Effect of irrigation scheduling on performance of summer legumes grown in association of sugarcane

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ABSTRACT

A field experiment was conducted during 2001-03 to find out an optimum irrigation schedule for intercrops grown in association with spring sugarcane, on silty clay-loam soil, having 23.4% moisture at field capacity and 8.6% at permanent wilting point (PWP). Daily evapotranspiration (ET) varied from 3.3 to 16.8 mm/day. Mungbean (Phaseolus radiatus L.), urdbean (P. mungo L.) and cowpea (Vigna unguiculata (L.) Walp.) gave highest yield of 4.1, 3.85 q/ha and 73.0 q/ha, respectively with irrigation at, IW : CPE ratio of 1.2 compared to 3.25, 2.75 and 6.10 q/ha with irrigations at flowering and pod-filling stage. All the intercrops reduced cane yield due to decline in number of millable canes and cane weight. Mean reduction in cane yield was 14.2% with cowpea, 11.5% with urdbean and 9.2% with mungbean. Irrigation at 1.2 IW : CPE ratio resulted in highest cane yield of 97.0 tonnes/ha, being respectively 3.7, 8.1 and 13.3% higher than IW : CPE ratio of 1.0, 0.8, and irrigations at critical growth stages. Sugarcane + cowpea gave highest mean cane-equivalent yield (107.0 tonnes/ha), being 6.8, 10.0, and 8.7% more than sole sugarcane and intercropping with urdbean and mungbean respectively. Sugarcane intercropped with cowpea gave highest gross return of Rs 101,650/ha followed by sugarcane alone (Rs 95,190) as against Rs 92,435 with sugarcane + urdbean. Respective Benefit : cost ratio was 0.89, 0.90 and 0.73. Irrigation applied at 1.2 IW : CPE ratio gave significantly highest cane-equivalent yield (109.5 tonnes/ha) with benefit : cost ratio of 0.85 as against 92.4 tonnes/ha and 0.77 with irrigation at critical growth stages of intercrops.

Key words : Sugarcane, Intercropping, IW : CPE ratio, CEY, Monetary returns

MATERIALS AND METHODS

A field experiment was carried out during 2001–2003 at the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar Uttarakhand, on silty clay-loam soil having bulk density of 1.66 g/cc, moisture content of 23.4% at field capacity and 8.6 % at permanent wilting point (PWP). The soil was neutral in reaction, rich in organic carbon, medium in available phosphorus and potassium. Treatments comprising combination of cropping system, i.e. sole sugarcane and intercropping with cowpea, urdbean and mungbean, and irrigation schedules at IW: CPE ratio of 1.2, 1.0, 0.8 and at critical growth stages of intercrops were replicated thrice in randomized block design. Sugarcane crop was planted on 5 March, during both the years and was raised with recommended package of practices. Two rows each of the cowpea ('Pusa Komal'), urdbean ('PU 19') and mungbean ('UPM 98') were grown in inter-row space of the sugarcane as per treatment. Cowpea was raised for green pod and others for grains. Sugarcane crop was fertilized with 120:60:40...
kg of N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O respectively. Half of the N and full P and K were applied basal. Intercrop was supplied with 16 kg N and 48 kg P<sub>2</sub>O<sub>5</sub>/ha. Half of N to sugarcane was applied at harvest of intercrops. A common irrigation to depth of 6 cm was applied 20 days after planting, irrespective of the treatments and later on crops were irrigated as per schedule during intercrop period and further as per need of sugarcane crop. Water-use efficiency (WUE) was calculated based on green pods and grain yield (kg) of intercrops, whereas in cane equivalent yield was used to compute computed WUE of the intercropping systems. Irrigation water was measured with Parshall flume. The intercrops were sown on 6 March and harvested on 30 May and 15 June during 2000–2001 and 2002–2003 respectively.

RESULTS AND DISCUSSION

Intercrops

Yield of intercrop (q/ha) varied significantly due to irrigation scheduling (Table 1). Irrigation at 1.2 : IW : CPE ratio resulted in highest yield of cowpea (73 q/ha green pods), urdbean (3.85 q/ha) and mungbean (4.1 q/ha), being respectively 18.7, 40.0 and 26.0% higher than irrigation at flowering and pod-filling stages. Increase in yield was attributed to more vigorous growth and higher order of yield attributes under frequent irrigation, as the atmosphere had high demand of evapotranspiration during crop period. Tewari and Chaplot (1995) and Kher et al. (1994) also reported higher yield of summer legumes with frequent irrigation. Water-use efficiency (kg/ha-mm) tended to decline with increasing frequency of irrigation, being 25.6, 1.15 and 1.35% in cowpea, urdbean and mungbean, respectively, with 2 irrigations at flowering and pod-filling stages; and 12.2, 0.64 and 0.68% with 7 irrigations. Among the crops, cowpea was the most efficient user of water (16.8 kg/ha-mm), followed by mungbean (0.9 kg/ha-mm) and urdbean (0.8 kg/ha-mm), attributed to their differential carbon assimilating power.

Table 1. Effect of irrigation schedules on yield and water-use efficiency (WUE) in intercrops

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Water requirement (mm)</th>
<th>Cowpea</th>
<th>Urdbean</th>
<th>Mungbean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yield</td>
<td>WUE</td>
<td>Yield</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(q/ha)</td>
<td>(kg/ha-mm)</td>
<td>(q/ha)</td>
</tr>
<tr>
<td>Irrigation schedule (IW:CPE ratio)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>1.20</td>
<td>73.0</td>
<td>12.2</td>
<td>3.85</td>
</tr>
<tr>
<td>1.0</td>
<td>0.80</td>
<td>67.1</td>
<td>14.0</td>
<td>3.45</td>
</tr>
<tr>
<td>0.8</td>
<td>0.40</td>
<td>64.5</td>
<td>15.4</td>
<td>3.00</td>
</tr>
<tr>
<td>Critical growth stages</td>
<td>0.20</td>
<td>61.5</td>
<td>25.6</td>
<td>2.75</td>
</tr>
<tr>
<td>CD (P&lt;0.05)</td>
<td></td>
<td>6.0</td>
<td></td>
<td>0.6</td>
</tr>
</tbody>
</table>

Table 2. Effect of cropping systems and irrigation schedules on growth, yield and yield attributes in sugarcane

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Shoot population ('000/ha)</th>
<th>Shoot height (cm)</th>
<th>NMC ('000/ha)</th>
<th>Cane weight (g)</th>
<th>Cane yield (tonnes/ha)</th>
<th>Sucrose (%)</th>
<th>CCS (tonnes/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HI</td>
<td>MT</td>
<td>HI</td>
<td>MT</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Cropping system

Sugarcane sole  | 142 | 161 | 181 | 230 | 104.6     | 1,138          | 100.2     | 16.6        | 10.3           |
Sugarcane + cowpea | 134 | 153 | 188 | 231 | 90.0     | 1,107           | 86.0     | 16.4        | 9.3            |
Sugarcane + urdbean | 127 | 154 | 172 | 133 | 91.3     | 1,103           | 88.7     | 16.1        | 9.5            |
Sugarcane + mungbean | 122 | 155 | 174 | 232 | 92.7     | 1,121           | 91.0     | 16.3        | 9.7            |
CD (P<0.05) | 14 | 6.0 | 12 | NS | 10.2     | 25             | 8.0       | NS           | 0.8            |

Irrigation (IW : CPE ratio)

<table>
<thead>
<tr>
<th></th>
<th>Shoot population ('000/ha)</th>
<th>Shoot height (cm)</th>
<th>NMC ('000/ha)</th>
<th>Cane weight (g)</th>
<th>Cane yield (tonnes/ha)</th>
<th>Sucrose (%)</th>
<th>CCS (tonnes/ha)</th>
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<td>HI</td>
<td>MT</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1.2         | 135 | 160 | 180 | 230 | 102.7     | 1,146           | 97.0     | 16.7        | 10.4           |
1.0         | 125 | 155 | 176 | 230 | 97.7     | 1,122           | 93.5     | 16.6        | 10.0           |
0.8         | 130 | 154 | 179 | 232 | 91.5     | 1,111           | 89.7     | 16.1        | 9.4            |
Critical growth stages | 135 | 154 | 181 | 234 | 86.8     | 1,090           | 85.6     | 15.9        | 9.0            |
CD (P<0.05) | 135 | 154 | 181 | 234 | 86.8     | 1,090           | 85.6     | 15.9        | 9.0            |

HI, Harvest of intercrop; MT, maximum tillering; CCS, commercial cane sugar
cane. The mean reduction was 16.6, 13.1 and 10.2% with cowpea, urdbean and mungbean, respectively, attributed to lower order of yield attributes. Respective reduction in number of millable canes was 16.2, 14.6 and 12.8%. Bhutada and Parashar (1981) also noted decline in cane yield with intercrops. Less number of millable canes with intercrops was attributed to poor tillering and further poor conversion of tillers into canes, as indicated by shoot count at harvest of intercrops and maximum tillering stage. The effect, however got narrowed down after harvest of intercrops but could not get nullified. Among the intercrops, lowest shoot population was recorded with mungbean. The findings are in conformity with those of Sethi and Parashar (1991).

Juice sucrose remained statistically unaffected by intercrops; however, lower values were observed with intercrops attributed to release of nitrogen in soil during later phase of sugarcane. Parashar and Prasad (1995) also noted adverse effect of increased availability of nitrogen during later part of crops on juice sucrose. Commercial cane sugar yield was in accordance to cane yield, the major sugar yield determinant in sugarcane. Water-use efficiency was higher in intercropping system owing to increased output in the better exploitation of soil moisture by well-distributed roots in the rhizosphere. Moreover, intercrops provided a good cover on soil surface and might have suppressed evaporation.

**Irrigation scheduling on sugarcane**

Irrigation schedule had significant effect on cane yield (Table 2). Highest cane yield (97.0 tonnes/ha) was obtained with irrigation applied at 1.2 IW : CPE ratio, being 8.1 and 14.1% higher than that with IW : CPE ratio of 0.8 and irrigation at flowering and pod-filling stages. The reduction in cane yield was in conformity to reduction in number of millable canes and cane weight, as also noted by Gulati et al. (1998) under less-frequent irrigations. Delayed irrigation might have lowered cell turgour pressure and consequently poor proliferation of tillers. Moreover, better nutrient uptake with frequent irrigation might have also contributed indirectly towards better growth and yield. Thanki et al. (2000) also reported similar results. Commercial cane sugar yield was in accordance to cane yield, the major sugar yield determinant in sugarcane. Water-use efficiency (kg/ha-mm) followed the law of marginal diminishing return, being highest of 101.5 kg/ha mm with 2 irrigations (flowering and pod-filling stages) and lowest with most frequent irrigation at 1.2 IW : CPE.

**Cane-equivalent yield and net returns**

Intercrop had significant effect on production efficiency of intercropping system and thereby monetary returns (Table 3). Highest cane-equivalent yield of 107 tonnes/ha was obtained with sugarcane + cowpea intercropping systems, being 6.7, 9.9 and 8.7% higher than that of sole sugarcane, and intercropping with urdbean and mungbean. Superiority of cowpea was attributed to higher green pod yield that fetched good price in the market. Sugarcane + cowpea intercropping systems returned Rs 47,741/ha over cost of cultivation with benefit : cost ratio of 0.89 as against Rs 45,097 and benefit : cost ratio of 0.90 from sole sugarcane. Malavia et al. (1992) also reported higher returns from intercropping systems than sole sugarcane.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cane equivalent yield (tonnes/ha)</th>
<th>Water requirement (ha-mm)</th>
<th>WUE (kg/ha-mm)</th>
<th>Net return (Rs/ha)</th>
<th>Net return (Rs/ha/day)</th>
<th>Benefit : cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropping system</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sugarcane sole</td>
<td>100.2</td>
<td>1,060</td>
<td>94.6</td>
<td>45,097</td>
<td>123.6</td>
<td>0.90</td>
</tr>
<tr>
<td>Sugarcane + cowpea</td>
<td>107.0</td>
<td>1,060</td>
<td>100.9</td>
<td>47,741</td>
<td>130.8</td>
<td>0.89</td>
</tr>
<tr>
<td>Sugarcane + urdbean</td>
<td>97.3</td>
<td>1,060</td>
<td>91.8</td>
<td>38,886</td>
<td>106.5</td>
<td>0.73</td>
</tr>
<tr>
<td>Sugarcane + mungbean</td>
<td>98.4</td>
<td>1,060</td>
<td>92.9</td>
<td>39,803</td>
<td>108.0</td>
<td>0.74</td>
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<tr>
<td>CD (P=0.05)</td>
<td>6.2</td>
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<td>4.8</td>
<td>2,000</td>
<td>5.0</td>
<td>0.06</td>
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<td>Irrigation (IW : CPE ratio)</td>
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<td></td>
</tr>
<tr>
<td>1.2</td>
<td>109.5</td>
<td>1,210</td>
<td>90.5</td>
<td>47,885</td>
<td>131.2</td>
<td>0.85</td>
</tr>
<tr>
<td>1.0</td>
<td>105.5</td>
<td>1,090</td>
<td>96.8</td>
<td>45,665</td>
<td>125.0</td>
<td>0.84</td>
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<tr>
<td>0.8</td>
<td>95.5</td>
<td>1,030</td>
<td>92.7</td>
<td>39,765</td>
<td>108.9</td>
<td>0.78</td>
</tr>
<tr>
<td>Critical growth stages</td>
<td>92.4</td>
<td>910</td>
<td>101.5</td>
<td>38,212</td>
<td>104.7</td>
<td>0.77</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>6.2</td>
<td></td>
<td>4.8</td>
<td>2,000</td>
<td>5.0</td>
<td>0.06</td>
</tr>
</tbody>
</table>

WUE, Water-use efficiency
intercropping systems varied significantly due to irrigation schedules (Table 3). Frequent irrigations resulted in significantly higher cane-equivalent yield (109.5 tonnes/ha) over irrigation at 0.8 IW : CPE ratio and only at flowering and pod-filling stages. Highest net return of Rs 47,885 with benefit : cost ratio of 0.85 were obtained under IW : CPE ratio of 1.2. The increase in net return was attributed to higher intercrop yields, resulting in highest cane-equivalent yield under frequent irrigation. The results are in conformity with those of Gulati et al. (1998).

REFERENCES


