Farmer Participatory Evaluation and Dissemination of Improved Groundnut Varieties in West Africa

International Crops Research Institute for the Semi-Arid Tropics

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Abstract

This report summarizes results from the Farmer Participatory Variety selection and dissemination activities conducted in Mali, Niger, Nigeria and Senegal under the CFC funded Groundnut Seed Project. Thirty-nine (39) new varieties were tested by farmers under their management and resources across the four countries. Out of the varieties tested, 17 were selected based on the farmers' village level criteria which included high pod and fodder yield, resistance to diseases, taste, oil content, drought tolerance and marketability. More than 30 farmers' associations and small scale seed producers emerged and are producing and distributing seed of selected varieties in the pilot areas. More than 150 tons of seed of different classes that could cover 100,000 hectares were produced. About 74% of the farmers in pilot sites are using modern varieties and about 67% of the groundnut area is planted with them. Participation of farmers in variety selection is major determinant of variety adoption.

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Contents

Summary

Farmer participatory variety selection (FPVS) trials were conducted in pilot sites of the Groundnut Seed Project (GSP) using a mother and baby trial design. Thirty nine improved varieties (released and pre- released) from ICRISAT and National Agricultural Research and Extension Systems (NARES) partners were evaluated in over 200 FPVS on-farm trials in 45 locations in Mali, Niger, Nigeria and Senegal. The objectives were to identify farmers' preferred traits and varieties and test a range of seed multiplication and delivery schemes. The farmers evaluated the different varieties under their own management practices and resources.

Preferred traits included: early maturity, high pod and fodder yield, resistance to diseases, seed color, taste, oil content, tolerance to drought and marketability. Preference often differed among the sites, which reflected differences in agro-ecological zones. In each location farmers selected at least two improved groundnut varieties based on some of these traits. Overall five varieties (Waliyartiga [ICG 7878], Fleur 11, JL 24, ICG [FDRS] 4 and Mossitiga) were selected in Mali; four (ICG 9346, RRB, J11 and T 81-73) in Niger; three (SAMNUT 21, SAMNUT 22 and SAMNUT 23) in Nigeria and five (ICGV 86124, ICGV 89063, PC 79-79, H 75-O and 55-33) in Senegal. Industrial testing showed that the varieties had oil content above the local check 47-10 in Mali and 55-437 in Niger.

After two years of evaluations, more than 30 farmers' associations and small-scale seed producers were involved in seed production and distribution. More than 150 tons of seed of different classes that could cover 100,000 hectares were produced. About 74% of the farmers in pilot areas are using modern varieties, and about 67% of the groundnut area is planted with them. In locations where FPVS was limited to providing only seed for experimentation without ensuring seed supply such as in Mandé and Dioila in Mali, the proportion of the area covered with improved groundnuts was low (28%), whereas in locations where FPVS was implemented in conjunction with setting up institutions and institutional arrangements to supply seed to farmers (such as in Kolokani, Mali), the uptake in areas around the pilot sites was estimated at 83%.

Introduction

Over the last 25 years, a range of varieties has been developed, tested and adapted in West and Central Africa. Thirty nine were found adapted according to Mayeux et al. (2003). However, resource-poor farmers seldom have access to such new varieties that may improve their livelihoods. Many farmers still grow old varieties and hence fail to benefit from the most modern products of crop improvement. One of the reasons for low adoption of new varieties is that farmers have little exposure to new varieties, or the varieties do not satisfy their preferences and needs. Thus, farmers need to test a range of varieties under their own conditions, resource levels and environment in order to select the ones they prefer. Farmers' participation in technology generation and selection as drivers to adoption are well documented (Ashby 1991; Sperling et al. 1993). FPVS has shown successes in identifying varieties preferred by farmers, and accelerated their dissemination (Joshi and Witcombe 1996; Witcombe et al. 1996; Mulatu and Belete 2001; Mulatu and Zelleke 2002).

The demand for varieties by farmers and oil processing industries is a result of plant, seed and other desirable traits that are embodied in the varieties. Knowledge of the range of plant, seed and processing traits are valuable for crop improvement programs and good market signals for processors (Ndjeunga et al. 2003). The demand for improved groundnut varieties will increase if varieties are designed to include producer and consumer preferred traits. Therefore, improving the performance of varieties accounting for all significant traits will contribute to the productivity and profitability of groundnut.

Choosing a variety is only half the story. Equally important is to ensure that seed of preferred varieties is accessible, and affordable to end-users. However, in West Africa, the constraints limiting the performance of seed supply systems remain the lack of awareness among farmers about new varieties, poor functional seed and product markets, limited access to seed of new varieties, limited supply of breeder/foundation/certified and commercial seed (Ndjeunga et al. 2006).

The objectives of the present study were: 1) to identify farmers' preferred traits and varieties through FPVS and 2) to test a range of seed multiplication and delivery schemes. This paper is organized as follows: Section 2 describes the context and production environment, Section 3 deals with methodology, Section 4 outlines the results and discussion and Section 5 supplies conclusions and lessons learned.

Context

In 1998, under a predecessor project, the Groundnut Germplasm project (GGP) supported by the Common Fund for Commodities (CFC), ICRISAT and partners coordinated a network of regional variety trials in 13 countries of West Africa to enable NARS have access to a diverse range of improved varieties and to select those adapted to a range of agroecologies. A total of 92 varieties with various economic traits such as resistance to foliar diseases and groundnut rosette, tolerance to aflatoxin contamination, tolerance to drought, having confectionery traits, and yield potential, were included in these trials. After four years of testing, 39 new adapted varieties were identified. A regional variety map was developed, based on agro-climatic criteria and results from the performance analysis of these new varieties, to facilitate easier choice of varieties and regional exchange. A bilingual variety catalogue describing the new varieties and zones of adaptation was published (Mayeux et al. 2003).

In addition to the variety trials, FPVS on-farm trials were initiated in Mali and Niger. In Mali these were conducted in the districts of Kolokani, Dioila, Mandé and Sanankoroba. Those in Kolokani started in 1998 and by 2002, nine varieties were evaluated by 166 farmers in 46 villages using a combination of the mother and baby trial designs. The number of farmers and varieties varied from year to year and/or according to the set of varieties tested. The major characteristics of the varieties were resistance to cercospora leaf spots, short to medium- maturity, medium-size pods and grains. Their yield potential ranged from 1-2 t/ha of pod and 2.5-4.0 t/ha of haulms (above ground dry matter). Haulms are important for livestock feed during the dry season.

Among the varieties evaluated in Kolokani, ICG 7878 (renamed Waliyartiga) was the most resistant to foliar diseases and produced the highest haulm yields (Table 1). ICGV 92093 and ICGV 92088 were also resistant to early leaf spot but had lower pod yield than the local check. The low haulm yield of Mossitiga and 47-10 are largely due to their susceptibility to early leaf spot which results in defoliation, thus reducing the above-ground biomass.

In 1999, ICRISAT made available seed of a set of nine varieties to Winrock International, an international NGO working through a network of local NGOs in Mali. The main characteristics of these varieties were similar to those tested in Kolokani. Trials/demonstrations were established in 15 villages in the districts of Sanankoroba and Ségou in Mali. After the first

Table 1. Late leaf spot (LLS) severity and yield of selected varieties in on-farm trials in Kolokani (averaged over 53 trials).

			Yield t/ha	
Cultivars	% LLS	% Defoliation	Pod	Fodder
ICGV 92088	17	13	1.06	1.61
ICGV 92093	22	18	1.23	1.80
ICG 7878	8	3	1.71	2.61
ICG (FDRS) 4	26	22	1.43	1.81
Mossitiga	56	52	1.97	0.69
47-10 (Local)	49	44	1.52	0.67
SE	2.6	2.66	0.081	0.076
CV (%)	38	46	24	23

year, selected varieties were put in larger multiplication plots of 500 sq m involving 23 farmers, the majority of whom were women.

From these trials and demonstrations, two varieties, ICG (FDRS) 4 and ICG (FDRS) 10 were selected by most farmers. The yield of these two varieties compared to the local variety is presented in Table 2. These varieties have comparable pod yield as the local variety with the added advantage of earliness (about three weeks earlier than the local) and resistance to foliar diseases.

In the 2000 crop season, five female farmers each from the districts of Mandé and Dioila visited ICRISAT research station and selected three varieties (ICGV 86124, Fleur 11 and JL 24) from a demonstration plot. After harvest, each farmer was given 1 kg each of the three varieties. They were told to grow the new varieties along with their own variety using their management practices and resource base. Other than occasional visits during the cropping season, no technical support was given to the farmers.

Table 2. Yield performance (kg/ha) of selected varieties in the NGO supervised trials.

Variety	Number of farmers	Range	Mean
ICG (FDRS) 4	22	350-1450	782
ICG (FDRS) 10	20	200-1350	729
Local (28-206)	22	360-1400	760

Source: Winrock International Annual Reports

After the first year of testing, farmers started exchanging small quantities of seed of the preferred variety. By 2003, 75 farmers had access to seed of the new varieties.

In Niger, 70 farmers from the villages of Bengou, Koita Tegui and Kouara Zeno near the research station of the Institut National de Recherche Agronomique du Niger (INRAN) at Bengou in Gaya, visited a large nursery of groundnut germplasm established by ICRISAT for characterization in 2000 crop season. Fascinated by the diversity of the varieties, farmers were eager to test some of them on their farms. Based on their observations and information given by ICRISAT technicians, the farmers selected 52 varieties. After harvest, each farmer was given one kilogram seed of the selected variety. In 2001, the farmers collectively grew the varieties on a 2-ha plot provided by the village chief of Bengou. ICRISAT technicians demonstrated to the farmers on how to sow in lines and taught farmers pre-and postharvest crop management. Each variety was grown in a 10 × 10 m plot. The farmers carried out all field operations (land preparation, planting, weeding and harvesting). The Programme d'Appui au Développement Local (PADEL), a Swiss-funded development project in Gaya, supported three field days: 45 days after planting to assess plant vigor, at harvest to assess yield and the third one during oil extraction to assess oil and cake yields. More than 150 women and men attended each of the field days. Twenty varieties were selected based on productivity.

Women with 20 years of experience in groundnut oil processing conducted the assessment of the selected varieties for oil and cake yields using traditional methods. From this assessment five varieties (ICGV 86124, 55-437, ICG 9346, ICG 9199 and ICG 7299) were selected. The average pod yield of these varieties ranged from 1.5 to 2.9 t/ha. The oil yield ranged from 218 to 287 g/kg, while cake yields ranged from 648 to 713 g/kg.

Methodology

Pilot sites

The Groundnut Seed Project (GSP) launched in 2003 was designed to promote groundnut varieties found adapted during the Groundnut Germplasm Project (GGP) through sustainable seed systems. Thus, FPVS on-farm trials were extended to pilot sites in other major groundnut growing regions of Mali, Niger, Nigeria and Senegal (Fig. 1). The sites span a range of socioeconomic and demographic settings and are representative of agro-ecologies suitable for groundnut production, ie, the Sudan-Sahelian zone with 400-700 mm rainfall, the Sudan Savanna zone (700-1000 mm) and the northern Guinean zone (1200-1500 mm). In Mali, the trials were extended to Kita and Kayes districts. In Niger, the pilot sites were in the departments of Dosso, Maradi and Zinder. In Nigeria, trials were set up in Kaduna, Kano and Kastina states, while in Senegal the trials were established in the northern, middle and southern regions of the groundnut basin.

Participatory variety evaluation

The trial designs

The mother and baby trial design was used as the main participatory tool in the evaluation and selection of varieties**.** These are single-replicate designs used to assess the relative performance of varieties. In mother trials many entries are grown together in the same field. The trials are researcher-designed but farmer-managed, and they are replicated across villages. They not only serve as demonstration plots or focal points for discussion but are also specifically designed to provide quantitative analyzable data on yield (Snapp 2002) and farmers' preference for traits embodied in the varieties.

In the baby trials, only farmers' perceptions on yield is collected. A farmer grows 1 to 3 new varieties along with the local variety under traditional management practices. Replication is across farmers, either in the same village or across villages. The varieties tested in the four countries are presented in Table 3. In 2003 crop season, 144 FPVS trials were established in 45 locations across the four countries. In 2004, the trials were increased to over 200.

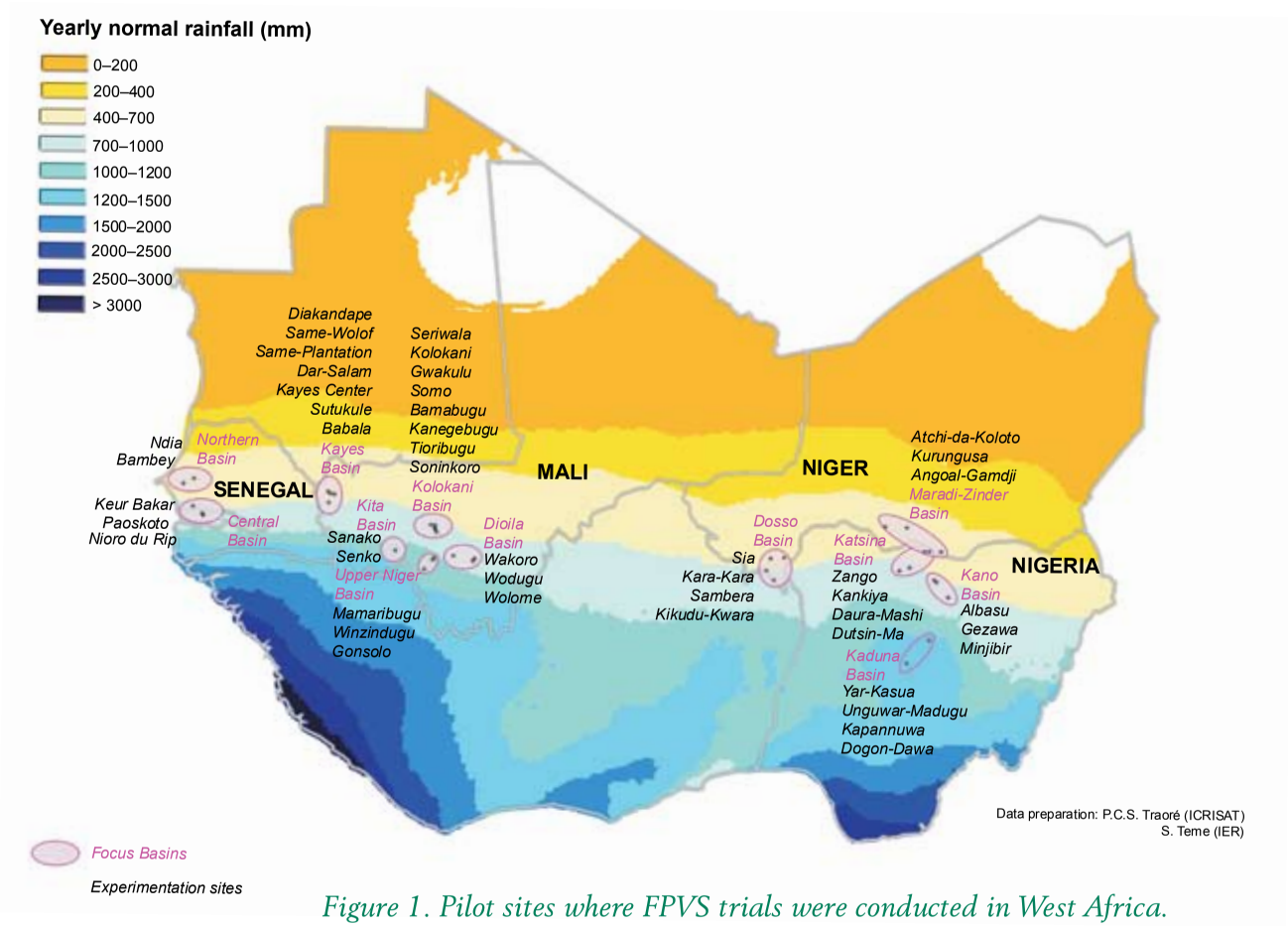

Figure 1. Pilot sites where FPVS trials were conducted in West Africa.

Table 3. Varieties and attributes of varieties in the FPVS on-farm trials in Mali, Niger, Nigeria and Senegal (2003-2004).			
Mali	Niger	Nigeria	Senegal
Released			
ICG (FDRS) 4	TS 32-1	SAMNUT 21	GH 119-20
ICG (FDRS) 10	RRB	SAMNUT 22	55-21
ICG 7878	796	SAMNUT 23	73-33
JL 24	55-437		
Mossitiga			
47-10			
Pre-release			
Fleur 11	ICG 9346		ICGV 89063
ICGV 86024	ICGV 96894		ICGV 86124
ICGV 86015	ICGV 86124		ICGV 89112
ICGV 86124	Fleur 11		ICGV 97065
ICGV 92093	T 169-83		ICGV 94222
ICGV 92088	T 177-83		H75-O
ICGV 97188	T 181-83		PC 79-79
	J11		55-33
Attributes			
Resistance to foliar diseases and tolerance to drought	Early maturity and high oil content	Resistance to groundnut rosette disease	Drought tolerance, early maturity and limited fresh seed dormancy, confectionary
Total: 13	12	3	11

Variety preference assessment

Plant and grain characteristics

In most locations, a simple and median ranking by the farmers based on their criteria were used. At harvest, farmers' perceptions were monitored for few traits such as crop cycle, pod yield and other traits of interest.

In the Dosso region of Niger, the mother trials were located on central or visible locations in the villages of Kara Kara, Sia and Sambera. Trials were set up in a randomized complete block design of 5 varieties and 5 replications. Plot size for each variety was 10 × 10 m per replication. The trials were implemented collectively by farmers selected by the village chief or farmers' associations. During the vegetative cycle, two assessments were carried out with farmers at flowering and another at the harvesting period. At harvest a preference survey was conducted involving 25 farmers.

The development of a survey instrument for data collection involved a number of steps. The available literature was reviewed to develop a list of important groundnut plant and seed characteristics for potential inclusion in the questionnaire. Germination, plant type, disease resistance, flowering, shape of leaves, maturity, pod and haulm yields, pod filling sizes of pod, seed, color were often cited as important plant and seed characteristics. Based on potential characteristics likely to explain choice for varieties, a participatory rural appraisal (PRA) was held with groundnut producers in the three villages in order to evaluate alternative question formats, contents and elicit general advice from consumers for different traits. The last stage in the process involved the development of the survey instrument. Only characteristics that were ranked high via the focus-group meetings were included in the questionnaire. Accordingly, 16 plant and seed characteristics were included (Table 4). Respondents evaluated the five groundnut varieties using a five-point preference scale (0 being the least preferred and 4 being the most preferred) using the 16 criteria.

Table 4. Comparison of the five groundnut varieties for plant and seed attributes in Dosso, Niger.

Attribute		VARIETY 55437	9346	96894	FLEUR 11	RRB	Total	Pearson Chi-square (df) P value
Germination	0	1		17	7		25	80.12 (8) ***
	1	12	9	14	30	15	80	
	2	37	41	19	13	35	145	
Plant type	0	2		8	9	1	20	27.53 (8) ***
	1	7	2	5	8	11	33	
	2	41	48	37	33	38	197	
Resistance to diseases	0	6	3	15	7	3	34	31.11 (8) ****
	1	6	1	11	6	11	35	
	2	38	46	24	37	36	181	
Flowering	0	1	2	1	2	1	7	10.13 (8)
	1	5	2	8	9	2	26	
	2	44	46	41	39	47	217	
Leaves	0			2	2	1	5	14.06 (8) *
	1	3	1	7	9	4	24	
	2	47	49	41	39	45	221	
Maturity (cycle)	0			10	3		13	66.86 (8) ***
	1	7	1	19	9	3	39	
	2	43	49	21	38	47	198	
Number of pods	1	2		5	2	2	11	18.07 (8)***
	2	14	9	15	24	16	78	
	3	34	41	30	24	32	161	
Pod yield	1	2		23	3	1	29	88.68 (8) ***
	2	11	9	15	18	5	58	
	3	37	41	12	29	44	163	
Haulm yield	1	4		5	2	2	13	19. 22 (8) **
	2	8	5	17	9	7	46	
	3	38	45	28	39	41	191	
Large pods	0			1			1	20.75 (8) ***
	1	9		2	1	5	17	
	2	41	50	47	49	45	232	

Table 4. (Continued) Comparison of the five groundnut varieties for plant and seed attributes in Dosso, Niger.

		VARIETY						
Attribute		55437	9346	96894	FLEUR 11	RRB	Total	Pearson Chi-square (df) P value
Pod filling	0			19	1		20	90.21 (8) ***
	2	14	5	15	12	10	56	
	3	36	45	16	37	40	174	
Beak	0			10			10	47.16 (8) ***
	2	11	4	10	10	8	43	
	3	39	46	30	40	42	197	
Pod constriction	0			3			3	16.74 (8) **
	2	7	5	11	8	5	36	
	3	43	45	36	42	45	211	
Reticulation	0	1		17			18	78.84 (8) **
	2	4	5	11	12	7	39	
	3	45	45	22	38	43	193	
Large seed	0			4	1		5	21.99 (8) ***
	1	7		2	2	4	15	
	2	43	50	44	47	46	230	
Seed color	0	3	1	3	2	1	10	2.08 (4)
	1	47	49	47	48	49	240	
Rank	1	3	15	24	6	4	52	92.55 (16) ***
		6.0%	30.0%	48.0%	12.0%	8.0%	20.8%	
	2	8	1	10	22	8	49	
		16.0%	2.0%	20.0%	44.0%	16.0%	19.6%	
	3	17	13	2	9	8	49	
		34.0%	26.0%	4.0%	18.0%	16.0%	19.6%	
	4	15	8	1	9	19	52	
		30.0%	16.0%	2.0%	18.0%	38.0%	20.8%	
	5	7	13	13	4	11	48	
		14.0%	26.0%	26.0%	8.0%	22.0%	19.2%	
Median ranking		3.30	3.06	2.38	2.66	3.50		
Average ranking		2	3	5	4	4		
Total		50	50	50	50	50	250	
		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

Oil content

In all the project countries, groundnut is used for oil extraction and varieties with high yield and oil content are sought by both village level and industrial vegetable oil processors. In Mali, 12 varieties introduced to farmers were assessed for oil content by the Huicoma Group Tomota – Mali, which processes cotton oil. In Niger, the analyses were conducted in the laboratory on samples of the varieties tested by the farmers in the different villages in the three regions.

Building seed supply and delivery systems

After varieties that are preferred by farmers or required by the market have been selected, access to seed becomes a major constraint to uptake. Thus, a range of institutions and institutional arrangements were tested to identify the best strategies involved in seed production and delivery to ensure a sustainable supply of high quality seed at affordable prices.

Breeder and foundation seed: The production of breeder and foundation seed is the responsibility of NARS. Technical support was provided to NARS to produce breeder and foundation seed stocks of the preferred varieties that can be used by farmers' associations, and small-scale seed producers to bulk into commercial seed stocks. A revolving fund scheme for these classes of seed was tested.

C*ommunity-based seed production and supply:* The aim was to help communities produce their own seed of acceptable quality and at affordable prices. This scheme essentially involved farmers' association and/or organizations and emerging small-scale private seed growers. Farmers were trained in crop management and seed production techniques, in marketing and small-scale business management.

Promotion of improved seed through the sale of small seed packs: The project pilot-tested the sale of small seed packets (1-5 kg) to respond to the need for farmers to experiment small quantities of seed, to uncover the size of the demand and identify the types of packaging, standard and norms that best suit end-users.

Enhancing linkages between producers, processors and other stakeholders along the value chain: This involved facilitating dialogue between the various actors along the value chain through groups meetings in the various location and/or national forums and workshops. This was stimulated by the need to establish trust and reputation among actors and favor contractual arrangements that could arise in order to ensure ready markets

for products demanded and stimulate uptake of improved technologies and innovations.

Assessing the performance of FPVS pathways

Baseline surveys were carried out in pilot sites in 2003 to assess households' resource endowments (natural, physical, human, economic and financial capital and social capital) at project inception. In addition, the seed supply schemes were assessed. At the end of the project in 2007, a survey was carried out to assess the level of uptake of varieties through the different alternative arrangements.

Pilot sites were randomly selected. Within pilot sites, farmer participants in the FPVS trials were randomly selected and non-participants were selected using a list of households provided by the chief of villages or developed by enumerators. Control sites were considered in neighboring villages where the project did not intervene.

Information was collected on farmers' socioeconomic profile (age, gender, education and family size); the institutional and infrastructural environment (access and availability of seed of preferred varieties and markets), technological constraints, plant type, cycle, seed size and color, utilization (oil, edible, confectionary, fodder for livestock) and resistance to foliar diseases were hypothesized to be the main constraints to uptake of modern groundnut varieties and factors explaining farmers' variety preferences. A simple system of mean and median ranking was used to assess farmers' preference for varieties.

Results and Discussions

Farmer Participatory Variety Selection

Mali

In Kolokani district, the most preferred traits cited by farmers were higher pod and haulm yield, large seed size, taste, and drought tolerance (Table 5). In particular, Mossitiga was well rated because of its high drought tolerance, early maturity and high yield compared to the local variety. Similarly, ICG (FDRS) 4 was preferred for the same reasons, but to a lesser degree. ICG 7878 was chosen for its high haulm yield, large pods and sweet taste. However, it was rated low for drought tolerance and pod yield. This variety is a medium-maturing (115-120 days) and yield can be severely affected if rains end early as is often the case in Kolokani.

In Kayes, the majority of farmers selected Fleur 11, JL24 and Mossitiga in the first growing season. The main criteria used were pod yield, bold pods, vegetative growth, haulm yield and taste. The yield performance of these varieties is presented in Table 6. Overall, the new varieties did not significantly out-yield the local variety. However, farmers preferred them over their traditional variety because the new varieties have larger seeds, and taste better than the local variety.

Table 5. Ranking* of the four most preferred groundnut varieties by traits against the local check in Kolokani, 2003.

	Variety name				
Trait	ICG (FDRS) 4	ICG 7878	ICGV 92093	Mossitiga	Local
Higher haulm yield	2	1	3	4	4
High pod yield	3	4	5	1	2
Large seed size	2	1	3	4	4
Early maturing	3	5	4	1	2
Taste	2	1	5	3	3
Marketability	3	5	3	1	2
Drought tolerance	3	5	4	1	2
Overall ranking	2	4	5	1	3

* Ranking was on a 1 to 5 scale, where 1= the best and 5 = the poorest.

Table 6. Yield performance of drought tolerant varieties conducted in Kayes 2003 averaged over 20 farmers.		
Variety	Pod yield (t/ha)	Haulm yield (t/ha)
Mossitiga	1.67	1.95
ICGV 86124	1.78	2.05
ICGV 86024	1.68	1.87
Fleur 11	2.02	2.30
JL 24	1.95	2.23
47-10 (local)	1.80	2.13
SE	0.052	0.058
CV (%)	13	13

In Kita, the new varieties were generally lower yielding that the local variety (Table 7). Nonetheless, farmers selected ICG 7878 for its big pods, while ICGV 92093 was selected based on its productivity comparable to the local variety. Both varieties are resistant to foliar diseases while the local variety is susceptible. The results from pilot sites in Mali indicate that farmers' choice of varieties is not based on yield alone.

Table 7. Yield (t/ha) of foliar disease resistant varieties evaluated by 10 farmers in Kita, 2003.		
Variety	Pod yield	Haulm yield
RMP 12	0.99	1.12
ICG 7878	1.11	1.28
ICG (FDRS) 4	1.10	1.24
ICG (FDRS) 10	1.11	1.22
ICGV 92093	1.57	1.66
28-206 (local)	1.56	1.77
SE	0.124	0.131
CV (%)	32	30

The oil content of 12 varieties as assessed by the Huicoma Group Tomota–Mali are presented in Table 8.

Five varieties had oil content ≥ 50%, three of which (ie, ICGV 86024, ICGV 86015 and ICGV 97188) were not among those selected by the farmers. This indicates that the linkage between groundnut producers and processors is critical in forging input and product market integration.

Table 8. Oil content of varieties exposed to farmers in Mali, 2005.

Variety	% Oil content
ICG (FDRS) 4	49.2
JL 24	51.4
ICGV 86024	52.5
ICG 7878	49.0
ICGV 86124	47.2
Fleur 11	49.8
47-10	47.8
55-437	45.0
Mossitiga	52.2
ICGV 86015	52.2
J 11	49.2
ICGV 97188	51.0

Niger

In the Dosso region, 47 of the 75 farmers participated in the evaluation of varieties in three villages (15 in Sia, 16 in Kara Kara and 16 in Sambera). Results from analyses of variance of pod and haulm yields are presented in Table 9. The average pod yield obtained in the three villages was 665 kg/ha (higher than the national average of 375 kg/ha) with significant differences in yields between varieties and villages. RRB and 55-437 had the highest yields and ICGV-IS-96894 the lowest. ICG 9346 produced significantly higher fodder yield than the other varieties.

Table 9. Average pod yield by variety in the pilot sites in the Dosso region, Niger.					
Pod yield (kg/ha)	N	Mean	Std	Min	Max
55-437	14	747	296	383	1213
Fleur 11	10	551	165	310	827
ICG 9346	11	735	283	393	1157
ICGV-IS 96894	14	504	294	123	1140
RRB	14	766	416	77	1477
Total	63	665	320	77	1476
Haulm yield (kg/ha)					
55-437	14	636	201	356	953
Fleur 11	10	616	184	320	930
ICG 9346	10	853	292	516	1456
ICGV-IS 96894	14	480	244	136	890
RRB	14	653	302	80	1193
Total	62	636	268	80	1456

There were significant differences in pod and haulm yields between villages with Sambera recording the highest yields for pod and fodder (data not shown).

The average ratings for the attributes and overall average rating for varieties indicate that the panelists were able to discriminate between varieties for each of the attributes and overall acceptability of the varieties (Table 4). While all traits were associated with varieties, only color and flowering were poorly associated. The mean ranking of overall acceptance of the varieties was estimated to range between 2.66 and 3.50 for RRB and 55-437 had the best overall ratings, while ICGV-IS 96894 had the lowest score.

In the other regions of Niger (Maradi and Zinder), the extension agent and farmers participated in the choice of varieties to include in the FPVS on-farm trials. Nine varieties (55-437, T 183-83, T 177-83, T 169-83,

796, TS 32-1, RRB, J 11 and ICGV 86124) were evaluated. In Maradi trials/demonstrations were set up in five locations. Plot sizes ranged from 750-1500 sq m. In Zinder, similar trials were conducted under the supervision of the regional agricultural extension agents. Overall, 15 trials and 6 demonstrations were set up in the two regions in 2003. In Maradi, farmers selected RRB and JL 24, while in Zinder, T 169-83 was selected.

The oil content of some of the varieties evaluated in Niger is presented in Table 10. Other than TS-32-1, all had average oil content of 48%, which is within the acceptable range.

Table 10. Oil content of some of the varieties tested by farmers in Niger.

Variety	Oil content (%)
RRB	47.8
55-437	46.7
T169-83	48.3
T181-83	48.0
JL 24	48.3
T177-83	48.5
TS 32-1	50.8
Local	48.0

Nigeria

FPVS on-farm trials focused on three groundnut rosette resistant varieties – SAMNUT 21, SAMNUT 22 and SAMNUT 23 released in 2001 from the predecessor project GGP. A total of 69 on-farm trials and 15 demonstrations across the pilot sites were conducted in 2003-2005. These were extended to Jigawa and Zamfara states. Farmer-to-farmer visits and field days were organized to provide training in pre-harvest crop management. The dual-purpose (pod and haulm), and medium-maturing (110-120 days) varieties (SAMNUT 21 and SAMNUT 22) were selected in the higher rainfall zones (northern Guinea savanna zone) of Kaduna state. SAMNUT 23, which is early-maturing (90-100 days) was selected by the farmers in the drier Sudanian savanna zones of Kano, Katsina, Jigawa and Zamfara states. The

criteria for choosing these varieties were earliness, good pod and fodder yields and resistant to groundnut rosette disease.

Senegal

Two types of FPVS trials were conducted. The first set involved 10 new early-maturing breeding lines developed for limited fresh seed dormancy. In the first year (2004 crop season) the trials were set up in seven sites in the groundnut basin-2 in the north, three in the central north and two in the central south. In the second and third years the sites were reduced to two in the central-north and 2 in the central south. Seven lines with fresh seed dormancy ranging from 21 to 30 days after physiological maturity were selected for further evaluation.

The second set involved released and pre-released varieties. The characteristics of these varieties were short- to medium-maturity, drought tolerant and edible groundnut traits. In 2003 crop season, nine FPVS trials were conducted in the central north and central south in six villages. After the first year of evaluation, six varieties were selected based on tolerance to drought (ICGV 86124), uniform maturity (PC 79-79 and 73-33), productivity (ICGV 89063) and for edible groundnut traits (H75-O and ICGV 94222). Most of the varieties presented to farmers were acceptable, and four have been proposed for release.

In the second year (2004 crop season) the crop was ravaged by desert locust in the northern central region of Senegal and in the third year (2005) floods in the central south affected the crop.

Building seed supply and delivery systems

Breeder and foundation seed production

After ensuring that the new variety meets the needs of the farmers and product market requirements, the next step is to produce and supply enough seed to all who want to grow it.

Breeder and foundation seed are critical for a successful seed sector. Lack of these classes of seed has been identified as one of the major constraints hindering the growth of the groundnut seed sector (Ndjeunga et al. 2006). The Agricultural Research Institutions are responsible for variety development and maintenance, production of breeder and foundation seed of both released and pre-release varieties. The quantities of breeder and foundation seed produced over the project period are presented in Table 11.

Table 11. Breeder and foundation seed production (tonnes) by institutions (2003-2006).

	2003		2004		2005		2006	
Institution	B	F	B	F	B	F	B	F
Mali	17	12.0	1.7	8.8	1	20	1.1	10.0
Niger	1.0	4.9	-	5.5	-	4.8	-	-
Nigeria	2.0	5.7	1.9	10.0	0.4	3.8	0.4	5.6
Senegal	0.7	-	-	1.0	0.6	3.2	1.2	7.4
ICRISAT	4.0	-	4.0	-	5.0	5.0	2.5	-
Total	9.4	22.6	7.6	25.3	7	36.8	5.2	23

B = breeder, F =foundation

In all countries, production of breeder and foundation seed as well as supply is inconsistent and very limited. This was attributed to a number of factors including climatic (drought), low yields, poor soil fertility and natural calamities such as desert locusts and flooding as happened in Senegal in 2004 and 2005. In Nigeria, the government provides very limited funding for breeder seed production and this activity is being carried out mostly through special projects. In Niger and Mali, there is no breeder seed production per se. This is often done in partnership with ICRISAT. In Senegal, on the other hand, the government provides funding for breeder seed production by the seed unit of ISRA. This is largely motivated by the high demand by the parastatal groundnut oil processing company, SONACOS. Efforts by IAR in Nigeria and INRAN seed unit in Niger at establishing revolving funds are underway. The success of these schemes will rely on the possibility to fully recover at least the cost of production (using economies of scale) and government commitment to encourage such schemes.

In Senegal, the government and projects subsidize groundnut breeder seed production. In 2004, breeder seed was sold at $1.62/kg whereas the average cost of production was estimated to $1.81/kg. In Nigeria, breeder seed production is profitable. In 2004/05, breeder seed was sold at $7.60/kg, whereas the average cost of breeder seed production was estimated

to be $6.44/kg[1]. In all countries except for Niger, groundnut foundation seed production is profitable. In Nigeria, foundation seed is sold at $3.81/kg whereas the average cost of production is estimated to $2.48/kg. In Senegal, the seed unit generates profits estimated to about $0.71/kg. Foundation seed is cheaper to produce in Senegal than in other countries providing opportunities for regional groundnut seed trade[2]. Similarly the price of certified seed is cheaper in Senegal than in Nigeria. In effect, while a kg of groundnut seed costs $0.82/kg in Senegal, it is about double in Nigeria estimated to about $1.62/kg.

Profits generated by seed companies are very narrow. Seed companies in Nigeria derive little profits from selling groundnut seed compared to other crops such as sorghum, pearl millet and maize or hybrid seeds.

While certified groundnut seed is sold at $1.62/kg and the average cost of production is estimated to $0.88/kg, the carry-over stocks are often too high on average 50% of seed produced limiting the returns to seed production.

Community-based seed production

In an attempt to resolve the access and availability of seed, ICRISAT initiated a small-scale seed production scheme with four farmers in Kolokani. To further enhance farmer access to modern varieties, three associations were also formed. Membership to these associations averaged 40 groundnut producers who were trained in seed production techniques. Most of the seed produced was distributed among members with little being sold in the market. The quantities of seed produced by the associations and individual farmers are presented in Tables 12 and 13.

Few case studies of small-scale seed entrepreneurs in Nigeria show that local village seed is cheaper. Price of seed is often set at about 12.50% above the price of grains in the market estimated to about $0.59 at planting times. Small-scale entrepreneurs are often farmers who have established their reputation in seed production. In effect, these farmers often favor social status over profits. They have accumulated more than 20 years of experience in producing seed for their neighbors. They often supply seed on credit recoverable at harvest. Despite potential profits that may be generated from seed production, it is still largely unsustainable.

[1] On average 1 USD equaled 136 Naira and 550 FCFA in 2004/05.

[2] This assumes that the intermediation costs (transport costs, import taxes and other intermediation costs are less).

Table 12. Quantity (in kg) of quality declared seed produced by farmers' associations in Kolokani (2003-2006).

Association	ICG (FERS) 4	Fleur 11	JL 24	ICG 7878	Mossitiga	ICGV 86124
2003						
Tioribougou	177	71	107			
Somon	142	71	80			
Kolokani	194	106	93			
Mambabougou	113	39	70			
Total	626	297	517			
2004						
Tioribougou	91	238	180	14	-	
Somon	76	72	-	-	-	
Kolokani	35	200	144		-	
Mambabougou	6	-	-	-	-	
Other	233	59	307	163	1241	
Total	441	569	631	177	1241	
2005						
Kolokani	1068	682	356			
Mambabougou	95	277	-			
Somon	80	679	67			
Tioribougou	241	541	403			
Total	1484	2179	826			
2006						
Kolokani	1140	2025		651		549

Table 13. Area planted (in ha) and seed produced (in kg) by individual seed producers in Kolokani (2003-2006).

	2003		2004		2005		2006	
Variety	Area	Quantity	Area	Quantity	Area	Quantity	Area	Quantity
Fleur11	0.8	693	7.4	4992	5.1	3644	10	9,859
ICG 7878	0.9	570	2.7	1356	1.3	694	6.3	5,780
ICG (FDRS) 4	1.4	1374	6.5	3313	6.0	3516	7.8	7,407
JL 24	0.6	517	4.6	2750	2.8	1879	3.5	3,043
ICGV 86124	0.05	30	1.0	920	2.7	1901	4.0	4,463
ICGV 86015	0.5	277	-	-	0.9	624	1.5	1,502
ICGV 97188	0.5	301	-	-	1.2	611	3.0	1,383
Total	5.0	3,762	22	13,330	20	12,869	36	33,437
Number of farmers	4	4	4	7				

Seed marketing and distribution

In 2003, ICRISAT and IER launched a pilot test of small packs of groundnut seed in the Kolokani district based on seed stocks from individual farmer associations. The major objectives were to assess the size of seed demand or the willingness of farmers to pay for new varieties and allow more farmers to experiment new varieties. The farmers were linked to the national seed certification agency. Two groundnut varieties were available, including Mossitiga and ICG (FDRS) 4 for a total supply of about 400 kg. Every farmer or farmer association was responsible for seed cleaning and packaging into three convenient pack sizes: 1, 2 and 5 kg. Seed was sold in the markets of Kolokani, Tioribougou, Nossombougou and Djidjeni, and direct links between farmers and small-scale retailers established. Seed prices were set at 420, 415 and 410 FCFA per kg of seed packs weighing 1, 2 and 5 kg respectively. A price margin of 15% was deducted from the sale

price. All groundnut seed was sold out only two weeks after the seed sale commenced, indicating potentially large demands (Ndjeunga and Ntare 2003).

A similar scheme was launched in the villages of Faska and Hankoura in the Dosso region of Niger in 2006. In Faska, three varieties were selected while five varieties were preferred by farmers in Hankoura (Table 14). Overall, about 640 kg of seed were sold through pack sizes of 0.5 kg and 1.0 kg by small retailers identified in the Bengou market. Sales started on 7 July 2006 and ended on 31 July 2007. Prior to sales, for one month and on a weekly basis, seed sales were advertised through rural radios to inform farmers on the characteristics of seed and location of sales as well as seed prices. Seed labeling was done *in situ* with simple labels in local languages and French indicating the name of the variety, the village, weight and the prices.

Seed prices were set in relation to the cost of production. Retailers were required to place a mark-up price to 15%. Prices for smaller size were a little higher than prices for larger sizes. For example, the price of 0.5 kg of seed was set to 425 FCFA/kg and that of 1.0 kg at 825 FCFA/kg. Information on seed purchasers were recorded by seed retailers to allow better monitoring and evaluation of variety use and perception by farmers.

This scheme was very successful. Within three weeks, more than 90% of seed packs were sold and by the end of the fourth week, all seed was sold. A large number of farmers were reached. In effect, more than 500 farmers purchased and used the seed. Although this scheme is efficient at disseminating seed, one could hypothesize that after farmers have acquired seed of new varieties, they will keep it for a long time before re-entering the market, rendering the seed market inconsistent and not attractive even for small-scale seed producers. One important lesson learned is that there is a need for supplying new varieties on a more regular basis to sustain the seed market. Additionally, there is a need for testing larger quantities of seed to assess the potential size of the seed market in order to uncover the demand for seed.

Table 14. Distribution of seed by seed stocks, quantity of packs sold by monitoring period in two villages, Faska and Hankoura, in Niger.

		Pack of 0.5 kg			Packs of 1.0 kg		
Village/Variety	Quantity (kg)	Number	Sold as on 7 July 07	Sold as on 31 July 07	Number	Sold as on 7 July 07	Sold as on 31 July 07
Faska							
RRB	179	180	104	180	89	75	89
ICG 9346	34	34	15	28	16	11	12
FLEUR 11	56	56	19	50	28	25	26
Sub-total (1)	269	270	138	258	133	111	127
Hankoura							
RRB	124.5	105	40	105	72	55	72
ICG 9346	110	70	17	60	75	45	60
FLEUR 11	11.5	15	5	10	4	4	4
55-437	25	30	8	20	10	7	8
J11	88	108	21	89	34	12	22
ICG 87003	9	0	0	0	9	9	9
Sub-total (2)	368	328	91	284	204	132	175
Total	637	598	229	542	337	243	302

Encouraging small-scale seed enterprises

Efforts have been made to help establish small-scale seed enterprises in few pilot sites. These efforts were limited to providing training in seed production, marketing and small-scale business skills. This has stimulated the emergence of community-based associations at the village level wanting to engage in seed production and supply. Four individual farmers and four associations in Kolokani district and a women's group association in Wakoro in Mali have begun to produce seed of selected varieties for sale in the community. A similar situation is occurring in the other countries. In all cases farmers reported the lack of credit as the main constraint to expanding groundnut production. In effect, credit will increase farmers' access to other inputs such as seed, fertilizer and pesticides. This is consistent with earlier findings from Niger (Baidu-Forson et al. 1997).

Increasing the outlets in reducing seed costs through fostering linkages with other projects (FAO input shops projects)

In Niger, there are about 300 input shops throughout the country. Some of these input shops are beginning to be used as seed outlets as well. In the two pilot sites of the Gaya region, the farmer groups have been encouraged to build their input shops with the support of FAO Projet Intrants. At the same time, the project fostered linkages between producers and small-scale retailers through dialogue meetings at the village level. This needs to be vigorously pursued.

Adoption by diffusion pathways

Seed was delivered to farmers using two different pathways. The first pathway was implemented in the Kolokani region and consisted of the mother and baby trial approach followed by the development of seed supply and delivery schemes to ensure access and availability of seed of preferred varieties. The second consisted of baby trials in the villages of Gonsolo in Mandé district and Dioila without follow-up and building up seed production schemes.

R&D interventions started in 1998 in the Kolokani region, and in the year 2000 in Gonsolo and 2001 in Dioila. Baseline surveys in 2003 showed that 32% of area in Kolokani was planted with improved varieties and about 10% in the Dioila and Gonsolo villages. Results from a survey undertaken in 2006/07 in the same villages showed that uptake had increased. In Kolokani about 83% of the area covered by surveyed farmers was planted with improved varieties and 28% in Gonsolo and Dioila. The proportion of farmers that have adopted new varieties is higher among those who participated in FPVS on-farm trials in pilot sites (94%) than among non-trial participants (69%) and a little lower in neighboring villages estimated at 51%. The area covered by trial participants is estimated at 68% compared to 42% for non-trial participants and 34% in neighboring villages. In Kolokani, factors driving the intensity of adoption of improved varieties include the total work force, the involvement of farmers in on-farm trials and their location with regard to pilot sites, the value of animal traction, low diseases and pests pressure, the market value and social capital (Table 15). However, household with larger families are less likely to intensify.

Table 15. Tobit results on the intensity of groundnut adoption in the Kolokani district of Mali.

	Tobit model			
Variable	Coef.	Std. Err.	T	P>t
Age of Household Head (years)	0.002055	0.003887	0.53	0.598
Family size	-0.0306	0.01479**	-2.07	0.041
Illiteracy (0=illiterate, 1=literate)	0.015804	0.127525	0.12	0.902
Cultivated area (ha)	0.01083	0.013898	0.78	0.438
Sex of farmer (0=female,1=male)	0.021822	0.075373	0.29	0.773
Marital status (0=not married, 1=married)	0.01574	0.067755	0.23	0.817
Total work force (adult equivalents)	0.053121	0.028045*	1.89	0.061
Dependency ratio	0.098414	0.061581	1.6	0.113
Location (0=control village, 1=non-participant, 2=participant)	0.252427	0.066277***	3.81	0
On-farm trial participant (0=No, 1=Yes)	0.069413	0.12408	0.56	0.577
Total value of crop production (FCFA)	-0.00056	0.000257**	-2.18	0.031
Total value of equipment (FCFA)	0.000258	0.000169	1.53	0.13
Off-farm revenue (FCFA)	0.000346	0.000325	1.07	0.289
Value of animal traction (FCFA)	4.03E-05	0.000022*	1.84	0.069
Seed constraint (0=No, 1=Yes)	-0.31462	0.152758**	-2.06	0.042
Low yield (0=No, 1=Yes)	0.311011	0.348402	0.89	0.374
Low diseases and/or pest (0=No, 1=Yes)	0.319776	0.11671***	2.74	0.007
Market value (0=No, 1=Yes)	0.703643	0.382106*	1.84	0.068
Kolokani (cf. Gonsolo and Dioila)	-0.16596	0.285151	-0.58	0.562
Social capital	0.12087	0.045041***	2.68	0.008
Constant	-0.39844	0.409781	-0.97	0.333
σ	0.33564	0.024195		
Number of censored observations	22			
Number of observations	128			
Pseudo R2	0.41			
LR chi2	77.46			

Women groundnut farmers' association in Fabidji, Niger

Conclusions and lessons learned

FPVS provides farmers with firsthand information on the characteristics of improved varieties and agronomic practices. They also empower farmers to select new varieties under their own management and criteria. The trials are also a source of good quality seed and farmers' hands-on training in seed production and variety maintenance. Individual farmers and farmers' associations willing to produce and supply seed have emerged in the pilot areas and are promising options for a sustainable community-based seed system. These programs need to be replicated in other target areas in collaboration with partners who have established links with farming communities there.

The participatory approach has led to rapid spread of groundnut varieties among farmers in the villages surveyed. This suggests that resource-poor farmers are constantly in search of new opportunities to diversify their income source to improve their well-being. Technologies that have a comparative advantage in farmers' agro ecological and socioeconomic conditions that provide new opportunities for income generation and diversification is critical. When a technology is appropriate, it stimulates an endogenous process of auto diffusion through a dynamic farmer-to-farmer horizontal spread of planting material. Thus, adoption coupled with building seed supply systems is crucial.

Agricultural research institutions can achieve substantial impact through a dynamic farmer participatory approach to technology development, dissemination and evaluation. However, to speed up dissemination and widespread adoption in other areas, there is a need to involve national agricultural extension services and non-governmental organizations as well as the private sector in making seeds available to larger numbers of farmers. This will undoubtedly make an important contribution to diversifying farmers' income opportunities and improving household food security.

Farmers have little access to other essential agricultural inputs to increase productivity as well as information on varieties and crop management practices. Technical, institutional and market solutions to improve access and availability of households to basic inputs should be vigorously pursued.

The sale of small seed packets of groundnut seed of preferred varieties involving farmers and village retailers gives an idea of the actual demand for seed as well as farmers' willingness to buy seed. It will also show to the private sector whether there was a small niche for marketing groundnut seed.

Seed production relying entirely on rainfall is highly risky. Efforts are needed to ensure that critical classes of seed such as breeder and foundation seeds are produced in secure environments with appropriate facilities including supplementary irrigation.

Training stakeholders along the value chain is critical for the sustainability of the interventions.

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