MAIZE PRODUCTION IN NWFP: A REVIEW OF TECHNOLOGICAL ISSUES IN RELATION TO FARMERS' CIRCUMSTANCES

Derek Byerlee
S. Sajidin Hussain

PARC/CIMMYT Paper No. 86-1

Agricultural Economics Research Unit (PARC), Tarnab, NWFP

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Preface

As Pakistan attains self-sufficiency in food grains, increasing attention is being given to raising coarse grain production, especially of maize, to meet the poultry industry's rapidly growing demand.

As part of this effort, the PARC Coordinated Maize Programme is working with provincial research institutes to increase availability of improved maize technology to farmers. Beginning in 1984, a stepped-up programme of onfarm research was initiated. This research aims at increasing the understanding of farm-level constraints on maize production, identifying appropriate technological solutions, and testing and demonstrating these technologies in farmers' fields. This onfarm research programme is multidisciplinary in character, and involves agronomists, plant improvement specialists, and social scientists. It also employs a farming systems perspective which recognizes that maize in Pakistan is often produced as part of a complex crop-animal system. This report is the first in a series reporting results from this onfarm research programme.

Muhammad Siddiq,
Director General,
Agricultural Research (NWFP)

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Abbreviations

BARD:	Barani Agricultural Research and Development Project.
CIMMYT:	International Maize and Wheat Improvement Center.
CCRI:	Cereal Crops Research Institute, Pirsabak.
NARC:	National Agricultural Research Center, Islamabad.
NWFP:	Northwest Frontier Province.
PARC:	Pakistan Agricultural Research Council.
RD:	Recommendation Domain.

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Executive Summary

(1). Maize is the second most important crop after wheat in the Northwest Frontier Province (NWFP), and for much of the province it is the dominant crop in the farming system. With rapid expansion of the poultry industry and increased industrial use of maize, the potential demand for maize is increasing rapidly. At the same time official statistics suggest that production has increased only modestly in the last decade.

(2). Based on a series of surveys conducted during 1984, it is now clear that there is a wide gap between farmers' maize production practices and practices recommended by the research and extension service. In particular, for much of NWFP farmers generally use local varieties or mixtures of local and improved varieties, broadcast seed rather than plant in lines, use three times the recommended seed rate, thin late in the growing season, and fail to use recommended phosphorous, seed treatment, and plant protection measures (herbicide and fertilizer). Comparison of these findings with survey results from 1974 indicates little improvement in the adoption of recommended practices, except for an increased use of nitrogen fertilizer, especially in barani areas. In some cases, this gap between recommended and farmer practices is due to problems of input supply, especially the nonavailability of seed of improved varieties.

In major maize producing areas of NWFP, farmers have been exposed to recommended practices through a widespread programme of onfarm demonstrations in the 1970's. The apparent rejection by farmers of many of these practices calls for a review of the agro-climatic and socio-economic circumstances under which maize is grown in NWFP, and farmers' decision-making criteria with respect to maize management practices. This paper examines these issues as a background to efforts to formulate a new research strategy.

(3). Controversy surrounds the current maize yields and trends in yields in NWFP. Evidence is presented that maize yields are substantially underestimated in official statistics, especially in Mansehra and Swat, and also that the so-called "yield gap" between present yields and potential yields is less than is commonly assumed.

(4). The maize production zones of NWFP are broadly classified by two main criteria:

(a) access to irrigation - rainfed or irrigated

(b) altitude - low land (< 600 m), mid (600-1,250 m) or high altitude (> 1,250 m).

These factors influence maize management through the choice of cropping pattern, planting dates, plant emergence problems, time of inter-culture in relation to monsoon rains, incidence of insect attack, and winter fodder needs. They indicate substantial differences in maize research priorities for each zone.

(5). Socio-economic circumstances under which maize is produced also vary widely between agro-climatic zones and between farmers in a zone, leading to differences in maize production practices. The most important of these socio-economic circumstances are: (a) competition for resources between maize and cash crops in irrigated areas, (b) the importance of animals in farm households with implications for fodder demands, and (c) the form of land tenancy and sharing of inputs, grain, and fodder in share tenancy.

There have also been important changes in the socio-economic environment of maize production in the last decade including: (a) rapid mechanization of land preparation and replacement of bullocks, (b) increasing costs of rural labour, (c) growing importance of animals relative to crops, and (d) transition of maize from a subsistence food and fodder crop to a cash crop.

(6). A complex issue in farmers' maize management practices has been the importance of maize as a dual purpose grain and fodder crop. Fodder is produced by removal of green maize plants and weeds and from harvest residues. Survey data and simple economic analysis suggest that the value of maize as a fodder may approach its value as a grain crop, especially in areas such as the Swat Valley, which has a high density of animals and a high price for fodder. Evidence is presented to show that farmers' management practices, such as use of a high seed rate and plant removal for fodder, may be an efficient "intercropping" method of producing both grain and fodder.

(7). Individual maize production practices are reviewed and the main issues are as follows:

(a) Variety - the major constraint on adoption of improved varieties is the lack of a seed delivery system. Beyond this, breeders may be able to better serve farmers' needs by selecting earlier varieties, considering fodder producing characteristics, and screening for tolerance to high population densities.

(b) Seed Rate and Plant Stand Management - this is a very complex issue relating to: (i) use of maize as a fodder, (ii) emergence problems at planting time (especially in rainfed higher altitude areas), and (iii) ability to "seel" the field during periods of heavy rain. Although final plant population densities seem to be close to the optimum for dual purpose grain and fodder production, more information is needed on farmers' criteria and constraints for plant stand management.

(c) Planting Methods - the widespread use of broadcast planting reflects a scarcity of bullocks and labour for line planting as well as some farmers' desires for a high plant population density, well-distributed in the field, in order to produce fodder.

(d) Weed Control - farmers commonly control weeds by "seeling" (cultivating) the field after emergence. However, weed problems are often severe in barani areas where weed population densities are high and farmers are not able to "seel" on time because of heavy rains and a scarcity of oxen.

(e) Fertilizer - the main issues in fertilizer use are: (i) circumstances under which phosphorous application should be recommended, and (ii) appropriate fertilizer rates for dual grain/fodder production.

(f) Insecticide - because most farmers use high seed rates, insecticide application does not seem to be a high priority in most areas.

(8). Aside from the questions of the relevance of the technological package, there is a need to disaggregate the package to identify two to three priority components for research and extension. The current package envisages a change in six different components (seed, fertilizer, insecticide, herbicide, population density, and planting method) and involves more than doubling the cost of maize cultivation.

(9). In the 1970's, periodic low prices and instability in maize prices seemed to be important disincentives to maize producers. However, increased commercialization of maize and a greater share of maize destined to non-food uses seems to have stabilized maize prices in the 1980's.

(10). This review suggests a number of considerations in planning future maize research and extension in NWFP. In particular, it is essential that NWFP be stratified into agro-climatic zones with recommendation domains delineated in each zone. Farm-level diagnostic surveys are needed in each recommendation domain to understand the circumstances of farmers in that domain in order to design a research and extension programme appropriate to the needs of those farmers. Research and extension efforts in each zone must also give high priority to development of a seed delivery system.

Introduction

Maize is the second most important crop after wheat in the Northwest Frontier Province, and for much of the province it is the dominant crop in the farming system and the staple food of the rural population. Accordingly, maize has attracted considerable attention from the agricultural research system, especially since the establishment of a maize research station at Pirsabak in 1970. It is now appropriate to review major technological and policy issues influencing maize production as a basis for developing a strategy for increasing maize productivity in NWFP in the future. At the present time, the potential demand for maize is increasing rapidly. With the dramatic expansion of the poultry industry it is quite likely that Pakistan will need to import maize and other feed grains in the near future (Amir, 1986). At the same time, maize research has not had the expected impact on production, at least judging by official production statistics[1] (Table 1). In some cases, this is clearly due to the lack of supporting inputs, most notably seed of improved varieties. However, in the area of cultural practices for maize production, maize researchers should be concerned about the lack of adoption of many recommendations following the thousands of maize demonstrations that were laid out in farmers' fields by the research and extension system in the 1970's (Raja et al., 1975).

The objective of this paper is to review technological issues and to a lesser extent, policy issues, in increasing maize productivity in NWFP and in the adjacent Islamabad District. In particular, the paper aims to spell out major issues in farmer acceptance of the recommended package of technologies in terms of the decision making environment, objectives, and resource constraints of farmers with small holdings, who are the dominant maize producers of the province.

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[1] However, official statistics undoubtedly underestimate yields (see Wedderburn et al., 1984).

Table 1. Trends in area and yield of maize in Mardan, Hazara and all NWFP, 1970-83.

	Irrigated		Rainfed	
	Area	Yield	Area	Yield
	(000 ha)	(t/ha)	(000 ha)	(t/ha)
Mardan District				
1970-73	55.80	1.26	-	-
1980-83	54.40	1.63	-	-
Growth rate (%/yr)	0.30	2.60	-	-
Hazara Division				
1970-73	13.20	1.27	102.30	1.27
1980-83	12.10	1.22	113.10	1.22
Growth rate (%/yr)	0.90	0.40	1.00	0.40
All NWFP[a]				
1970-73	206.60	1.24	119.90	0.78
1980-83	216.80	1.62	181.30	0.89
Growth rate (%/yr)	0.50	2.70	4.10	1.30

[a] Including Swat District, the largest maize producer in Pakistan. Statistics for Swat indicate major inconsistencies in data from year to year.

Methods

In 1984, major efforts were made to systematically understand the maize production decisions of farmers with small holdings in NWFP. A number of informal and formal surveys were conducted by maize agronomists and economists in each of the three major maize producing environments of NWFP, namely the Mardan, Swat, and Mansehra Districts (Fig. 1). In addition, in this paper, data from the neighbouring district of Islamabad are also discussed. Conditions for maize production in the Islamabad District are similar to those in the contiguous Haripur Tehsil of Abbottabad District.

Surveys conducted were:

(1). A brief informal survey by economists and agronomists in each major maize producing area. This survey did not use a questionnaire but was based on in-depth interviews with individual farmers and groups of farmers, and on observations

Figure 1. Major maize producing districts of N.W.F.P.

in farmers' fields.

(2). A maize/fodder/population density survey. Researchers in each area recorded plant population densities at two to three week intervals in selected farmers' fields from plant emergence to harvest. At each plant count, farmers were also interviewed about the sources and types of fodder given to their animals on the day preceding the interviews.

(3). A survey of production practices and yield. This survey followed the methods used in 1983 by Wedderburn et al. (1984). Farmers harvesting their crops were interviewed and a sample of the harvested field was weighed to estimate plant population densities and yield. In 1984, the questionnaire was designed on the basis of the informal survey and included improvements over the 1983 survey.

(4). A survey of maize in the farming system in Swat Valley. This survey was conducted after harvest in 1984/85 and aimed to verify hypotheses on reasons for farmers' practices that were formulated in the informal survey. A part of this survey also elicited information on maize utilization and marketing for the 1984 crop cycle.

In this paper we focus on information obtained in the informal survey with some reference to other surveys. More in-depth analyses of maize production issues in specific areas are found in Hussain et al. (1985), Sheikh et al. (1986), and Byerlee et al. (forthcoming). We first provide an overview of maize production practices in relation to recommended practices. Changes in production practices and yields in the last 10 years are also briefly summarized. The bulk of the paper is then devoted to a systematic review of each recommended component of the technology in relation to farmer acceptability in different production environments.

An Overview of Farmers' Maize Production Practices In Relation to the Recommended Package

Farmers' Practices and the Recommendations

Farmers' maize production practices in NWFP are summarized and compared with research recommendations in Table 2. The intensity of land preparation is generally lower in higher altitudes, reflecting the limited turn around time from wheat to maize. In irrigated areas, land preparation more or less follows recommendations.

Except for the Mardan District, maize is almost universally broadcast at a seed rate of about three times the recommended rate. About three weeks to a month after planting, a "seel" operation is performed which eliminates approximately

Table 2: Comparison of farmers' production practices and recommended practices for maize in NWFP.

PRACTICE	Recommended Practice	COMMON FARMER PRACTICE			
		MARDAN (Low altitude irrigated)	UPPER SWAT (Med.altitude irrigated)	MANSEHRA (Medium altitude barani)	ISLAMABAD (Low altitude barani)
No. of Ploughings	3-4	2-3	None	1-2	2-3
Seed Rate (kg/ha)	30	40	80-100	80-100	60-100
Planting Method	In lines	Line and some broadcasting	Broadcast	Broadcast	Broadcast
Variety	Sarhad White, Azam (for earlier maturity)	Swabi White	Mixed Local Changez Zia and Others.	Double Hazara	Local
Weed Control:					
Interculture (seel)	1	1	1	1	1-2
Hoeings	2 or	1-2	None	None	None
Herbicide	Primextra	None	None	None	None
Time of Thinning	At 3 weeks	Continuous thinning upto maturity			
Fertilizer:					
N (kg/ha)	114 (Irrigated) 74 (Barani)	88	55	64	58
P_2O_5 (kg/ha)	57 (Irrigated) 37 (Barani)	0	29	0	0
Seed Treatment	Benlate Detan	None	None	None	None
Insecticide	Diazin Furadan	Few Farmers	None	None	None

one third to a half of all plants and also controls weed growth. "Seeling" is the process of ploughing a broadcast maize field at a row spacing of 25-30 cm with an animal drawn plough after crop emergence. Less frequently, a tractor drawn cultivator is used with one row of tynes removed. After seeling maize plants are manually thinned up to harvest time.

Mardan District is the exception to these practices. Here seed rates are only slightly above the recommended level and maize is planted in lines in over half of all fields. Interculture by animals is performed in line planted fields but not in broadcast fields. Most fields in Mardan are also weeded by hoe once or twice during the growing cycle. Reasons for variation in these practices between Mardan and other areas will be discussed in more depth in later sections.

Maize varieties used by farmers are usually local or older improved varieties often mixed with more recently released improved varieties. Few farmers are planting recommended varieties.

Fertilizer is now used by most farmers in NWFP but at somewhat lower rates than are recommended. Nitrogen rates in irrigated areas are significantly lower than those recommended. In barani areas, nitrogen fertilizer is used at close to the recommended level. However, phosphorous is not commonly used on maize except in Swat, where nearly half the farmers apply it.

Insecticides and herbicide use is negligible. Insecticides have been widely demonstrated and considerable research work has been conducted on herbicides in the last few years.

Clearly, in most of NWFP, there is a wide divergence between farmers' practices and researchers' recommendations, especially with respect to variety, seed rate, planting method, insect control, and thinning. However, in the Mardan District, many farmers use close to the recommended seed rates as well as line planting.

Changes In Farmers' Practices, 1974-1984

Some evidence is available on changes in maize production practices in Hazara and Mardan by comparing recent survey results with results of a comprehensive survey of maize producers by Ashraf and Winkelmann (1976[1]). The two major changes in production practices are the rapid adoption of

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[1]Care should be exercised in making these comparisons since sampling and interview methods differ between the two surveys.

tractors for land preparation and, more recently, maize shellers, and the increased use of nitrogenous fertilizer in rainfed Hazara (Tables 3 and 4). Use of phosphorous fertilizer seems to have increased little and may have declined in the Mardan District. Nor have there been any significant changes in the use of improved varieties or line planting. In fact, broadcasting of maize seed seems to be on the increase in the Mardan District.

In summary, it would seem that the largest changes in yield-increasing technology have come about through an increasing use of fertilizer, especially nitrogen, in rainfed areas[1]. The distribution of seed of improved varieties through demonstration programmes in the 1970's has also undoubtedly increased yields, however, due to a lack of continuous infusion of improved seed, most farmers now grow varieties which are a mixture of local and improved materials. Most other components of the technological package which was extensively demonstrated in the 1970's appear not to have been adopted[2]. In some cases, this lack of adoption clearly reflects supply constraints on necessary inputs (especially seed of improved varieties). In other cases, such as line planting, farmers appear to have rejected the recommendations.

The "Yield Gap"

With the divergence between farmers' practices and the recommended package, it has been assumed that there is a large yield gap between present and potential maize yields that can be narrowed if farmers adopt the recommended package. It has been fashionable to compare farmers' yields based on official statistics with experimental yields, often derived from research station results. Thus the "yield gap" in maize is estimated to be the difference between official estimates of farmers' yields of 1.3 t/ha and experimental yields of 6.9 t/ha, or a yield gap of 82 percent. The logical interpretation of these results is that major efforts need to be placed on extension of the technological package.

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[1] Unfortunately, there is little evidence for changes in yield between the two periods outside of those provided by official statistics. The only data available are from Baffa village in the Mansehra District, where yields changed from 13.5 mds/ac in 1954 to 23.8 mds/ac in 1983 (Institute of Development Studies, pers. comm.).

[2] For details of the demonstration programme conducted in the 1970's, see Raja et al. (1975).

Table 3. Comparision of maize production practices in 1974/75 and 1983/84 in Hazara Division and Mardan District.

	Hazara			Mardan		
	1973[a]	1983	1984	1974/75[a]	1983	1984
Percent who:						
used improved variety	5	1	4	12	10	4
broadcast	99	100	96	13	36	42
used fertilizer	48	90	85	93	89	91
Average rate of: (kg/ha)						
N	32	64	67	74	88	81
P	5	10	12	23	15	15

[a] Sources: Ashraf and Winklemann (1976), and maize surveys conducted in 1983 and 1984.

Table 4. Use of tractor and bullock power in maize production in NWFP.

	Hazara		Mardan	
	1974/75[a]	1984[b]	1974/75[a]	1984[b]
Percent who:				
used a tractor	0	62	7	68
used bullocks only	100	38	93	32
owned a bullock	82	57	88	63

[a]Source: Ashraf and Winklemann (1976).
[b]Maize harvest surveys conducted by CCRI and NARC in 1984.

However, we believe that it is important to be realistic about the potential gains to be achieved through the use of improved maize technologies. There is now convincing evidence that official statistics substantially underestimate farmers yields. In NWFP, official statistics have been traditionally collected by the revenue department without any statistically sound methodology. Maize researchers have estimated yields in 1983 and 1984 in NWFP based on crop cuts in over 500 fields. Results are compared with officially estimated yields in Table 5, and indicate that farmers' yields average at least 2.5 t/ha

Table 5. Estimates of maize yields in NWFP by district, 1983-84.

District/Tehsil	Official Estimates		Researchers' Estimates[c]	
	Official Yield Statistics[a]	Measured Yield[b]		
	1983	1984	1983	1984
	(t/ha)	(t/ha)	(t/ha)	(t/ha)
Mardan[d]	1.60	2.0	2.5	na
Swat	1.30	na	4.3	3.9[e]
Mansehra	0.86	2.1	2.6	3.4[f]
Abbottabad	0.71	1.6	2.7[g]	na

[a] Source: Government of Pakistan, 1984.
[b] Source: Khan and Haq, 1985. Statistics converted to 15% moisture.
[c] Source: NARC and CCRI surveys.
[d] Irrigated areas only.
[e] Upper Swat only.
[f] Pakhli Valley only.
[g] Haripur Tehsil only.

na = not available.

compared to the official estimate of 1.3 t/ha[1]. In 1984, the NWFP government began its own maize yield survey based on crop cutting methods (Khan and Haq, 1985). Average yields were slightly over 2 t/ha, however, the largest and highest yielding maize producing district (Swat) was not included in their sample.

In comparison, the average yield from over 1,000 extension demonstrations in NWFP conducted using improved technology from 1974 to 1976 was 3.8 t/ha (Maize and Millet Research Institute, 1976). Given newer varieties and an increase in the recommended level of fertilizer in the 1980's, we can probably assume average potential farmer yields of 4.0 t/ha, with, of course, substantial variation between regions. Hence, assuming farmers' yields of 2.0-2.5 t/ha, a more realistic estimate of the average "yield gap" is 1.5-2.0 t/ha.

The Need to Review the Maize Production Package

It is clear that there is a wide gap between farmer practices and the recommended package of technology throughout much of NWFP. In this paper, we present four major premises which we believe are important in bridging this gap and developing appropriate technological recommendations for maize in NWFP.

(1). Maize in NWFP is produced under a wide range of agro-climatic and socio-economic conditions, each with particular production problems and potential. Hence further research and extension efforts need to be formulated for specific subgroups of farmers or recommendation domains (RDs)[2].

(2). In each recommendation domain, maize is produced as part of a farming system, and production decisions made for maize often reflect wider concerns of farmers for optimizing resource use within the farming system. In particular, maize in NWFP is often a dual purpose crop producing grain as well as fodder (green and dry fodder and weeds). If this is the case, improved technologies for maize should be evaluated in terms of both grain and fodder production.

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[1] The crop cutting method used by the researchers undoubtedly overestimated yields by 10-20 percent because of a small sample frame (12-27m^2), a limited harvest period, and concentration on major maize producing areas readily accessible by vehicle.

[2] A recommendation domain is a relatively homogeneous group of farmers for whom we can make more or less the same recommendation (Harrington and Tripp, 1984).

(3). Farmers do not adopt technological packages but rather make improvements in a step-wise manner (Byerlee and Hesse de Polanco, 1982). The currently recommended maize production package involves changes in seven different technological components and implies adoption of almost a completely new farming system. There is an urgent need to disaggregate the package and select two to three priority components for research and extension in each RD. Priorities should be selected in terms of their potential to increase farmers' productivity when added to farmers' existing technology (rather than by their contribution to the total package).

(4). The price policy environment for maize is not a constraint to increased maize productivity if the right recommendations and associated inputs are provided to farmers. In particular, it is widely assumed that low maize prices and uncertainty in the maize market are a disincentive to maize producers. It seems that this situation has now changed, and we can look forward to reasonably high and stable maize prices.

We believe that these four premises are central to the design of an efficient maize production strategy for NWFP.

Major Production Environments for Maize in NWFP

Agro-climatic Environments

Maize in NWFP is produced under a wide range of agro-climatic environments. Table 6 shows a broad classification of environments based on altitude and access to irrigation. These together have a number of important implications for maize production.

(1). The growing cycle reflects a combination of elevations and access to irrigation. At lower elevations, planting occurs in early to mid July after the beginning of the monsoon. Where irrigation water is available earlier planting is possible, however, stem borer attacks in hot, dry June weather may be very severe. At higher elevations it is necessary to plant earlier because of cooler temperatures and the longer growing season required for maize. In rainfed elevated areas such as Mansehra, maize must often be planted under marginal moisture conditions.

In rainfed areas, especially at lower elevations, September rainfall is often erratic, so that the growing cycle is shorter than in irrigated areas where one or two irrigations may be applied to extend the growing period through September. In irrigated areas, irrigation is used at this period as well as at planting if moisture is not adequate. During the remainder

Table 6. Broad classification of agro-ecological environments and growing cycles for maize in NWFP and adjoining areas.

	Altitude (masl)		
	<600	600 - 250	>1250
Rainfed:			
	Haripur Tehsil, Islamabad District	Mansehra Tehsil	Swat mountains Balakot, Batag-gram, Kohistan and much of Azad Kashmir
Growing period	Early July-late September	Early June-early October	May - October/November
Irrigated:			
	Mardan District Lower Swat Bannu	Upper Swat Valley	Higher valleys of Chitral and Gilgit
Growing period	Mid July[a] -mid/late October	Mid June-early October	May/June - October/November

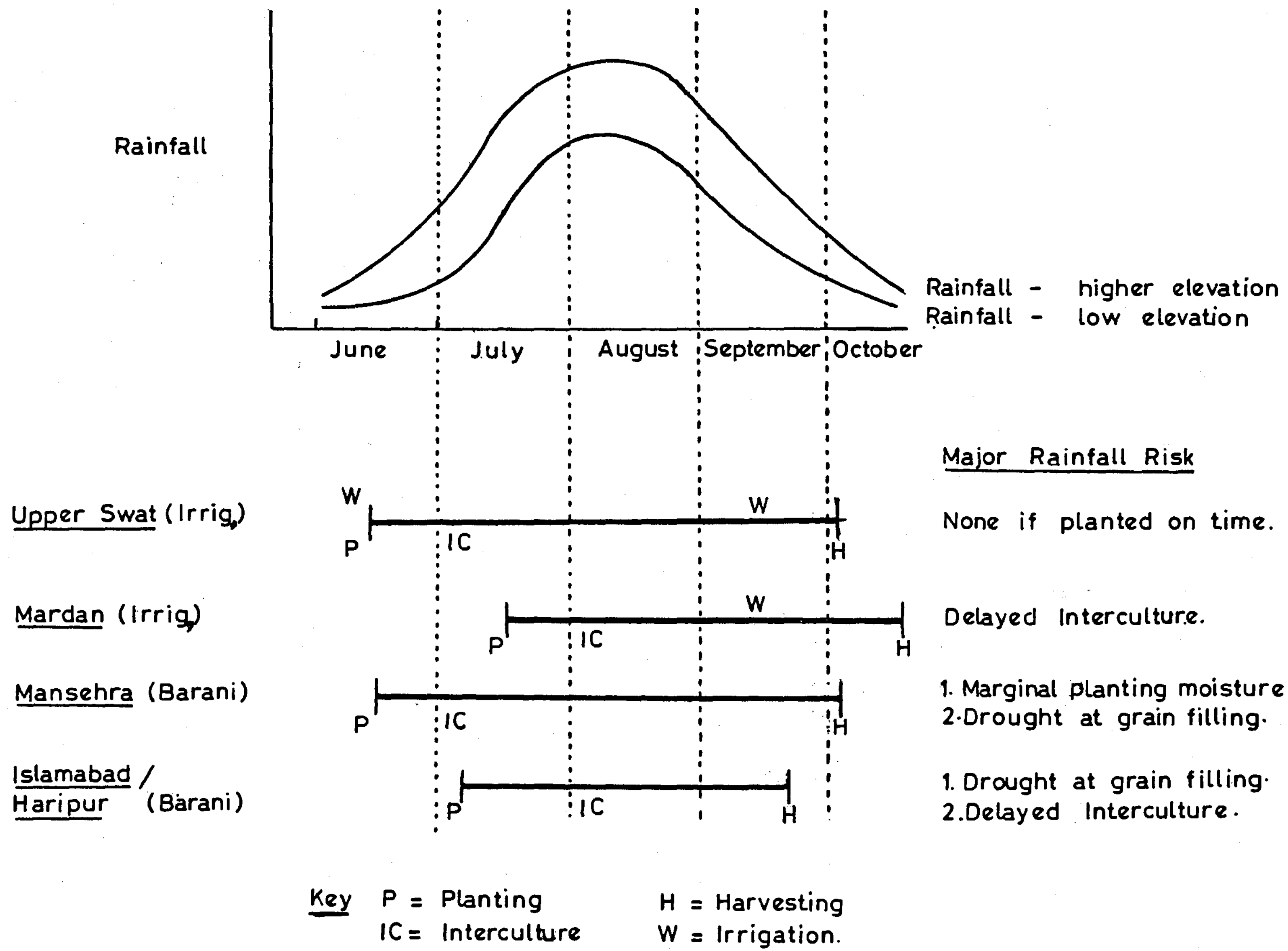
[a]This is the major maize growing cycle. However, planting and harvesting dates may be quite variable in these areas depending on the particular cropping pattern employed.

of the growing cycle, rainfall is usually relied on to supply moisture, even in irrigated areas.

Differences in planting dates also lead to differences in the time of inter-culture operations in relation to the peak of the monsoon rains. Figure 1 shows that at higher elevations, the first weeding will normally be performed before heavy monsoon rains begin. In lower elevation areas, inter-culture will coincide with the rainy period and prevent timely weeding operations. The main risks caused by rainfall patterns faced by farmers in each of these agro-climatic environments are shown in Fig. 2. Clearly, the barani areas are exposed to more climatic risks.

(2). The cropping pattern imposes different constraints at each elevation. At low altitudes (< 600 m), ample time is

Figure. 2 Schematic Representation of Rainfall Distribution, Growing Cycle and Cultural Operations in Maize in NWFP.



available between wheat harvesting and maize planting[1]. Hence delays in wheat harvesting do not delay maize planting and sufficient time is available for land preparation (if moisture is available). In the medium elevation areas the turn around time from wheat to maize is limited, and timely maize planting and adequate land preparation may not be possible. In the high altitude areas, only one crop, usually maize, is produced.

(3). In elevated areas, the winter is longer and more severe and this places a premium on conservation of dry fodder for animals. In lower elevation areas green fodder may be available as early as January.

Socio-economic Environments

Variation in Socio-Economic Circumstances Between Zones and Farmers: There are significant differences in socio-economic circumstances between agro-climatic zones and between farmers in a given zone (Table 7). These have a number of implications for designing appropriate maize production technologies. Some of the most important variations in socio-economic circumstances of farmers are as follows:

(1). In rainfed areas, maize is the dominant kharif crop for both subsistence food production and for cash generation. In irrigated areas, especially those in flat areas with easy access to markets, maize is usually of lower priority and often grown as a "fill-in" crop, and increasingly is being replaced by higher value crops such as vegetables, tobacco, orchards etc. Farmers in these areas generally give priority to allocating scarce labour and cash resources to cash crops rather than to maize.

(2). There is a wide range in the importance of animals in NWFP farming systems. This is seen by the ratio of animals to cultivated area in each agro-climatic zone (Table 7). Swat has the highest pressure from animals per household and per unit of cropped area. Within a given zone, this ratio varies widely, with farmers who own small holdings and who are specialized in animal production for meat or milk production having a high ratio of animals to maize area. A high ratio of animals to cultivated area implies a greater pressure on maize fields to produce fodder. This pressure is modified if pasture or fallow land is available to provide alternative sources of fodder, as in some barani and mountainous areas.

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[1]In irrigated areas with ample water supplies, more intensive cropping systems are often employed which may reduce the turn around time for maize planting.

Table 7. District-wise summary of major difference in tenancy, farm size, maize area, and number of animals in NWFP 1972-80.

	Hazara		Mardan		Swat
	1972	1980	1972	1980	1980
Percent owner operated farms	77	88	52	53	72
Average farm size (ha)	2.1	2.3	2.3	1.9	1.5
Average cultivated area (ha)	1.0	1.0	2.1	1.7	1.3
Maize area as percent of total cropped area	50	52	31	34	-
Average number of animals per household	0.84	1.70	0.92	3.60	5.60
Number of animals per cultivated ha	0.84	1.68	0.44	2.12	4.51

Source: Pakistan Census of Agriculture, 1972 and 1980.

(3). Both ownership and share tenancy are common in NWFP, with a higher proportion of tenants in irrigated areas of Mardan and Swat. Conditions of share tenancy vary substantially, but there is a tendency for share farmers to receive a higher proportion of the fodder than the grain produced from maize fields. The tenant usually receives all the green fodder and in extreme cases receives all the dry fodder but only one quarter of the grain. These tenancy conditions therefore provide an incentive for tenants to produce fodder at the expense of grain.

Trends in Socio-economic Circumstances Over Time: The socio-economic environment in which farmers make decisions on maize production practices is undergoing some major long term changes which should be considered in any research efforts for the future. The most important of these are as follows:

(1). Farmers in NWFP have switched dramatically in the last decade or so from animal to tractor power (Table 4). Many farmers, especially those in flatter areas, do not now own draught animals. Practices which depend on timely availability of draught animals, such as the "kera" method of line planting or inter-culture "seeling", have become more difficult for farmers to manage.

(2). During the same period, real costs of rural labour have risen substantially. Data on rural wages are fragmentary but indicate an increase in real agricultural wages from 1975 to 1984 of 40 percent (Irfan and Ahmed, 1985). This means that labour intensive practices, such as hoeing, have become relatively more costly and farmers are seeking ways to reduce labour requirements.

(3). Animals for meat and milk have become relatively more important and place greater pressure on fodder production from the available cultivated area. Figures in Table 7 suggest that the number of animals per ha of cultivated land more than doubled from 1971 to 1981[1]. This, together with efforts to keep grain prices low to urban consumers, has probably led to an increase in the price of fodder relative to grain. (Prices of livestock products have not been subject to government control). The evidence on this trend is difficult to document, but one survey undertaken in Hazara in 1970 (Rochin, 1971) estimated a grain to bhusa price ratio of 4:1 compared to a ratio of about 2.5:1 in 1984.

(4). An increasing proportion of maize is destined to the market. This is in part due to increased production of wheat with the sowing of semi-dwarf varieties and a preference for wheat for home consumption[2]. Also, atta (wheat flour) has been made available at subsidized rates, so that even at high elevations where no wheat is grown, farmers now sell maize and purchase atta. Furthermore, and consistent with this switch from maize to wheat in diets, a greater proportion of marketed maize is now destined for industrial and animal feed uses (Amir, 1986). This has reduced maize price variability (see later section). It also opens up a potential market for yellow

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[1] These statistics should be treated cautiously as they represent an unlikely jump in animal numbers in a 10 year period. However, special bank loans for animal purchases by the landless as well as the investment of migrant remittances in animals has undoubtedly increased animal numbers.

[2] The preference for atta seems to relate to a number of factors, including the ease of preparation and the better keeping quality of wheat chappaties.

maize in NWFP where farmers have traditionally producted white maize to satisfy their food preferences.

Maize As A Dual Purpose Grain And Fodder Crop

Undoubtedly one of the most complex issues in increasing maize productivity is how to meet both the grain and fodder needs of farmers. The importance of maize as a fodder to different types of farmers has not been quantified, nor have trade-offs between grain and fodder production been measured. A common recommendation has been to plant separate grain and fodder plots if the farmer needs fodder for his animals and so increase grain yields in the plot reserved for grain.

In 1984, surveys were conducted specifically to address these questions. Data were analysed in depth by Fischer and Javed (1986). Here we present an overview of some of the issues involved - especially from an economic's perspective.

Figure 3 shows the complexity of the maize production system that farmers operate in all districts except Mardan. Initial plant population densities are dependent on germination and seed rate. Population densities are reduced by the seeling operation and are then further decreased by manual removal of plants, especially weak and barren plants, during the remainder of the growing season. Dry matter is then partitioned between grain and stover depending on plant population density. Plant density will also determine the texture of dry stover - lower population density fields produce thicker stalks which may have a different value as a fodder.

Specific inter-relationships in Fig. 3 are discussed in more detail in later sections. It is sufficient to note here that fodder may be produced in three forms from the maize fields: (a) by cutting weeds, (b) by cutting green stalks, and (c) by saving the dry stover. The green weeds and green stalks are usually, but not always, for immediate consumption, while dry stover is usually stored for later consumption over the winter period. Hence fodder value is defined by: (a) the quantity, (b) the quality (i.e. green or dry, weeds or stalk, thickness of stalks), (c) the time of availability, and (d) the time of consumption.

Many factors are likely to determine the farmers' specific needs for fodder from the maize field. These include: (a) the ratio of animals to maize area, (b) the type of animal (buffalo, cow or bullock; dry or milch), (c) location of the maize field in relation to the farmer's house, (d) availability of alternative sources of fodder at a given time (i.e. fallow, pasture land, weeds or by-products of non-maize fields), and (e) the length and severity of the winter period. Supply of

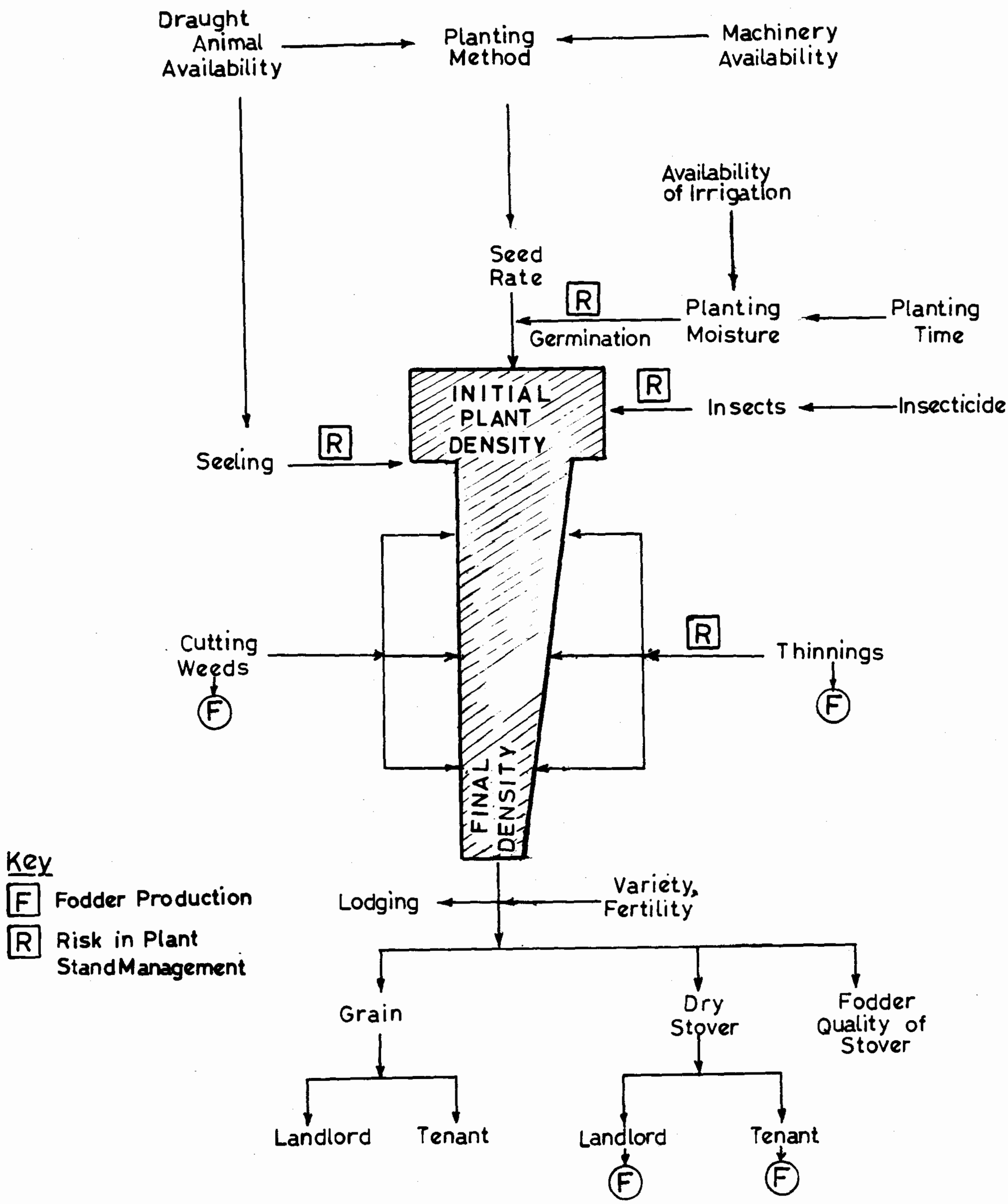

Figure 3. Schematic representation of factors affecting plant density and fodder production over the growing season.

fodder in turn depends on farmers' management practices (e.g. seed rate, seeling, and plant removal) interacting with climatic factors (e.g. moisture at germination or rains at the time of seeling).

To understand these interactions, several types of information are needed. First, it is important to try to place a relative economic value on the grain and fodder produced. It is easy to determine that in areas with a high number of animals to maize area, income from maize is secondary to that from animals. For example, in Swat with three milk animals/ha producing 71 t milk/animal at Rs five/L, the gross value of milk produced over a maize cycle of 100 days would be Rs 10,000, or about double the value of maize grain/ha.

It is also possible to directly value the fodder. For example in 1984, maize fields near Mingora sold for green fodder were priced at about Rs 2,000/ac or Rs 5,000/ha net of harvest costs. Assuming that in a field of maize producing both grain and fodder, 75,000 plants/ha are removed for fodder, this would be equivalent to 0.375 ha of a maize fodder field with a population density of 200,000 plants/ha or a value of Rs 1,875/ha (0.375 x 5,000). The value of the maize plants removed may also be estimated indirectly, since farmers use these green plants to substitute for bhusa (wheat straw) and oil seed cake that is fed to animals in June before green fodder becomes available. Again in Swat, with five adult animals (milk and dry)/ha of maize, we have estimated that maize thinnings substitute for 10 kg/day of bhusa and one kg/day of oil seed cake for each animal over a two month period. Using a price of bhusa in that season of Rs 20 per 40 kg and a price of oilseed cake of Rs four/kg, we arrive at the following:

- bhusa saved:	10 kg/day x 60 days x Rs 0.5 x 5 animals	=	Rs 1,500
- oilseed cake saved:	1 kg/day x 60 days x Rs 4 x 5 animals	=	Rs 1,200
			Rs 2,700

This estimate is a little higher than the direct estimate, probably because some green fodder is provided from bunds and non-maize fields, and because costs of fodder cutting are not netted out. Let us assume an intermediate value of the two estimates of Rs 2,000/ha for the plants removed as green fodder. In addition, the dry stover is sold at around Rs 1,000/ac or Rs 2,500/ha. Hence the total value of production is as follows:

Product	Value (Rs/ha)
Maize grain (4 t/ha x price net of harvesting of Rs 1,300/t)	5,200
Fodder - green	2,000
- dry	2,500

Percent of gross value product from fodder	46

Clearly, fodder in this case is nearly as important as grain in gross benefits[1]. If the farmer is a tenant, he commonly receives all the green fodder but only half of the grain. Tenant farmers then probably often receive more income from fodder than grain, and have additional incentives to use management practices biased toward fodder production.

Having roughly qualified and valued fodder production, the next issue is, what are the trade-offs between grain and fodder production? These are likely to be different for green and dry fodder. In the case of green fodder, limited data are available on the reduction in grain yields due to plant removal by farmers' methods. Table 8 summarizes data from a trial at Yousafwala, which demonstrated that grain yield declined by 24 percent or 1.2 t/ha when thinning was done at the 12 leaf stage[2]. While this is a significant decline, the value of the green fodder produced in the example above for Swat is equivalent to about 1.5 t/ha of grain (Rs 2,000/1.3).

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[1]These estimates are slighly lower than those of Fischer and Javed (1986), which were calculated on the basis of a physiological model of maize grain and fodder production. Experiments have been planted in 1985 to measure more precisely the yield of green and dry fodder under farmers' management practices.

[2]Plant population density following thinning was not reported in the source (Chaudhry, 1983).

Table 8. Effect of date of thinning on grain yields, Yousafwala.

Leaf stage at thinnng	Grain yield (t/ha)	Percent barren plants
3	5.1	2.0
6	4.9	3.5
9	4.3	4.0
12	3.9	8.5

Source: Chaudhry (1983).

Trade-offs between grain and stover production are given in the analysis by Fischer and Javed (1986). They suggest that there may be some increases in stalk yield at the same time that grain yield decreases slightly above the optimum population density. There may also be trade-offs in quality if thick stover is not valued as highly as the thin stover produced in high population density fields. However, even if thick stover is not suitable for animals, it is used as fuel, and this trade-off may not be as important as commonly assumed.

The above examples suggest that farmers may be quite rational in producing both grain and fodder in the same field. It is useful to calculate a yield equivalent ratio (YER) to show the increase in grain yield that would be needed for separate grain and fodder plots to give the same grain and fodder production as in joint production in the same plot by farmers' methods (Table 9). Applying this ratio to Swat by assuming that 75,000 plants/ha are thinned, grain yield would have to increase to over 6 t/ha with no other change in technology except the separation of grain and fodder production. This is above average yields obtained from the recommended technology in onfarm research experiments in 1984.

Finally, it should also be noted that farmers are well aware of the alternative of a separate fodder plot. Most farmers in irrigated areas maintain a separate field of shaftal or berseem. In Upper Swat this accounts for one third or more of the rabi cropped area, indicating the importance of fodder production. However, these same farmers plant one field of maize in the kharif cycle to jointly produce grain and fodder.

In summary, the questions that need to be addressed in solving this important issue are:

(1). What are the types, quantities,and values of fodder produced from maize fields in each RD?

Table 9. Yield-equivalent ratios for maize thinnings of different intensities.

Number of plants thinned	Plants thinned as percent of pure maize fodder area[a]	Yield-equivalent ratio[b]
(A)	(B)	(C)
25,000	12.5	1.14
50,000	25.0	1.33
75,000	37.5	1.60
100,000	50.0	2.00

[a]Assumes a population density in maize fodder plot of 200,000 plants/ha. That is, B = (A/200,000) x 100.
[b]Calculated as C = 100/(100-B). That is, if 100,000 plants are normally thinned for fodder, then one half of the area would need to be given to fodder production for separate grain and fodder production. Grain yields would need to double (YER=2) to give the same grain and fodder yields as in joint production. Of course, at recommended levels of technology these trade-offs could be quite different.

(2). What are the technical and economic trade-offs in grain and fodder production over space (i.e. joint or separate production) and over time (different times of thinnings and also production of dry fodder)?

(3). How do these trade-offs interact with elements of the recommended package such as improved variety and fertility?

(4). What is the potential for providing fodder from other sources, including specialized fodder crops such as a maize/cowpea mixture, more effective use of crop residues, and improvement of natural pastures?

Recommendations for Each Technological Component In Relation to Farmer Circumstances

Variety

The breeding programmes of CCRI and, more recently NARC, have produced a number of improved varieties of different maturities which offer increased yields, greater responsiveness to improved management, and better disease resistance. These varieties seem to be appropriate to farmers of the area. However, it is widely recognized that the lack of a seed multiplication system has effectively kept adoption of these improved varieties at negligible levels. Any maize production programme must address this issue. Until a seed industry is established in NWFP, production programmes must depend on onfarm seed multiplication and dissemination.

Beyond this, there are a number of issues which are relevant to the setting of future priorities for development of improved varieties.

(1). Major emphasis in the Mardan, Swat, and Mansehra Districts has been placed on development and demonstration of full season varieties. While full season varieties seem appropriate given the agro-climatic situation of these areas, in practice full season varieties such as Sarhad White are usually later than the local variety, and farmers have strong preferences for earlier varieties. Many farmers plant late because of the cropping pattern (e.g. after onions in Swat or Virginia tobacco in Mardan) or lack of moisture. Hence greater emphasis needs to be placed on varieties of medium/early maturity.

(2). Little attention has been placed on breeding varieties for fodder production or for both grain and fodder production. The importance of maize as a green fodder in many areas indicates the need for attention to fodder producing characteristics. Farmers do not seem to like varieties, such as New Shaheen, which provide a low stover production.

(3). The increasing proportion of maize grain destined for industrial and livestock feeding warrants some attention to characteristics suited to these uses. We believe that there is a ready market for yellow maize in NWFP. Maize traders accept yellow maize at the same price as white maize and say they have no difficulty in disposing of it. In the Islamabad District, yellow maize sells for a small premium of about five percent above white maize.

(4). If we accept that farmers will continue to plant at high population densities in the future, then some screening of varieties for tolerance to high population density stresses may be warranted.

Seed Rate and Plant Population Density

Most farmers tend to use higher than recommended seed rates, with resulting high plant population densities. This creates a very complex issue, as shown above in Fig. 3. Initial plant population densities reflect the seed rate and the germination percentage. Farmers appear to increase seed rate to produce fodder, as shown by the significant correlation between seed rate and animals per ha of maize in Swat and Islamabad (Byerlee et al., forthcoming; Sheikh et al., 1986). Germination percentages are largely affected by the moisture available at planting. In barani areas, and particularly in Mansehra where maize is planted before the onset of the monsoon, the risk of poor germination can be quite high. Soon after germination plant stands may be further reduced by insect attacks. In broadcast fields the farmer will then seel to eliminate a substantial number of plants. The final population density is established after the farmer's selective process of removing weak and diseased plants.

This process of arriving at a final population density is even more complex when one considers the uncertainty (denoted by "R" in Fig. 3) in plant stand management (e.g. planting moisture, insect attacks, timely seeling). To some extent farmers can compensate for this uncertainty in the seeling operation (by widening the distance between cultivations or by not seeling at all) and in the intensity of manual thinning. Even so, there is likely to be substantial variation around an optimum population density for the farmer's desired grain and fodder production due to the above uncertainty in managing plant stands. However, the greater the value of fodder relative to grain, the more farmers will risk arriving at a population density higher than is optimum, since above the optimum the fodder value is preserved, while at low population densities farmers lose both fodder and grain values.

This uncertainty in managing plant stands to produce the optimum population density is demonstrated by the wide variation in final population densities reported by surveys in 1983 and 1984. These surveys show that the averge population density achieved by farmers at harvest time is probably not far from the optimum of 60,000-80,000 plants/ha for joint grain and fodder production (Fischer and Javed, 1986). However, a significant group of 20-30 percent of farmers had a final population density of over 100,000 plants/ha, which almost certainly reduced productivity of the system. To some extent these high population density fields could be traced to stand management practices (e.g. lack of seeling - see Byerlee et al., forthcoming), however, more information is needed on precisely what difficulties farmers faced in performing these management practices.

A further complicating factor in choosing an optimum population density is that seed rate and population density interact with almost all the other elements of the technological package. At high seed rates, we expect less response to insecticides, since loss of plants to insects can be compensated by reducing the intensity of later plant removal. Insect damaged plants are also removed as fodder. On the other hand, use of high seed rates increases the cost of using certified seed. This is particularly critical if hybrid varieties are promoted, since seed costs are higher than synthetic varieties, and the cost must be paid each year. Finally, if farmers really desire high population densities, then line planting loses much of its advantages relative to broadcasting.

In summary, the important issues to be understood in evaluating optimum seed rates and plant stand management over the cycle are as follows:

(1). The farmers' criteria for using high seed rates - i.e. to avoid poor stands and/or to produce fodder. Farmers can usually provide their reasons for this practice and most farmers are aware of the reduction in grain yields associated with higher population densities.

(2). The trade-offs between grain and fodder production and between green and dry fodder production for various methods of managing plant stands over the production cycle.

(3). The risks of obtaining low or high population densities brought about by climatic factors, pest incidence, and farmers' inabilities to perform cultural practices, such as seeling, on time.

(4). The interaction of population density with other components of the recommended package, especially variety and planting method.

Planting Method

Closely related to the issues of seed rate and plant stand management is the widespread use of broadcast planting. Only in Mardan is line planting by the "kera" or "choppa" (by hand with khurpa - small hoe) methods a common practice, but even here broadcasting has increased in recent years.

In general, farmers have consciously rejected line planting. Most farmers have a knowledge of line planting and many have tried it in the past. This knowledge is no doubt due to the large scale demonstration programme conducted with line planting in the 1970's. However, even farmers who were an integral part of these demonstrations were using broadcast planting when they were revisited in 1984.

The major problems of line planting expressed by farmers are as follows:

(1). Line planting requires considerably more labour and time. Approximate labour requirements for different planting methods are as follows:

	Man days/ha
Broadcasting and covering by tractor	0.5
Broadcasting and covering by animals	2.0
Line planting - kera method	5.0
Line planting - choppa method	10.0

The additional labour required increases the cost of line planting. This is particularly true for the "choppa" method, which is mainly used for planting under very wet conditions. In some cases, such as in Swat, the planting period for maize is the busiest time of the year for farmers, as maize planting conflicts with work in cash crops such as tomatoes and rice, and with wheat threshing. In barani areas, farmes are in a hurry to plant as soon as it rains.

(2). The "kera" method requires the use of a bullock. The fact that many farm families now do not own bullocks means that this method involves the costs and risks of obtaining a bullock on time. Bullocks also require training for line planting.

(3). Farmers use broadcasting to obtain a higher seed rate. Broadcasting also distributes the seed through the soil profile, and when seed is planted under marginal moisture conditions this may increase the probability that at least some of it will germinate (deeply planted seeds germinate on residual moisture while seeds near the surface may germinate with showers after planting).

(4). Broadcasting distributes the seed evenly throughout the field and farmers feel that they are utilizing scarce land area more fully. (Recall that many plants are removed early for fodder).

(5). Broadcasting is preferred in fields with little or no land preparation where it would be difficult to use the "kera" method. In higher elevation areas, particularly in Swat, farmers often do not do any land preparation before planting.

In most respects, farmers in Mardan are exceptions to these rules. Maize planting usually takes place several weeks after wheat harvesting, following the onset of the rains and at a time when there is little work to do in other crops. Moreover, bullocks in Mardan are trained in row crop operations, especially in sugarcane. Ironically, however, these same farmers in Mardan have consistently rejected line planting of wheat in favour of broadcasting, largely because the period around wheat planting is a busy time for farmers.

Against this background, we are convinced that farmers now broadcasting will not adopt line sowing behind animals (kera method) and that, in fact, line sowing will continue to decline in the future. Hence the major issues that need to be addressed in planting method are as follows:

(1). What are the benefits of line planting versus broadcasting at farmer levels of technology and at recommended levels of technology given joint grain and fodder production and for different growing conditions (e.g. marginal moisture versus fully irrigated)? Unfortunately no data are available which compare yields for each planting method. It is sometimes argued that line planting would facilitate inter-culture operations. However, since most farmers use the seel method, this may not be a major issue.

(2). If broadcasting is primarily employed to save time and labour (i.e. in Mardan and Islamabad), then the obvious solution is mechanization of planting - especially by tractor drawn planters. Suitable planters that can be manufactured locally or attached to conventional cultivators are needed to provide low cost mechanical planting. However, if broadcasting is used by farmers to guard against poor germination or to increase fodder production (e.g. in Swat), then priority should probably be placed on research on these issues rather than on line planting per se.

Weed Control

The nature of the weed problem varies substantially between different zones of NWFP. The weed problem is defined by the extent of the weed population and potential losses in maize yields, the effectiveness of weed control methods, and the importance of weeds as fodder.

In general, weed populations are higher in barani areas. In irrigated areas, smaller farm size, more intensive cropping patterns, crop rotations, and delaying of planting until after weeds are germinated by a pre-planting irrigation or early rains all help to reduce the weed problem.

In all zones except Mardan, seeling is the major weed control method, and is usually conducted once at about three to four weeks after planting. Farmers have three main objectives in seeling: (a) weed control, (b) population density control, and (c) earthing-up and soil aeration. In barani areas, weed control is the most important objective, while in irrigated areas (such as Swat), management of population density is the main objective of seeling. In barani areas, tractors are increasingly used for seeling by removing the front tynes of a cultivator. In Mardan, seeling is done by farmers with large holdings, but only in line planted fields and between the rows (i.e. few plants are removed).

In general, farmers attempt to control early weed growth through seeling, leaving some weeds which are then removed as fodder later in the cycle. In principle this system has many advantages. Seeling is inexpensive (about Rs 200/ha by bullock or Rs 120-150/ha by tractor), and when performed on time, controls weeds (and plant population density) quite effectively. Remaining weeds do little damage since the maize crop is already well established, and they are also often valued for fodder.

In practice, seeling is becoming less effective. In fields planted after the beginning of the monsoon (i.e. after July 1st), seeling must be performed during the peak of the monsoon rains. Farmers who increasingly depend on a borrowed bullock or a rented tractor for seeling have additional uncertainty in obtaining these services when they are needed. Hence, it is often difficult to seel on time during periods of wet weather, especially in areas of medium to heavy soils.

Manual weed control methods are also used. Hoeing is common in irrigated areas but requires about 20 man days of labour/ha. In Swat, hoeing has largely been replaced by seeling in the last 20 years. Hoeing is also difficult to perform in late planted fields in wet areas. In most areas farmers cut weeds from maize fields with a sickle after the first weeding has been done by hoeing or seeling. However, weed cutting is performed more to provide fodder for animals than to control weeds in the maize crop.

In looking to the future, four major issues in weed control need to be addressed:

(1). There is a need to clearly identify the zones and types of farmers where weeds are a problem, that is, where (a) weeds substantially reduce yields (e.g. Islamabad/Haripur), or (b) weed control incurs a high cost to farmers (e.g. farmers in Mardan who hire labour to hoe). Based on these criteria, some areas, such as those in Upper Swat, seem to have few weed problems.

(2). The role of weeds from maize fields as fodder at different times in the season must be understood. What are the alternative possibilities for producing fodder, such as interplanting cowpeas in maize? The answer to this question is likely to vary substantially from farmer to farmer even within a given zone.

(3). Given the decrease in bullock ownership, what are the possibilities of substituting tractor cultivation? Farmers with small holdings in irrigated mixed cropping areas often do not have tractor access to their maize fields after planting because tractors cannot pass through adjoining fields. Moreover, most farmers claim that tractor seeling is inferior to bullock seeling, probably because there is no opportunity to adjust the path of the tynes to suit the population density. Are there alternative tractor mounted implements that could do a better job? If acceptable methods are found for line planting, will this encourage wider use of tractors for seeling and more effective weed control? Finally, it should be recognized that tractor cultivation, especially by a hired tractor, is subject to the same delays by heavy rains as other mechanical/manual methods.

(4). Herbicides such as Primextra offer substantial potential for weed control, especially in the following situations:

(a) fields in barani areas planted at or after the beginning of the monsoon, when mechanical control is often delayed by heavy rains resulting in ineffective weed control,

(b) fields which are hoed, especially by hired labour where the cost of hoeing is higher than the cost of herbicide (i.e. farmers with large holdings in Mardan), and

(c) farmers who have fodder sources alternative to weeds from maize fields.

Under these conditions, there are a number of researchable issues that need to be addressed.

(1). When maize is planted in dry conditions, as in Mansehra, Primextra applied prior to emergence is often not effective. The risks of herbicide application might be reduced by post-emergence application after a shower of rain.

(2). Herbicide adoption will be accelerated if it can be applied in granular form.

(3). Where herbicide is to substitute for seeling in broadcast fields, lower seed rates will have to be used since seeling is also a means of reducing plant population densities[1]. This again may create risks of poor stands in fields planted in marginal moisture conditions, such as in Mansehra.

Fertilizer

We have shown earlier that fertilizer use in maize has increased substantially in barani areas in the last decade and is now used by most farmers in both irrigated and barani areas. The major immediate research and extension issues in fertilizer use in maize are the following:

(1). Few farmers, except in Swat, are using phosphorus. In some cases (e.g. the Islamabad District) farmers apply phosphorous to the wheat crop preceding maize. However, a significant number of farmers (e.g. in Mardan) do not use phosphorous in either wheat or maize, and there is evidence of substantial phosphorous deficiencies in this rotation (Hussain et al., 1985).

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[1] Without seeling to earth-up, lodging will probably also increase.

(2). In barani areas, there is likely to be a significant difference between "lepara" land (land close to the village) and "mehra" land (land farther from the village) in fertilizer response due to the use of farmyard manure on lepara land. Hence fertilizer recommendations need to be developed for specific cropping patterns and land types.

(3). Fertilizer response has been evaluated from the viewpoint of grain production. If farmers derive significant returns also from fodder production and continue to do so in the future, then should we also be evaluating fertilizer response in terms of fodder production? Response of fodder yield is likely to be different to grain yield response and lead to a different fertilizer recommendation.

Insecticide

Only Mardan farmers use insecticides on maize, and even there few farmers use it. Some farmers have knowledge of insecticides (probably due to their widespread demonstration) and some insecticides are available in larger towns. The major issues in research and extension on insecticides are:

(1). For farmers who broadcast maize at high seed rates, insect damage probably does not affect yields significantly. Plant population density is reduced and damaged plants are removed for fodder. Hence, insecticide use is probably only relevant if farmers adopt the full package of technology.

(2). Use of systematic insecticides such as Furadan with the seed at planting time has three major drawbacks:

(a) systemic insecticides are expensive (about Rs 400/ha),

(c) plants from Furadan treated fields could be highly toxic to animals when removed in early stages of growth for animal fodder, and

(d) systemic insecticide is applied as a preventative measure. Farmers are more likely to adopt post-emergent insecticide application which can be applied depending on the extent of insect damage, and hence costs and risks can be reduced.

The Recommended Package of Practices: Does it Pay?

Before leaving this discussion of farmers' versus recommended technology it is also useful to look at the economics of the total package of practices being recommended. Disregarding fodder production, which was discussed above, Tables 10 and 11 show approximate calculations of costs and returns in maize produced using the farmers' technology compared to recommended

Table 10. Calculation of returns to adoption of improved package of technology, Upper Swat Valley, 1984.

	Price /unit (Rs)	Farmer technology Quantity /ha	Rs /ha	Improved package of technology Quantity /ha	Rs /ha
Inputs:					
Seed					
Local	1.4/kg	100 kg	140	-	-
Imported	2.5/kg	-	-	40 kg	100
Fertilizer					
Urea	133/50 kg	80 kg N	416	115 kg N	526
DAP	136/50 kg	20 kg P_2O_5	118	57 P_2O_5	336
Herbicide	160/L	-	-	2.5/L	400
Insecticide	25/kg	-	-	20 kg	500
Machinery and labour:					
Ploughing	150/ha	1	150	2	300
Planting	25/md	1 md	25	5 md	125
Thinning	25/md	-	-	2 md	50
Interculture	150/ha	1 animal	150	-	-
Application of chemical	25/md	-	-	2 md	50
Total costs that vary	-	-	995		2,387
Gross benefits	1,330/t[a]	4 ton	5,200	6 ton	7,800
Net benfits	-	-	4,205	-	5,463
Marginal rate of return	-	-	-	-	90%

[a] Maize price net of harvesting, shelling and marketing costs.

Table 11. Calculation of returns to adoption of improved package of technology, Islamabad, 1984.

	Price /unit (Rs)	Farmer technology Quantity /ha	Rs /ha	Improved package of technology Quantity /ha	Rs /ha
Inputs:					
Seed					
Local	4/kg	60 kg	84	-	-
Imported	2.5/kg	-	-	30	75
Fertilizer					
Urea	133/50kg	57 kg N	329	107 kg N	493
DAP	136/50kg	-	-	57 kg P_2O_5	336
Herbicide	160/L	-	-	2.5/L	400
Insecticide	25/kg	-	-	20 kg	500
Machinery and labour:					
Ploughing	150/ha	3 times	450	3 times	450
Planting	30/md	1 md	30	5 md	150
Thinning	30/md	-	30	2 md	60
Interculture	75/ha	once	75	-	-
Application of chemical	30/md	-	-	2 md	60
Total costs that vary	-	-	998		2,524
Gross benefits	1,300/t[a]	1.2 ton	1,560	3 ton	3,900
Net benfits	-	-	4,205	-	5,463
Marginal rate of return	-	-	-	-	90%

[a] Maize price net of harvesting, shelling and marketing costs.

practices in Upper Swat, the highest yielding area, and Islamabad, the lowest yielding area. Yields for the recommended technology are based on results of onfarm experiments[1].

Tables 10 and 11 reveal a number of important points:

(1). Maize in Swat is a low input crop giving high net benefits per Rupee invested. By contrast, the profitability of maize in Islamabad is quite low, especially given the risks of maize production in this variable rainfall area.

(2). The recommended technology more than doubles the variable cost of maize production. This exposes farmers with small holdings to considerable risks.

(3). The rate of return on the capital investment needed to adopt the package is 42 percent for Islamabad and 90 percent for Swat.

These are not particularly high rates of return to induce adoption by farmers with small holdings and without access to credit, especially in Islamabad.

Nonetheless there are almost certainly some components of the package which provide high pay-offs when adopted individually or along with one or two other complementary components. These components are likely to be specific to each zone and should be the basis of priority research and extension efforts.

Maize Marketing: An Issue?

Any efforts to increase maize production must also consider marketing aspects, especially since uncertainty in marketing has long been regarded by as a major constraint by observers of the Pakistan maize scene.

Figure 4 shows average real maize prices (adjusted for inflation) in Peshawar in August (before harvest) and November (after harvest). There was clearly a great deal of year-to-year variability in maize prices during the 1970's. Moreover, during some years, such as 1979, the maize price fell sharply from August to November. However, from 1981 to 1984, maize prices have been remarkably stable, both between years and between the pre-harvest and post-harvest months.

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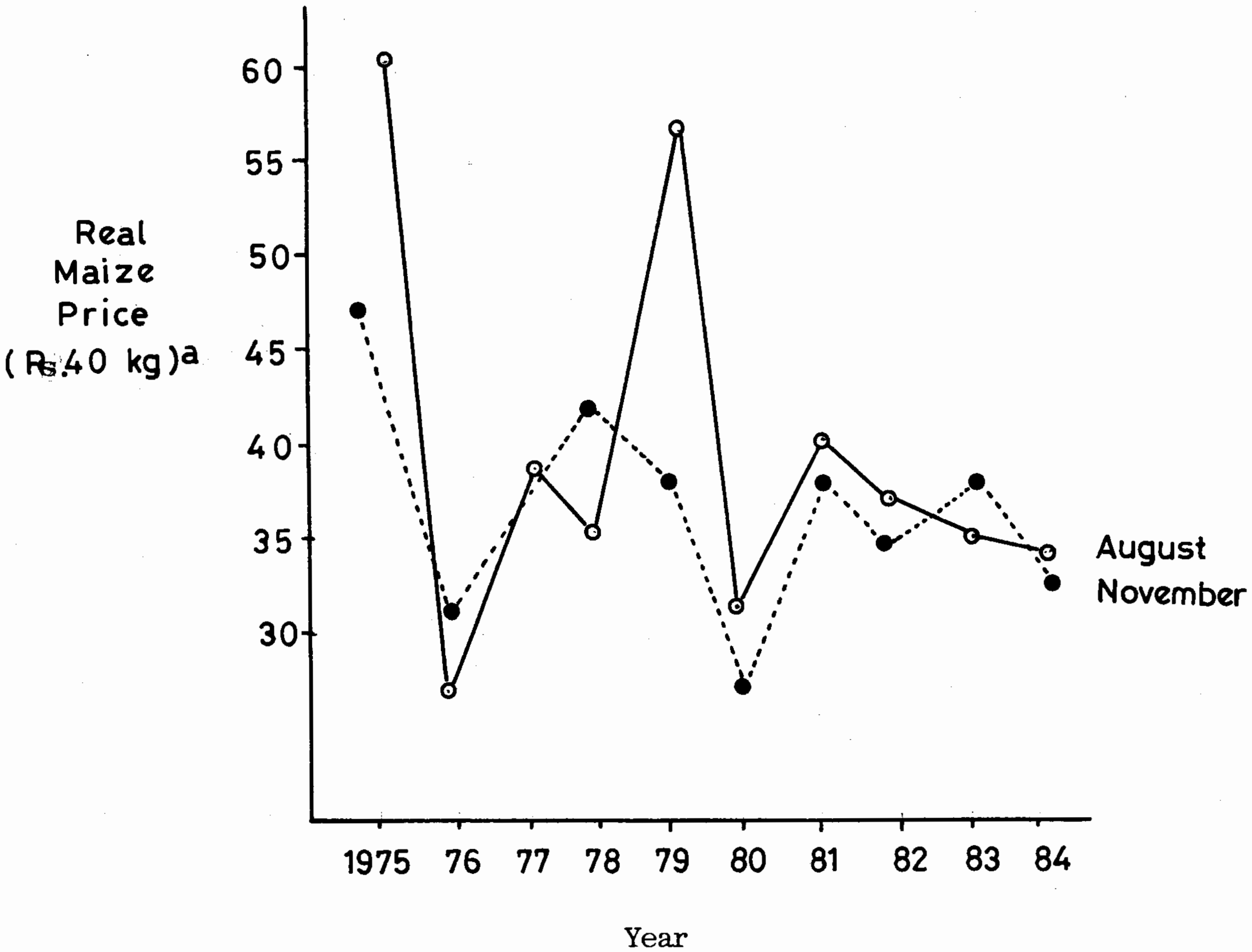
[1]Average yields in onfarm experiments in Upper Swat in 1984 were about 6.5 t/ha. This yield has been adjusted downward by 10 percent to reflect expected differences between farmers' and experimental yields using the same technology. A larger adjustment was made for Islamabad, where 1984 was an unusually good season.

Figure 4. Real wholesale prices of maize in Peshawar in August and November, 1975-84.



a Prices deflated by Consumer Price Index, 1975 Rupees

These observations are supported by interviews with farmers and maize traders in NWFP during 1984. Few farmers reported difficulties in recent years in selling maize at expected prices. Even if wet weather sets in after harvest, traders have been able to sell maize with a high moisture content directly to industrial users without loss.

We believe that this relative stability in maize prices will continue into the future, with maize prices being generally near or above wheat prices. We hypothesize that factors on both the supply and demand sides have stabilized maize prices. On the supply side, maize has traditionally been a subsistence food for farmers with small holdings. Farmers would sell off their surplus in a good crop year but would not sell it in a poor crop year. This meant that the marketed surplus was subject to a great deal of year to year variability depending on crop conditions. However, as farmers have switched from maize to wheat consumption, the marketed surplus of maize has increased, and year to year variability in supplies is less.

On the demand side, maize was traditionally exchanged as a food, and the demand for staple foods is not usually very sensitive to prices. Hence an increase in supplies required a large decrease in prices to clear the market. Now, the majority of marketed maize is destined to industrial uses and to poultry feed (Amir, 1986). Industrial demand has increased steadily, while the demand for maize in poultry feed essentially provides a cushion on prices. Because there are many substitutes for maize in poultry feed, maize replaces other feed ingredients when the its price falls and vice-versa.

Implications for Planning Research and Technology Transfer

Issues raised in this paper have a number of important implications for the planning of research and technology transfer activities in the future.

(1). Because NWFP has a number of distinct maize production environments, decision making for onfarm research and extension activities must be decentralized. This would allow researchers in charge of running programmes to be involved in the selection of experimental treatments, designs, data analysis, and formulation of recommendations that are appropriate to maize farmers' circumstances in specific regions.

(2). Within each maize producing region it is necessary to identify tentative recommendtion domains and then choose one or two priority domains as the focus of research and extension. Several factors have emerged in this paper as being potentially important in delineating RDs, including access to irrigation, cropping pattern, and farmers' dependence on maize fields for fodder.

(3). For each priority RD, there is a need to identify two to three priority technological components which we can be fairly sure that farmers will adopt and which will also make a significant impact on productivity. These priorities are sometimes based on their contribution to increasing yield. However, farmers will adopt those components with a high return on expenditures, low risks, and which do not conflict with other farm enterprises, such as livestock. Improved varieties may give only modest increases in yields, but because they are a low cost change, they will often be rapidly adopted by farmers. Integrated agronomic-economic surveys of farmers and their fields are needed in each recommendation domain in order to diagnose priorities and select research and extension priorities.

(4). Priority technological components should be verified under farmers' management practices. That is, if variety and chemical weed control are identifed as the priorities in an area where farmers broadcast their maize (e.g. Islamabad/ Haripur), then these two components should be tested under broadcast planting unless line planting is also identified as a priority[1]. Farmers do not adopt packages, so technological components should be introduced in a logical sequence. In this example, if line planting is identified as the second priority, then it should be tested with an improved variety and chemical weed control.

(5). When onfarm researchers are confident that they have identified the priority technological components, these components should be verified with a significant number of farmers, say 20, in one or two villages. Extension workers should be an integral part of these efforts. Farmers should be monitored in the following season to see if they have adopted the recommendations. Only then can we be confident of a useful recommendation that warrants extension on a large scale.

(6). Finally, since use of an improved variety emerges as a priority technological component in most zones, it is essential to solve the problem of multiplication and distribution of improved seed. Until NWFP establishes a viable seed industry, it will be necessary to incorporate these functions into the onfarm research and extension programme. The example of BARD at Haripur in establishing a farmers' seed cooperative should be closely monitored.

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[1] However, if chemical weed control is to be used in broadcast fields then a lower seed rate will also be needed to compensate for the lack of plant removal by seeling.

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