Using competition ratios and total revenue parameters to assess millet and legume intercropping under conservation agriculture production system in Nepal

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OVERVIEW OF PRESENTATION

• Background
• Objective
• Methodology
• Result and discussion
  ▪ Total revenue
  ▪ Land Equivalency Ratio (LER)
  ▪ Competition ratio (CR)
  ▪ Aggressivity
  ▪ Monetary Advantage Index (MAI)
• Conclusion
BACKGROUND

- Nepal
  - Nearly $\frac{1}{4}$ population below poverty line;
  - Agriculture: 75% of the population, about $\frac{1}{3}$ GDP
  - About half of agriculture land is sloping land

(CIA World Fact book, 2012)
Nature of hill farming system

- Fragile hill (sloping) land agriculture
- High soil loss
  
  2.7 to 8.2 ha\(^{-1}\) year \(^{-1}\) \((Gardner \ and \ Gerrard, \ 2002)\); 5-15 ton ha\(^{-1}\) year \(^{-1}\) soil loss \((MoEST, \ 2006)\)
- Land remains open fallow for 6 months \((Khanal \ et \ al, \ 2004)\)
- Maize, millet, legumes are major crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield crops in sole crop trials (ton/ha)</th>
<th>National average (ton/ha) (MOAC, 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>1.14±0.12**</td>
<td>2.28</td>
</tr>
<tr>
<td>Millet</td>
<td>0.91±0.28**</td>
<td>1.12</td>
</tr>
<tr>
<td>Cowpea</td>
<td>0.87±0.19</td>
<td>0.95</td>
</tr>
</tbody>
</table>

** indicate yield lower than national average at 99% confident level
• Economic benefits is major factor for farmers to decide adoption of new technology (e.g. Cary and Wilkinson, 1997)

• Comparison of individual crop yield do not reflect the true profitability in intercropping because of combined yield

• Intercropping ratios (indices) are used to compare evaluate the performance in intercropping (e.g. Dordas et al., 2012; Ghosh et al., 2007; Osman et al., 2011)
OBJECTIVE

- to assess millet and legume intercropping under conservation agriculture production system (CAPS) in Nepal by using total revenue and intercropping ratios
METHODOLOGY
On-farm trials

- On-farm, participatory (farmers’ field) trials
- Farmers from three villages in central mid hills in Nepal
- Research plots established in 25 farmers’ field
- All farmers from Chepang (tribal community)
- The Conservation Agriculture Production System (CAPS) treatments were identified through discussion among farmers, researchers and development actors
Major crops in system

Main season (March-June)
Maize 90%

Second season (July – October)
• Cowpea = 46%
• Black gram = 26%
• Millet = 8%

(source-unpublished baseline data)
## CA Treatments

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Cropping pattern</th>
<th>Tillage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Season</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; season</td>
</tr>
<tr>
<td></td>
<td>(March-June)</td>
<td>(July-October)</td>
</tr>
<tr>
<td>CT(M-Mi)</td>
<td>Maize</td>
<td>Millet</td>
</tr>
<tr>
<td>CT(M)-legume</td>
<td>Maize</td>
<td>Legume</td>
</tr>
<tr>
<td>CT(M-Mi+legume)</td>
<td>Maize</td>
<td>Millet + legume</td>
</tr>
<tr>
<td>ST(M-Mi+legume)</td>
<td>Maize</td>
<td>Millet + legume</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION
Maize yield under CAPS

ANOVA results:
Village effect highly significant (p<0.001), Year effect significant (p=0.039)
Higher yield in second year except in strip tillage plots
Revenue from the second season was significantly affected by treatment, village, year main effects and treatment*year interaction, and village*year interaction (R²=0.47)

Av. revenue of 2nd year (847.30 ± 89.1) was significantly lower than 1st year ($982.2 ± 89.1)
<table>
<thead>
<tr>
<th>Cropping System</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LER of legume</td>
<td>LER of millet</td>
</tr>
<tr>
<td>CT (M-Mi)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CT (M) legume</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>CT (M-Mi + Legume)</strong></td>
<td>0.755 (59.4)</td>
<td>0.515 (40.6)</td>
</tr>
<tr>
<td>ST (M-Mi + Legume)</td>
<td>0.703 (63.4)</td>
<td>0.462 (41.7)</td>
</tr>
</tbody>
</table>

Γ denote percentage of respective row total
ANOVA: Types of tillage, intercropping practice were significant (p values, 0.03 and <0.001)

• LER of CT was significantly higher than ST
• Intercropping system had higher LER than sole crops
• CR of legume decreased from 1.24 to 0.26 1\textsuperscript{st} to 2\textsuperscript{nd} year

• Interaction between year and cropping practices on CR
Aggressivity

- ‘legume aggressivity to millet’ was negative
- -0.49 in first year with cowpea
- -0.38 in 2\(^{nd}\) year with black gram
• MAI was more than 0 for all (P =0.002)
• MAI of 2\textsuperscript{nd} year (0.31) more than MAI of 1\textsuperscript{st} year (0.11)
• MAI of ST (=0.26) was lower than MAI value of CT (=0.36)
CONCLUSION

- clear economic benefit to adopt the ‘maize followed by cowpea’ system (already popular)
- By replacing cowpea with black gram increased total LER, reduced the total revenue due to reduced contribution of legume
- LER and total revenue was lower in ST as compared to CT
- not enough economic incentives for autonomous adoption of CAPS
• for further questions,

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Thank you!
REFERENCES


Land Equivalency Ratio (LER)

- denotes total land area required for sole crop to yield same amount of yield given by intercropping mixture (Osman et al., 2011)

\[ LER_{total} = LER_a + LER_b \]

\[ LER_a = \frac{Y_{I(a)}}{Y_{S(a)}}, \text{where } Y_{I(a)} = \text{millet yield in intercrop and } Y_{S(a)} = \text{millet yield in sole crop} \]

\[ LER_b = \frac{Y_{I(b)}}{Y_{S(b)}}, \text{where } Y_{I(b)} = \text{legume yield in intercrop and } Y_{S(b)} = \text{legume yield in sole crop} \]
Competition ratio (CR)

- Assess whether the intercropping association is advantageous or not
- CR > 1 implies crop is competitive in mix

\[ CR_a = \frac{LER_a}{LER_b} \times \frac{Z_{ab}}{Z_{ba}} ; \text{where } Z_{ab} = \text{proportion of crop 'a',} \]
\[ Z_{ba} = \text{proportion of crop 'b'} \]
Aggressivity:

- Measure of magnitude of competitive effects of crops in intercropping.
- If, $AG_{ab} = 0$, crops equally competitive.
- Positive value indicate dominance of the crop

$$AG_{ab} = \frac{Y_{I(a)}}{Y_{S(a)} \times Z_{ab}} - \frac{Y_{I(b)}}{Y_{S(b)} \times Z_{ba}}$$
Monetary Advantage Index (MAI)

- compares the monetary value of the yields of two crops in intercropping with that of sole cropping

\[
MAI = (P_{ab} + P_{ba}) \times \left( \frac{LER - 1}{LER} \right) \quad \text{; where, } P_{ab} = Y_{I(a)} \times P_a, \\
P_{ba} = Y_{I(b)} \times P_b \text{ when } P_a = \text{price of 'a', } P_b = \text{price of 'b'}
\]
\[ TR = \sum_{i=1}^{4} Y_i \cdot P_i \] where, \( Y_i \) = yield of crop \( i \), \( P_i \) = price of crop \( i \)
Land Equivalency Ratio (LER)

\[ \text{LER}_{\text{total}} = \text{LER}_a + \text{LER}_b \]

\[ \text{LER}_a = \frac{Y_I(a)}{Y_S(a)}, \text{ where } Y_I(a) = \text{millet yield in intercrop and } Y_S(a) = \text{millet yield in sole crop} \]

\[ \text{LER}_b = \frac{Y_I(b)}{Y_S(b)}, \text{ where } Y_I(b) = \text{legume yield in intercrop and } Y_S(b) = \text{legume yield in sole crop} \]
Competition Ratio

\[ \text{CR}_{a} = \frac{\text{LER}_{a}}{\text{LER}_{b}} \times \frac{Z_{ab}}{Z_{ba}} \]; where \( Z_{ab} = \text{proportion of crop 'd'}, \)
\( Z_{ba} = \text{proportion of crop 'b'} \)
Aggressivity

\[ AG_{ab} = \frac{Y_{I(a)}}{Y_{S(a)}} \times Z_{ab} - \frac{Y_{I(b)}}{Y_{S(b)}} \times Z_{ba} \]