Bangladesh J. Agric. Econs. XXIII, 1 & 2(2000) 19-34

RAINFED GROUNDNUT IN INDIA: PRIORITIZING PRODUCTION CONSTRAINTS AND IMPLICATION FOR FUTURE RESEARCH

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ABSTRACT

Groundnut is the principal vegetable oil crop in India and occupies the top slot in terms of area as well as production of total oilseeds in the country. However, about 85 percent area under groundnut remains rainfed of which nearly 80 percent comes under dryland where irrigation facilities do not exist at all. There has been gradual increase in the productivity of this crop over the last three decades. However, the enhancement was particularly spectacular in better environments. In harsh environment, not only the yields are low but also it fluctuates violently. Introduction of exotic varieties could not mitigate this problem; rather increased the problem of insect pests and disease pathogens in rainfed groundnut. Concerns are also being raised on the very profitability and sustainability issues of this oilseed crop under free economy hypotheses. On the other hand, if yield gap statistics are any indication then there exists a large potential to raise productivity of this crop. Keeping these issues in mind efforts have been made in this study to identify and prioritize production constraints in rainfed groundnut production system and to explore major researchable issues.

I. INTRODUCTION

Groundnut is the principal vegetable oil crops in India and occupies the top slot in terms of area as well as production of total oilseeds in the country. However, about 85 percent area under groundnut remains rainfed of which nearly 80 percent comes under dryland where irrigation facilities do not exist at all. By 2020 AD, the demand for oilseed in India will double (World Bank, 1999) and requirement of groundnut will reach at least 14 million tonnes. However, the present level of production is around 9 million tonnes only. To bridge this gap. the productivity of groundnut needs to be enhanced at a rate of 2.2 percent per annum. There is gradual increase in the productivity of this crop over the last three decades. However, the increase was particularly spectacular in better environments. In fact, in harsh environments , there was no significant productivity growth during the said period. In such environment, not only the yields are low but also it fluctuates violently. Introduction of exotic varieties could not mitigate this problem. Instead, with the intensive foliage and nutrient contents in them, they become good recourse for insect pests and disease pathogens. Concerns are now being raised on increased evidences as well as emergence of new insect pests and disease pathogens for various oilseed crops, particularly for groundnut, castor and sunflower (Vasudeva and Chaudhary, 1999 and Huger, 1999). Concerns are also being raised on the very profitability and sustainability issues of these oilseed crops under free economy (Gulati et al, 1996). These issues have far reaching consequences and there is urgent need to address

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these problems. On the other hand, if yield gap statistics are any indication then there exist a large potential, even at current level of technology, to raise the productivity. Diagnostic surveys have been conducted and some constraints have been identified (Vasudeva and Chaudhary, 1999 and Huger, 1999) for few pockets but those studies were focussed on kharif groundnut alone and failed to quantify the magnitude of losses arising from this set of constraints. Not much information is available which could form the base to prioritize the production constraints in groundnut production system (GNPS). Prioritizing production constraint research in India is primarily confined to rice production system (Roy and Datta, 2000; Ramaswamy et al, 1996; Widawsky and O'Toole, 1996) and that too for biotic and abiotic constraints, leaving aside socio-economic issues. Earlier studies on constraint analysis also suffer from another limitation that they used the state boundary rather than agroecological regions or sub-regions as the target domain. Those studies have seldom identified homogeneous production zones where the constraints were of more or less similar in nature and research outputs have homogeneous impacts. Thus, efforts have been made in this study to delineate rainfed groundnut based production system and sub-system in India (GNPS), to identify production constraints that causes significant production losses, and to rank these constraints in terms of their impact on production losses. The study also explores researchable issues on the basis of constraint prioritization in groundnut production system under rainfed agro-ecosystem as defined by National Agricultural Technology Project (NATP).

II. METHODOLOGY

Delineation of Study Area: To undertake focused research, it is necessary to identify the research domain. Groundnut production system, in rainfed India, is dominant mainly in two zones- i) the southern peninsula (GNPS1), and ii) Saurashtra region of Gujarat (GNPS2). These two zones differ in terms of agro-ecological characteristics as well as socio-economic development status. Therefore it is expected that the nature and magnitude of production constraints will also differ. This study covers both the zones. A total of 14 districts were delineated that constitutes the boundary of GNPS. Districts falling under this production system were delineated considering the predominance of groundnut crop in gross cropped area and percent of net sown area irrigated. The districts with less than 40 percent net irrigated area and where groundnut is the major crop were selected. For this, districts having groundnut area more than 20 percent in the gross cropped area were retained to focus on rainfed groundnut based system. The GNPS1 includes nine districts viz., Anantapur, Chittor, Cuddapah, Kurnool, Chitradurga, Kolar, Tumkur, Dharmapuri and Salem. The other zone i.e. GNPS2 includes five districts viz., Amreli, Bhavnagar, Jamnagar, Junagadh and Rajkot.

Sampling Design: After delineation, district Anantapur from GNPS1 and Rajkot from GNPS2 were selected purposively keeping in view the highest acreage under groundnut. Moreover, there are quite a few research stations engaged in groundnut research in the areas. In the next stage of sampling, three blocks (talukas) were selected randomly from each of these two districts[2]. Then three villages from each of selected blocks were chosen randomly by random process from the list of blocks and villages. Finally, 10 households from each of these 18 villages were selected randomly based on probability proportionate to different size groups, for conducting household survey, constituting the total sample size of 180 respondents.

Identifying production constraints: In this study, household survey was conducted and agro-biological scientists already working on various aspects of groundnut based system were contacted for detailed discussion. An exhaustive list of constraints for major crops as well as livestock with special reference to GNPS was prepared by reviewing the literature and through interactive process with extension workers and scientists. Subsequently, the constraints having economic significance were short-listed for which information was gathered. The constraints include technical and socio-economic factors that limit yields of major crops and dairy animals. We categorized the technical constraints for crops as: (1). diseases, (2). insect and pests, (3) weeds, (4). water related problems, (5). soil related problems, and (6). others (physiological/agronomic)

Estimation of intensity/severity of constraints and calculation of production loss: The severity of each constraint was assessed through estimation of yield loss. For each crop the average absolute quantity of yield loss attributed to each constraint was estimated from the response given by the farmers. These information were then cross-checked by the scientists and extension personnel. The farmers were also asked to estimate the proportion of area affected, for each of the major crops, by each constrains and to estimate the long term probability of occurrence of a particular constraint on the basis of their past experiences. Estimates of sample households were then averaged for each crop and constraint. Total yield loss was calculated from these averages. The average yield loss multiplied by area affected and then by the prices of particular crop (recommended by the Commission for Agricultural Costs and Prices) provided the value of production foregone. The procedure for calculating production loss is given as:

$$\varphi = n.p.l$$

where, φ = average yield loss attributed to each constraint (kgs/ha)

n = proportion of area affected (%)

p = probability of occurrence of a particular constraint (%)

l = absolute yield loss attributed to each constraint (kgs/ha)

$$\eta = \varphi.N$$

where, η = total production loss ('000 tonnes)

N = area under individual crop in target area (million ha.)

$$Z = \eta.P$$

where, Z = value of production loss (Rs. million)

P = price of output (Rs./kg)

An example of a production loss calculation is given in Table 1.

Table 1: Production loss due to tikka disease in kharif groundnut in GNPS1.

Data: Area affected	= 10.0 percent			Probability of occurrence	= 33.33 percent
Loss per hectare	= 410 kg/ha			Area under kharif groundnut in GNPS1	= 1869971 ha
Calculation:	(Area affected)	x (probability of occurrence)	x (loss)	= Average loss per hectare	
	0.10	x 0.3333	x 410	= 13.67 kg/ha.	
	(Avg. loss)	x (cropped area)		= Total production loss	
	13.67	x 1869971		= 25562500 kgs	
	(Prod. loss)	x (Price)		= Value of production loss	
	25562500	x (Rs. 10.40 per kg)		= Rs. 265850000	

Result: Value of production loss from tikka in kharif groundnut in GNPS1 is estimated to be Rs. 265.85 million per year

Prioritizing socio-economic constraints is more difficult. Season wise analysis was not possible as the same set of constraint affect the entire region irrespective of season or crops. However, the nature and magnitude of socio-economic constraints differs over space. The study assumed yield gap II is the culminating effect of both technical and socio-economic production constraints. Therefore, the differences between yield gap II and losses due to technical constraints were considered as a proxy for losses due to socio-economic constraints. Moreover, total losses from socio-economic constraints could not been segregated on account of individual constraints. Therefore, cardinal measurement of their impact on yield gap could not been tried but the farmers were asked to rank the constraints as per their severity. A comprehensive list of socioeconomic constraints were given to them and asked to assign the value one to the most limiting constraint, two to the next important one, and so on. Then the rank values were averaged across sample households and a composite score was obtained on the basis of which socioeconomic constraints were prioritized for both the sub-system differently.

III. SALIENT FEATURES OF THE GROUNDNUT BASED PRODUCTION SYSTEM

Agro-climate of the system: Groundnut is a typical crop which requires a long warm growing season while water logging, drought and cold weathers are extremely detrimental to its growth. Soils that are well drained, light coloured, loose, fertile, sandy loam, rich in calcium and moderate organic matter with pH ranging from 5.0 to 8.5 is ideal for groundnut cultivation. Table 2 shows salient agro-ecological features of two sub-systems. One important point is that, though normal rainfall in GNPS districts ranges between 537 to 905 mm per annum, the actual rainfall in most of the years is even less than 600 mm. More than the total rainfall in a given year, it is the inadequate distribution of rainfall during the season which causes intermittent and prolonged droughts leading to either complete crop failure or drastic fall in crop yields. Soils are poor in fertility status and also subjected to various forms of degradation including erosion due to water (runoff) and wind. Some parts are toxic with iron (GNPS1) or salt affected (coastal areas of GNPS2).

Performance of agriculture in GNPS: The average yield of groundnut in India is miserably poor and incomparable to that obtained in other countries. In 1990-93 the pod yield obtained was 940 kg/ha as compared to 2387 kg/ha in USA and a world average of 1141 kg/ha (DES, 2001). Groundnut yield fluctuates enormously particularly in the poor environment. Yet it is accepted as an important crop for two reason, namely, it meets the fodder requirement and still it is profitable. The productivity gain in oilseeds have been insignificant mainly due to their cultivation in marginal lands and absence of major breakthrough in the development of management practices and input responsive crop varieties. During the last decade, the groundnut area has increased gradually from 7.4 million hectare in 1981 to 8.0 m ha in 1990. However, the production fluctuated violently primarily because of erratic distribution of rainfall. Groundnut yields fluctuates from 550 to 1100 kgs/ha and consequently the total production also varied from 4.3 Mt to 9.0 Mt. Groundnut is an exhaustive crop that utilizes large quantities of nutrients from soils resulting in nutrient deficiencies. These deficiencies are probably associated with low and declining level of organic carbon due to decreasing use of organic manure and unbalanced use of fertilizers. Apart from groundnut, the production scenario of other crops in GNPS are also quite concerning (Table 3).

Table 2. Salient agro-climatic features of the system.

Particulars	*GNPSI*	*GNPS2*
1. Normal rainfall (mm/annum)	817 (725-905)	615 (537-850)
2. Actual rainfall (mm/annum)	736 (575-1343)	632 (491-913)
3. C.V. of actual rainfall (%)	30	38
4. Probability of deficit rain fall (<75%)	0.38	0.41
5. July-September rainfall	80%	70%
6. Frequency of severe drought (%)	10-12	7-9
7. Frequency of moderate drought (%)	15-20	21-25
8. Maximum temperature (^{0}C)	38 (April/June)	41 (May/June)
9. Minimum temperature (^{0}C)	17 (December/January)	8
10. Soil type	Red soil with patches of black soils	Mainly shallow medium black soil
11. Soil class	Mainly sandy alfisol	Mainly orthids and
12. Soil fertility	Very poor (low in organic matter content, N, Zn, P and K)	Poor (low in P, S and K)
13. Soil pH	<6.5	>7.5
14. Length of growing period (days)	141 (81-186)	148(97-189)
15. Overall climate	Arid	Semi-arid, dry sub

Table 3. Area, production and yield of important crops in *GNPS (1990-94)*.

Crops	*Area ('000 hectare)*	*Output ('000 tonnes)*	*Yield (Kgs/ha)*	*Yield Range (Kgs/ha)*
Sorghum	513.50	430.08	837.55	641 - 1371
Groundnut	3839.88	2726.83	710.13	244 -1534
Finger millet	485.46	704.66	1451.56	939 -2020
Rice	462.63	1191.79	2576.12	1971-3148
Pearlmillet	428.21	404.96	945.71	345 -1963
Cotton	422.02	134.01	317.54	286- 403
Wheat	139.07	350.85	2522.83	1519 -
Maize	~1.80	175.81	2844.82	1618-3166
R&M	i 4.86	12.68	853.30	323- 1060
Soybean	0J6	0.31	322.92	224-750

Data Source: ICRISAT, 1998

Trends in area, production and yield of groundnut: Table 4 gives the estimated growth rates in area, production and yield of groundnut in GNPS. To place the growth in GNPS in the proper perspective, the comparative growth rates for all India are also given. All the growth rates, except for production in GNPS, are statistically significant. The table reveals that there has been gradual increase in area, production and productivity of this crop over the last three decades. But compared to all India, the yield growth rates in GNPS are lower though it is higher for area and production growth rates. In fact, in GNPS2, the recent trend growth rates for yield is negative. Perusal of the table reveal an interesting fact that in GNPS2 even under the situation of negative yield growths there has been an increase in acreage under this crop and in GNPS1 the largest expansion came during 1980s when the yield started declining. This expansion in area appears to be a result of price hike in edible oils in the country. The larger area shift in favour of groundnut, in GNPS, can be explained due to a shift in the relative prices between groundnut and competing crops. It has replaced basic cereal crops, which from society's point of view have higher social profitability.

Table 4. Trends in area, production and yield growth of groundnut.

Region	**Period**	**Compound growth rate (percent/annum)**		
		Area	***Production***	***Yield***
All India				
	1966-80	-0.14	0.05	0.19
	1981-97	0.70	2.12	1.42
	1966-97	0.46	1.46	1.00
GNPS				
	1966-80	0.98	4.03	3.05
	1981-95	3.28	3.35	0.07
	1966-95	1.84	2.38	0.54
GNPS 1				
	1966-80	0.99	1.77	0.78
	1981-95	5.81	5.92	0.11
	1966-95	3.24	3.82	0.58
GNPS2				
	1966-80	0.96	5.24	4.28
	1981-95	0.65	-2.33	-2.98
	1966-95	0.53	-0.14	-0.67

Note: Log-linear function was used to compute growth rates

Cropping pattern and changes therein: The last three decades have brought a significant change in the existing cropping pattern, in this area, in favour of groundnut. Being a predominant rainfed system, the main cropping season is kharif (87 percent of total cropped area), and groundnut is the most important crop occupying 46 percent of gross cropped area (GCA). The changes in cropping pattern in GNPS are presented in Table 5. The figures clearly indicate a shift in favour of groundnut. The data presented are based on triennium averages centered at 1967 and 1994. The increased importance of groundnut can be seen from their share in gross cropped area. The area under cereals in the zone declined from 52 percent in 1966-68 to 27 percent in 1993-95. The decline has come mainly from coarse cereals like sorghum, pearl millet and finger millets as well as from rice. Area under sorghum has declined from 15 percent to 6 percent and pearl millet area declined from 11 percent to 5 percent only. The corresponding decline in paddy and finger millet is from 8 to 6 percent and from 8 to 5 percent, respectively. Wheat, and sugarcane are not a significant crop in this zone though they have improved their share in the gross cropped area.

Table 5. Changes in cropping pattern in GNPS (percent to GCA).

Particulars			**GNPS1**		**GNPS2**		**GNPS**	
		Year	***1966-68***	***1993-95***	***1966-68***	***1993-95***	***1966-68***	***1993-95***
Cereal			*61.49*	*30.52*	*34.84*	*20.72*	*51.55*	*26.58*
	Sorghum		16.78	6.89	13.52	4.62	15.49	6.07
	Rice		12.16	8.64	0.48	0.03	7.81	5.51
	Finger millet		12.30	8.26	0.00	0.00	7.71	5.26
	Pearl millet		6.40	0.97	17.41	11.52	10.50	4.80
	Wheat		0.06	0.66	2.77	4.17	1.07	1.94
	Other cereals		13.80	5.10	0.66	0.38	8.97	3.00
Pulses			*9.26*	*7.51*	*0.68*	*1.37*	*6.06*	*5.32*
	Horse gram		Na	2.74	Na	0.03	na	1.75
	Pigeon pea		1.88	2.32	0.00	0.06	1.18	1.50
	Cow pea		0.36	1.18	0.07	0.39	0.31	0.97
	Other pulses		6.78	1.27	0.61	0.89	4.57	1.10
Oilseeds			*19.25*	*39.74*	*50.97*	*58.17*	*31.07*	*46.33*
	Groundnut		17.08	38.93	48.68	52.6	28.86	43.89
	Sesamum		0.94	0.42	2.26	5.30	1.43	2.19
	Rape and mustard		0.02	0.05	0.00	0.27	0.01	0.13
	Castor		0.64	0.15	0.04	0.00	0.41	0.05
	Other oilseeds		0.57	0.19	0.00	0.00	0.36	0.07
Cotton			*4.84*	*2.94*	*6.77*	*8.80*	*5.56*	*5.06*
Sugarcane			*0.63*	*1.14*	*0.55*	*0.50*	*0.60*	*1.10*
Fruits &vegetable			2.32	*16.55*	0.51	3.17	1.65	11.77
Others			2.21	*1.60*	5.68	7.27	3.51	3.84
Total			**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
GCA	*('000 ha)*		***5222***	***5911***	***3102***	***3284***	***8324***	***9195***

However, area under cotton has declined marginally during the corresponding period. The major gainer, beside groundnut, is fruit and vegetables. Area under various pulses has also declined in GNPS1 but the same is not the case for GNPS2. Oilseeds, particularly groundnut appears to be the major beneficiary in gaining area in GNPS1, while it is groundnut and sesame in GNPS2. The area under groundnut, in GNPS, has increased from 29 percent in 1966-68 to 44 percent in 1993-95 though the major expansion has occured in GNPS1 and that too during 1980s.

IV. RESULTS AND DISCUSSIONS

Yield gap analysis: The estimates of yield gaps are presented in Table 6. These estimates illustrate considerable yield gaps in both the sub-systems. As expected, yield gap in percent terms, is smaller in rabi groundnut where one expects to find modern varieties, high inputs and assured irrigation to a large extent. The highest yield gap in percentage terms occurs in kharif groundnut in GNPS1, which is grown mainly under stress situation, in marginal lands and is susceptible to a wide range of pests and diseases. The average yields obtained by the farmers, in almost all the situation, are less than half of experiment station yield and yield gap II, like yield gap I, is also very large. This support the views that though the HYVs were started with a premise that they would perform superior even under stress condition but since they demand more nutrients, their performance in low fertility condition is inadequate. The yield gap statistics suggests that there are large potentials exists, which can be managed by exploiting the potentials of existing technologies and/or by replacing them with some more appropriate, need based, doable technologies.

Table 6. Estimated yields and yield gaps in groundnut.

(kgs/ha)

Particulars of yields	*GNPS1 (Kharif)*	*GNPS1 (Rabi)*	*GNPS2 (Kharif)*
1. Experiment Station Yield	2400	3000	2319
2. On-farm Experiment Yield	1635	1981	1716
3. Actual Farm Yield	877	1448	986
4. Yield Gaps			
a. Yield Gap I	765	1019	603
b. Yield Gap II	758	533	730
c. Yield Gap (I+II)	1523	1552	1333
d. Yield Gap total (percent)	174	107	135
e. Yield Gap II (percent)	96	37	74

Estimates of yield losses

Kharif groundnut in GNPS1: The cropping pattern of GNPS1 is dominated by kharif groundnut and average yield losses were 758 kg/ha that accounts for as high as 96 percent of farm level yield. This demonstrates the magnitude of production losses and opportunities therein in kharif groundnut. Losses due to technical constraints are 453 kg/ha, which accounts for nearly 60 percent of the estimated yield gap. Water stress tops the list among all constraints by causing a maximum yield loss of 55 kg/ha. Absence of rain during critical growth stages of kharif groundnut not only causes significant reduction in yield but also in oil content. As a group, insect pests cause maximum damage to this crop. Spodoptera and leaf miner are major insect pests followed by red hairy caterpillar, root grab, helicoverpa and leaf weeber. Among diseases, stem rot is most serious problem contributing nearly 21 kg/ha to the yield loss. Other diseases, in order, are budnecrosis, tikka, rust and root rot. Severe infestation of weeds, mainly cynodon and celesia, is an important constraint contributing 63 kg/ha to the yield losses. The crop also suffers from poor soil health, as a result of nutrient deficiency, low organic matter content and due to various forms of soil erosion, together they cause 54 kg/ha yield loss to this crop. The problem of aflatoxin, a poisonous moulds developed when groundnut pods are not properly stored, becoming a threat to both human as well as to the cattles fed on groundnut cake. Other important constraints are mainly physiologic or agronomic. Important among them are poor seed viability and poor quality seeds, improper spacing and delayed sowing, and imbalance use of chemical fertilizers.

Table 7. Estimated Yield Losses due to Major Constraints in Groundnut.

(Kgs/ha)

Constraints	*GNPS1(Kharif)*	*GNPS1(Rabi)*	*GNPS2 (Kharif)*
Insects	*103*	*72*	*140*
Spodoptera	30	21	
Leaf miner	23	17	15
Red hairy caterpillar	18	16	
Grubs	14		5
Helicoverpa	10	9	6
Leaf weeber	8	8	
Thrips			36
Jassid			33
Prodenia			24
Aphids			22
Diseases	*728*	*67*	*113*
Stem rot	21	14	4
Budnecrosis	17	21	
Tikka	14	12	60
Rust	11	10	22
Root rot	9	11	
Collar rot			26
Minor diseases			1
Weed	*63*	*69*	*104*
Cynodon	39	17	37
Celesia	23	11	
Cyprus		41	13
Digera			55
Soil	*54*	*33*	*10*
Nutrient deficiency (Yellowing)	26	19	5
Poor organic matter	18	14	
Soil erosion	11		
Salinity			5
Water	*61*	*20*	*53*
Water stress/drought	55	20	53
Water logging	6		
Others	*99*	*56*	*18*
Aflatoxin	27	5	
Poor seed viability	19	17	
Improper spacing	17		
Grain colour and size	12	23	18
Delayed sowing	11	6	
Imbalance use of NPK	9		
Birds	5	6	
Technical	*453*	*318*	*440*
Socio-economic	*305*	*215*	*290*
Total	**758**	**533**	**730**

Rabi groundnut in GNPS1: Yield gap when measured in percent term, is lowest in this crop. It is not surprising in a situation where this crop is grown mainly with some irrigation facilities and thus does not suffer much from water stresses as in case of kharif groundnut. Among diseases, budnecrosis causes the greatest damage (21 kg/ha) followed by stem rot, tikka, root rot and rust. The damages caused due to insect pests are more or less similar as in case of kharif groundnut but with slightly lesser intensity. The problem of water stress is not that much severe as in case of kharif groundnut however problem of weed is quite severe. Cyprus rotundas causing large damage, among weeds, followed by cynodon and celesia. Poor soil fertility, in terms of nutrient deficiency and low organic matter content, is also causing considerable damage to this crop. Among the agronomic and other constraints, poor seed quality, birds, delayed sowing and aflatoxin contributed 39, 6, 6 and 5 kg/ha of yield losses respectively.

Kharif Groundnut in GNPS2: Average yield losses in kharif groundnut in GNPS2 due to all the constraints worked out to be 730 kg/ha, which is about 74 percent of the average farm level yield. Therefore, there exists a 74 percent potential to increase the productivity of kharif groundnut in GNPS2, through elimination of the losses. Total losses from technical constraints are 440 kg/ha, which accounts for about 60 percent of the estimated yield gap. Tikka disease tops the list of damages by causing a maximum yield loss of 82 kg/ha. Generally tikka is followed by rust that causes 22 kg/ha yield loss. Among diseases, in order, are the collar rot, stem rot and other minor disease. Incidence of stem rot has been increasing in recent years due to continuos mono-cropping of this crop. Among the insect pests, thrips is the major problem causing yield loss of about 36 kg/ha followed by jassid. Prodenia, aphids, leaf miner, helicoverpa and white grubs are the other insects together causing yield loss of about 72 kg/ha. Digera arvensis, Cynodon dactylon and Cyprus rotundas are major weeds, together contributing 104 kg/ha to the yield losses. Water stress is very common and cause quite large yield losses (53 kg/ha). Frequent drought and uneven distribution of rainfall results in this loss. Over/under maturity of groundnut pod is second important abiotic constraint causing average yield loss of about 18 kg/ha. Other important abiotic causes to yield loss are nutrient deficiency and problem of soil salinity.

Groundnut system: As the yield losses across sub-systems and seasons can not be summed directly to provide the aggregate loss, the estimates of total value losses due to various constraints in groundnut system is reported in Table 8. Value losses from major constraints• were aggregated across season and sub-systems to characterize losses for the groundnut system. Total losses from technical constraints in GNPS amounted to Rs. 19219 million, making up 60 percent of yield gap II. The results are important for two reasons. First, a large portion of the yield gap was attributed to technical constraints, demonstrating that solution of these constraints is not trivial. Secondly, loss estimates, when aggregated, are not larger than the yield gap. The latter is a hazard in summing loss estimates for individual constraints (Widawsky and O'Toole, 1996), but not encountered in this study. It is not

Table 8. Estimated value of production losses due to major constraints (Rs. million).

Constraints	*GNPS1(K)*	*GNPS1(R)*	*GNPS1*	*GNPS2(K)*	*GNPS*
Insects	*2006*	*298*	*2304*	*2902*	*5206*
Leaf miner	448	72	520	317	837
Thrips				739	739
Jassid				679	679
Spodoptera	579	88	667		667
Prodenia				498	498
Aphids				444	444
Red hairy caterpillar	356	68	423		423
Grubs	274	0	274	106	379
Helicoverpa	203	38	241	121	362
Leaf weeber	147	31	178		178
Diseases	*1404*	*279*	*1683*	*2337*	*4020*
Tikka	266	50	316	1244	1560
Rust	216	40	255	452	708
Collar rot				542	542
Stem rot	405	57	462	75	537
Budnecrosis	338	89	426		426
Root rot	180	45	224		224
Minor diseases				23	23
Weed	*1224*	*287*	*1510*	*2156*	*3666*
Cynodon	761	72	833	754	1587
Digera				1131	1131
Celesia	462	44	506	0	506
Cyprus		171	171	271	442
Soil	*1059*	*138*	*1197*	*211*	*1408*
Nutrient deficiency (Yellowing)	501	79	581	109	689
Poor organic matter	349	59	408		408
Soil erosion	209		209		209
Salinity				102	102
Water	*1188*	*84*	*1272*	*1101*	*2373*
Water stress/drought	1066	84	1150	1101	2251
Water logging	122		122		122
Others	*1935*	*234*	*2169*	*377*	*2546*
Aflatoxin	520	22	542		542
Grain colour and size	241	95	336	377	713
Poor seed viability	372	69	441		441
Improper spacing	326	0	326		326
Delayed sowing	215	24	239		239
Imbalance use of NPK	169	0	169		169
Birds	93	25	118		118
Technical	*8816*	*1320*	*10135*	*9084*	*19219*
Socio-economic	*5926*	*892*	*6818*	*5986*	*12804*
Total	***14742***	***2212***	***16953***	***15070***	***32023***

surprising that a higher proportion of the production losses is attributable to socio-economic constraints in GNPS as this is one of the most backward region in the country. Resource poor farmers are not able to use modern farm inputs and thus farming remains at subsistence level. Poor state of rural infrastructure development is another reason. Therefore, socio-economic constraints assume significant role in limiting yield.

Table 9. Ranking of constraints by seasons and regions in groundnut.

Rank	*GNPS1 (Kharif)*	*GNPS1 (Rabi)*	*GNPS1 (Total)*	*GNPS2 (Kharif)*	*GNPS (Total)*
I	Water stress	Cyprus	Water stress/drought	Tikka	Water stress
II	Cynodon	Grain colour and size	Cynodon	Digera	Cynodon
III	Spodoptera	Budnecrosis	Spodoptera	Water stress	Tikka
IV	Aflatoxin	Spodoptera	Nutrient deficiency	Cynodon	Digera
V	Nutrient deficiency	Water stress/drought	Aflatoxin	Thrips	Leaf miner
VI	Celesia	Nutrient deficiency	Leaf miner	Jassid	Thrips
VII	Leaf miner	Leaf miner	Celesia	Collar rot	Grain colour and size
VIII	Stem rot	Cynodon	Stem rot	Prodenia	Rust
IX	Poor seed viability	Poor seed viability	Poor seed viability	Rust	Nutrient deficiency
X	Red hairy caterpillar	Red hairy caterpillar	Budnecrosis	Aphids	Jassid
XI	Poor organic matter	Poor organic matter	Red hairy caterpillar	Grain color and size	Spodoptera
XII	Budnecrosis	Stem rot	Poor organic matter	Leaf miner	Collar rot
XIII	Improper spacing	Tikka	Grain color and size	Cyprus	Aflatoxin
XIV	Grubs	Root rot	Improper spacing	Helicoverpa	Stem rot
XV	Tikka	Celesia	Tikka	Nutrient deficiency	Celesia
XVI	Grain colour and size	Rust	Grubs	Grubs	Prodenia
XVII	Rust	Helicoverpa	Rust	Salinity	Aphid
XVIII	Delayed sowing	Leaf weeber	Helicoverpa	Stem rot	Cyprus
XIX	Soil erosion	Birds	Delayed sowing	Minor diseases	Poor seed viability
XX	Helicoverpa	Delayed sowing	Root rot	--	Budnecrosis

Priority research problems: The ranking of the top 20 research problem areas on the basis of estimated loss of value production (drawn from Table 8) can be seen from Table 9. When the constraints were ranked in terms of their contribution to value production loss the traditional problems, viz., water scarcity, soil fertility, weeds etc appeared as the major constraints in rainfed groundnut production. The water stress topped the list and affects groundnut yield irrespective of production environment or crop season indicating thereby the urgency for research intervention to contain the damage. Cynodon weed was particularly endemic in kharif groundnut. The other weeds causing large damages were cyprus, celesia (GNPS1) and digera (GNPS2). Among insects, spodoptera and leaf miner were serious problem in GNPS1 while thrips and jassid in case of GNPS2. Problem of aflatoxin became a major threat in GNPS1 where groundnut cake was being used as a feed to the cattle. This problem was very severe in kharif season and could jeopardize our export earnings from groundnut cake. The problem of nutrient deficiency was common in both the sub-systems. However, two of the top twenty constraints were related to seed. Invariably the quality of the produce was found to be inferior as the grains were not fully developed or the colour was not attracting. This was a result of poor seed quality and moisture stress during pod formation. Introduction of exotic varieties had resulted into increased incidence of several disease pathogens that caused greater damage to the yield and quality of the crop. Important among them were tikka, rust, rot and budnecrosis.

As regard to socioeconomic constraints the 10 topmost damaging problems were related to inadequate and untimely supply of critical inputs, risk in production as well as price, and poor rural infrastructure (Table 10). Since the ranking of socio-economic constraints is ordinal, it was difficult to compare them with technical constraints. Production of groundnut in GNPS was very risky as it suffered from a large number of biotic and abiotic stresses. The most important was very low and highly erratic rainfall pattern. Thus fear of crop failure was very common among farmers. This problem was aggravated due to lack of irrigation facilities. Also, failure of power supply during the critical stages i.e., flowering, pegging and pod formation of groundnut restricted the application of life saving irrigation. The farmer's access to cash was frustrated by financial institutions, which adopted complicated procedures for granting and recovering agricultural loans. Poor credit facilities to small and marginal farmers forced them to adopt traditional agriculture. Incidence of insect pests and diseases were very high in groundnut. Numerous pesticides had been recommended but their non-availability in remote villages forced the farmers to apply pesticides at a sub optimal level. Non-availability of quality seeds on time and selling of substandard seeds also put a barrier in groundnut cultivation as the farmers kept on growing whatever seed material they possessed. Some farmers, even if they wanted to purchase quality seeds, could not got them at the time of sowing. Marketing of groundnut was highly unregulated resulting into large fluctuation in prices which caused greater discouragement to the farmers. Since everyone grown the same crop in the same season they became ready for sale at the same time. Inadequate and inefficient procurement system coupled with predominance of local traders reduced the profitability and the farmers did not got their due share despite of a high price paid by the consumers. The poor storage and transport facilities added to this problem. Lack of awareness about improved technologies and transfer of technology from research station to the farmer's field had been probably another major hurdle in achieving potential yield in these regions.

Table 10. Important socio-economic constraints in GNPS.

Rank	*GNPS1*	*GNPS2*
I	Fear of crop failure (Production risk)	Lack of irrigation facility
II	Lack of credit facilities	Fear of crop failure (Production risk)
III	Fear of glut in the market/Price risk	Poor electrification for agriculture
IV	Non-availability of seeds in time	Non-availability of agro-chemicals in time
V	Lack of irrigation facility	Non-availability of seeds in time
VI	Poor electrification for agriculture	Poor transfer of technology
VII	Unorganized marketing	Lack of credit facilities
VIII	Non-availability of agro-chemicals in time	Fear of glut in the market/Price risk
IX	Poor transfer of technology	Unorganized marketing
X	Poor seed quality	Poor storage and transport facility

V. CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

Elimination or partial solution of these priority constraints would have a major impact on rainfed groundnut system. Based on the magnitudes of crop losses due to major constraints, it is possible to identify a partial research agenda for the groundnut system in GNPS. The top 20 technical constraints to groundnut system cover all six categories studied. To achieve sustainable increase in crop productivity, it is important to improve the efficiency of all critical inputs particularly water. Intelligent management of water resource will be particularly critical for the sustainability, productivity and dependability of crop production in decades ahead. This can be achieved through introduction of short duration and drought tolerant crop cultivars, mulching to reduce evaporation, land leveling and optimum irrigation scheduling. Tolerance to water stress is crucial since most of the areas in groundnut system experience periodic drought and losses from water stress is very high. An analysis of the rainfall for identifying the assured growing season particularly at the development stages of the crop would also provide the framework for breeding specific duration varieties for various production environments. Significant losses from insects like spodoptera, leaf miner, red hairy caterpillar, grubs and helicoverpa demonstrate the acute need for genetic resistance. Genetic resistance to insects has a twofold advantage: it serves to increase yields and reduces the dependency of farmers on insecticides, thereby addressing environmental concerns. Varietal resistance to diseases, particularly for stem rot, budnecrosis and tikka, are needed against which there is currently no effective genetic resistance. Chemical and cultural controls need to be maintained, and search for genetic resistance should be continued. Also, there is a need for greater thrust on promotion of technologies which could minimize the use of costly inputs and result in natural resource conservation such as integrated pest management (IPM) and integrated nutrient management (INM) that would be the key for an ever green revolution. Some mechanism to reduce losses due to weeds, particularly Cynodon dactylon, is clearly necessary. Although many conventional methods are available, they are not successful enough to prevent huge production loss. Integrated weed management techniques will have to be evolved to solve this problem in existing areas and to limit its spread in new areas. Soil salinity due to flash floods in GNPS2, zinc deficiency, and iron toxicity are major soil related constraints for which there are some conventional solutions, but these methods of soil reclamation are very costly and take many years. Biotechnology embraces a range of technical possibilities, the future potential of which is still being hypothesized. However, basic research on transfer of tolerant genes is distinct possibility.

The socio-economic constraints confronting the groundnut system also need to be addressed through development and policy intervention. Realizing the risky phenomenon of agriculture in rainfed agriculture the crop insurance scheme must be implemented effectively. Failure of power supply during the critical stages i.e., flowering, pegging and pod formation of groundnut restrict the application of life saving irrigation. The task emanating here is to ensure regular power supply to the farm sector. Contrary to popular belief, ground realities indicate that farmers are not against payment for the electricity bills, if regular supply is ensured. Similarly, policies toward fertilizer subsidy need to be restructured especially in favour of potassic and phosphatic fertilizers. At the same time policies are also needed to encourage the use of potential biological substitutes to the agro-chemicals. There is an overkill by profit mongers in selling the concept of vermicompost. Presently it is very expensive. Its on-farm production may alleviate the position to some extent. The research findings on IPM and INM technologies are still to be translated into reality for want of required policy support. Equally important will be timely supply of quality inputs, especially in remote areas. This requires revamping the entire infrastructure for an effective input supply system. The farmer's access to cash is frustrated by financial institutions, which adopt complicated procedures for granting and recovering agricultural loans. De-bureaucratization of distribution of agricultural credit system would enthuse the farmers. Industry can play a vital role in the key sector of seed supply, particularly for crops like groundnut. They can become partners on a no-loss-no-profit basis in producing/procuring the much-needed seed meant for their respective industry. Finally, development agencies and private sector should ensure that the critical inputs, like quality seeds of recommended groundnut cultivars, pesticides, fertilizers, and credit necessary for productive rainfed groundnut farming are timely available.

Foot notes:

[1] In this study irrigated production environment, including irrigated groundnut (Rabi) under rainfed eco-system, is described as 'better environment' while production environment totally on the mercy of rainfall is described as 'harsh environment'. These terms are recently used by World Bank (1999) as an alternative to favourable and unfavourable production environment

[2] Total no. of blocks (Talukas) in Anantapur and Rajkot districts were 12 and 13, respectively. Corresponding population figures for the year 1998 were 1.6 and 2.2 millions, respectively.

[3] It is important to note here that a farmer might come across lots of problems during the production of a particular crop. However, it is quite obvious that all production constraints do not occur together and do not affect the entire region at once. The extent of damage caused by a particular constraint may vary from one region to another. Similarly the proportion of area affected by a particular constraint and its probability of occurrence in a year may also differ. If the extent of maximum damages is added together to estimate the extent of maximum yield loss it would present a misleading picture. Hence, it would be quite logical to convert the extent of maximum damage, during the period of occurrence of a particular constraint, into the stream of average annual yield loss after considering its probability of occurrence and proportion of affected area.

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