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Farmer participatory pest management evaluations and variety selection in diagnostic farmer field Fora in cowpea in Ghana

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Participatory diagnostic farmer field fora (FFF) were conducted at two communities, Savelugu and Bukpomo, in northern Ghana to build the capacity of farmers on integrated pest management in cowpea production. The FFF involved a season-long comparative evaluation of farmers' practices (FP) and integrated pest management (IPM). Farmers' practices relied wholly on calendar insecticide sprays while IPM plots employed proven agronomic practices and treatment with neem (*Azadirachta indica* A. Juss) extract for insect pest control. Results showed that insect pest densities (Flower thrips, *Megalurothrips sjostedti* Trybom and pod-sucking bugs' for example, *Clavigralla tomentosicollis* Stal.) and percent damaged pods as well as grain yield were similar in FP and IPM plots at both Savelugu and Bukpomo. Partial budget analysis showed positive returns to investment in IPM and a near loss in FP. Post training ballot box test showed that 80% of the farmer participants across locations showed improved knowledge and skills in IPM after the training compared with about 30% before the training. An ancillary study to the FFF was conducted to expose the farmers to different cowpea genotypes in a participatory variety selection trial. Results showed that some of the genotypes selected by farmers as their most preferred genotypes at the vegetative stage were also selected at the podding stage but there were no significant correlations between these farmer preferences and yield. These findings are discussed in the context of sustainable cowpea production through farmer empowerment and involvement in technology generation and dissemination.

Key words: Farmer field fora**,** participatory variety selection, cowpea, *Azadirachta indica.*

INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walpers, is an important food crop and a major source of protein for many families in Ghana and other countries in sub-Saharan West Africa. The dry grain with about 23 to 25% protein, supplies much of the protein needs of the rural poor who lack the needed capital to purchase animal protein.

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In addition to the food value of the grain, the foliage and stems are a good source of fodder for livestock, green manure and cover crop (Abudulai et al., 2006; Anonymous, 2012).

Despite its importance, cowpea production is faced with a lot of challenges, including the threat of insect pests that attack the crop throughout its growth, and low access of farmers to improved technologies (Jackai et al., 1992). Cowpea is very susceptible to many insect pests that need to be controlled to obtain economic yield. Insect pests, particularly aphids (*Aphis craccivora* Koch), thrips (*Megalurothrips sjostedti* Trybom) and a complex of pod-sucking bugs (PSBs) (for example, *Clavigralla tomentosicollis* Stal., *Aspavia armigera* F. and *Anoplocnemis curvipes* F.) inflict heavy damage to the crop and can cause complete crop failure in unprotected cowpea (Karungi et al., 2000; Abudulai et al., 2006).

Though a few cowpea varieties have shown slight to moderate levels of resistance to one or a few insect pests, there is no variety that has demonstrated resistance to the wide array of insect pests that attack the crop (Jackai and Dauost 1986). Consequently, most farmers use insecticides to control insect pests on their fields. However, because of lack of knowledge about the proper use of insecticides and their abuse, insect control is generally poor on farmers' fields. In addition, there are reported cases of insect resistance and detrimental effects of insecticides on the environment and human health (Jackai and Dauost, 1986; Karungi et al., 2000).

Scientists from both national and international research institutes have developed improved technologies including improved pest management options and high yielding cowpea varieties but only a few are adopted by farmers (Mulatu and Belete, 2001). The reasons for the low adoption rate include inadequate exposure to the new technologies or the technologies do not adequately satisfy farmers' needs (Richards, 1985; Ntega-Nanyeenya et al., 1997; Beshir, 2014).

Farmers operate in a heterogeneous environment that requires site-specific solutions to problems on their farms. Therefore, there is the need for a paradigm shift from merely transferring technologies to farmers to one that seeks to empower farmers with the requisite knowledge and skills to enable them make informed decisions about their farm operations. Scientists need to work with farmers and other stakeholders to diagnose and experiment for workable solutions suitable for the small-scale farmer (van Huis et al., 2007; Struik et al., 2014). Farmer empowerment through participatory technology development (PTD) recognizes the indigenous knowledge of farmers and puts them at the forefront of technology generation (van Huis and Meerrman, 1997).

Empowering farmers with the requisite knowledge about insect pests and control options such as those that are effective and environmentally friendly will improve their ability for effective insect control for improved yields. Also, participatory testing of crop cultivars with farmers helps in identifying cultivars preferred by farmers and accelerating their dissemination (Joshi and Witcombe, 1996).

The core objective of this study was to strengthen the capacities of small farmers on proper pest management practices for cowpea through participatory diagnostic farmer field fora (FFF). The FFF is one novel strategy that brings together scientists, extension officers and farmers in the technology development and dissemination process. The other objective aimed at improving farmers' access to quality seeds through participatory variety selection/testing.

MATERIALS AND METHODS

Farmer field fora (FFF)

This study involved a group training of farmers on integrated pest management (IPM) using farmer diagnostic exploratory approach in a farm setting. The study was mounted in two cowpea farming communities, Bukpomo and Savelugu, in the Guinea Savanna Zone of the Northern Region of Ghana from 2010 to 2011. Participating farmers were drawn from the two communities and also from nearby communities. The farmers in each community were put into five working groups (at least 8 farmers in a group) representing five replications to test the two treatments, viz Farmers' practice (FP) and IPM, of insect pest management in cowpea. Farmers said at the starting of the experiments that they use insecticides primarily the pyrethroid lambda-cyhalothrin to control insect pests, and this was documented and followed as their practice. For IPM, plots were treated with 10% (w/v) aqueous suspension of neem seed extract (NSE) with one round of lambda-cyhalothrin applied at 0.02 kg ai ha^{-1} at initiation of flowering. The cowpea cv Padi-Tuya was used. Plot sizes were 10 x 10 m. IPM and FP plots were laid side by side in each replicate. The plots were planted from 5 to 20 August in each year and farming community.

The training sessions were interactive and were held once a week. On each training day, farmers in each group or replicate met during Agro-ecosystem analysis (AESA) to diagnose problems on their plots, and also take records (e.g. pest/disease incidences) based on which they suggested possible solutions or interventions for their problems. Ten plants were randomly sampled in each plot during each AESA to record insect and disease incidences. The number of pods per plant was recorded at harvest. The total number of shriveled, unfilled pods and those with feeding scars were recorded as damaged by PSBs, and used to estimate percentage PSB damaged pods. The records from the groups were processed and presented at a plenary session, which were discussed by participants for consensus building on the appropriate interventions if any (for example, weed control, pest control, harvesting of plots) to apply to each field plot.

Researchers, technicians and staff of the Ministry of Food and Agriculture (MoFA) facilitated the training process. The farmers learnt crop growth habits, early preventive measures for insect pests and diseases, and acquired skills in the identification of insect pests and diseases and their management. Farmers' capacities also were strengthened through presentations of special topics on relevant areas of cowpea production by resource persons. Topics presented included:

1. Site selection, land preparation and soil management
2. Cowpea phenology and morphology.
3. Introduction to IPM/FFF

Table 1. Numbers and distribution by sex of farmers trained at farmer field fora at Bukpomo and Savelugu in 2010 and 2011.

Community	Year	Sex of facilitator		Total
		Male	Female	
Bukpomo	2010	65	25	90
Savelugu	2010	45	15	60
Bukpomo	2011	25	15	40
Savelugu	2011	35	25	60

4. Introduction to AESA.
5. Cowpea insect pests/diseases identification and management.
6. Safe and effective use of pesticides.
7. Preparation and application of botanicals
8. Natural enemies in cowpea production.

A pre- and post- training ballot box tests were conducted to evaluate the knowledge and skills of participants before and after the training, respectively. In these tests, farmers were asked certain key questions pertinent to the field ecology of cowpea such as

1. Identification of key insect pests of cowpea
2. Parts of cowpea plants attacked by these insect species
3. Type of damage they cause to plants
4. General methods of control if any
5. Timing of control practice
6. Natural enemies of insect pests and their importance.

Farmer participatory variety selection (PVS)

As part of the FFF, the participating farmer groups also evaluated 22 cowpea genotypes/varieties hereinafter referred to as genotypes in a participatory action research trial to expose them to the different genotypes of cowpea released or being evaluated for release by the Institute. Each genotype was planted in four rows, 5 m long by 2.4 m wide. There were 0.60 m spacing between rows and 0.20 m between plants in a row. The experimental design was a randomized complete block and treatments were replicated three times. Normal agronomic practices for cowpea production in northern Ghana were followed and the plots were protected against insect pests with Chlorpyrifos (as D-ban Super 48% EC) applied at 0.20 kg ai ha^{-1} at the vegetative stage and Lambda-cyhalothrin (as Lambda Super 2.5 EC) applied at 0.02 kg ai ha^{-1} during flowering and podding. The farmers' assessed the genotypes based on a preference score of 1 to 3, where 1 = poor or least preferred, 2 = average and 3 = good or most preferred. The assessments were done during the vegetative stage at 20 days after planting (DAP) and also during podding at 50 DAP. In all the assessments, farmers were asked to assign reasons for choosing or scoring a particular genotype higher over another.

Data analysis

The insect densities, damage and grain yield data for the FFF and the preference scores for the PVS study were analyzed using ANOVA for a randomized complete block design and when significant, treatment means were separated using Fisher's LSD test at P < 0.05 (SAS Institute, 1998). The pre- and post- ballot tests conducted at the FFF were analyzed using paired t-test to evaluate the knowledge and skills gained by the participants after the FFF training. Partial budgeting was used to estimate gross margin per hectare for IPM and FP. Gross margin for each treatment was estimated by deducting the total variable cost from the total revenue. The benefit-cost ratio was calculated by dividing the gross margin by the total cost of each treatment. The relationships between farmers' preference scores at the PVS and the agronomic performance of the genotypes were computed using simple correlation analysis.

RESULTS AND DISCUSSIONS

Farmer field fora (FFF)

A total of 130 cowpea farmers comprising 90 males and 40 females participated in the training at Bukpomo while a total of 120 comprising 80 males and 40 females participated at Savelugu during the two years of the FFF (Table 1). The influence of the two pest control technologies tested on insect pest densities, damage and grain yield is presented in Table 2. There were no significant differences between IPM and FP in the densities of thrips (*M. sjostedti*) and PSBs (*C. tomentosicollis, A. curvipes and A. armigera*) at the two locations tested. Also, percentage damaged pods due to the PSB complex was not different between the treatments. However, pod load or mean number of pods per plant was significantly higher in IPM than in FP at Bukpomo but there were no such differences observed between the treatments at Savelugu. There were no significant grain yield differences measured between the two treatments at both locations. Yields, however, were generally lower at Savelugu compared with those at Bukpomo. Planting of the trial at Savelugu coincided with the period of heavy rains which probably affected plant development and yield (Wright and Nageswara Rao, 1994).

These results demonstrated the insecticidal efficacy of neem in the IPM (Schmutterer 1990) comparable to the synthetic insecticide in FP. Neem also acts as an antifeedant to insects and probably prevented feeding in the neem-treated IPM plots (Mordue and Blackwell, 1993, Isman, 2006), which resulted in comparable damage to the synthetic insecticide control in the FP. The significantly higher number of pods per plant measured in IPM plots compared with FP at Bukpomo was also probably due to the antifeedant effect of neem which resulted in higher pod retention. PSB feeding in cowpea causes pod abscission (Jackai et al., 1992; Karungi et al., 2000).

Results of the ballot box tests showed that farmers gained more knowledge and skills about the cowpea ecology and management after the training than before the training (Table 3). About 80% of the participating farmers demonstrated improved knowledge and skills in IPM after the training compared with about 30% before the training. They exhibited adequate knowledge about the major insect pests of cowpea, their damage and how

Table 2. Influence of pest control technologies on insect densities, damage and cowpea yield at Bukpomo and Savelugu farming communities.

Parameter	Bukpomo			Savelugu		P-value
	IPM	FP	P-value	IPM	FP	
Thrips/20 flowers	37.6±9.3 a	27.6±6.7 a	0.4063	34.2±4.9 a	37.5±5.9 a	0.5731
PSB/m	2.1±0.5 a	1.4±0.2 a	0.1715	2.4±0.4 a	2.1±0.4 a	0.4853
% damaged pods	21.6±2.3 a	21.9±3.2 a	0.9387	15.2±1.6 a	18.3±2.4 a	0.3924
# of pods/ Plant	15.7±0.9 a	10.7±0.6 b	0.0039	7.8±0.8 a	6.4±0.6 a	0.1462
Yield	867.3±39.5a	934±69.6a	0.1664	595.2±45.9 a	651.9±52.7 a	0.3930

Values are pooled means of 2010 and 2011 seasons. Means in a row at a farming community with the same letters are not significantly different according to Fisher's LSD test at P < 0.05.

Table 3. Mean % of farmers' demonstrating knowledge and skills to do IPM assessed at pre- and post- ballot tests at Bukpomo and Saveleugu.

Location[1]	% (±SE) farmers showing knowledge and skills in IPM		t-value	P > t
	Pre-test	Post-test		
Bukpomo	29.6±4.6	80.0±4.5	7.90	<0.0001
Savelugu	34±3.9	81.0±4.8	7.41	<0.0001

[1]Savelugu, n =120; Bukomo, n = 130.

to manage them in their fields. Godtland et al. (1994) and Asiabaka (2002) reported that Farmer Field School training improves farmers' knowledge and skills for sustainable agricultural production. Farmers' participation in experimental groups increases their self-confidence and capacities through interacting with their peers and researchers to solve problems better on their fields (Sterk et al., 2013).

The cost of the IPM technology was relatively lower than the FP technology (Table 4). This resulted in positive returns to investment in the IPM and a near loss in the FP. For example, at Bukpomo farmers gained about 180% returns to their investment in IPM but made a marginal gain of about 5% with their own practice. Opare-Atakora et al. (2014) reported that the adoption of IPM technologies in yam production led to increased returns to farmers. The results further showed that farmers gain more when they reallocate their resources from their own practice to IPM. As opposed to calendar insecticide sprays in FP, some level of pest attack is tolerated in IPM which results in reduced use of pesticide and lower cost of production in IPM compared with FP (Mariyono 2007).

Only one round of chemical insecticide was applied in IPM as against six rounds of sprays in the FP. Further, IPM plots were protected against insect pests using mainly neem extract which is cheap because of abundance of neem trees in the wild in the trial area. There is therefore a high incentive for farmers to want to adopt the IPM technology because of its comparable yields with their own practice and lower cost of production (Timu et al., 2014). Struik et al. (2014) observed that smallholder farmers often capture limited benefits from appropriate and desirable technologies because of limited capital resources to invest in new technologies. Besides the economic benefits, adoption of the IPM technology that relies on the use of neem will lead to improved health of the farm family and the environment as opposed to the use of the more toxic synthetic pesticides. Neem has been reported to be relatively safe to humans and the environment (Schmutterer, 1990; Mordue and Blackwell, 1993).

Farmer participatory variety selection (PVS)

By consensus, plant vigor and/or weed competitive ability epitomized by the level of branching of a genotype were the key criteria used by famers for selection of a genotype at the vegetative stage. Genotypes with high levels of these traits were much preferred and scored higher than those with low levels of the traits. The criteria advanced for the podding stage assessment were earliness and pod load, with pod load being the overarching consideration for the selection of a genotype. Genotypes with heavy pod load were scored higher than those with low pod load. All the genotypes evaluated were white seed coated, which is the preferred choice of farmers in the study area (Etwire et al., 2013).

The preference scores given by farmers and grain yield for the 22 cowpea genotypes evaluated at Savelugu and Bukpomo are presented in Table 5. The scores at both the vegetative and podding stages were significantly

Table 4. Performance indicators of Farmers Practice (FP) and Integrated Pest Management (IPM) strategies in cowpea at Savelugu and Bukpomo.

Partial budget analysis	Savelugu		Bukpomo	
	FP	IPM	FP	IPM
Total variable cost (gh ¢ per ha)	541.32	377.38	740.77	256.65
Yield (kg/ha)	651.9	595.2	934	867.3
Price of grain (GHc/kg)	0.83	0.83	0.83	0.83
Revenue (GHc/ha)	541.07	494.02	775.22	719.86
Gross margin (gh ¢ per ha)	-0.25	116.64	34.45	463.21
Benefit-cost ratio/ total factor productivity(per ha)	-0.0005	0.30	0.05	1.80

FP; Farmers practices relied wholly on synthetic insecticide sprays to control insects; IPM: Combined monitoring of insects before control with neem seed extract (10% w/v) with one round of insecticide at flowering.

Table 5. Mean scores[2] of farmers' preferences[1] for cowpea genotypes at the vegetative and podding stages, and yields in a participatory varietal selection conducted at Bukpomo and Savelugu.

Genotype	Scores at vegetative stage		Mean	Scores at podding Stage		Mean	Yield kg/ha		Mean
	Savelugu	Bukpomo		Savelugu	Bukpomo		Savelugu	Bukpomo	
IT 95k-193-2	2.3 d-g	2.7 a	2.5	2.4 b-e	2.7 ab	2.6	847.2 a-d	759.7 a-e	803.5
SARC 3-129-2	2.4 c-f	2.2 a-e	2.3	2.1 e	2.1 c-f	2.1	605.6 e-g	654.2 c-g	629.9
IT 98K-506-1	1.7 i-j	2.6 ab	2.2	2.6 a-d	2.3 b-f	2.5	708.3 c-f	644.4 c-g	676.4
IT 97K-499-35	2.5 b-e	2.2 a-e	2.4	2.8 ab	2.7 ab	2.8	957.4 a	890.3 a	923.9
SARC 4-75	2.7 a-d	2.5 a-c	2.6	2.6 a-d	3.0 a	2.8	737.5 b-e	838.9 a-c	788.2
SARC 1-71-2	2.8 a-c	2.3 a-d	2.6	2.3 c-e	2.1 c-f	2.2	665.3 d-f	700.0 a-f	682.7
SARC 2-51-1	2.2 e-h	2.0 c-e	2.1	2.2 de	1.5 g	1.9	923.6 ab	825.0 a-d	878.8
SARC 3-154-1	1.9 g-j	2.0 c-e	2.0	2.9 a	2.3 b-f	2.6	875.0 a-c	827.8 a-d	851.4
SARC 3-90-2	1.9 g-j	1.8 de	1.9	2.7 a-c	1.9 fg	2.3	619.4 e-g	619.0 e-g	619.2
PADI-TUYA	3.0 a	2.0 c-e	2.5	2.7 a-e	2.7 ab	2.7	670.8 d-f	719.4 a-e	695.1
SARC 1-136-1	2.5 b-e	2.1 b-e	2.3	2.1 e	2.7 ab	2.4	600.0 e-g	500.0 fg	550.0
SARC 3-103-1	2.6 a-e	2.3 a-d	2.5	2.1 e	2.1 c-f	2.1	669.4 d-f	684.7 b-f	677.1
SARC 2-115-1	1.7 ij	2.1 b-e	1.9	2.8 ab	2.0 e-g	2.4	787.5 a-e	763.9 a-e	775.7
SARC 1-18-2	1.8 h-j	2.2 a-e	2.0	2.6 a-d	2.4 b-e	2.5	377.8 h	477.8 g	427.8
SARC 4-51	1.5 j	1.8 de	1.7	1.7 fg	2.1 c-f	1.9	727.8 c-e	691.6 a-f	709.7
SARC 3-74A-2	2.7 a-d	2.2 a-e	2.5	2.9 a	2.3 b-f	2.6	429.2 gh	497.2 fg	463.2
SARC 1-82-1	2.1 f-i	2.5 a-c	2.3	2.8 ab	2.5 a-d	2.7	666.7 d-f	627.4 d-g	647.1
SARC 1-13-1	2.9 ab	2.1 b-e	2.5	2.4 b-d	2.5 a-d	2.5	693.1 c-f	706.9 a-e	700.0
SARC 1-71-1	1.9 g-j	2.1 b-e	2.0	2.1 e	2.4 b-e	2.3	759.7 b-e	711.2 a-e	735.5
SARC 4-40	1.9 g-j	2.1 b-e	2.0	1.5 g	2.6 a-c	2.1	525.6 f-h	601.4 e-g	563.5
MARFO-TUYA	2.1 f-i	1.7 e	1.9	2.4 b-c	2.3 b-f	2.4	694.4 c-f	689.4 a-f	691.9
APAGBAALA	2.5 b-e	2.3 a-d	2.4	2.5 b-e	3.0 a	2.8	729.2 c-e	887.5 ab	808.4
P > F	< 0.0001	0.0425	-	< 0.0001	< 0.0001	-	<0.0001	0.0035	-
CV (%)	28.2	36.6	-	25.7	30.1	-	16.9	17.9	-

[1]Pooled data for two years (2010 and 2011); there were 3 replications in each year; [2]A score of 1 = least preferred and 3 = most preferred. Means in a column followed by different letters are significantly different according to Fisher's LSD mean separation test at P < 0.05.

different for the genotypes. At the vegetative stage, six genotypes including Padi-Tuya, SARC 1-13-1, SARC 1-71-2, SARC 4-75, SARC 3-74A-2 and, SARC 3-103-1 had the highest scores compared to most of the genotypes and thus were the most preferred by farmers at Savelugu. Among others, the genotypes SARC 4-75, SARC 3-74A-2, SARC 1-71-2 and SARC 3-103-1 ranked highest at Savelugu at the vegetative stage also were the most preferred at Bukpomo. At the podding stage, four genotypes including SARC 4-75, IT 97K-499-35, Padi

Tuya and SARC 1-18-2 were the most preferred at both locations. Grain yields differed significantly among the genotypes at both Savelugu and Bukpomo.

At both locations, significantly higher yields were recorded for the genotypes IT 95K-193-2, IT 97K-499-35, SARC 2-51-1, SARC 3-154-1 and SARC 2-115-1. Correlation analyses did not reveal any significant relationships between yields and farmers preference scores at the vegetative and podding stages for both Savelugu ($r = 0.00472$, $P = 0.9700$ and $r = 0.08476$, $P = 0.4986$) and Bukpomo ($r = -0.01011$, $P = 0.9358$ and $r = 0.01107$, $P = 0.9297$), respectively. This showed that the genotypes selected by farmers as their most preferred were not necessarily the highest yielding.

In addition to grain yield, farmers in the study area also make substantial use of cowpea leaves as vegetables in soup and stew, as snack and as fodder for livestock. These competing uses could have influenced farmer preferences for the genotypes resulting in the lack of significant correlations between the farmer preferences and yield. Moreover, different preferences between the sexes for germplasm have been reported (Defoer et al., 1997; Mulatu and Zelleke, 2002). In this study, the preference scores for males and females were assessed together, which divergent preferences could have resulted in the nonsignificant correlations observed between yield and farmers preferences. However, contributions of female and male farmers in a participatory selection program are necessary for addressing the overall needs of the household (vom Brocke et al., 2010). Farmers' preferences are important when developing a variety as their needs for attributes of a variety must be met to enhance its adoption (Richards, 1985; Mulatu and Belete, 2001). Among the genotypes evaluated, IT 95K-193-2 was released to farmers as Bawutawuta by the Institute for its relative resistance to the witch weed *Striga gesneroides*, IT 97K-499-35 as Songotra for aphid resistance and SARC 4-75 as Zaayura for its high preference by farmers.

Conclusion

The results of the FFF training showed that the participating farmers gained a lot of knowledge working to discover solutions they could apply to solve their site-specific problems on their farms. A post training ballot box test conducted at the end of the training showed that 80% of the participants across locations had improved knowledge in the ecology of the crop and skills in general pest management. The results of the participatory variety selection trial showed that some of the genotypes selected by farmers as their most preferred genotypes at the vegetative stage were also selected at the podding stage but there were no significant correlations detected between these farmer preferences and yield. Among the genotypes evaluated, IT 95K-193-2, IT 97K-499-35 and SARC 4-75 have been released to farmers for cultivation as Bawutawuta, Songotra and Zaayura, respectively.

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Conflict of interests

The authors have not declared any conflict of interests.

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