitrogen

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Abstract

A field experiment was conducted during summer and winter seasons of 2009-10 and 2010-11 at Research Farm of Division of Agronomy, Indian Agricultural Research Institute, New Delhi to study the effects of nitrogen levels applied to sweet sorghum genotypes on productivity, nutrient uptake and profitability of sweet sorghum-mustard cropping system. Pooled analysis of data indicated that there was significant increase in green biomass, stalk, juice, brix (%), fermentable sugar and estimated ethanol yield due to application of nitrogen up to 100 kg N ha⁻¹ over control. The highest grain yield (2.7 t ha⁻¹) and fodder yield (15.6 t ha⁻¹) were recorded with application of 150 kg N ha⁻¹. Pooled analysis of data showed that hybrid 'CSH 22 SS' recorded the highest stalks (85.6 t ha⁻¹), juice (30 t ha⁻¹), fermentable sugar (4.6 t ha⁻¹) and estimated ethanol yield (2.6 kl ha⁻¹). On an average grain yield (2.5 t ha⁻¹) of hybrid 'CSH 22 SS' was 31.5% and 45.8% higher than 'RSSV 9' and 'SSV 84', respectively. Application of 150 kg N ha⁻¹ to preceding sweet sorghum produced the highest values of plant height, number of branches plant⁻¹, number of siliqua plant⁻¹, number of seeds siliqua⁻¹, siliqua length, seed yield, biological yield and oil yield. Oil percent in mustard declined as nitrogen dose applied to preceding sweet sorghum increased. Residual effect of sweet sorghum genotypes on performance of succeeding mustard was not significant. Productivity, nutrient uptake and economics of sweet sorghum-mustard cropping system significantly increased due to application of nitrogen up to 150 kg ha⁻¹. The highest sorghum equivalent yield (6.2 t ha⁻¹), net returns (₹ 66300= US $ 1326) and net benefit cost ratio (2.8) were recorded when 150 kg N ha⁻¹ was applied. Among genotypes, including of CSH 22 SS hybrid significantly enhanced productivity, nutrient uptake and economics of system.

Key words: Nitrogen; Sweet sorghum genotypes; Productivity; sweet sorghum-mustard cropping system

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1. Introduction

Sweet sorghum is attractive because of the easy accessibility of readily fermentable sugars combined with very high yields of green biomass suitable for production of more quantity of ethanol per unit time, per unit cost and per unit of water used (Vermerris et al., 2007). Sweet sorghum is the only crop that provides grain and stem that can be used for sugar, alcohol, syrup, fodder, fuel, bedding, roofing, fencing and paper making. Sweet sorghum varieties differ greatly in their qualities and in their adaptation to various soil and climatic conditions (Ratnavathi et al., 2010). The varieties with a high yield of medium to large stalks per unit area, non-lodging, high percentage of extractable juice, juice with a high brix content, resistance to diseases, tolerant to drought, tolerant to excessive water, and produce a high quality syrup are preferred for bio-fuel production (Ratnavathi et al., 2010).

Nitrogen is often the most limiting nutrient for crop yield in many regions of the world (Giller, 2004); at the same time it is one of the main inputs for crop production systems. Although N plays a very important role for good growth and development of sorghum, over-fertilization is often harmful as it results in lower yield and quality (Parikshya Lama Tamang, 2010). Optimum amounts of N fertilizer combined with other input factors play crucial roles in yield and overall quality of sorghum products. The optimum amount of fertilizer is related to maximum efficiency of production (Wiedenfeld, 1984). The responses of the succeeding crops in a cropping system are influenced greatly by the preceding crops and the inputs applied therein. Therefore recently greater emphasis is being laid on the cropping system as a whole rather than on the individual crops. Beside organic manures and biofertilizers, which have carry-over effect on the succeeding crops, around 30% of the applied nitrogen may become available to the immediate crop and rest to the subsequent crops (Jamaval, 2006). Maintenance of soil fertility is important for obtaining higher and sustainable yield due to large turnover of nutrient in the soil-plant system. Since the information on the direct and residual effect of nitrogen and also sweet sorghum genotypes on performance of sweet sorghum-mustard cropping system in western parts of India is lacking, the present study was conducted to assess the direct and residual effect of nitrogen and sweet sorghum genotypes on productivity, nutrients status and economics of system.

2. Material and Methods

A field experiment was conducted during winter 2009-10 and 2010-11 at Research Farm of Division of Agronomy, Indian Agricultural Research Institute, New Delhi to study the effects of nitrogen and sweet sorghum genotypes on performance of sweet sorghum-mustard cropping system. The experiment was conducted under split plot design with three replications. Four levels of residual nitrogen (0, 50, 100 and 150 kg N ha\(^{-1}\)) were assigned to the main plots and three sweet sorghum genotypes to the sub plots. The soil of experimental site was sandy loam in texture with pH of 7.82 and 178, 13.6, 218 kg ha\(^{-1}\) available of NPK and 0.36 % organic carbon. In sweet sorghum crop, as per N treatment \(\frac{1}{2}\) of the N, the recommended dose of phosphorus (60 kg P\(_2\)O\(_5\) ha\(^{-1}\)) in the form of single super phosphate and potassium (50 kg K\(_2\)O ha\(^{-1}\)) as muriate of potash were applied as basal. The remaining \(\frac{1}{2}\) of the N was applied at 45th days after sowing. Crop was sown on 9\(^{th}\) July and 30\(^{th}\) June in 2009 and 2010, respectively at 60 cm row to row spacing. At
approachable emergence stage, plant to plant spacing of 20 cm was maintained after thinning excess.

Atrazine was sprayed as pre-emergence for the control of weeds. Beside, Atrazine spray, two hand weeding were done at 20 and 40 days after sowing for effective weed control. Thiodan was sprayed twice to protect crop from stem borer. Crop received five irrigations during 2009 and three irrigations during 2010. Other management practices were adopted as per recommendations of sweet sorghum crop. For obtaining of total green biomass yield, juice yield, yield of fermentable sugar and bio-ethanol yield from stalks, sweet sorghum plants were harvested at physiological maturity stage. Immediately after harvest, canes from each net plot were cleaned and crushed using three-roller squeezer to extract juice. Brix percentage in juice was recorded using digital hand refractometer model HI 96801. Yield of fermentable sugars and potential alcohol yield per hectare were obtained using following formula (Spencer and Mead, 1963):

\[
\text{Yield of fermentable sugars (t ha}^{-1}) = \text{Juice yield (t ha}^{-1}) \times \text{Brix percentage} \times 0.85
\]

\[
\text{Potential ethanol yield (L ha}^{-1}) = \text{Juice yield (t ha}^{-1}) \times \text{Brix percentage} \times 0.85 / 1.76
\]

Mustard crop was sown randomly in preceding plots of nitrogen applied to sweet sorghum genotypes on 25th and 16th November in 2009 and 2010, respectively at 45 cm row to row spacing. Plant to plant spacing of 10-15 was maintained at 15 DAS by thinning out excess plants. Recommended dose of 80: 40: 40 kg NPK ha\(^{-1}\) were applied from sources of urea, SSP and MOP, respectively. Beside, pendimethalin spray, two hand weeding were done at 20 and 40 days after sowing for effective weed control. Crop received 4, 3 and 2 irrigations, respectively during 2009-10 and 3, 2 and 2 irrigations, respectively during 2010-11. Observations were recorded on growth and yield performance of crops.

The nitrogen concentration in plant samples was determined by modified Kjedahl method (Prasad et al., 2006) and total phosphorus by Vanadomolybdo Phosphoric acid yellow colour method and using Spectrophotometer, total potassium by flame photometry method, as described by Prasad et al., (2006). The N, P and K uptake in plant samples was worked out by multiplying their content with the corresponding yield. The oil content in mustard seed was estimated by Pulse Nuclear Magnetic Resonance (NMR) Technique (Tiwari and Burk, 1980). Economic analysis of data was done based on the prevailing cost of inputs/operations and price of produce. The cost of cultivation for growing crops involved the expenditure towards land preparation, seed and sowing, fertilizers and their application, pest control, irrigation, harvesting and threshing, and rental value of land. Statistical analysis of the data was done using ANOVA following SPSS software. The treatment means were compared at P < 0.05 level of probability working out LSD values.

3. Result and Discussion

3.1 Sweet sorghum
Data pertaining on total green biomass yield, juice yield, brix (%), fermentable sugar yield and ethanol yield has been presented in Table 1. Nitrogen fertilization up to 150 kg N ha\(^{-1}\) markedly increased total green biomass yield, juice yield, fermentable sugar yield and ethanol yield (Fig. 1).
An increase to the tune of 42, 76.7, 80.2 and 80.5% in total green biomass yield, juice yield, fermentable sugar yield and ethanol yield, respectively was recorded due to application of 150 kg N ha⁻¹ over control. Increase in brix (%) with application of nitrogen was significant only up to 100 kg N ha⁻¹. Percent increase in brix (%) due to application of 100 kg N ha⁻¹ was 3.85% over control. These variations in yield and yield attributes due to N application may be traced to the variation in growth attributes. Increase in ethanol yield due to nitrogen in sweet sorghum genotypes was primarily due to increase in fresh stalk yield, juice yield and sugar concentration. The results are in agreement with those obtained by Kumar et al. (2008), Poornima et al. (2008) and Ratnavathi et al. (2010). The difference in total green biomass yield, juice yield, brix (%), fermentable sugar yield and ethanol yield among the three genotypes under investigation were significant. Hybrid ‘CSH 22 SS’ was superior to varieties, except brix (%), which was the highest in RSSV 9’. Based on two years average, ‘CSH 22 SS’ recorded 47.9, 110.5, 111 and 112.2% increase in total green biomass yield, juice yield, fermentable sugar yield and ethanol yield, respectively compared to ‘SSV 84’. Increase in brix (%) of ‘RSSV 9’ over ‘SSV 84’ was 5.3%.

Variations in the growth parameters among the genotypes account for variation in green biomass yield and juice yield. This in turn helped in absorption of large amount of solar radiation and thus production of large quantities of photosynthates, which were eventually accumulated in stalks. Plants of hybrid ‘CSH 22 SS’ produced greater estimated ethanol yield, which was the natural corollary of stripped stalk weight. Similar findings were expressed by Propheter et al. (2010) and Wortmann et al. (2010).

Grain yield, fodder yield, biological yield were significantly increased by nitrogen application up to 100 kg N ha⁻¹ (Table 1). Application of 100 kg N ha⁻¹ caused 94%, 50% and 38% increase in grain yield, fodder yield and biological yield respectively over control. Increased grain yield due to N application could be ascribed to increased biomass production, improved harvest index and increased seed set with N fertilization. Positive effect of nitrogen on grain yield and yield attributes of sweet sorghum was reported by Buah and Mwinkara (2009) and Hugar et al. (2010).
Table 1: Productivity of sweet sorghum as influenced by nitrogen levels and genotypes (mean of 2 years)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Green biomass yield (t ha⁻¹)</th>
<th>Juice yield (*KL ha⁻¹),</th>
<th>Fermentable sugar yield (t ha⁻¹)</th>
<th>Brix (%)</th>
<th>Ethanol yield (KL ha⁻¹)</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Fodder yield (t ha⁻¹)</th>
<th>Biological yield (t ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen levels (kg ha⁻¹)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>67.79</td>
<td>15.81</td>
<td>2.41</td>
<td>17.82</td>
<td>1.37</td>
<td>1.21</td>
<td>9.93</td>
<td>15.92</td>
</tr>
<tr>
<td>50</td>
<td>78.61</td>
<td>18.73</td>
<td>2.90</td>
<td>18.14</td>
<td>1.65</td>
<td>1.85</td>
<td>12.90</td>
<td>19.13</td>
</tr>
<tr>
<td>100</td>
<td>92.76</td>
<td>25.10</td>
<td>3.96</td>
<td>18.51</td>
<td>2.25</td>
<td>2.35</td>
<td>14.97</td>
<td>22.00</td>
</tr>
<tr>
<td>150</td>
<td>94.89</td>
<td>27.94</td>
<td>4.34</td>
<td>18.21</td>
<td>2.46</td>
<td>2.68</td>
<td>15.64</td>
<td>23.44</td>
</tr>
<tr>
<td>SEM±</td>
<td>3.47</td>
<td>0.61</td>
<td>0.10</td>
<td>0.13</td>
<td>0.06</td>
<td>0.03</td>
<td>0.74</td>
<td>0.27</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>12.0</td>
<td>2.11</td>
<td>0.35</td>
<td>0.45</td>
<td>0.21</td>
<td>0.10</td>
<td>2.56</td>
<td>0.93</td>
</tr>
<tr>
<td>Sweet sorghum genotypes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSSV 9</td>
<td>78.34</td>
<td>21.42</td>
<td>3.43</td>
<td>18.78</td>
<td>1.95</td>
<td>1.92</td>
<td>13.36</td>
<td>19.38</td>
</tr>
<tr>
<td>SSV 84</td>
<td>73.50</td>
<td>14.28</td>
<td>2.17</td>
<td>17.85</td>
<td>1.23</td>
<td>1.67</td>
<td>11.51</td>
<td>16.34</td>
</tr>
<tr>
<td>CSH 22 SS</td>
<td>98.71</td>
<td>29.99</td>
<td>4.59</td>
<td>17.89</td>
<td>2.61</td>
<td>2.48</td>
<td>16.84</td>
<td>24.64</td>
</tr>
<tr>
<td>SEM±</td>
<td>3.01</td>
<td>0.53</td>
<td>0.09</td>
<td>0.11</td>
<td>0.05</td>
<td>0.03</td>
<td>0.39</td>
<td>0.24</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>9.29</td>
<td>1.59</td>
<td>0.27</td>
<td>0.33</td>
<td>0.15</td>
<td>0.09</td>
<td>1.17</td>
<td>0.72</td>
</tr>
</tbody>
</table>

*KL= Kilo-liter
Table 2 Productivity and yield characters of mustard as influenced by nitrogen levels applied to sweet sorghum and sweet sorghum genotypes (mean of 2 years)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Branches plant(^{-1})</th>
<th>No of Siliquae plant(^{-1})</th>
<th>No of Seeds Siliquae(^{-1})</th>
<th>1000-seed weight</th>
<th>Seed yield (t ha(^{-1}))</th>
<th>Biological yield (t ha(^{-1}))</th>
<th>Oil (%)</th>
<th>Oil yield (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>134</td>
<td>4.9</td>
<td>144</td>
<td>12.1</td>
<td>3.91</td>
<td>0.97</td>
<td>4.16</td>
<td>4.16</td>
<td>37.8</td>
</tr>
<tr>
<td>50</td>
<td>150</td>
<td>6.1</td>
<td>176</td>
<td>13.1</td>
<td>4.03</td>
<td>1.32</td>
<td>5.12</td>
<td>5.12</td>
<td>37.2</td>
</tr>
<tr>
<td>100</td>
<td>156</td>
<td>7.4</td>
<td>194</td>
<td>13.6</td>
<td>4.16</td>
<td>1.70</td>
<td>5.95</td>
<td>5.95</td>
<td>36.7</td>
</tr>
<tr>
<td>150</td>
<td>159</td>
<td>8.1</td>
<td>214</td>
<td>14.0</td>
<td>4.33</td>
<td>1.84</td>
<td>6.29</td>
<td>6.29</td>
<td>36.4</td>
</tr>
<tr>
<td>SEM±</td>
<td>1.37</td>
<td>0.18</td>
<td>3.87</td>
<td>0.23</td>
<td>0.22</td>
<td>0.04</td>
<td>0.11</td>
<td>0.11</td>
<td>0.16</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>4.97</td>
<td>0.63</td>
<td>13.40</td>
<td>0.76</td>
<td>NS</td>
<td>0.13</td>
<td>0.38</td>
<td>0.53</td>
<td>52.72</td>
</tr>
</tbody>
</table>

Nitrogen levels (kg ha\(^{-1}\)) applied to preceding sweet sorghum

Preceding sweet sorghum genotypes

RSSV 9   | 151              | 6.5                      | 181                           | 13.2                          | 4.05             | 1.39                 | 5.22                   | 5.22   | 37.3             |
SSV 84   | 150              | 6.7                      | 190                           | 13.4                          | 4.19             | 1.53                 | 5.53                   | 5.53   | 37.0             |
CSH 22 SS| 147              | 6.6                      | 176                           | 13.0                          | 4.09             | 1.46                 | 5.39                   | 5.39   | 36.9             |
SEM±     | 0.87             | 0.13                     | 4.44                          | 0.46                          | 0.16             | 0.03                 | 0.11                   | 0.11   | 0.15             |
CD (P=0.05) | 2.97            | NS                       | NS                            | NS                            | NS               | NS                   | NS                     | NS     | NS               |

Preceding sweet sorghum genotypes

Control | 134              | 4.9                      | 144                           | 12.1                          | 3.91             | 0.97                 | 4.16                   | 4.16   | 37.8             |
50       | 150              | 6.1                      | 176                           | 13.1                          | 4.03             | 1.32                 | 5.12                   | 5.12   | 37.2             |
100      | 156              | 7.4                      | 194                           | 13.6                          | 4.16             | 1.70                 | 5.95                   | 5.95   | 36.7             |
150      | 159              | 8.1                      | 214                           | 14.0                          | 4.33             | 1.84                 | 6.29                   | 6.29   | 36.4             |
SEM±     | 1.37             | 0.18                     | 3.87                          | 0.23                          | 0.22             | 0.04                 | 0.11                   | 0.11   | 0.16             |
CD (P=0.05) | 4.97            | 0.63                     | 13.40                         | 0.76                          | NS               | 0.13                 | 0.38                   | 0.53   | 52.72            |
Among genotypes, Hybrid 'CSH 22 SS' produced the highest grain yield, fodder yield and biological yield. Hybrid 'CSH 22 SS' recorded 48%, 46% and 51% increase in grain yield, fodder yield and biological yield, respectively. Variation in yield and yield attributes of sweet sorghum genotypes was reported by many workers viz., Belumnel et al. (2009) and Delcay et al. (2010).

3.2 Performance of mustard
Data regarding to growth, productivity, yield attributes and oil content of mustard as influenced by various nitrogen levels applied to previous sweet sorghum and sweet sorghum genotypes are presented in Table 2. A significant increase in number of branches plant\(^{-1}\) (8.1) number of silique per plant (214), number of seeds silique\(^{-1}\) (14) and 1000-seed weight (4.3 g) of mustard was recorded with 150 kg N ha\(^{-1}\) applied to preceding sweet sorghum over control (Table 2). Seed yield (1.84 t ha\(^{-1}\)), biological yield (6.29 t ha\(^{-1}\)) and oil yield (671 kg ha\(^{-1}\)) also was improved due to application of 150 kg N ha\(^{-1}\) to previous sweet sorghum (Table 2). The adequate application of nitrogen enabled the crop to make rapid leaf growth to intercept more solar radiation and thus to produce and fill more pods (Cheema et al., 2010). Similar findings were observed by Singh et al. (2008) and EL-Nakhawy and Bakhashwain (2009). The highest oil yield with increasing rate of N fertilizer application was probably due to their higher seed yield. These results are in line with those of Cheema et al. (2010). There were not significant variations in yield, yield attributes of mustard crop sown after preceding sweet sorghum genotypes.

3.3 System productivity
System productivity was influenced significantly by nitrogen levels and sweet sorghum genotypes. Sweet sorghum equivalent yield (6.22 t ha\(^{-1}\)) of system was higher when 150 kg N ha\(^{-1}\) was applied to sweet sorghum (Table 3 and Fig 2,a). The highest productivity of systems due to application of nitrogen is owing to greater availability of nitrogen to the plants which improved growth attributes through higher net photosynthesis by rapid CO\(_2\) which in turn resulted in increased absorption nutrients including nitrogen from the soil. These findings were supported by several researchers who revealed that nitrogen application improved plant growth and yield attributes in sweet sorghum [Delacy et al, 2010 & Poornima et al., 2008] and mustard (Si et al., 2003) System under hybrid 'CSH 22 SS' recorded the higher equivalent yield (5.45 t ha\(^{-1}\)) compared to SSV 84 (4.82 t ha\(^{-1}\)) and RSSV 9 (4.72 t ha\(^{-1}\)).
Fig. 2. Effect of nitrogen (a) and sweet sorghum genotypes (b) on sorghum equivalent yield of system

varieties (Table 3 and Fig 2,b). The improve in productivity of systems when hybrid ‘CSH 22 SS’ was sown, attributed to genetic make up and higher physiological efficiency of hybrid which lead to better growth, development and higher productivity of hybrid. Similar finding was reported by Heslehrst (1983).

3.4 System economics
Variations in gross return, net return and net B: C ratio of system due to application of nitrogen to sweet sorghum and different sweet sorghum genotypes were significant. Maximum gross return (₹139100= US $2782) and net return (₹66300 =US $1326) and net Benefit: cost ratio (2.8) was observed when 150 kg N ha⁻¹ was applied to sweet sorghum. Economics enhancement of systems due to nitrogen fertilization is owing to higher yield of system components with increasing dose of nitrogen. Many workers reported that nitrogen application increased gross return, net return and net B: C ratio in sweet sorghum (Akbari, 2000) and mustard (Cheema et al., 2010). The higher gross returns (₹134690= US $2694), net returns (₹52520= US $1050) and net Benefit: cost ratio (2.13) in systems was recorded where hybrid ‘CSH 22 SS’ was sown. This might due to higher productivity of systems under hybrid ‘CSH 22 SS’ compared to other genotypes.

3.5 System nutrient uptake
Nitrogen application increased NPK uptake in systems over control. The highest uptakes of nutrients (263.6-38.6-305.2 kg NPK ha⁻¹) were recorded with application of 150 kg N ha⁻¹ (table 3 and fig 3,a). Increase in nutrient uptake of system can be traced to the higher biological yield, especially in sweet sorghum crop and nutrient content within the season and across the years. Increase in NPK uptake due to application of N was reported by Addy et al. (2010) and Shaheen et al. (2010). Total NPK uptake of system under hybrid ‘CSH 22 SS’ (227.3-35.8-295.2 kg NPK ha⁻¹) was higher compared to other genotypes (Table 3 and fig 3, b). This is attributed to the highest biological yield and ability of this genotype to absorb more nutrients compared to varieties.
Table 3 System productivity, nutrient uptake and economic analysis as influenced by nitrogen levels and sweet sorghum genotypes (mean of 2 cropping cycles).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean productivity (t ha(^{-1}))</th>
<th>Economics ((\times 10^3)(\text{Rs} ha^{-1}))</th>
<th>Nutrient uptake (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sweet sorghum</td>
<td>Mustard</td>
<td>Total sorghum equivalent</td>
</tr>
<tr>
<td><strong>Nitrogen levels (kg ha(^{-1}) applied to preceding sweet sorghum</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1.46</td>
<td>0.97</td>
<td>3.42</td>
</tr>
<tr>
<td>50</td>
<td>1.90</td>
<td>1.32</td>
<td>4.59</td>
</tr>
<tr>
<td>100</td>
<td>2.28</td>
<td>1.70</td>
<td>5.73</td>
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<tr>
<td>150</td>
<td>2.47</td>
<td>1.84</td>
<td>6.22</td>
</tr>
<tr>
<td>SEM±</td>
<td>0.03</td>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.10</td>
<td>0.13</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>Preceding sweet sorghum genotypes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSSV 9</td>
<td>1.87</td>
<td>1.39</td>
<td>4.70</td>
</tr>
<tr>
<td>SSV 84</td>
<td>1.72</td>
<td>1.53</td>
<td>4.82</td>
</tr>
<tr>
<td>CSH 22 SS</td>
<td>2.49</td>
<td>1.50</td>
<td>5.45</td>
</tr>
<tr>
<td>SEM±</td>
<td>0.31</td>
<td>0.05</td>
<td>0.07</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.94</td>
<td>NS</td>
<td>0.21</td>
</tr>
</tbody>
</table>

* \(\text{Rs}\) is Indian Rupee.
4. Conclusion

It is concluded that application of 150 kg N ha\(^{-1}\) and including of CSH 22 SS hybrid in system is recommendable for the highest productivity, economics and nutrient uptake of sweet sorghum-mustard cropping system.

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