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

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F-CASA
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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 ¼ population below poverty line;
  - ❑ Agriculture: 75% of the population, about 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

Crop	Yield crops in sole crop trials (ton/ha)	National average (ton/ha) (MOAC, 2011)
Maize	1.14±0.12**	2.28
Millet	0.91± 0.28**	1.12
Cowpea	0.87± 0.19	0.95

** indicate yield lower than national average at 99% confident level

Rationale

- 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)

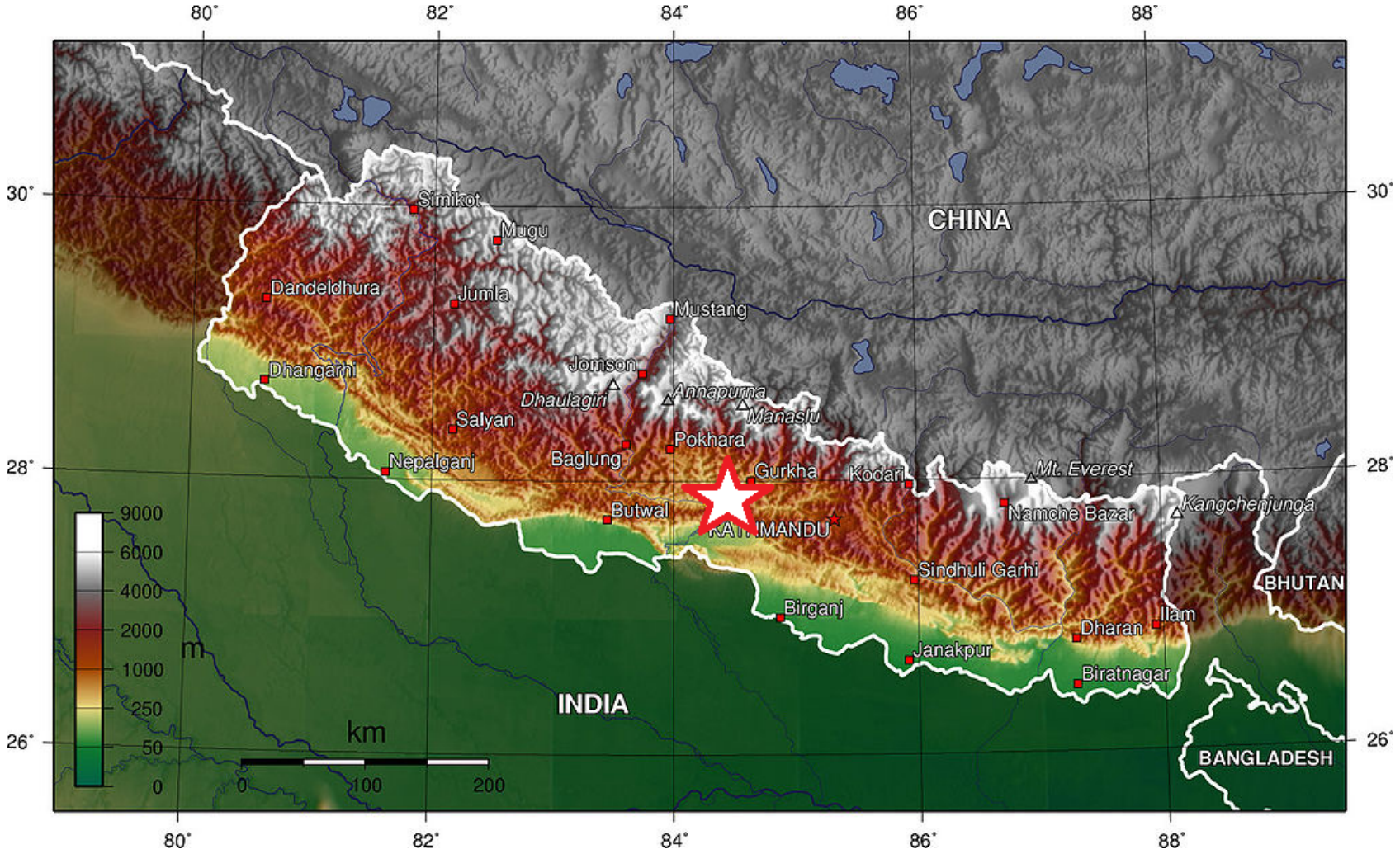
- Cowpea = 46%
- Black gram = 26%
- Millet = 8%

(source-unpublished baseline data)

CA Treatments

Treatments	Cropping pattern		Tillage
	1st Season (March-June)	2nd season (July-October)	
CT(M-Mi)	Maize	Millet	Conventional
CT(M)-legume	Maize	Legume	Conventional
CT(M-Mi+legume)	Maize	Millet + legume	Conventional
ST(M-Mi+legume)	Maize	Millet + legume	Strip - tillage

PROJECT (SITE)



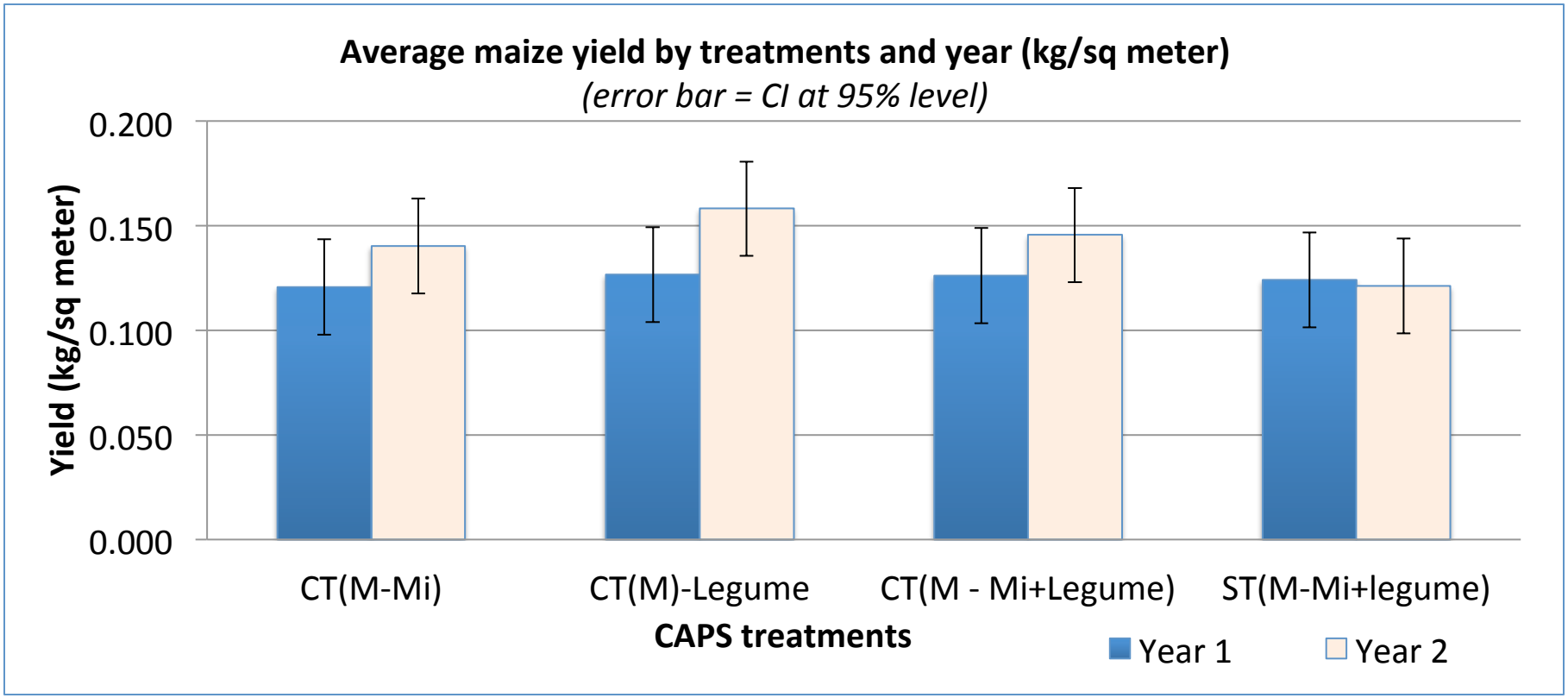
RESULTS AND DISCUSSION

Maize yield under CAPS

ANOVA results:

Village effect highly significant ($p<0.001$), Year effect significant ($p=0.039$)

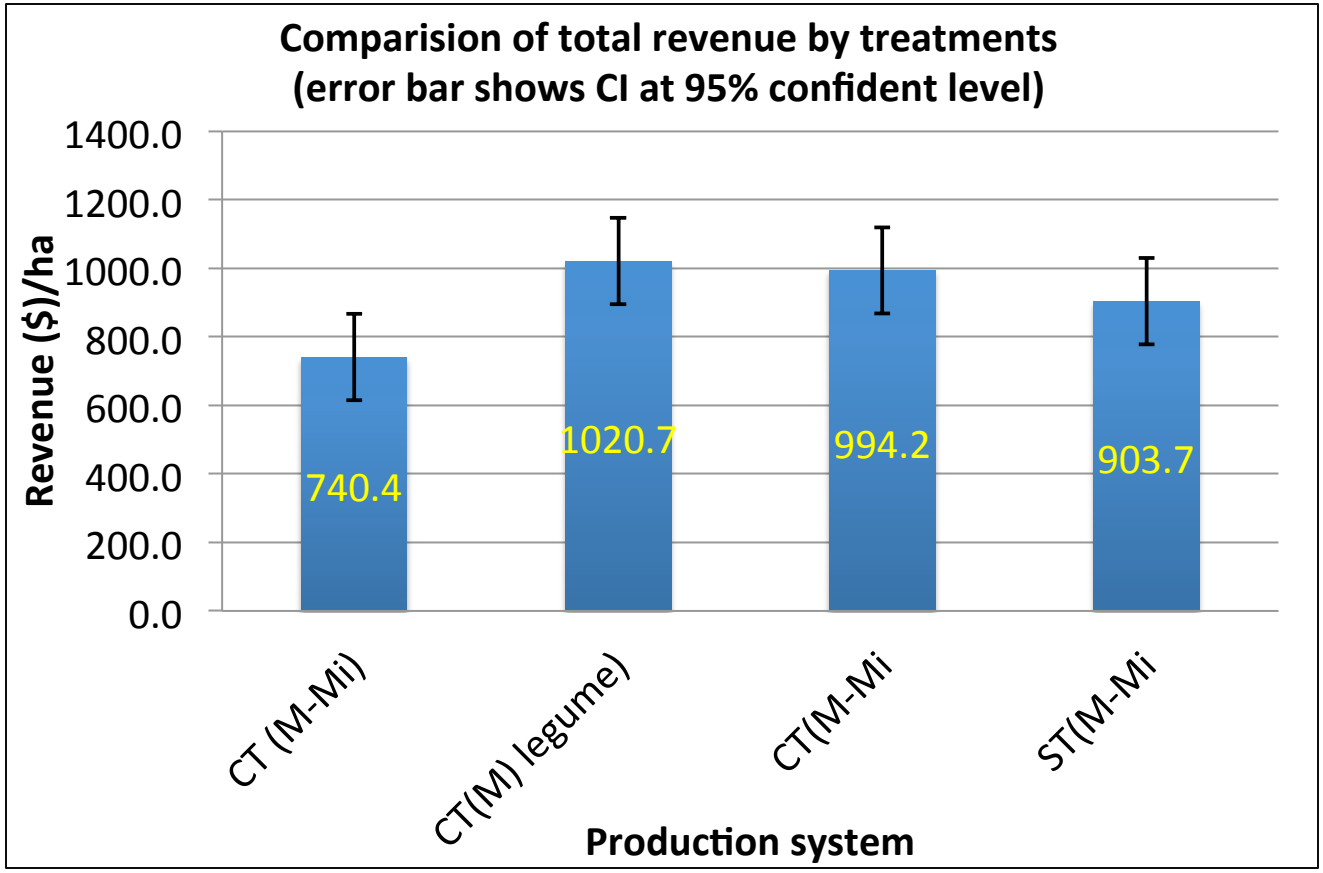
Higher yield in second year except in strip tillage plots



Revenue

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)



Average LER by year and treatments

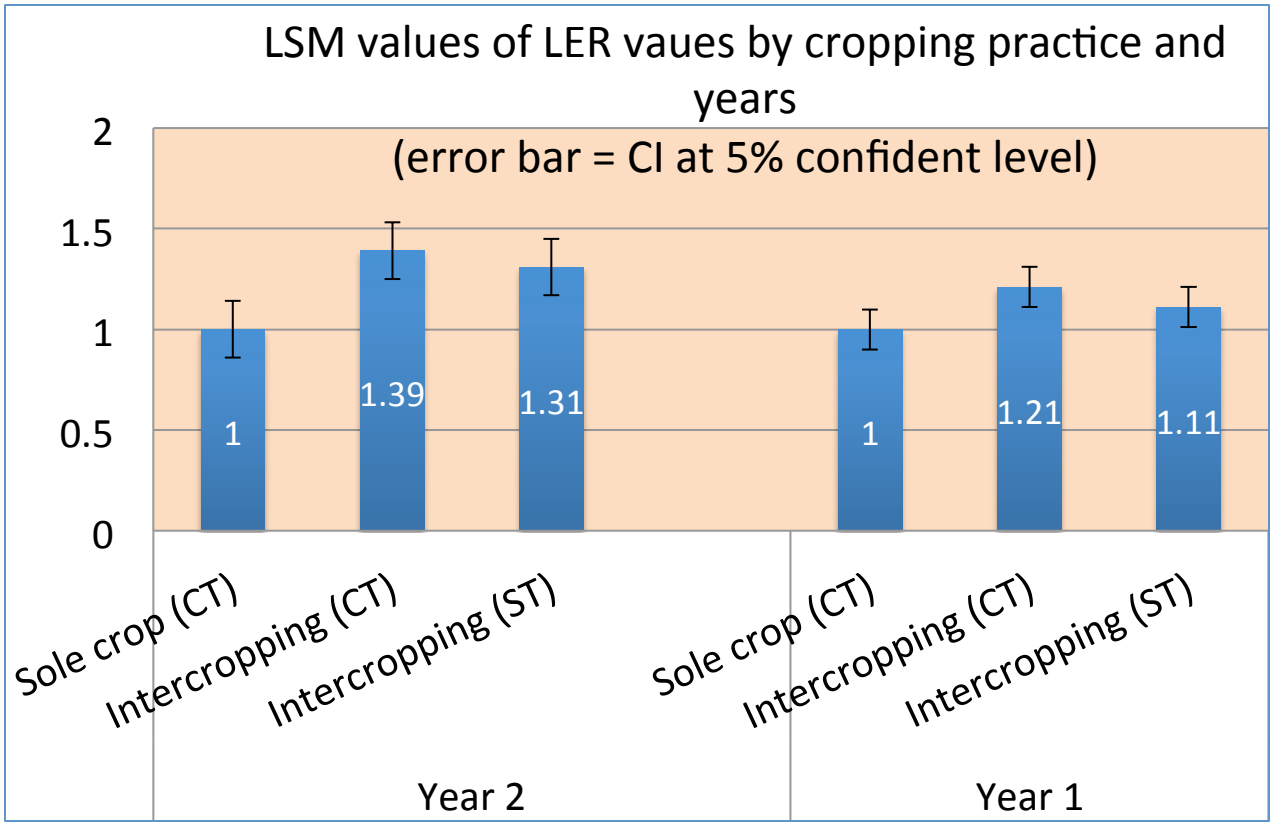
Cropping System	Year 1			Year 2		
	LER of legume	LER of millet	Total LER	LER of legume	LER of millet	Total LER
CT (M-Mi)	1	1	1	1	1	1
CT (M) legume)	1	1	1	1	1	1
CT (M-Mi +Legume)	0.755 (59.4)[Γ]	0.515 (40.6)	**1.270** (100)	0.586 (42.0)	0.810 (58.0)	**1.396** (100)
ST (M-Mi +Legume)	0.703 (63.4)	0.462 (41.7)	**1.164** (100)	0.502 (38.3)	0.810 (61.7)	**1.312** (100)

[Γ]denote percentage of respective row total

LER

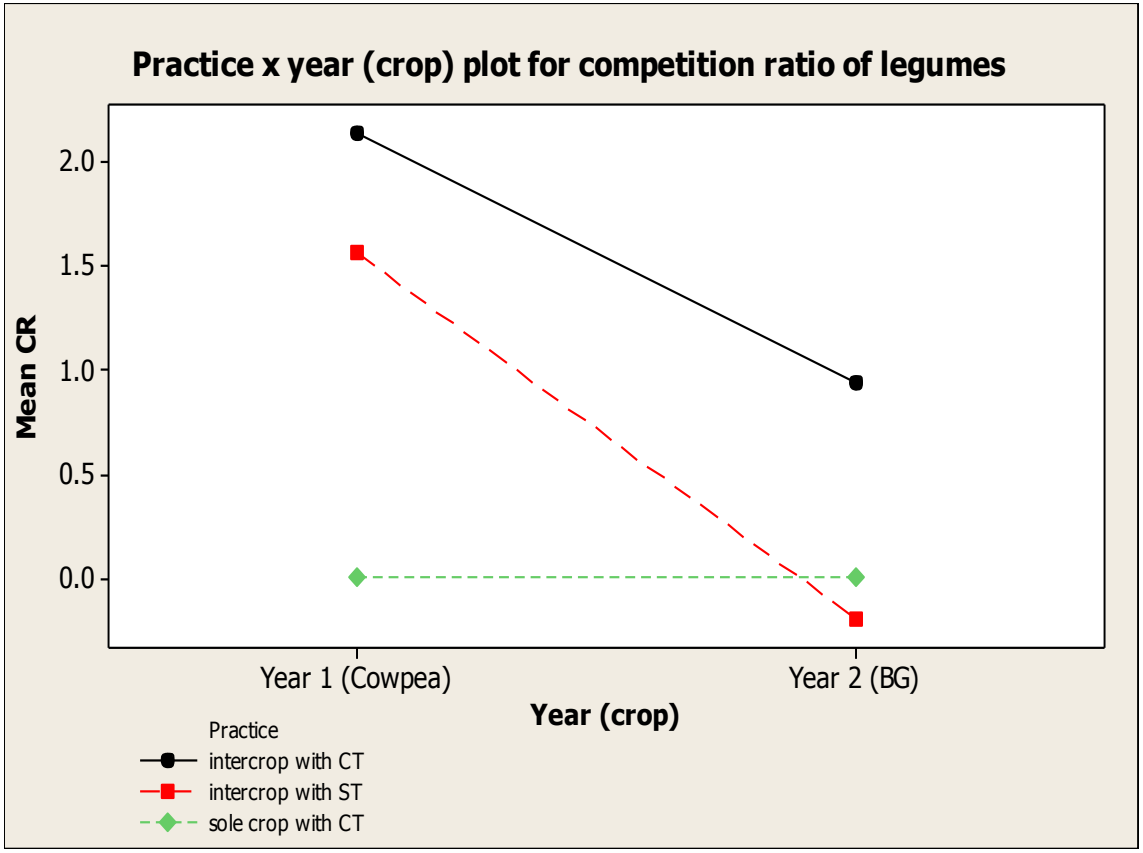
ANOVA: Types of tillage, intercropping practice were significant (p values, 0.03 and <0.001)

- LER of CT was significantly higher than ST
- Intercropping system had higher LER than sole crops



Competition ratio (CR)

- CR of legume decreased from 1.24 to 0.26 1st to 2nd year
- Interaction between year and cropping practices on CR

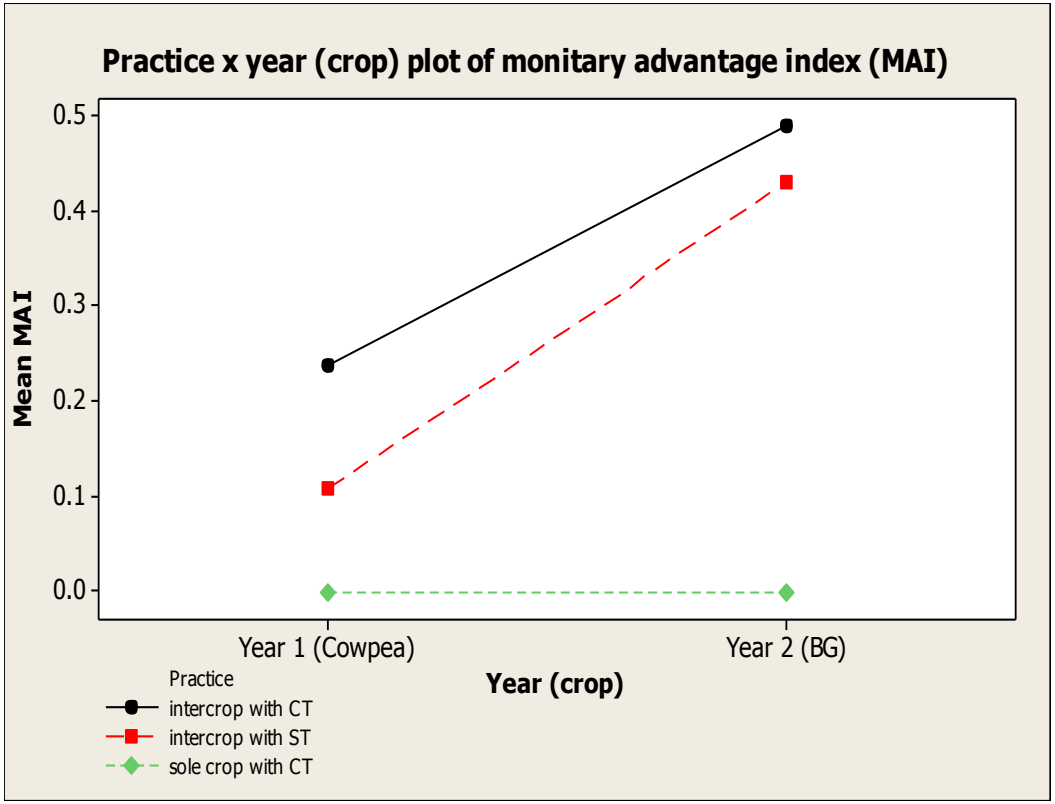


Aggressivity

- ‘legume aggressivity to millet’ was negative
- -0.49 in first year with cowpea
- -0.38 in 2nd year with black gram

Monetary Advantage Index (MAI)

- MAI was more than 0 for all (P =0.002)
- MAI of 2nd year (0.31) more than MAI of 1st 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

Cary, J. W., & Wilkinson, R. L. (1997). Perceived Profitability and Farmers' Conservation Behaviour. *Journal of Agricultural Economics*, *48*(1-3), 13-21.

CIA World Fact book, 2012 Nepal

Dordas, C. A., Vlachostergios, D. N., & Lithourgidis, A. S. (2012). Growth dynamics and agronomic-economic benefits of pea–oat and pea–barley intercrops. *Crop and Pasture Science*, *63*(1), 45-52.

Gardner, R.A.M. and A.J. Gerrard. 2002. Runoff and soil erosion on cultivated rainfed terraces in the Middle Hills of Nepal. *Applied Geography,* 23, 23–45

Ghosh, P. K., Bandyopadhyay, K. K., Wanjari, R. H., Manna, M. C., Misra, A. K., Mohanty, M., & Rao, A. S. (2007). Legume effect for enhancing productivity and nutrient use-efficiency in major cropping systems–an Indian perspective: a review. *Journal of Sustainable Agriculture*, *30*(1), 59-86.

Khanal, R.P. and A. Shrestha. 2005. Control free grazing for soil management in slope land (in Nepali). Success story of Village Income Generation Project in Arghakhanchi, Nepal.

MoAC (2011). Ministry of Agriculture and Cooperative, Nepal. Statistical information in Nepalese Agriculture, 2010-11. Kathmandu, Nepal.

Osman, A.N.; Raebild, A., Christiansen, J.L.; Bayala, J. (2011). Performance of cowpea (Vigna ungiculata) and pearl millet (Pennisetum glaucum) intercropped under Parkia biglobosa in an agroforestry system in Burkina Faso. Af. J. Agr. Res. 6(4):882-891.

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)

$$LER_{total} = LER_a + LER_b$$

$$LER_a = {Y_{I(a)}}/{Y_{S(a)}}, where\ Y_{I(a)} = millet\ yield\ in\ intercrop\ and\ Y_{S(a)} = millet\ yield\ in\ sole\ crop$$

$$LER_b = {Y_{I(b)}}/{Y_{S(b)}}, where\ Y_{I(b)} = legume\ yield\ in\ intercrop\ and\ Y_{S(b)} = legume\ yield\ in\ sole\ crop$$

Competition ratio (CR)

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

$$CR_a = \frac{LER_a}{LER_b} X \frac{Z_{ab}}{Z_{ba}}; where\ Z_{ab} = proportion\ of\ crop\ 'a',$$
$$Z_{ba} = proportion\ of\ crop\ 'b'$$

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

$$MAI = (P_{ab} + P_{ba}) \times \frac{(LER - 1)}{LER} \; ; where, P_{ab} = Y_{I(a)} \times P_a,$$
$$P_{ba} = Y_{I(b)} \times P_b \; when \; P_a = price \; of \; 'a', Pb = price \; of \; 'b'$$

TR

$$TR = \sum_{i=1}^{4} Y_i P_i \quad \text{where, } Y_i = \text{yield of crop } i,\ P_i = \text{price of crop } i$$

Land Equivalency Ratio (LER)

$$LER{\downarrow}total = LER{\downarrow}a + LER{\downarrow}b$$

$$LER{\downarrow}a = Y{\downarrow}I(a) / Y{\downarrow}S(a) \text{ , where } Y{\downarrow}I(a) = \text{millet yield in intercrop and } Y{\downarrow}S(a) = \text{millet yield in sole crop}$$

$$LER{\downarrow}b = Y{\downarrow}I(b) / Y{\downarrow}S(b) \text{ , where } Y{\downarrow}I(b) = \text{legume yield in intercrop and } Y{\downarrow}S(b) = \text{legume yield in sole crop}$$

Competition Ratio

$$CR_a = LER_a / LER_b \times Z_{ab} / Z_{ba} \text{ ; where } Z_{ab} = \text{proportion of crop 'a'}, Z_{ba} = \text{proportion of crop 'b'}$$

Aggressivity

$$AG{\downarrow}ab = Y{\downarrow}I(a) \,/ Y{\downarrow}S(a) \times Z{\downarrow}ab \; - \; Y{\downarrow}I(b) \,/ Y{\downarrow}S(b) \times Z{\downarrow}ba$$