Okra (*Abelmoschus esculentus* L.)-maize (*Zea mays* L.) intercropping as affected by cropping pattern at Assosa, Benishangul Gumuz Region, western Ethiopia

Accepted 20th April, 2018

ABSTRACT

Intercropping has been a regular practice carried out by the farmers in Benishangul Gumuz Regional State to make efficient use of limited arable land. However, the major constraint is the cropping pattern, which has not been determined. This field experiment was conducted during 2015 and 2016 cropping seasons at Assosa Agricultural Research Center, western Ethiopia to avail suitable cropping pattern in okra and maize intercropping system for attaining higher yield and economic return. The treatments include 1O:1M alternate stands, 2O:1M alternate stands, 1O:1M alternate rows, 2O: 1M alternate rows, sole okra and sole maize. The trial was laid in RCBD with three replications. Local okra and improved maize variety (BH540) were used for the study. The result revealed that sole okra gave the highest okra equivalent yield (14.02 t ha\(^{-1}\)), followed by 2O:1M alternate rows cropping pattern where the okra equivalent yield was 12.49 t ha\(^{-1}\). The highest total LER values in 2015 and 2016 cropping seasons (1.414 and 1.181, respectively), as well as the highest average LER (1.298) with a highest percentage of land saved (22.94%) was obtained from 2O:1M alternate rows cropping pattern. Thus, this indicates that the greatest productivity per unit area was achieved by growing the two crops together with this pattern than growing them separately. Apart from this, the economic analysis showed that the maximum gross return (255,300.00 ETB ha\(^{-1}\)), gross margin (208,174.16 ETB ha\(^{-1}\)) and benefit cost ratio (5.4) were recorded in sole okra, followed by 2O:1M alternate rows cropping pattern is the most productive cropping pattern in such a way that the use of 2O:1M alternate rows crop pattern will be a preferred alternative to sole okra.

Key words: Okra, maize, LER, equivalent yield, economic analysis, benefit cost ratio.

INTRODUCTION

Crop production in Benishangul Gumuz region is dominated by subsistence farming bias towards multiple cropping with over 75% of the cultivated land area based on crop mixtures of varying complexities. Intercropping has been a regular practice carried out by the farmers in the region to make efficient use of limited arable land. The planting patterns followed by subsistence farmers, which involve multiple cropping systems, are complex and divers. It varies from simple replacement mixtures to complex superimposed mixtures. These mixtures may be planted either in alternate rows or, intra-row. Multiple cropping has long been recognized as a valuable practice among...
substance farmers in the region. There are several reasons for encouraging small farmers to adopt intercropping system, which include improvement in stability of yield within cropping system (Lithourgidis et al., 2006), a better variety of returns from land and labor (Okigbo, 1977), increase in efficiency of scarce resources utilization (Dhima et al., 2007), reduce the risk of dependence upon a sole crop that is susceptible to environmental and economic fluctuations (Sharaiha and Hadidi, 2015), enhancing light, water and nutrient use (Lithourgidis et al., 2008), soil conservation improvement (Anil et al., 1998) and a method of control for weeds, insects and/or diseases (Vasilakoglou et al., 2008).

The main concept of intercropping is to obtain increased total productivity per unit area and time, besides equitable and judicious utilization of land resources and farming inputs including labour (Marer, 2007; Ijoyah, 2012). Grubben (1999) also defined intercropping as the growth of two or more crops with distinct row arrangement. Limited availability of additional land for crop production, along with declining yield per unit area have heightened concerns about the introduction of cropping systems which are sustainable and economically viable. A possible way of increasing productivity would be through multiple cropping systems, such as intercropping, which is one of the options to feed more mouths (Moradi et al., 2014). On the other hand, intercropping system becomes productive and economical only when it is done properly by selecting compatible crops (Santalla et al., 2001), and by shifting the period of peak demand for growth resources through changing the time of sowing of the component crops (Santalla et al., 1999). In addition to this, Huxley and Maingu (1978) suggested that maximum productivity in intercropping could be achieved when inter- and intra-crop competitions are minimal for growth limiting factors and the density of each crop is adjusted to minimize competition between them.

Okra (Abelmoschus esculentus (L) Moench) is an important vegetable crop which is grown and consumed throughout the region and is mainly grown for its young immature pods, known as ‘lady's finger’, or ‘bamia’ which are consumed as a vegetable and can be conserved by drying. Considering the importance of vegetables in the diet of man, this research cannot be more justified, particularly when one observes that okra is rich in protein, energy, vitamins and minerals which are both vital to man's growth and development, and most often lacking in most dietary in-takes in Africa. While the matured okra seeds are used for oil (oil content is about 200 mg g⁻¹) and amino acid (Purseglove, 1977). More importantly, okra is also valuable with regards to anti-carcinogenicity, human immunity promotion, ageing prevention and health care, and traditionally, the fresh fruits and leaves are boiled and eaten to cure cough and throat infection (Ibeawuchi, 2007). The mucilage preparation from the immature pod is also used medicinally in the treatment of ulcers and in the relief of hemorrhoids (Yadev and Dhanker, 2002).

On the other hand, maize (Zea mays L.) is the third most important food grain for human after rice and wheat. It is the primary staple food in many developing countries (Morris et al., 1999). Maize in Benishangul Gumuz region is an important crop and relatively esteem among the farmers mainly due to high yield, more economic return and versatile uses. This experiment was, therefore, carried out to avail suitable cropping pattern in okra and maize intercropping system for attaining higher yield and economic return.

MATERIALS AND METHODS

Description of experimental site

The trial was conducted at the Assosa Agricultural Research Center at Kamash sub-station during 2015 and 2016 main cropping seasons. The center is located at latitude of 10°02’ N and longitude of 34°34’ E in Benishangul Gumuz Regional State, western Ethiopia. It is located on altitude of 1553 m a.s.l and has a mean annual rainfall of 1275 mm. The rainy season extends from April to October and maximum rain is seen in the months of June to August. It has a warm humid climate with mean maximum and minimum temperatures of 32 and 17°C, respectively. The soil of the area is characteristically reddish, brown, Nitosol, which is slightly acidic with pH of 5.1 (EARO, 2004).

Treatment and field management

The experiment was used a Randomized Complete Block Design (RCBD) with three replications. A local variety of okra with broad leaves and moderate canopy height intercropped with an improved variety of maize (BH540). The treatment were arranged as one stand of maize alternated with one stand of okra (1M:10 alternate stands); one stand of maize alternated with two stands of okra (1M:20 alternate stands); one row of maize alternated with one row of okra (1M:10 alternate rows); one row of maize alternated with two row of okra (1M: 20 alternate rows) in addition to sole maize and okra were used as controls (Table 1).

The site was ploughed and harrowed well. Both crop seeds were sown on the flat bed plot (a population of 105 plants per area of 23.63 m²) with spacing of 0.25 m x 0.75 cm in both mono-cropping and mixed stands. Okra and maize were sown in June 2015 at the same date. Two seeds of both maize and okra were sown per hill, and later thinned to one plant per stand two weeks after sowing (WAS). A basal application of 160 kg Urea and 100 kg DAP ha⁻¹ was used. Plots were manually weeded regularly and maintenance activities were simultaneously carried out.
Table 1: Treatment arrangement of okra-maize intercropping.

<table>
<thead>
<tr>
<th>Treatment No</th>
<th>Treatment arrangement</th>
<th>Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>One stand of okra alternated with one stand of maize (1O:1M alternate stands)</td>
<td>MOMOMOMOMOMO MOMOMOMOMOMO</td>
</tr>
<tr>
<td>T2</td>
<td>Two stands of okra alternated with one stand of maize (2O:1M alternate stands)</td>
<td>MOOMOOMOOMOMO MOOMOOMOOMO</td>
</tr>
<tr>
<td>T3</td>
<td>One row of okra alternated with one row of maize (1O:1M alternate rows)</td>
<td>MMMMMMMMMMM OOOOOOOOOOO MMMMMMMMMM OOOOOOOOOOO</td>
</tr>
<tr>
<td>T4</td>
<td>Two rows of okra alternated with one row of maize (2O:1M alternate rows)</td>
<td>MMMMMMMMMMM OOOOOOOOOOO OOOOOOOOOOOO MMMMMMMMMM</td>
</tr>
<tr>
<td>T5</td>
<td>Sole okra</td>
<td>OOOOOOOOOOOO OOOOOOOOOOOO</td>
</tr>
<tr>
<td>T6</td>
<td>Sole maize</td>
<td>MMMMMMMMMMM MMMMMMMMMMM</td>
</tr>
</tbody>
</table>

Where, O=Okra and M=Maize.

The maize and okra seeds required for a hectare were 50 and 60 kg.

Data collection and analysis

The yield data was taken from the whole plot for both okra and maize crops. The pods and cobs were weighed using an electronic digital balance. The cobs were later shelled manually and the total grains for each plot weighed to obtain the yield (t ha⁻¹). All the outputs were valued at the prevailing farm gate based on market prices for the products.

Okra equivalent yield was computed by converting yield of intercrops on the basis of prevailing market price of individual crop as shown in the following formula (Singh et al., 1990):

\[
\text{Okra equivalent yield} = Y_{io} + \frac{(Y_{im} \times P_{m})}{P_{o}}
\]

Where, \(Y_{io}\) = Yield of intercrop okra, \(Y_{im}\) = Yield of intercrop maize, \(P_{m}\) = Market price of maize and \(P_{o}\) = Market price of okra.

Land use efficiency of okra/maize intercrop was determined using land equivalent ration (LER) concept (Mead and Willey, 1980). LER was defined as the ratio of intercrop yield to sole crop and computed as follows:

\[
LER = \frac{\text{Yield of intercropped of okra}}{\text{Sole yield of okra}} + \frac{\text{Grain yield of intercropped of maize}}{\text{Sole yield of maize}}
\]

Where, LER is land equivalent ratio.

The percentage (%) land saved was calculated as described by Willey (1985) using the formula below to determine the productivity of the intercropping system and to assess the compatibility and suitability of the crops for intercropping:

\[
\% \text{Land Saved} = 100 - \frac{1}{LER} \times 100
\]

Where, LER is land equivalent ratio.

Records were taken on the level of resource used (labor, input, etc). The amount of daily laborer wage 30 ETB for 8-h day (that is, one man-day) and the man-day required for plowing, planting, fertilizer application, weeding, harvesting, threshing of maize and packing of okra pods were 8, 5, 1.5, 20, 10, 18 and 10, respectively. The average price of inputs were 25.4, 85.3, 13 and 15.55 ETB for maize seed, okra seed, Urea and DAP, respectively. The local
Table 2: Okra and maize yield mean squares as influenced by cropping pattern during 2015 and 2016 cropping seasons.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean squares</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015</td>
</tr>
<tr>
<td>Degree of freedom (d.f)</td>
<td>5</td>
</tr>
<tr>
<td>Okra pod yield (t ha(^{-1}))</td>
<td>56.66**</td>
</tr>
<tr>
<td>Maize grain yield (t ha(^{-1}))</td>
<td>10.07**</td>
</tr>
<tr>
<td>Okra average equivalent pod yield (t ha(^{-1}))</td>
<td>71.98**</td>
</tr>
</tbody>
</table>

Where, **, * = indicate significant differences at 1% and 5% level of significance, respectively.

Table 3: Effect of cropping pattern on yield of okra-maize intercropping for the season 2015 and 2016.

<table>
<thead>
<tr>
<th>Cropping pattern</th>
<th>Okra pod yield (t ha(^{-1}))</th>
<th>Maize grain yield(t ha(^{-1}))</th>
<th>Okra average equivalent pod yield (t ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015</td>
<td>2016</td>
<td>Mean</td>
</tr>
<tr>
<td>1O:1M alternate stands</td>
<td>5.62c</td>
<td>7.92c</td>
<td>6.77d</td>
</tr>
<tr>
<td>20:1M alternate stands</td>
<td>6.07c</td>
<td>14.29b</td>
<td>10.18bc</td>
</tr>
<tr>
<td>1O:1M alternate rows</td>
<td>6.31c</td>
<td>12.36b</td>
<td>9.33c</td>
</tr>
<tr>
<td>20:1M alternate rows</td>
<td>9.43b</td>
<td>13.17b</td>
<td>11.30b</td>
</tr>
<tr>
<td>Sole okra</td>
<td>13.05a</td>
<td>20.99a</td>
<td>17.02a</td>
</tr>
<tr>
<td>Sole maize</td>
<td>0.00d</td>
<td>0.00d</td>
<td>0.00e</td>
</tr>
<tr>
<td>Mean</td>
<td>6.75</td>
<td>11.46</td>
<td>9.10</td>
</tr>
<tr>
<td>Level of sign.</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>LSD (%)</td>
<td>2.84</td>
<td>3.03</td>
<td>1.86</td>
</tr>
<tr>
<td>CV (%)</td>
<td>23.12</td>
<td>14.53</td>
<td>11.23</td>
</tr>
</tbody>
</table>

Means with the same letter along the column are not significantly different.

RESULTS AND DISCUSSION

Influence of cropping pattern on yield

Two years results revealed that okra and maize yields were varied highly significantly (P<0.001) influenced due to the cropping pattern of the okra-maize intercropping (Table 2). Results indicated that, in all seasons and combined cases, the highest yields (13.05, 20.99 and 17.02 t ha\(^{-1}\), respectively in the above mentioned order), as well as the highest okra average equivalent pod yield (17.02 t ha\(^{-1}\)) were recorded in sole okra and were statistically different to the other cropping patterns. These might be due to the greater efficiency of sole okra in utilizing the growth environment (Madu and Nwosu, 2001), population advantage of okra in the pattern and less intra-specific competition among each other. On the other hand, the lowest okra equivalent pod yield (2.35 t ha\(^{-1}\)) was obtained from sole maize, followed by 10:1M alternate stands cropping pattern (8.32 t ha\(^{-1}\))(Table 3).This might be due

Gross margin \( (GM) = \text{Gross return} - \text{Cost of production} \)

Gross profit margin is a profitability ratio that measures how much of its return left over paying cost of production, which is calculated as:

\[
\text{Gross profit margin \( (GM) \text{\%} = \frac{\text{Gross return} - \text{Cost of production}}{\text{Gross return}} \)}
\]

While the benefit cost ration is the ratio of the gross return to the cost of production (Hoagland and Williamson, 2000) and was estimated as follows:

\[
\text{Benefit cost ratio \( (BCR) = \frac{\text{Gross return}}{\text{Cost of production}} \)}
\]

Data were analyzed using analysis of variance procedures on the appropriate statistical analysis software (SAS, 2010) version 9.0, as well as costs and returns techniques. Whenever the treatment differences show significance, mean differences was tested using LSD at 5% level of significance. Economic analysis was also done considering local market price of harvested crops.

Market prices of the produced okra pods and maize grains were 15 and 7 ETB per kg, respectively. Costs and returns technique was used to calculate gross margin and other financial estimates for performance evaluation and economic feasibility of okra maize intercropping. Gross margin is gross profit expressed in terms of percentage, which determine how much of the money generated by the business activity (Richter, 2010) and was computed as follows:

\[
\text{Gross margin (GM) = Gross return} - \text{Cost of production}
\]

Two years results revealed that okra and maize yields were varied highly significantly (P<0.001) influenced due to the cropping pattern of the okra-maize intercropping (Table 2). Results indicated that, in all seasons and combined cases, the highest yields (13.05, 20.99 and 17.02 t ha\(^{-1}\), respectively in the above mentioned order), as well as the highest okra average equivalent pod yield (17.02 t ha\(^{-1}\)) were recorded in sole okra and were statistically different to the other cropping patterns. These might be due to the greater efficiency of sole okra in utilizing the growth environment (Madu and Nwosu, 2001), population advantage of okra in the pattern and less intra-specific competition among each other. On the other hand, the lowest okra equivalent pod yield (2.35 t ha\(^{-1}\)) was obtained from sole maize, followed by 10:1M alternate stands cropping pattern (8.32 t ha\(^{-1}\))(Table 3).This might be due
to higher competition among the plants for nutrients, water, light and other natural resources (Olasantan, 1998; Girardin and Tollenaar, 1994). With yield performance among the pattern laid under alternate stands and rows, relative better okra average equivalent pod yield was obtained from 20:1M alternate rows (12.78 t ha⁻¹) followed by 20:1M alternate stands (10.88 t ha⁻¹) (Table 3).

In general, greater competition for available nutrients and light could have been responsible for the decrease in the production of pods, pod weight and yield obtained. In general, this result is in agreement with that of Sharma and Choubey (1991) who stated that the yield advantages in intercropping system are mainly because of differential use of growth resources by component crops.

Similarly, in both cropping seasons and combined analysis, the cropping pattern influenced the maize grain yield highly significantly (P<0.001). The highest maize grain yields (5.41, 4.64 and 5.03 t ha⁻¹) were obtained in sole maize in 2015, 2016 cropping seasons and combined yield, respectively. While the lowest maize grain yields were found in all cases with the use of cropping pattern of 20:1M alternate rows in the okra-maize intercropping system (Table 3).

The result indicated that the highest okra equivalent yield (17.02 t ha⁻¹) was found in sole okra, followed by 20:1M alternate rows cropping pattern where the okra equivalent yield was 12.25 t ha⁻¹ (Table 3). Conversely, the lowest okra equivalent yield (8.32 t ha⁻¹) was secured in 10:1M alternate stands cropping pattern.

### Efficiency of intercropping

The LER is the most common index for measuring the efficiency of using intercropping systems on the combined yield of both crops (Francis and Decoteau, 1993) and the partial, total and average LER are shown in Table 4. The maximum partial LER from the treated cropping pattern in the two cropping seasons (2015 and 2016) did not show consistency for both okra and maize crops. The maximum partial LER for okra was obtained from 20:1M alternate rows (0.723) and 20:1M alternate stands (0.681) in 2015 and 2016 cropping seasons, respectively, while in the case of maize, it was obtained from 10:1M alternate stands (0.754) and 10:1M alternate rows (0.558) in the respective above mentioned order. However, the highest total LER values (1.414 and 1.181 in 2015 and 2016 cropping seasons, respectively), as well as the highest average LER (1.298) with a highest percentage of land saved (22.94%) was obtained from 20:1M alternate rows cropping pattern. In general, this signifies that the greatest productivity per unit area was achieved by growing the two crops together in 20 rows alternate with 1M row cropping pattern than growing them separately.

It is obvious that the efficiency of intercropping was affected by the cropping pattern since each cropping pattern allowed the planted crops to special local microenvironment that changes to a certain limit for competition for light, moisture and nutrients. This showed higher efficiency of intercropping and yield advantage as compared with sole cropping since the yield produced in the 20:1M alternate rows cropping pattern would be 41.4%, and 18.1% more land would be required for sole crops to produce the yields under intercropping situation in 2015 and 2016 cropping seasons, respectively (Table 4). This study was supported by Vandermeer (1992) who reported that if LER values become over the unity under intercropping system, this system would be superior to the sole cropping system.

### Economic performance evaluation

Economic analysis is an important tool to evaluate the economic feasibility of intercropping systems and monetary advantage was evaluated according to Shah et al. (1991). The mean gross return, gross margin, and benefit cost ratio (BCR) are shown in Table 5. All treatments were subjected to cost benefit analysis and the maximum gross return (255,300 ETB ha⁻¹) and gross margin (208,174.16 ETB ha⁻¹) were recorded in sole okra, followed by 20:1M alternate rows (191,700.00 and 147,451.71 ETB ha⁻¹, respectively in the above-mentioned order). Sole maize gave the lowest gross returns (35,250.00 ETB ha⁻¹) and gross margin (-13,625.38 ETB ha⁻¹). The data showed that sole okra gave the highest BCR (5.4), followed by 20:1M alternate rows (4.3). While the lowest BCR (0.7) was recorded in sole maize.
The highest values were obtained by 20:1M alternate rows cropping pattern. In case of LER and percentage of land saved, the highest values were obtained from 20:1M alternate rows cropping pattern and this signifying that the greatest productivity per unit area was achieved by growing the two crops together with this pattern than growing them separately. Apart from this, the economic analysis showed that the maximum gross return, gross profit margin and benefit cost ratio were recorded in sole okra followed by 20:1M alternate rows cropping pattern. In this study, sole okra is the most profitable one, while 20:1M alternate rows cropping pattern is the most productive cropping pattern and as such, will be an alternative option than sole okra.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Jemal Ibrahim, previous technical assistance from Assosa ARC, who actively participated in the management and data collection, Abebaw Mekuonant and Tesfaye Fentaw, the field technicians from Assosa ARC, who were performed most of the physical work for this study. Besides, we would like to acknowledge EIAR for budget support and the Assosa ARC Finance and Administration Teams without their smooth cooperation this work will not be fruitful. Lastly, we have a great thanks for all AsARC drivers for their unlimited patience and safe driving while this work was done.

REFERENCES


**Table 5:** Cost benefit analysis of okra-maize intercropping system as influenced by cropping pattern.

<table>
<thead>
<tr>
<th>Cropping pattern</th>
<th>Gross return (ETB ha⁻¹)</th>
<th>Cost of production (ETB ha⁻¹)</th>
<th>Gross margin (ETB ha⁻¹)</th>
<th>Gross profit margin (%)</th>
<th>Benefit cost ratio (BCR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:1M alternate stands</td>
<td>124,800.00</td>
<td>48,058.93</td>
<td>76,741.07</td>
<td>61.5</td>
<td>2.6</td>
</tr>
<tr>
<td>20:1M alternate stands</td>
<td>171,600.00</td>
<td>47,709.02</td>
<td>123,890.98</td>
<td>72.2</td>
<td>2.6</td>
</tr>
<tr>
<td>10:1M alternate rows</td>
<td>163,050.00</td>
<td>48,125.58</td>
<td>114,924.42</td>
<td>70.5</td>
<td>3.4</td>
</tr>
<tr>
<td>20:1M alternate rows</td>
<td>191,700.00</td>
<td>44,248.29</td>
<td>147,451.71</td>
<td>76.9</td>
<td>4.3</td>
</tr>
<tr>
<td>Sole okra</td>
<td>255,300.00</td>
<td>47,125.84</td>
<td>208,174.16</td>
<td>81.7</td>
<td>5.4</td>
</tr>
<tr>
<td>Sole maize</td>
<td>32,250.00</td>
<td>48,875.38</td>
<td>-13,625.38</td>
<td>-38.7</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Note: Average local market prices of okra pod and maize grain were 15 and 7 ETB per kg, respectively, and the wage for 1 man-day is 30 ETB.

CONCLUSION AND RECOMMENDATIONS

The above results revealed that intercropping of okra with maize in different cropping pattern could influence the total productivity and economic return over sole maize. Sole okra gave the highest okra equivalent yield followed by 20:1M alternate rows cropping pattern. In case of LER and percentage of land saved, the highest values were obtained from 20:1M alternate rows cropping pattern and this signifying that the greatest productivity per unit area was achieved by growing the two crops together with this pattern than growing them separately. Apart from this, the economic analysis showed that the maximum gross return, gross profit margin and benefit cost ratio were recorded in sole okra followed by 20:1M alternate rows cropping pattern. In this study, sole okra is the most profitable one, while 20:1M alternate rows cropping pattern is the most productive cropping pattern and as such, will be an alternative option than sole okra.


Submit your manuscript at http://www.academiapublishing.org/ajsr