Performance of advance pearl millet hybrids and mungbean under sole cropping and intercropping systems under semi-arid environment

Renu, Anil Kumar and Parveen Kumar

Abstract

A field experiment was conducted during Kharif 2015 at Research Farm of the Department of Genetics and Plant Breeding, CCS Haryana Agricultural University; Hisar to study the performance of newly released hybrids of pearl millet intercropped with green gram. The experiment was laid out in Randomized Block Design (RBD) with three replication and nine treatments comprising of five sole treatments having four pearl millet hybrids (HHB 67 Improved, HHB 197, HHB 226 and HHB 234) and one variety of green gram (MH 421) and four intercropping treatments (pearl millet hybrids + green gram). The results revealed that growth parameters per plant and yield contributing traits among pearl millet hybrids were decreased by the intercropping of green gram. Among all the sole and intercropping treatments, the pearl millet hybrid HHB 197 intercropping with green gram variety MH 421 exhibited its superiority in respect of pearl millet equivalent yield, gross returns, net returns and benefit-cost ratio. The intercropping of this hybrid with green gram was also found most compatible as indicated by the higher values of the biological parameters viz., land equivalent ratio, area time equivalent ratio, total crowding coefficient, aggressively, competition ratio, monetary advantage index and income equivalent ratio as compared to all other pearl millet hybrid based intercropping systems.

Keywords: pearl millet, green gram, intercropping, biological parameters, gross & net returns (Rs/ha)

Introduction

Pearl millet [Pennisetum glaucum (L.) R.Br.] is the third most important food grain crop in India. India is the largest producer of pearl millet in the world occupying an area of 7.1 million hectare, production of 9.1 million tonne per year with average productivity of 12.72 q/ha (Anonymous, 2015) [1]. Being inherent drought-escaping mechanism and adaption to drier and low fertile conditions, it occupies a prime place in dryland agriculture and contributing significantly to country’s food security. Globally as well as locally, limited availability of additional land for crop production and declining soil fertility has raised concerns about the sustainability of agricultural production at current levels. Thus, strategies for increasing and sustaining agricultural productivity will have to focus on using available land and nutrient resources more effectively than in the past. This objective can be achieved by inserting an additional population of a second crop through suitable alteration in normal planting geometry of the main crop, commonly known as intercropping.

Farmers in the arid and semi-arid regions practice generally mix/intercrop pearl millet with legumes to increase productivity per unit area or avoid risk of failure of crops as the legume crops, especially mungbean are more stable in grain yields in arid region (Ram and Meena 2014) [14]. Many new hybrids of pearl millet are being released for rainfed situation and they may respond differently with intercrop green gram. Information is scanty regarding comparative performance of these new pearl millet hybrids intercropping with green gram as intercrop. In order to obtain more information with regard to the complementary effect of green gram intercropping on different newly released hybrids of pearl millet under semiarid conditions the present investigation was carried out.

Materials and Methods

The field experiment was conducted at Research Farm of the Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar, which is situated at latitude of 29°10’ North, longitude of 75°46’ East and elevation of 215.2 m above mean sea level in the subtropical climate zone of India. The experiment was laid out in Randomized Block Design (RBD) with nine treatments viz. The sole crop of four pearl millet hybrids; T1 = HHB 67 Improved, T2 = HHB 197, T3 = HHB 226, T4 = HHB 234 along with four intercropping systems of these hybrids with green gram variety MH 421 viz. T5=HHB 67
Improved + MH 421 (2:1), T₀=HHB 197 + MH 421 (2:1),
T₀=HHB 226 + MH 421 (2:1), T₀=HHB 234 + MH 421 (2:1)
and Sole MH 421 of Green gram crop (T₀).
The sowing of main as well as intercrop was done manually in flat beds with
the help of a hand plough. The sole crop of pearl millet and
green gram was sown in rows 45 cm apart, whereas, in
intercropping treatments, sowing was done in paired row of
30:60 cm spacing to achieve equal number of rows for main
crop both in sole and intercropping stands. One row of green
gram was inserted in 60 cm row spaced pearl millet crop.
The sowing was done on 3rd July 2015 using seed rate 5 and 25
kg/ha for pearl millet and green gram crops, respectively.
The soil of the experimental field was sandy loam in texture,
slightly alkaline in reaction (pH=8.0), low in organic carbon
(0.33 %) and available nitrogen (135 kg/ha), medium in
available phosphorus (18.0 kg/ha) and potassium (260 kg/ha).
A total rainfall of 220.3 mm (July to September) was received
during the crop season. The rainfall received was 156.1, 54.8
and 9.4 mm during July, August and September month,
respectively. Pre-sowing field preparation was done after the
receipt of rainfall on 25th June (55.8 mm) and then 3.5 and
9.7 mm rainfall was received on 27th and 30th June,
respectively, which again was utilised for crop sowing. A
uniform dose of nitrogen 40 and phosphorus 20 kg/ha was
drilled in the field as basal dose through urea and
diammonium phosphate. The potash was not applied since the
soil of the experimental field was rich in available potassium.
The nitrogen and phosphorus @ 20 and 40 kg/ha, respectively
were applied to sole green gram as per the recommendation.
Periodical observations on growth parameters of pearl millet
were recorded at 20, 40, 60 days after sowing (DAS). The
grain, straw and biological yield were recorded for both pearl
millet and green gram at harvesting. The economics of
various treatments was calculated in terms of gross returns
(Rs./ha), net returns (Rs/ha) and B:C ratio. The assessment of
yield advantage were calculated as per the following indices;

**Land equivalent ratio**
Land equivalent ratio of different intercropping system was
 calculated by the following formula given by Willey (1979)
[17].

\[ \text{LER} = \frac{La + Lb}{Ta + Tb} \]

Where, La and Lb are land equivalent ratio of main and
intercrops, respectively. Ya and Yb are yield of main crop.
Ybb and Yba are the yield of intercrop in sole stands and in
intercropping, respectively

**Area-time equivalent ratio**
It takes into account the duration of the crops and permits an
evaluation of crops yield per day basis. It is calculated by the
following formula of Hiebsch and Mc-Collum (1987):

\[ \text{ATER} = \frac{La X Ta + Lb X Tb}{T} \]

Where, La and Lb are partial LER of component crops A
(pearl millet) and B (green gram). Ta and Tb are duration of
crops A and B. T is total duration of the intercropping system

**Income equivalent ratio**
It is just conversion of land equivalent ratio (LER) into
economic terms. It is calculated by the following formula:

\[ \text{IER} = \frac{Ya}{Sa} + \frac{Yb}{Sb} \]

Where, Ya and Yb are value of produce (Rs./ha) of individual
crop in intercropping system. Sa and Sb are the values of
produce of sole crops

**Monetary advantage index**
Monetary advantage index (MAI) refers to an index by taking
into account the relative money value of produce under
intercropping system.

\[ \text{MAI} = \text{Value of combined yield of intercropping system} \times \frac{\text{LER}}{\text{LER}} \]

Where, LER is land equivalent ratio.

**Aggressivity of main crop:** It was proposed by Mc-Gilchrist
(1965). Aggressivity gives simple measure of how much the
relative yield increase in component .a is greater than that for
component .b. It is usually denoted by A.

\[ (Aab) = \left( \frac{Yab/Yaa \times Zab}{Yba/Ybb \times Zba} \right) \]

Where,
Yaa = Yield of component .a. as sole crop, Ybb = Yield
of component .b. as sole crop
Yab = Yield of component .a. as intercrop grown in
combination with component .b.
Yba = Yield of component .b. as intercrop grown in
combination with component .a.
Zab = Sown proportion of component .a. in combination .b.
Zba = Sown proportion of component .b. in combination .a.

**Relative crowding coefficient**
Relative crowding coefficient was proposed by de-Wit (1960)
[3]. Each component has its own coefficient (K), which gives a
measure of whether that component has produced more or
less yield than expected. It can be calculated by the following
formula

\[ K = \frac{Yab \times Zba}{Yaa \times Zab} \times \frac{Yba \times Zab}{Ybb \times Zba} \]

K = Relative crowding coefficient of the intercropping system
Kab = Relative crowding coefficient of main crop, Kba =
Relative crowding coefficient of intercrop
Yaa = Yield of component .a. as sole crop, Ybb = Yield
of component .b. as sole crop
Yab = Yield of component .a. as intercrop grown in
combination with component .b.
Yba = Yield of component .b. as intercrop grown in
combination with component .a.
Zab = sown proportion of component .a. in combination .b.,
Zba= sown proportion of component .b. in combination .a.

**Competitive ratio**
Competitive ratio is simply the ratio of individual LERs of the
two component crops but correcting for the proportion,
in which, they were initially sown (Willey and Rao, 1980).[16]

\[ \text{CR} = \frac{\text{CRa} + \text{CR b}}{\sqrt{\text{CRa} \times \text{CR b}}} \]

Where,
\[ \text{CRa} = \frac{(\text{LER a} /\text{LER b}) \times (Z ba/Z ab)}{\text{LERa} /\text{LER b}} \times (Z ab/Z ba) \]
CRb = Competitive ratio for intercrop green gram
LERAa = Partial LER of component .a., LERb = Partial LER of component .b.
Zab = Proportion of intercrop area allocated to main crop
Zba = Proportion of intercrop area allocated to intercrop
The economics of various treatments was calculated in terms of gross returns (Rs/ha), net returns (Rs/ha) and B:C ratio.

Results and Discussion
Growth parameters
Among sole and intercropping treatments, no significant difference was observed in plant height of pearl millet hybrids at initial stage (20 DAS) of crop growth. In general, plant height of pearl millet sole and intercropping increase with the advancement of crop growth but, the plant height of pearl millet hybrids decreased significantly from 40 DAS until harvest by intercropping of green gram variety MH 421 as compared to their respective sole stands. Intercropped plants may decrease (Lawson et al., 2007) [11], increase (Misra, 1996) [13] or maintain their normal height (Singh and Khan, 2003) [15] depending on the nature of interference of the component crops. The maximum plant height at harvest was recorded in the sole HHB 197 hybrid. Leaf Area Index (LAI) increased considerably at 40 and 60 DAS, and thereafter, these values decreased. The parameters of LAI in pearl millet hybrids were decreased by intercropping of green gram as compared to their sole stands (Fig.1). The trend of dry matter accumulation (DMA) depicted from figure 1 shows pearl millet hybrids DMA/plant decreased significantly with intercropping of green gram as compared to sole pearl millet hybrids. At harvest, maximum dry matter per plant was recorded in HHB 197 hybrid followed by HHB 226, and both the hybrids were found significantly superior to HHB 67 Improved and HHB 234 in sole as well as intercropping treatments. Intercropping has been found to decrease the LAI, growth rate and net assimilation rate due to increased competition for the available resources (Gardiner and Cracker, 1981) [4].

Fig 1: Periodical changes in plant height (cm), Leaf area index (LAI) and dry matter accumulation (DMA) g/plant of pearl millet

Yield attributes and yield
Yield of a crop is the function of interaction between genetic potential of the crop cultivar and the environment. When two or more crops are grown in association, the genetic potential being constant, environment component is modified, per se affecting the different components of yield. The sole pearl millet hybrids produced more number of total and effective tillers per plant, ear head length, ear head girth and test weight as compared to their respective intercropping treatments at the time of harvest. The hybrid HHB 197 produced maximum number of effective tillers per plant followed by its intercropping treatment. The same trend of effective tillers was also observed for earhead length, earhead girth and test weight. The pearl millet grain, stover and biological yield were observed maximum in sole pearl millet hybrid HHB 197, which was found comparable to sole HHB 226 and its own intercropping system with green gram but significantly superior to the remaining treatments. Intercropping of green gram with pearl millet hybrids in 2:1 row ratio produced statistically at par grain yield as compared to their respective sole hybrid stands. The harvest index of pearl millet hybrids was not significantly influenced by various treatments (Table1). Similar findings were reported by Baldev et al. (2003) [2] and Yadav and Yadav (2001) [18].

Table 1: Effect of different intercropping treatments on yield attributes and yields of pearl millet hybrids

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total tillers/plant at harvest</th>
<th>Effective tillers/plant at harvest</th>
<th>Earhead length (cm)</th>
<th>Earhead girth (cm)</th>
<th>Test weight (g)</th>
<th>Grain yield (q/ha)</th>
<th>Stover yield (q/ha)</th>
<th>Biological yield (q/ha)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1: HHB 67 Improved</td>
<td>3.2</td>
<td>2.3</td>
<td>20.7</td>
<td>2.3</td>
<td>8.6</td>
<td>22.22</td>
<td>65.26</td>
<td>87.48</td>
<td>25.4</td>
</tr>
<tr>
<td>T2: HHB 197</td>
<td>3.9</td>
<td>2.8</td>
<td>23.7</td>
<td>2.7</td>
<td>9.0</td>
<td>27.58</td>
<td>74.66</td>
<td>102.24</td>
<td>26.9</td>
</tr>
<tr>
<td>T3: HHB 226</td>
<td>3.5</td>
<td>2.6</td>
<td>21.7</td>
<td>2.6</td>
<td>7.9</td>
<td>25.52</td>
<td>71.99</td>
<td>97.51</td>
<td>26.2</td>
</tr>
<tr>
<td>T4: HHB 234</td>
<td>3.4</td>
<td>2.3</td>
<td>23.3</td>
<td>2.2</td>
<td>7.5</td>
<td>23.54</td>
<td>67.29</td>
<td>90.83</td>
<td>25.9</td>
</tr>
<tr>
<td>T5: HHB 67 Improved + MH 421</td>
<td>3.0</td>
<td>2.1</td>
<td>20.5</td>
<td>2.2</td>
<td>8.4</td>
<td>20.34</td>
<td>60.21</td>
<td>80.54</td>
<td>25.2</td>
</tr>
<tr>
<td>T6: HHB 197 + MH 421</td>
<td>3.6</td>
<td>2.6</td>
<td>23.5</td>
<td>2.6</td>
<td>8.8</td>
<td>26.63</td>
<td>71.42</td>
<td>98.04</td>
<td>27.1</td>
</tr>
<tr>
<td>T7: HHB 226 + MH 421</td>
<td>3.3</td>
<td>2.4</td>
<td>21.4</td>
<td>2.5</td>
<td>7.8</td>
<td>24.10</td>
<td>69.82</td>
<td>93.92</td>
<td>25.7</td>
</tr>
<tr>
<td>T8: HHB 234 + MH 421</td>
<td>3.2</td>
<td>2.3</td>
<td>23.0</td>
<td>2.1</td>
<td>7.3</td>
<td>21.29</td>
<td>61.31</td>
<td>82.60</td>
<td>25.7</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.4</td>
<td>0.4</td>
<td>2.1</td>
<td>0.4</td>
<td>0.6</td>
<td>3.01</td>
<td>3.82</td>
<td>5.89</td>
<td>NS</td>
</tr>
</tbody>
</table>
Competition indices

The intercropping of HHB 197 and HHB 226 with green gram variety MH 421 exhibited the highest LER value of 1.29, indicating the superiority over HHB 67 Improved and HHB 234 hybrids. Similarly, the maximum ATER was obtained in intercropping of HHB 197 pearl millet hybrid with green gram followed by HHB 67 Improved + green gram and HHB 226 + green gram treatments, respectively. Ghihotia et al. (2015) reported that the land equivalent ratio was significantly higher in intercropping than sole treatments. The main crop of pearl millet had positive values of aggressivity and the intercrop green gram had negative values. This indicates that pearl millet was the dominant component in intercropping system, and green gram was the dominated one. The highest value of aggressivity was recorded in HHB197 based intercropping treatment followed by HHB 226 based system. The total crowding coefficient was higher in intercropping systems of HHB 197 (1.8) and HHB 226 (1.4) with green gram indicating yield advantage as these values were more than unity. The highest competitive ratio was observed in pearl millet hybrid HHB 197 + green gram system followed by HHB 226, HHB 67 Improved and HHB 234 based intercropping systems, thereby indicating that all these hybrids had produced more than expected yield in pearl millet and were more competitive too. The highest monetary advantage index (MAI) and income equivalent ratio (IER) were realised in the HHB 197 + green gram intercropping system, which was followed by HHB 226 + green gram, HHB 234 + green gram and HHB 67 Improved + green gram treatments, respectively (Table 2).

Pearl millet equivalent yield and Economics

The intercropping of green gram with different pearl millet hybrids gave significantly higher pearl millet equivalent yield than their sole cultivation. Similar results were reported by Kumar et al. (2005) and Kumar et al. (2006). However, among all the sole and intercropping treatments, the intercropping of green gram with HHB 197 produced the highest pearl millet equivalent yield of 42.58 q/ha. The intercropping of different pearl millet hybrids with green gram resulted in higher gross and net returns than their respective sole hybrids. The intercropping of green gram in 2:1 row ratio with pearl millet hybrid HHB 197 gave maximum gross and net returns. The benefit-cost ratio was also obtained maximum when pearl millet hybrid HHB 197 (2.3) was intercropped with green gram, followed by its sole treatment with a value of 2.2(Table 3) Hooda et al. (2004) Kuri et al. (2012) also reported that intercropping of pearl millet with green gram recorded highest net return and B:C ratio over sole pearl millet.

Table 2: Effect of different intercropping treatments on various yield indices in pearl millet-mungbean intercropping system

<table>
<thead>
<tr>
<th>Treatments</th>
<th>LER</th>
<th>ATER</th>
<th>Aggressivity Pearl millet(Green-gram)</th>
<th>Crowding coefficient Pearl millet(Green-gram)</th>
<th>Competitive ratio Pearl millet(Green-gram)</th>
<th>MAI Rs/ha</th>
<th>IER</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1: HHB 67 Improved + MH 421</td>
<td>1.25</td>
<td>1.24</td>
<td>0.371</td>
<td>-0.371</td>
<td>7.07</td>
<td>0.11</td>
<td>0.8</td>
</tr>
<tr>
<td>T2: HHB 197 + MH 421</td>
<td>1.29</td>
<td>1.25</td>
<td>0.457</td>
<td>-0.457</td>
<td>16.01</td>
<td>0.11</td>
<td>1.8</td>
</tr>
<tr>
<td>T3: HHB 226 + MH 421</td>
<td>1.29</td>
<td>1.24</td>
<td>0.389</td>
<td>-0.389</td>
<td>11.85</td>
<td>0.12</td>
<td>1.4</td>
</tr>
<tr>
<td>T4: HHB 234 + MH 421</td>
<td>1.27</td>
<td>1.21</td>
<td>0.110</td>
<td>-0.110</td>
<td>4.93</td>
<td>0.13</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Table 3: Effect of different intercropping treatments on pearl millet equivalent yield and economic in pearl millet-mungbean intercropping system

<table>
<thead>
<tr>
<th>Treatments</th>
<th>PEY (q/ha)</th>
<th>Gross returns (Rs./ha)</th>
<th>Cost of cultivation (Rs./ha)</th>
<th>Net returns (Rs./ha)</th>
<th>B:C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearl millet</td>
<td>Green-gram</td>
<td>Total</td>
<td>Pearl millet</td>
<td>Green-gram</td>
</tr>
<tr>
<td>T1: HHB 67 Improved</td>
<td>31.44</td>
<td>40082</td>
<td>-</td>
<td>40082</td>
<td>-</td>
</tr>
<tr>
<td>T2: HHB 197</td>
<td>38.12</td>
<td>48603</td>
<td>-</td>
<td>48603</td>
<td>-</td>
</tr>
<tr>
<td>T3: HHB 226</td>
<td>35.68</td>
<td>45500</td>
<td>-</td>
<td>45500</td>
<td>-</td>
</tr>
<tr>
<td>T4: HHB 234</td>
<td>33.04</td>
<td>42129</td>
<td>-</td>
<td>42129</td>
<td>-</td>
</tr>
<tr>
<td>T5: HHB 197 + MH 421</td>
<td>34.81</td>
<td>36767</td>
<td>7608</td>
<td>44375</td>
<td>22553</td>
</tr>
<tr>
<td>T6: HHB 197 + MH 421</td>
<td>42.58</td>
<td>46804</td>
<td>7481</td>
<td>54285</td>
<td>22553</td>
</tr>
<tr>
<td>T7: HHB 226 + MH 421</td>
<td>40.06</td>
<td>43297</td>
<td>7778</td>
<td>51075</td>
<td>22553</td>
</tr>
<tr>
<td>T8: HHB 234 + MH 421</td>
<td>36.56</td>
<td>38181</td>
<td>8430</td>
<td>46611</td>
<td>22553</td>
</tr>
<tr>
<td>T9: Sole MH 421</td>
<td>17.90</td>
<td>-</td>
<td>22829</td>
<td>22829</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: PEY- Pearl millet equivalent yield; MSP of pearl millet grain Rs. 1275/q and stover Rs. 180/q; MSP of mung bean grain Rs. 4850/q and stover Rs. 80/q

Conclusion

Based upon one year data of the present investigation, it is concluded that the growth attributes (plant height, LAI, total tillers and dry matter accumulation per plant) and yield contributing traits (effective tillers per plant, earhead length, earhead girth and test weight) among pearl millet hybrids were decreased by the intercropping of green gram. However, all the intercropping treatments in terms of pearl millet equivalent yield (PEY), the gross returns, net returns and benefit-cost ratio exhibited their superiority over their respective sole stands. The economic analysis of sole and intercropping treatments reveals that the intercropping of green gram variety MH 421 with pearl millet hybrid HHB 197 gave maximum pearl millet equivalent yield (42.58 q/ha), gross returns (Rs. 54285/ha), net returns (Rs. 30166/ha) and benefit-cost ratio (2.3).

References


