On-farm performance evaluation of conservation agriculture production systems (CAPS) in the central mid-hills of Nepal

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Hot topics

Abstract
Traditional agriculture in central mid-hills of Nepal is characterized by cultivation of steeply sloping lands, resulting in lower productivity and degradation of soil health. The Sustainable Management of Agro-ecological Resources in Tribal Societies (SMARTS) project applied a participatory agro-ecological research framework to develop an improved conservation agriculture production system (CAPS) to contribute to the sustainable livelihoods of marginalized tribal farmers.

Experimental plots were established in 24 farmers' fields at three villages in the central mid-hills of Nepal. These villages were Hyakrang village in the Jogimara Village Development Committee (VDC) of Dhading district, Thumka village in Bhumlichok VDC of Gorkha district and Kholagaun village in Chimkeshori VDC of Tanahun district. All these villages fall between latitude of N 27°47'- 27°50' and longitude of E 84°30' - 84°41. Altitude of these village ranges from about 200- 1000 meter above mean sea level, which sub-tropical climate where temperature decreases with increase in altitude. These villages were selected because they predominantly consist of Chepang tribal members, one of the most marginalized communities in Nepal. Available agricultural lands in this area are marginalized land, characterized by low natural productivity and sloppy terrain. Historically, these have been used as shifting cultivation lands. However, increased population pressure has led farmers to rely on intensified agricultural production including reduced fallow periods (Kafle, 2011), leading to soil degradation and reduced yields. Conservation agriculture systems have been evaluated as a potential solution because they promote a healthy agronomic environment and enhance economically sustainable production (Kassam et al, 2008; Jat et al, 2010).

Potential new CAPS technologies were identified through interactive village workshops of researchers, farmers and development workers. As a result, some principles of conservation agriculture (i.e. cropping system management, minimum tillage and soil cover management) were incorporated to improve maize-based upland farming systems. The first season (March–July) crop was maize, which was sown with either conventional tillage (CT) or strip tillage (ST). The selected CAPS treatments for the second season (July – October) included sole cowpea with conventional tillage, millet-cowpea intercrop with conventional tillage and millet-cowpea intercrop with strip tillage. Cowpea-millet intercropping and strip tillage practices are completely new technologies in the study areas. A randomized-block experimental design with villages as blocks and farmers considered as replications was laid. The experimental plots were completely managed by farmers using their own practices with very low external inputs. Agriculture technicians ensured proper implementation of CAPS in the on-farm trials and collected data on agronomic, yield and economic parameters.

Crop yields and total biomass productions were compared among the treatments using general linear regression models. Biomass production in intercropping was compared by estimating the Land Equivalency Ratio (LER) as done by Osman et al. (2011). Crop yields were also converted to protein equivalent, carbohydrate equivalent, and imputed revenue and compared.

Verifying the marginality of the agriculture system, yield of maize and millet single-crops were 1.14±0.12 and 0.91± 0.28 tons ha^{-1}, respectively, which were significantly lower than the national averages (2.28 and 1.12, respectively) (MoAC, 2011) ($p<0.001$ and 0.02), whereas yield of cowpea single-crop was 0.87± 0.19 tons ha^{-1} which was comparable to the Nepal national average of 0.95 tons ha^{-1}.

The effect of village on maize yields in the first cropping season, and cowpea and millet in the second cropping season was significant (p values were 0.04, 0.004 and <0.001, respectively for maize, cowpea and millet). The effect of intercropping in millet yield was significant ($p<0.001$), indicating that millet yield in intercropping was significantly lower than with a single-crop. Nevertheless, yields of maize and cowpea in intercropping were comparable with that of single-crop. Thus, although yield of millet decreases with the use of intercropping, farmers will still benefit through the cowpea yield. Yield of crops in conventional tillage and strip tillage was also comparable. When comparing the LER of different treatment combinations, it was found the millet-cowpea intercrop with conventional tillage (LER = 1.20) had significantly higher LER than any single-crops. This major gain was attributed to cowpea, which produced 75% of its single-crop yield in intercropping. However, the LER of millet-cowpea intercrop with strip tillage was comparable with single-crops. Thus, results suggest that strip tillage had a negative effect on the overall biomass production during the first growing season.

Since most crop production is for household consumption, we also analyzed how CAPS treatments affected the total protein and carbohydrate availability and revenue in households. Protein and carbohydrate yields of CAPS treatments i.e. sole cowpea with CT, millet+cowpea with CT, millet+cowpea with ST were compared with traditional practice i.e. millet with CT. Analysis showed that CAPS treatments were found to significantly affect protein yield ($p=0.006$) and revenue generation ($p=0.01$) per-hectare, but had no effect on carbohydrate yield. This analysis suggested that integrating cowpea in the agricultural system, either by single cropping or intercropping, provides the potential of increasing protein availability and household revenue. This increased availability of protein is particularly crucial since protein deficiency has been identified as a major health problem in Nepal.

The preferences of farmers regarding CAPS were assessed using Analytic Hierarchy Process (AHP) with 41 randomly selected farmers. Farmers were asked to give the factor that affects their agricultural income and weight them according to their importance. Results indicate that farmers perceived soil quality as the most important factor to their goal of improved income (49%), followed

by yield (25%), profit (14%), and labor savings (11%). This perception of farmers was understandable because quality of land directly affects income through yield, profitability and labor saving. Farmers weighted cowpea single-crop with conventional tillage as having the highest contribution toward improved income (35%), followed by millet-cowpea intercrop with strip tillage (34%), and millet-cowpea intercrop with conventional tillage (22%).

In conclusion, while the long-term effects of CAPS on soil and environmental health remains to be analyzed, the initial results provide evidence of the positive impacts of cowpea intercropping with millet. Moreover, the strip tillage seem to affect the total biomass yield negatively, but still comparable in initial years. Hence, increase yield and contribute to sustainable food and nutritional security in Nepal.

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