Asian Society of Agricultural Economists

8th International Conference

VIABILITY OF SMALL FARMERS IN ASIA

15-17th October 2014 Savar, Bangladesh

Organized session 5

Targeting of Grain Legumes for Income and Nutritional Security in South Asia

16th October 13.30 to 15.30

TROPICAL LEGUMES II

Targeting and Diffusion of Groundnut improved cultivars in Tamil Nadu state of India

KR Karunakaran
Madhu Sudan Bhattarai
D Kumara Charyulu
Moses Shyam Davala

TAMILNADU AGRICULTURAL UNIVERSITY,COIMBATORE

AND

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS, PATANCHERU, ANDHRA PRADESH-502 324

HYDERABAD

August 2014

1. Introduction

India is a major grower and producer of oilseeds as well as a major importer of vegetable oils, ranks fourth among the countries in oilseed economy, next to USA, China and Brazil spending USD 10 billion in 2012-13. Nearly 14 million farmers are involved in oilseed production, mostly in arid and semi-arid regions of the country, whose capacity to adopt modern technology are constrained by poor resource base. This is coupled with aberration in monsoon and market economy presents a formidable challenge to make oilseed production sustainable in the long run. In order to curtail the growing vegetable oil import bills and increase the production and productivity of oilseeds, the Technology Mission on Oilseeds (TMO) was initiated in 1986 with the following objectives; (i) self-reliance in edible oils (ii) reduce imports almost to zero (iii) raise oilseeds production to 18 million tonnes (mt) by 1989-90 and 26 mt of oilseeds and produce 8 mt of vegetable oil by 2000 AD. However, the TMO had unable to create a sustained growth in area under groundnut and the trend was reversed. Before the initiation of TMO (TE 1986-87), the area, production and productivity of groundnut was 7.08 million ha (m ha), 5.81 mt and 795 kg per ha of which, almost 85 per cent as rainfed crop. Implementation of TMO created marked improvement in the first decade and shifted the area, production and productivity to 7.80 ha, 7.84 mt and 993 kg per acre in TE 1995-96 which recorded an increase of 11, 35 and 21 per cent, respectively. Though the irrigated cropped area has increased to 19 per cent, the country production decreased to 6.33 mt from lesser area (5.33 m ha) by shifting its productivity to 1.3 t/ha in 2011-12.

1.1 Performance of groundnut in TLII Targeted districts and in Tamil Nadu

Groundnut is an important oilseed in Tamil Nadu, which constituting 7.51 per cent of area and 13.67 per cent of production with nearly two times higher (2.41 t/ha) than the national productivity (1.3 t/ha) in 2011-12. Though, Tamil Nadu stands better position in productivity, the overall performance needs to be studied by analyzing the changes in area, production and productivity of the selected districts viz., Erode, Namakkal and Thiruvannamalai and which has to be compare with the performance of state during last two decades. This will help in identify the trend in area, production and productivity of groundnut and helps to formulate necessary strategy for its improvement. The results are presented in Table 1-3.

Table 1 Performance of Groundnut area in TLII project districts and Tamil Nadu

District	Area (ha)			Decadal change%			Compound growth rate (%)		
	TE1992 -93	TE2002 - 03	TE2011 - 12	TE1992 to 02	TE2002 to 11	TE1992 to 11	TE 1992 to 01	TE 2002 to 11	TE1992 to 11
Erode	0.79	0.39	0.19	-50.61	-50.86	-75.73	-6.01	-7.14	-6.86
Namakkal	0.75	0.61	0.30	-18.46	-51.76	-60.66	-1.81	-7.61	-6.79
Thriuvannamalai	1.47	0.90	0.62	-38.50	-30.73	-57.40	-7.89	-3.65	-4.57
3Dts total	2.26	1.91	1.11	-15.64	-41.63	-50.76	-1.83	-5.39	-3.85
Tamil Nadu	10.83	6.21	3.95	-42.64	-36.49	-63.57	-5.36	-6.88	-6.32

It could be caution to note from above table in last two decades, area under groundnut has shrink to 3.95 lakh ha in TE 2011-12 from 10.83 ha in 1992-03. The results revealed a huge rate of decline in

area under groundnut was the highest in Namakkal at 7.61 per cent during the last decade (TE2002-03 to TE2011-12) and it was -7.14 per cent in Erode and -3.65 per cent in Thiruvannamalai registering a negative annual growth of -5.39 per cent for the three targeted districts. Erode and Namakkal lost half of its total groundnut area while one third of its area has been fallen in Thiruvannamalai district. It was noticed that in TE1992-93 total area in three selected districts was 2.26 ha has been recorded a sharp fall to 1.9l ha in TE2002-03 hand further declined to 1.11ha in TE 2011-12. In all, the TL II targeted districts lost half of its area under groundnut in last two decades.

Table 2 Performance of Groundnut Production in TLII project districts and Tamil Nadu

District	Production (lt)			Decadal change%			Compound growth rate (%)		
	TE 1992 -93	TE 2002 -03	TE 2011 -12	TE 1992 to 02	TE2002 to 11	TE1992 to 11	TE 1992 to 01	TE 2002 to 11	TE1992 to 11
Erode	1.35	0.63	0.32	-53.31	-49.32	-76.34	-5.63	-5.27	-7.16
Namakkal	1.21	1.13	0.62	-6.83	-44.60	-48.39	3.17	-4.35	-6.46
Thriuvannamalai	1.62	1.39	1.31	-14.12	-5.39	-18.75	-2.95	1.14	-1.77
3Dt total	2.97	3.15	2.26	6.02	-28.24	-23.92	2.36	-1.68	-2.20
Tamil Nadu	14.88	11.08	9.51	-25.49	-14.24	-36.10	-2.72	-0.70	-3.60

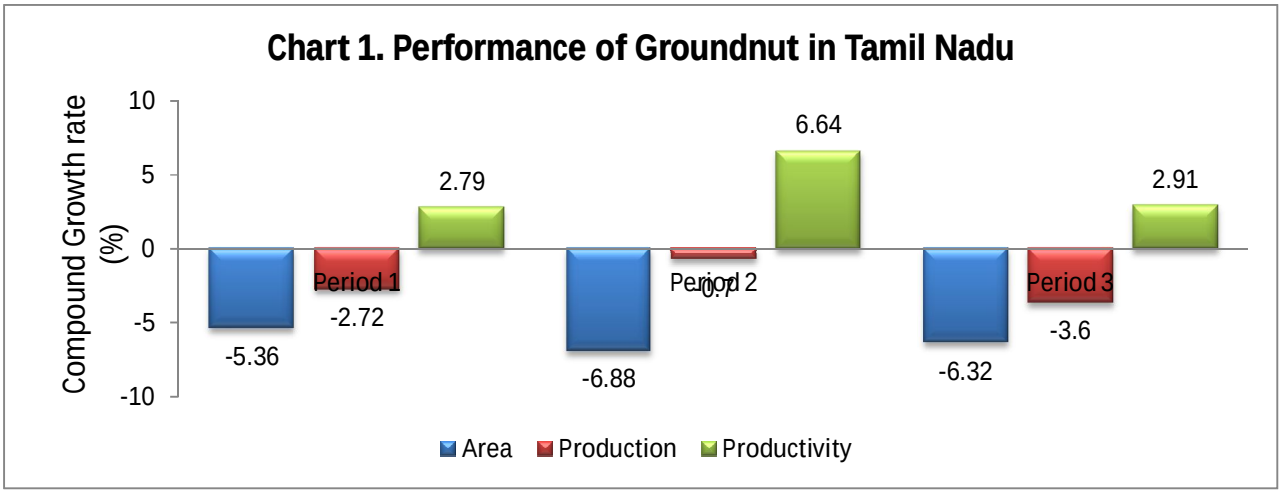
Similar declining trend has been also noticed in production. Tamil Nadu recorded the groundnut pod production of 14.88 lakh tons (lt) in TE1992-93, which has shrunk to 9.51 lt in TE2011-12. Similar sharp declining trend also noticed in Erode and Namakkal from 1.35 and 1.24 lt to 0.32 and 0.62 lt over last two decades which registering a negative growth of -7.16 and -6.46 per cents, respectively. However, Thiruvannamalai recorded relatively lesser negative growth (- 1.77 %) in the above period, this may be due to productivity improvement observed in last two decades.

Table 3 Performance of groundnut productivity in TL II project districts and Tamil Nadu

District	Productivity (lha)			Decadal change%			Compound growth rate (%)		
	TE 1992 -93	TE 2002 -03	TE 2011 -12	TE 1992 to 02	TE2002 to 11	TE1992 to 11	TE1992 to 01	TE 2002 to 11	TE1992 to 11
Erode	1.70	1.61	1.66	-5.46	3.12	-2.51	0.41	2.01	-0.32
Namakkal	1.61	1.84	2.11	14.27	14.83	31.21	5.07	3.53	0.35
Thriuvannamalai	1.10	1.54	2.10	39.65	36.59	90.74	5.37	4.97	2.93
3Dt total	1.31	1.65	2.03	25.68	22.94	54.50	4.26	3.93	1.72
Tamil Nadu	1.37	1.78	2.41	29.90	35.04	75.41	2.79	6.64	2.91

The productivity changes in targeted districts and for Tamil Nadu are analyzed and the results are presented in Table 3. In general, the productivity of groundnut has been improved in all the districts and Tamil Nadu. Particularly, the groundnut productivity has improved from 1.37 tons per ha in TE 1992-93 to 2.41 tons per ha in TE 2011-12, registering 75 per cent increase in the state, while 90 per cent increase was noticed in Thiruvannamalai from 1.1 tons per ha to 2.1 tons per ha in last two decades. Tamil Nadu registered the highest productivity growth in last decade (CGR of 6.64 %) compared to first decade (2.79%), while the TL II targeted districts recorded relatively lesser growth in productivity at 2.01, 3.53 and 4.97 per cent per year for Erode, Namakkal and Thiruvannamalai,

respectively during last decade. While considering last two decades, Erode turned negative productivity growth and Namakkal the productivity growth was stagnated over last decade. The above performance analysis confirmed the negative trend in all the three selected districts and Tamil Nadu for the last two decades which was also confirmed from the downward bars shown in all the charts (Charts 1-4).



Nevertheless, groundnut breeders have conducted research to genetically improved new and better varieties for the bunch and semi spreading types, however, the adoption of these technologies has been limited. The process of social learning involves awareness creation about an innovation hence it falls with the paradigm of the innovation-diffusion model which states that although an innovation may be technically and culturally appropriate, it may not be adopted due to asymmetric information and high search cost (Uaiene et.al., 2009., Smale et al., 1994).Explaining the significance of social learning in the adoption process Foster and Rosenzweig (1995) reported that farmers may initially not adopted a new technology because of imperfect knowledge about its management; however, adoption eventually occurs due to own experience and neighbors' experience.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in collaboration with national partners, has developed and released a number of improved groundnut varieties as a way of improving groundnut productivity and competitiveness. In order to address these overlapping constraints and harness the untapped potential in groundnut for poor farmers, ICRISAT has initiated a major legume projects: Tropical Legume II (TLII) supported by the Bill & Melinda Gates Foundation, in 2007-08.The project was designed to increase the legume productivity by 20 per cent, ensure the share of improved varieties to 30 per cent of the cropped area and reaching the benefits to 57 million poor. The project also set short term (3 years) objectives to increase the legume productivity to five per cent, improved varieties to the extent of 10 per cent of cropped area and gaining more than $ 75 million. Groundnut has been selected for Tamil Nadu among six crops covered under TL II. The project has two components; the first one is to identify the best varieties to the locality for up scaling and prioritizing the breeding work and the second component has targeted to assess the present status by baseline and groundnut market surveys with the intention to track the early adoption of improved varieties, mid-term evaluation of the project and focused to draw factors for better efficiency of the project intervention through ex-ante and ex-post evaluation methods.

Based on the distribution of area under rainfed groundnut cultivation in the state, Thiruvannamalai, Erode and Namakkal districts were selected for TLII project in both Phase-I and Phase-II and considering variability in production and budget availability, only Thiruvannamalai and Erode districts were considered forsocio-economic studies under phase I and II of the project.

2. Sampling methodology

The real time tracking (RTT) survey is designed to trace the diffusion of new varieties particularly in the targeted villages in the selected districts such as Namakkal for Co6 and Thiruvannamalai/Erode districts for Co7 variety as a project interventionin TL II phase. The details of the farmers participated or surveyed in the TL II intervention are presented in Table 2.1.

In last 5 years, the project has covered 16 mandals in 213 villages benefiting 2394 farmers through FPVS and PCT activities. More number of farmers (964 from 92 villages) were benefitted from Namakkal followed by Thiruvannamalai 710 farmers for 66 villages and 650 farmers from 55 villages. In the phase I, the baseline survey has been conducted from Erode and Thiruvannamalai districts in 270 farmers including seed benefited and control villages. The paired comparison trails (PCT) were laid in all the three districts and a total of 875 farmers were participated in the trails in last three years.

Table 2.1 Project intervention through FPVS methodology in groundnut production system in Tamil Nadu

Year	Erode (4 Mandals)		Namakkal (5 Mandals)		Thiruvannamalai (7 Mandals)		Tamil Nadu (16 Mandals)	
	Village*	Farmers*	Village	Farmers	Village	Farmers	Village	Farmers
2008	9	107	9	90	9	99	28	296
2009	9	87	8	237	9	81	29	414
2010	8	103	12	196	18	90	38	389
2011	21	202	58	281	18	150	94	633
2012	8	221	18	160	15	290	28	671
5 yrs	55	650	92	964	66	710	213	2394

*numbers

The details of baseline farmer and PCT farmer were participated in 2009, 2010 and 2011 were presented in Table 2.2. Considering the trail intervention, budget and time, 500 farmers were selected from real time tracking (RTT) covering from both baseline (75 farmers) and seed benefited farmers (425) in all the targeted districts. All the basic farmer, crop specific information were collect from the sample farmers, data were computerized and analyzed to track the diffusion of new groundnut cultivars. The results were presented in subsequent section.

The real time Tracking (RTT) survey is designed to track the diffusion of newly distributed improved groundnut cultivators through the paired comparison trial among the trial farmers in the targeted villages of selected districts. The distributions of targeted villages for the paired comparison trial conducted in 2009-11 were shown along with the sample village selected for RTT (Table 2.2). Out of

875 paired comparison trials laid during 2009-11, 500 sample farmers were selected for the survey distributed in all the three districts including 75 farmers from base line farmers contacted in Phase I of the project. The real time tracking survey instrument was designed to track the diffusion pattern of new variety from the targeted area. The sample village distribution clearly confirmed the even distribution of samples from all the blocks and villages from the paired comparison trials conducted in TLII. The major objective of the RTT study is to track the diffusion of new varieties among trial farmers.

Table 2.2 Distribution of sample farmers in real time tracking survey in TLII Phase II

District (1)	Block (2)	Baseline farmers		Paired comparison trials			Total Samples in RTT 4+7=8
		Total BL farmers (3)	sample in RTT (4)	No village (5)	Total (exc BL farmers) (6)	Actual sample in RTT (7)	
Erode	Ammapet	45	15	8	99	45	60
	Nambiur	45	15	10	119	48	63
TV malai	TV malai	45	15	6	45	15	30
	Keelpennathur	45	15	5	45	20	35
	Thandrampet	45	15	4	36	15	30
Namakkal	Elachipalayam			12	220	99	99
	Paramathi			16	145	82	82
	Tiruchangodu			12	166	101	101
		270	**75**	**73**	**875**	**425**	**500**

The further analysis on farm characteristics, varietal distribution, adaption, source of seed before and after the benefited years, diffusion of new varieties, willingness to increase new varieties area, output utilization, cost and return, seed sharing with others were analyzed for two groups via 482 seeds benefited farmers (SBF) and 18 non-benefited farmers (NBF). This total sample represents 500 samples from the selected districts including 425 paired comparison trial farmers and 75 baseline (50 adapted village and 25 non adopted villages) farmers.

2.2 Analytical techniques: In this study tabular analysis was adopted to compile the general characteristics of the sample farmers, the resource structure, cost structure, returns, profits and opinions of farmers regarding the problems in production and marketing. Simple statistics like averages and percentages were used to compare, contrast and interpret results in an appropriate way. To analyse and study the traits preferred in chickpea cultivars by the farmers, weighted average ranking method was used.

3. Results and discussions

3.1 Sample distribution in selected blocks in targeted districts

The distribution of sample among selected blocks are shown in Table 3.1. Among 500 sample farmers surveyed in RTT, it was observed that 96.40 percent of farmers were seed beneficiary (SBF) i.e., who received the improved groundnut seeds identified through the FPVS trials conducted in previous year. While, remaining 18 farmers were non beneficiary (NBF) of improved groundnut seed

varieties were selected as control farmers from the baseline survey who contacted in the RTT survey from same village for comparison.

When compared to three sample districts, trials farmers from Namakkal benefited highly (55.2 per cent sample farms), followed by Erode 25.6 per cent and Thiruvannamalai has constituted 19.2 per cent sample farms in the RTT study. The NBF were 10 per cent of its total sample farm in Tiruvannamalai and only 3.9 per cent in Erode. While, all the sample in Namakkal were benefited by this project. The sample farmers were evenly distributed in all the block.

Table 3.1 Sample distribution of the real time tracking survey, 2013 (no.)

District	Non-BL Beneficiary HH	BL ben. HH**	Baseline HH*	BL Control HH#	BL control HH ben.	All	%	Beneficiary		Non Beneficiary	
								No	%	No	%
1. Erode	98	17	3	5	5	128	25.6	120	93.8	8	3.9
Ammapettai	48	7	3		5	63	12.6	60	95.2	3	4.8
Nambiyur	50	10		5		65	13.0	60	92.3	5	7.7
2. Thiruvannamalai	51	30		10	5	96	19.2	86	89.6	10	10.4
Keelpenathur	20	10			5	35	7.0	35	100	0	0.0
Thandrampet	16	10		5		31	6.2	26	83.9	5	16.1
Thiruvanamalai	15	10		5		30	6.0	25	83.3	5	16.7
3. Namakkal	276					276	55.2	276	100	0	0.0
Elachipalayam	83					83	16.6	83	100	0	0.0
Paramathy	80					80	16.0	80	100	0	0.0
Thiruchengodu	113					113	22.6	113	100	0	0.0
Total	425	47	3	15	10	500	100.0	482	96.4	18	3.6
%	85	9.4	0.6	3	2	100					

3.2 Socio-economic characteristics of sample households

Age,Education,Community,Experience and training attended are the farmer's basic characteristics, which are much influencing in adoption of new technology in general, the farmer and farm characteristics of the SBFs and NBFs were analyzed and the result are presented in Table-3.2.

It could be inferred from the table there is no much difference in (year of schooling) level of education among two farmers' group however, NBFs had 8.4 years schooling compared to 8.1 years of schooling by SBFs.Just like any other activity, experience in farming also expected to provide enhanced farming efficiency. The longer the farming experience would improve the farm efficiency and realize better farm income. Farming experience of sample farmers were reported in Table 3.2. The overall result indicated that the farmers had an average of 23.8 years of farming experience in the study area. The SBFs had 28.2 years of average farming experience while NBFs had 23.6 years of average experience.

From the table it could be interpreted that farmers are marginal to small size of operational holding with the average of 2.39 ha of dry lands. The SBFs farmers had 2.15 ha of operational land and NBFs having 1.9 ha of operational land. In 2012, it extended to 1.09 ha. The NBFs cultivated the groundnut crop relatively more area than NBFs. Non Seed Beneficiary cultivate in 1.16 ha and 1.08 ha by Non Seed Beneficiary farmers, respectively. When comparing the allocation of area under groundnut

cultivation for all samples (500 samples) during last three years, 67.2 per cent of farmers inferred that the area had been decreasing while only for 6.4 per cent of them opinioned that there was an increase in groundnut area. Among seed beneficiary farmers 67 per cent of the farmers concluded that area under groundnut has been decreasing while 25 per cent of the beneficiary sample farmers said that the groundnut cropped area was neither increasing nor decreasing, it left constant and for remaining 8 per cent of the farmers opinioned that the groundnut area showed an increasing trend in last three years. Similarly, among 18 non-beneficiary groundnut farmers, none of them were reported the increasing trend in groundnut area. Half of the NBFs felt that groundnut area showed decreasing trend and the remaining sample farmers reported the groundnut area remained constant in last three years. The decreasing growth rate recorded in selected districts from the performance study results confirmed the sample farmers' opinion.

In case of source of irrigation, it could be interpreted that 99 per cent of groundnut farmers raised the groundnut crops under rainfed condition and all the NBFs groundnut farmers cultivate the groundnut crop under rainfed condition. It could be inferred from the survey that average distance to the regulated market was about 12.2 kms. The SBFs need to travel 12.3 kms and NBFs for 9.1 kms to access the regulated market. Similarly, it could be concluded from the table that average distance to Research Station from farmer's village was about 43.5 kms, for beneficiary farmers it was 57.8 kms, for non-beneficiary farmers it was 42.9 kms.

Average distance to Agricultural Office from the sample farmers village had been calculated, it could be inferred from the result that for SBFs needs to travel 11.3 kms and NBF it was about 10.8 kms to reach the agricultural department office for getting any technology input. Similarly, the average distance to the storage facilities from farmer's village was about 12.1 kms. The storage facility could be reached in 11.4 kms by the SBFs and 12.2 kms by the non-seed beneficiary farmers. Generally, agricultural office, regulated market, regulated market yard are located in the block headquarters.

Table 3.2 Socio-economiccharacteristics of sample HH

Item	Seed beneficiaries (N=482)	Non-seed beneficiaries (N =18)	Sample average (N=500)
Education *(years of schooling completed)*	8.1	8.4	8.2
Caste category (no.)			
MBC	28	2	30
SC:	15		15
ST:	3		3
BC:	430	16	446
OC:	6		6
No. of years of experience in Chickpea cultivation *(years)*	23.6	28.2	23.8
Extent of own land *(including rainfed and fallow in ha)*	2.39	2.15	2.39
Extent of operational land *(in ha)*	2.15	1.90	2.11
Area under Groundnut cultivation in 2012 (in ha)	1.08	1.16	1.09
Allocation of area under Groundnut cultivation during last three years (no.)			
Constant	123	9	132
Decreasing	327	9	336

Increasing	32		32
Did you irrigate your chickpea field (no.)			
NO	481	18	499
YES	1		1
Distance to regulated market *(kms)*	12.3	9.1	12.2
Distance to Research station *(kms)*	57.8	42.9	43.5
Distance to Agricultural Office *(kms)*	11.3	10.8	11.2
Distance to Storage facility *(kms)*	11.4	12.2	12.1
Are you member of any organization/society			
No	248	10	258
Yes	234	8	242

The study results revealed that 51.8 per cent of total sample farmers were not a member in any organization/society while remaining were the members. Among beneficiary framers 49per cent of the farmers were member whereas, remaining 51 per cent of them were not a member of society/organization. Similarly, in case of non-seed beneficiary farmers about 56 per cent of the farmers were not in any organization. Few groundnut production organization like self helps groups and effective function of PACS are village level organization in which most of the sample farmers are members.

3.3 Project beneficiary details

In order to assess the type of cultivars and quality of seed material distributed and status of sowing the given seed in last three years [2009-10, 2010-11 and 2011-12] were analyzed and the results are presented in Table 3.3. This would help to know, how far the project is benefited to farmers, from the result, it could be inferred that most of the farmers (319 samples) got benefited during 2010-2011 whereas, another 74 farmers were received seeds in 2009-10 from Namakkal district**.**

Table 3.3: Project beneficiary details (Seed beneficiary only N =482)

Details	2009-10	2010-11	2011-12
Is this HH TL-II project seed beneficiary (no.)	74	319	108
Which varieties of seed provided(no.)			
1. CO 6	59	168	68
2. CO 7	15	151	40
3 TMV 13*		60	26
Avg. quantity of seed provided (kgs.)			
1. CO 6	8.89	10.00	10.00
2. CO 7	5.00	8.00	7.25
3 TMV 13*		5.00	5.00
Did the house hold sown this variety			
YES	74	319	108
NO	0	0	0
* Newly released variety from Tamil Nadu Agricultural University			

Majority of the beneficiary farmers received Co6 variety seed followed by Co7 due to more number of pared comparison trials were laid in Namakkal district. In 2010-11, 168 BSFs received Co6 (particularly for Namakkal area) followed by Co7 variety seeds to 151 farmers in Erode and Thiruvannamalai districts. An average 10 Kg of Co6 variety was given to Namakkal farmers' in 2010-11 and 2011-12 while Co7 was distributed in Erode and Thiruvannamalai districts around 7 to 8 kg pack. Among the TNAU released groundnut variety, TMVGn13 was distributed in Thiruvannamalai district at 5kg pack to 60 farmers in 2011-12 and 26 farmers in 2011-12 to assess it performance along with ICRISAT varieties. All the sample farmer who received the improved cultivar of Co6, Co7 and TMV13 was taken up sowing at right time in all the three years. This confirms no one wasted the distributed new seed materials. In general, it could be finally interpreted that Co6 variety was provided to majority of the farmers followed by Co7 & newly released variety from TNAU that is TMV13 was least supplied through the TLII project intervention.

3.4 Extent of adoption of improved cultivars

Table 3.4:Extent of adoption of improved cultivars(sum of area in ha)

seed beneficiaries (N= 482)							Non seed beneficiaries (N= 18)						
prevoius year of benefitted year			Seed benefitted year				prevoius year of benefitted year			Seed benefitted year			
Pre_variety	pre_ Area (ha)	%	Ben_Variety	Ben_year	Ben_Area (ha)	%	Pre_variety	pre_Area (ha)	%	Ben_Variety	Ben_year	Ben_Area (ha)	%
CO2	124.7	20.5	Co6	2009-10	2.4	0.5	CO2	1.0	2.8				
MIXED	0.4	0.1		2010-11	7.1	1.5	TMV7	14.2	97.2				
POL2	32.9	5.4		2011-12	6.8	1.4							
TMV1	153.2	25.2											
TMV2	2.6	0.4	Co6 Total		16.3	3.4							
TMV7	103.2	17.0	Co7	2009-10	0.4	0.1							
VRI2	165.4	27.2		2010-11	6.6	1.4							
VRI6	3.4	0.6		2011-12	3.4	0.7							
VRI7	22.1	3.6											
			Co7 Total	10.4	25.6	2.2							
			CO2	95.9	236.9	20.2							
			POL2	130.3	321.95	27.5							
			TMV-13	4.8	11.95	1.0							
			TMV1	90.7	224.1	19.1							
			TMV2	1.2	2.9	0.2							
			TMV7	3.5	8.6	0.7							
			VRI2	101.1	249.65	21.3							
			VRI6	2.9	7.1	0.6							
			VRI7	16.8	41.4	3.5							
			sub Total		447.2	94.4							
Grand Total	607.9	100.0			473.8	100		36.0	100.				

The diffusion of new varieties would be traced by tracking the area expansion by newly distributed groundnut varieties over years among sample farmers.Inorder to assess the status of diffusion of new varieties, year wise and varietal wise area under groundnut crop on benefited and previous year seed distribution was estimated separately among SBFsand NBFs and the results are presented on Table 3.4.

It could be inferred from the table CO2, TMV2, VRI2 and TMV7 are the ruling groundnut varieties, which are released more than two decades ago, still dominated in 90 per cent in groundnut area. TNAU GnCo6 and Co7 groundnut varieties were introduced by this project.In general, the groundnut was cultivated in 607.69 ha in previous year of seed supply but groundnut area has reduced to 473.68 ha during the seed benefited year, in which about 94 per cent groundnut area still occupied by old varieties. The reduction in total groundnut area between previously benefited and benefited year again and indicated declining trend in groundnut area in the study area. The new varieties TNAUGnCo6 occupied 3.4 per cent and Co7 by 2.2 per cent of the total groundnut area 446.96 ha in the sample.

Among beneficiaries farmers, VRI2 occupied 165.35 ha in previous year of seed supply, while the area decreased to 119.29 ha in seed benefited year. Similarly, second highly cultivated variety was TMV1 in previous year which has also decreased to 90.73 ha from 153.24 ha in seed benefitted year. In seed benefitted year majority farmers' cultivated POL2 variety (130.34 ha) followed by VRI2 in 101.07 ha. In case of non-seed beneficiary farmers, they cultivated TMV7 (14.17 ha) at larger extend, whereas only one acre of Co2 was cultivated & no variety was cultivated in seed benefitted year.

3.5 Major source of seed

Source of other than TL-II project supplied varieties

Similarly, major source of seed after initializing TL-II project & other than TL-II supplied varieties are given in Table 3.5

Table 3.5 Source of seed non TLII varieties (No.)

Sources	Very old Variety	Old variety	Recent Variety	Total
Farmer club	30	8	33	71
Farmer to farmer seed exchange (relative, friends *etc*)	30	17	38	85
Govt. agency	44	0	28	72
Inherited from family	23	3	38	64
Local seed producers	41	20	77	138
Local trader or agro-dealers	192	18	202	412
Other farmers	62	0	63	125
Through contact farmer	5	0	15	20
NGO's	11	0	11	22
Grand Total	438	66	505	1009
%	43.41	6.54	50.05	100.00

The varieties are categorized as three different types based on the time of release of varieties. They were very old varieties (includes CO 2, mixed, POL 2, TMV 1 & TMV 2), old varieties (TMV 7 & VRI2) and recent varieties (TMV 13, VR I6 & VR I7). It could be inferred from the table still 43 per

cent of the groundnut area occupied by very old varieties which were released 20 years ago. It could be also noted that another half of the groundnut area occupied by recent new varieties.

Among very old variety the major sources of seed were from local trader or agro dealers. About 43 per cent of the sample farmers received seeds from these sources andthe second highest seed source was other farmerswho supplied to 14 per cent of the sample farmers. It could also be inferred that in old variety, the local seed producers were the major source, whereas local trader or agro dealers were the major suppliers of recent varieties. Local traders and other farmer still meet the around two thirdof the seed supply indicated any program of introduction new varieties could needs to design by integrated the private seed traders in seed distribution chain for sustained seed production.

3.6 Diffusion of new varieties in study area

The diffusion of new varieties were assessed by estimating the allocation of area after supplying the seed from TL-II under different cultivars in three different years (2009-10, 2010-11) are given in Table 3.6 and 3.7 respectively. Seed distributed after 2009-10, the area under new varieties has increased in 1.9 ha in 2010-11 to 13.8 ha in 2011-12. However, the area under new varieties had decreased in 2012. It could be interpreted that majority (i.e., 201.9 ha) of area was allocated under very old varieties like CO 2 and TMV 1 in 2011-12 followed by 146.2 ha under old varieties TMV 7 and VR 12and the under new varieties occupied 3.7 per cent in 2011-12.

Table 3.6 Area allocation under different cultivators

Sum of area after seed supplier(2009-10), ha						
Cultivar name	2010-11	%	2011-12	%	2012-13	%
Very old variety	34.0	53.0	201.9	53.7	40.0	44.9
New variety	1.9	2.9	13.8	3.7	2.8	3.2
Old variety	24.3	37.9	146.2	38.9	46.1	51.9
Recent variety	4.0	6.2	14.2	3.8	0.0	0.0
Grand total	642	100.0	376.0	100.0	88.9	100.0

Table 3.7 Sum of area after seed supplied (2010-11) (ha)

Cultivar name	2011-12	%	2012-13	%
Very old variety	36.11	47.8	190.57	54.9
New variety	1.46	1.9	4.66	1.3
old variety	31.98	42.3	138.22	39.8
recent variety	6.07	8.0	13.77	4.0
Grand total	75.63	100.0	347.33	100.0

Similarly Table 3.9 showed the allocation of area after supplying the seed in 2010-11. It could be highlighted from the table that as same as in previous year major area was allocated for very old varieties 190.57 ha in 2012-13 followed by old varieties 138.22 ha.

It could be inferred from the above two table, the area under newly introduced varieties were increased over years. The change in new varieties was from 1.9 ha to 13.8 ha in 2011-12 after seed

distributed in 2009-10. Similarly, in case of seed distribution in 2010-11, the change in area under new varieties was 1.46 ha to 4.66 ha in 2012-13 confirmed the increasing trend in new varieties area in the sample districts.

3.7 Willingness to increase area under TL -II introduced cultivators

The groundnut farmers reported different reasons for willingness to increase the area under new varieties and same is presented in Table 3.8. Farmers willingness to increase area under TL-II introduced cultivars from the seed benefited farmers, around 36.6 per cent of the farmers willing to take-up the new varieties due to better taste and bigger kernel size followed by 35.89 per cent farmer preferred the varieties for the high price, profit and another 27.6 per cent of farmers for higher yield potential of the new varieties.

Table 3.8 Willingness to increase area under TL -II introduced cultivators

Willingness	Seed Benefited farmers			Non - Seed Benefited farmers		
Yes	482			18		
No	0			0		
If Yes, Reasons	Reason	sum of Reason	%	Reason	sum of Reason	%
	Better taste and bigger size	175	36.31	Better taste and bigger size	5	27.78
	High price and profit	173	35.89	High price and profit	6	33.33
	High Yield	133	27.59	High Yield	7	38.89
	Pest and disease resistance	1	0.21			
	Grand Total	482	100.00	Grand Total	18	100.00

Among the 18 non-seed benefited farmers, about 39, 33 and 27 per cent of farmers preferred the new varieties due to the high yield, high price and better taste as the major reasons for their preference, respectively.

3.8 Output utilization pattern

The output utilization pattern would clearly guide us to understand the path way of varietal diffusion time, and hence the variety wise total groundnut pod produced and its utilization among SBF and NBF were analyzed and the results are presented in Table 3.9. Among the SBF the major ruling varieties much as, TMV1, VRI2, TMV7 and CO2 produced more than 80 per cent total groundnut pod output in last three years. They produced 22.72, 21.15, 18.63 and 17/30 per cent of the total pod (140.26 tons) produced.

While the new varieties Co6 produced 76.7 tons and Co7 produced 26.96 tons contributing 5.47 and 1.92 per cent of the total pod production of the study area, indicated the lower share due to low coverage of new varieties.The analysis of output utilization pattern of groundnut confirmed that, being a commercial crop, around 80 per cent total groundnut output were sold to market, around 14 per cent were kept for own seed use and another one per cent sold for seed purpose.

Table 3.9 Output utilization pattern for Seed benefited farmers (N=482) (Sum of production)

	Grain output		Output utilization (kgs)					Output utilization (%)					
Variety	kgs	%	consumed, kgs	other use, kgs	ownseed, kgs	sold seed, kgs	out_ sold	consumed, kgs	other use, kgs	ownseed, kgs	sold seed, kgs	Output sold	Total output
Seed benefited farmers(N=482)													
Co2	242580	17.30	26865	280	27580	2200	185655	11.07	0.12	11.37	0.91	76.53	100.00
POL2	37140	2.65	1780	710	6280	500	27870	4.79	1.91	16.91	1.35	75.04	100.00
TMV1	318640	22.72	3540	500	49510	800	264290	1.11	0.16	15.54	0.25	82.94	100.00
TMV2	7900	0.56	100	200	1600	200	5800	1.27	2.53	20.25	2.53	73.42	100.00
TMV7	261295	18.63	9850	6400	34500	500	210045	3.77	2.45	13.20	0.19	80.39	100.00
VRI2	296620	21.15	2310	2050	42710	2600	246950	0.78	0.69	14.40	0.88	83.25	100.00
Mixed	63380	4.52	2150	650	11120	700	48760	3.39	1.03	17.54	1.10	76.93	100.00
TMV13	2410	0.17	0	0	0	0	2410	0.00	0.00	0.00	0.00	100.00	100.00
VRI6	12440	0.89	0	0	800	0	11640	0.00	0.00	6.43	0.00	93.57	100.00
VRI7	56520	4.03	0	0	3380	0	53140	0.00	0.00	5.98	0.00	94.02	100.00
Co6	76705	5.47	7323	70	13110	820	55382	9.55	0.09	17.09	1.07	72.20	100.00
Co7	26962	1.92	0	25	4461	5010	17466	0.00	0.09	16.55	18.58	64.78	100.00
All	1402592	100.00	53918.2	10885	195051	13330	1129407.7	3.84	0.78	13.91	0.95	80.52	100.00
Non Seed benefited farmers(N=18)													
CO2	4600	7.89	0	0	400	0	4200	0.00	0.00	8.70	0.00	91.30	100.00
Local	3640	6.24	0	0	400	0	3240	0.00	0.00	10.99	0.00	89.01	100.00
TMV7	39550	67.85	2050	1750	2860	0	32890	5.18	4.42	7.23	0.00	83.16	100.00
VRI2	10500	18.01	0	0	1170	0	9330	0.00	0.00	11.14	0.00	88.86	100.00
All	58290	100.00	2050	1750	4830	0	49660	3.52	3.00	8.29	0.00	85.19	100.00

Among the newly introduced varieties Co 6 and Co 7, output retained for seed purpose was more (17 per cent) in Co 6 and 16.55 per cent in Co 7 varieties. Hence, the new varieties are cultivated as rainfed crop; the output share for seed use was low may be due to poor quantity of production not suitable seed purpose due to occurrence of terminal drought and other biotic stress particularly during the pod maturity stage during 2008-12. This would clearly guide us to change the seed production strategy for new varieties under irrigated condition. Among NBFs, about 85 per cent of total output were sold while, only 8.29 per cent of total production was kept for own seed purpose, indicated that still farmers are largely depended the market or other farmers for groundnut seed. This may be due to high value of output coupled with poor seed retention power and poor quality output from rainfed production system.

3.9 Profitability of new cultivars in Tamil Nadu

The cost and returns analysis always useful in understanding the profitability of new cultivars in Tamil Nadu.The estimated cultivation cost only consider the variable cost excluding land rent, since 99 per cent farmers are own land operators. The total cultivation expense was around 21 thousand per acre for both new and old cultivars. The cost of seed has not been included for new cultivar which was supplied on free of cost to the farmers. Seed cost contributed 8 per cent of total cost Rs. 1400-1800 per acre (see Table 3.10).

Expenditure on land preparation and weeding are the other major cost in groundnut cultivation which costing 3 to 4 thousand per acre, which almost same for old and new varieties. Farmers applied relatively higher dose of fertilizer for new cultivars or varieties, which in-turn respond more when it receive proper rainfall during critical stages of its growth.

The new varieties realized relatively 14 per cent higher pod yield, in Namakkal and five per cent in Erode and Thiruvannamalai, the poor yield advantage may be due to yield loss caused by drought damage in last 3 years. The average productivity Co6 in Namakkal was 941 kg per acre, while the old varieties yield was 823 kg per acre. Whereas in Erode and Thiruvannamalai, the new variety Co7 realized an average 774 kg per acre, which is fiveper cent higher than the ruling varieties (POL 2, TMV 7 and VR I2).

Table 3.10: Profitability of old and new varieties in Tamil Nadu

Operation	Namakkal				Erode &Thiruvannamalai			
	New cultivar		old cultivar		New cultivar		old cultivar	
	Co6	%	TMV1	%	Co7	%	TMV7, POL2 & VRI2	%
Sum of area	**17.3**		**230.0**		**8.7**		**386.8**	
No of farmers	**71**		**63**		**64**		**137**	
Land pre.	3728	17.9	3708	17.7	3057	15.0	3125	14.9
FYM\compost	2943	14.1	2479	11.8	2832	13.9	2853	13.6
seed cost	0	0.0	1620	7.7	0	0.0	1840	8.8
sowing cost	3300	15.8	3324	15.8	3281	16.1	3203	15.3
Fertilizer cost	1692	8.1	1525	7.3	1576	7.7	1545	7.4
Micro nutrient cost	0	0.0	0	0.0	12	0.1	91	0.4
Inter culture cost	0	0.0	0	0.0	24	0.1	0	0.0
weeding cost	3630	17.4	3216	15.3	3738	18.4	3086	14.7
plant protection cost	542	2.6	487	2.3	557	2.7	417	2.0
Irrigation cost	0	0.0	0	0.0	0	0.0	0	0.0
watching expenses	16	0.1	34	0.2	0	0.0	0	0.0
harvesting cost	2295	11.0	2144	10.2	2389	11.7	2246	10.7
Threshing cost	2600	12.5	2339	11.1	2719	13.4	2449	11.7
Marketing cost	103	0.5	110	0.5	119	0.6	121	0.6
Rental value	0	0.0	0	0.0	59	0.3	0	0.0
Total Cost	**20850**	**100.0**	**20986**	**100.0**	**20363**	**100.0**	**20976**	**100.0**
Pod yield (kgs)	941		823		774		738	
fodder yield(kgs)	1344		686		1218		794	
Pod value	26284	93.0	24048	92.5	25141	92.6	25911	93.2
Fodder value	1983	7.0	1949	7.5	1995	7.4	1899	6.8
Total Value(pod & fodder)	**28267**	**100.0**	**25997**	**100.0**	**27136**	**100.0**	**27811**	**100.0**
Net Income (Rs/ac)	7418		5011		6773		6835	
Cost of production (Rs/qtl)	1404		2775		1508		2403	
Benefited cost Ratio	1.4		1.2		1.3		1.3	

In groundnut cultivation, besides the high seed cost, cultivation expenses on harvesting and threshing costing around 23 per cent of total cost in all the old and new varieties, next to that, weeding operation costing 14-15 per cent of total cultivation cost both in old and new varieties. Farmer realized an average pod price of Rs 27.93 for new varieties and 29.22 per kg of dry pod in 2011-12. The gross return (value of pod and fodder) was the highest (Rs. 28267 per acre) in Co6 in Namakkal followed by Rs. 25997 per acre for old varieties. The gross return in Co7 was Rs 27136 per acre and for old varieties it was Rs 27811 per ac in Erode and Thiruvannamalai. However, the net return for new varieties was the highest Rs 7418 per acre in Namakkal and Rs 6773 per acre for new variety and Rs 6835 for old varieties.

The cost of production per quintal of dry pod was Rs.1404 per quintal in Co6 at Namakkal, while it was Rs. 1508 per quintal for Co 7 realized 97 and 59 per cent lesser cost over variable cost in new varieties over ruling varieties in Namakkal and Thiruvannamalai/Erode districts, respectively. It is also note that, the highest benefited cost ratio has recorded at 1.4 in Co 6 indicating return per rupee investment was the highest for Co 6 followed by Co 7, VR I2, POL 2 and TMV 7.

4. Summary and conclusions

India is being a second largest producer of groundnut next to China contributing 14% of world groundnut production (41.269 mt) sharing 19.90% of global groundnut area (24.6mha from world). Next to USA, China and Brazil, India is a fourth largest importer of vegetable oils worth of spending 10 billion USD in 2012-2013. Various programs like Technology mission on oilseeds TMO in 1986, other state and central government programs related to area and technology development programslike ISOPAM, OPDP are creating positive impacts on oil seed production in the country and state. Presently the country producing 4.74mt of groundnut from 4.75 m/ha with an average productivity of 0.996 t/ha of dry pods in 2012-13. Tamil Nadu is one of major groundnut producing state next to Andhra Pradesh, contributing 18.11 per cent country groundnut production from only 7.55 per cent of country's groundnut area with nearly two and half times higher than the national average pods productivity of 2.39 t/ha against the national average productivity of 0.996 t/ha in 2012-2013.

Regardless of the considerable area share, productivity advantage and various development programs, the Tamil Nadu phased unfavorable negative trend in area (-6.88 annual growth) during last decade resulting 50 per cent loss its area from 6.21 lakh ha in TE 2002-2003 to 3.95 lakh ha in TE 2011-2012, however the improvement in production which registered the annual growth of 6.64 per cent between TE 2002-2003 to TE 2011-2012 have minimize the negative growth in production to -0.70 per cent in the above period. This unfavorable trend in groundnut performance need further shift in productivity. The negative trend in area under groundnut may be due to i) low productivity of ruling varieties, ii) low market demand, iii) under developed seed and input delivery system, iv) vulnerability of common variety to biotic and aboitic problems and v) large dependence on monsoon (rainfed production system 64 per cent groundnut area).The cumulative effects of these factors cause low adoption of available improved technologies, low competitive and inability to access high value market to enjoy premium for quality.

In order to address the multi-pronged problems in groundnut production system International Crops Research Institute for Semi-Arid Tropics (ICRISAT), in collaboration with other national partners, has designed a Tropical Legume II (TLII) project in 2007 with the objective to increase the Legume productivity by 15 per cent, ensure the share of improved varieties to 30 per cent of total groundnut area and reaching the benefits to 57 million poor's. Tamil Nadu is one of the major partners in India in TL II and selected the groundnut under this project mainly targeted the major rainfed groundnut production system in Tamil Nadu *viz* Thiruvannamalai, Erode and Namakkal districts. The major objective is to introduce the new cultivar suited for the region by Farmer's Participatory Variety Selection (FPVS) trials' method beside development of new varieties to address above biotic and abiotic impediments in shifting the productivity. This project also tries to document the socio economic profile of the groundnut farmer, identify the role of market institution, availability of infrastructure, fertilizer use, profitability of existing & new varieties and adoption & dis-adoption pattern of new cultivars in the study area. In the first phase of TL II project, besides developing a new cultivar through FPVs method is followed to identify the best suited variety to the region by the

farmer and multiply and distributed through paired comparison field trials (PCT) for fast tracking the adoption process. In the second phase of the TLII project, in order to track the diffusion of new varieties introduced, a Real Time Tracking (RTT) survey was designed and conducted to assess the diffusion pattern, seed storage, output utilization change in some of seed *etc*., to understand the rate adoption and develop strategy for future development. The RTT survey is conducted from 500 farm sample, of which 75 out of 270 from Baseline survey farmers and 475 out of 875 PCT farmers evenly distributed in 82 villages who received seeds during 2009 to 2012. Various information on farm characteristics varietal distribution, adoption, some of seed before and after the seed distribution, diffusion of new varieties, willingness to increase the area under new varieties, output utilization, cost and return, seed sharing pattern and seed storage system were collected in the RTT filed survey from the sample farmers. Out of 500 sample farmers, 482 received seeds through paired comparison called Seeds Benefited Farmers (SBF) and 18 were not received improved seeds (NBF) by this project. The collected information were computerized and processed to draw the meaningful interpretation. The major findings of the RTT survey are summarized as follow;

1) The sample farmers' distribution showed that more than half of them were from Namakkal district, followed by Erode district sharing one fourth and 20 per cent from Thiruvannamalai districts.
2) In the study area, the average schooling years for SBFs was 8.1 years and 8.4 years for the NBFs. They have good farming experience with 23.6 and 28.2 years by the two groups, respectively.
3) The operational holding size was 2.15 ha for SBF and 1.9 ha for NBF, where groundnut crop occupied 1.16 and 1.08 ha, sharing 54 and 57 per cent of the total operational land area, respectively.
4) As confirmed from the groundnut crop performance analysis, about two third groundnut farmers opinioned that groundnut area has been decreased continuously and only one fourth of them reported that there was no change in groundnut area in last three years.
5) Majority of the sample farmers received about 10 kg of Co 7 variety groundnut seeds and 7.8 kg of Co 7 variety seeds were distributed through the paired comparison trials.
6) It was caution to note that still 94 per cent area were occupied by old groundnut varieties while the new variety Co 6 covers 3.4 per cent and Co 7 occupied 2.2 per cent of the total groundnut area.
7) Among old varieties, Co 2 and TMV 1 were dominated in Namakkal district while VRI 2, TMV 7 and POL 2 were dominated in Erode and Thiruvannamalai districts.
8) Among old varieties, more than two fifth of the groundnut area were occupied by very old varieties which were released 20 years ago. The local traders or agro dealers were the major seed source to meet more than two fifth of the total seed demand in the study area.
9) After the seed supplied in 2009-10, the area under new varieties had doubled in 2010-11. The slower rate of diffusion of new varieties may be due to deficit rainfall received during sowing and pod maturity stage. Inadequate and poor distribution of monsoon rainfall during the project period caused a declining trend in rainfed groundnut area particularly in the TL II project study districts.
10) Through unfavorable monsoon has been experienced from the project study area, considering positive trait characteristics like the better taste, bigger size, high price and higher yielding nature of new varieties, most of the sample farmers reported their willingness to take up the new varieties.

11) About one fifth of total output of new varieties were kept for own seed purpose for own farm area expansion and two third of output still sold in the market due to poor quality
12) New variety (Co 6 and Co 7) realized about 14-20 percent high yield than ruling varieties and costing 97 and 59 percent lesser cost of production over the ruling varieties with the cost benefit ratio of 1.4 and 1.3 per rupees of investment compared to 1.2 in case of ruling varieties.
13) The entire sample farmers followed traditional seed storage method and only 3 farmers shared the new seed materials to others due to inadequate surplus over their own seed demand so they sold the poor quality output to market.
14) The agro traders and local dealers are played important role in seed chain, seed to consider in designing the new seed multiplication program.

Way forward

The location specific development programmed for area expansion need to be formulated by removing the production constraints to revert the declining trend in area and production of groundnut particularly in the rainfed production system.There is a need for further intervention in terms of supply of seeds of improved varieties for commercial cultivation in the adopted villages to see the actual demonstration effect.Yield boosting technology needs to be developed to address the drought resistant varieties to overcome the frequently occurring monsoon deficit situations in the study area.Local traders and agro dealers still played important role in the seed supply chain in the study area which necessitate to formulate public-private partnership self-sustained seed multiplication model for fast track diffusion of identified new varieties in the study area.Frequent and severs monsoon deficit particularly during the sowing season and crop maturity was found as major reason for poor quality seed produced thus farmers sold the output to market. This need to identify the irrigated seed production system in Rabi season and used the new seed for next Kharif season for successful and sustained seed multiplication and support for faster expansion of new varieties area in the rainfed groundnut production system. Seed multiplication process in the farmers' field along with buyback arrangement and onward distribution of seeds to the farmers through the institutional agencies like KOF, UASR helps in adoption uptake process.Monsoon deficit and frequent drought occurrence was found as major reason, hence the breeder need to develop drought resistant varieties particulars during terminal crop period.Already half of the farmer are member in any one of the organization in the groundnut production system therefore organizing groundnut producer and marketing organization at village land and link them to groundnut producing consortium help them to realize the premium market advantage through suitable following good production practice and value addition and modern storage system to reap market prize advantage through group approach.There is a need to strengthen seed production, supply and distribution through seed village and seed bank programs where the actual seed supply is only 7 per cent of seed requirement.

Lessons learnt

- Area and production has declined in last two decades even with increasing productivity
- Intermittent drought, rainfall deficit during sowing season drought need for development of tolerant varieties and seed treatment management technologies.

- Increase the seed supply from 2.5 kg to 25-50 kg per farmer in PCT trails would increase the famers attention in seed multiplication' programme. To the cluster of less number of farmers so as to set buy back arrangements for linking the seed chain in up-scaling
- Traders contributed 70% of purchased seeds. PPP concept has to be followed to involve the traders in seed multiplication chain.
- A model of tripod arrangement consisting SAU, DOA, Farmers and Traders need to develop.
- Target the demo area with irrigation for seed multiplication programs in Post rainy season.
- Possible to form seed producer groups/ use available women SHG and NGOs etc. for seed village programs
- More publicity by organizing mega field days and State level Exhibition for larger coverage by inviting farmers of non-targeted area.

References

Foster.A and M. Rosenzweig. (1995). Learning by Doing and Learning from Others: Human Capital and Farm household Change in Agriculture. Journal of Political Economy 103(6): 1176-1209.

Uaiene R.N., C. Arndt and W. A. Masters: (2009) Determinants of agricultural technologyadoption in Mozambique; Discussion papers No. 67E Accessed at http://www.mpd.gov.mz/gest/documents/67E_AgTechAdoptionMoz.pdf on March 2010

Smale, M., Just, R., Leathers, H. D. (1994). Land Allocation in HYV Adoption Models: AnInvestigation of Alternative Explanations. Amer. J. of Agric. Econ. 76(3): 535-546.

SimtoweFranklin ,BekeleShiferaw, Tsedeke Abate, GeofreyMuricho (2009a): Socioeconomic Assessment of Baseline Pigeonpea and Groundnut Production Conditions, Farmer Technology Choice, Market Linkages, Institutions and Poverty in Rural Malawi

Besley, T. and A. Case. 1993. "Modeling Technology Adoption in Developing Countries." TheAmerican Economic Review 83:396-402.

Faltermeier, L. and A. Abdulai, 2009. The Adoption of Water Intensification Technologies and Farm Income: A Propensity Score Analysis for Rice Farmers in Northern Ghana."Agricultural Economics 40:365-379.

****