Innovative participatory farming system design: combining on-farm crop/livestock trials with ex-ante trade-off analysis

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1 Introduction

In Southern Mali, farmers grow cotton for income generation, cereals for food self-sufficiency and keep livestock for draught power, milk, meat, manure, and buffer against risk. Due to increasing land and market pressure, farmers need to adapt to the decline of cotton sector (Coulibaly et al., 2015) and decreasing fodder availability for livestock. This study presents an innovative approach to design adaptive farming systems based on participatory on-farm crop/livestock trials and ex-ante analysis, using farmers' input at every stage of the process.

2 Materials and Methods

An iterative learning cycle of testing and refining seven options for sustainable intensification was applied in the Koutiala district with farmers belonging to four farm types: High Resource Endowed farms with Large Herds (HRE-LH), High Resource Endowed farms (HRE), Medium Resource Endowed farms (MRE), and Low Resource Endowed farms (LRE). The options were co-designed by farmers and researchers and each contained two to four treatments. For maize, sorghum and groundnut, improved varieties combined with fertilizer and manure were compared with farmer practice. For soybean and two improved varieties of cowpea, inoculation (soybean) and addition of P (cowpea and soybean) was compared with a control with no input. Two other options included cereal/legume intercropping and stall feeding of lactating cows during the dry hot season. This basket of options was tested by 12, 121, and 132 farmers in 2012, 2013 and 2014 respectively in a total of 451 on-farm trials. Farmer practice for maize, sorghum and groundnut, and soybean and cowpea were assessed based on yield and gross margin (revenue-variable costs). Treatments with extra input (e.g. inoculation, addition of mineral fertiliser, cotton seed cake) were assessed based on yield increase, return to investment and probability to generate profit (based on spatial variability in trials). Participatory Analysis of Variance (PANOVA) of yields in trials was carried out and farmers were asked to indicate possible reasons for the yield differences observed in contrasting trials. After the field visits, a productivity and profitability analysis was discussed with 30 farmers who were asked to indicate options and specific treatments they preferred. Scenarios integrating these preferred options were designed with 12 farmers (three per farm type) during individual sessions and assessed with a simple farm trade-off analysis linking crop area and yields to total production and total income from crops and lactating cows. The trade-off analysis was refined based on farmers' feedback, measured yields and results from soil analyses. Yields were averaged per soil type and previous crop when there was a significant effect or averaged across soil type and previous crop when there was no significant effect. Cowpea fodder was assumed to be fed to lactating cows in the stall (for HRE-LH and HRE farms) and surplus sold. Using the current cropping pattern of 37 farms, we performed ex-ante trade-off analysis of the farmer-designed scenarios and assessed the effect on average food self-sufficiency and average increase in net cash income per farm type.

3 Results - Discussion

Average grain yields with farmer practice were 1.83, 1.03 and 0.54 t ha^{-1} with an average gross margin of 191, 244, 527 USD ha^{-1} year^{-1} for maize, sorghum and groundnut respectively. Improved maize and sorghum varieties did not increase yields, while groundnut improved variety gave a 28% yield increase, a 1.46 return to investment and a 58% chance to generate profit. Soybean, cowpea grain variety and cowpea fodder variety with no inputs were more profitable (280, 311, 750 USD ha^{-1} year^{-1} respectively), but yielded less grain (0.41, 0.23 and 0 t ha^{-1} respectively) compared to maize and sorghum with farmer practise. Addition of P did not increase cowpea grain yield but gave a 126% yield increase for soybean, with a 1.7 return to investment and a 49% chance to generate profit. Mixing cowpea with maize gave a 4 and 13% decrease in maize yield, a 7.4 and 16.3 return to investment with a 60% and 76% chance to generate profit for the cowpea grain and fodder variety respectively. During the PANOVA, farmers indicated that soil type and previous crop could explain spatial yield variability. This perception, substantiated with a statistical analysis of trial results, allowed for identification of specific niches for intensification: (i) on clay soils after cotton or maize, soybean was two times more profitable than sorghum (ii) on gravelly and sandy soils, cowpea grain variety was 2 and 1.4 times more profitable than sorghum respectively, (iii) after cotton or maize, there was no maize grain yield penalty due to the intercropping with cowpea. HRE-LH farmers preferred the maize/cowpea option, HRE farmers the cowpea fodder variety option, MRE farmers the maize option and LRE farmers the cowpea grain variety option (Table.1).

Table. 1. Percent farmers who chose the option (all treatments taken together).

farm type	n	maize	sorghum	maize/cowpea	sorghum/cowpea	cowpea grain	Cowpea fodder	Soybean
HRE-LH	7	57	14	71	0	43	57	43
HRE	12	50	50	33	8	50	67	42
MRE	6	83	17	17	0	50	50	33
LRE	5	80	60	20	0	100	0	40

Stall feeding of lactating cows showed a four-fold increase in total milk yield and a doubling of total manure production compared to the farmer practice of free grazing, with a 0.4 return to investment. During participatory scenario design, HRE-LH and HRE farmers wanted to evaluate the combination of maize/cowpea intercropping with stall feeding of cows. MRE farmers wanted to assess substitution of sorghum by soybean, while LRE farmers were interested in substitution of sorghum by cowpea grain variety.

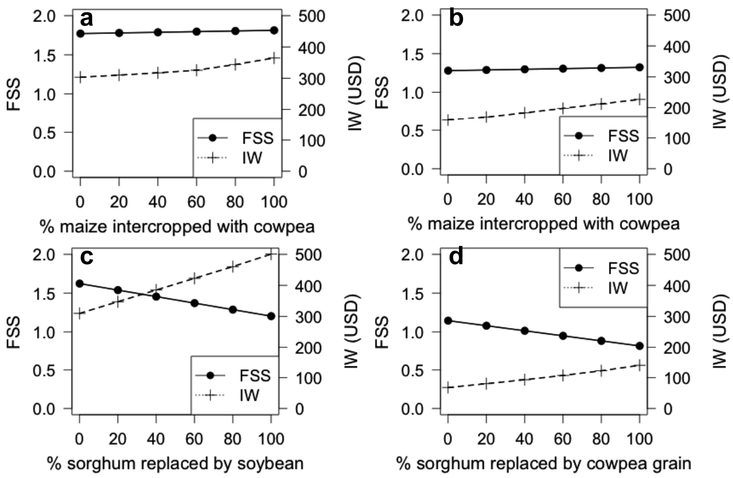

Fig. 1. Ex-ante trade-off analysis for HRE-LH farms (a), HRE farms (b), MRE farms (c) and LRE farms (c). FSS= household Food Self-Sufficiency, IW= net cash Income per Worker

Ex-ante trade-off analysis showed that for HRE-LH farms, intercropping with cowpea on 60% of the maize area after cotton would allow to feed all the lactating cows in the stable during the dry hot period (results not shown) without compromising household food self-sufficiency (Fig.1a). For HRE farms who keep less cattle, this percentage would be reduced to 30%. In those two scenarios, income increase would be limited (Fig.1a&b) as the extra milk barely offsets the cost of cotton seed cake to feed the cow. However, 2 and 0.3 t of extra manure would be produced by HRE-LH and HRE farms respectively, and better reproductive performance of the herd would be achieved in the long term (de Ridder et al., 2015). Intercropping 100% of maize with cowpea and selling the fodder produced beyond cows need would lead to a 20 and 42% income increase for HRE-LH and HRE respectively. MRE farms replacing 50% of sorghum by soybean (on clay soils after cotton) would increase their income by 30% while maintaining food self-sufficiency (Fig.1c). LRE farms replacing 30% of sorghum by cowpea grain (on gravelly and sandy soils) and selling cowpea fodder would increase their net IW by 28% without compromising food self-sufficiency (Fig.1d).

4 Conclusions

The trust built through regular interactions between farmers and researchers, combined with reflective on-farm testing, participatory appraisal and participatory scenario design and analysis led to to the identification of farm type-specific promising pathways to agro-ecological intensification. Farmers were enthusiastic about results of the scenarios and some farmers who did not participate in the research buy improved grain and fodder variety cowpea seeds. Other farmers expressed their interest to expand the area allocated to soybean. Our work highlights the value of designing adaptive farming systems based on participatory on-farm crop/livestock trials and ex-ante analysis, using farmers' input at every stage of the process.

References

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