E C O N O M I C S

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Triticale Production and Utilization in Tunisia: Constraints and Prospects

Maurice E. Saade

CIMMYT

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Abstract: This study offers new, in-depth information about the production and utilization of triticale in Tunisia as a better basis for assessing alternative policy measures. Specifically, it analyzes recent trends in triticale production and utilization in Tunisia and identifies the related policy issues; examines how Tunisian farmers in different agroclimatic zones integrate triticale into their farming systems; determines the extent and modes of triticale utilization on the farm; identifies agronomic and socioeconomic constraints to the adoption and diffusion of triticale; examines alternative short- and long-term policy measures related to triticale production, utilization, marketing, and pricing; and recommends future directions for triticale research.

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Executive Summary

Triticale Production and Utilization in Tunisia: Constraints and Prospects

Problem Definition and Objectives

The Tunisian Ministry of Agriculture started promoting triticale production in the early 1980s to replace maize in poultry feed and thus reduce maize imports. Although triticale area increased rapidly to reach a peak of 16,500 ha in 1991, it started declining in 1992 to reach 13,200 ha in the 1993 crop season. On the demand side the opposite pattern occurred. Triticale utilization remained very limited until 1990, but a sudden and dramatic increase followed in 1991 and 1992. Thus, although limited demand and the rapid buildup of government triticale stocks constituted the main concern related to triticale before 1991, recent concerns focus on rapidly increasing demand and declining supplies, leading to the elimination of all stocks and the rationing of sales.

These trends in triticale production and utilization suggest a chronic imbalance between supply and demand, which is the major difficulty facing Tunisian decision makers as they attempt to deal with this new crop. Prior to any re-evaluation of the triticale policy, there is an urgent need to acquire a more detailed understanding of the current triticale situation, particularly at the farm level. Thus, the main objectives of this study were to analyze the factors underlying recent trends in triticale production and utilization, examine how farmers have integrated triticale into their farming systems, identify the agronomic and socioeconomic constraints to triticale adoption, and examine alternative policy measures.

Results

The study is based on a survey of 52 private triticale growers and four cooperative farms (UCPAs) in the northern districts of Mateur, Mejez-el-bab, and Goubellat. The survey data were complemented with information obtained through discussions with Tunisian officials and by a detailed analysis of secondary data. The main findings of the analysis of secondary data suggest that the recent reversals in triticale consumption trends can be largely explained by the changes in the official selling prices for barley. The triticale-to-barley price ratio dropped from 1.3 in 1989 to 0.8 in 1991. Although most triticale is currently used to feed ruminants, there are clear indications that recent increases in maize selling prices are leading to greater triticale use in poultry feeds. Thus, under prevailing feed selling prices, the demand for triticale is expected to continue increasing and may soon exceed 100,000 t per year. Meeting such a demand, however, will require increasing triticale area from the current 13,200 ha to at least 50,000 ha.

The results of the farm survey clearly show that triticale cultivation is highly adapted to farming conditions in Northern Tunisia. Triticale was easily adopted by cereal growers without any major adjustments in their farming systems, particularly in the case of large-scale farmers. Although adoption by smaller-scale farmers is gradually increasing, triticale remains a crop essentially grown on large private and cooperative farms (these farms

account for 95% of production). Survey farmers consistently praised triticale's high grain and straw yields, its resistance to disease and lodging, and its tolerance to drought. The survey results also showed that on-farm utilization of triticale is limited but rapidly increasing. An average of 15% of total grain output was used to feed sheep and cattle on the farm, and farmers were very satisfied with the results, especially when triticale was used to feed milking cows and ewes. These advantages have led farmers to grow triticale not only at the expense of barley area (38% of the area), but also bread wheat (26%), durum wheat (5%), and forage crop (13%) area.

Triticale demonstrated a clear yield advantage over barley (grain yields on average were 22% higher). Given triticale's higher producer price, its yield advantage makes the cultivation of triticale substantially more profitable than barley, with average gross revenues for triticale being 55% higher than barley. On the other hand, triticale's yield advantage over wheat was very modest (5-7% in normal years). Given wheat's higher producer prices, triticale's gross revenues in normal years were on average 21% lower than revenues for durum wheat and 13% lower than bread wheat revenues. During dry years, however, triticale's yield advantage over wheat was more apparent. In such years, triticale yielded 40% more than durum wheat and 10% more than bread wheat, and its gross revenues were 14% higher than those of durum or bread wheat.

According to survey farmers, the abrupt reduction in triticale area (about 39%) in 1991/92 was caused by rumors that the government intended to stop accepting triticale deliveries as a result of the 1991 record harvest and accumulation of triticale stocks. Though these rumors were not confirmed officially, they introduced a high degree of uncertainty that seems to have constituted the key constraint to triticale cultivation.

Implications for Policy and Future Research

Although the introduction of triticale in Tunisia may lead to higher import costs of barley and wheat, these costs will be compensated by reduced maize imports and savings in feed costs. The study results indicated that each ton of triticale produced and consumed in Tunisia contributes an average of 21-72 TD/yr to the Tunisian economy, including 8-47 US$/yr in net savings in foreign exchange. Although such contributions are substantial, they are not large enough to justify the current government subsidy of TD 61 per ton of triticale. Thus, there is a need to modify current triticale prices, not only to reduce subsidies but also to improve economic efficiency and fairness in pricing. Based on the results of this study, it is recommended that the selling price of triticale be increased from 150 to 164 TD/t, while the producer price should be reduced from 170 to 153 TD/t. Such recommended prices will reduce government subsidies on triticale from 61 to 30 TD/t.

However, for these recommended triticale prices to be efficient and fair, they need to be accompanied by similar adjustments in barley prices, given the close substitution between triticale and barley in both consumption and production. At present, barley seems to be excessively overpriced in Tunisia (when local prices are compared to international prices), both on the production and consumption sides. This implies that "too much" barley is currently produced at the expense of other crops such as wheat and triticale. To achieve a

more efficient allocation of resources and greater fairness in pricing, it is recommended that the selling price for barley be reduced from 168 to 131 TD/t and that the producer price be reduced from 150 to 110 TD/t.

The analysis described in this paper confirmed that barley pricing policy is the key determinant of triticale production and consumption trends. Most problems associated with the chronic imbalance between the supply and demand of triticale seem to have their roots in more serious imbalances in the barley subsector. Therefore, as long as barley consumer and producer prices are not modified, the imbalances in the barley subsector will continue to destabilize the triticale subsector and may undermine attempts to establish a coherent, independent triticale policy.

Future triticale research ought to focus on selecting new varieties more suitable for poultry feeding, which possess a higher crude protein content as well as metabolizable energy. Chemical analysis of promising triticale lines should become a regular feature in varietal screening activities at CIMMYT and in Tunisia to identify the varieties with the most desirable nutritional profile. Greater attention should also be given to selecting heat-tolerant varieties that would permit triticale cultivation to expand to Central Tunisia. Although triticale use in food is not a high policy priority in Tunisia, future research ought to examine that possibility, including a detailed evaluation of its technical and economic feasibility.

Résumé

La Production et l'Utilisation du Triticale en Tunisie: Contraintes et Perspectives

Problématique et Objectifs

Le Ministère de l'Agriculture en Tunisie a commencé àpromouvoir la production du triticale au début des années 1980 pour remplacer le maïs dans l'alimentation des volailles afin de réduire les importations du maïs. Bien que la superficie totale du triticale a augmenté rapidement pour atteindre un maximum de 16.500 ha en 1991, elle a commencé à baisser en 1992 pour atteindre 13.200 ha en 1993. Quant à la demande, elle a vu une évolution opposée à celle de l'offre, avec une utilisation très limitée jusqu'en 1990 suivie par une augmentation soudaine et très rapide depuis 1991. Donc, alors que la demande limitée et l'accroissement des stocks gouvernementaux constituaient le souci principal des responsables tunisiens avant 1991, les soucis actuels se concentrent sur l'augmentation de la demande alors que l'offre est en train de diminuer, ce qui a mené à l'élimination des stocks et le rationnement des ventes du triticale.

Cette évolution de la production et de l'utilisation du triticale montre l'existence d'un déséquilibre chronique entre l'offre et la demande. Ceci est une indication des quelques difficultés et dilemmes que les décideurs tunisiens continuent à faire face avec l'introduction d'une nouvelle culture telle que le triticale. Cependant, avant de ré-évaluer la politique actuelle du triticale, les responsables tunisiens auraient besoin d'une compréhension plus détaillée de la situation actuelle du triticale, surtout au niveau de l'exploitation. Donc, les principaux objectifs de cette étude consistaient àanalyser les facteurs qui ont contribué à l'évolution récente de la production et de l'utilisation du triticale; examiner comment les agriculteurs ont intégré le triticale dans leurs systèmes de production; identifier les contraintes agronomiques et socio-économiques à l'adoption du triticale; et examiner les mesures de politique agricole alternatives.

Résultats

L'étude est basée sur une enquête auprès de 52 producteurs privés de triticale et quatre coopératives agricoles (UCPAs) dans les délégations de Mateur, Mejez-el-bab et Goubellat. Les résultats de l'enquête ont été augmentés par des discussions avec des responsables et chercheurs tunisiens et par une analyse détaillée des statistiques nationales et d'autres données secondaires. L'analyse des données secondaires a montré que les changements récents dans l'évolution de la consommation du triticale sont essentiellement liés aux changements du prix de vente officiel (prix de rétrocession) de l'orge, avec le ratio du prix du triticale à celui de l'orge diminuant de 1,3 en 1989 à 0,8 en 1991. Bien que l'utilisation principale du triticale reste toujours dans l'alimentation des ruminants, l'augmentation récente du prix de vente du maïs semble avoir déjà un effet sur l'augmentation de l'utilisation du triticale dans l'alimentation des volailles. Vu les prix actuels des aliments du bétail, la demande pour le triticale devrait continuer à augmenter et pourrait bientôt surpasser les 100.000 tonnes par an. Cependant, ceci demanderait une augmentation de la superficie du triticale de son niveau actuel de 13.200 ha à au moins 50.000 ha.

Les résultats de l'enquête auprès des agriculteurs montrent clairement que la culture du triticale est hautement adaptée aux conditions agricoles du Nord de la Tunisie. Le triticale a été facilement adopté sans modifications majeures dans les systèmes de production, surtout en ce qui concerne les grands agriculteurs. Bien que l'adoption du triticale par les petits et moyens agriculteurs est en train de croître graduellement, le triticale demeure toujours une culture cultivée essentiellement sur les grandes exploitations privées et coopératives (95% de la production). Les agriculteurs enquêtés semblent très satisfaits de la productivité du triticale, de sa résistance aux maladies et à la verse et de sa tolérance à la sécheresse. Les résultats ont aussi montré que l'auto-consommation du triticale est toujours limitée mais en train d'augmenter rapidement. En moyenne, 15% de la production de grain est utilisée pour alimenter les ovins et les bovins de l'exploitation, et les éleveurs enquêtés semblent très satisfaits des résultats, surtout quand le triticale est utilisé dans l'alimentation des vaches et des brebis laitières. Ces avantages ont mené les agriculteurs àcultiver le triticale non seulement aux dépens des superficies de l'orge (38% de la superficie), mais aussi aux dépens du blé tendre (26%), du blé dur (5%) et des fourrages (13%).

Le triticale a démontré une productivité bien supérieure à celle de l'orge (rendement en grain 22% plus haut en moyenne). Puisque le prix à la production du triticale est supérieur à celui de l'orge, la culture du triticale est nettement plus profitable que celle de l'orge, avec un revenu brut moyen 55% plus haut que celui de l'orge. La supériorité du rendement du triticale à celui des blés est bien plus modeste (5-7% en années normales). Puisque les prix actuels des blés sont nettement plus hauts que celui du triticale, le revenu brut moyen du triticale est inférieur de 21% à celui du blé dur et de 13% à celui du blé tendre. Cependant, durant les années sèches, la productivité du triticale est nettement plus apparente avec un rendement en grain surpassant celui du blé dur de 40% et celui du blé tendre de 10%, avec un revenu brut supérieur de 14% à celui du blé dur et du blé tendre.

Selon les agriculteurs enquêtés, la baisse soudaine de la superficie du triticale (environs de 39%) en 1991/92 a été essentiellement causée par les rumeurs que le gouvernement avait l'intention de ne plus accepter les achats de triticale à cause de la récolte record de 1991 et l'accroissement des stocks de triticale. Bien que ces rumeurs n'ont pas été officiellement confirmées, elles ont introduit un grand degré d'incertitude qui semble constituer à présent la contrainte principale à la culture du triticale.

Implications pour la Politique Agricole et la Recherche Future

Bien que l'introduction du triticale en Tunisie mènerait à une augmentation des coûts d'importation de l'orge et du blé, ces coûts seront compensés par la diminution de l'importation du maïs et par la réduction des coûts des aliments du bétail. Les résultats de l'étude ont montré que chaque tonne de triticale produite et utilisée en Tunisie contribue en moyenne 21 à 72 DT/an à l'économie tunisienne, y compris 8 à 47 $US/an en épargnes en devises étrangères. Bien que ces contributions sont considérables, elles ne sont pas assez larges pour justifier les subventions gouvernementales actuelles de 61 DT par tonne de triticale. Donc, il existe un besoin de modifier la structure actuelle des prix du triticale non seulement afin de réduire les subventions mais aussi pour améliorer l'efficacité économique et l'équitabilité de la structure des prix. Basé sur les résultats de cette étude, il est à

recommander que le prix de vente du triticale soit augmenté de 150 à 164 DT/tonne, alors que le prix à la production devrait être réduit de 170 à 153 DT/tonne. De telles modifications des prix devraient réduire les subventions sur le triticale de 61 à 30 DT/tonne.

Cependant, pour que les prix du triticale soient efficaces et équitables, ils devraient être accompagnés par des modifications similaires dans la structure des prix de l'orge, vu la forte substitution entre la production ainsi que l'utilisation de l'orge et du triticale. Comparés aux prix internationaux, les prix actuels à la production ainsi qu'à la consommation de l'orge semblent très élevés. Ceci implique que la Tunisie produit actuellement "trop" d'orge aux dépens d'autres cultures telles que le blé et le triticale. Afin d'atteindre une allocation des ressources plus efficace et des prix plus équitables, il est à recommander que le prix de vente de l'orge soit réduit de 168 à 131 DT/tonne, alors que le prix à la production devrait être réduit de 150 à 110 DT/tonne.

L'analyse a confirmé que la politique des prix de l'orge joue un rôle primordial dans l'évolution de la production et de l'utilisation du triticale en Tunisie. La plupart des problèmes liés aux déséquilibres chroniques entre l'offre et la demande du triticale semblent avoir leurs racines dans les déséquilibres encore plus sérieux qui caractérisent la filière orge. Donc, tant que la structure des prix à la production et à la consommation de l'orge n'a pas été modifiée, les déséquilibres de la filière orge continueraient à déstabiliser la filière triticale et pourraient bien saper les tentatives d'établir une politique cohérente et indépendante pour le triticale.

Les efforts d'amélioration génétique du triticale devraient se concentrer à sélectionner des nouvelles variétés mieux adaptées à l'alimentation des volailles, avec des taux de protéine et d'énergie métabolisable plus élevés. Des analyses chimiques des lignées prometteuses de triticale devraient faire partie des activités régulières de la sélection variétale au CIMMYT et en Tunisie afin d'identifier les variétés ayant le profil nutritif le plus désirable. Il faudrait aussi mettre plus d'effort pour sélectionner des variétés tolérantes aux coups de chaleur, ce qui permetterait une expansion de la culture du triticale vers les zones du Centre. Bien que l'emploi du triticale dans l'alimentation humaine ne constitue pas à présent une priorité de la politique agricole tunisienne, il faudrait bien examiner cette option dans le future, y compris une évaluation détaillée de sa faisabilité technique et économique.

Triticale Production and Utilization in Tunisia: Constraints and Prospects

Maurice E. Saade

Introduction

Triticale — a cereal grain that is the product of a cross between wheat and rye — appears to be a particularly promising "new" crop for farmers because of its high yield potential, stress tolerance (especially drought tolerance), and disease resistance. The Tunisian Ministry of Agriculture began promoting triticale in the early 1980s, mainly to reduce Tunisia's imports of maize for poultry feed (see, for example, Ben Salem 1982). Two other potential uses of triticale made it attractive as well: it could substitute for barley in livestock feed and, in the long run, perhaps could substitute for wheat flour in bread making and contribute to reducing bread wheat imports.

As in other countries where triticale has been introduced, in Tunisia policy and marketing considerations will play a major role in the crop's ultimate success or failure. Tunisia is still in the process of developing a "triticale policy," which so far seems to be characterized by short-term reactions to changes in supply or demand rather than to be a consistent strategy designed to achieve long-term policy objectives. However, prior to any re-evaluation or modification of the policy, Tunisian decision makers urgently need more detailed information about current production and utilization of triticale. The information presently available is based largely on aggregate national statistics. Farm-level data are very sketchy, requiring validation and substantial augmentation.

On the production side, information is needed on how triticale has been integrated into Tunisian farming systems. Better knowledge of farmers' constraints would allow breeders, both in Tunisia and at research institutions such as the International Maize and Wheat Improvement Center (CIMMYT), to produce materials better adapted to local farmers' requirements. Similarly, a better understanding of agronomic and socioeconomic factors related to farmers' adoption of triticale should help in developing more effective extension programs (Tripp and Winkelmann 1985).

On the utilization side, sufficient information is available on the potential role of triticale in poultry feeding. However, very little is known about triticale utilization in livestock feed in Tunisia, especially at the farm level. Do farmers sell the entire crop to the State? Is it consumed partly or totally by animals on the farm? If so, in what form is it consumed (grain, straw, etc.), and how does it compare with other feed sources?

Given that Tunisia is one of the few countries (and the only country in North Africa) where triticale production has reached a commercial scale, the Tunisian experience can offer valuable information for developing new strategies to extend triticale production to other countries. In addition, given the many possible end-uses of triticale — bread-making, feed

grain for poultry and livestock, forage, and silage, to name a few — CIMMYT breeders are interested in developing triticale materials specific to each mode of utilization (Pfeiffer 1992). By identifying the main uses of triticale in Tunisia, CIMMYT and Tunisian breeders can develop materials that respond to the needs of triticale producers as well as users.

In light of these circumstances, the main goal of this study is to provide Tunisian decision makers, researchers, and extension officers, as well as scientists outside of Tunisia, with in-depth information about the production and utilization of triticale in Tunisia. Such information will constitute a better basis for assessing alternative policy measures. The specific objectives of the study are to:

- analyze factors underlying recent trends in triticale production and utilization in Tunisia and identify the related policy issues;
- examine how Tunisian farmers in different agroclimatic zones integrate triticale into their farming systems;
- determine the extent and modes of triticale utilization on the farm;
- identify agronomic and socioeconomic constraints to the adoption and diffusion of triticale;
- examine alternative short- and long-term policy measures related to triticale production, utilization, marketing, and pricing; and
- recommend future directions for triticale research in Tunisia and at CIMMYT.

This study is organized as follows. Triticale research — especially research on the feed uses of triticale — is discussed briefly. Next, national statistics and other secondary data on triticale production and utilization are reviewed and analyzed, along with information provided by Tunisian officials and researchers during formal and informal discussions. The next part of the paper summarizes results of a formal survey of triticale farmers in Northern Tunisia, along with results of informal discussions with farmers and local officials. The concluding section of the paper synthesizes the findings of the study and highlights implications for policy and future research.

Triticale Research and Development[1]

Although the first cross between wheat and rye was reported in 1875, research to develop triticale (x *Triticosecale* Wittmack) as a commercial crop did not begin until the 1950s. The first commercial triticale varieties had serious problems of floral sterility, shriveled seed, lodging, late maturity and sensitivity to daylength. Soon after triticale research was initiated at CIMMYT, a breakthrough in triticale research occurred with the spontaneous appearance of the "Armadillo" strain in CIMMYT plots in 1967. Armadillo possessed excellent agronomic traits, which CIMMYT breeders used to overcome most of the problems associated with the first triticale varieties.

[1] This section draws heavily from Varughese, Barker, and Saari (1987).

CIMMYT established the International Triticale Yield Nursery (ITYN) in 1969; eventually the ITYN was grown in as many as 71 countries each year. Intensive efforts to improve triticale paid off. By 1984/85, some triticales yielded as well as wheat in all ITYN locations and were clearly superior under certain stress conditions. In addition to their wide adaptability, high yield potential, and stable yields, these new triticales showed good resistance to common cereal diseases such as rusts, bunts, smuts and Septoria diseases. Moreover, triticale exhibited good yield potential in difficult production environments, particularly where soils are acidic (e.g., Brazil) or where drought stress is a problem (e.g., North Africa).

Triticale possesses nutritional qualities very similar to those of wheat, though it has a higher lysine content and better mineral balance and protein digestibility. These characteristics make triticale suitable for both human and animal consumption. Although 90% of world production of triticale is currently destined for animal feed, much of the work at CIMMYT has focused on triticale's potential as a food crop (Skovmand, Fox, and Villareal 1984; Varughese, Barker, and Saari 1987). The development of triticale varieties with flour-milling characteristics similar to those of bread wheat remains a major challenge, but triticale is highly suited to producing unleavened products such as cookies, cakes, waffles, noodles, flour tortillas, and spaghetti, and can be used to produce leavened bread as long as the proportion of triticale flour blended with bread wheat flour is less than 30%.

Triticale's good protein digestibility and its high content of essential amino acids make it a suitable substitute for most cereal grains used in ruminant and nonruminant feed diets. Some livestock feeding trials using some of the first triticale cultivars reported that triticale contained some antinutritional factors such as trypsin and chymotrypsin inhibitors that may depress feed intake (Belaid 1994). Although such findings imply that caution should be taken when triticale is incorporated in feed rations, numerous other studies using more recently developed cultivars have demonstrated triticale's potential role as a substitute for wheat, maize, sorghum, barley, and rye in livestock feed without any significant detrimental effect on feed intake, digestibility, or performance (Belaid 1994). Triticale also exhibits special qualities as a forage crop. It has a higher protein content than oats and produces higher forage and silage yields than oats, barley, wheat, or rye (CIMMYT 1986).

Owing to its high content of essential amino acids (such as lysine) and minerals (such as phosphorus), triticale is particularly attractive in poultry and swine feeding. In a review of a large body of poultry feeding studies, Belaid (1994) concluded that, despite some contradictory findings reported in the literature, there is sufficient evidence to suggest that triticale, especially the more recent cultivars, can be used safely in cereal-based diets for broiler and layer chickens. Belaid cautioned, however, that the use of tabulated nutrient values such as those provided by the US National Research Council (NRC) may lead to inaccurate results because of variation in the nutrient content of triticale (caused by variation among varieties or environmental factors).

Triticale's multiple end-uses, its adaptability to difficult environments, and its good nutritional quality combine to make it an attractive option for farmers worldwide. Triticale

is a commercial crop in more than 30 countries, where nearly 2.5 million hectares were planted to triticale in 1991/92 (Table 1). Most of these countries are higher or middle-income nations; among them, Poland, France, and the former USSR account for a considerable share of triticale area. About 10 lower income countries currently grow triticale on a commercial scale, and they account for less than half of the world's triticale area.

Table 1. Estimated triticale area in countries growing 1,000 hectares or more

Country	Area (ha) sown to triticale in: 1986	1991/92
Algeria	0	10,000
Argentina	10,000	16,000
Australia	160,000	100,000
Austria	1,000	2,000
Belgium	5,000	10,000
Brazil	5,000	90,000
Bulgaria	10,000	100,000
Canada	6,500	2,000
Chile	5,000	10,000
China	25,000	1,500
Czechoslovakia	na	25,000
France	300,000	162,000
Germany	30,000	207,000
Hungary	5,000	5,000
India	0	500
Italy	15,000	30,000
Kenya	na	8,000
Luxembourg	400	2,000
Mexico	8,000	3,000
Morocco	0	10,000
Netherlands	1,000	4,000
New Zealand	na	2,000
Poland	100,000	659,300
Portugal	7,000	90,000
Romania	na	20,000
South Africa	15,000	95,000
Spain	30,000	80,000
Sweden	na	1,000
Switzerland	5,000	11,000
Tanzania	400	na
Tunisia	5,000	15,900
UK	16,000	16,000
USA	60,000	180,000
Former USSR	250,000	500,000
Total	**1,075,800**	**2,467,700**

Source: CIMMYT Wheat Program and Belaid (1994).

Triticale in Tunisia

Background

Tunisia is characterized by a Mediterranean climate with cool and wet winters (rainfall is concentrated between September and May) and hot and dry summers. Tunisia is commonly divided into three main agroclimatic regions, as shown in Map 1 (Ministry of Agriculture, Republic of Tunisia, and ICARDA, 1986):

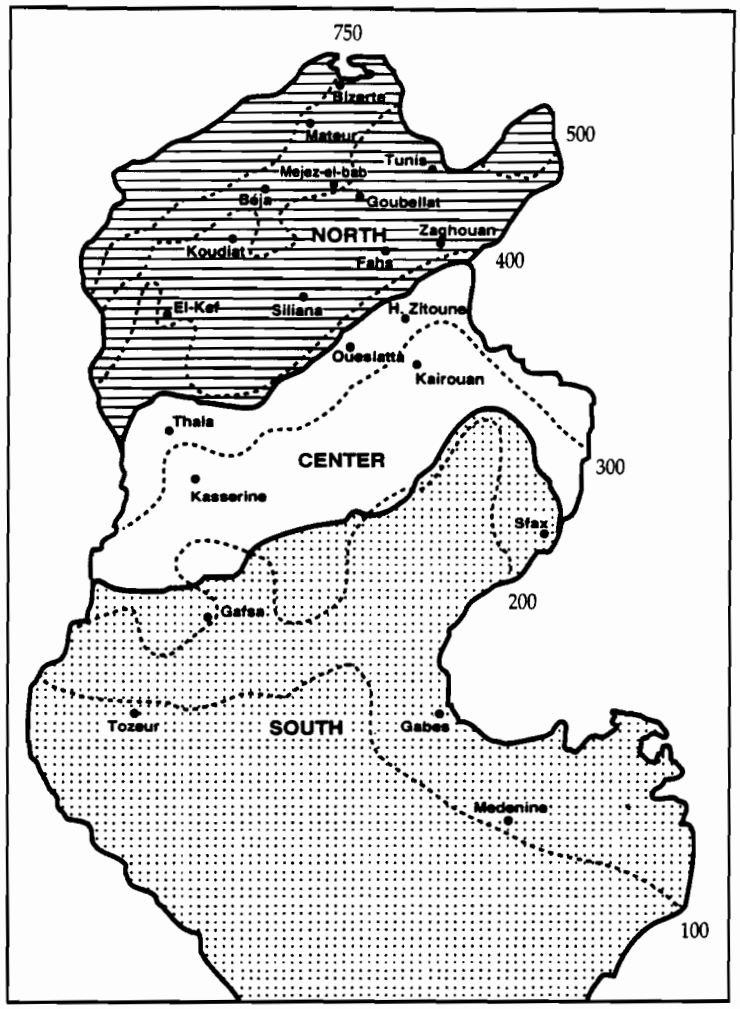
- **Northern Tunisia** (relatively regular rainfall averaging 350-600 mm/yr). Although rainfed cereals are the dominant crops in this region, forages, grain legumes, vegetables, fruit trees, and irrigated industrial crops are also widely grown. Livestock production is often integrated in the diverse farming systems of the region.

- **Central Tunisia** (annual rainfall between 200 and 350 mm). Because of low and irregular rainfall levels, production of barley and livestock (primarily sheep and goats) constitutes the main farming system, although durum wheat is grown in the wetter fringe and olive orchards are predominant along the coast.

- **Southern Tunisia** (less than 200 mm average annual rainfall). Rainfed agriculture is limited to the coastal areas where some barley and olive trees are grown. The rest of Southern Tunisia is essentially desert, with the exception of irrigated palm groves and vegetable gardens in the oases.

Total arable land in Tunisia covers about 4.7 million hectares, with cereals (mainly rainfed durum wheat, bread wheat, and barley) accounting for an average of one-third of total planted area. Northern Tunisia accounts for slightly more than half of the cereal area, and because of higher rainfall it accounts for almost 80% of cereal production (Ministry of Agriculture, Republic of Tunisia, and ICARDA 1986). An average of 61% of durum wheat, 77% of bread wheat, and 37% of barley area is found in the North (Table 2). Cereal production in Tunisia is characterized by highly variable yields resulting from severe fluctuations in rainfall. For instance, recent years include three of the worst crop seasons on record (1986, 1988, and 1989) and three of the best (1985, 1987, and 1991). Cereal crop yields average 1.1 t/ha in Northern Tunisia and 0.4 t/ha in Central and Southern Tunisia.

Between 1964 and 1984, total cereal production increased from 0.7 to 1.2 million tons, an average annual growth rate of 2.7%, which is higher than the rate of population growth (République Tunisienne 1987). However, demand for cereals has increased at a much faster rate than production, leading to a gradual increase in imports, which rose from 0.35 million tons in 1970 to more than 0.9 million tons in 1986. Wheat imports have risen the most. Tunisia, an occasional exporter of durum wheat in the 1970s, now imports



Map 1. Bioclimatic zones, Tunisia.
Source: Ministry of Agriculture, Republic of Tunisia, and ICARDA (1986).

Table 2. Cereal crop area and production in Tunisia by region (average, 1981-90)

Cereal	North	Center and South	Total Tunisia
Durum wheat			
Area (000 ha)	482	309	791
Production (000 t)	534	122	656
Barley			
Area (000 ha)	224	374	598
Production (000 t)	200	131	331
Bread wheat			
Area (000 ha)	100	30	130
Production (000 t)	145	17	162
Total cereals			
Area (000 ha)	806	713	1,519
Production (000 t)	879	270	1,149

Source: Ministère de l'Agriculture, République Tunisienne (1992).

0.7 million tons of wheat per year on average (60% bread wheat and 40% durum wheat), which represent 42% of total wheat consumption (République Tunisienne 1987).

Although Tunisia continues to be relatively self-sufficient in barley, which is predominantly used as animal feed, imports of other feed ingredients increased sharply during the 1970s and 1980s as the poultry industry grew substantially. Maize imports rose from 22,000 t in 1972 to 285,000 t in 1992, while imports of soybean meal jumped from 7,000 to 135,000 t over the same period (Kristjanson et al. 1990 and Office des Céréales, unpublished data). Faced with these alarming increases in imports and their potential drain on foreign exchange reserves, in the late 1970s the Ministry of Agriculture initiated a research program to evaluate alternative sources of poultry feed that could be grown in Tunisia, including triticale (Ben Salem 1991).

Triticale Research in Tunisia

Poultry feeding studies show that poultry diets containing up to 30% triticale have no negative effect on performance (Belaid 1991; see also Khorchani 1981, Bergaoui 1982, and Ghouhis 1984). The incorporation of triticale in poultry diets has been found to improve the consumption index, resulting in significant savings in feed costs and in increased weight gain (Belaid 1991).

Along with the studies of triticale's nutritional value in poultry feeding in Tunisia, other research was conducted on triticale's potential role in food for human consumption, particularly in bread making (Ben Salem 1982; see also Benbelkacem, 1989, for similar research in Algeria). Results of this research suggest that triticale has much poorer milling and baking properties than wheat because of its low test weight, low gluten content, and high levels of alpha-amylase activity. However, bread was produced by blending triticale flour with wheat flour at an optimum rate of 20%, although the bread had a slightly different taste and relatively more compact texture than the bread commonly consumed in North Africa (Ben Salem 1991).

Tunisian researchers at the Institut National de la Rechèrche Agronomique de Tunisie (INRAT) started testing CIMMYT triticale cultivars in the early 1970s. Yield trials on experiment stations in the favorable zones of Northern Tunisia showed that, in good years, triticale grown as a primary cereal (i.e., following a legume crop or fallow) yields as well as the best durum and bread wheat varieties (Maamouri et al. 1988). These results are confirmed by the results of on-farm trials conducted by the Office des Céréales, which show that in good years, such as 1990/91 and 1991/92, triticale yields are virtually identical to yields of the durum and bread wheat varieties most commonly grown in Tunisia (Table 3). Triticale's yield advantage becomes apparent in drier years, such as 1989/90, when triticale yielded 8-20% better than wheat and 38% better than barley (Tables 3 and 4).

Rotation trials conducted by INRAT have shown that when triticale is grown as a secondary cereal (i.e., following durum or bread wheat), in the favorable zones triticale yielded consistently higher than wheat and barley (INRAT 1989). Triticale was also found to be more resistant than barley to lodging and most diseases, and more resistant to some wheat diseases such as Septoria, powdery mildew, and the rusts, though it was as susceptible as

wheat to attacks by fusarium in some years (Maamouri et al. 1988). In the northern district of Sedjnane, where periodic waterlogging and acidic soils constitute serious constraints to cereal crop production, triticale was found to be much more adapted than wheat or barley. Triticale yielded more than 60% better than the best durum wheat variety and more than 50% better than the best bread wheat variety in trials conducted in Sedjnane during the 1989/90 season (Ben Salem 1991).

Although Central Tunisia was officially designated as the target area for triticale cultivation (République Tunisienne 1987), triticale yield trials in this region are more recent and research activities more modest than in the North. For instance, in on-farm trials in Kairouan, triticale yielded 2.04 t/ha in 1992, only slightly better than the barley varieties

Table 3. Wheat and triticale yields from on-farm trials (1990, 1991, and 1992 crop seasons)

	1989/90		1990/91		1991/92		Average, three years	
Cereal	Yield (t/ha)	Percentage of triticale yield	Yield (t/ha)	Percentage of triticale yield	Yield (t/ha)	Percentage of triticale yield	Yield (t/ha)	Percentage of triticale yield
Durum wheat varieties								
Karim	2.02	80	4.84	101	4.92	106	3.93	98
Razzak	2.20	87	4.72	99	4.52	97	3.81	95
Bread wheat varieties								
Salambo	2.20	81	4.45	93	4.86	105	3.79	95
Byrsa	2.33	92	4.81	100	4.62	99	3.92	98
Triticale	2.54	100	4.79	100	4.65	100	3.99	100

Source: Office de Céréales (*Rapport annuel*, 1990, 1991, 1992).
Note: Data for 1989/90 and 1990/91 represent an average of yields over five sites; data for 1991/92 are averaged over six sites.

Table 4. Barley and triticale yields from on-farm trials (1990, 1991, and 1992 crop seasons)

	1989/90		1990/91		1991/92		Average, three years	
Cereal	Yield (t/ha)	Percentage of triticale yield	Yield (t/ha)	Percentage of triticale yield	Yield (t/ha)	Percentage of triticale yield	Yield (t/ha)	Percentage of triticale yield
Barley varieties								
Martin	1.43	62	3.14	78	3.20	91	2.59	79
Rihane	1.43	62	4.27	105	3.37	96	3.02	92
Triticale	2.31	100	4.05	100	3.52	100	3.29	100

Source: Office des Céréales (*Rapport annuel*, 1990, 1991, 1992).
Note: Data for 1989/90 and 1991/92 represent an average of yields over five sites; data for 1990/91 are averaged over four sites.

Martin (1.92 t/ha) and Rihane (1.76 t/ha) (Office des Céréales 1992, p. 21). In general, results of the few trials in this region suggest that triticale may be as adapted as barley to the dry conditions of Central Tunisia, though triticale may have the potential for higher yields. The main constraint, however, is triticale's poor tolerance of hot temperatures during plant development (see, for example, Hadjichristodoulou 1984). The prevalence of hot spring winds (Sirocco) in Central Tunisia exacerbates the problem of shriveled triticale grain, which severely undermines its marketability (Belaid 1991). Thus before promoting triticale in Central Tunisia, Tunisian officials seem to prefer to wait until more heat-tolerant varieties become available, especially since barley diseases and lodging are not serious problems in that region.

Based on these findings, researchers recommended that farmers grow triticale as a secondary cereal, substituting for barley, in the favorable zones of Northern Tunisia and on waterlogged and acidic soils in the Sedjnane area (Maamouri et al. 1988). The same cultural practices used for wheat production are recommended for triticale, with the exception of seed rate (a 20% higher rate is recommended to compensate for triticale's limited tillering) and nitrogen fertilizer application rates (also higher than for wheat). Farmers are also recommended to be more careful with storing triticale grain, given that it is more susceptible than wheat and barley to attacks by storage insects.

Currently, two triticale varieties, TCL 8 and TCL 13, are the main varieties grown in Tunisia. These varieties, released in 1985, are sister lines[2] (Juanillo 86 and 97, respectively) introduced from CIMMYT in 1981 and selected by INRAT. Their morphological and physiological characteristics are almost identical, and they are recommended for the same cultural and climatic conditions (Maamouri et al. 1988). Two new varieties selected by INRAT, TCL 82 and TCL 83,[3] were officially registered in late 1992 and are expected to be released to farmers in 1993/94.

Trends in Triticale Production

Triticale cultivation, like other innovations, was first introduced on state-owned cooperative farms (Unités Coopératives de Production Agricole, or UCPAs) by the Ministry of Agriculture in the early 1980s. Given the UCPAs' heavy emphasis on animal production, triticale was integrated easily by the cooperatives as an ingredient for sheep and cattle feed. The impressive triticale yields obtained at the UCPAs soon attracted the attention of neighboring private farmers, who obtained seed from the UCPAs and started experimenting with the new crop. The establishment of a guaranteed official producer price in 1983 further encouraged farmers to cultivate triticale; total area sown to the crop reached 4,300 ha in 1984. Since then, total area sown to triticale has increased rapidly, reaching 16,500 ha in 1991 for a total production of 44,200 t (Table 5).

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[2] Their pedigree is DRIRA//KISS/ARM"S"-X-21295 (Abdalla et al. 1986).

[3] Their pedigrees are as follows (A. Maamouri, personal communication):
TCL 82: COORONG//AV/DOVE"S"-CIT 1312-3Y-4Y-503Y-OB;
TCL 83: MUS"S"/BTA"S"-X65.985-5M-3Y-2M-1Y-4M-1Y-1M-OY.

Triticale's good resistance to diseases and lodging and its superior productivity played a key role in its rapid adoption by farmers in the North. The average triticale yield largely exceeds that of barley, durum wheat, and, to a lesser extent, bread wheat (Table 6). On average, triticale yields twice as much as barley and outyields durum wheat by more than 55% and bread wheat by more than 25%. In the dry years of 1986, 1988, and 1989, the average yield of triticale was almost four times that of barley and about twice that of wheat.

However, these yield comparisons may be biased, since data on yields of triticale, wheat, and barley based on national average yield figures are not necessarily comparable, given the high concentration of triticale and, to a lesser extent, bread wheat production on larger farms. In contrast, average national yield figures for barley and durum wheat are heavily weighted by the substantially lower yields obtained on smaller farms. Therefore, such yield comparisons could seriously overestimate the magnitude of triticale's yield advantage over wheat and barley, leading to potentially overly optimistic expectations about the future diffusion of triticale in Tunisia.

Table 5. Triticale production in Tunisia, 1984-93

Year	Area (ha)	Production (t)
1983-84	4,300	8,700
1984-85	4,800	12,500
1985-86	7,000	13,000
1986-87	14,000	32,500
1987-88	11,600	7,000
1988-89	14,400	15,500
1989-90	15,600	33,700
1990-91	16,500	44,200
1991-92	15,900	41,100
1992-93	13,200 [a]	..

Source: Ministère de l'Agriculture, République Tunisienne (1992).

[a] Provisional estimate by the Office des Céréales (unpublished data).

Table 6. Wheat, barley, and triticale yields (t/ha), Northern Tunisia, 1984-92

Year	Durum wheat	Bread wheat	Barley	Triticale
1983-84	1.04	1.40	0.90	2.00
1984-85	1.60	2.25	1.26	2.60
1985-86	0.75	0.89	0.39	1.90
1986-87	1.80	2.35	1.53	2.30
1987-88	0.33	0.55	0.14	0.60
1988-89	0.55	0.59	0.39	1.10
1989-90	1.27	1.43	0.94	2.20
1990-91	2.04	2.44	1.77	2.69
1991-92	2.11	2.18	1.58	2.59
Average (1984-92)	1.27	1.57	1.00	2.00
Average, dry years (1986, 1988,1989)	0.54	0.68	0.31	1.20

Source: See Table 5.

The rapid increase in triticale area up to 1991 was reversed in 1992, when total area declined slightly to 15,900 ha. A sharper drop occurred in 1993, bringing total area down to 13,200 ha (see Table 5). Three main reasons are often given to explain this sharp reversal: 1) government officials were discouraging farmers from growing triticale; 2) price policies made triticale less competitive with durum and bread wheat; and 3) supplies of certified triticale seed were insufficient. Each of these reasons is explained in greater detail in the paragraphs that follow.

Given the surplus triticale stocks at the Office des Céréales and after the record 1991 crop, at the beginning of the 1991/92 season local officials reportedly were instructed to discourage farmers from growing triticale.[4] This resulted in widespread rumors that the government

[4] Based on personal communication with several local officials from the Ministry of Agriculture and the Office des Céréales. This information, however, was denied officially.

was about to abandon its guaranteed purchases of triticale deliveries, causing many farmers to reduce their triticale area or to eliminate it completely.

Although there were no confirmed reports that any triticale deliveries were not accepted after the 1992 harvest, data on triticale purchases by the Office des Céréales (and other parastatal agencies) suggest that some deliveries may have been rejected. Between 1986 and 1990, an average of 80-90% of triticale production was purchased by the State (Table 7). In contrast, only 65% of the triticale crop was purchased following the 1992 harvest, suggesting that about 8,000 t of triticale may have been rejected.

In any case, the rumors continued unabated throughout the 1992/93 season, likely reinforced by an administrative decision of the Office des Céréales to stop accepting triticale deliveries for one month as of 15 August 1992. As explained by officials from the Office des Céréales, this decision was taken to allow the government to start selling triticale at a price much lower than the official producer price, without creating opportunities for fraudulent resale of triticale back to the Office des Céréales. It can be construed from the data in Table 7 that such activities might have been widespread after the 1991 harvest, which may explain why official purchases were higher than total triticale production in 1991. However, discussions with farmers clearly indicated that this decision was interpreted by most farmers (and even by local officials) as the long-awaited government decision to stop supporting triticale production.

The second possible explanation for the decline in triticale production is the stagnation in triticale producer prices, which have remained constant since 1988 while wheat prices have increased substantially (Table 8). Although the triticale price in 1986 was equal to 88% of the durum and bread wheat prices, by 1992 it had dropped to 65% of the price of durum wheat and 76% of the price of bread wheat. In contrast, triticale has maintained its price advantage

Table 7. Government triticale purchases, Tunisia, 1986-92

Year	Production (t)	Purchases (t)	Purchases as percentage of production
1986	13,000	10,128	78
1987	32,500	26,955	83
1988	7,000	6,440	92
1989	15,500	13,842	89
1990	33,700	26,642	79
1991	44,200	49,438	112
1992	41,100	26,865	65

Source: Office des Céréales, Direction Approvisionnement, Service Achat de Céréales, unpublished data.
Note: Purchases are the combined purchases by the Office des Céréales, CCGC, and COCEBLE.

Table 8. Producer prices (TD/t) of cereals in Tunisia, 1985-93

Year	Durum wheat	Bread wheat	Barley	Triticale
1985	150	145	105	120
1986	160	160	110	140
1987	185	170	120	150
1988	210	190	140	170
1989	225	199	145	170
1990	245	209	150	170
1991	245	209	150	170
1992	260	225	150	170
1993[a]	260	225	150	170

Source: Ministère de l'Agriculture, République Tunisienne (1991).
Note: US$ 1.00 = 0.95 Tunisian dinar (TD) (official exchange rate, average January to June, 1993).
[a] Projections (Office des Céréales, unpublished data).

of about 13% over barley, which, combined with triticale's clear yield advantage, should continue to make triticale an attractive substitute for barley cultivation in Northern Tunisia. In practice, though, triticale's price advantage over barley has not always been apparent to farmers because of the substantial discounts imposed on triticale deliveries mixed with barley. According to officials in Béja, a stricter enforcement of grading rules in 1992 caused about 90% of the triticale delivered to the local Office des Céréales collection center to be purchased at the lower barley price. In fact, many farmers perceived this as a drop in the official price of triticale, which they interpreted as another sign of the government's intention gradually to reduce its support to triticale production.

With the exception of about 100 ha in Central Tunisia, all triticale is produced in Northern Tunisia. In 1991, more than 75% of the triticale area was concentrated in three northern provinces where rainfall levels are predominantly favorable: Bizerte (5,300 ha), Béja (4,800 ha), and Ariana (2,500 ha) (Table 9). Triticale production in the semiarid zones of Northern Tunisia remained somewhat limited, except for the provinces of Siliana and Zaghouan, which accounted for less than 10% of total triticale area in 1991.

Trends in triticale production did not follow the same pattern in all regions. While triticale area declined sharply in Ariana, Bizerte, and Béja in 1992/93, triticale area actually increased in semiarid Siliana and Zaghouan (Table 9). By 1993, the combined triticale area in Siliana and Zaghouan amounted to 2,700 ha, almost double the area in 1991, and these provinces accounted for more than 20% of the triticale area in Tunisia. Such regional differences could indicate a long-term trend involving the gradual shift of triticale towards the drier areas, where its comparative advantage is greater given its yield and price advantages over barley. This trend can be observed in Béja, where the combined triticale area in the semiarid districts of Mejez-el-bab, Testour, and Goubellat more than doubled between 1988 and 1992, whereas triticale area in the favorable district of North Béja declined by one-third over the same period (CRDA de Béja, various years).

Table 9. Triticale area (ha) in the major triticale-producing provinces of Tunisia, 1988/89-1992/93 cropping seasons

Type of zone and province	1988/89	1989/90	1900/91	1991/92	1992/93[a]
Favorable zone					
Ariana	700	1,600	2,500	1,500	600
Bizerte	5,200	4,600	5,300	5,000	3,700
Béja	4,100	4,700	4,800	4,800	3,200
Subtotal	**10,000**	**10,900**	**12,600**	**11,300**	**7,500**
Semiarid zone					
Siliana	700	1,100	1,000	2,000	1,900
Zaghouan	800	600	400	500	800
Subtotal	**1,500**	**1,700**	**1,400**	**2,500**	**2,700**
Total, Northern Tunisia	**14,400**	**15,600**	**16,500**	**15,900**	**13,100**

Source: Ministère de l'Agriculture, République Tunisienne (1992).
[a] Provisional estimate by the Office des Céréales (unpublished data).

Finally, it should be noted that the lack of certified triticale seed could also have contributed to the recent decline in triticale area. Limited seed production has long been recognized as one of the weakest links in the triticale diffusion process in Tunisia (Belaid 1991). Although distribution of certified triticale seed increased gradually from 50 t in 1983/84 to peak at 550 t in 1989/90, it dropped sharply to 114 t in 1991/92 (Office des Céréales, unpublished data). By the 1992/93 season, production of certified triticale seed had been virtually abandoned: a mere 33 t of seed was distributed to farmers.

The CCSPS (Coopérative Centrale des Semences et Plants Séléctionnés), the agency responsible for triticale seed production, justified this situation by citing farmers' lack of demand for certified seed (Belaid 1991). Farmers, on the other hand, say that triticale seed bought from the State is of low quality and often mixed with barley, and that they prefer to use their own seed or to buy seed from other farmers or the UCPAs.

Triticale Utilization

Despite the rapid increase in triticale production, utilization remained very limited through 1990. In that year, triticale consumption was only 5,100 t, about 15% of production, leading to a dramatic increase in stocks (Table 10). Starting in 1991, however, triticale utilization increased spectacularly, reaching 62,200 t in 1991 and 74,700 t in 1992. In this section, the reasons for the limited utilization of triticale prior to 1991 and the factors underlying the recent reversal in consumption trends will be examined.

Triticale utilization before 1991 — Prior to 1987, the UCPAs, who were the main producers of triticale, were also its main users. Some UCPAs are sufficiently equipped to produce their own feed mixes for their cattle and sheep, with triticale as a main ingredient, while others have to sell their triticale output to the CCGC (Coopérative Centrale des Grandes Cultures), a parastatal cereal-marketing and feed-manufacturing cooperative closely associated with the UCPAs. The CCGC produces sheep and cattle concentrates, with triticale as a main ingredient, and has special arrangements with the UCPAs to provide them with concentrates at subsidized prices.

Table 10. Triticale consumption, production, and stocks (000 t), Tunisia, 1985-92

Year[a]	Consumption	Production	Difference (production less consumption)	Computed stocks[b]
1985	4.0	12.5	8.5	8.5
1986	3.2	13.1	9.9	18.4
1987	11.8	32.5	20.7	39.1
1988	18.6	7.0	-11.6	27.5
1989	7.3	15.5	8.2	35.8
1990	5.1	33.7	28.6	64.4
1991	62.2	44.2	-18.0	46.4
1992	74.7	41.1	-33.6	12.8

Source: Consumption data from Kristjanson et al. (1990) and Office des Céréales (unpublished data). For the source of the production data, see Table 5.

[a] Calendar year for consumption data; crop year for production data.

[b] Data on actual stocks not available. Computed based on cumulative differences between production and consumption, starting from 1985.

The UCPAs provided only a limited market for triticale utilization and could not absorb the rapidly increasing production, particularly after the bumper crop of 1987. The resulting accumulated stocks of triticale amounted to about 40,000 t by the end of 1987 (Table 10). The government was increasingly concerned, not only by the accumulation of expensive stocks but also by the limited use of triticale in poultry feed and the continued increase in maize imports. In response to this situation, the government decided in 1987 and 1988 to limit maize imports to less than 200,000 t so feed millers would use triticale. Moreover, according to discussions with poultry producers, the government made it compulsory for feed millers to incorporate a certain minimum level of triticale into poultry concentrates.[5]

These actions resulted in a modest increase in triticale consumption, which reached 18,560 t in 1988 and accounted for less than 4% of total consumption of blended feed, coupled with a relative drop in stocks (Table 10). However, such drastic measures created an apparent backlash against triticale by the poultry feed-milling industry, which also controls the bulk of poultry production. Industry officials embarked on an active campaign against triticale, claiming that it had negative effects on poultry performance. The campaign put forward a variety of claims, none supported by any convincing evidence, of a lower consumption index and a drop in weight gain and egg production, in addition to various diseases and a higher death rate associated with triticale use.

The poultry industry made these claims despite the ample evidence (described earlier) from Tunisian research showing the positive effects of triticale in poultry nutrition.[6] The only somewhat valid claim was based on the problem that a high percentage of barley, as much as 35% in some instances, was mixed with the triticale bought from the Office des Céréales. Industry officials contended that barley's relatively high fiber content drastically lowered the nutritive value of poultry feed blends. According to an animal nutritionist working for the CCGC, the main problem is not the high fiber content *per se*, but rather the wide variation in the percentage of barley contained in the different batches of triticale. More frequent and costly chemical analyses are needed to ensure that fiber content does not exceed the prescribed maxima in the diet. Similar problems are associated with variability in triticale protein content, which, according to chemical analyses conducted by feed millers in Tunisia, ranged from 7% to 15%.[7]

The main apparent reason for the poultry industry's strong reluctance to use triticale was the fear of losing the heavy government subsidies on other feed ingredients such as maize, barley, and sorghum. For instance, in 1985 the maize selling price to feed blenders was set at 85 TD/t, compared to 113 TD/t for triticale (Belaid 1991), thus creating price disincentives for incorporating triticale in blended poultry feed. Starting in 1986, the selling price of maize was increased to equal that of triticale (Table 11). However, as shown by Belaid (1994), a triticale-to-maize price ratio of 1 does not provide sufficient cost-saving incentives for including triticale in poultry diets, especially if the supply of triticale is less reliable than that of maize.

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[5] This information was unofficially confirmed by officials from the Ministry of Agriculture.

[6] See, for example, Khorchani (1981), Bergaoui (1982), and Ghouhis (1984).

[7] Personal communication with T. Najar, animal nutritionist at the Institut National Agronomique de Tunisie (INAT).

Although in 1987 the government reached an agreement with the World Bank to eliminate feed subsidies gradually, the subsidy reduction program had to be frozen as a result of the severe drought in 1988 and 1989 (Kristjanson et al. 1990). To avoid a sharp increase in meat prices following the drought, the government imported substantial quantities of barley (and sorghum), which were sold to livestock producers and feed blenders at highly subsidized prices. The official selling price of barley was reduced in 1988 to 95 TD/t, compared to 127.5 TD/t for maize and triticale (Table 11).

The subsidies on maize, barley, and sorghum caused triticale utilization in poultry and ruminant diets to decline sharply after 1988, falling to 5,100 t in 1990, when Tunisia produced 33,700 t of triticale. Government stocks rose sharply; according to officials from the Ministry of Agriculture, stocks stood at about 65,000 t by the end of 1990.

Triticale utilization, 1991/93 — The feed subsidy removal program resumed in 1990 when production conditions returned to normal. In May 1990, the official selling price for barley rose to 125 TD/t, almost equal to that of triticale (127.5 TD/t). At the same time the price of maize increased to 158.1 TD/t, bringing the triticale-to-maize price ratio down to 0.81 (Table 11). These readjustments substantially improved triticale's attractiveness to feed millers. The availability of monthly data on sales of feed ingredients by the State, starting in January 1991, allows for a closer examination of short-term fluctuations in sales in response to changes in selling prices (Figure 1). These monthly data show that, as the probable result of the price adjustments introduced in 1990, triticale consumption had increased substantially by the beginning of 1991, with total sales of 16,000 t between the first of January and the end of May.

Triticale's competitiveness over barley was much improved in June 1991 when the selling price of barley was set at 158 TD/t, bringing the triticale-to-barley price ratio down to 0.81 (Table 11). For the first time since triticale was introduced in Tunisia, the triticale price was

Table 11. Selling prices of triticale, maize, and barley, 1986-93

Year (Month)	Selling price (TD/t)			Price ratio	
	Triticale	Maize	Barley	Triticale-maize	Triticale-barley
1986	127.5	127.5	107.4	1.00	1.19
1987	127.5	127.5	107.4	1.00	1.19
1988	127.5	127.5	95.0	1.00	1.34
1989	127.5	127.5	95.0	1.00	1.34
1990 (May)	127.5	158.1	125.0	0.81	1.02
1991 (June)	127.5	158.1	158.0	0.81	0.81
1991 (Nov.)	127.5	185.0	158.0	0.69	0.81
1992 (May)	127.5	185.0	168.0	0.69	0.76
1992 (Jul.)	150.0	185.0	168.0	0.81	0.89
1992 (Nov.)	150.0	185.0	128.0	0.81	1.17
1993 (Feb.)	150.0	185.0	168.0	0.81	0.89

Source: Kristjanson et al. (1990) and Office des Céréales (unpublished data).

substantially lower than the barley price. Given triticale's better nutritional profile, this further increase in the selling price of barley made triticale unquestionably more attractive in ruminant feed than barley. The price reduction was accompanied by an aggressive campaign by the Office des Céréales to sell its triticale stocks, not only to feed millers but also to sheep and cattle producers throughout the country. These measures elicited a spectacular rise in triticale consumption, with total sales between June 1991 and May 1992 amounting to 99,400 t, compared to 150,900 t for barley (Figure 1). By May 1992, all government triticale stocks were eliminated.

Although the selling price of triticale was increased to 150 TD/t in July 1992, triticale's relative price with respect to maize and barley remained virtually unchanged due to earlier increases in prices of maize (November 1991) and barley (May 1992) (Table 11). Soon after the 1992 harvest, triticale sales resumed at a rate as high as that of the previous season to reach an average monthly rate of about 7,000 t in September and October. In November 1992, however, triticale sales dropped abruptly to 1,500 t per month, and they remained at a relatively low level until May 1993, with average monthly sales ranging between 2,000 and 3,000 t. Total triticale sales between June 1992 and May 1993 amounted to only 34,500 t, about one-third of the previous season's record level.

There are two possible reasons for this most recent drop in triticale consumption. First, since the 1992 crop was not large enough to satisfy demand, and since all stocks from previous years had been sold, the government had to ration sales of triticale to a maximum of 4,000 t per month, which allowed supplies to last until May 1993. The second possible reason for the drop in consumption was the government's decision to sell part of its large surplus stocks of barley at very low prices (128 TD/t compared to the previous price of 168 TD/t). This decision was prompted by expectations of a drought, which would result in higher feed costs and meat prices for consumers, and the decision enabled the government to unload some of its expensive barley stocks, which had accumulated after record harvests in two consecutive seasons.

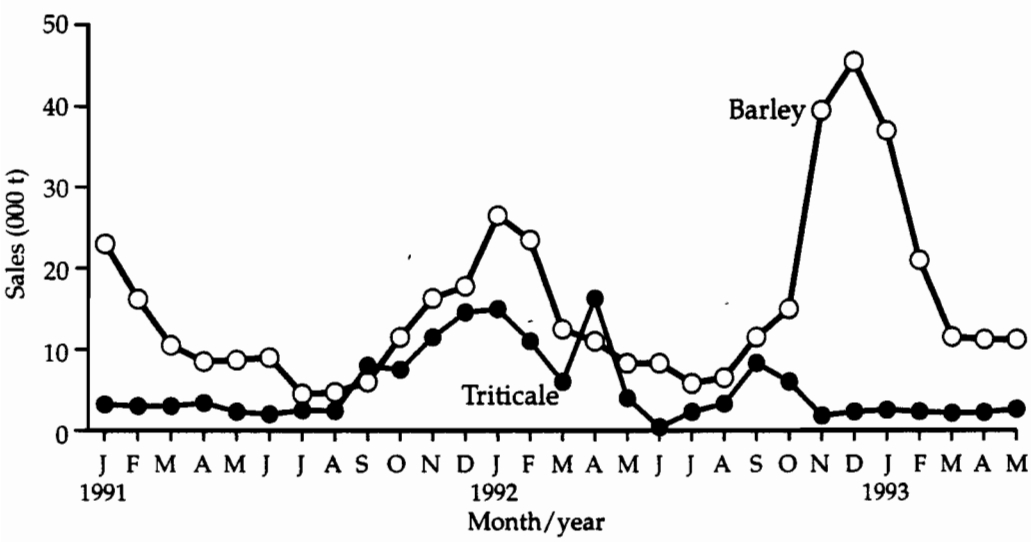

Figure 1. Monthly sales of triticale and barley (January 1991 to May 1993), Tunisia.
Source: Office des Cereales (unpublished data).

Although the drought never occurred (good rains arrived in November and December), the sale of cheap barley continued until February 1993, when the old price of 168 TD/t was restored. However, during this short period, feed millers and livestock producers accumulated quite large amounts of barley that will likely reduce their purchases of both barley and triticale for months to come. During the three months that barley was available at the lower price, 121,500 t of barley was sold by the State, twice as much as the 60,800 t sold at the same time the previous year (Table 12).

Moreover, while combined sales of barley and triticale remained relatively constant at about 250,000 t in 1991/92 and 1992/93, barley sales increased by 71,600 t in 1992/93 and sales of triticale declined by a similar amount (64,900 t). These patterns clearly suggest that the sharp increase in barley sales was at the expense of triticale consumption, although it can be argued that, regardless of the low price of barley, barley consumption would have increased to fill the gap left by insufficient triticale production.

In any case, it seems clear from the monthly sales data that triticale and barley have become almost perfect substitutes in ruminant feed, with feed users easily shifting back and forth between the two cereals depending on the prevailing relative selling prices. The fact that close to 100,000 t of triticale were used in 1991/92 is a clear indication that triticale is widely known by Tunisian feed millers and livestock producers. The key determinant of utilization seems to be triticale's selling price relative to other feed ingredients, particularly barley (Table 11). The triticale-to-barley sale price ratio constitutes the most important determinant of future triticale utilization in Tunisia and is a crucial policy variable that requires more attention from decision makers.

Triticale utilization in poultry feeding — In the absence of data on the breakdown of triticale use between poultry and ruminant feed, recent trends in utilization suggest that sheep and cattle feed still account for most triticale utilization. This is clearly illustrated by monthly sales data from 1991/92 (Figure 1), which show that triticale and barley sales follow similar seasonal patterns, reflecting the seasonal variation in the availability of natural pastures and crop residues for livestock grazing. Thus, demand for both barley and triticale grain increases in early fall, when all crop residues have been grazed, and peaks in December or January. After January, demand for feed grain gradually declines as natural pastures become available because of the fall and winter rains.

Table 12. Government sales (t) of triticale and barley, Tunisia, 1991/92 and 1992/93

	Triticale		Barley	
Period	**1991/92**	**1992/93**	**1991/92**	**1992/93**
June-October	22,200	19,800	35,500	47,000
November-January	40,500	5,900	60,800	121,500
February-May	36,700	8,800	54,600	54,000
Total	**99,400**	**34,500**	**150,900**	**222,500**

Source: Office des Céréales (unpublished data).

Compared to sales of triticale and barley, data on monthly sales of maize and triticale seem completely uncorrelated (Figure 2), with no indication of any large-scale substitution between triticale and maize. In fact, when triticale consumption reached record levels in 1991 and 1992, maize consumption was also increasing, from 245,000 t in 1990 to 285,000 t in 1992 (Office des Céréales, unpublished data). However, there are some indications that triticale utilization in poultry feed might be increasing. Sales of triticale continued throughout the three-month period when the barley price was substantially lower than the triticale price. Thus, it is safe to assume that most of the triticale sold during that period was for poultry feeding, i.e., about 2,000 t per month, or 20,000 t per year (based on a production cycle of 10 months per year), which represents only about 7% of total maize consumption.

An increasing use of triticale in poultry feed was confirmed during meetings with officials from the CCGC. Although the CCGC is considered the largest producer of concentrates for ruminants in Tunisia, about one-third of its annual feed output of 35,000 t is for poultry feed. Triticale is mixed in ruminant as well as in poultry concentrates at the following inclusion rates: 20-30% for ruminants, 15% for broiler chickens, 20-25% for starter pullets, and 10-20% for layers. Thus, the CCGC's total utilization of triticale amounts at present to an average of 8,000 t/yr, including about 2,000 t/yr for poultry feeding.

Although the CCGC uses relatively large quantities of triticale in poultry feed mixes, its total production of poultry concentrates accounts for barely 3% of Tunisia's poultry feed production. In contrast, the Groupe Poulina, a private corporation that controls a large share of the poultry industry, produces about 190,000 t/yr of poultry feed, representing more than half of national production, in addition to 30,000 t/yr in ruminant feed.[8] Therefore, the extent of triticale's use in poultry feeding in Tunisia depends essentially on what happens at Poulina. Poulina officials did not provide detailed information about their

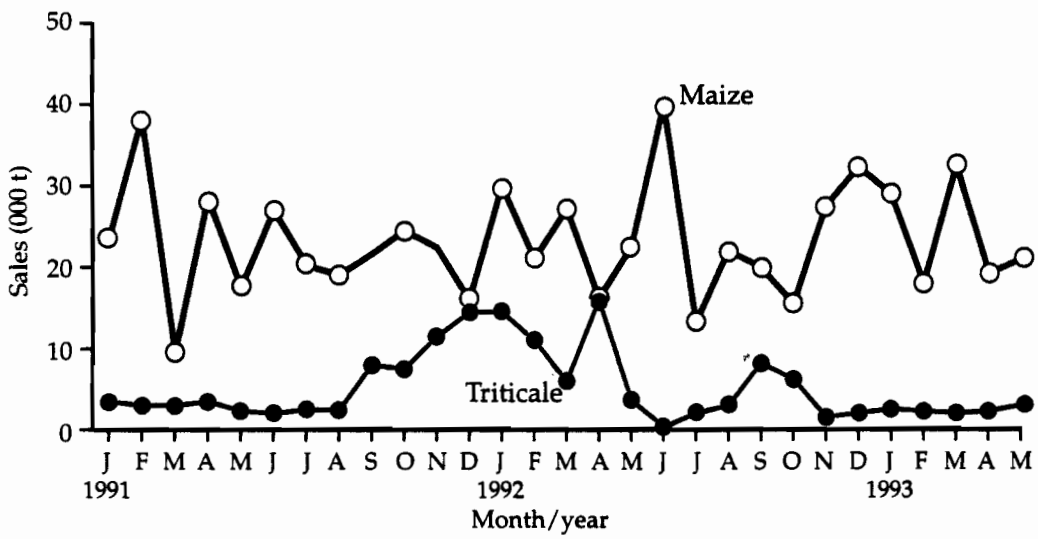

Figure 2. Monthly sales of triticale and maize (January 1991 to May 1993), Tunisia.

[8] Personal communication with A. Ben Ayed, President Director General of Groupe Poulina.

triticale use. However, they indicated that Poulina regularly uses substantial amounts of triticale in ruminant concentrates, while the use of triticale in poultry feed is recent but increasing as a result of the current favorable price of triticale compared to maize.

Furthermore, Poulina officials pointed out that including triticale in poultry feed will remain profitable as long as the price of triticale is lower than the price of maize. They also asserted that Poulina's decision not to incorporate triticale in poultry feed in the past was purely economic and had nothing to do with triticale's alleged negative effects on poultry performance. Such an assertion should put to rest the arguments over triticale's negative effects in poultry feed, especially since it comes from Tunisia's largest poultry producer, once the strongest opponent of including triticale in poultry diets.

These positive signals from Poulina suggest that triticale utilization in poultry feed could increase rapidly in the near future, especially at the current triticale-to-maize price ratio of 0.81. As shown by Belaid (1994), incorporating triticale in poultry diets is likely to continue to be profitable even if the price of triticale is slightly higher (3.5% to 4.2%) than the price of maize, as a result of triticale's higher protein content.[9] Using a linear programming model, Belaid showed that the inclusion of triticale in the feed rations of broiler and layer chickens would allow balanced diets to be formulated with less maize and soybean meal and at significant cost savings. Based on the current triticale-to-maize price ratio of 0.81, the modeling results indicated that triticale could substitute completely for maize and partially for soybean meal, leading to 14-17% savings in the costs of layer rations and 8-12% cost-savings in the rations of broiler chickens. Even when triticale was limited to a maximum of 30% in layer diets and 20% in broiler diets, Belaid found that the cost of layer diets would be 12% lower and broiler diets 3% lower.

Although no evidence links triticale use with reduced poultry performance, Tunisian animal nutritionists remain somewhat cautious about triticale in poultry diets, recommending maximum inclusion rates as low as 15% (e.g., Najar, forthcoming). Nevertheless, even an inclusion rate of 15% would translate into an annual triticale consumption of 29,000 t for Poulina alone, in addition to the 2,000 t/yr currently used by the CCGC in poultry feed. Should the 15% inclusion rate be applied by all poultry feed manufacturers, total triticale use in poultry rations could quickly jump to 60,000 t/yr, a 200% increase over the current estimated levels of about 20,000 t/yr.

This increase in triticale utilization for poultry feed would soon bring total demand to at least 110,000 t/yr, compared to the current Ministry of Agriculture estimate of 70,000 t/yr. To satisfy this rising demand, a total triticale area of about 55,000 ha would be needed, which is more than four times the current area sown to triticale. Therefore, unless policy measures are taken soon, current excess demand is expected to worsen over the coming years and is likely to constitute the main concern for decision makers dealing with triticale in Tunisia.

[9] Triticale contains an average of 12% crude protein, compared to 8.2% for maize (Belaid 1992, p. 40).

Results of the Farm Survey

Survey Objectives and Methods

Triticale farmers were surveyed in Northern Tunisia during June-September, 1992, to:

- examine how Tunisian farmers in different agroclimatic zones integrate triticale within their farming systems;
- determine the extent and modes of triticale utilization on the farm;
- identify the agronomic and socioeconomic constraints to the adoption and diffusion of triticale;
- compare triticale's profitability with that of competing cereals; and
- provide the farm-level information needed to assess the economic feasibility of triticale production in Tunisia and examine alternative policy recommendations.

The farm survey focused on the two regions where most triticale production is concentrated. The first one is the district (*délégation*) of Mateur in the province of Bizerte, located in the subhumid zone where annual rainfall averages 550 mm (Map 1). The second region covers two districts, Mejez-el-bab and Goubellat, in the southeastern corner of Béja Province, located in the semiarid zone[10] and receiving average annual rainfall of 350-450 mm.

The survey covered a random sample of 52 private farmers who had grown triticale in the past, divided equally between the two agroclimatic regions (26 in Mateur, 17 in Mejez-el-bab, and 9 in Goubellat). The farmers were interviewed using a formal questionnaire, and these interviews were augmented by informal discussions with farmers, local officials, and extension agents. Given the relative importance of the UCPAs in triticale production, the managers of four UCPAs (one in Mateur, one in Mejez-el-bab and two in Goubellat) were interviewed using a modified version of the questionnaire.

The private triticale growers included in the survey sample were identified mainly by compiling a list of names of possible triticale growers provided by local key informants (primarily extension agents), followed by on-farm visits and interviews. However, because extension agents tend to have more contact with larger farmers, such an approach was likely to involve some bias in favor of larger farmers.

The Survey Area

In 1990/91, the triticale area in the three districts covered by the survey amounted to 4,800 ha, or about 30% of Tunisia's triticale area (Table 13). The UCPAs and private farmers in Mateur and Mejez-el-bab Districts were among the earliest adopters of triticale cultivation, and triticale production in the two districts had reached a commercial scale by 1985. In contrast, triticale seems to be a relatively new crop in Goubellat, where only 250 ha were sown to the crop in 1990. This area, however, sharply increased to 1,130 ha in 1991 and was projected to reach 1,400 ha in 1992.

[10] Mejez-el-bab and Goubellat are often classified as part of the *Semi-aride Supérieure* zone, which comprises the wetter fringes of the semiarid zone. This seems to be more applicable to the Mejez-el-bab area than to the drier areas of Goubellat.

Table 13. Triticale area (1983-93) in the districts covered by the farm survey, Tunisia

Year	Mateur	Mejez-el-bab	Goubellat
1983	na	132	70
1984	na	200	0
1985	na	100	0
1986	na	1,351	0
1987	na	na	na
1988	na	1,985	30
1989	na	2,250	100
1990	1,500	2,200	250
1991	2,086	1,580	1,130
1992	2,600	2,500 [a]	1,400 [a]
1993	1,995 [a]	na	na

Source: Data for Mejez-el-bab and Goubellat are from CRDA de Béja (various years). Data for Mateur are unpublished data provided by local officials from the Ministry of Agriculture.
na = data not available.
[a] Projected.

Table 14. Crop mix in the districts covered by the farm survey, Tunisia, 1991/92

Crop	Mateur	Mejez-el-bab[a]	Goubellat[a]
Percentage area sown to:			
Durum wheat	34.0	35.0	22.6
Bread wheat	12.5	15.3	26.1
Barley	3.3	13.9	22.6
Triticale	6.0	7.3	6.3
Total cereals	**55.9**	**71.5**	**77.6**
Forages	32.0	21.1	20.0
Legumes	12.1	7.5	2.4
Total area sown to field crops (ha)	**43,055**	**34,040**	**22,140**

Source: See Table 13.
[a] Projected.

Agriculture in the three survey districts is essentially based on the cultivation of rainfed field crops and livestock production, with production of vegetables and industrial crops limited to a relatively small area on the irrigated perimeters. Cereals are the dominant crops, though they are relatively less important in Mateur, where higher rainfall allows greater production of forages and legumes (Table 14). Rainfall levels also influence the relative importance of wheat and barley area. Barley and, to a lesser extent, bread wheat become more important as one moves from the more favorable zone of Mateur to drier Goubellat.

Profile of Triticale Growers

The most striking characteristic of the 52 private triticale growers surveyed is the very large size of their farm holdings (measured in terms of total arable land owned, shared, or rented). The average farm amounted to 186 ha of arable land, more than three times the average farm size in Northern Tunisia. Farm holdings in the favorable zones were somewhat smaller, averaging 159 ha in Mateur, compared to 196 ha in Mejez-el-bab and 247 ha in Goubellat.

Farm size varied greatly among the survey farmers, ranging from 3 ha up to 1,500 ha in total arable land. The median farm size of 65 ha indicates an extremely skewed land distribution in favor of larger farms. In fact, large-scale farmers (with more than 50 ha) constitute 64% of the sample and account for 95% of the arable land (Table 15). This is in sharp contrast to land ownership statistics for Northern Tunisia, which show that large farmers constitute only 4% of all farmers and own 42% of the land.

The very large average farm size of the surveyed triticale growers may reflect bias in the sampling method. To assess the magnitude of this potential bias, the survey results were compared to data collected in a recent (1991) survey of cereal farmers in Northern Tunisia (INRAT/ICARDA, unpublished data). The random sample of 236 private cereal farmers covered by the INRAT/ICARDA survey included 18 triticale growers (8% of the sample).

Farm-size distribution among these triticale farmers was similar to that observed in this study: large farms (more than 50 ha) accounted for 61% of the growers, compared to 64% in our sample. However, the average farm size among triticale growers in the INRAT/ICARDA sample was 92 ha (compared to 53 ha for the entire sample), which is about half the average size (186 ha) observed in this study.

Given that the sample in the INRAT/ICARDA survey was carefully selected to reflect the actual farm-size distribution among the population, the comparison above suggests that the sample in this study is strongly biased in favor of large farms. In fact, the largest third of the sample farms had an average farm size of about 450 ha. To better account for this skewed distribution, the sample was subdivided into three farm-size categories, each containing about one-third of the farmers:

- Small and medium-sized holdings of *less than 50 ha*, with an average of 20 ha per holding, which includes 17 farmers (32.7% of all farmers).

- Large holdings ranging from *50 to 149 ha*, with an average of 113 ha per holding, which includes 19 farmers (36.5% of all farmers).

- Very large holdings of *150 ha or more*, with an average of 450 ha per holding, which includes 16 farmers (30.8% of all farmers).

In 1990/91, the 52 private farmers surveyed grew a total of 977 ha of triticale, which accounts for approximately one-third of the triticale grown on private farms in the three districts covered by the survey. The four UCPAs grew an additional 272 ha of triticale, bringing total triticale area covered by the survey to 1,249 ha, or about 8% of total triticale area in Tunisia. The combined triticale output of all private and cooperative survey farms amounted to 4,000 t in 1991, close to 10% of national output.

Table 15. Land distribution by farm size among survey farmers compared to farmers in Northern Tunisia as a whole

	Percentage of farms in category		Percentage of total arable land	
Farm size (ha)	Survey farms	Northern Tunisia	Survey farms	Northern Tunisia
<5	3.8	43.0	0.1	7.0
5-20	15.4	42.0	1.2	31.0
21-50	17.3	11.0	3.3	20.0
51-100	23.1	2.5	8.9	14.0
> 100	40.4	1.5	86.5	28.0
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: République Tunisienne (1987) and survey data.

The UCPAs, where triticale was first introduced, still sow a relatively large area to triticale. Whereas the UCPAs account for only 15% of total arable land in the three survey districts, they account for about 30% of triticale area in Mateur and 45% in Mejez-el-bab and Goubellat.[11] In comparison, the combined triticale area grown by the four UCPAs surveyed represented only 22% of the 1,249 ha of total triticale area covered by the survey. This suggests that the UCPAs were underrepresented in the sample, which should be taken into consideration when interpreting the results.

[11] Based on data provided by local officials.

Very large farms, growing on average 44 ha of triticale, accounted for 72% of the triticale area on private land, while large farms (averaging 11 ha of triticale per farm) accounted for 21% of the triticale area on private land (Table 16). In contrast, small and medium farms produced an average of 4.2 ha of triticale per farm and accounted for only 7.2% of all triticale grown on private land. Clearly triticale is essentially grown by large-scale farmers and UCPAs, who account for the bulk of triticale area (94.4%).

Several explanations may account for the limited triticale cultivation by small-scale farmers. First, small-scale farmers tend to rely on durum wheat as their main subsistence as well as cash crop. For this reason they prefer the traditional two-course rotation of durum wheat/legumes (or durum wheat/fallow in the drier areas) that allows them to obtain acceptable wheat yields with lower fertilizer (mainly nitrogen) costs. Moreover, small-scale farmers capitalize on abundant family labor to grow more labor-intensive and cash-generating crops such as food legumes, which are also consumed on the farm. Therefore, if triticale is to be adopted by these farmers, it would have to be at the expense of durum wheat, which, given its much higher price, is usually more profitable than triticale.

Furthermore, the lack of a private triticale market implies that farmers have to sell their marketable surplus to the State. Small-scale farmers, however, are usually reluctant to sell their entire output immediately after harvest, incur substantial transaction costs, repay whatever they owe the State in debts and tax arrears, and often endure complex procedures and delays before they are paid for their deliveries. The existence of a tolerated parallel market for durum wheat in virtually every town in Tunisia, where prices are only slightly lower than official prices, constitutes an important incentive for small-scale farmers to focus on durum wheat production rather than triticale.

In comparison, larger-scale farmers generally practice a three-or four-course rotation, with durum wheat as a primary cereal followed by secondary cereals, such as bread wheat and/or barley, and a forage crop such as oats or a vetch/oats mixture. By increasing their fertilizer rates, large-scale farmers can minimize their food legume areas, thus reducing their labor costs, and capitalize on their available machinery to focus on cereal and forage production. Triticale, cultivated as a secondary or tertiary cereal, can be integrated easily without any major change in rotations or cultural practices.

Table 16. Average triticale area and its distribution by survey farm category, Tunisia, 1990/91

Farm-size category	Average triticale area (ha)	Area distribution (%)	
		Private farms	All farms
Small and medium (n=17)	4.2	7.2	5.6
Large (n=19)	11.0	21.0	16.4
Very large (n=16)	44.0	72.0	56.3
Total private farms (n=52)	**18.8**	**100.0**	**78.2**
UCPAs (n=4)	68.0	..	21.8
All farms (n=56)	**22.3**	**..**	**100.0**

Source: Survey data.

One final reason to explain why few small-scale farmers grow triticale is their limited access to information in comparison to large-scale farmers. When farmers were asked when they had first heard of triticale, the average answer was "1988" for small- and medium-scale farmers, "1986" for large-scale farmers, and "1983" for very large-scale farmers (Table 17). Because of the lag in smaller-scale farmers' access to information, the diffusion of triticale cultivation to those farmers seems to be a relatively recent phenomenon. In fact, only 29% of small- and medium-scale farmers grew triticale before 1990, compared to 57% of larger farmers. Moreover, by 1992, small- and medium-scale farmers had grown triticale for an average of only two years, compared to four years for larger farmers (Table 17).

Although the great majority of the farmers surveyed (83%) and all the UCPAs had some livestock on the farm, the average number of livestock varied greatly by farm size. Very large-scale farmers owned on average 34 cows and 149 head of sheep; large-scale farmers had 6 cows and 48 sheep; and small- and medium-scale farmers owned on average only 4 cows and 15 sheep. Substantial differences in ownership of agricultural machinery were also observed between the three farm-size categories. While all very large-scale farmers and 84% of large-scale farmers owned at least one tractor, only 41% of small- and medium-scale farmers had a tractor. Similarly, 79% of very large-scale farmers owned a combine harvester, compared to 26% of large-scale farmers and only one medium-scale farmer. Finally, the relative importance of off-farm work also varied by farm size, with 41% of small- and medium-scale farmers reporting some off-farm work, compared to only 11% of large-scale farmers, whereas none of the very large-scale farmers reported off-farm work.

Trends in Triticale Area

Prior to 1984, none of the four UCPAs and only one farmer out of the 52 private farmers surveyed grew any triticale. After 1984, triticale area gradually increased, first at the UCPAs and later at the private farms, with the number of private triticale growers increasing from 15 in 1988 to 40 in 1991 (Figure 3). Similarly, while cooperative farms in 1984 grew more triticale than private farms, the share of private farms increased rapidly to reach 81% of total triticale area in 1990 (Figure 4). Moreover, while triticale production was the exclusive domain of UCPAs and large farmers prior to 1986, the diffusion of triticale cultivation to smaller-scale farmers seems to be increasing, as implied by the gradual decline in average triticale area among private farms from 36 ha in 1986 to 24 ha in 1991 (Figure 3).

Table 17. Triticale diffusion patterns among survey farmers by farm-size category, Tunisia

	Farm size (ha)		
	< 50	50-149	≥150
First year heard of triticale (average)	1988	1986	1983
Percentage of farmers who grew triticale before 1990	29	53	62
Numbers of years growing triticale (average)	2.2	3.6	4.1

Source: Survey data.

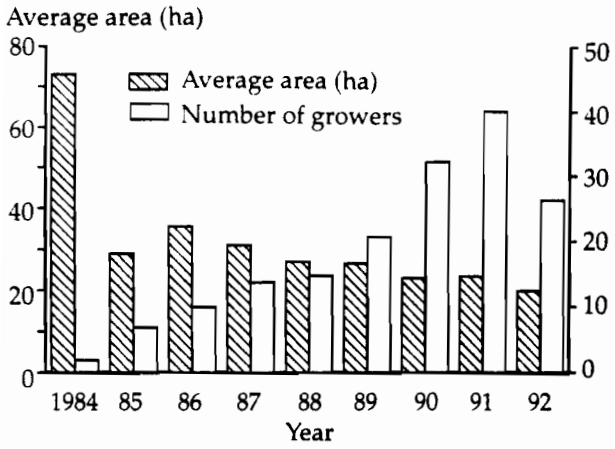

Figure 3. Number of triticale growers and average areas sown to triticale, 1984-92, survey area, Tunisia.
Source: Survey data.

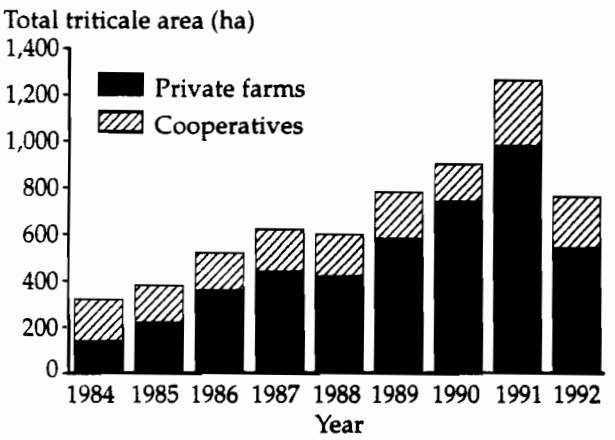

Figure 4. Area sown to triticale on private and cooperative farms, 1984-92, survey area, Tunisia.

The steady upward trend in triticale growers and area was sharply reversed in 1992, when only 26 private farmers grew a total of 533 ha of triticale, in addition to 225 ha at the UCPAs. This represented a 39% drop in triticale area among farmers covered by the survey, compared to 1991 levels. Twenty out of forty private farmers who grew triticale in 1991 did not plant it in 1992. Of these 20 farmers, four stated that they decided not to grow triticale anymore because of unsatisfactory profitability (low yield and/or low price). The remaining 16 farmers, however, had decided to stop triticale cultivation temporarily as a result of the rumors that the government would not accept triticale deliveries in 1992. These rumors prevented about half of potential growers from sowing triticale in 1991/92, while farmers who did grow triticale in this season reduced their average areas by about 20% (from 28 ha in 1991 to 22 ha in 1992).

The 39% decline in triticale area between 1991 and 1992 on the survey farms seems exaggerated when compared to the 4% decline in total triticale area at the national level over the same period (Table 9). The decline was slightly higher (10%) in provinces with favorable rainfall.

At the national level, the main drop in triticale area occurred in 1992/93, when triticale area in Tunisia was 21% lower than in the peak season of 1990/91. In the favorable provinces area dropped by 40% (Table 9). While the survey farmers' response to the rumors was similar in magnitude to that observed nationally, the timing was a year earlier. It is very likely that farmers in the survey districts, where triticale production is concentrated, had heard the rumors concerning triticale before the 1991/92 sowing period. In contrast, farmers elsewhere heard the rumors after they had already sown their triticale.

Triticale in the Farming System

The introduction of triticale into the farming system requires farmers to reduce the area allocated to other crops and/or fallow. As noted earlier, triticale was initially promoted to replace fallow in Central Tunisia, but yield trials in Northern Tunisia encouraged officials to

recommend triticale as a secondary cereal in the favorable zones of the North to replace barley, which suffers from lodging and diseases. Among the 56 survey farms, barley was the crop most commonly (34% of farms) replaced, either partially or totally, by triticale (Table 18). However, other crops replaced by triticale included bread wheat (21% of farms), durum wheat (16%), and forages (16%). Based on the 1991 figures reported by the survey farmers, 38% of the area currently sown to triticale was estimated to have been sown to barley; 26% to bread wheat; 5% to durum wheat; 13% to forages; and 18% to other crops (Table 18).

To accommodate triticale, farmers may decide to extend their rotation by one year, which implies a reduction in the area of all crops grown in the rotation, rather than the replacement of a single specific crop. This was the case with 8% of the survey farmers, who reported extending their usual three-course rotation (durum wheat/bread wheat/legumes or forages) by one year, growing triticale as a tertiary cereal following bread wheat (Table 19). Most farmers, however, did not extend their usual rotations but chose instead to grow triticale as a secondary cereal, following durum wheat and replacing bread wheat or barley. Such a practice was reported by 55% of all farmers and was relatively more common in the semiarid districts of Mejez-el-bab and Goubellat (65% of farmers) than in the favorable district of Mateur (42%).

Table 18. Crops replaced by triticale on survey farms, Tunisia

Crop replaced	Percentage of all survey farmers (n = 56)	Percentage of all triticale area in 1991 (Total = 1,249 ha)
Durum wheat	16.4	4.8
Bread wheat	21.3	26.3
Barley	34.4	38.2
Forages	16.4	13.2
Other	11.5	17.5
Total	**100.0**	**100.0**

Source: Survey data.

Table 19. Triticale in the rotations practiced by survey farmers, by zone, Tunisia

Rotation	Percentage of farms on which rotation is practiced		
	Favorable zone (n=27)	Semiarid zone (n=29)	All farms (n=56)
Two-course rotations	**30.7**	**26.4**	**28.3**
Triticale/legumes	11.5	14.7	13.3
Triticale/forages	19.2	2.9	10.0
Triticale/fallow	0.0	8.8	5.0
Three-course rotations	**42.3**	**64.7**	**55.0**
Durum wheat/triticale/legumes	30.8	41.2	36.7
Durum wheat/triticale/forages	7.7	8.8	8.3
Durum wheat/triticale/barley	3.8	2.9	3.3
Durum wheat/triticale/fallow	0.0	11.8	6.7
Four-course rotations	**11.5**	**5.9**	**8.3**
Durum wheat/bread wheat/triticale/legumes	7.7	0.0	3.3
Durum wheat/bread wheat/triticale/forages	3.8	5.9	5.0
Other rotations	**15.4**	**2.9**	**8.3**
Total	**100.0**	**100.0**	**100.0**

Source: Survey data.

In addition to the dominant three-course rotation, the more traditional two-course rotation was practiced by a sizable number (28%) of farmers. They grew triticale as a primary cereal in place of durum or bread wheat, followed by legumes or fallow. This was more common in the drier zones, where the more moisture-conserving two-course rotation is often considered essential for producing a good cereal crop. In contrast, the triticale/forage rotation was found primarily on farms with waterlogged soils, which are very common in Mateur. Farmers in this area reported that both triticale and oats are apparently much more tolerant of waterlogging than either wheat or barley.

Survey farmers were asked to compare triticale either with the crop it replaced or with their main cereal crop in terms of cultural practices and input use. Their responses suggest that, except for minor differences, cultural practices for triticale are very similar to those used for the other cereals, especially bread wheat and barley (Table 20). Land preparation for durum wheat usually consists of one deep plowing (performed by 92% of respondents), followed by an average of 4 diskings. In comparison, only 55% of respondents reported deep plowing before planting triticale, followed by 3-4 diskings. These operations were the same for bread wheat and barley, though deep plowing was relatively more common for barley (64%) and bread wheat (60%).

The majority of farmers sowed triticale in November (as with wheat and barley). However, sowing in December was more common for triticale than for wheat, with 8 out of 52 farmers planting triticale in December compared to only one farmer (of a total of 31 respondents) who reported regularly sowing wheat in December. Tunisian researchers have recommended a sowing date that is later than for wheat (Maamouri et al. 1988). The survey results seem to confirm the soundness of this recommendation, given that average triticale grain yield was higher for triticale sown in December (3.3 t/ha) than in November (average of 2.9 t/ha).

Table 20. Cultural practices and input use on triticale, wheat, and barley on survey farms, Tunisia

Practice	Triticale (n=45)[a]	Durum wheat (n=26)[a]	Bread wheat (n=5)[a]	Barley (n=14)[a]
Percentage performing deep plowing	55	92	60	64
Average number of diskings	3.6	4.1	3.8	3.5
Percentage sow in:				
October	6	0	0	29
November	79	100	80	50
December	15	0	20	21
Average seeding rate (kg/ha)	137	140	135	116
Percentage use herbicides	90	96	100	93
Average fertilizer rates:				
N (kg/ha)	76	83	68	59
P_2O_5 (kg/ha)	69	77	73	55

Source: Survey data.

[a] n = number of respondents.

Farmers used an average seeding rate of 137 kg/ha for triticale, a rate similar to that for wheat but substantially higher than that for barley (116 kg/ha), because of barley's relatively higher propensity for tillering. The majority of farmers (90%) applied herbicides on triticale, as they did with wheat and barley. Fertilizer applications on triticale, however, showed some significant differences in comparison to the other cereals. On average, farmers applied the equivalent of 76 kg/ha of elemental nitrogen (N) and 69 kg/ha of phosphate (P_2O_5) on triticale. Although these rates were very close to those for bread wheat, they were significantly lower than the average rates for durum wheat and much higher than the rates for barley (Table 20).

Given the few differences reported in input use and cultural practices between triticale, wheat, and barley, the differences in costs of production were minimal. Based on 1991 input prices, triticale's cost of production was estimated to be lower than durum and bread wheat by 12.5 TD/ha and 10 TD/ha, respectively, but higher than barley by 12 TD/ha. This is in comparison to total costs of production of about 235 TD/ha for wheat and 140 TD/ha for barley.[12]

Farmers were also asked to compare the agronomic characteristics of triticale with the other cereals. Farmers indicated that triticale had a clear advantage over barley and wheat in terms of disease resistance (Table 21); only three respondents expressed concern about triticale's sensitivity to disease. Farmers thought triticale tended to be more tolerant to drought and to the hot Sirocco winds than either durum or bread wheat. However, when comparing triticale with barley, more farmers thought triticale was more resistant than barley to the Sirocco but less tolerant to drought. As to susceptibility to lodging and to excess moisture, the majority of respondents believed that triticale was more resistant than barley, but opinions were divided when comparing triticale with wheat.

When asked to list the main advantages of triticale, most farmers (69%) mentioned its high grain yield, although straw yield was also an important advantage reported by 29% of

Table 21. Farmers' opinions of triticale, compared to wheat and barley

	Durum wheat (number of respondents)			Bread wheat (number of respondents)			Barley (number of respondents)		
	Triticale is:			Triticale is:			Triticale is:		
Quality	Better	Same	Worse	Better	Same	Worse	Better	Same	Worse
Early maturity	8	4	6	1	2	3	3	2	23
Tillering	10	2	7	3	2	1	11	2	15
Drought resistance	11	0	5	4	1	1	8	2	10
Resistance to excess water	5	6	7	1	2	0	10	5	2
Resistance to Sirocco	9	2	6	4	0	1	9	5	6
Disease resistance	12	6	1	4	2	0	14	8	2
Lodging resistance	8	2	8	1	2	3	21	1	6

Source: Survey data.

[12] Computed from cost of production figures provided by Roth et al. (1989), adjusted based on 1992 prices.

respondents (Table 22). Other advantages included good resistance to disease and drought and good performance as a secondary cereal, in poor soils, and under low input levels. Also, 12% of the survey farmers mentioned triticale's resistance to attacks by birds as a highly appreciated characteristic, particularly when compared to barley. In fact, barley's early maturity exposes it to severe attacks by birds (mainly sparrows) during the early stages of grain maturity, especially in more humid areas and in fields located close to streams or wooded areas. This has encouraged some farmers to replace barley with triticale, which, according to several farmers, resists attacks by birds better than all other cereals.

Triticale's flexible harvesting date is another advantage. Owing to barley's high rate of head breakage, farmers often have to harvest it immediately after maturity, when the rental rates for combine harvesters are very high. In contrast, triticale harvesting can be delayed without any yield loss until the end of the harvest season, when rental rates are much lower. Many smaller-scale farmers, who do not own machinery, have mentioned triticale's flexible harvesting date as an important factor in their decision to replace barley with triticale.

Triticale Yields and Gross Revenues

Because the farm survey was conducted before some farmers had finished harvesting their cereals in 1992, farmers were asked to provide yield projections for 1992 as well as to specify the actual yields obtained in 1991. However, since both 1991 and 1992 were exceptionally good years for cereal production in Northern Tunisia, farmers were also asked to provide figures on their past yields, including yields in good, normal, and dry years. The results in Table 23 indicate that the average projected grain yield of triticale in 1992 is about 2.6 t/ha, slightly lower than the 1991 average yield of 2.9 t/ha and about the same as the average yield in a normal year (2.5 t/ha). Triticale yields varied from an average of 1.4 t/ha in dry years to 3.5 t/ha in good years. The average triticale straw yield in a normal year amounted to 125 bale/ha, or about 1.9 t/ha (average weight of 15 kg/bale).

The survey results also indicate that triticale grain yield is a function of farm size. In normal years, average triticale yields were significantly lower on small- and medium-sized farms (1.9 t/ha on average), compared to yields on larger farms (2.6 t/ha on average) (Table 23). The highest yields were obtained on the UCPAs, averaging 3.4 t/ha in normal years. Triticale yields also showed some variation by agroclimatic zone, with average grain yields in a normal year slightly higher in the drier districts of Mejez-el-bab and Goubellat than in the more humid areas of Mateur, indicating triticale's high adaptability to the drier areas of Northern Tunisia (Table 23).

Table 22. Farmers' assessments of triticale's main advantages, Tunisia

Advantage	Percentage of respondents (n=52)
High grain yield	69
High straw yield	29
Good performance in poor soils	23
Good performance as a secondary cereal	15
Good performance under low levels of inputs	15
Resistance to diseases	19
Resistance to drought	17
Resistance to attacks by birds	12
No head-breakage	12

Source: Survey data.

Table 23. Farmers' average yields of triticale, by farm-size category and district, Tunisia

	Triticale yield (t/ha)
Grain yield:	
1992[a]	2.6
1991	2.9
Good years	3.5
Normal years	2.5
Dry years	1.4
Average straw yield	1.9[b]
Average grain yield, by farm-size category:	
Small and medium (< 50 ha)	1.9
Large (50-149 ha)	2.6
Very large (≥150 ha)	2.5
UCPAs	3.5
Average grain yield, by district:	
Mateur	2.4
Mejez-el-bab	2.6
Goubellat	2.6

Source: Survey data.
[a] Projected.
[b] 125 bales/ha (a bale of straw weighs about 15 kg, on average).

Yield comparisons between triticale and wheat grown on the same farm clearly demonstrate triticale's yield advantage, particularly in drier years (Table 24). During good years, triticale yields were about 15% lower than yields of durum and bread wheat, whereas in normal years triticale showed only a modest advantage, yielding 5% more than durum wheat and 7% more than bread wheat. In contrast, during dry years triticale yields were 40% higher than durum wheat and 10% higher than bread wheat. Triticale's high yield potential is even more apparent when compared to barley, particularly in normal and dry years, when triticale outyields barley grown on the same farm by an average of 23% (Table 24). Moreover, since the triticale varieties grown in Tunisia are relatively much taller than the barley and semidwarf wheat varieties widely cultivated in Tunisia, triticale tends to produce more straw than either wheat or

Table 24. Relative grain yield of triticale to durum wheat, bread wheat, and barley, Tunisia (by data source)

	Triticale yield as percentage of yield of:		
Data source	**Durum wheat**	**Bread wheat**	**Barley**
National statistics for northern Tunisia:[a]			
Good years (1987, 1991, 1992)	127	109	155
Average years (1984, 1985, 1990)	174	135	221
Dry years (1986, 1988, 1989)	222	176	387
Results of on-farm trials:[b]			
Good years (1991, 1992)	99	101	108
Normal year (1990)	120	112	162
Cross-sectional average of survey farms:[c]			
Good years	100	101	125
Normal years	123	122	165
Dry years	168	158	211
Relative yields for each survey farm:[c]			
Good years	85	85	102
Normal years	105	107	122
Dry years	140	110	124

[a] Computed from data in Table 6.
[b] Computed from data in Tables 3 and 4.
[c] Computed from survey data.

barley. The survey results showed that, on average, triticale produces 10% more straw than bread wheat, 14% more than durum wheat, and 35% more than barley.

It should be noted that these yield comparisons are based on yields obtained on the same farm. Such farm-by-farm comparisons are likely to be more accurate than cross-sectional comparisons,[13] though they are based on smaller subsamples. As shown in Table 24, a comparison of average yields across all survey farms leads to a significant bias in favor of triticale, and national average yield figures substantially overestimate the magnitude of triticale's yield advantage over wheat and barley. (As noted earlier, the main source of bias in national statistics is the high concentration of triticale production on large farms and UCPAs).

The yield comparisons listed above provide a basis for assessing the relative profitability of triticale and competing cereals. Given that differences in costs of production were minimal, gross revenues were the only key indicators used in comparing profitability. Gross revenues were computed based exclusively on the value of grain production,[14] excluding straw value because differences in straw yield between the various crops are somewhat small and the value of straw is much lower than that of grain.

Comparisons of gross revenues for triticale and wheat clearly show that triticale's modest yield advantage in normal years is insufficient to compensate for the substantially higher producer prices of durum and bread wheat. Triticale's gross revenues in normal years are 21% lower than durum wheat and 13% lower than bread wheat (Table 25). In normal years, only 19% of the respondents obtained a gross revenue from triticale that was superior to that obtained from durum wheat, and 24% obtained a triticale gross revenue higher than that of bread wheat.

Table 25. Relative gross revenue of triticale in comparison to wheat and barley, Tunisia

	Durum wheat	Bread wheat	Barley
Triticale's relative gross revenues (%):			
Good years	61	69	121
Normal years	79	87	155
Dry years	114	114	172
Percentage of survey farmers with relative triticale gross revenues greater than 100%:			
Good years	3	4	89
Normal years	19	24	83
Dry years	40	33	69

Source: Computed from survey data.

[13] Ideally, yield comparisons ought to be made between crops grown not only on the same farm but also on the same plot, in order to control for differences in soil types, slopes, etc.

[14] Official 1992 producer prices were used in the calculation of gross revenues: durum wheat: 260 TD/t; bread wheat: 225 TD/t; barley: 150 TD/t; and triticale: 170 TD/t.

However, in dry years triticale's yield advantage over wheat compensates for its lower price, resulting in 14% higher gross revenues for triticale compared to durum and bread wheat (Table 25). During dry years, 40% of the respondents obtained a triticale gross revenue superior to durum wheat, whereas 33% had a triticale gross revenue higher than that of bread wheat. Although triticale production is on average less profitable than either durum or bread wheat, higher revenues during dry years make it an attractive alternative to wheat for a significant number of farmers who rely on triticale to further diversify their crop mix and to reduce their risks.

Triticale's higher producer price compared to barley, coupled with its substantial yield advantage, make triticale unquestionably more profitable than barley. Triticale's gross revenues are consistently higher than those from barley during good, normal, and dry years (Table 25). Gross revenues from triticale were on average 55% higher than those from barley; 83% of the respondents obtained a superior gross revenue from triticale.

Triticale On-Farm Utilization

The private farmers surveyed were asked to state their first and second most important reasons for growing triticale. The majority of farmers (79%) grew triticale mainly as a cash grain crop, with more than half of the farmers growing it exclusively for sale (Table 26). Just 17% of farmers produced triticale primarily to feed animals on the farm; an additional 26% stated that on-farm feeding of triticale grain was their second most important reason for growing triticale. Only two farmers grew triticale mainly to produce silage to feed on-farm livestock, and only one farmer regarded producing triticale silage as the second most important reason (after feed grain) for growing triticale. On average, about 82% of triticale grain output was sold and only 15% consumed by animals on the farm (Table 27).

Triticale in food — Although 21% of farmers reported having tried triticale in food, only minute quantities of total triticale production were actually used for human consumption (Table 28). Farmers reported experimenting with triticale in a variety of foods, including bread, couscous, soups, and sweets. Bread made entirely from triticale flour was reported to

Table 26. Farmers' main objectives in growing triticale, Tunisia

	1st objective (% farmers) (n=52)	2nd objective (% farmers) (n=50)
Grain for sale	79	14
Feed grain on farm	17	26
Silage on farm	4	2
No second objective	..	58

Source: Survey data.

Table 27. Farmers' utilization of triticale, Tunisia

	Percentage of triticale production:	
Triticale utilization	**Grain**	**Straw**
Sale	82.2	46.6
Feed on farm	14.9	29.6
Seed	2.2	..
Storage and other uses	0.7	23.8[a]
Total	**100.0**	**100.0**

Source: Survey data.
[a] Storage = 12.7%; bedding for animals = 11.1%.

be darker and to "contain less dough" than bread made from wheat flour. Farmers' opinions about triticale bread were divided; some preferred it to traditional types of bread and praised its "more healthful" characteristics, while others disliked the taste of triticale bread, its texture, and/or its dark color. Nevertheless, it was clear from discussions with farmers that triticale flour is unlikely to become a major substitute for wheat in bread made at home. At best, triticale could become a regular component in specialty dishes, such as specialty breads, which are usually consumed in very small quantities.

However, triticale may have an impact as a substitute for barley in bread-making in Central and Southern Tunisia, where the consumption of barley bread is very common. In the northern rural areas, however, barley is generally consumed in very small quantities, mainly as a specialty food or in barley bread praised for its medicinal characteristics. The consumption of barley bread in Northern Tunisia tends to be more important on small farms, where triticale could play a more important role should it replace barley in bread-making. In fact, 29% of the survey farmers with small and medium-size holdings reported experimenting with triticale in food, compared to only 18% of larger farmers (Table 28). Although some farmers reported that triticale bread was easier and less time-consuming to prepare than barley bread, most farmers seemed to prefer barley bread. In fact, one very small-scale farmer reported that triticale's poor bread-making quality was the main reason he stopped growing triticale in favor of barley.

Triticale as feed grain — Of the private farmers surveyed who own livestock (83%), 70% have experimented with triticale as a feed grain, though only 53% (23 farmers) reported regularly feeding triticale to their animals. Only five of these 23 farmers used more than 50% of their output to feed their animals. Nine used 11-50% of their production to feed animals, whereas the remaining nine farmers used less than 10% of their output for animals (Table 29).

Table 28. Percentage of survey farmers using triticale and barley for human consumption, by farm-size class, Tunisia

	Percentage of farmers who use:	
	Triticale in food[a]	Barley in food[b]
Farm size:		
Small and medium (<50 ha)	29	53
Large (50-149 ha)	21	47
Very large (≥150 ha)	13	38
All survey farmers	**21**	**47**

Source: Survey data.

[a] Farmers who reported trying to use triticale in food preparations.

[b] Farmers who regularly use barley in food preparations.

Table 29. Proportion of the triticale grain crop used to feed livestock on survey farms, Tunisia

Proportion of triticale grain crop used in animal feed	Number of farmers
Farmers who own livestock (n=43):	
None	20
10% or fewer	9
11-50%	9
> 50%	5
No livestock on farm	**9**

Source: Survey data.

Triticale was rarely the only component in animal feed. Farmers reported a wide range of combinations and ratios of triticale grain and other feed ingredients. Triticale grain was fed to sheep either as whole grains or broken into smaller pieces, and was commonly mixed with barley, faba beans, and/or wheat bran. Most farmers considered triticale to be equal or superior to barley in sheep feed, especially if the sheep were kept mainly for milk production, whereas faba beans were usually preferred to triticale for feeding sheep for meat production. Moreover, triticale was particularly praised as an additive, either in substitution or in combination with purchased concentrates, to the diets of pregnant and nursing ewes.

The main difference reported between using triticale for sheep and cattle feed was the need to grind triticale (and all other grains) before feeding it to cattle to avoid problems of stomach bloating, which drastically reduce feed intake and may occasionally be fatal. Triticale grain was generally as important in the diets of beef cattle as in the diets of sheep kept for meat production, though triticale tended to be less important than other feed ingredients. In contrast, triticale constituted the main feed ingredient in the diets of dairy cows. Two of the three dairy farmers produced their own concentrates using triticale as the main energy source and mixed with either soybean meal or faba beans, to which they added a purchased mineral-vitamin complex.

It should be mentioned that women on most survey farms raised some poultry, mostly for home consumption. Given that all interviews were conducted with male farm operators, it was not possible to get details on the number of birds and their diets. Nevertheless, most triticale growers reported using some triticale grain to feed chickens, but one farmer mentioned that some of his chickens died as a result of being fed nothing but triticale. The manager of a UCPA in the Mejez-el-bab area reported that triticale had been successfully used in the past as the main feed component in a large swine production operation.

The very positive results with triticale grain feeding obtained by some of the livestock producers suggest that more farmers will use triticale in the future for feeding animals on the farm. Although only 15% of triticale grain output is currently consumed by animals on the farm, the fact that a relatively large number of triticale growers seem to be experimenting with triticale in animal feeding clearly suggests that the prospects for much higher on-farm consumption are promising. Moreover, such positive results may induce some non-growers to start experimenting with triticale feeding prior to deciding whether to adopt triticale cultivation. Discussions with 18 small livestock producers within the survey area who had never grown triticale indicated that one-third of them were either experimenting with feeding triticale grain or were already including it in animal feed on a regular basis.

Triticale for forage production — In addition to the potentially important role of triticale grain in feed, triticale straw could also play a secondary role in feeding animals on the farm. Of the triticale growers who owned livestock, 64% had used triticale straw to feed their animals. On average, about 47% of total triticale straw production was sold, 30% was fed to animals on the farm, about 11% was used as bedding for animals, and the remaining 13% was stored on the farm (Table 27).

Triticale straw was more commonly fed to sheep than cattle, with many farmers reporting that cereal straw in general was never fed to milking cows or ewes since it suppresses milk production. Although triticale tended to yield more straw than wheat or barley, farmers often complained about its poor quality (too thick and rough), particularly when compared to barley straw, and opinions varied as to its quality compared to that of wheat. Market prices for straw of the various cereals tended to reflect these perceived differences in quality somewhat, with barley straw fetching the highest price, followed by durum wheat straw, and finally by similarly priced bread wheat and triticale straw.

Triticale's high production of green matter makes it particularly attractive as a green forage, especially for making silage. Silage production in Tunisia is limited to a very small number of large State and private dairy farms where oats are usually used to produce silage. In 1989, early fall rains resulted in severe disease attacks on oats (crown rust and, to a lesser extent, barley yellow dwarf virus), which virtually destroyed the entire crop (INRAT 1990). This has led some State farms to experiment with triticale to make silage, a practice that seems to be spreading rapidly among large dairy farmers.

As noted earlier, three dairy farmers who grow triticale for silage were covered by the farm survey. These three farmers had started making triticale silage only recently (1-2 years) and were extremely satisfied with the results. One farmer reported that the quality of silage made from oats was slightly better, whereas the other two farmers obtained triticale silage that was as good as oat silage. Triticale yields, however, ranged from 30 to 40 t/ha of green matter, about 40% higher than the average yield of oats (25 t/ha). Triticale's good disease resistance compared to oats allowed the three farmers to eliminate the cost of fungicidal treatments. Also, triticale's much cheaper seed compared to oat seed further contributed to reducing the costs of silage production. Two farmers reported cutting triticale in February, compared to May for oats, which allowed them to increase their cropping intensity by planting the harvested triticale plot with spring chickpeas.

In spite of triticale's high production of green matter, none of the 52 survey farmers reported growing triticale for hay. Farmers' lack of information about triticale's potential as a forage crop may be one reason to explain this phenomenon, although the poor hay quality of the current triticale varieties (TCL 8 and TCL 13) compared to oats (or a vetch/oats mixture) could be the main reason. As explained by one farmer, the thin, "sweet" oat stems are much more palatable to sheep than triticale, with its thick stems and rough leaves.

Eight of the 52 survey farmers reported experimenting with grazing their animals on green triticale. Although triticale tended to grow back after one grazing by sheep (usually in March), the resulting grain yields were generally disappointing, especially in comparison to barley's excellent regrowth and grain yield after grazing. Thus, some farmers preferred to set aside small portions of their triticale plots to be grazed completely by sheep. It should be noted that triticale's poor performance after green-grazing is a problem specific to the varieties currently grown in Tunisia, and may be resolved if some of the dual-purpose varieties selected at CIMMYT are shown to be adapted to Tunisian conditions.

Production Constraints and Future Trends

In light of the results of the farm survey, it is clear that triticale cultivation is highly adapted to farming conditions in Northern Tunisia, both in the favorable subhumid zones such as Mateur and in semiarid areas such as Mejez-el-bab and Goubellat. Although triticale adoption by smaller-scale farmers is gradually increasing, triticale remains a crop essentially grown on large farms and UCPAs (95% of production).

Triticale is substantially more profitable than barley, so triticale area is likely to continue expanding at the expense of barley in the subhumid as well as semiarid zones. In contrast, triticale's only advantage over wheat seems to be its superior profitability in drier years. This advantage may constitute a good enough reason for many farmers to continue growing triticale at the expense of wheat in order to diversify their crop mix and to reduce their production risks.

The survey results also showed that on-farm utilization of triticale is fairly limited but increasing rapidly. Given that a relatively large number of triticale growers are still experimenting with small quantities of triticale in animal feeding, the positive results obtained by more experienced farmers clearly suggest that the prospects for much higher on-farm consumption are promising.

Farmers' uncertainty over the government's plans to continue purchasing triticale was very clear. Only 17% of the respondents planned to increase their triticale area in 1992/93, and 4% said they would maintain the same area as in 1991/92 (Table 30). In contrast, 27% of the respondents planned to reduce their triticale area, while the remaining 52% stated that their plans were conditional on the State's acceptance of triticale deliveries.

Although rumors about the future of triticale cultivation constituted the main concern for most triticale growers, they also expressed concern about the stagnant producer price of triticale at a time when wheat prices have been increasing steadily. To examine the possible contribution of low prices to the decline in triticale area, farmers were asked to indicate how much triticale they would grow in 1992/93 should the government guarantee acceptance of all deliveries and should the producer prices of all cereals, including triticale, remain equal to 1992 levels. The answers to this hypothetical question indicated that the combined triticale area planted by the 52 farmers in 1992/93 would amount to 749 ha. Although this area is 40% larger than that grown in 1992, it is still lower than the 1991 area by about 23%. This suggests that the relatively low producer price of triticale must have had as much of a negative effect as the rumors on the decline in total triticale areas in 1992.

Table 30. Farmers' plans for triticale cultivation in 1992/93, Tunisia

Triticale area planned for 1992/93, compared to area in previous season	Farmers	
	(number)	(%)
Larger	9	17
Same	2	4
Lower	14	27
Uncertain	27	52
Total	**52**	**100**

Source: Survey data.

Similar hypothetical questions were also used to elucidate farmers' potential response to possible changes (increases or declines) in the producer price of triticale. The results clearly suggest that farmers are likely to be highly responsive to changes in the producer price. Based on farmers' responses, it was estimated that, for every 10% increase (or decrease) in the producer price, farmers may increase (or decrease) their triticale area by about 40-50%. If such very rough estimates are extrapolated to the national level, the results suggest that current producer prices would lead to the cultivation of 12,600 ha, provided the State guarantees acceptance of all triticale deliveries. This area could increase to 19,700 ha if the triticale price is set at 190 TD/t and to 29,600 ha if the price is increased to 210 TD/t (slightly lower than the current producer price of bread wheat). Although a more detailed supply response analysis is needed for an accurate estimate of the magnitude of farmers' response to price changes, the above results are indicative of the important role of producer pricing as a potentially very effective policy instrument to influence triticale production in Tunisia.

The importance of policy variables, such as producer pricing and guaranteed marketing, as the key constraints to the expansion of triticale production was clearly demonstrated when survey farmers were asked to list the main disadvantages of triticale cultivation. The two most important disadvantages reported by far were triticale's low producer price (42% of respondents) and farmers' uncertainty about its acceptance by the State (33%) (Table 31). In contrast, agronomic constraints to triticale production, such as difficulty in mechanical harvesting or grain and straw quality, seem to be of concern to relatively few farmers.

Implications for Policy and Future Research

Main Policy Issues for Triticale

It is clear that government policy measures have, deliberately or inadvertently, played a crucial role in shaping recent trends in triticale production and utilization in Tunisia. Over a short period, triticale has moved from a situation of excess supply to excess demand. This chronic imbalance between supply and demand is an indication of some of the difficulties and policy dilemmas facing Tunisian decision makers in dealing with triticale.

Table 31. Farmers' opinions about the disadvantages of triticale cultivation, Tunisia

Disadvantage of triticale	Percentage of respondents (n=52)
Low producer price	42
Uncertainty over triticale's acceptance by the State	33
High production costs	15
Difficulty in mechanical harvesting	13
Seed mixed with barley	10
Low yield	8
Poor straw quality	8
Shriveled seed	6
Poor performance as secondary cereal	6
Lodging	4

Source: Survey data.

The key policy issues associated with the triticale dilemma in Tunisia can be summarized in two basic questions. First, should the government continue to promote triticale cultivation and utilization in

Tunisia? This question needs to be asked in light of three important factors, which were probably not taken into consideration when triticale was first introduced in Tunisia:

- Triticale cultivation expanded not only at the expense of barley area but also at the expense of a significant wheat area.
- Prolonged difficulties were encountered in promoting triticale use by feed millers. The recent sharp increases in triticale use have been primarily in ruminant feed, with only limited (though increasing) triticale use in poultry feed.
- The expansion in triticale production and consumption required substantial government subsidies. At present, government subsidies on triticale amount to a total of 61 TD/t.[15] The sale of close to 100,000 t of triticale in 1991/92 was possible only because the government was willing to incur approximately six million Tunisian dinar in subsidy payments. This heavy burden on the public treasury is unlikely to be sustained, given the government's current budgetary constraints.

If the answer to the first question is "yes," and triticale production and consumption are still economically justifiable in Tunisia despite the three factors described above, then the second question may be asked: what are the most efficient policy measures for ensuring that limited triticale supplies are allocated to poultry feeding (its best alternative use) rather than to ruminant feeding (the second best alternative)? Each of these questions is examined in detail in the following sections.

Economic Feasibility of the Triticale Option in Tunisia

The "triticale option" in Tunisia consists of incorporating triticale in poultry feed as a partial substitute for maize. Although this option will reduce maize imports, it will increase barley and wheat imports, because triticale cultivation will expand at the expense of these two crops. The farm survey has demonstrated that triticale cultivation is economically feasible for farmers, particularly when triticale replaces barley rather than wheat. Similarly, Belaid (1994) and Najar (forthcoming) have demonstrated that the incorporation of triticale in poultry diets, at the expense of maize, is economically feasible for feed millers.

However, the economic feasibility of triticale production or utilization from the viewpoint of private economic actors, such as farmers and feed millers, does not necessarily guarantee that the triticale option is economically feasible for the Tunisian economy as a whole. This is caused primarily by the substantial divergence between official prices (either producer or selling prices) of cereals and of feed ingredients and their true value, as a result of the various direct and indirect subsidies on these commodities. Thus, prior to assessing the economic feasibility of the triticale option in Tunisia, it is important first to determine the true value of the main commodities involved in such an assessment: those competing with triticale in production (durum wheat, bread wheat, and barley) as well as those competing in utilization (maize and soybean meal, in addition to barley).

[15] Current subsidies on triticale include the 20 TD/t difference between the producer price (170 TD/t) and the selling price (150 TD/t), in addition to 41 TD/t in handling, transport, and storage costs incurred by the Office des Céréales.

What is the "true value" of triticale? — In a free and competitive market economy the forces of supply and demand should ensure that market prices reflect the "true value" of a given commodity to both producers and consumers and that resources are efficiently allocated in the production and consumption of that commodity. However, in Tunisia (as in many other countries, developing and developed), the market for food grains and feed ingredients is highly controlled by the government, which regularly fixes producer and consumer prices. In the absence of a domestic free market, the best approximation of the "true value" of a commodity is its international market price, which often constitutes the opportunity cost of that commodity.

Throughout this analysis, international import prices will therefore be used as the best available proxies for the true value of all cereals and feed ingredients that are either imported or substitute for imports. However, international import prices need to be adjusted for all the costs incurred in the import process (port charges, handling, transport, etc.). These adjusted prices are often referred to as the import parity prices (IPPs) and are commonly used as a basis for economic analysis.[16] The IPP for any tradable commodity can be calculated either for consumers or for producers. In Tunisia, the IPP for consumers (feed millers) is equal to the import price (cargo, insurance, and freight, or CIF) plus a 5% margin to cover the Office des Céréales handling costs. Import duties and taxes are not usually included in calculating IPPs, since they constitute transfers within the economy rather than real costs. Based on these assumptions, consumer IPPs for the main cereals (wheat and barley) and feed ingredients (maize and soybean meal) in Tunisia were computed (Table 32).

Table 32. Consumer and producer import parity prices (IPP) for the main cereal crops and feed ingredients, Tunisia, 1993

Price	Durum wheat	Bread wheat	Barley	Triticale	Maize	Soybean meal
FOB (US$/t)[a]	162	147	70	..	96	197
CIF (US$/t)[b]	197	182	105	..	131	212
CIF (TD/t)[c]	187	173	100	..	124	201
Consumer IPP (TD/t)[d]	197	182	105	131	131	211
Producer IPP (TD/t)[e]	149	136	65	90	..	..

Source: International prices from USDA-FAS (1993).

[a] Durum wheat: Canada No. 1 CW Amber Durum, FOB Thunder Bay; bread wheat: US No. 2 Hard Winter Ord. Prot., FOB Gulf ports; barley: Canadian Feed No. 1, Winnipeg Grain Exchange Monthly Average Cash Price, FOB Thunder Bay; maize: US No. 2 Yellow, FOB Gulf ports; soybean meal: US 44% extraction, CIF Rotterdam.

[b] An amount of US$ 35/t is added to FOB prices of wheat, barley, and maize for ocean freight from Canadian or US ports to Tunis, whereas US$ 15/t is added to the price of soybean meal for ocean freight from Rotterdam to Tunis.

[c] An average exchange rate of TD 0.95 to US$ 1.00 is used.

[d] Consumer import parity prices (IPPs) are computed by adding a 5% margin to cover costs (handling, etc.) incurred by the Office des Céréales. The triticale IPP is assumed to be equal to that of maize.

[e] Producer IPPs are computed by deducting from the consumer IPP costs of transport, handling, and other costs incurred by the Office des Céréales, as follows: TD 48/t for durum wheat, TD 46/t for bread wheat, TD 41/t for triticale, and TD 40/t for barley.

[16] See, for example, Scandizzo and Bruce (1980), Gittinger (1982), Westlake (1987), and Byerlee and Morris (1993).

The lack of an international triticale price prevents direct computation of an IPP for triticale. Nevertheless, given that triticale is a direct substitute for maize imports, its IPP is assumed to be equal to that of maize. To calculate producer IPPs, further adjustments are needed to account for transfer costs from the point of production to that of consumption. In 1992, the Office des Céréales incurred transfer costs (transport, storage, financial costs, handling, etc.) amounting to 48 TD/t for durum wheat, 46 TD/t for bread wheat, 41 TD/t for triticale, and 40 TD/t for barley (Office des Céréales unpublished data, 1993). Based on these adjustments, the producer IPP for triticale would be 90 TD/t. Similar calculations give the producer IPPs for durum wheat (149 TD/t), bread wheat (136 TD/t), and barley (65 TD/t) (Table 32).

Social costs and benefits of triticale — Assessing the economic feasibility of the triticale option in Tunisia involves comparing the social costs and benefits of that option and estimating the net social gains (or losses) of that option. The term "social" is used here to indicate that the feasibility analysis is based on the "true economic value" (the IPP) of cereals and feed ingredients rather than on official prices.

Social gains from triticale production. On the production side, the net gain from triticale cultivation is equal to the difference in value between triticale and the other competing cereals, adjusted for differences in costs of production. Based on the results of the farm survey, the following average yields are used (Tables 24 and 25): triticale: 2.5 t/ha; durum wheat: 2.4 t/ha; bread wheat: 2.3 t/ha; and barley: 2.0 t/ha. Gross revenues per hectare are computed for each crop based on the producer IPPs:

Triticale:	2.5 t/ha x 90 TD/t = 225 TD/ha
Durum wheat:	2.4 t/ha x 149 TD/t = 358 TD/ha
Bread wheat:	2.3 t/ha x 136 TD/t = 313 TD/ha
Barley:	2.0 t/ha x 65 TD/t = 130 TD/ha

Thus, each hectare planted to triticale results in the following net gains (or losses):

Durum wheat:	225 - 358 + 13 = -120 TD/ha
Bread wheat:	225 - 313 + 10 = -78 TD/ha
Barley:	225 - 130 - 12 = +83 TD/ha

These results confirm that triticale production is economically justifiable only if triticale is cultivated at the expense of barley. Given the current low triticale producer price compared to wheat, it is very likely that any future expansion of triticale area will be primarily at the expense of barley rather than wheat area. Under this somewhat optimistic assumption, the net social gains from triticale production would amount to 83 TD/ha, or an average of about 33 TD/t of triticale produced.

In contrast, if we assume that triticale area continues to replace both wheat and barley area at the same rate as in the past, then the net social gains of triticale production are calculated based on a weighted average between the net losses from the replacement of wheat and the net gains from the replacement of barley. If, for the sake of this analysis, we ignore the area

of forages and other crops replaced by triticale, the results of the farm survey can be extrapolated to provide the following weights (Table 18): 7% for durum wheat, 38% for bread wheat, and 55% for barley. The weighted average of the net gains from triticale production would therefore be: Average Net Gains = (83 x 0.55) - (78 x 0.38) - (120 x 0.07) = 7.6 TD/ha, i.e., an average of 3 TD/t of triticale produced.

Net gains from triticale utilization. On the utilization side, the net gains from triticale consist of the savings in the cost of poultry and ruminant feed rations. In the case of poultry rations, Belaid (1994) estimated that the incorporation of 20% triticale in the feed concentrate for broiler chickens would save 7.5 TD/t of concentrate. Thus, each ton of triticale used in broiler rations will result in 38 TD in cost savings. Similarly, the incorporation of 30% triticale in the feed rations of layers would lead to a savings of 11.9 TD/t of concentrate, or 40 TD in cost savings per ton of triticale used. Given that layers account for an average of 60% of poultry feed in Tunisia, compared to 40% for broilers (Kristjanson et al. 1990), each ton of triticale used in poultry feed will result in an average of 39 TD in cost savings.

In contrast, Najar (forthcoming) estimated that incorporating 20% triticale in feed concentrates for ruminants would result in 3.6 TD cost savings per ton of concentrate. Thus each ton of triticale used in ruminant feed would save an average of 18 TD. Although triticale utilization is economically justifiable in both poultry and ruminant feed, it is very clear that it is much more economically efficient to incorporate triticale into poultry diets than into ruminant feed.

Net social gains of the triticale option. In light of these estimates of social gains from the production and utilization of triticale, the net contribution of the triticale option to the Tunisian economy can be computed based on the following worst-case and best-case scenarios. The best-case and most economically efficient scenario consists of growing triticale at the expense of barley and utilizing it exclusively for poultry feed. Under this scenario, the net economic contribution of triticale would amount to 72 TD (33 TD net gains from production plus 39 TD net gains from utilization) for each ton of triticale produced and consumed in Tunisia. Assuming a realistic target of 15% incorporation of triticale in all poultry feeds in Tunisia, this implies a total triticale consumption of about 55,000 t, which would require the cultivation of about 25,000 ha. Thus, triticale's net contribution to the Tunisian economy would amount to approximately 4.0 million TD per year.

In contrast, the worst-case scenario consists of growing triticale at the expense of both barley and wheat (55% barley, 38% bread wheat, and 7% durum wheat) and limiting utilization to ruminant feeding only. Under this scenario, the net economic contribution of triticale would amount to 21 TD (3 TD net gains from production plus 18 TD net gains from utilization) for each ton of triticale produced and consumed in Tunisia. Given current triticale area of about 13,000 ha and average yields of 2.0 t/ha, total annual production would amount to an average of about 25,000 t. This implies that triticale's total contribution to the Tunisian economy would amount to only 0.5 million TD/yr.

Realistically, however, triticale's future contribution to the Tunisian economy will be somewhere between these two scenarios. Should triticale cultivation expand again, it is likely that this expansion would occur more at the expense of barley area rather than wheat. Similarly, depending on relative feed selling prices, triticale utilization in ruminant feed is expected to continue, though the share of triticale in poultry feed may increase. Thus triticale's annual contribution to the Tunisian economy would range between 21 and 72 TD/t, or an average of about 47 TD/t.

Foreign exchange implications — The underlying objective of the triticale option in Tunisia is to reduce maize imports, which were placing an increasingly heavy burden on Tunisia's foreign exchange reserves. In fact, each ton of locally grown triticale used in poultry feed will reduce maize imports by US$ 131.

At the same time, each hectare of barley replaced by triticale cultivation would result in an average of two additional tons of barley imports (at US$ 105/t) to compensate for the foregone barley output (assuming all triticale is fed to poultry). Given an average triticale yield of 2.5 t/ha, this implies that each ton of triticale produced in Tunisia would result in an increase of US$ 84 in barley imports. Under the best-case scenario described earlier, each ton of triticale produced and consumed in Tunisia would result in net foreign exchange savings of US$ 47 (US$ 131 in savings in imported maize minus US$ 84 in additional barley imports). In 1991, when national triticale output reached a record 44,200 t, the net savings in foreign exchange as a result of triticale amounted to US$ 2.1 million.

Even under the worst-case scenario mentioned earlier, the foreign exchange required to import the additional wheat and barley would amount to US$ 123/t of triticale produced,[17] which would be offset by the US$ 131 in savings due to lower imports of maize.

Triticale Pricing Policy

This analysis clearly demonstrates that both triticale production and utilization are economically justifiable in Tunisia, even under the most pessimistic assumptions. Furthermore, although it is economically feasible to use triticale in poultry and ruminant feed, the incorporation of triticale in poultry diets is by far the most economically efficient mode of utilization. On the production side, the most economically efficient expansion of triticale area will be at the expense of barley rather than wheat.[18] In fact, the expansion of triticale at the expense of either durum or bread wheat would most likely lead to substantial economic losses and should be avoided.

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[17] This is based on the following calculations of the import value of the foregone wheat and barley output:
Durum wheat: 2.4 t/ha x 197 US$/t = 473 US$/ha;
Bread wheat: 2.3 t/ha x 182 US$/t = 419 US$/ha;
Barley: 2 t/ha x 105 US$/t = 210 US$/ha.

Weighted average = (473 x 7%) + (419 x 38%) + (210 x 55%)
= 308 US$/ha or 123 US$/t of triticale.

[18] Not enough data are available to examine the feasibility of triticale replacing other crops such as forages or legumes.

Given the substantial contribution of triticale production and utilization to the Tunisian economy, the next step is to determine the most efficient policy measures for expanding both production and utilization. More specifically, it is important to identify which policy measures will promote the most economically efficient modes of triticale utilization (i.e., in poultry feed) and production (i.e., at the expense of barley rather than wheat area), at the lowest cost possible to the government budget.

Since the Tunisian government is directly involved in setting producer and consumer prices for most cereals and feed ingredients, pricing policy is likely to be the most effective policy instrument at the disposal of the government to influence triticale production and consumption trends. Thus, the analysis in this section will focus entirely on the issue of how to set triticale producer and consumer prices. Given the close substitution between triticale and barley in both production and consumption, barley pricing policy will also be examined in some detail.

The determination of triticale prices in Tunisia should take three basic factors into consideration:

- Triticale producer and consumer prices should lead to *economic efficiency*. Prices should reflect the "true value" of triticale to the Tunisian economy, thus ensuring that farmers do not allocate too much (or too little) of their limited resources (land, labor, purchased inputs, etc.) to triticale production in comparison to competing cereal crops. It will also ensure that feed millers do not include too much (or too little) triticale in the formulation of least-cost animal feed rations, in comparison to other available feed ingredients.

- Triticale producer and consumer prices should be *"fair."* The triticale producer price should reflect the same amount of direct or indirect subsidy (or tax) as the competing cereals. Similarly, the triticale consumer price should include a subsidy (or tax) equal to that for competing feed ingredients.

- Triticale prices should be set to minimize the need for either producer or consumer subsidies, thus taking government budget constraints into consideration.

Determining efficient, fair triticale consumer and producer prices — For triticale prices to be economically efficient, they need to reflect as much as possible the "true value" of triticale to the Tunisian economy. If triticale consumer and producer prices are based on the consumer IPP (131 TD/t) and producer IPP (90 TD/t), this should ensure economic efficiency as well as eliminate the need for government subsidies. However, to ensure fairness in pricing, triticale prices should result in the same degree of protection as competing cereals (wheat and barley) and feed ingredients (maize, soybean meal, and barley). In other words, the magnitude of implicit subsidy (positive protection) or implicit tax (negative protection) on triticale should be in the same range as subsidies (or taxes) on other commodities.

One common measure of the degree of protection (positive or negative) to consumers or producers is the nominal protection coefficient (NPC).[19] For a tradable commodity, the NPC is defined as the domestic price of that commodity divided by its IPP. For consumers (feed millers), an NPC greater than unity indicates that the commodity in question is implicitly taxed, while a value smaller than unity suggests implicit consumption subsidy. Conversely, for farmers, an NPC greater than unity implies production subsidies, while a value smaller than unity indicates an implicit tax on production.

Consumer prices. Based on the consumer IPPs, consumer NPCs for the main feed ingredients were calculated (Table 33): 1.41 for maize, 1.26 for soybean meal, 1.60 for barley, and 1.15 for triticale. Thus, compared to other feed ingredients, triticale seems to be relatively underpriced, whereas barley seems highly overpriced. Given that all imported feed ingredients and cereals in Tunisia are subject to explicit import duties and taxes amounting to about 25%,[20] "fairness" in consumer pricing implies the need for substantially reducing the price of barley and increasing the price of triticale to a level where their rate of protection will be equal to about 25% (NPC=1.25). This implies that the barley consumer price should be reduced from 168 to 131 TD/t, while the price of triticale should be increased from 150 to 164 TD/t (Table 33).

Table 33. Import parity prices (IPPs) and official and recommended consumer and producer prices for the main cereal crops and feed ingredients, Tunisia, 1993

Price	Durum wheat	Bread wheat	Barley	Triticale	Maize	Soybean meal
Consumer prices (TD/t)						
IPP[a]	197	182	105	131	131	211
Official[b]	122	100	168	150	185	265
NPC consumer[c]	0.62	0.55	1.60	1.15	1.41	1.26
Recommended	..	..	131	164	..	..
NPC	..	..	1.25	1.25	..	..
Producer prices (TD/t)						
IPP[d]	149	136	65	90	..	..
Official[e]	260	225	150	170	..	..
NPC producer[f]	1.74	1.65	2.31	1.89	..	..
Recommended	..	..	110	153	..	..
NPC	..	..	1.70	1.70	..	..

Source: For international prices, see Table 32. Domestic producer prices from Ministère de l'Agriculture, République Tunisienne (1991). Domestic consumer prices from information provided by officials of the Office des Céréales.

[a] Consumer IPPs from Table 32.

[b] Prices paid by millers (*"prix de retrocession"*), May 1993.

[c] Nominal protection coefficient (NPC) for consumers = ratio of official consumer price to consumer IPP.

[d] Producer IPPs from Table 32.

[e] Prices received by farmers, 1992/93 crop season.

[f] NPC for producers = ratio of official producer price to producer IPP.

[19] See, for example, Scandizzo and Bruce (1980) and Westlake (1987).

[20] Consisting of 17% in import duties, 6% in value added tax (TVA), and 1.75% in other taxes and fees (0.25% in *redevance compensatoire* and 1.5% in *tax compensatoire*) (Kristjanson et al. 1990).

These recommended readjustments in selling prices will substantially increase the triticale-to-barley price ratio from 0.89 to 1.25, while the triticale-to-maize price ratio will also increase, but only slightly, from 0.81 to 0.89. Such dramatic changes will have several implications for the utilization of both triticale and barley. The sharp drop in the price of barley will probably trigger substantial increases in barley consumption, as was the case between November 1992 and February 1993 when barley was sold by the government at 128 TD/t. Increased barley consumption will lead to the gradual elimination of the expensive government barley stocks as a result of the bumper crops of 1991 and 1992. Moreover, the lower barley consumer price will result in cheaper feed costs in general, which will lead to lower consumer prices of red meat and other animal products.

By replacing barley with triticale in making concentrates for sheep and cattle, many feed millers have been able to produce more nutritious feed at a lower cost. The proposed triticale consumer price is much higher than that of barley (164 and 131 TD/t, respectively), which should partially reflect triticale's nutritional advantage. As a result, many feed millers are likely to switch back to barley in making concentrates for sheep and beef cattle, while the more expensive (and more nutritious) triticale would be reserved for making concentrates for poultry and, possibly, for dairy cattle. Thus, the bulk of the limited triticale supplies would be available to be incorporated in poultry feed without the need for the government to ration sales of triticale. With a triticale price still lower than maize, the feed industry should continue to find it profitable to replace maize with triticale in poultry feed, though the cost-saving incentive will be slightly lower.

The current "overpricing" of barley (compared to international market prices) constitutes a very high implicit tax on barley users, which seems paradoxical given that barley is by far the most important locally produced feed ingredient in Tunisia. This can only be explained as an apparent attempt by the government to maintain a relatively very high producer price for barley (compared to international prices) by implicitly taxing barley users (feed millers and livestock producers). Thus, when feed users are purchasing barley at 168 TD/t instead of an "optimum" price (consumer IPP) of 105 TD/t, they indirectly subsidize barley producers at a rate of about 63 TD/t. This indirect subsidy by barley users is augmented by a 22 TD/t direct subsidy paid by the government, resulting in a total producer subsidy of 85 TD/t of barley. This allows the government to pay barley farmers the current producer price of 150 TD/t instead of the "optimum" price (producer IPP) of 65 TD/t.

Producer prices. The overpricing of barley is clear on both the consumption and production sides. Barley's producer NPC of 2.31 indicates a much higher implicit producer subsidy to barley than to durum wheat (NPC=1.74), bread wheat (NPC=1.65), or triticale (NPC=1.89) (Table 33). This implies that farm resources in Tunisia may currently be inefficiently allocated to produce "too much" barley, at the expense of "too little" wheat and triticale. Given an average 70% protection for wheat producers,[21] "efficiency and fairness" in producer pricing requires a reduction in the price of barley and, to a lesser extent, in that of triticale to a level where their rate of protection will be equal to wheat's. Therefore, this

[21] That is, the average between an NPC of 1.74 for durum wheat and 1.65 for bread wheat.

implies that the triticale producer price should be reduced from 170 to 153 TD/t. The largest adjustment, however, is needed in the barley producer price, which should be reduced from 150 to 110 TD/t (Table 33).

These recommended adjustments in producer prices will substantially increase the triticale-to-barley producer price ratio from 1.13 to 1.39, while the triticale-to-bread wheat price ratio will decline slightly from 0.76 to 0.68. Therefore, despite the modest decline in triticale prices, the sharp drop in barley prices should encourage farmers to switch from barley cultivation to either wheat or triticale.

Implications for government expenditures — If the triticale producer price is set at 153 TD/t and its consumer price at 164 TD/t, the implicit tax on triticale consumption will rise from 19 to 33 TD/t, while the implicit producer subsidy will fall from 80 to 63 TD/t (Table 34). Therefore, total government subsidy payments could drop from their current level of 61 TD/t to 30 TD/t, a net savings to the government budget of 31 TD/t of triticale. In light of earlier results indicating that triticale contributes an average of about 47 TD/t to the Tunisian economy, a subsidy of 30 TD/t would be justified economically, unlike the current subsidy (61 TD/t). In the case of barley, if the producer price is set at 110 TD/t and the consumer price at 131 TD/t, the implicit taxes on barley users would be reduced dramatically from 63 to 26 TD/t, accompanied by a similar reduction in implicit producer subsidies from 85 to 45 TD/t (Table 34). Thus, while total government subsidy payments on barley will decline only slightly, from 22 to 19 TD/t, the share of these payments between producers and consumers will be much fairer.

Table 34. Implicit and actual taxes and subsidies on barley and triticale consumption and production under current and recommended prices, Tunisia, 1993

	Barley		Triticale	
	Current price	Recommended price	Current price	Recommended price
Consumers (TD/t)				
IPP[a]	105	105	131	131
Official price[a]	168	131	150	164
Subsidy (Tax)	(63)	(26)	(19)	(33)
Producers (TD/t)				
IPP[a]	65	65	90	90
Official price[a]	150	110	170	153
Subsidy (Tax)	85	45	80	63
Government subsidy payments (TD/t)	22	19	61	30

[a] Computed from Table 33. Refer to notes in Table 33 for definitions of terms.

It should be noted that government subsidies on either triticale or barley can be eliminated completely either by reducing producer prices, increasing consumer prices, or a combination of both. Given the relatively high rate of protection to producers, the logical move will be to reduce producer prices to bring them closer to international prices. However, to maintain fairness and efficient allocation of resources, producer prices ought to be reduced for wheat as well as for barley and triticale. As shown in Table 33, the most economically efficient producer prices, i.e., those based on international prices (producer IPPs), are: 149 TD/t for durum wheat, 136 TD/t for bread wheat, 65 TD/t for barley, and 90 TD/t for triticale.

If, however, the government decides to maintain subsidies on wheat production (for national food security or any other reason), then the same level of protection will be needed for barley and triticale to ensure fairness as well as an efficient allocation of farm resources in production. Therefore, increasing consumer prices will be the only alternative to reduce government subsidies. But this, in return, will result in unfairly high feed prices that may lead to higher consumer prices for animal products.

In the case of triticale, if the recommended producer price of 153 TD/t is set, then a consumer price of 194 TD/t will be needed to eliminate government subsidy payments. However, such a price will be higher than the current maize price and, very likely, too high to justify the utilization of triticale in poultry feeding. Therefore, as long as triticale production is subsidized (as well as the production of wheat and barley), government payments will be needed to cover producer subsidies.

Summary of Policy Implications

These analyses clearly demonstrate that the production and utilization of triticale in Tunisia are economically justifiable from the viewpoint of farmers and feed millers and the Tunisian economy as a whole. Furthermore, the incorporation of triticale in poultry diets is by far the most economically efficient mode of utilization. The most economically efficient expansion of triticale area will be at the expense of barley rather than wheat area; the expansion of triticale at the expense of either durum or bread wheat is likely to lead to substantial economic losses and should be avoided.

The analysis also indicates that each ton of triticale produced and consumed in Tunisia contributes an average of 21-72 TD/yr to the Tunisian economy, including 8-47 US$/yr in net savings in foreign exchange expenditures. Although such contributions are substantial, they do not seem large enough to justify the current government subsidy of 61 TD per ton of triticale. Such a large subsidy is also difficult to justify socially, especially since the main beneficiaries are large farmers and large corporations (feed millers). Yet if the government does not guarantee triticale marketing and provide some subsidies, triticale cultivation in Tunisia will probably drop to a mere 3,000 ha for on-farm animal feeding. Without government support, it is very likely that Tunisia will see the virtual disappearance of a crop that has shown great adaptability and productivity under Tunisian conditions and that could gradually lead to substantial savings in foreign exchange resulting from lower maize imports.

One possible alternative to government support for triticale production is to establish direct production contracts between large feed millers in Tunisia, such as Poulina, and triticale growers. Such contractual arrangements have been reported in South Africa, where a large poultry company announced its readiness to buy the entire triticale crop at guaranteed prices set at 82.1-92.3% of the maize price, depending on the protein content of the triticale (Roux and Marais 1993).

However, should the Tunisian government decide to continue its support to triticale production, there is a need not only to reduce its subsidies to triticale but also to reform its triticale pricing policy to improve economic efficiency and fairness in pricing. Based on the results of this study, it is recommended that the consumer price of triticale be increased from 150 to 164 TD/t, while the producer price should be reduced from 170 to 153 TD/t. This will reduce total government subsidy payments from the current level of 61 TD/t to 30 TD/t. Unlike current subsidies, this reduced subsidy is economically justifiable since it is much lower than the net social gains from triticale.

Moreover, for the recommended triticale price adjustments to be efficient and fair, they need to be accompanied by similar adjustments in barley prices, given the close substitution between triticale and barley. Barley seems to be excessively overpriced compared to international prices, both on the production and consumption sides, implying that "too much" barley is produced at the expense of other crops such as wheat and triticale. To achieve greater economic efficiency and better fairness in pricing, it is recommended that the barley consumer price should be reduced from 168 TD/t to 131 TD/t and that its producer price be reduced from 150 TD/t to 110 TD/t. These readjustments will bring barley prices closer to international prices and will slightly reduce total government subsidies for barley from 22 to 19 TD/t.

This analysis reconfirms the crucial role of barley pricing policy as the key determinant of triticale production and consumption trends in Tunisia. Most problems associated with the chronic imbalance between the supply and demand of triticale seem to have their roots in the more serious imbalances that characterize the barley subsector. Therefore, as long as the problems of barley consumer and producer pricing are not sorted out, imbalances in the barley subsector will likely continue to have a destabilizing influence on the triticale subsector and may undermine any attempts to establish a coherent triticale production and consumption policy independently of barley.

Future Research

When survey farmers were asked about the disadvantages of triticale cultivation, apart from the marketing and pricing issues, most of them expressed full satisfaction with the crop. The only two "agronomic" disadvantages frequently mentioned were poor straw quality and shriveled seed (Table 31). Thus future breeding work should focus on alleviating these two problems. The issue of poor straw quality may not play an important role in the diffusion and adoption of triticale, since its higher straw yield compared to other cereals is likely to compensate for its slightly lower straw price. However, more detailed economic analyses are needed for an accurate assessment of the economic significance of triticale's poor straw quality.

The problem of shriveled seed, which is more common with older triticale varieties, could be reduced if some of the newer varieties available at CIMMYT are selected for Tunisian conditions. This is particularly important given the expansion of triticale in the drier areas. However, according to Tunisian researchers, the main obstacle to further triticale expansion in the drier areas of Northern and Central Tunisia is triticale's sensitivity to heat, which exacerbates the problem of shriveled seed. The development of more heat-tolerant varieties should be an important priority for triticale breeding in Tunisia and at CIMMYT. Such varieties would encourage triticale cultivation in the more marginal areas of Central and Southern Tunisia which are unsuitable for wheat or barley.

In Northern Tunisia, research should focus on triticale grown as a secondary cereal, because triticale's yield advantage over wheat or barley is more apparent when it is grown this way. On-farm and on-station yield trials should be planned to take that characteristic into consideration; currently, all the cereals in the trial are sown as primary cereals.

On the utilization side, most triticale in Tunisia is still used in ruminant feed despite clear evidence that triticale is substantially more economical in poultry feed. However, triticale use in poultry feed has been increasing and could soon become the dominant mode of triticale utilization in Tunisia. As shown by Belaid (1994), triticale's high protein and lysine content makes it possible to reduce the share of soybean meal in the poultry ration. At the same time, because maize has a higher content of metabolizable energy than triticale, a relatively higher share of triticale will be needed in the ration. The higher the metabolizable energy, crude protein, and essential amino acid content of triticale, the higher will be its profitability in poultry feed. In light of the recent end-use orientation in CIMMYT's triticale breeding program (Pfeiffer 1992), breeding at CIMMYT should concentrate on new triticale lines with higher crude protein content, higher content of essential amino acids such as lysine, and a higher level of metabolizable energy.

Given that the current worldwide utilization of triticale is primarily for animal feed, including poultry feed, chemical analyses of promising triticale lines should become a regular feature of varietal screening at CIMMYT. Such analyses would not only identify lines with the most desirable chemical profile for animal feed, but could also test for antinutritional factors common in older triticale varieties. Moreover, the serious problems created by the Tunisian feed industry's prolonged reluctance to use triticale in poultry feed points to the need for more research on the impact of triticale on poultry performance, including large-scale trials with poultry producers. More detailed research is also needed in Tunisia to determine triticale's maximum inclusion rates in the diets of the various stages of broiler and layer chickens.

Similar research is also needed to look into the impact of triticale on ruminant feeding and performance, and to determine the optimum inclusion rates of triticale in the diets of ruminants. Furthermore, it is important that Tunisian researchers make better use of the germplasm available at CIMMYT to select locally adapted dual-purpose varieties, varieties suitable in forage mixtures, and varieties for making silage.

Finally, it is very important that future research in Tunisia focus on the possibility of using triticale in making bread and other foods, such as couscous and pasta. Although this does not currently constitute a priority for policy makers, the future incorporation of triticale in bread-making may substantially reduce Tunisia's growing imports of bread wheat. Such an option needs to be examined seriously, including a detailed assessment of all its technical aspects as well as a thorough evaluation of its economic feasibility.

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