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Research Conducted on Wheat Production Constraints in Ethiopia

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Summary

Wheat, occupying about 700 000 ha, ranks fifth in total production and area and fourth in yield among the principal cereal crops of Ethiopia. Durum wheat, which is produced exclusively by peasant farmers, covers about 60% of the total wheat area; the remaining 40% is covered by bread wheat. Average national wheat yields are low, ranging from about 1.1 t/ha on peasant farms to about 2.0 t/ha on the state farms.

Wheat production practices vary across the major growing areas (central, southeastern, northwestern and northern highlands of the country). In most regions, wheat is sown only once per year during the main rainy season. However, in some areas, such as parts of Bale Region, wheat is sown twice, using both the belg and the meher rains, but in different fields. In most areas, a pair of oxen are used for land preparation while in Inewari horses are also used. The time of sowing wheat in the meher season ranges from mid June to August depending

on soil type, the level of rainfall and the varieties used. Generally, wheat is sown on flat land. However, farmers in Inewari sow wheat on hand-made broadbeds and furrows, and at Aleltu-Sendafa wheat is sown on ridges. Both practices are intended to alleviate waterlogging. Seed and fertilizer are broadcast and covered by maresha. The most common fertilizer used on wheat is diammonium phosphate (18% N and 46% P_2O_5). Weed control practices include hand weeding and the use of a postemergence herbicide, commonly 2,4-D. However, most farmers in Aleltu-Sendafa and in Bale Region do not weed wheat fields. The time of wheat harvesting in the meher season varies between November and February, depending on the sowing date and the varieties used. Harvesting is done manually using a sickle, and threshing is done by animal trampling.

The major wheat production constraints are categorized into two: technical and socio-economic. The technical constraints include low soil fertility, high incidence of weeds, pests and diseases, and lack of seed of improved varieties. Low soil fertility is aggravated by continuous cultivation since land is seldom fallowed. Yield losses due to weeds in bread wheat reach up to 36%. The weed problem is aggravated by overlapping of activities. The use of weed biomass as animal feed often results in delayed weeding. Herbicides not only effectively control weeds, but release labor for weeding other crops. A number of fungal diseases, principally the rusts, can cause considerable damage to durum as well as bread wheat. Some studies have estimated yield losses of 53 to 96% due to diseases. Wheat aphids and grasshoppers cause considerable damage; in some cases, total crop failure has been reported by farmers. Many of the local durum wheat varieties possess low yield potential, have low resistance to diseases and lodging, and respond poorly to fertilizer.

The socio-economic constraints consist of unavailability of improved inputs (seed, fertilizer and pesticides), seasonal labor and draft power shortages, land shortage, lack of credit and low produce prices. The shortage of land caused by population pressure and the competition among various enterprises has led to the fragmentation of plots. In the highlands, most of the crops are planted at the same time, causing a

shortage of labor during the peak period for weeding and harvesting. Draft power shortage in wheat growing areas has resulted in poor land preparation, leading to poor plant establishment, high weed infestation and low yields. Although wheat farmers are interested in using recommended inputs, these are often not available in sufficient quantities and on time to meet their demand. Input prices are high, while produce prices are low, reducing farm incomes, hindering farm investment and discouraging the use of inputs. There is no credit scheme for purchasing inputs other than fertilizer.

Introduction

The wheat growing environments of Ethiopia can be classified into two major types: highland cool wet areas (> 1500 m, rainfed) and low altitude warm dry areas (ca. 700 m.a.s.l., irrigated) (4, 27, 28). Rainfall in the highland areas is bimodal and annual totals vary from 600 to 2000 mm. Most of the wheat crop is produced during the main rainy season, June to September, although some areas produce wheat during the short rains from March to May (17).

Wheat ranks fifth in production and area and fourth in yield among the principal cereal crops in Ethiopia. *Wheat* occupies about 700 000 ha with durum wheat (tetraploid wheat) covering about 60% of this area and bread wheat (hexaploid wheat) covering the remaining 40%. In the warm dry areas, potential exists for double cropping of up to 175 000 ha of irrigated wheat with cotton. Durum wheat, which is indigenous to Ethiopia, is produced primarily by peasant farmers. The state farms produce about 80 000 ha of bread wheat. Average national mean yields are low ranging from about 1.1 t/ha for peasant farms to about 2.0 t/ha for state farms (17, 27, 29).

Current Production Practices

The central, southeastern and northwestern regions of the country are the predominant wheat growing areas. Wheat production practices vary

from region to region. In most areas, wheat is planted only once, during the main rainy season. However, in some areas such as Sinana, wheat is planted twice, during both the short and the main season, but in different fields.

Land preparation commences at the onset of rains during January to April. Prior to the rains, the soil is too hard to plow with the local plow. In most areas, a pair of oxen are used for land preparation, but in Inewari horses are also used. The number of plowings depends on the nature of the soil, the onset of rains and the condition of the draft animals.

Sowing dates range from mid June to August depending on the soil type, the level of rainfall and the varieties used. For example, in the Holetta red soil zone, wheat is planted in June. In Inewari and Aleltu-Sendafa, where the soils are Vertisols and waterlogging is a major problem, wheat is planted in August. In most of the wheat growing areas, wheat is planted on flat land. However, in Inewari, farmers plant wheat on hand-made broadbeds and furrows, and, at Aleltu-Sendafa, planting is done on ridges constructed by ox-plow. Both methods are used to alleviate the waterlogging problem. Seed and fertilizer are broadcast and covered by animal-drawn plows.

The most common fertilizer used on wheat is diammonium phosphate (DAP) (18-46 N-P_2O_5). The percentage of farmers using fertilizer depends on the fertility of the soil in a specific area and fertilizer availability. The rate of application ranges from 50 to 125 kg/ha, whereas the blanket recommended rate is 60-60 kg of N-P_2O_5/ha. However, the quantity of fertilizer supplied to farmers is generally less than the demand.

Both hand weeding and post-emergence herbicide are common weed control practices in wheat growing areas. However, most farmers in Aleltu-Sendafa and Sinana do not weed wheat. Farmers in other areas weed later than recommended because of an overlapping of activities (Holetta) and the need of weed biomass for livestock feed (Inewari). Many farmers around Holetta and Kulumsa use post-emergence herbicide (2,4-D) to control broadleaf weeds and partially remove grass weeds by hand.

The time of harvesting wheat extends from November and February, depending on the sowing date and the varieties used (early *vs.* late maturing). Harvesting is done manually using a sickle. Harvested wheat is piled until threshing. Threshing is done by using livestock to trample the grain on a small threshing ground, a hard surface plastered with fresh cow dung and sun-dried.

Research on production constraints is reviewed under two categories: technical and socio-economic.

Technical Constraints

Low Soil Fertility

Low soil fertility has been noted as a major problem in the production of wheat in Ethiopia. Fertility problems are aggravated by water erosion and the farmers' practice of continuous cultivation without fallowing (2, 5, 6, 19, 22).

On-farm wheat fertilizer trials have established the profitability of fertilizer. For instance, 25 on-farm fertilizer (N x P) trials were conducted in 1988 on bread wheat in five high priority agro-ecological zones for bread wheat production (3). The trial results demonstrated significant and profitable response to fertilizer in each zone. There were dramatic differences in fertilizer response and economic optimum levels across zones, suggesting that blanket recommendations on a national level are not appropriate and that zone specific recommendations would be more beneficial. Relative to the MOA's current 41 kg N and 46 kg P_2O_5/ha blanket fertilizer recommendation, grain yield increases at the optimum fertilizer level determined in each zone ranged from 195 to 1061 kg/ha, or, expressed as a percentage, from 7.2 to 35.3%. Net benefit to the farmer increased from 64 to 375 Birr/ha. Relative to the zero level of fertilizer practised by many farmers, the corresponding yield increase was from 787 to 1957 kg/ha (40.1 to 179.9%), representing an increase in net benefit to the farmer ranging from 248 to 622 Birr/ha.

Weeds

Weeds are a major problem in wheat producing areas. A general review of weed science research activities on wheat and barley in Ethiopia reported that weed competition reduced wheat yields by up to 36.4% (26). Weed damage is aggravated by an overlapping of activities at the time of weeding and the use of weeds as animal feed which delays weeding (1, 2, 6, 16).

The economics of herbicide application was studied at Holetta in comparison with the recommended practice of one or two hand weedings. Results from two years were consistent: the application of pre-emergence herbicide with one supplementary hand weeding gave the highest yield as well as the highest net benefit, resulting in a yield 35% higher than the recommended single, hand weeding. The use of herbicide not only increased yield, but it released labor for operations on other crops. This implies that if farmers use herbicides they could alleviate their labor bottleneck during the peak period, resulting in higher yields and returns relative to their current practice in the Holetta mixed farming zone. Currently, the major constraint to the use of herbicides is their limited availability (15).

The economics of hand weeding was analyzed at ARDU based on the results of 49 trials conducted over the period 1967-1981 (23). The average yield increment of 510 kg/ha over the unweeded check (2130 kg/ha) represented a 23.9% increase. Using a market price of 60 Birr/100 kg and a measured labor requirement for hand weeding of 33 work-days/ha, the researcher calculated a return to labor of 9.3 Birr/-work-day; this represents a return to the cost of hired labor of approximately 375%. Thus, hand weeding was considered to be profitable.

Research conducted on the sites managed by the Kulumsa Research Center over the period 1967 to 1985 indicated little or no benefit from post-emergence herbicide application relative to hand weeding (23), but survey data showed that both the weed density and species composition differed dramatically between research sites and neighboring farmers' fields (6).

A general review of the economic return to herbicide usage in Ethiopia suggested that on small grain cereals pre-emergence herbicides might be expected to be more beneficial as they would eliminate weed competition during the critical early weeks of crop development (24).

On-farm verification of four bread wheat varieties under high and farmers' weed management levels showed a 10% increment in yield due to the recommended hand weeding practice (10); however, the trial was conducted during the meher season when farmers consider weed competition to be low (2).

Diseases and Pests

Surveys conducted in the wheat growing areas of Ethiopia have shown diseases and pests to constrain wheat production (1, 2, 6, 16, 18).

A number of fungal diseases cause considerable damage to durum wheat. Among these, leaf, stem and stripe rust are the most important but stem rust is considered the major constraint (17, 28, 30). Other diseases that cause considerable damage in some areas include leaf and glume blotches, bunt, *Helminthosporium* spp., *Fusarium* spp. and, recently, bacterial stripe. The extent of damage due to these diseases depends on weather conditions (30).

In bread wheat, the major diseases are stripe, stem and leaf rust, depending on the altitude. Stripe rust seems to be on the increase and *Septoria tritici* can be of local importance (17, 28). Some of the studies conducted in Ethiopia have estimated that these diseases can cause severe yield losses. In one, losses were estimated to range between 53 to 96%, while another study estimated 82% (11, 25).

One of the insects commonly attacking wheat is the Russian wheat aphid (*Diuraphis noxia*) (17, 30). Aphids cause considerable damage; in some cases, total crop failure has been reported by some farmers (1, 2, 5). Grasshopper damage also occurs frequently in Ada-Lume-Akaki areas (32).

Varieties

Many of the local durum wheat varieties have low yield potential and tend to be weak-strawed; they also have low resistance to diseases and lodging (17, 29, 30). Although, some high yielding improved varieties of durum wheat have been released and distributed to farmers, the area under improved varieties is estimated at less than 10% (29, 30). In general, the use of high yielding wheat varieties in Ethiopia is limited. For instance, it has been estimated that the area planted to semidwarf varieties is about 10% of the total wheat area (8).

Surveys conducted in wheat producing areas show that farmers obtain low yields primarily due to the use of low yielding local varieties (2, 5). The benefits of growing improved varieties have been demonstrated by a study in the Sinana area (10). In this study, ET13 gave the highest net benefit of 1322 Birr/ha. It also had the highest incremental net benefit over the local variety (Wollandi).

Local wheat cultivars also respond poorly to fertilizer. Trials conducted around Ada in 1983 and 1984 showed that the response of local cultivars to fertilizer was about 40% less than that of improved varieties (9).

Vertisols in the Ethiopian highlands, over 1500 m, cover about 7.6 million ha, of which only 25% is cropped because of waterlogging during the main rainy season. There is no indigenous animal-drawn surface drainage implement. ILCA introduced the broadbed maker (BBM), and tested it on farmers' fields with the participation of different organizations (IAR, AUA and MOA). The BBM is a low cost device based on the local maresha and is used to construct 120 cm wide broadbeds and furrows (BBF).

In Inewari, where farmers traditionally make BBFs by hand, the BBM reduced human labor input in BBF construction. As a result, return to labor increased by 140% for wheat. At Debre Zeit, wheat grain yields and returns to labor were 25% and 40% higher, respectively, on BBFs than on flat. In Wereilu, wheat yielded 131% more grain on BBFs than on flat (13).

Some agronomic practices impose additional constraints on yield especially under peasant farmer management. The use of the traditional wooden ox-plows gives poor penetration of the soil and forms poor seedbeds resulting in thin plant stands (17, 28). The optimum sowing dates vary across areas and late sowing tends to reduce yields by as much as 34% (14). The effects of different sowing dates and fertilizer rates on agronomic characteristics of three Ethiopian varieties of bread wheat have been demonstrated. The two improved varieties, Dashen and ET13 possessed significantly higher yield potential than the local line, Israel. Additionally, the improved varieties were superior to the local in terms of stature, disease resistance and maturity. The optimum sowing dates in northwestern Ethiopia ranged between May 31 and June 15 for the two improved varieties. Sowing of the local line later than June 30 resulted in significant yield depression primarily due to increased levels of stem rust infection (31).

Low-altitude Warm Dry Areas

The potential exists for the double cropping of up to 175000 ha of irrigated wheat with cotton in the Awash river basin during the cool season (November-March) (20, 27, 28). The technical constraints limiting wheat production in these areas differ from those in the highland cool wet areas. The major constraints to the realization of potential wheat area is the ability to harvest the cotton crop in a timely fashion, and the supply of water from the Awash river. Other potentially serious limitations to the future of wheat production in the irrigated area include grass weeds and the high rate of salinization of crop land in the lowland cotton growing areas (27, 28).

Socio-economic Constraints

Unavailability of Improved Inputs

Various studies have shown that the use of improved seeds, fertilizers,

and herbicides can increase wheat production (3, 5, 7, 10, 15, 22, 23, 24, 31). Although peasant farmers have shown great interest in using such inputs, these inputs are not available in sufficient quantities to meet the demand and in a timely fashion when farmers need them (6, 17, 29, 30). Furthermore, prices of some inputs such as improved seed are considered to be too high for farmers. For example, improved wheat seed sells for 86 Birr/100 kg whereas the official price farmers received for wheat was only 35 Birr/100 kg in the past (17). Also, government policy gave priority to state farms and producer cooperatives in the allocation of these inputs (17). As a result, farmers used fewer inputs than recommended.

Seasonal Labor Shortage

In the highlands, most crops are planted at the same time. Surveys in these areas have shown that this results in a labor shortage during the peak season for weeding and harvesting (2, 6). The most important crop in many wheat growing areas, tef, is usually planted about one month later than wheat. Important labor overlaps between the two crops still occur: the weeding time for wheat coincides with land preparation and planting of tef. As a result, wheat is weeded late. The harvesting labor bottleneck is especially problematic because some varieties are prone to shattering; if harvesting is delayed, late rainfall may also damage the crop (17).

Draft Power Shortage

Surveys conducted in the wheat growing areas have identified draft power shortage as a constraint to wheat production (1, 2, 6, 16, 18, 32), resulting in poor land preparation. Poorly prepared land leads to poor plant establishment, high weed infestation and low yields (17, 28).

Land Shortage

Shortage of land limits wheat production as population pressure and

competition between various enterprises has led to the fragmentation of plots (1, 6, 16). It was also aggravated in the past by the expansion of producer cooperatives, which were allocated land from peasant farmers (17). Table 2.1 shows the crops that compete with wheat for farmers' resources including land in the major wheat growing areas.

Low Prices

Low fixed prices are also an important constraint. Research conducted at six locations over the period 1985-1987 showed that local market prices for wheat grain were on the average 2.7 times higher than the fixed, official prices (12). Low official prices had two important effects on production. First, they reduced farm income, reducing the farmers' abilities to invest in the farms. Second, they discouraged the use of improved inputs such as fertilizer and improved seed. For example, data from on-farm fertilizer trials on major crops show that at fixed official prices fertilizer was profitable at only 43% of the 28 sites where trials were conducted. Using local market prices, fertilizer became profitable at 79% of the sites (12). It is likely that raising wheat prices would encourage the use of improved inputs and enhance increased production. Recent policy pronouncements especially on liberalizing grain marketing is expected to change the situation just described.

Lack of Credit

Lack of credit is also an important constraint to increased wheat production (21). Credit for purchasing fertilizer is available but inadequate. The Agricultural and Industrial Development Bank (AIDB) extends credit for fertilizer to farmers through their service cooperatives. Nearly all fertilizer supplied to farmers is sold on credit in this manner. However, if less than 95% of a PA's fertilizer debt is repaid, credit is not extended to any farmer in the PA the following year. AIDB also makes loans to individual farmers, but the supply has been extremely small since most agricultural credit was allocated to state farms

Table 2.1. Importance of wheat in selected wheat growing areas of Ethiopia

Region	Area	Major crops* (in order of importance by area)	% of farmers growing wheat	Total area cultivated per farm (ha)	Wheat area per farm (ha)	% of wheat area
Shewa	Holetta	T,W,B,F	85	2.6	0.7	27
Shewa	Inewari	W,T,F,L	100	2.2	0.7	33
Shewa	Aleltu-Sendafa	W,T,C,L	100	3.4	0.8	24
Arsi	Kulumsa	B,W,P,F	93	2.2	0.9	39
Bale	Sinana	B,W,P	85	4.0	1.0	25

Source: (2, 6, 16, 18).

* W = wheat, F = faba bean, C = chickpea, B = barley, T = tef, P = pea, L = lentil

and producer cooperatives.

Low-altitude Warm Dry Areas

The socio-economic constraints likely to limit wheat production in these areas are the availability of sufficient labor for timely hand harvest of the cotton crop and the competition with other crops such as sorghum (27, 28). Research elsewhere shows that in the dry environments the main constraints to wheat production tend to be economic, especially the high cost of irrigation, inappropriate technology, and competition from alternative crops and livestock enterprises (4).

Conclusion

This chapter has reviewed wheat production practices and constraints in Ethiopia. These constraints were broadly grouped into two categories: technical and socio-economic. The two major wheat growing environments were covered: highland cool wet areas and low-altitude warm dry areas.

Although there has been a fair amount of research to quantify the impact of technical constraints on wheat production, research on socio-economic constraints has mainly been qualitative. There is, therefore, a need to shift the emphasis of socio-economic research to quantitatively determine the impact of socio-economic constraints on wheat production.

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3

Wheat Genetic Resources in Ethiopia

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Summary

Ethiopian agriculture has a long history manifested in the considerable number of crop species and their genetic diversity. Some of the early introductions, particularly wheat, barley and chick pea, acquired tremendous genetic variability. Among the cereals, wheat is known to have immense diversity, and Ethiopia was recognized by Vavilov as a secondary center of diversity for tetraploid wheats.

Plant genetic materials are a dwindling resource. The collection and conservation of these resources form the basis for their rational utilization. The Plant Genetic Resources Center/Ethiopia (PGRC/E) has, since its establishment, carried out a series of plant exploration expeditions to collect, conserve and evaluate these dwindling resources. To date, a total of 2726 accessions of *Triticum* spp. have been collected from various agro-ecological zones by PGRC/E. The gene bank currently possesses a total of 11069 accessions which include materials obtained through donations, repatriations, selections and previous collections.

The materials collected have been safely stored in suitable conditions for both short and long-term conservation and utilization. A significant portion of the collected wheat material has been evaluated for specific agro-morphological traits in appropriate agro-ecological zones.

This paper reviews the collection, conservation, characterization, and evaluation of the Ethiopian wheat material.