Benefits from Improved Soil-Water-Nutrient Management Research:
The Case of Groundnut Production Technology

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Abstract

Adoption assessment and quantification of returns to investment of soil-water-nutrient management research outputs received little attention in the literature. This paper attempted to estimate the adoption and measure impact of the research information related to soil-water-nutrient management. A specific case, the Groundnut Production Technology, was selected. The study finds that farmers adopt concept and modify the package as per their needs, convenience and resource endowments. It was found that there was differential adoption of various components of the Groundnut Production Technology package. The adoption of various components related to nutrient management was ranging from 10% for ferrous sulphate, to 35% gypsum, and 50% single super phosphate. Adoption of soil management component was in about 29% groundnut area. Water management through sprinkler irrigation was adopted in about 11% area. Farm-level benefits were realized in terms of yield gains, higher income, better output prices, efficient utilization of inputs, etc. The benefits were quite higher than the research and packaging cost of the Groundnut Production Technology. Investment on extension of the technology to cover more area may be very rewarding.

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Earlier studies on measuring returns to agricultural research investment were largely confined to the contribution of genetic enhancement of various crops. Adoption assessment and quantification of returns to investment in soil-water-nutrient management research received scant attention. Soil-water-nutrient management research, often known as crop and resource management research, shares a large part of the research resources. These target to achieve higher crop productivity, increase input use efficiency and improve the sustainability of natural resources. Often adoption studies encountered with complexities when research information at farm level was modified and partially adopted. A high degree of spatial and temporal variability was observed in adoption of soil-water-nutrient management research information. It calls for developing a framework to assess the adoption of information on various components of the soil-water-nutrient management over time and space.

The objectives of this study are (i) to develop a framework to estimate the adoption pattern of research information on soil-water-nutrient management, and (ii) to quantify benefits of soil-water-nutrient management research. The study evaluates a specific technology-- the Groundnut Production Technology (GPT)--which encompasses research information on soil, water and nutrient management. The technology was aimed to enhance the production of groundnut being an important oilseeds crop in India which contribute more than 53% to the oilseed production.

History of the Technology:

Basic and strategic researches on soil-water-nutrient management are integral part of the research agenda of most of the research organizations aiming to increase agricultural production, achieve more efficient input use, and improve the sustainability of natural resources. Numerous research information are generated, and relevant ones are integrated in a technology package to attain higher production potential and derive maximum research benefits (Fig. 1). The technology package is further investigated and refined to adapt in different regions. The package is usually divisible and can easily be disaggregated into subsets of one or two or a mix of few components. Such a scenario provides flexibility and enables farmers to adopt only those components which provide highest rate of return on capital expenditure (Ryan and Subrahmanyan, 1975) and alleviate major production constraints.

The development of the Groundnut Production Technology (GPT) follows the same trajectory. To meet the rising demand of edible oil in the country, the Government of India in 1986 introduced a massive program known as 'Oilseed Technology Mission' by allocating more resources to research and technology transfer activities, and offering remunerative prices to producers. The program yielded desirable results. Production of oilseeds during the late eighties increased substantially. ICRISAT was an active partner with the Ministry of Agriculture and the National Agricultural Research System (NARS) in increasing the production of oilseeds between 1987 and 1991. A technology package was integrated at ICRISAT by reviewing relevant research information available at ICRISAT and elsewhere after carefully identifying constraints in oilseeds production in major oilseeds producing regions. The package was thoroughly discussed with the NARS and the state departments of agriculture. Since a particular set of technological component performed better under one type of environment and poorly on another, a unique set of technology package was suggested for every possible location after characterizing soil, climate, nutrient, water, etc. Several on-farm trials and demonstrations were conducted in eight States of India. These States were Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu and Uttar Pradesh. Technology packages were regularly monitored, refined and tuned to meet the local requirements during the on-farm trials[1]. Following steps were adopted to come-up with the GPT package for on-farm trials:

- identification of farm-level constraints related to soil, water, nutrients, insects and pests,
- extraction of relevant ICRISAT researches to alleviate production constraints,
- collation of published and unpublished literature in case research activity was not pursued at ICRISAT,
- integration of all research components in a package for on-farm trials,
- discussion about the package with the NARS, department of agriculture, and agencies engaged in increasing oilseeds production,
- conduct 141 on-farm trials jointly with the state departments of agriculture to demonstrate the higher potential of the GPT in comparison to the existing popular package,
- organize training programs for the extension staff, and farmers' days to disseminate the technology at a fast rate,
- modification of the package with time to suggest alternatives.

Important components of the GPT are listed in Table 1. Some of the components of the improved GPT were already known and recommended by various research institutions, including ICRISAT. Ironically, their large scale adoption was not popular amongst farmers because of lack of knowledge and unavailability of the components. However, few progressive farmers were adopting those components. ICRISAT's role was to integrate all essential components, popularize them amongst extension staff and the farmers, and facilitate in accelerating their adoption. It contributed in reducing the adoption lag of those components which were known earlier but not adopted. The package demonstrated the potential of each component in enhancing the yield levels of groundnut.

[1] For example, when the crop was showing the symptom of iron deficiency, the application of ferrous sulphate was recommended.

Methodology:

i. Study area:

Maharashtra State, located in western part of India, was selected for this study. The State accounts for about 10% of the total groundnut area in India, and contributes between 8-14% production. Though it is not a major groundnut producing State, it was selected because of: (i) the average groundnut yield (736 Kg ha^{-1}) was less than the all-India average (815 Kg ha^{-1}), but there exists enormous potential to increase the yield levels, (ii) it was envisaged that the State was leading in adoption of the GPT, and (iii) there was a follow-up in technology dissemination after ICRISAT withdrew its on-farm activities. Three districts, namely Parbhani, Nanded and Yawtmal, were selected because on-farm trials and demonstration during 1987-91 period were conducted in these districts. Groundnut is an important crop in these districts. Its cultivation in these districts is shifting from rainy to summer season because of the availability of water and high yield potential during the latter season. Important features of the groundnut in these three districts are given in Table 2.

One block from Parbhani district, and two each from Nanded and Yawatmal districts were selected on the basis of the area under groundnut during the past five years. A sample of 48 GPT adopter, and 52 non-adopter was selected from seven villages of three districts.

ii. Data

Relevant information was collected from the selected farmers in a specially structured questionnaire. Farmers were personally interviewed. The information was collected on the adoption of various components of the technology, their initial adoption year, modification, if any, made, and the status of the technology adoption during 1993-94. Data were also generated on the cost and benefits of different components of technology.

Information was also compiled from the T & V department of the agriculture, office of the agricultural development officer, and several traders dealing with the components of the GPT.

iii. Approach:

Most of the soil-water-nutrient management technologies are either adopted partially or modified by the farmers depending upon their convenience, resource endowments and knowledge. Broadly, two major problems are encountered in measuring the impact of resource management technologies. These are (i) how to identify the specific research recommendation adopted by the farmers, and (ii) how to quantify the adoption and impact of different components.

To overcome such problems few studies in the past were conducted (Ryan and Subrahanyam, 1975; Byerlee and Polanco, 1986; Traxler and Byerlee, 1992), and following steps were suggested: (i) identify each component of the technology relevant to the recommended package adopted by the farmer, (ii) assess the proportion of each technology adopted by the farmer, (iii) ascertain the area covered under particular component of the technology, and (4) assign adequate weight to each component of the technology. We identified 11 important soil-water-nutrient research products as a part of the GPT package.

In our survey, each sample farmer was asked the year when he first adopted the specific component of the technology package. This was complemented by the inquiry on (i) how much area was allocated to that technology component, and (ii) how much quantity of this specific input was applied. A time series was developed to estimate adoption of each component.

To measure returns to investment in GPT, economic surplus and internal rate of return were estimated under varying assumption. Other farm-level impact indicators, namely yield gains, higher income, cost saving and gender implications, were also evaluated.

Adoption of soil-water-nutrient research:

Adoption of research information related to soil-water-nutrient management depends upon several agroclimatic and socioeconomic factors. The adoption pattern of various components were intrapolated and presented in Table 3. It was observed that improved varieties, single super phosphate and the seed treatment were adopted even before developing the package. Improved varieties were adopted since 1976. Use of fungicide for seed treatment was started in 1981, while application of single super phosphate in 1982. It may be noted that adoption became faster after these components became a part of the package and were demonstrated under on-farm trials by ICRISAT. It took eight years to adopt the seed treatment in 10% of the groundnut area before it was a part of the package, but only 3 years to practice in another 10% area after it was a component of the package. Similarly, it took four years to adopt the application of single super phosphate in 10% area while only one year to cover other 10% area after the GTP was designed.

One of the important component of the GPT, which was most relevant to ICRISAT research, was the broad-bed and furrow. In our sample of adopter category only 2% farmers adopted the concept of raised-bed and furrow in the year 1989; 72% by 1992; and remaining in the following year. The area under this component increased from 0.15% of the total groundnut area in 1989 to 27.91% in 1992, and reached to about 49% in 1994 season. As stated earlier, farmers did not adopt the recommended practice of making a bed of 1.5 m. It was modified as per the local needs and resources. Though the concept of planting crop on the raised-bed was used but the technology was partially adopted by the farmers.

Gypsum is another important component of the GPT. It improves the physical and chemical properties of soil, and contributes in increasing crop yields. Gypsum application by the sample farmers started from 1991. The area under gypsum application in groundnut increased from 2.69% in 1991 to 35.23% in the present season of 1994. About 19% farmers did not apply gypsum in the current season. About 240 Kg/ha of gypsum was applied by the GPT adopter farmers in comparison to recommended level of 400 kg/ha (Table 4).

Application of zinc sulphate and ferrous sulphate, and use of some chemicals for seed treatment were other important components of the GPT. The recommended level of zinc sulphate was 10-20 Kgs/ha once in three years. About 40% of the GPT adopter sample farmers applied zinc sulphate to groundnut during the year 1994. The area treated under zinc sulphate increased from 0.60% in 1992 to 18.7% in the current season of 1994. The adoption level of zinc sulphate was about 4 kg/ha, about 40% of the recommended level.

Ferrous sulphate was applied by 31% of the adopter category of the sample farmers. However, there was awareness among the farmers about the use of micro-nutrient, but unavailability constrained its desired adoption. It may be noted that zinc sulphate and ferrous sulphate were also applied to other crops, important among others is rice.

Harvesting at 65-70% of pod maturity, and using sprinkler method of irrigation are also becoming popular. These are adopted in about 28% and 11%, respectively, of the groundnut area. Since Government of India is extending huge subsidy on sprinkler sets, their wide-scale adoption is expected very soon.

Benefits of the GPT package:

Several on-farm benefits were realized by those who adopted the GPT. These were related to yield gains, higher income, better output prices and cost saving (Table 5), and conservation of soil and water resources. Labor and purchased input used and their cost to produce groundnut are given in Annexure I and II.

i. Yield gains:

One of the most important impact indicators which attracts the farm producers is the contribution of the improved technology in enhancing the yield levels. A technology is often preferred if the potential yields of the improved technology is higher than that of the existing technology with the available resources. It was observed that there was a significant yield advantage by adopting the GPT. The adopter category of sample farmers obtained higher yields of groundnut than those of non-adopter of the technology. The average groundnut yield of the adopter category was 1.95 t/ha in contrast to 1.43 t/ha of non-adopter of the technology, an increase of about 36%. More than 50% of the farmers who adopted the technology obtained groundnut yields ranging between 2-2.5 t/ha, while about 16% non-adopter farmers achieved this level (Table 6). As high as 70% farmers who adopted various components of the technology obtained groundnut yield greater than 1.5 t/ha, while about 30% non-adopter farmers reached this level. Yield of groundnut under on-farm trials in Maharashtra was 3.49 t/ha with the improved GPT, while 2.56 t/ha with local practice (Pawar, et al., 1993). Bhoyar (1992) reported that the yield levels with the GPT were ranging from 2.08 t/ha on light soil to 2.9 t/ha on medium soil. The corresponding values for the local practices were ranging between 1.6 and 2.0 t/ha.

Improved GPT also provided better plant growth, and yielded higher fodder production. The average fodder yield of the GPT adopter group of farmers was 1.91 t/ha while that of non-adopter farmers was 1.78 t/ha, an increase of about 7.13%.

ii. Income:

Groundnut is a cash crop and produced commercially by the farmers. As expected, income of the adopter category of farmers was more than the non-adopters. It was Rs. 15.60 thousand ha^{-1} of those adopted the GPT in contrast to Rs. 6.50 thousand ha^{-1} of the non-adopters, a net additional gain of Rs. 9.1

thousand ha^{-1} (about 140%). The higher income was generated because of more groundnut yield as well as better output prices. It was observed that improved practices helped in better pod development and therefore a price premium (about 19%) to the bold grain was received by the adopter farmers. More than 50% of the adopter farmers reported that the improved soil-water-nutrient management practices facilitate in better pod development.

The increase in yield is a joint impact of improved cultivars and better soil, water, and nutrient management practices, and higher quantity of some of the inputs. Variety wise income of adopter and non-adopter category was assessed and results are given in Table 7. It was found that ICGS 21 yielded highest net returns, followed by TAG 24. Therefore, farmers in the study area were adopting ICGS 21 in more than half of the groundnut area (about 54%). The existing most popular variety, namely SB 11, which accounted about 48% of all groundnut area, was performing better under local managed practices as compared to the improved practices. TAG 24 is at the early stage of adoption and expected to cover large area because of high yield potential and other physiological benefits.

iii. Cost saving:

The most important impact indicators of the technical change is saving of cost to produce one unit of output. Pooled results of all varieties indicated that the cost of production under improved management was Rs. 6.04/kg in comparison to Rs. 7.43/kg under local practices, a saving of about 18.7%. Analyzing the variety-wise results, it was observed that saving was highest for ICGS 21 variety (about 44%). It was about 18% in case of ICGS 11. The improved package was not feasible with local varieties. It indicates high complementarity between the improved varieties and the better management practices.

Some of the critical resources are also saved and increased their efficiency by adopting the GPT. One of the important components of the technology is the adoption of sprinkler or furrow method of irrigation. Both approaches saves a lot of water and improved irrigation water use efficiency. It is evident from the results that it required about 22 days of irrigation by adopter category as compared to about 26 days by the non-adopter. Water is a critical input in the SAT environment. Saving of water and its efficient utilization may facilitate extensive irrigation cover in SAT and contribute in increasing production.

iv. Implications on gender:

The raised-bed and furrow method was designed and advocated to ease certain agricultural operations. It was observed that operations like interculture, weeding, irrigation and harvesting required less labor by those adopted the improved package as compared to those following local practice (Table 8). Labor requirement was less ranging from 11% in case of weeding to 59% for interculture operation. Interestingly, most of the weeding and harvesting operations are traditionally performed by the female labor force of the family. Almost all weeding and about 86-87% of harvesting were done by the female labor in both adopter and non-adopter category. Less exertion and lower labor requirement, especially female family labor, will have implications on the gender related issues. These may be on health, child development, and engagement in more productive activities. These were not investigated in this study, however, focussing attention in the gender research at ICRISAT.

v. Spill-over effects:

The components of the GPT were not only confined to groundnut crop. The components, especially the raised-bed and furrow, are also becoming popular in other regions for other crops, like chickpea, soybean, sorghum, pigeonpea, sunflower, mustard, ladies finger and some minor legumes. In our sample, 10% farmers were practicing the raised-bed and furrow for chickpea cultivation, 6% in sunflower and mustard. Farmers reported 15-45% gain in chickpea yields, 15% in sunflower, and 20% in mustard. Similarly, the application of micro-nutrients in some important crops was also becoming popular in regions where farmers practicing the GPT package.

Estimation of economic surplus:

i. Research cost:

Research resource allocation to generate a specific research information is not usually maintained. So was for the GPT package at ICRISAT. The research activities were covered under two erstwhile programs, namely the Farming System, and the Resource Management, while packaging of the technology and its transfer were done thorough the LEGOFTEN. These programs covered several research and extension activities. Expenditure by ICRISAT especially on developing the concept of the raised-bed and furrow started way back in 1974. The cost was estimated by assuming the share of scientists in the above stated respective research activity (Annexure III). LEGOFTEN was started in 1987. Since the program was conducted for three crops, therefore the budget allocation of this program was distributed to represent the GPT package (Annexure IV). The budget of the state department for the extension activities for the GPT was met from the LEGOFTEN program.

ii. Economic surplus:

Economic surplus was estimated by assuming a perfect market economy. The estimated adoption rates, ceiling levels were used to assess the returns to research and extension investment on GPT. The demand elasticity was considered at 0.5%, while that of supply 0.1% (Radhakrishna and Ravi, 1990). The economic surplus and the internal rate of returns were estimated under a range of assumptions. First was related to the actual and potential area under the GPT. Since the technology was mostly adopted by medium and large farmers, only these groups were considered for assessing the impact. The analysis was first done for Maharashtra State by including only large farmers (about 12% of the groundnut area) as adopter of the technology. In the next step upper half of the medium category of farmers (about 18%) were also included. The analysis was further extended by including Gujarat and Karnataka.

Four level of adoption ceilings were assumed to estimate the benefits of the GPT. These were: (i) 15% ceiling level, a pessimistic scenario on technology adoption, (ii) 20% level, the present level of adoption of total package, (iii) 30% level, and (iv) 55% ceiling level, which is considered for the adoption of raised-bed and furrow, and assumed that all technological components may follow this in years to come.

Table 9 presents the results on net present value and the internal rate of returns of the investment on the GPT. The estimates revealed that the internal rate of return of the GPT was 14.4% when the adoption level of the technology was considered at 55% on the large farms. On a pessimistic level of adoption, the rate of return was only 8.16%. This shows that though returns were positive at 8% discount rate, these were very low, and need further extension efforts to increase ceiling level of the technology.

By expanding the target group of farmers in Maharashtra, the internal rates of return increased modestly. The IRR was ranging between 13.7 and 20.0% (Table 10). The internal rate of return was quite high when Gujarat and Karnataka States were also included in the analysis (Table 11). The internal rate of return was 33.29% at 20% ceiling level, and 37.88% at 55% adoption ceiling. These numbers indicate that further investment on extension activities may be rewarding to cover larger group of the farmers.

Summary

On the basis of above discussion, it can be stated that the GPT was adopted by the farmers. The most important component, i.e. the raised-bed and furrow method of cultivation, was becoming popular amongst farmers, especially with the large and the medium farmers. Other components, especially the sprinkler method of irrigation, use of some micro-nutrients, need better market access for their adoption. The Government of India is already extending subsidy on purchase of sprinkler sets. It is expected that in years to come the sprinkler method of irrigation will be largely adopted, which is at present at incipient stage of adoption.

The technology yielded positive results. These were interms of higher grain yield and income, better grain prices, saving of important inputs, including irrigation and female labor force for some tedious operations. The GPT has significant implications on the issues related to gender.

Investment on research and extension on GPT generated consumers' and producers' surplus. Although the rate of returns were positive but quite low. However, there is good potential to increase the returns by giving adequate support to make available important inputs to the farmers.

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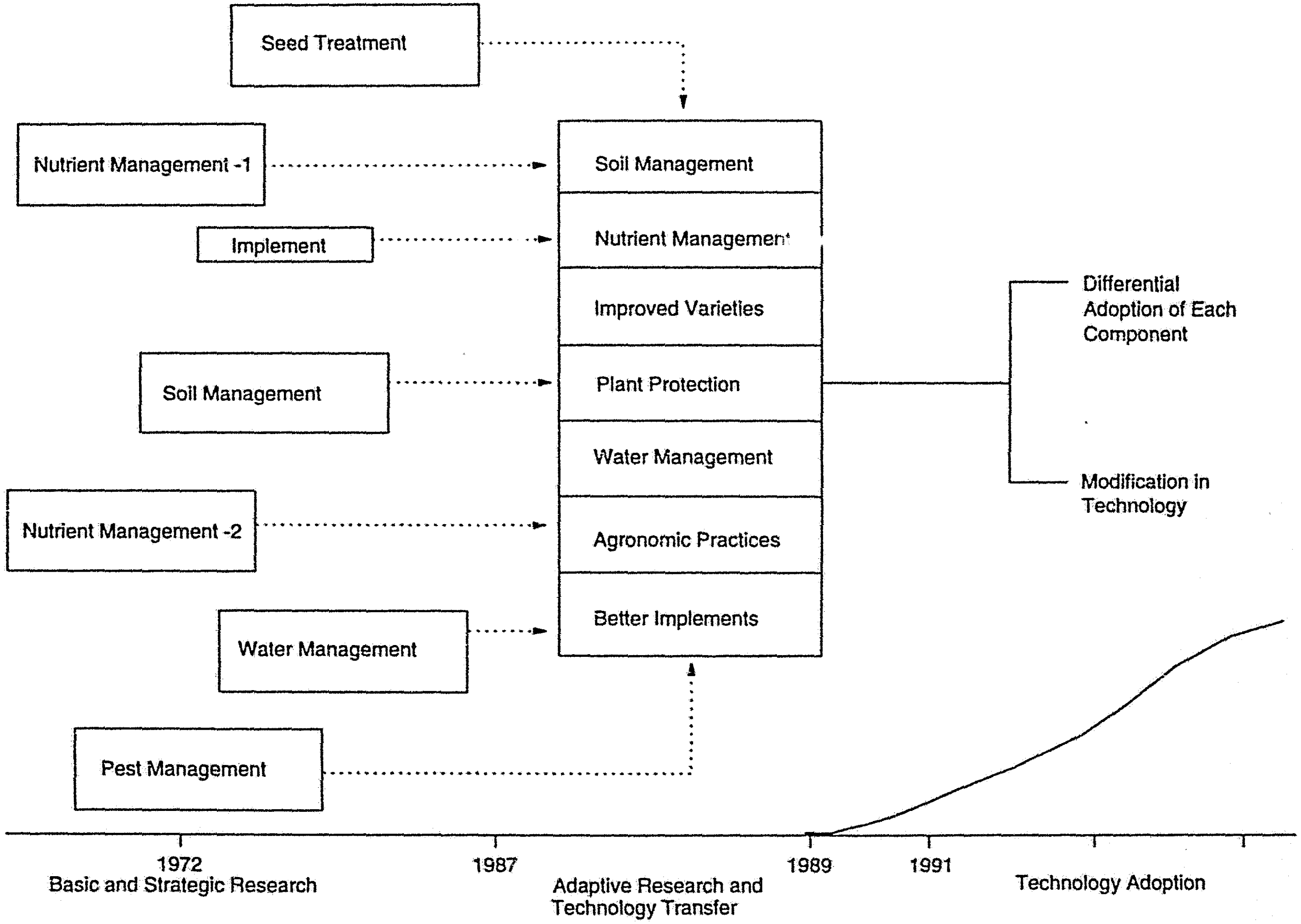

Fig 1. Components of resource management research and their packaging

Table 1: Improved and local package of groundnut production

Component	Local practice	Improved package
Soil management		
Seedbed	Raised-bed & furrow	Flat
Nutrient (ha^{-1})		
FYM	5-12 t	10 t
Ammonium sulphate	100 Kg	DAP: 100 kg
SSP	300-400 kg	MOP: 100 kg
Zinc sulphate	10-20 kg/ 3 years	20 kg
Ferrous sulphate	2-3 g kg^{-1}	-
Gypsum	400 kg	200 kg
Seed		
Improved variety	ICRISAT varieties	State released
Seed rate	125-150 kg ha^{-1} Thiram,	120-125 kg ha^{-1}
Seed treatment	Bavistine or Dithane	Thiram
Plant protection	Bavistine, Dimethoate, Monocrotophos	Need based
Water management	Furrow or sprinkler	Flood

Table 2: Area, production and yield of summer groundnut in selected districts of Maharashtra, India

District	Area (ha)	Production (tons)	Yield (kg ha^{-1})
Nanded	23433 (82.32)	28767 (92.30)	1234
Parbhani	47167 (84.03)	73567 (94.03)	1558
Yawatmal	9267 (50.82)	11900 (70.97)	1282
Maharashtra	233900 (26.95)	384850 (39.06)	1640

Note: Figures in parentheses are the percent share of summer groundnut in total groundnut.

Source: 1. Govternment of India (1993)

2. Various issues of *Agricultural Situation of India.*

Table 3: Acreage allocation to different components of the GPT (%)

Technology component	Ist year of adoption	1989	1990	1991	1992	1993	1994
Raised-bed & furrow	1989	0.15	2.24	5.82	27.91	35.22	48.95
Single super phosphate	1982	36.41	42.23	43.42	46.70	47.30	50.44
Gypsum	1991	0.00	0.00	2.69	23.73	35.07	35.23
Zinc sulphate	1992	0.00	0.00	0.00	0.60	15.53	18.66
Ferrous sulphate	1993	0.00	0.00	0.00	0.00	8.96	10.30
Improved variety	1976	37.30	38.20	38.80	38.80	38.80	50.15
Seed dressing	1981	13.13	15.52	18.21	25.97	35.37	35.67
Drying in sheds	1989	2.99	2.99	3.59	11.05	24.78	28.06
Planting method	1980	19.70	19.70	22.69	22.69	22.69	17.93
Sprinkler irrigation	1992	0.00	0.00	0.00	6.87	10.15	11.34

Table 4: Adoption of individual components of the technology

Sl. no.	Technology component	Quantity applied	Adoption Index* (%)
1	Raised-bed and furrow	-	50.00
2	Gypsum	238.35	59.35
3	Single super phosphate	313.54	88.01
4	Zinc sulphate	3.75	31.00
5	Ferrous sulphate	1.45	72.50
6	Improved varieties	101.98	85.00
7	Seed treatment	0.19	46.56
8	Drying in shade	-	28.06**
9	Planting method	-	17.93**
10	Sprinkler irrigation	-	11.34**
11	Ammonium sulphate	0.00	0.00

Note: * Indicates the percent application to the recommended level.

** Indicates percent area under that component

Table 5: Yield and price indicators of the GPT package

Impact indicator	Unit	Adopter	Non-adopter	Difference (%)
1. Yield				
i. Grain	t ha^{-1}	1.95	1.43	35.88
ii. Fodder	t ha^{-1}	1.91	1.78	7.13
2. Net income	th Rs ha^{-1}	15.60	6.50	140.00
3. Output prices				
i. Grain	Rs kg^{-1}	13.47	11.30	19.20
ii. Fodder	Rs kg^{-1}	0.58	0.56	3.57
4. Cost of production				
i. Variable cost	Rs kg^{-1}	5.20	6.35	-18.11
ii. Total cost	Rs kg^{-1}	6.04	7.43	-18.71

Table 6: Frequency distribution of yield of adopter and non-adopter of the GPT

Yield (t ha^{-1})	Adopter	Non-adopter
0.50 - 1.00	14.3	21.6
1.00 - 1.50	4.1	47.1
1.51 - 2.00	26.5	15.7
2.01 - 2.50	44.9	15.7
2.51 & above	10.2	-

Table 7: Variety wise net income of groundnut with improved package and local practice

Variety	Adopter	Non-adopte	Difference (%)
ICGS 11	7086.66	4014.18	76.54
ICGS 21	12854.67	3475.48	263.86
TAG 24	12765.96	n.a.	-
SB-11	7425.05	6868.97	8.10

Table 8: Implications of GPT on gender related issues

Operation	Unit	GPT adopter	GPT non-adopter	Difference (%)
Interculture	days ha^{-1}	1.36 (0.00)[2]	3.29 (0.00)	-58.66
Weeding	days ha^{-1}	37.80 (98.17)	42.68 (99.69)	-11.43
Irrigation	days ha^{-1}	22.65 (0.58)	25.84 (0.00)	-14.67
Harvesting	hrs kg^{-1}	0.22 (86.18)	0.29 (87.59)	-24.13

[2] Figures in parentheses are the share of female labor in total employment.

Table 9: Net Present Value and the Internal Rate of Return of the investment on the GPT, 12% targe population in Maharashtra, India

Discount rate (%)	Technology adoption ceiling level (%)			
	15	20	30	55
8	30.60	173.88	453.97	1000.90
15	-193.73	-165.85	-111.84	-15.38
20	-194.41	-184.90	-166.57	-136.00
IRR (%)	8.40	9.94	12.10	14.68

Table 10: Net Present Value and the Internal Rate of Return of the investment on the GPT, 30% target population in Maharashtra, India

Discount rate (%)	Technology adoption ceiling level (%)			
	15	20	30	55
8	717.63	1075.83	1776.06	3143.37
15	-55.99	13.69	148.74	389.86
20	-146.26	-122.47	-76.70	-0.15
IRR (%)	13.70	15.28	17.50	20.00

Table 11: Net Present Value and the Internal Rate of Return of the investment on the GPT, target population in Maharashtra, Gujarat and Karnataka, India

Discount rate (%)	Ceiling level (%)	
	20	55
8	24723.05	59314.13
15	4721.98	11014.62
20	1513.99	3560.58
IRR (%)	33.29	37.88

Annexure 1

Input use for groundnut cultivation with improved technology and local practice

Item	Adopter	Non-adopter	Difference
Labor (days ha^{-1})			
- Male	57.93	61.26	-3.33
- Female	106.33	114.55	-8.22
- Bullock	14.61	15.87	-1.26
Seed & treatment (kgs ha^{-1})			
- Seed	101.98	86.24	15.74
- Rhizobium	0.48	0.00	0.48
- Baviston	0.08	0.005	0.07
- Thiram	0.02	0.007	0.01
Nutrient (kg ha^{-1})			
- FYM	2456.00	995.00	1461.00
- Urea	23.82	74.63	-50.81
- DAP	89.64	59.36	30.28
- Gypsum	238.35	19.61	218.74
- Zinc	3.75	0.00	3.75
- Fe Sulphate	1.45	4.84	-3.39
- SSP	313.54	202.97	110.57
- 18:18:0	2.50	29.70	-27.18
- MOP	7.06	0.00	7.06
Pesticide	1.12	0.47	0.65
Irrigation	22.05	25.84	-3.79

Annexure II

Cost of groundnut cultivation with improved and local practice
(Rs/ha)

Item	Adopter	Non-adopter	Difference
Labor			
- Male	1266.05	1300.60	-34.55
- Female	1282.99	1394.45	-111.46
- Bullock	766.25	836.25	-70.00
Seed & treatment			
- Seed	3161.38	2673.44	487.94
- Rhizobium	9.60	0.00	9.60
- Baviston	20.00	1.25	18.75
- Thiram	1.90	0.66	1.23
Nutrient			
- FYM	368.38	149.25	219.15
- Urea	64.31	201.50	-137.18
- DAP	582.66	385.84	196.82
- Gypsum	54.82	4.51	50.31
- Zinc	60.00	0.00	60.00
- Fe Sulphate	14.50	48.40	-33.90
- SSP	658.43	426.23	232.19
- 18:18:0	9.57	112.86	-103.28
- MOP	22.59	0.00	22.59
Pesticide	201.60	84.60	117.00
Irrigation	277.83	325.58	-47.75
Fixed cost including depreciation	1630.00	1554.00	76.00
Interest on working capital	205.56	170.60	34.96
Misc expenses	451.42	405.81	45.61
Total cost	11766.86	10652.54	1114.32

Annexure III

Research cost of ICRISAT to develop and package GPT

Component	Salary	Time	Total cost
Principal Scientist	$ 80,000	0.25	$ 20,000
Senior Scientist	$ 6,500	1.00	$ 6,500
Research Associate	$ 3,000	1.00	$ 3,000
Field Assistant	$ 1,500	2.00	$ 3,000
Labor	$ 1,200	2.00	$ 2,400
	Total salary		$ 34,900
Operations			$ 8,725
NARS contribution @ 10%			$ 4,362
	Total cost		$ 47,987

Annexure IV

Cost of packaging and disseminating the GPT

Year	Total budget	Allocated to GPT
1987	$ 50,000	$ 50,000
1988	$ 50,000	$ 20,000
1989	$ 50,000	$ 20,000
1990	$ 50,000	$ 20,000
1991	$ 50,000	$ 10,000