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Participatory Evaluation of Improved Cowpea Lines and Cropping Systems for Enhancing Food Security and Income Generation in Niger Republic, West Africa

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Abstract: On farm participatory evaluations of sole cropping of improved cowpea [*Vigna unguiculata* (L.) Walp.] varieties and cowpea-cereal strip cropping systems were conducted around Maradi and Zinder region, Niger Republic in 2002 and 2006. Majority of the improved cowpea varieties showed resistance to the common diseases in these areas with four of them immune to Striga infestation. They were however judged to produce lower grain and fodder yields than traditional varieties under traditional intercropping system. The improved cowpea varieties however produced higher grain and fodder yields when planted as sole crop or in an improved intercropping system. The farmer participatory evaluations produced valuable feed back for breeders and agronomist on the perception of research results and open new research areas. Result showed that combined grain yields of local cowpea and cereals ranged from o to 950 kg/ha, generally there was over 300% increase in cowpea grain yield and over 200% increase in value of products when improved varieties were used in improved cropping system compared to the traditional systems using the local varieties. The improved planting system also produced better quality crop residues due to the higher proportion of legume residue. Four varieties (IT90K-372-1-2, IT97K-499-38, IT97K-499-35 and IT89KD-374-57) have been identified as having higher grain and fodder yield on-farm. Two of these, (IT97K-499-38 and IT97K-499-35) are resistant to Striga and would be widely used especially in areas with high Striga infestations.

Key word: Cowpea · Cropping system · Farmer participatory evaluation · Striga resistance

INTRODUCTION

The rapid increase in population and consequent pressure for food is driving agriculture towards greater intensification in West Africa [1]. The long fallow periods have not only diminished but agriculture has now been pushed on to marginal lands leaving little or no scope for further expansion in the cultivated area [2]. This has led to continuous decline in per capita availability of food leading to widespread malnutrition and hunger. This is more pronounced in the dry savannas of West Africa where rainfall is low and soils are predominantly sandy with low organic matter, low phosphorus and poor water holding capacity [2]. Also, bulk of the agriculture in this region is still based on intercropping involving cereals and legumes. Yield of major crops like maize, sorghum, millet, cowpea and groundnut in these systems are very low due to a number of biotic and abiotic constraints on one hand and due to low fertility and lack of inputs like improved seeds, fertilizers and pesticides on the other hand. Recent study, Van Ek *et al.* [3] indicated that farmers obtain less than 1 ton food per hectare which perpetuates poverty through the vicious circle of 'low input – low production – low income'. Experiments have shown that by using improved seeds and adequate doses of fertilizers and pesticides the average yields can be raised 3 to 4 times [4], but in practice only limited quantities of these inputs are available and that also not within the easy reach of small holder farmers in terms of physical distance and cost. The average use of fertilizers in West Africa is less than 10 kg/ha/year compared to 100-4000in other countries [5]. Recent estimates indicated that the annual nutrient losses exceed 26 kg of N, 3 kg of P and 19 kg K ha^{-1} [1]. This leads to negative balance of nutrients in the soil and continuous decline in crop yields. This trend must be reversed. It is a known fact that

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without inputs, yields can not be increased substantially but at the same time large quantities of fertilizers and chemicals are neither available nor desirable. Thus, the challenge is to maximize the benefits of small amount of purchased inputs like improved seed, fertilizer and chemicals and use of manure from the existing livestock to enhance organic matter in the soil and increase and sustain crop productivity. This is possible only by developing improved crop-livestock systems and the use of dual purpose crops and varieties. Improved crops and cropping systems may be used as good innovations towards green revolution in Africa to enhance food security and income generation. Improved varieties of several crops are available but their adoption is slow or in some cases they may not be adopted due to non compatibility or relevancy with the farmers' situations. It has been increasingly realized that new technology alone is insufficient for achieving impact [6], as a result, many research organizations have moved from a primary focus on productivity to include concerns about the environment, poverty and food and financial security, reflecting a growing understanding that securing food, eradicating poverty and protecting natural resources are inseparable goals [7]. Farmers' participatory evaluations of crop varieties and cropping systems are a better option in improving the adoption of the new varieties and technologies. A farmer participatory on-farm evaluation and dissemination of cowpea varieties and improved crop-livestock system is in progress in the Sahel of South east Niger Republic. Some of the results of the trial are presented in this paper.

MATERIALS AND METHODS

IITA started Farmer's participatory evaluation of improved cowpea varieties in Niger Republic in 2002, with the involvement of Institut de la Recherches Agronomiques du Niger (INRAN), NGOs and several farmer groups. Eleven promising cowpea varieties selected from the on-station trials in Toumnia (13^0 58`N $09^0$ 01`E) were given to 70 farmers from 7 villages. Each farmer was given 500 gm each of two varieties and was encouraged to plant in their traditional practices. Subjective data were taken and questioner was administered on each farmer. Farmers were required to rank the performances of the improved varieties and state whether they were worse than, better than or as good as the local varieties in attributes such as seed sizes, seed color, germination, pest and diseases incidence, days to flowering and maturity and grain and fodder yields.

A follow up was made in 2006; it started with a Stakeholder workshop, during which all the relevant stakeholders were invited to a one day workshop. Discussions were held with the Scientist, Government Representatives and farmer groups and various NGOs present in the regions. During these meetings, villages were recommended for inclusion in the project. 10 villages from 3 departments were recommended from Maradi Region while 16 Villages from 5 departments were recommended from Zinder region. Scientist and selected NGOs and farmers' representative undertook a visit of all recommended villages and had village level discussions with the farmers and farmers' groups. A total of 159 farmers from 19 villages in 2 regions (Mardi and Zinder) were selected to participate in the project in 2006 including 28 women farmers. During the village meetings the proposed activities were explained to the farmers and feedback were taken from them about the important constraints to increasing agricultural productivities. The farmers interacted freely with the Scientist and promised to give full cooperation for the success of the project. Each participating farmer was therefore required to reserve 0.1 ha of land for the trial. It was agreed that all the 159 farmers would participate in the cowpea variety trial while the cowpea-cereal cropping system trial would be conducted at group level. The Research Institute supplied the seed, insecticide and fertilizer on credit to farmer. Credits were paid back at harvest in kind with seeds of the best two varieties. These seeds were stored at the community level, for distribution to other interested farmers within the community in the next season. Group trainings were organized on selected farmers' fields before major farm operations were carried out. Group trainings were therefore carried out on operations like planting (spacing and plant geometry), fertilizer application and spraying (safe use of insecticide). The plots were managed by the farmers who carried out all major operations. Scientist, extension agents and lead farmers and representatives of farmers groups went around to the farmers for discussions and supervision of planting and during major operations to ensure that the recommended practices were carried out.

Cowpea variety trial involved 10 cowpea varieties; however each participating farmer was given 6 varieties of contrasting attributes to answer some of the issues raised during the various discussions. These varieties therefore included extra-early, early and medium maturing varieties, different (white and brown) seed coat colour, in addition to resistance to many of the biotic and abiotic constraint found in these areas. Farmers were advised to apply 1 ton

of organic manure per ha and 15 kg N, 15 kg P_2O_5 and 15 kg K_2O ha^{-1}, broadcasted on the plot before planting. Each variety was planted in sole crop in a plot size of 165 m^2 giving total land area of about 0.1ha. They were planted in rows 75cm apart, hill to hill spacing was 20 cm, 3 seeds were planted per hill and thinned to two plants per hill two weeks after planting. Cowpea plants were sprayed with insecticide twice (at flowering and at full podding). At maturity pods from individual varieties were harvested separately, sun dry and weighed. Sun dried pods were threshed and grains weighed and recorded. Grain yield ha^{-1} was extrapolated from the grain weights per plot.

Two cowpea varieties selected from the six above, based on discussions with farmers and seed availability were evaluated in the cropping systems trials. The two varieties were grown in 1sorghum: 4 cowpea and 2 sorghum: 4 cowpea row to row strip cropping systems. Cowpea spacing was as in sole crop above, while sorghum was planted at a distance of 30 cm within row and millet at 100 cm within rows. The total plot size was about 0.1 ha (35 x 30 m). The fertilizer application was as in sole above. This was tested on 20 farmers' fields, in 8 departments selected around Maradi and Zinder. The farmers' tradition cereal-cowpea systems were used as control. The cereals used by the farmers were either millet or sorghum depending on group's choice. Harvesting of cowpeas was as sole cowpea. The cereal panicle from each cropping system and variety were harvested separately and sun dried. The sun dried panicles were threshed separately and weighed. At maturity pods from individual varieties were harvested separately, sun dry and weighed. Sun dried pods were threshed and grains weighed and recorded. Grain yields per ha were extrapolated from the grain weights per plot.

RESULTS AND DISCUSSION

The result of the adaptive trial in 2006 is given in Table 1. The qualitative data taken gave the researchers lot of insight to farmers perceptions of the cowpea varieties and the characters of interest to farmers. It was noted that farmers would generally prefer a medium to

Table 1: Qualitative (%) comparism of improved cowpea varieties with local varieties under farmers systems

Variety	Degree of differences	Seed size	Seed color	Germ	Disease	Striga	Days to Flower	Mature	Grain Yield	Fodder Yield
IT97K-819-220	worse	35	10	17	19			10	41	80
	asgoodas	12	10	33	25	50		10	12	10
	better	53	80	50	56	50	100	80	47	10
IT97K-499-16	worse	46	10	17	31	10	14	10	38	82
	asgoodas	27	31	24	25	20	10		12	
	better	25	59	59	44	70	76	90	50	18
IT89KD-349	worse	36	20	27	40	20	10	22	50	50
	asgoodas	18	30	28	30	40	10	22	20	17
	better	45	50	45	30	40	80	56	30	33
IT97K-819-154	worse	50	20	20	14	10	10	10	45	76
	asgoodas	23	35	40	31	50	15	10	15	10
	better	27	55	40	55	40	75	80	40	16
IT97K-205-9	worse	45		36	42		23	11	50	100
	asgoodas	10		36	17		62		20	
	better	45	100	27	42	100	15	89	30	
IT97K-205-10	worse		21						88	50
	asgoodas	80	15	70	20	25				40
	better	20	64	30	80	75	100	100	12	10
IT88D-867-11	worse	25	10	8	25	17			36	45
	asgoodas		36	31	17	33				27
	better	75	57	62	58	50	100	100	64	27
IT97K-499-38	worse	70	14	21	31		10	15	50	69
	asgoodas	10	22	22	23	75	30	15	10	
	better	20	64	57	46	25	60	70	40	31
IT97K-819-118	worse	40	13		22	30	11	25	67	80
	asgoodas	20	25	50	23	33				
	better	40	62	50	55	37	89	75	33	20
IT89KD-374-57	worse	50	33	20	27				43	80
	asgoodas	21		10	13	22	20		10	10
	better	29	67	73	60	78	80	100	47	10
IT97K-819-132	worse	75	12	20	25		13		43	75
	asgoodas			20	13	33	25		28	13
	better	25	88	60	62	67	62	100	29	12

large seeded varieties as compared to small seeded varieties as many farmers scored the small seeded varieties (IT97K-819-132, IT97K-819-132 and IT97K-499-16) as worse than local cowpea varieties in seed size, while the large seeded varieties IT8D-867-11) was scored better than local in terms of seed size by 75% of the farmers. Seed coat color preference was however not specific as both brown and white seeded varieties were scored as better than the local varieties in seed color. It was however noted that IT97K-205-9, a bright white seed variety was scored better than the local varieties by all of the farmers. Most of the farmers stated that the improved varieties were more resistant to diseases than the local varieties. Of the eleven varieties tested 8 were noted by the farmers to be Striga resistant and better than local varieties. Early maturity was an important consideration in the selection of varieties and majority of the farmers reported the tested varieties to be earlier in flowering and maturing than their traditional varieties. The farmer's perception of cowpea grain yields of the improved varieties compared to the traditional varieties were generally that it was not as good as the locals. Only in two varieties (IT97K-499-16 and IT88D-867-11) did 50% and above of the farmers scored the improved varieties as better than locals. The general perception of fodder production of the improved varieties was that they produced less fodder than the local varieties under the traditional planting system.

Lesson Learnt: The result of this trial gave lots of insight to the attributes most desirable in cowpea varieties by the farmers and an understanding of this would aid adoption and impact of research results. The biotic constraints to increase productivities according to farmers were aphids, pods sucking bug, Striga, bacterial blight and grasshopper, while the abiotic constraint include soil fertility and drought. It was clear to us and the participating farmers that the improved varieties were superior in disease and *Striga* resistance, however their grain and fodder yields under the prevailing traditional planting systems needs to either be improved or we modified the traditional planting systems. The yearly average growth rate of cereal production in the Sudano-Sahelian zone has been about 1%, compared to an average population growth rate of 3% [8], therefore the cropping systems need to be improved as the present system cannot meet the growing food needs of the region. Sole cowpea and cereal-legume rotation are not common as farmers intercropped legume and cereals in wide spacing with little or no input and giving low yields. Farmers were interested in early maturing varieties with good seed germination and high pod load. It was also noted that there were local preference for cowpea seed coat color. Farmers recognize the importance of soil fertility and tried to use livestock manure to ameliorate the problem, but they are not able to generate enough good quality manure for their farms. High fodder yield is an important consideration for cowpea variety adoption however high grain yield was more important than fodder yield. It was however concluded that the present cropping system cannot meet the growing food demand and therefore needed to be modified.

The second farmers' participatory trial started in 2006 with trials on both cowpea varieties and cowpea-cereal planting system. The monthly rainfalls (mm) of some locations are given in Fig. 1. The rains started late in most part of Niger in 2006 and first planting started in Maradi in the first week of July and by 10th of August all the farmers had completed the plantings in the two regions. The mean cowpea grain yields from the various departments are given in Table 2. The mean cowpea grain yields within the departments ranged from 357 kg/ha in Bande to 1033 kg/ha in Zermou. Mean varietal grain yields ranged from 934 kg/ha in IT90K-372-1-2 to 553 kg/ha in IT93K-205-8. Several large and mini farmer field days were held in some of these plots inviting other farmers from the villages and surrounding villages. It was noted that some farmers diverted some or all of the fertilizer given to them to cereals crops. This however proved that the farmers are aware of the importance of fertilizer to cereals as well as there leguminous crops. Bationo *et al.* [9] also noted that the importance of fertilizers as key inputs in accelerating food production in the West African Semi-Arid Tropics is well recognized by researchers and policy makers. Many farmers however were not able to generate the required quantities of manure for there fields and this was noted to affect grain and fodder yields with higher productivities obtained from fields with manures. It was however convincingly demonstrated that the improved cowpea varieties can give higher grain yields in farmers' field under optimum management especially in sole cropping. Discussions were held with the farmers on the appropriateness of each variety in order to identify the most promising varieties for wider usage. Group discussions were held with participating farmers and farmers from each department were asked to nominate the best two varieties in their areas.

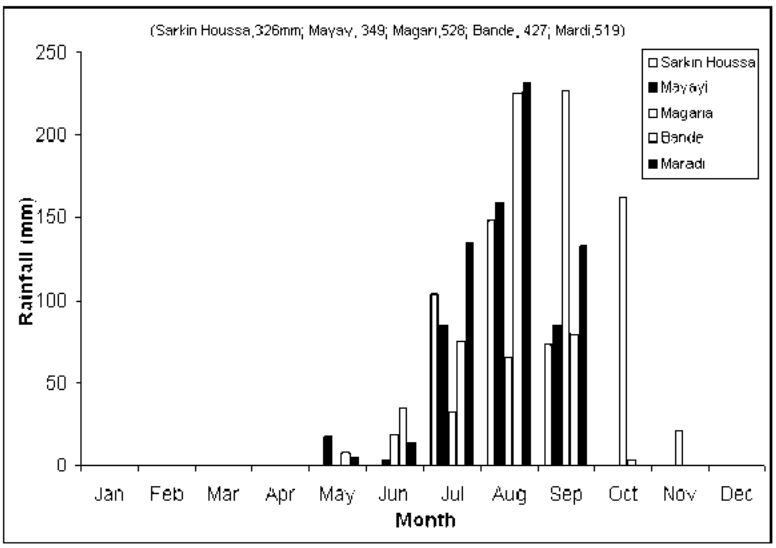

Fig. 1: Total monthly rainfall (mm) in some trial site, 2006

Table 2: Mean grain yield of tested cowpea varieties in farmer's field in Niger, 2006

	Region			Maradi			Zinder		
Variety	Madarunfa	Tessaoua	Mayayi	Bande	Magaria	Achi Lafia	Zermou	Dakora	Mean
IT90K-372-1-2	907	866	1028						934
IT97K-499-38		544	1865	432	1296	337			895
IT89KD-374-57			632		222	905	1404	868	806
IT97K-499-35	701	719	759	520	1022		1211	361	756
TN5-78		755		185	778		1354	437	702
TN256-87	721		584	274				895	619
IT00K-1148						609			609
IT88D-867-11	769		707	284	642	550	751	500	600
IT97K-819-118	824	897	1083	211	681	348	449	222	589
IT98K-205-8	687	364		587	938	187		533	553
Mean	768	691	951	357	797	489	1033	545	706

Table 3: Selected cowpea varieties by farmers groups in 2006

Department	1ST Choice	2nd Choice
Tessaoua	IT90K-372-1-2	IT97K-499-35
Madarumfa	IT90K-372-1-2	IT97K-499-35
Mayahi	IT97K-499-38	IT97K-499-35
Bande	IT97K-499-35	IT98K-205-8
Magaria	IT97K-499-35	IT97K-499-38
Zermou	IT89KD-374-57	IT97K-499-38
Dakora	IT89KD-374-57	IT97K-499-38
Achi Lafia	IT89KD-374-57	IT88D-867-11

Two selected varieties from each department are given in Table3. A total of six varieties (IT90K-372-1-2, IT97K-499-38, IT97K-499-35, IT89KD-374-57, IT88D-867-11 and IT98K-205-8) were chosen by the farmers for further trials. Four varieties (IT90K-372-1-2, IT97K-499-35, IT97K-499-38 and IT89KD-374-57) have been identified as having higher grain and fodder yields on-farm. Of these however, IT97K-499-35 and IT97K-499-38 had complete field resistance to Striga and would be used widely while the other two would be used in area known to have relatively less Striga. It was however interesting to note that in villages that participated in the 2002 trials, some of the varieties

introduced have been spreading through farmer to farmer diffusion. While sampling for traditional system as control the researchers frequently saw IT89KD-374-57, IT88D-867-11 and IT97K-499-38 as farmers' variety in Zermou, Magaria and Bande, three locations that were involved in the 2002 trial. Of these cowpea varieties, IT89KD-374-57 was the most common.

In the cropping system trial, several farmers planted sorghum at a spacing of 50 cm within rows instead of the 30 cm recommended. Result from the cropping system showed that combined grain yield of local cowpea and cereals ranged from 0 to 950 kg/ha and generally there was over 300% increase in cowpea grain yield and over 200% increase in value of product. Results showed that the 1: 4 was better than the 2: 4 in low rainfall areas but in higher rainfall areas the 2:4 was produced higher returns than the 1:4 systems. Because current traditional cropping system are not keeping pace with food demand and the low use of input, causing soil degradation and becoming less productive, they are not sustainable. The must therefore be intensified in manners that meet local food demands, protect or improve soil resource base and generate income. The strip cropping system (1:4 or 2:4 row to row of cereal to cowpea) offer opportunity to increase productivity of the legumes which are food as well as cash crops and encourage conservation of the soil resources. The system could be rotated with sole cropping of cereals. Bationo *et al.* [9] noted that with no application of N, millet yield after cowpea increase by 58 to 100%. The improved system put only about 25 to 33% of the plot to cereal while the remaining land is on legumes and therefore the plot may benefit from the rotation effect of sole cowpeas. The improved systems also produced better quality crop residues with increase in the leguminous portion of the residues and therefore improved productivity of the livestock and encouraged integration of the crop and livestock systems. The availability of quality crop residues would be an incentive to integrate crop-livestock systems for higher productivities and sustainability of both systems. For sustainability, farmer groups formed were encouraged to evolve into cooperative societies. The cooperative societies when formed would hopefully be involved in sourcing for input as well as markets for farmers.

CONCLUSION

Results of farmer participatory trial have shown that improved cowpea varieties and improved cowpea-cereal cropping systems can considerably increase productivities of resource poor farmers in the Semi-arid regions of Niger. Farmers who are reluctant to plant sole cowpea have options of planting the strip cropping of cowpea in either 2:4 or 1:4 rows: row of cereal to cowpea depending on the cereal needs and rainfall. Livestock manure and inorganic fertilizer are however very important to obtain high grain and fodder productivities in the improved systems. The most encountered systems in that area is mostly the association millet/cowpea, millet/groundnut, sorghum/cowpea or sorghum/ groundnut etc. However, these cropping patterns are carried out in very low plant population, low input with poor quality, leading to low yield and therefore low income. The intensification of the systems on a relatively small area with high quality, early and resistant to *Striga* cowpea seeds like IT98K-499-38 recommended to farmers could give both grain and fodder in one row of millet or sorghum for four rows of cowpea in low rain area. The two rows of millet for four rows of cowpea strip cropping is recommended in the area with high rain fall. Cowpea lines IT98K-499-35 or IT98K-499-38 are recommended to farmers on fields infested with *Striga* while IT89KD-374-57 or IT90K-372-1-2 is recommended on the fields with less *Striga*. It is also recommended that cowpea breeders should urgently improve the other two varieties by incorporating Striga resistance genes in them.

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