INNOVATIVE FARMER-PARTICIPATORY COTTON IMPROVEMENT PRGRAMME IN THE SAVANNA AGRO-ECOLOGY

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Abstract

By initiating a participatory cotton breeding experiment in 1996, researchers have designed new technologies to adapt to the diversity of local farming conditions. The study compared the performance of farmer selected populations derived after 4 cycles of recurrent mass selection. These populations were evaluated along with 2 commercial checks, STAM 18 A and H-279-1 and the original population AGP 0 at five locations, Angaradebou, Mone, Savalou, Okpara in Benin republic and Samaru in Nigeria in two years. In comparison with the average of the local checks, the farmers made significant improvement in population density, days to boll opening, seed cotton yield and seed index. The average of the populations from farmer's selection was compared to the average of the research selection. The results showed that there were significant differences between farmer's selection and research selection with respect to seed cotton yield (68.5 kg/ha) and lint yield (34.2 kg/ha). These characters were improved by the farmers. During years of experiment, the farmers worked with enthusiasm and were able to select promising cotton populations with good parameters. The final genetic material (lines) will soon be available for on farm testing in more contrasting cropping systems and environments.

Key words: cotton breeding experiment, new technologies, characters, selected population, seed cotton yield, genetic material

INTRODUCTION

Cotton has been the driving force of the economic development in Benin. The lack of markets for alternative cash crops and the scarcity of off-farm employement are the main driving force for small-farm holders to engage in cotton production in order to satisfy cash demand. However there are limitations as yields are stagnating or even decreasing. Moreover the cotton research environment is changing and with government disengagement from direct production, new partners and producers are emerging. Presently farmers have organized themselves into various cooperatives (Cuzon, 1997). Consequently, researchers have to design new adaptive technologies to meet the diversity of local farming conditions. Courtois *et al.* (2001) assumed that it is very difficult for a breeder to anticipate farmers' preferences and that his/her participation is necessary to improve breeding efficiency. In 1996, a participatory cotton breeding programme was initiated by Benin cotton research programme in order to to strengthen its links with producers for potential future partnerships (Lançon, 1998).

Although participatory plant breeding (PPB) was originally designed for complex, diverse and risk-prone environments more frequent in the contexts of marginal areas and subsistence agriculture (Hardon, 1996), this work was intended to demonstrate as suggested by Witcombe (1999), the suitability of PPB approach for a commercial

crop grown under rain-fed semi-intensive cropping systems and in areas with medium yield potential.
The objective of this study was to evaluate and compare the performance of selected populations by cotton farmer-breeders after four cycles of selection.

MATERIALS AND METHODS

Generation of initial population (AGP 96-0)

In 1996, a highly variable population was constituted at the cotton research station in Benin by inter-crossing 14 genotypes of diverse origin (West and Central Africa, USA, Argentinia and Australia). The genotypes were selected based on their morphological attributes as well as their agronomic and fibre quality traits.
In both neighbouring female and male plots, each parent was represented by 5 plants randomly distributed. Each plot was 100 m² sowed with a space of 1 x 1 m for 20 parents. At the time of flowering the pollens were collected from the male plots in a mixture to intercross randomly all the flowers of the female plots where the stamens had been removed manually before the opening of the flower. The pollen was collected as a mixture and applied to emasculate flowers with a brush. All the seed cotton from the female plot was harvested in bulk and the seed constituted the initial population (AGP 0) in 1996.

Populations obtained by participatory cotton breeding in Benin

From AGP 0, a team of three farmers and formal breeders derived the subsequent populations by mass selection. The three farmers carried out their selection work in their fields located at Djougou (9°41' N, 1°40' E), Savalou (7°56' N, 3°02' E) Kandi (11°08' N , 2°56' E) in Benin republic. The farmers were within the major cotton growing areas. The formal breeder worked on-station at Okpara (9°18' N, 2°41'E).
At each location, seeds were planted on 1,000 hills spaced at 1 × 0.40 m giving a plant population of 25,000 plants/ha and, after emergence, they were thinned to one plant per hill. Each farmer selected and harvested about 200 single plants from his field in separate bags. The seed cotton was ginned and the fibre quality was tested with a high volume instrument (HVI) run by the cotton development company (SONAPRA). The formal breeder and the farmer-breeders met finally to decide the best 50–60 plants to retain from each site. Seeds from these plants were sampled equally (up to 50 g per plant) and thoroughly mixed to produce the next breeding cycle.
Each selection cycle involved (i) field screening done by the farmer-breeder alone or in collaboration with a group of other cotton farmers and (ii) selection of the best plants on their individual performances carried out by the research-breeder in collaboration with the farmers.
Bred populations were identified by combining the name of each site and a number to specify the breeding cycle. For example, the 3rd cycle of the selection in Savalou was called Savalou – 3. These are the derived populations: Djougou – 1, Djougou – 2, Djougou – 3, Djougou – 4; Kandi – 1, Kandi – 2, Kandi – 3, Kandi –4; Okpara – 1, Okpara – 2, Okpara – 3, Okpara – 4; Savalou – 1,Savalou – 2, Savalou – 3, Savalou – 4. All the first cycles have been lost.

Experimental materials

The 12 populations produced by the 2nd, 3rd and 4th cycles of selection in each of the 4 breeding sites were compared with the original population AGP 0 as well as the two local commercial cultivars , STAM 18 A and H 279-1. The trials were carried out at the sub-stations located near the farmer breeders' farms at Moné (Djougou), Savalou, Angaradebou (Kandi), Okpara central research station and Samaru (11°11' N, 7°38' E) in Nigeria in 2001 and 2002.
Experimental Layout
The experiment was laid out in a randomized complete block design with 5 replications. Plots were single rows, 20 m length and 0.80 m apart with 0.30 m plant spacing.

Cultural practices

Four delinted seeds were sown per hole. The seedlings were thinned to one plant per hole at 4 weeks after emergence. NPK fertilizer was applied to the experimental area at the rate of 200 kg per hectare at 21 days after emergence. Nitrogen was applied at the rate of 50 kg per hectare at 40 days after emergence. Insect pests were controlled using fortnightly sprays of Endosulfan 700 EC at the rate of 2 litres/ha for the first and the second sprays, Dursban B 218 EC at the rate of 1 litre/ha for the third and the forth sprays, Conquest 176 EC 1 litre/ha at the rate of 1 litre/ha for the fifth and the sixth sprays, starting from 45 days after emergence. For weed control, a pre-emergence herbicide, cotodon was applied after sowing at the rate of 4 litres/ha. Two hoe weedings were done, followed by earthening up (ridge moulding).

Parameters and data collection

Eight agro-morphological traits were measured either on plot basis or by sampling 10 individual plants per plot**.** Population density (%): Ration of present plants to total plants expressed as a percentage per hectare. Hairiness (HAI): Measured using a scale 1 (low hairiness) to 4 (high hairiness). Boll weight (BW): Average weight of twenty bolls expressed in grammes (g). Ginning outturn (% F): Ratio of lint to seed cotton expressed as a percentage. Seed-index (SI): Weight (g) of 100 seeds. Lint yield (kg/ha): Weight of lint expressed in kg/ha. Boll opening (BO): Number of days from seedling emergence to boll opening. Seed cotton yield (YLD): Weight of seed cotton expressed in kg/ha.

Focus groups discussions

After the selection of 200 plants in the farmers' fields by the farmers, searchers met the group of farmers that participated in the selection in each site of selection to discuss with them. The discussions generally focused on

every farmer in the group. Every farmer tried to explain the characters he used to make the choice of plants in the fields.
The questions were addressed to farmers by the researchers in order to know their opinions in participation of this type of selection.

Statistical analysis
Analysis of variance was performed for all characters from each experiment. The analysis for each character was computed on plot means. Entries were treated as fixed effects, locations and years as random effects.
Duncans Multiple Range Test (DMRT) was used to test significant differences between means.

RESULTS

The comparisons between populations gave an indication of the level of progress realised, as a result of selection by the farmers and breeders for different characters. These comparisons are presented in Tables 1 to 7.
Compared to the initial population AGP 0, the farmers have made improvement in their selection in the following characters: hairiness, gining outturn, lint yield and seed cotton yield (Table 1).
In comparison with the average of the local checks, the farmers made significant improvement in population density, days to boll opening, seed index and seed cotton yield (Table 2). However, no significant improvements were recorded from farmers' selection with respect to the other characters when compared to the initial population or the local checks.
The average of the populations from farmer's selection in a particular location was compared to the average of the local checks. The results from Djougou showed that there were significant differences between farmer's selection and the average of the checks with respect to some char acters (Table 3). Improvements were recorded for lint andseed cotton yield which showed significant increases of 23.2 kg/ha and 58.2 kg/ha, respectively, over the local checks. The farmers at Kandi obtained similar results (Table 4). Improvements were recorded for lint and seed cotton yield which showed significant increases of 31.2 kg/ha and 46.8 kg/ha, respectively, over the local checks.
The farmer's selection of Savalou showed significant improvement in all characters except boll weight (Table 5) while the researcher selection showed improvement in population density, the number of days to boll opening, seed-index and boll weight (Table 6). The average of the populations from farmers' selection was compared to the average of the research selection (Table 7).

Tab. 1: Comparative performance of farmers' selection and the initial population across environments

Varieties	Population density	Hairiness	Days to boll opening	Boll weight	Ginning outturn	Lint yield	Seed index	Seed cotton yield
	%	(0–4)	dae	g	%	kg/ha	g/100	kg/ha
Famer's selection	76.6 a	3.1 a	107.7 a	4.7 b	44.8 a	738.2 a	7.7 a	1647.8 a
AGP 0	75.4 a	2.7 b	107.5 a	5.0 a	43.6 b	656.0 b	7.7 a	1504. 0 b
Difference between farmer's section and AGP 0	1.2	0.4*	0.2	–0.3*	1.2*	82.2*	0.0	143.8*

* = significant at 0.05 level, dae = days after emergence

Tab. 2: Comparative performance of farmers' selection and the average of local check varieties across environments

Varieties	Population density	Hairiness	Days to boll opening	Boll weight	Ginning outturn	Lint yield	Seed index	Seed cotton yield
	%	(0–4)	dae	g	%	kg/ha	g/100	kg/ha
Famer's selection	76.6 a	3.1 a	107.7 a	4.7 a	44.8 a	738.2 a	7.7 a	1647.8 a
Average local check	70.2 b	3.1 a	106.4 b	4.6 a	44.6 a	699.5 a	7.1 b	1571.5 b
Difference between farmer's section and average local check	6.4*	0.0	1.3*	0.1	0.2	38.7	0.6*	76.3*

* = significant at 0.05 level, dae = days after emergence

Tab. 3: Comparative performance of farmers' selection from Djougou and the average of local check varieties across the environments

Varieties	Population density %	Hairiness (0–4)	Days to boll opening day	Boll weight g	Ginning outturn %	Lint yield kg/ha	Seed index g/100	Seed cotton yield kg/ha
Djougou	75.9 a	2.9 a	107.1 a	4.8 a	44.3a	722.7a	7.8a	1629.7a
Average local check	70.2 b	3.1 a	106.4 a	4.6 a	44.6a	699.5b	7.1b	1571.5b
Difference between Djougou and average local check	5.7*	–0.2	0.7	0.2	–0.3	23.2*	0.7*	58.2*

* = significant at 0.05 level, dae = days after emergence

The results showed that there were significant differences between farmers' selection and research selection with respect to lint yield (34.2 kg/ha) and seed cotton yield (68.5 kg/ha). These characters were improved by the farmers.

From 1997 to 2000 the farmer breeders selected the plants on the basis of the number of bolls, the size of bolls, plant height, pattern of boll opening and the easiness of harvesting. They did not choose the plants with young and green leaves at harvest stage because of *Bemisia tabassi and Aphis gossypii* that can live under those leaves.

Based on the questionnaires administered, the farmers said that they were interested in cotton participatory plant breeding programme because they could learn how to carry out some breeding work. They did not participate for monetary gain. They were of the opinion that cotton participatory plant breeding could bring them closer to the research. They got the opportunity of training in research work. In the villages, our producer colleagues

Tab. 4: Comparative performance of farmers' selection from Kandi and the average of local check varieties across the environments

Varieties	Population density %	Hairiness (0–4)	Days to boll opening dae	Boll weight g	Ginning outturn %	Lint yield kg/ha	Seed index g/100	Seed cotton yield kg/ha
Kandi selection	76.3 a	3.0 a	107.4 a	4.6 a	45.2 a	730.7 a	7.5 a	1618.3 a
Average local check	70.2 b	3.1 a	106.4 a	4.6 a	44.6 b	699.5 b	7.1 b	1571.5 b
Difference between Kandi section and average local check	6.1*	–0.1	1.1*	0.0	0.6*	31.2*	0.4*	46.8*

* = significant at 0.05 level, dae = days after emergence

Tab. 5: Comparative performance of farmers' selection from Savalou and the average of local check varieties across the environments

Varieties	Population density %	Hairiness (0–4)	Days to boll opening dae	Boll weight g	Ginning outturn %	Lint yield kg/ha	Seed index g/100	Seed cotton yield kg/ha
Savalou selection	77.7 a	3.4 a	108.6 a	4.6 a	45.0 a	761.3 a	7.9 a	1695.3 a
Average local check	70.2 b	3.1 b	106.4 b	4.6 a	44.6 b	699.5 b	7.1 b	1571.5 b
Difference between Savalou selection and average local check	7.5*	0.3*	2.2*	0.0	0.4*	61.8*	0.8*	123.8*

* = significant at 0.05 level, dae = days after emergence

Tab. 6: Comparative performance of research's selection and the average of local checks across the environments

Varieties	Population density %	Hairiness (0–4)	Days to boll opening day	Boll weight g	Ginning outturn %	Lint yield kg/ha	Seed index g/100	Seed cotton yield kg/ha
Researcher selection	76.4 a	3.0 a	107.5 a	4.9 a	44.7 a	704.0 a	7.7a	1579.3 a
Average local check	70.2 b	3.1a	106.4 b	4.6 b	44.6 a	699.5 a	7.1a	1571.5 a
Difference between Researcher selection and average local check	6.2*	–0.1	1.1*	0.3*	0.1	4.5	0.6*	7.8

* = significant at 0.05 level, dae = days after emergence

Tab. 7: Comparative performance of farmers' selection and research's selection across the environments

Varieties	Population density %	Hairiness (0–4)	Days to boll opening day	Boll weight g	Ginning outturn %	Lint yield kg/ha	Seed index g/100	Seed cotton yield kg/ha
Farmer's selection	76.6 a	3.1 a	107.7 a	4.7 a	44.8 a	738.2 a	7.7 a	1647.8 a
Research's selection	76.4 a	3.0 a	107.5 a	4.9 a	44.7 a	704.0 b	7.7 a	1579.3 b
Difference between farmers' selection and research's selection	0.2	0.1	0.2	–0.2	0.1	34.2*	0.0	68.5*

* = significant at 0.05 level, dae = days after emergence

believe in us and can consult us any time even if it is not the problem of breeding. They said that they are respected in the village and particularly in the producer organization. The present system of selling the cotton seed may change. As participatory cotton breeders, they can be the ones chosen for cotton seed production.

DISCUSSION AND CONCLUSION

A comparative analysis of the selected populations and checks (Tables 14 to 20), showed that each group of poulations and the average of farmer selections had population density improved. This character plays an important role in cotton production. If the population density is optimum in a field, this contributes to increment in crop production. The improvement of this character in the selected populations in comparison to the checks is a progress. This could be due to the way of selection. While selecting healthy plants, the farmers indirectly selected plants which were resistant to common diseases which could affect seed germination and the growth of the seedling.

It was observed that only populations from Savalou showed significant differences when compared with the average local check in terms of hairiness. This was a good character farmers from Savalou had unconsciously selected in their populations. This selection is useful because "hairness" is a character of resistance to some pests. The implication of this result is that the hairy populations from Savalou were somewhat protected against some pests which is an advantage over the other populations.

The populations from Savalou, Kandi showed significant differences when compared with the average of the local check for days to boll opening. These populations were late maturing. This indicates that for this character these populations did not perform well in comparison with the checks. Generally, breeding work is focused on the character of earliness in order to limit the time the crop stays in the field. The farmers in looking for taller plants had unconsciously selected late maturing populations.

The boll weight of populations from the researchers was significantly larger than that of average local check. The boll weight is one of yield components. The researchers pay attention to it because it can contribute indirectly to increase the yield.

It was observed that Savalou and Kandi farmers had significantly improved the ginning outturn when compared with the average local check. Ginning outturn is the most important element in cotton production. The two populations could be useful where increased lint production is the objective. All farmers had simultaneously and significantly improved lint yield. This improvement was unconsciously done but it is good because ginners would certainly prefer populations that will provide them more cotton lint. A variety which gives

much lint is appreciated by ginners since it permits them to gain more money.

The seed index was significantly improved by all farmers and researchers when compared with that of average local check. The seed-index is one of the components of yield. Its weight should not be too low if not it passes into the fibres when the ginning is going on. This will cause problem to the ginner. That is why the populations selected with improvement in seed index will be well appreciated by the ginners.

The seed cotton yield was significantly improved by each group of farmers and researchers when compared to the average local check. The yield is definitely the most important characters considered in cotton production. The cotton farmers grow cotton crop because of seed cotton yield. They are very much interested in varieties which can give more yields. They were able to choose plants which according to them could give better yield.

Cotton plant is the first cash crop that procures money for the farmers in the Republic of Benin. Although the farmer is not the end user of the product, he can identify in the fields, from the agronomical and morphological characteristics the type of cotton plant that would give increased seed cotton yield. The cotton grower can evaluate his plant just as well as the food crop plant grower can do. The farmers were involved in a mass selection after they were given a cotton seed full of variability created by cotton researcher's on-station according to panmictic method (Lançon, 1998). The first thing that was noticed with participating farmers was their enthusiasm in doing the research work because they recognized the confidence the researchers reposed on them. They then believed that research pays attention to their own problems of cotton cultivation. During the years of experimental trials, the collaboration was excellent between farmers and researchers. Since the farmers got the opportunity to discuss first between themselves and secondly between them and the researchers on the major farmer-relevant parameters they used in their selection. The two partners learnt from each other. This really justifies the importance of the decentralization of plant breeding research which many workers have advocated (Maurya *et al*., 1988; Farrington and Martin, 1988; Galt, 1989; Joshi and Sthapit, 1990; Sperling *et al*., 1993; Sthapit *et al*., 1994; Joshi and Witcombe, 1996; Witcombe *et al*., 1996). Even the farmers were able to give some suggestions on the method used for some observations in the field. This confirmed that farmers can significantly contribute to the success of a breeding programme, but also that with participatory plant breeding approach breeders should be open to unexpected and unplanned contributions of ideas (Ceccarelli, 2000).

The major limitation in this study was the lack of literature in participatory cotton breeding. All literature consulted was in food crop plant participatory breeding. Although there was unavailability of up-to-date information on cotton participatory plant breeding, the study was carried out successfully with the contribution of the cotton growers who were able to identify the type of cotton they needed. Participatory plant breeding was originally designed for complex, diverse and risk-prone environments more frequent in the contexts of marginal areas and subsistence agriculture (Hardon, 1996). This study intended to demonstrate as suggested by Witcombe (1999), the suitability of participatory plant breeding approach for a commercial crop grown under rain-fed semi-intensive cropping systems and in areas with medium yielding potential.

Like with Sthapit *et al.* (1996) in Nepal, the farmers have proven their ability to conduct efficient selection. However, the simple mass selection method is not sufficient to produce the stable and homogeneous genetic material which is required for a commercial crop with an industrial destination. The farmers have increased their skills through several years of common work with formal breeders. They are now able to use more sophisticated breeding techniques, like pedigree selection to produce stabilized lines.

Although the cotton participatory plant breeding is still in its infancy, this present study demonstrated that it is possible for researchers to embark on this participatory selection with farmers in order to select commercial cotton varieties in target environments for a large proportion of the cotton growing farmers, suitable for the same environment characterized by rain-fed semi-intensive cropping systems without using necessarily the formal plant breeding methods. For four years of experiment, the farmers worked with enthusiasm and were able to select promising cotton populations with good parameters.

The final genetic material (lines) will soon be available for on farm testing in more contrasting cropping systems and environments.

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