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Improving productivity and household incomes of resource-poor farmers: The case of cassava-cowpea intercrop

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Abstract. Intercropping is a widespread practice in tropical developing countries. The cassava-cowpea intercrop system was identified as one of the major four cropping systems in the forest and southern Guinea savanna zones of West and Central Africa. The objectives of the study were to evaluate the relative times of planting cowpea, cowpea row arrangement and cassava variety in cassava/cowpea intercrop in farmers' fields on: (a) the crop productivity of the systems, (b) assess their economic return and (c) identify those suitable for further on-farm demonstrations and transfer to farmers. Cassava/cowpea intercrops were tested on farmers' fields in 2000-2002 in the transition and coastal savannah zones of Ghana for sustained crop productivity and household incomes. An incomplete block design was used to assign a factorial combination of three cassava varieties, two relative times of planting and three row arrangements to farmers' fields. The 1 row Afisiafi cassava or local cassava combined with 2- or 3-rows of Asetenapa cowpea; with Asetenapa planted 4 weeks after cassava were the most productive systems. Productivity (LER) over the sole crops ranged from 41% for Afisiafi to 113% for the local variety. Abasafitaa, Afisiafi and local cassava planted 4 weeks before Asetenapa yielded 41-51%, 67-87% and 109-112% of sole crop, respectively. Asetenapa yielded 20% higher under the local than the improved cassava varieties. Averaged over both years, the 1 row cassava (all varieties)/ 2 rows cowpea with cowpea planted 4 weeks after cassava system gave the highest benefit/ cost ratio (2.72-3.56) and net benefits (¢2.25 million - ¢3.35 million) over the other intercrop systems and the sole crops. Sole cowpea gave the lowest benefit/cost ratio (1.50) and net benefits (¢627,000.00).

Introduction

Intercropping systems involving root crops and legumes have been important traditional farming systems in the developing tropics, especially West Africa. They have been stable production systems that have achieved a level of productivity satisfying prevailing needs of the smallholder farmers and their families. In a general survey of cropping systems in West and Central Africa from 1988-90, the cassava-cowpea intercrop system was identified as one of the major four cropping systems in the forest and southern Guinea savanna zones (Singh, 1993). In Ghana, it is practiced extensively in the forest-savanna transition, forest and coastal savanna zones. While the cassava serves as the main staple (carbohydrate source), the cowpea provides an inexpensive, affordable source of high quality protein to supplement the starchy-based diets and additional cash benefits. Cowpea may also help improve soil fertility through N_2-fixing, and control erosion and weeds.

The system thus, has a great potential to meet future demands such as sustaining increased food production and contributing highly to food security, reduction of malnutrition, hunger and poverty, and maintenance of soil fertility. However, farmers in these zones generally plant their intercrop crops randomly without any defined row arrangements, use variable relative planting times and also use low yielding varieties (especially the cassava). This has resulted in lower component crop populations, difficulty in management, low crop yields and overall productivity of the systems. Because traditional cropping systems are not necessarily stagnant, but innovation and change are normal features (Ruthenberg, 1980), the challenge is to accelerate this process while maintaining the benefits inherent in stable systems. The challenge faced by researchers is to improve the yield and overall productivity of the cassava-cowpea intercrop system to provide a unique prospect for alleviating poverty and sustaining the livelihood of the numerous resource-poor farmers practicing it. This demands a good understanding of the agro-economic effects or interactions of the system. It was with the purpose of evaluating alternative management systems that are close to farmers' current practices that a verification trial was initiated. The objectives were to evaluate the relative times of planting cowpea, cowpea row arrangement and cassava variety in cassava/cowpea intercrop in farmers' fields on (a) the productivity of the systems, (b) their economic return and (c) identify those suitable for further on-farm demonstrations.

Materials and Methods

A cassava/cowpea intercrop verification trial was conducted on farmer's fields in the forest, forest-savanna transition and coastal savanna zones of Southern Ghana during the 2000/01 and 2001/02 cropping seasons. The three ecological zones have bimodal pattern of rainfall with major rainy season in April-July and minor rainy season in September-November. The verification was planted in April/May in both seasons at all agro-ecologies. An incomplete-block factorial design was used to assign a combination of (i) *2 relative times of planting cowpea* (i.e. cowpea planted 2 weeks before cassava (WBC) or 4 weeks after cassava (WAC), (ii) *3 cowpea row arrangements* (i.e. 1 row cassava alternating with 2, 3 or 5 rows of cowpea) and (iii) *3 cassava varieties* (Afisiafi, Abasafitaa and Local (farmer's variety)) to farmers. Afisiafi and Abasafitaa are high branching, improved cassava varieties and mature in 12 months. There were 12 farmers or locations in 2000/01 and 18 farmers in 2001/02. Plot sizes were 12 m long and 3, 4 and 6 m wide for the 2, 3 and 5 rows treatments, respectively. Between row spacing was 50 cm for all intercrops, while within row spacing was 1 m (1 plant/hill) for cassava and 20 cm (2plants/hill) for cowpea. Sole cassava and sole cowpea controls were spaced at 1 m x 1 m (1 plant/hill) and 50 cm x 20 cm (2plants/hill), respectively. The cowpea variety used was 'Asetenapa' (a 60-65 day maturing semi-erect improved variety). Land preparation involved slashing or ploughing. Subsequent weed control was by hand (two weedings for the intercrops and sole cowpea and three or four for sole cassava). Cowpea was protected against insect pests with two applications of Karate 2.5EC (a.i lambda-cyhalothrin 25g/l) at a rate of 600 ml/ha and one application of Cymethoate EC (a.i cypermethrin 35g/l and dimethoate 250g/l) at a rate of 1000 ml/ha.

At maturity, whole plots were harvested. Data were collected on grain and tuber yields of cowpea and cassava. The prices for both inputs and outputs were collected in both seasons from the farmers and local markets. Labour data were recorded from farmers using the "by-day" or tractor (in the case of ploughing) charges at each locality. The range for labour charges among the localities was very small that average charges were calculated for various field operations. Mixed models were used to statistically analyze the productivity (cowpea and cassava yields) using SAS (SAS, 1988). Farmers or sites were treated as random. The land equivalent ratio was calculated to assess the advantages of intercropping. Partial budget analyses were done to calculate the net returns for each treatment and the marginal rate of return (MRR) and to identify the dominated treatments (CIMMYT, 1988). The MRR was calculated as:

$MRR = (NR_i - NR_j)/(TVC_i - TVC_j)$

where: NR_i = net revenue for treatment i
NR_j = net revenue for treatment j
TVC_i = total variable cost for treatment i
TVC_j = total variable cost for treatment j

Results and Discussion

Crop yields and productivity. The Afisiafi, Abasafitaa and local cassava varieties yielded 37-84 %, 51-85% and 34-66 % of sole crop yield, respectively, when cowpea was planted two weeks before in both seasons (Figs. 1a and 2a). However, when planted 4 weeks before cowpea, Afisiafi, Abasafitaa and local cassava yielded 52-94 %, 62-83 % and 42-73 % of sole crop yield, respectively. Across all row arrangements and both relative times of planting, the improved cassava varieties (Abasafitaa and Afisiafi) yielded 100-200 % higher than the local varieties under both sole cropping and intercropping (Figs. 1a, 1d, 2a and 2d). Several other workers have also shown improved cassava varieties to be higher yielding than local ones in intercropping (Hahn et al. 1979; Nweke *et al.* 1988; Ennin *et al.*, 2001). Nweke *et al.* (1988) and Ennin *et al.* (2001), for example, reported that improved cassava varieties yielded 71% and 150 % higher than local ones in intercropping systems, respectively. Generally, all the cassava varieties in cowpea planted 4 weeks after cassava (4WAC)(Figs. 1d and 2d), yielded higher than cassava in cowpea planted 2 weeks before cassava (2WBC) (Figs. 1a and 2a), indicating more competition from the cowpea when it was planted earlier. On the average, all cassava varieties yielded higher when intercropped

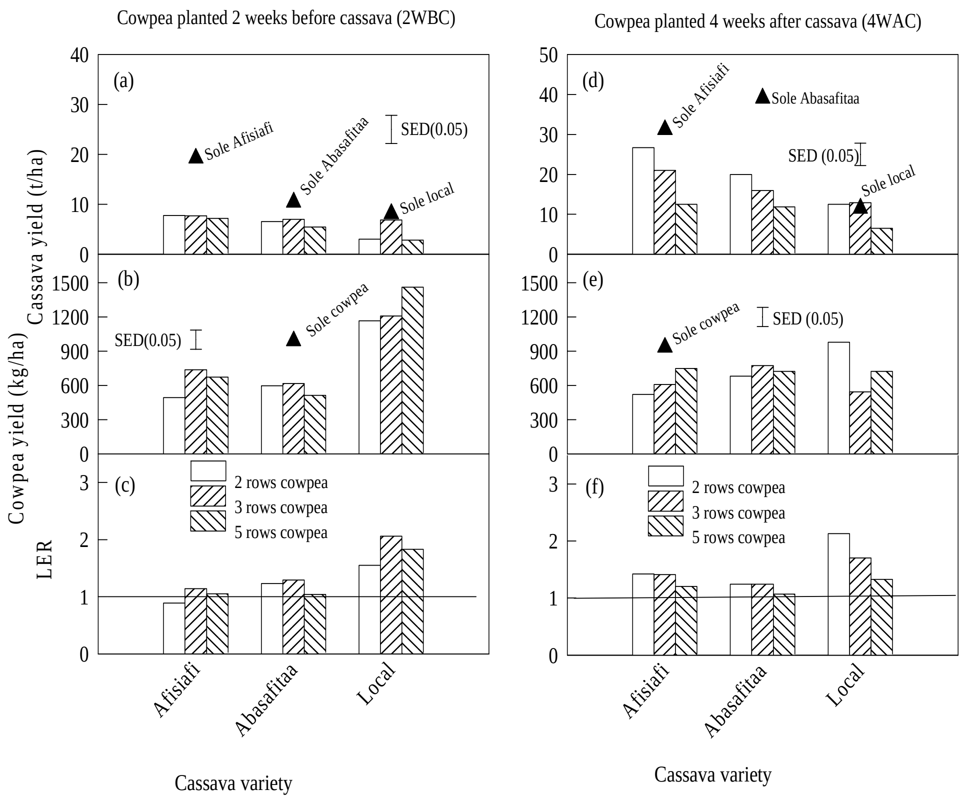

Figure 1: Cassava tuber and cowpea grain yields and LER of a cassava-cowpea intercrop as affected by cassava variety, row arrangement and relative times of planting in the forest, transition and coastal savanna zones of Ghana, 2000/01.

with less rows of cowpea. In 2000/01, cassava yields were particularly low when cowpea was planted 2 weeks before (Fig. 1a). This was due to competition from the cowpea and the inability of cassava to recover faster and fully after cowpea harvest as a result of the intermittent drought conditions experienced in many sites in August-October 2000. In such stress situation, the cassava in more rows of cowpea, yielded equally as cassava in less rows of cowpea, indicating the positive effects of more legume rows through N-fixation, soil moisture, etc, on cassava during the stress periods.

In both seasons, cowpea planted 2 weeks before or 4 weeks after the local cassava variety at any of the row arrangements produced similar or higher yields than sole cowpea (Figs. 1b, 1e, 2b and 2e). Generally, Asetenapa cowpea yielded 20 % higher under the local variety than the two improved cassava varieties. This can be attributed to the less branching and less competitive ability of the local variety compared to the more aggressive improved varieties (Abasafitaa and Afisiafi). It must, however, be noted that the local varieties differed from farmer to farmer as these were taken from the localities the verification was tested. Between the relative planting times, cowpea planted 2 weeks before any of the cassava varieties did not yield significantly different from cowpea planted 4 WAC (Tables 1 and 2). The slow growth of cassava and the drought experienced in many parts of the country, especially in the 2000/01 season, affecting cassava growth and its competitive ability might have accounted for this. Cowpea yield did not differ among the row arrangements under the improved cassava varieties, when

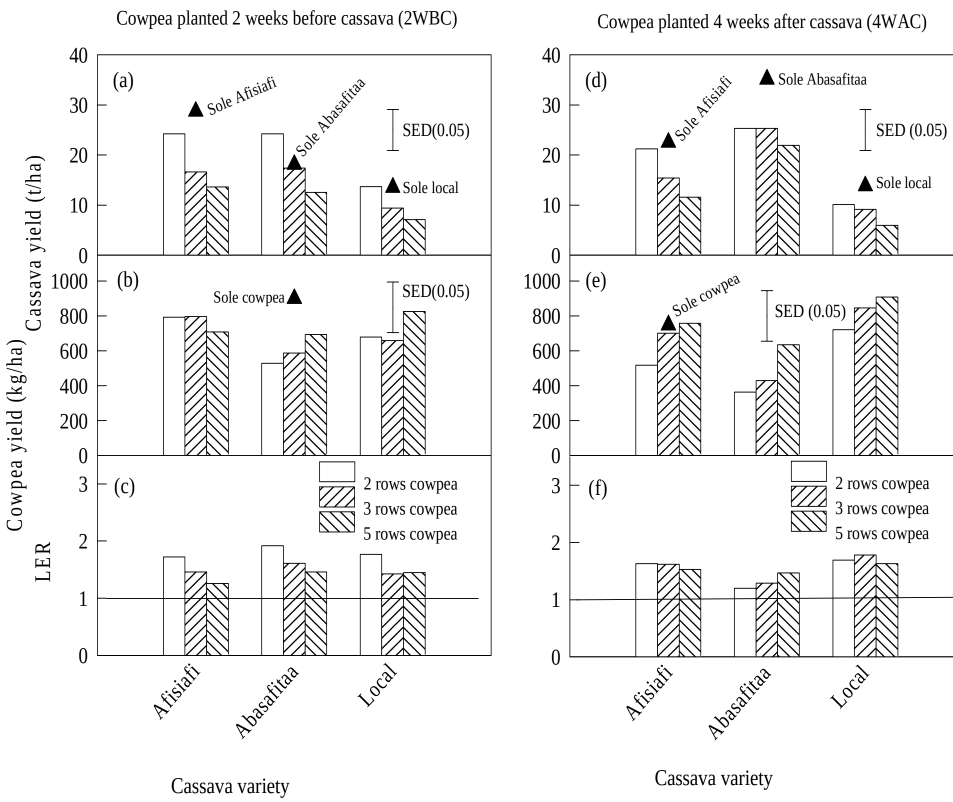

Figure 2: Cassava tuber and cowpea grain yields and LER of a cassava-cowpea intercrop as affected by cassava variety, row arrangement and relative times of planting in the forest, transition and coastal savanna zones of Ghana, 2000/02.

Table 1: A partial budget analysis of Asetenapa planted 4 weeks after Afisiafi under different row arrangements averaged over 2 years in southern Ghana.

	Treatments				
	2 rows	3 rows	5 rows	Sole cowpea	Sole cassava
Gross farm gate benefit from cassava (¢ x 10^3)	3487.12	2651.38	1754.48	-	3907.90
Gross farm gate benefit from cowpea (¢ x 10^3)	1170	1473.75	1698.75	1894.5	-
Total gross farm gate benefits (¢ x 10^3)	4657.12	4125.13	3453.23	1894.5	3907.90
Seed/planting material costs (¢ x 10^3/ha)	266.6	247	227.4	196	200
Labour costs (¢ x 10^3/ha) [3]	930	930	930	905	1000
Insecticides costs (¢ x 10^3/ha)	110.6	124.5	138.31	166	0
Total variable input cost (¢ x 10^3)	1307.29	1301.5	1295.71	1267	1200
Net benefit (¢ x 10^3/ha)	3349.83	2823.63	2157.52	627.5	2707.90
Benefit/Cost ratio	3.56	3.17	2.67	1.50	3.26
Dominance analysis			D	D	
Marginal rate of return (MRR)	102.96[4] 90.8[6]	115.04[4]			5.98[5]

[1] Farm gate price of cassava fresh root yield = ¢182,000.00/ton. [2] Farm gate price of cowpea = 2,500.00/kg.
[3] Labour cost for land preparation, planting, weeding, spraying and harvesting. D = Dominated by sole cassava
[4] MRR of 2 rows and 3 rows over 5 rows. [5] MRR of 2 rows over sole cassava. [6] MRR of 2 rows over 3 rows.

Table 2: A partial budget analysis of Asetenapa planted 4 weeks after Abasafitaa under different row arrangements averaged over 2 years in southern Ghana.

	Treatments				
	2 rows	3 rows	5 rows	Sole cowpea	Sole cassava
Gross farm gate benefit from cassava (¢ x 10^3) [1]	3297.84	3000.82	2459.18	-	5398.85
Gross farm gate benefit from cowpea (¢ x 10^3) [2]	1174.5	1354.5	1527.75	1894.5	-
Total gross farm gate benefits (¢ x 10^3)	4472.34	4355.32	3986.93	1894.5	5398.85
Seed/planting material costs (¢ x 10^3/ha)	266.6	247	227.4	196	200
Labour costs (¢ x 10^3/ha) [3]	930	930	930	905	1000
Insecticides costs (¢ x 10^3/ha)	110.6	124.5	138.31	166	0
Total variable input cost (¢ x 10^3)	1307.29	1301.5	1295.71	1267	1200
Net benefit (¢ x 10^3/ha)	3165.05	3053.82	2691.22	627.50	4198.85
Benefit/Cost ratio	3.42	3.35	3.08	1.50	4.50
Dominance analysis	D	D	D	D	
Marginal rate of return (MRR)	40.92[4] 19.21[5]	62.62[4]			

[1] Farm gate price of cassava fresh root yield = ¢182,000.00/ton. [2] Farm gate price of cowpea = 2,500.00/kg.
[3] Labour cost for land preparation, planting, weeding, spraying and harvesting. D = Dominated by sole cassava
[4] MRR of 2 rows and 3 rows over 5 rows. [5] MRR of 2 rows over 3 rows.

it was planted 2 WBC (Figs. 1b and 2b). However, under the local variety, the 5 rows yielded 21-25 % higher than the 2-rows and 3-rows in both years (Figs. 1b and 2b). When planted 4 WAC, cowpea yields were similar for all row arrangements under all varieties. These results suggest that it may be profitable for a farmer interested in cowpea to adopt the 2- or 3-row instead of the 5-row arrangement, which obviously involved more cost for labour and seed. In addition, more cassava rows or stands on per hectare basis will be harvested in the 2- or3-row arrangement.

The land equivalent ratio (LER) has been a biological index used to compare the advantages (or productivity) of intercropping over sole cropping (Mead and Willey, 1980). The cassava variety influenced the LER (productivity) of the systems. Although the improved cassava varieties produced higher tuber yields, mean LER values were, on the average, lower than those for the local cassava varieties under either of the relative planting times (Figs 1c, 1f, 2c and 2f). Productivities for both years ranged from 0.89-1.72, 1.04-1.92 and 1.33-2.13 for Afisiafi, Abasafitaa and Local, respectively. Dapaah *et al.* (2003) obtained similar results, where intercrops involving an improved cassava variety “Gblemoduade” had lower mean LER values than those for a local variety “Ankra”, despite higher tuber yields. These differences in LER were due mainly to the partial LER contributions of the cowpea crop. Several studies (Fisher, 1977; Francis *et al.*, 1982; Ofori and Stern, 1987) have shown that even though the cereal or root crop components usually contribute a greater proportion of the mixture yield (e.g. about 80 %) (Fisher, 1977), the magnitude of intercropping advantage or efficiency measured in terms of LER follows the trend in the legume yield. Therefore, the inclusion of cowpea in the cassava/cowpea system increases the efficiency of land use and may also improve soil fertility and conserve soil. Some reported gains in land use efficiency of involving legumes in intercrops are 30-52 % for cassava/soybean (Ennin-Kwabia *et al.,* 1993), 20-62 % for maize/cowpea (Asafu-Agyei *et al.*, 1997; Ennin *et al.*, 1999) and 58-128 % for cassava/maize/cowpea (Ennin *et al.,* 2001). The 1 row Afisiafi or local cassava variety combined with 2 or 3 rows of Asetenapa, with cowpea planted 4 WAC were the most productive systems (Figs. 1f and 2f). Productivities over the sole crops ranged from 41-63 % for Afisiafi and 69-113 % for the local variety. Intercrops involving Abasafitaa gave the lowest LERs (7-47 %). Generally, productivities were higher with the 2 and 3-row arrangements than the 5-row arrangement. Combining the yields of both cassava and cowpea, and their efficiencies of land use (productivities), planting cowpea 4 WAC and at 2- or 3 rows gave higher combined yields of both crops.

Economic analyses. Partial budget analyses were done for only cowpea planted 4 WAC, since that option was more productive in terms of cassava and cowpea component crop yields and land use efficiencies. The economic analyses results, combined over both seasons are shown in Tables 1, 2 and 3. In general, all treatments including the sole crops were economically attractive as they had positive net benefits. Furthermore, the benefit/cost ratios for all, except for sole cowpea and sole local cassava, were greater than 2.0 (Tables 1, 2 and 3).

Results from the analysis for the treatments under Afisiafi showed that 5-rows gave the least benefit/cost ratio and net benefits among the row arrangements (Table 1). The dominance analysis showed that sole Afisiafi had higher net benefit and lower total variable input cost than those of 5-row arrangement and sole Asetenapa. Therefore, 5-row and sole Asetenapa were dominated by sole Afisiafi. The MRR results gave ratios of 102.96 (or 10296 %) between 2 rows and 5 rows (Table 1). Between 2 rows and 3 rows and 2 rows and sole Afisiafi, MRR ratios of 90.8 (908 %) and 5.98 (598 %), respectively were obtained. Adoption of the 2-row arrangement over the 5-row would give an additional gain of ¢9296 for every ¢1000 invested in the process of production.

Table 3: A partial budget analysis of Asetenapa planted 4 weeks after Local under different row arrangements averaged over 2 years in southern Ghana.

	Treatments				
	2 rows	3 rows	5 rows	Sole cowpea	Sole cassava
Gross farm gate benefit from cassava (¢ x 10^3) [1]	1645.28	1600.14	902.72	-	1844.75
Gross farm gate benefit from cowpea (¢ x 10^3) [2]	1917.00	1566.00	1836.00	1894.50	-
Total gross farm gate benefits (¢ x 10^3)	3562.28	3166.14	2738.72	1894.50	1844.75
Seed/planting material costs (¢ x 10^3/ha)	266.6	247	227.4	196	200
Labour costs (¢ x 10^3/ha) [3]	930	930	930	905	1000
Insecticides costs (¢ x 10^3/ha)	110.6	124.5	138.31	166	0
Total variable input cost (¢ x 10^3)	1307.29	1301.5	1295.71	1267	1200
Net benefit (¢ x 10^3/ha)	2254.99	1864.64	1443.01	627.50	644.75
Benefit/Cost ratio	2.72	2.43	2.11	1.50	1.54
Dominance analysis				D	
Marginal rate of return (MRR)	70.12[4] 67.42[6]	72.82[4]			15.01[5]

[1] Farm gate price of cassava fresh root yield = ¢182,000.00/ton. [2] Farm gate price of cowpea = 2,500.00/kg.
[3] Labour cost for land preparation, planting, weeding, spraying and harvesting. D = Dominated by sole cassava
[4] MRR of 2 rows and 3 rows over 5 rows [5] MRR of 2 rows over sole cassava. [6] MRR of 2 rows over 3 rows

Similarly adopting the 2-row intercropping arrangement over the 3-row or sole cropping would give an additional gain of ¢808 for every ¢1000; or ¢498 for every ¢1000, invested in the process of production. Adopting the 3-rows over the 5-rows gave a MRR of 115.04 (11504 %). The difference between MRR and AMRR were also very high. Therefore, with Afisiafi, the 2-row arrangement is recommended, although the 3-row arrangement was also profitable.

The partial budget analysis for all treatments under Abasafitaa also showed that the 5-row arrangement gave the least net benefit and benefit/cost ratio (Table 2). However, the dominance analysis indicated that sole Abasafitaa dominated all treatments, with the highest net benefit but the lowest TVIC. These results indicate that sole Abasafitaa was more profitable than intercropping with cowpea; and that Abasafitaa does not lend itself well to intercropping due to its lowly place and higher number of branches compared with Afisiafi. However, if any intercropping is to be done, then the 2-row arrangements is also recommended because it gave higher net benefit, benefit/cost ratio and MRRs of 19.21 (1921 %) and 40.92 (4092 %) over the 3-rows and 5-rows arrangements.

With the local cassava varieties, the results showed they lend themselves very well to intercropping because all the intercropping gave higher net benefits and benefit/cost ratios than the sole cropping, and none of them was dominated by the sole cropping (Table 3). Similar to the results obtained with Afisiafi and Abasafitaa, the 2-row arrangement gave MRR values of 67.42 (6742 %) and 70.12 (7012 %) over the 3-row and 5-row arrangements, respectively.

Conclusion

The productivity and economic analyses indicate that intercropping Asetenapa with Afisiafi or the local cassava varieties, with Asetenapa cowpea planted 4WAC and at 1 row cassava alternating with 2- or 3-rows cowpea are systems recommended for further demonstrations and potential adoption by farmers. These systems, particularly the 1 row cassava alternating with 2 rows cowpea, were not dominated by other systems and also had very high MRR. Discussions with farmers revealed most farmers preferred 1 row cassava/ 2 or 3 rows cowpea based on cowpea and cassava performance and yield. This was confirmed by the analyzed results. However, most indicated higher preference for the 1 row cassava/2 row cowpea over the 3 rows, because of wide spaces left in between cassava rows as a result of failure to follow-up in the minor season with a third crop. In the zones where most farmers are already practicing the cassava/cowpea intercrop system, except that the crops are randomly planted, some have adopted the row planting of either 1 row of cassava with 2 rows or 3 rows cowpea. This system has all the potential for improving and sustaining crop productivity and household incomes and nutrition of the farmers.

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