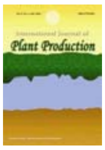

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Wheat and barley seed system in Syria: farmers' varietal perceptions, seed sources and seed management

Z. Bishaw[a,*], P.C. Struik[b], A.J. G van Gastel[c]

[a]*Seed Section, ICARDA, P.O. Box 5466, Aleppo, Syria.*
[b]*Center for Crop Systems Analysis, Wageningen University, Wageningen, The Netherlands.*
[c]*Harspit 10, 8493KB, Terherne, The Netherlands.*
*Corresponding author. E-mail: z.bishaw@cgiar.org

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Abstract

A total of 206 wheat and 200 barley farmers were interviewed in northeastern Syria to understand farmer perceptions and practice relating to modern varieties, seed sources and seed quality. Wheat farmers had better awareness and grew modern varieties (87%), applied fertilizers (99.5%), herbicides (93%), seed treatment (90%) or insecticides (41%). In contrast barley growers had low awareness (36%) and use (0.5%) of modern varieties, herbicides (4%), insecticides (3%) and fertilizers (56%). Grain yield, grain size, food quality and tolerance to lodging, drought and frost were the agronomic characteristics farmers sought from new wheat varieties. For barley, grain yield, grain size, grain color, feed quality, marketability and tolerance to diseases and drought were the key traits sought. The informal sector-seed retained from the previous harvest or obtained from neighbors or local traders/markets-was the main source of seed for both wheat and barley. Most farmers practiced on-farm seed selection, cleaning, treatment, separate storage or quality assessment of seed that was obtained locally. Farmers' perceptions and preferences of new varieties/technologies and their seed sources and seed management practices must be taken into account in any efforts to develop or to strengthen seed sector development.

Keywords: Syria; Seed system; Seed source; Seed management.

Introduction

Wheat and barley are strategic crops, important for food and feed security. The two crops are widely grown but in contrasting agro-ecologies. Wheat is a major food staple while barley is mostly used for livestock feed (Bishaw, 2004).

Syria's plant breeding program began with the establishment of the Department of Agricultural and Scientific Research (DASR) in the 1960s. Several varieties were released with recommended agronomic packages for wheat (Hamblin et al., 1995; Nachit et al., 1998; Mazid et al., 2003) and barley (Haddad et al., 1997). The General Organization for Seed Multiplication (GOSM) was established in 1976 as the sole public sector agency supplying certified seed of a range of crops. During 1994-1999, average annual seed supply was 227,869 tons; of which 74% was agricultural crop seed. Wheat and barley accounted for 94% and 3.4% of agricultural crop seeds distributed in the country. In the past 10 years, little has changed in the structure and performance of the formal seed sectors for wheat and barley.

Adoption studies assume that new agricultural technology is appropriate and suits farmers' needs. In Syria and elsewhere, little information is available on farmers' perception and preferences of wheat and barley varieties and crop management technologies, farmers' seed sources and seed management practices. This study of wheat and barley seed systems compares the two crops at different stages in the technology adoption process. The objectives of the study were to: (i) understand the functioning of the wheat and barley seed systems, particularly the informal sector; (ii) understand farmers' perceptions and preferences relating to modern varieties and associated technologies; (iii) document farmers' seed sources and knowledge of seed management to strengthen seed delivery systems.

Materials and Methods

Selection of study areas and administration of survey questionnaires are described in Bishaw et al. (2010). A multistage purposive random sampling procedure was followed from higher to lower administrative levels, comprising selection of provinces, districts, zones, villages and individual wheat or barley farmers. In each district zones 1 and 2 were sampled for wheat, and zones 2, 3 and 4 for barley. A semi structured questionnaire was used to gather data on farmers' perceptions, adoption and diffusion of modern varieties, farmers' seed sources, selection and management. This was supplemented by secondary data from different sources.

Study Areas

Aleppo, Raqqa and Hassakeh, three major wheat and barley production provinces in northeastern Syria, were selected based on secondary data from the Central Bureau of Statistics (Figure 1). These provinces together account for nearly 65% of wheat and 78% of barley area in the country and provide contrasting situations in terms of agro-ecology, farming systems, and proximity to agricultural research and service institutions.

Data Collection

Wheat: the survey was conducted in November and December in the 1998/99 crop season. A total of 206 wheat farmers were surveyed from three provinces, six districts and 61 villages. These farmers were located in Aleppo (36%), Raqqa (15%) and Hasakeh (49%) provinces. In total, 33% of farmers were in zone 1 and 67% in zone 2.

Barley: the survey was conducted in October and November in the 1997/98 crop season, with 200 farmers (not covered by he wheat survey) in three provinces, eight districts and 59 villages. These farmers were located in Aleppo (47%), Raqqa (24%) and Hasakeh (30%) provinces. In total, 47% of farmers were in zone 2, 38% in zone 3 and 26% in zone 4.

In both surveys, a minimum of two farmers were interviewed in each village. Data were analyzed using SPSS software where descriptive statistics were used.

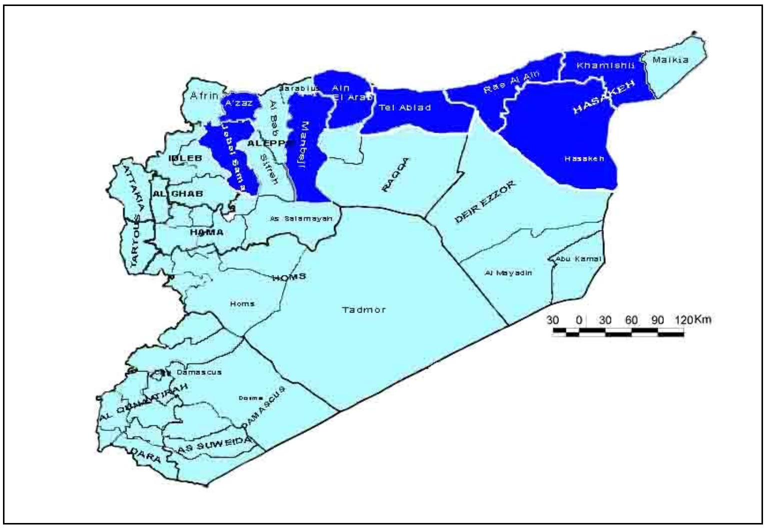

Figure 1. Wheat and barley seed system study areas (dark shade) in Syria.

Results and Discussion

Demographic and Socio-Economic Factors

The average age of the farmers surveyed was 46 (wheat) and 47 (barley); all had many years of farming experience. About 86% of wheat and 94% of barley farmers were married, with an average of 7 children and 1:1 female to male ratio in both groups. The findings for wheat differ from Issa (1991), but the barley findings are similar to those reported by Mazid (1994).

Education levels were different in wheat and barley growers: 54% of wheat farmers could read and write, nearly 20% had formal education (elementary or secondary school). In contrast, 47% of barley farmers were illiterate and many lacked formal education, probably because some barley growing areas (zone 4) were remote. These differences in education might influence the adoption of new agricultural technologies.

Almost 88 and 95% of wheat and barley growers respectively, own land. The remaining farmed on government land. About 54% and 5% of wheat farmers (n=206) owned tractors and combine harvesters, compared to 34% and 9% of barley farmers (n=200). Mazid (1994) also reported that 29% of barley growers owned tractors and 10% owned combine harvesters.

Agriculture is the main source of income for all wheat farmers and they were less likely to engage in seasonal labor migration. In contrast, barley farmers in drier zones work as migratory seasonal labor during the off-season.

Awareness of Wheat and Barley Production Technologies

Modern agricultural technologies in each environment have been recommended for wheat production, but less so for barley. Wheat farmers (n=206) had better awareness of and information about modern varieties (100%), agronomic practices (100%), fertilizers

(99%), herbicides (97%) and seed treatment (96%) compared to barley growers (Table 1). In both crops, fellow farmers (relatives, neighbors and other farmers) were the main sources of information, rather than formal extension services. This has been reported in other studies as well, e.g. Tripp and Pal (1998) for hybrid pearl millet growers in India.

Table 1. Farmers' awareness and sources of information for technology packages.

Crop	Awareness of information	Modern variety	Agronomy	Fertilizers	Herbicides	Fungicides[1]	Insecticides	Grain storage
Wheat (n=206)	Farmers	206	206	204	200	197	124	115
	%	100	100	99	97	96	60	56
Barley (n=200)	Farmers	72	187	159	62	-	62	141
	%	36	94	79	31	-	31	71

Note: [1]Seed treatment (chemical stores).

Among wheat growers, agricultural extension was the most important source of information for herbicides (52%), seed treatment (34%) and varieties (22%). Among barley growers, one-third had heard about new varieties and pesticides, the extension services being the main source of information. Although 36% of farmers were aware of new barley varieties none had tried growing them due to farmer preferences, lack of adapted varieties or seed availability. Farmers in zone 4 were less aware of modern varieties, herbicides and fertilizers; in this zone use of such inputs is officially discouraged in order to limit expansion of barley cultivation to marginal areas.

Although agricultural extension offices are well spread in Syria and many farmers are aware of their offices and activities (Mazid, 1994), only 38% of farmers visited them and only 23% of farmers had ever been visited by an extension agent. The existence of extension services alone is not sufficient for transfer of technology unless regular training is provided and research-extension-farmer linkages are created.

Adoption and Perception of Wheat and Barley Varieties

Adoption of varieties

Wheat

Since 1977, the Directorate of Agricultural and Scientific Research (DASR) has released eight bread and seven durum wheat varieties developed in partnership with CIMMYT/ICARDA and three varieties developed with ACSAD. In 1998/99, about 62 and 38% of sample farmers (n=206) grew durum and bread wheat varieties or landraces in Aleppo, Raqqa and Hasaskeh provinces respectively (Table 2). Farmers grew seven modern durum varieties (five recommended, one obsolete, one not released) and one landrace. Among durum varieties Cham 3 was planted by 26% of farmers on 26.3% of wheat area followed by Lahan (10% and 7%), Bohouth 5 (8.4% and 15%) and Cham 1 (6% and 2%). Nachit et al. (1998) found that Cham 1 and Cham 3 were the most widely grown durum varieties, both in terms of area (33 and 30% of area) and the proportion of farmers growing them (22 and 24% of farmers). Van Gastel and Bishaw (1994) found that Cham 1 was grown by 28% of farmers and Cham 3 by 11% in Aleppo province. Since then the proportion of Cham 1 has declined whereas that of Cham 3 has increased steadily. Similarly, bread wheat growers planted eight modern varieties (five recommended, one obsolete, two not released). Cham 6 was planted by 23% of farmers on 26.1% of the wheat area followed by Cham 4 (9.5% and 7.6%), Bohouth 6 (2.2% and 1.9%) and Bohouth 4 (1.1% and 0.6%). The number of farmers growing Cham 4 was almost doubled compared to earlier reports (van Gastel and Bishaw, 1994). Bread wheat varieties from the 1970s (Mexipak) and 1980s (Cham 2) were still grown by a smaller proportion of farmers, showing the persistence of older varieties.

Table 2. Wheat varieties grown by farmers in different regions of Syria (n=273).

Wheat type	Variety	Origin	Year released	Aleppo	Raqqa	Hasakeh	Total[a]	%
Durum wheat								
Recommended	Cham 1	DASR/ICARDA	1984	16	-	-	16	5.9
	Cham 3	DASR/ICARDA	1987	25	-	46	71	26
	Cham 5	DASR/ICARDA	1994	4	1	6	11	4
	Acsad 65	ACSAD	1987	9	-	9	18	6.6
	Bohouth 5	DASR	1987	1	9	13	23	8.4
Not recommended	Lahan	CIMMYT/ICARDA	-	19	2	5	26	9.5
Obsolete	Gezira 17	DASR	1975	-	2	-	2	0.7
Landrace	Hamari	Local		1	-	-	1	0.4
	Sub-total			75	14	79	168	61.5
Bread wheat								
Recommended	Cham 2	CIMMYT/ICARDA	1984	1	-		1	0.4
	Cham 4	CIMMYT/ICARDA	1986	3	15	8	26	9.5
	Cham 6	CIMMYT/ICARDA	1991	24	3	35	62	22.7
	Bohouth 4	DASR	1987	-	3	-	3	1.1
	Bohouth 6	DASR	1991	3	1	2	6	2.2
Not recommended	Memof	CIMMYT/ICARDA		1	-	-	1	0.4
	Lagous	CIMMYT/ICARDA		2	-	-	2	0.7
Obsolete	Mexipak	CIMMYT	1971	-	-	4	4	1.5
	Sub total			34	22	49	105	38.5
	Total			109	36	128	273	100

[a] 214, 22 and 5 farmers, respectively planted one, two and three wheat varieties.

Earlier studies showed that Hourani was the most widely grown landrace before the introduction of modern varieties such as Senator Cappelli and Florence Aurore followed by semi-dwarf wheat varieties like Mexipak in the 1970s (Bailey, 1982). The area under modern varieties increased dramatically (Table 2) with the introduction of mechanization, irrigation and intensification of agriculture from 8% of wheat area in 1973 to 55% in 1977 (Bailey, 1982), 89% in the early 1990s (Nachit et al., 1998) and 100% in the late 1990s (Pingali, 1999). These varieties replaced the landraces, but were grown for market, not for home consumption. Virtually the entire production is sold to government agencies at attractive prices (di Fonzo et al., 1995). Wheat landraces were abandoned because of low grain yield and low economic returns. Many farmers, however, continue growing small plots of durum landraces for home consumption because of preferences in taste and cooking quality for traditional foods (di Fonzo et al., 1995). In a targeted survey some durum landraces such as Bayadi, Hamari, Hourani, Hourani-Bayadi and Swadi were found grown in isolated pockets in Aleppo and Idleb provinces. Some landraces were traded over long distances from south to north Syria (Dara'a to Aleppo) by local merchants, demonstrating that farmers' varietal choices are not based solely on grain yield.

Cham 1, Cham 2, Cham 4, Bohouth 5, Bohouth 6 and Gezira 17 were recommended for irrigated and high rainfall areas (zone 1), whereas Cham 3 and Cham 5 were recommended for dry areas in zone 2 (Hamblin et al., 1995; Nachit et al., 1998). An old variety ACSAD 65 and later releases like Cham 6 and Cham 7 were recommended for zones 1 and 2. Bohouth 1 and Cham 8 were released exclusively for irrigated conditions. Almost all wheat varieties were grown interchangeably in zones 1 and 2 and under rainfed and irrigated conditions despite the recommendation domains based on agro-ecological zones. For example, 33% of respondents (n=273) grew varieties outside the recommended zones. Nachit et al. (1998) also found that Cham 3 was widely grown in zone 1 and under irrigated conditions despite the recommendation to grow the variety in zone 2. It is critical that varieties be matched to agro-ecological adaptation and recommendation domains, for maximum economic returns. Extension services and seed suppliers should make concerted efforts to ensure that farmers are aware of this.

Barley

Barley is grown in marginal environments where severe drought and thermal stress at maturity accompanied by spatial and temporal variations in rainfall remain major production constraints. Developing varieties with high yield and yield stability for such risky environments is difficult. From 1981 to 1994, however, seven modern barley varieties were released in Syria: three from ACSAD (ACSAD 60, ACSAD 68 and ACSAD176) and four from ICARDA (Badia, Furat 1, Furat 2 and Arta) materials. However, none of these varieties has been widely adopted; possibly because of poor adaptation or farmers' preferences. During the survey, farmers across different provinces and zones predominantly grew one landrace, Arabi Aswad (99%; n=200). Arabi Abiad (0.5%) and Furat 1 (0.5%) were grown by two farmers. Mazid (1994) also found a single farmer who adopted a modern barley variety in northwestern and northeastern Syria. Similar situations are reported in other countries. Despite numerous variety releases, new varieties occupied <2% of pearl millet area in Niger (Ndjeunga, 2002) and 12% of sorghum area in the eastern lowlands of Ethiopia (Mekbib, 2007).

Arabi Aswad (black seeded) and Arabi Abiad (white seeded) are the two landraces primarily cultivated in two distinct regions. Arabi Abiad is adapted and mostly cultivated in the wetter areas in western and northwestern Syria. Arabi Aswad is adapted to drier areas and popular in the northeast. It is important to note the predominance, in the entire survey region, of a single landrace (Arabi Aswad) with low on-farm varietal diversity. This demonstrates broad adaptation of this landrace to different production environments. In contrast, farmers in Ethiopia grew 14 different varieties (6 modern, 14 local) (Woldeselassie, 1999) probably owing to the diversity of agro-ecology and end-uses.

It is also interesting to note that one fourth of wheat growers who planted modern varieties grew only landrace of barley. In contrast, from 200 barley growers, over 50% also planted modern bread and durum wheat varieties, but still continued growing a barley landrace. In Ethiopia, although 61% of barley growers surveyed adopted modern bread wheat varieties, they continued cultivating barley landraces (Woldeselassie, 1999). Bishaw (2004) also found that from 304 wheat farmers, two-thirds grew barley; and two thirds of these grew landraces. Low adoption of modern barley varieties might be due to several factors: (i) barley is grown in harsh environments and farmers are risk averse, unwilling to try new varieties; (ii) new barley varieties might not be high yielding as claimed from on-station and on-farm trials; (iii) quality traits of new varieties may not fully meet farmer preferences; (iv) differential grain price incentives encouraged greater resource allocations to wheat at the expense of barley.

Perception of varieties

Wheat

Wheat growers articulated their perceptions of modern varieties they grew on their farms (Figure 2). Of the 206 farmers, 96% were satisfied with existing commercial wheat varieties and believed they are adapted to local conditions and have a good combination of agronomic traits. Cham 3 was rated high for its grain yield, grain quality, food quality, frost tolerance, drought tolerance and better response to low moisture. Lahan was appreciated for its high yield, grain size, non-lodging and frost tolerance. ACSAD 65 and Cham 5 were rated high for their low water requirements. In bread wheat Cham 6 was rated highly for grain yield, food quality, non-lodging and high yield with limited water. In contrast, Cham 4 was rated highly for yield, but low for other agronomic traits. This demonstrates that farmers' decisions to grow a particular wheat variety are primarily based on yield and economic returns (di Fonzo et al., 1995).

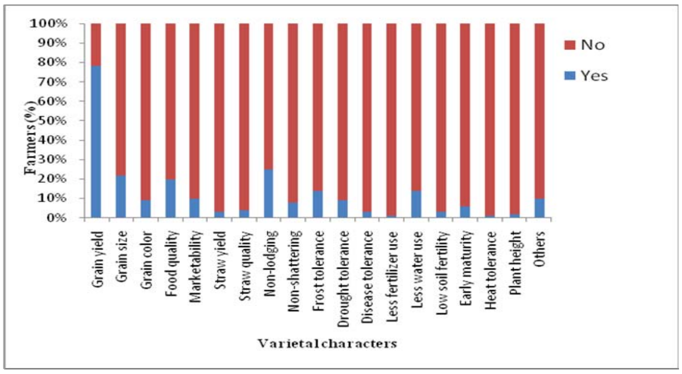

Figure 2. Farmers' perception of commercial wheat varieties (n=273).

Non-shattering and non-lodging appeared factors farmers considered most important, probably based on practical experience during crop production. The existing varieties were rated as very poor for both criteria by 33% and 17% of farmers, respectively. Under irrigated conditions farmers apply very high amounts of fertilizers to maximize productivity. This could increase lodging, which is apparently more affected by management than by variety alone. Similarly, mechanical harvesting of wheat might result in shattering particularly if delayed. Therefore, there is strong demand for varieties with better input response but also good agronomic characters such as tolerance to lodging and shattering.

Grain color and marketability appeared to be less important in wheat unlike for wheat in Ethiopia and barley in Syria (Bishaw, 2004). At present, neither the government nor the flour industry pays premium prices for grain quality. Wheat production at the time was attractive because of price incentives as most farmers produce the grain for direct marketing to government rather than for domestic consumption (di Fonzo et al., 1995). Farmers' perceptions on productivity of wheat varieties were heavily influenced by the amount and distribution of rainfall in a particular year. Farmers who were entirely dependent on rainfall expected large fluctuations in wheat production and productivity. There was a general perception that productivity of wheat varieties had increased over the years. More than 50% of farmers expected wheat yield of 3 to 5 t ha^{-1} while one-fifth expected over 5 t ha^{-1} probably due to adoption of high yielding varieties, and continued expansion of irrigation facilities.

Interestingly high yield, non-lodging, non-shattering, yield with less water, frost tolerance, and drought tolerance appeared to be varietal characteristics farmers expected in new wheat varieties (Figure 3). Maximizing productivity become the major criterion for adoption of new varieties as part of agricultural intensification whereas non-lodging and non-shattering requirements are a response to mechanized harvesting. Erratic rainfall and declining availability of irrigation were major concerns for farmers who seek alternative varieties with drought tolerance and low water requirements. Adoption of modern varieties could be influenced by yield, disease resistance and particularly early maturity which are valuable in drought prone areas (Tripp, 2000; Mekbib, 2007).

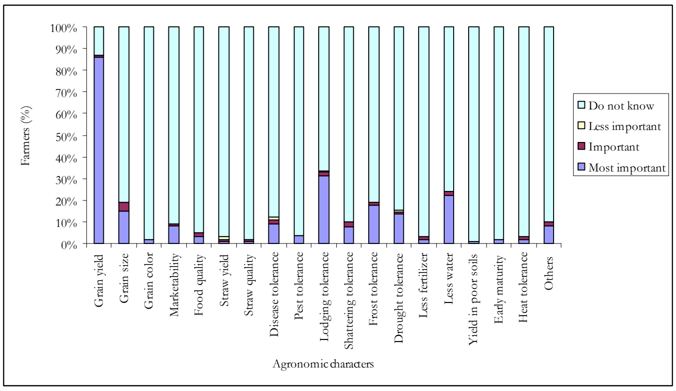

Figure 3. Farmers' criteria for adoption of new wheat varieties (n=206).

Barley

Farmers had a very positive perception of the barley landrace Arabi Aswad (one third see no disadvantage) and continued growing it for generations (Figure 4). Grain yield, grain size, grain color, feed quality and marketability were considered important varietal characters. The majority of farmers (57%; n=198) believed this landrace gives good and stable yield under erratic rainfall and stress conditions. Feed quality appeared the second most important characteristic, mentioned by 41% of farmers. This is crucial in crop-livestock systems. Farmers' preference for Arabi Aswad is linked to their perception of better animal productivity and milk quality compared to other landraces (Arabi Abiad) or modern varieties. Although there is no evidence to substantiate the difference in feed quality between black and white seeded barley landraces, adoption of modern varieties depends ultimately on farmers' perceptions and preferences. Grain color is associated with the marketability of barley for feed or seed through local market channels as farmers use barley grain for livestock feed (91%), sale surplus on market (85%) or for seed (46%). Haddad et al. (1997) reported that farmer preferences for grain color was a major constraint to the adoption of modern varieties. Since black-seeded barley is preferred it would be difficult if not impossible to introduce other types.

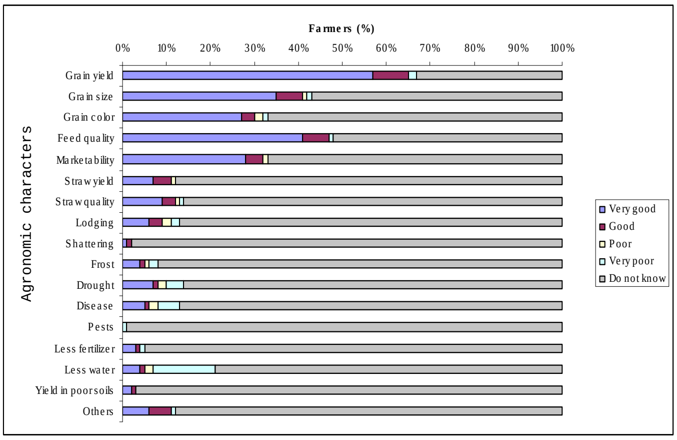

Figure 4. Farmers' perception of barley landrace (*Arabi Aswad*) in Syria (%; n=198).

Adoption of new varieties is based on several criteria (Figure 5). About 65% of farmers said grain yield was the most important factor, followed by grain color (44%) and grain size (37%). Farmers appeared to link grain color with marketability and grain size with feed quality; they valued their landrace based on these criteria. Farmers also sought varieties that could give high and stable yield under moisture stress. Participatory plant breeding has identified grain yield, kernel weight, spike length and plant height as most important selection criteria in barley (Ceccarelli et al., 2000). Aw-Hassan et al. (2008) reported that barley farmers mentioned up to 15 criteria; the most important being grain yield (53%), lodging resistance (31%), grain size (16%), plant height (12%), feed quality (9%) and drought tolerance (6%).

The survey results indicate that there is no single variety that embodies all the traits demanded by wheat and barley farmers. Farmers are explicit in their demand for agronomic or quality traits in each crop and plant breeders should target these traits in breeding programs to provide portfolio of new varieties.

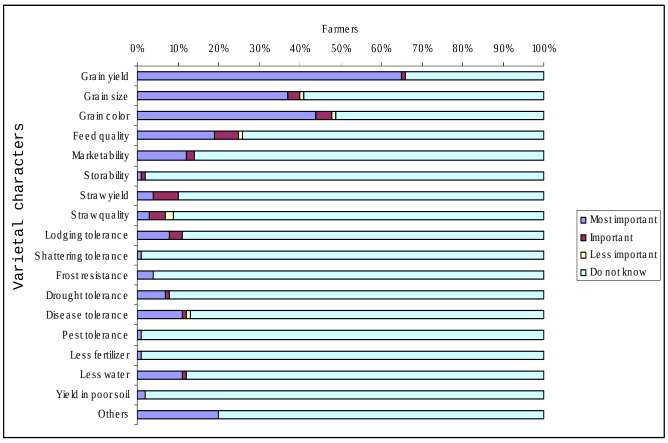

Figure 6. Farmers' criteria for adoption of new barley variety (%; n=200).

Farmers' Seed Sources and Perceptions

Seed acquisition patterns are rather complex with no single seed source. Farmers obtain seed from multiple sources including the formal and informal sectors. Walker and Tripp (1997) reported that the proportion of seed obtained from a particular source differed among farmers, crops, seasons, regions and countries. Bishaw et al. (2010) and Mekbib (2007) identified four key factors that would influence farmers' seed sources: ecological-adaptation to production environments; biological-variety characteristics and farmer preferences; economic-perceived benefits; and social-cultural values or consumptive uses.

Variety sources

For variety sources, one could distinguish between the 'primary' source of a newly introduced variety, and 'secondary' seed source of earlier released varieties. In wheat, the formal sector was the initial source of new varieties for nearly 60% of farmers (Table 3), although the informal sector (farmers 28% and traders 13%) also played important roles in varietal diffusion. On the other hand, the informal sector was reported as the major initial source of new varieties for wheat in Pakistan (Tetlay et al., 1991) and maize in Ghana (Tripp, 1997). In barley, almost all farmers grew Arabi Aswad; 88% initially obtained the landrace from informal sources (Table 3). In contrast, parents were identified as the 'sole' initial seed source for sorghum landraces in Ethiopia (Mekbib, 2007). The wheat and barley cases demonstrate the importance of the informal sector in acquisition and diffusion of landraces as well as new varieties.

Seed sources

In the 1998/99 crop season, 150, 44 and 12 farmers planted one, two and three wheat varieties respectively, using 273 seed lots from different sources. Among 273 wheat seed lots, 59% sourced on-farm, 24% from the formal sector, 13% from neighbors/other farmers and less than 5% from markets/traders (Table 3). Hasan (1995) and van Gastel and Bishaw (1994) found similar results in both Jordan and Syria, with the majority of wheat farmers using on-farm or informal sources rather than the formal sector. In the 1997/98 crop season, no farmer in the survey obtained barley seed from the formal sector; 83% used their own seed. This pattern is similar in most years, with local traders or markets accounting for less than 15%. However, a non-random barley diffusion study in Syria reported that about half of barley farmers used their own seed saved from the previous season, and 37% of them purchased seed from neighbors (Aw Hassan et al., 2008). The informal sector remains the major source of seed in developing countries: barley in Ethiopia (Woldeselassie, 1999) and Syria (Aw-Hassan et al., 2008), lentil in Jordan (Al-Faqeeh, 1997), sorghum in Ethiopia (Mekbib, 2007) and pearl millet in Niger (Ndjeunga, 2002).

Table 3. Farmer's wheat and barley varietal and seed sources in Syria.

Variety sources			Seed sources		
Wheat (n=273)[a]					
Variety sources	Counts	Responses (%)	Seed sources in 1998/99	Counts	Responses (%)
Formal sector	162	60	Formal sector	65	24
Relatives	2	1	Neighbors/other farmers	34	13
Neighbors	28	10	Local traders/markets	12	4
Other farmers	45	17	Own seed	162	59
Local traders/markets	35	13			
Total	272	100	Total	273	100
Barley (n=200)					
Variety sources	Farmers	%	Seed sources in 1997/98	Farmers	%
Formal sector[b]	27	14	Formal sector	0	0
Neighbors/other farmers	71	36	Neighbors/other farmers	22	11
Local traders/markets	37	19	Local traders/markets	13	7
Relatives	65	33	Own saved seed	165	83
Total	200	100	Total	200	100

Note: [a] 214, 22 and 5 farmers respectively planted one, two and three wheat varieties; [1] One farmer get seed of one variety from two sources; [b] GOSM still produces and distributes barley landraces.

Formal sector seed sources

The formal sector was the second most popular wheat seed source. One fourth of respondents obtained their seed (Table 4) on credit from ACB (56%; n=65 responses) and farmers' cooperatives (27%) or by direct cash purchase from GOSM (19%). ACB and GOSM have 45 and 14 seed sale points respectively in the surveyed provinces. More than half of the farmers had high appreciation for the quality of certified seed (58%); and purchase it for yield benefits (22%) or to replace an old variety (16%) or to obtain fresh seed (24%). Most farmers indicated that it was always available, properly cleaned, properly treated and of good quality. Similar positive perceptions for certified seed were also observed for wheat in Jordan (Hasan, 1995) and Syria (van Gastel and Bishaw, 1994). However, only 36% were satisfied with price, although certified seed is distributed at nominal profit in Syria (Rohrbach et al., 1997). For wheat the relatively high use of certified seed could be attributed to five possible factors: (a) sustained government policy promoting use of modern varieties; (b) low seed price which is provided at production cost;

(c) farmers' perception of certified seed quality and benefits; (d) adequate facilities and rural infrastructure guaranteeing better access to inputs; (e) better grain marketing incentives delivering directly to government depots at premium prices.

For barley none of the sample farmers obtained seed from the formal sector during the survey year although some farmers had purchased seed in earlier years. Since the early 1990s, barley seed purchases from the formal sector have declined steadily, particularly due to the increased seed price to grain price ratio. In 1997/98, GOSM distributed 4214 t of barley seed, sufficient for only 3% of national barley area. In such circumstances it was not surprising not to find a single barley grower who purchased seed from the formal sector in less favorable environments of zones 2, 3 and 4.

Table 4. Farmers' perceptions of formal wheat seed sources (n=65).

Seed sources	Farmers	%	*Distance traveled (km)*	Farmers	%
ACB	36	55.6	Up to 10	22	33
Cooperatives	17	26.7	10.1 to 20	20	31
GOSM	12	17.8	20.1 to 30	4	7
Why purchase certified seed			30.1 to 40	4	7
Replace old variety	10	16	40.1 to 50	10	16
Replace old seed	16	24	Over 50	4	7
Better seed quality	38	58	*Time seed purchased (months)*	Farmers	%
Better grain yield	14	22	8/9	7	11
Cheap price	1	2	10	14	22
No own seed	3	4	11	32	49
Others (credits)	7	11	12	12	18

Off-farm local seed sources

Although only 13% and 4% of wheat farmers (n=273) sourced seed from other farmers and local traders, respectively in the 1998/99 season (Table 5), most of them had previously obtained seed from other local sources. From 46 farmers who sourced off-farm seed locally, 50% got their seed from other farmers; 26% and 24% got their seed from neighbors and traders, respectively. Farmers cited several reasons for acquiring seed off-farm locally: perception of good seed quality (57%), timely availability (13%), lack of own seed (15%), low price (13%) or interest in changing variety or seed (11%). Similarly, timely availability and adaptation of variety were the main reasons for acquiring seed from these sources in Jordan (Hasan, 1995). Farmers who sourced off-farm wheat seed locally also gave several reasons for not purchasing certified seed from the formal sector. Non-availability, quality and price of certified seed together accounted for 59% of farmers (n=46) not sourcing seed from the formal sector (Table 5). Lack of access to credit (e.g. because of defaulting cooperative members) is also an impediment to formal sector purchase. This has also been observed elsewhere (Beyene et al., 1991). Such group obligations appeared problematic where farmers associations are dysfunctional. Moreover, bureaucratic credit procedures oblige farmers to use alternative sources.

Barley farmers who purchased seed off-farm from other farmers and from local traders or markets were pooled together for analysis (Table 3). During the 1997/98 crop season, close to one-fifth of barley growers (n=200) sourced their seed from other farmers (11%) and local traders (7%) although previously more farmers had obtained seed from these sources on several occasions and for various reasons. The overriding factor for obtaining seed from outside was lack of own seed (80%) followed by perception of good seed quality (20%) from their neighbors, other farmers or traders. About 83% of the farmers were satisfied with the price of seed purchased from their neighbors and/or traders. Price was the most important reason (97%) for not acquiring seed from the formal sector. It was reported elsewhere in this article that the removal of price incentives for barley has led to decline for barley seed demand. Bishaw et al. (2010) indicated that in the absence of subsidized seed the actual seed demand from the formal sector may not be necessarily high for self-pollinated crops.

Table 5. Farmers' perceptions of off-farm local seed sources.

Why source seed from neighbors/traders	Farmers	%	*Why not source seed from formal sector*	Farmers	%
Wheat (n=46)					
Seed quality is good	26	57	Certified seed is expensive	16	35
Seed available on time	7	15	Certified seed not available	11	24
Seed price is cheap	6	13	Certified seed is of poor quality	5	11
No own saved seed	7	15	No cash to buy certified seed	6	13
Certified seed not available	4	9	No credit to buy certified seed	3	7
Acquire variety or seed change	5	11	Not aware of certified seed	3	7
Others[a]	9	20	Others[b]	7	15
Barley (n=35)					
No own seed	28	80	Formal seed is expensive	33	97
Seed quality is good	7	20	Formal seed not available	1	3
Seed available on time	4	11	Cash shortage	4	11
Own seed not good	1	3	Lack of awareness	1	3
Exchange old seed	1	3	Others (small quantity, etc)	1	3
Price is cheap	1	3	Certified seed is expensive	3	14

Note: [a] Labor exchange, combine rent; [b] Long process, etc.

On-farm seed sources

Although farmers obtain seed off-farm for various reasons they are more likely to use retained seed particularly for self-pollinating crops such as wheat and barley (Table 6) where seed quality can be easily maintained. A significant number of wheat farmers used retained seed (62%; n=273) and their overall perception was high in terms of seed quality, timely availability, etc. Most farmers (61%; n=127) believed that own saved seed was of good or better quality and preferable because they considered certified seed involves extra cost, is not readily available on the market and involves bureaucratic procedures (Table 6). Price remained the single most important factor for farmers not purchasing certified seed (47%). In Jordan, 34.1% of wheat farmers used retained seed (Hasan, 1995) whereas the figure is over 85% for lentil (Al-Faqeeh, 1997) showing great variation between crops.

About 165 barley growers (82.5%; n=200) used own saved seed, and among them 144 (87%; n=165) were satisfied with the quality. A little over 50% of farmers considered the quality of own saved seed better or equal to seed from the formal sector or other sources. Moreover, timely seed availability (27%), seed price (6%), lack of improved variety (4%) and small quantity of seed required (2%) were some of the reasons for sourcing seed on the farm. The overriding issues for farmers not buying seed from the formal sector were seed price (71%), cash shortage (15%) and lack of credits (4%). The absence of modern barley varieties also contributed to farmers not sourcing seed from the formal sector. In Ethiopia, lack of alternative seed sources (57%), better adaptation of landraces (41%) and good quality of own seed were the main reasons for barley farmers using retained seed (Woldeselassie, 1999). Lyon and Danquah (1998) reported that farmers who use their own seed do not incur a transaction cost; this is an economic incentive. For most self-pollinated cereal crops such as wheat and barley, own seed is the major source in developing (Bishaw, 2004) as well as developed countries (Stanelle et al., 1984).

Table 6. Farmers' perception of on-farm seed sources in Syria.

Why farmers source seed on-farm	Farmers	%	*Why farmers not source certified seed*	Farmers	%
Wheat (n=127)					
Seed quality is good	77	61	Certified seed is expensive	59	47
Seed available on time	14	11	Certified seed not available	21	17
No extra seed cost	7	6	Poor certified seed quality	6	4
Certified seed not available	12	9	No cash/credit to buy certified seed	19	15
Difficult credit procedures	7	6	Not aware of certified seed	2	2
Variety is not adapted	3	2	Own saved seed is good	13	10
Others	10	8	Others	7	6
Barely (n=165)					
Why farmers source seed on-farm			*Why farmers not source formal seed*		
Perception	Farmers	%	Certified seed is expensive	117	71.3
Seed available on time	45	27.3	No cash to buy certified seed	25	15.2
Good seed quality	90	54.6	Lack of credit	7	4.2
No extra seed cost	10	6.1	No new variety	5	3.0
Small seed quantity	3	1.8	Lack of awareness	3	1.8
No improved variety	6	3.6	Poor seed quality	5	3.0
Others	10	6.1	Lack of seed	2	1.2

Seed Flow, Retention and Transaction

While the formal sector remains a source of 'primary' diffusion for injecting new crop varieties, the informal sector serves as 'secondary' diffusion through farmer-to-farmer seed exchange. Compared to the formal sector, local seed systems are traditional, informal and operate at community level (Cromwell et al., 1993).

Local seed flow

Wheat (50%; n=206) and barley (58%; n=200) farmers indicated that they exchanged seed of modern wheat varieties and barley landraces with other farmers (Table 7). Local seed exchange for wheat was slightly lower than barley, probably because of high varietal turnover and seed replacement rates from the formal sector. Nachit et al. (1998) reported that wheat farmers in irrigated areas are more dependent than in rainfed areas on seed from the formal sector. Although almost all barley farmers used a landrace the practice of seed exchange was high (Table 7). Aw-Hassan et al. (2008) reported that 24% of barley growers sold seed of new varieties to other farmers. However, the retention of barley seed for longer periods might have reduced local seed turnover. For wheat and barley farmers who reported selling seed informally, the major customers were other farmers, neighbors, relatives or local grain traders.

Table 7. Wheat and barley seed flow among farmers in Syria.

Wheat (n=206)			Barley (n=200)		
Local seed transaction mechanisms	Farmers	%	*Local seed transaction mechanisms*	Farmers	%
Local seed sales			*Local seed sales*		
Not sale/exchange seed	103	50	Not sale/exchange seed	85	43
Sale/exchange seed	103	50	Sale/exchange seed	115	58
Users of seed exchange			*Users of seed exchange*		
Relatives	50	49	Relatives	53	46
Neighbors	71	69	Neighbors	61	53
Other farmers	72	70	Other farmers	74	64
Others (traders)	2	2	Others (traders)	-	-
Mechanism of exchange			*Mechanism of exchange*		
Cash	100	97	Cash	102	89
Others (gift, seed exchange)	3	3	Others (gift, seed exchange, etc)	13	11

Local seed exchange is important for not only acquiring seed but also for introducing new crops/varieties over long distances and increasing on-farm crop/varietal diversity. Bajracharya (1994) reported the role of women as key players in such endeavors in Nepal. Empirical evidence from Ethiopia, Syria (Bishaw, 2004) and elsewhere demonstrates this. Wheat farmers had traveled over 50 km to buy certified seed; one third of farmers traveled up to 10 km (33%) and 20 km (31%). Barley farmers traveled up to 50 km to buy seed from local markets or traders, but about two thirds of them traveled < 25 km. Tetlay et al. (1991) found that 80% of farmers who sourced seed of new wheat varieties from other farmers get the seed within 5 km. Cromwell et al. (1993) reported that farmers in Malawi walk over 30 km for bean seed and undertake five day's travel in Nepal to acquire potato seed. Mekbib (2007) also reported the role of informal sorghum landrace seed exchange extending over 300 km in eastern Ethiopia.

Some farmers who provided seed to others were contract growers for GOSM serving as potential nodes for diffusion of new varieties. Moreover, farmers who rented combine harvesters and receive payment in kind, also assisted in varietal and/or seed diffusion: they use the grain as seed or sell it to other farmers for planting. Even in situations where modern varieties are widely adopted, farmer-to-farmer exchange still remains the main diffusion mechanism for new varieties.

Seed retention

Several factors influence farmers' decision to change variety and/or seed stock. These include yield gains from new variety, and perceived decline in performance of existing varieties (Heisey and Brennan, 1991; Mpande and Mushita, 1996). Almost all sample farmers (n=206) who planted wheat in the 1998/99 crop season had replaced their wheat seed stock within the previous five years: 41% obtained fresh certified seed or changed their seed informally in survey year; 35% retained seed for one year; 14% for two years; 8% for three years; and 2% for four years (Table 8). Among certified seed users the wheat seed replacement rate was high: about two thirds claimed buying seed from the formal sector annually; the rest buy seed every three years. High seed replacement rate is useful provided new varieties are released frequently and seed is available in the market. Van Gastel and Bishaw (1994) found high seed renewal rates among wheat growers in Syria where nearly

80% replace seed within three years. Byerlee and Moya (1993) and Nachit et al. (1998) found low average age of wheat varieties in Syria, an indicator of rapid varietal turnover probably due to such quick seed replacement. Cromwell et al. (1993) reported that over 75 and 40% of farmers growing soybean and beans, respectively, replaced their seed in less than five years.

Table 8. On-farm seed retention among wheat and barley farmers in Syria.

Wheat (n=273)			Barley (n=200)		
Number of years	Farmers	%	Number of years	Farmers	%
0	111	41	0	35	18
1	95	35	1	23	12
2	37	14	2	21	11
3	22	8	3	13	7
4	3	1	4	15	8
5	2	1	5	20	10
≥ 5	3	1	6-9	19	10
			10-19	43	22
			≥20	11	6
Total	273	100	Total	200	100

There was a relatively high turnover of barley seed although all farmers were growing a landrace (Table 8). About two thirds of farmers replaced their seed during the previous five years; 85% during the previous 10 years. This high turnover is driven by three factors. First, the formal sector used to provide cleaned and treated seed of the landrace at a relatively low price. Second, the government grain price for barley prompted farmers to sell their produce and buy subsidized seed from the formal sector. Third, frequent droughts and crop failures particularly in marginal areas forced farmers to seek seed from outside sources. When different grain and seed prices for barley and wheat were introduced, farmers opted to use their own seed. Purchases from the formal sector dropped significantly except in drought years.

Despite frequent droughts and crop failures, 25% of farmers still retain barley seed for over 10 years. In Ethiopia, for example 30% of barley farmers who used own saved seed retained the same seed lot for over nine years while some of them claim they inherited it from their ancestors (Woldeselassie, 1999). Similarly, Cromwell et al. (1993) quoted data from Nepal where farmers typically replace wheat seed every 7 years, open pollinated maize every 10 years and rice seed every 20 years. Nagarajan and Smale (2007) also reported that farmers' cultivars of sorghum and millets have been grown for longer periods (25-32 years) than improved open-pollinated sorghum varieties (10 years) or hybrid sorghum or pearl millet (5-7 years). Mpande and Mushita (1996) indicated that sorghum and pearl millet farmers in Zimbabwe keep enough seed for two seasons as security against droughts. Mekbib (2007) also emphasized the survival of three predominant sorghum landraces extending over several regions in eastern Ethiopia. This might explain the survival of two barley landraces with better adaptation to the extremely harsh environments in Syria.

Seed transactions

Wheat and barley farmers who sold and/or acquired seed off-farm from local sources (relatives, neighbors, other farmers, traders or markets) used a variety of different transactions including cash, gifts, seed swaps, in-kind seed loans or labor exchange (GTZ and CGN, 2000). Most wheat (97%; n=103) and barley (89%; n=115) seed transactions locally, however, were in cash showing how the cash economy is replacing traditional exchange mechanisms as farmers become integrated into commercial markets. Some earlier studies also showed that almost all local seed transactions were cash purchases: few were gifts or exchanges for wheat in Pakistan (Tetlay et al., 1991), barley in Syria (Aw-Hassan et al., 2008) or for beans in Rwanda (Sperling, 1998).

On the contrary, Rohrbach et al. (1997) found that about 80% of local seed exchange among smallholder sorghum and pearl millet farmers in southern Zimbabwe was in the form of gifts; and relatives and other farmers accounted for nearly 30% of the seed supply. Mekbib (2007) also reported that apart from own stock, gifts were the important sorghum seed source in eastern Ethiopia. However, this form of transaction could be possible because only a small amount of seed (less than 2 kg) is exchanged particularly for millets compared to wheat and barley where larger quantities of seed are required.

Empirical evidence shows that smallholder farmers are willing to pay cash: twice the grain price in Zimbabwe (Mugedza and Musa, 1996), 32% more than the price of certified seed for new wheat varieties in Ethiopia (Ensermu et al. (1998). However, high price and lack of credit remain constraints for buying certified seed (Rohrbach et al., 1997) or for adopting new varieties (Kotu et al., 2000).The high level cash transactions observed in this study suggest opportunities for local seed businesses that would facilitate the introduction and diffusion of new varieties. However, any local initiative requires careful consideration of crop suitability and socio-cultural factors.

Farmers' Seed Management

In traditional agriculture, genetic resources conservation, crop improvement, crop production and seed supply are integrated at the farm level. Farmers-consciously or unconsciously-manage their genetic resources by continuously selecting and adapting landraces to their environment, and selecting seed as an integral part of crop production. Plant/seed selection, seed cleaning, seed treatment and monitoring quality are closely linked. A decision to use a given seed lot for planting involves continuous monitoring and evaluation of the entire crop growth in the field, later at harvesting, threshing and during storage to differentiate between seed for planting and grain for consumption. This approach although it persists in many areas, is rapidly changing in commercial agriculture as farmers are increasingly dependent on the formal seed sector. A broader understanding of farmers' seed management practices is useful to develop strategies for strengthening the informal seed sector.

Perception of seed quality

Farmers clearly differentiate seed from grain. All wheat growers (98%; n=200) distinguish seed from grain and attributed the difference to cleanliness (53%), chemical treatment (18%), freedom from weeds (31%) and diseases (9%), good germination (6%) and seed size (13%). They clean (90%), treat (89%), store separate (64%), select (54%) and check germination (4%) of wheat seed. Likewise, from 200 barley growers, 99% recognize seed from grain and attributed the difference to purity (17%), seed size (9.5%), treatment (2.5%), quality (2%) and freedom from weeds (1%). Most barley farmers also clean their seed (91%), store separately (76%) and select (46%), but fewer apply seed treatment (7%) or check germination (3%).

Germination is an important aspect of seed quality, but there is little evidence to suggest that farmers monitor it effectively. Few wheat and barley farmers reported checking germination before planting. Similarly, sorghum farmers in Zimbabwe did not consider germination as important in seed quality (Mugedza and Musa, 1996). Few maize farmers in Ghana considered poor field establishment to be associated with poor seed quality (Walker and Tripp, 1997). Introducing simple and practical germination tests using cheap and locally available materials could help farmers monitor germination (Mathur and Talukder, 2002).

Plant/seed selection

Seed selection is part of on-farm seed management (Walker and Tripp, 1997); and selection time and subsequent management practices determine seed quality. Almost half of wheat (n=206) and barley (n=200) farmers claimed to practice seed selection (Table 9). The selection criteria are based on conditions of standing crops or grain quality at harvesting time, on threshing floors, during storage or at planting time. Famers decide which field or part of field could be harvested and further evaluate the product to differentiate between seed for planting or grain for food/feed. Most wheat farmers select a field or section of a field of standing crops (87%; n=111) and usually before (6%) or at harvesting time (87%). Most barley growers also select a field or section of a field (79%; n=99) usually before (20%) or at harvesting time (76%). Similar results were reported for sorghum and pearl millet: seed is selected mostly in the field and at threshing time (Mpande and Mushita, 1996), allowing farmers to evaluate the crop for agronomic characters like lodging, pest infestation, etc.

Table 9. Farmers' plant and/or seed selection in Syria (n=206).

Plant/seed selection	Wheat (n=206)		Barley (n=200)		*Selection criteria*	Wheat (n=111)		Barley (n=99)	
	Farmers	%	Farmers	%		Farmers	%	Farmers	%
Not select for seed	95	46	101	51	Early maturity	5	5	10	10
Select for seed	111	54	99	50	Shattering tolerance	3	3	1	1
Method of selection[1]					Lodging tolerance	5	5	-	-
Select field/part of field	96	87	79	79	Disease tolerance	20	18	3	3
Select grain	14	13	23	23	Pest tolerance	3	3	-	-
Select ears	8	7	1	1	Plant height	12	11	13	13
Select plants	2	2	8	8	Ear size	38	34	22	22
Others	2	2	-	-	Grain yield	19	17	41	41
Time of selection[1]					Grain size	36	32	68	69
At planting	6	5	5	5	Grain color	8	7	42	42
Before harvesting	7	6	19	20	Marketability	1	1	4	4
At harvesting	96	87	75	76	Straw yield	2	2	4	4
During storage	1	1	-	-	Straw quality	2	2	1 (3)	1 (3)
Responsibility for selection[1]					Freedom from weeds	80	72	55	56
Men	109	98	95	96	No offtype/other crop	7	6	5	5
Both (men and women)	2	2	4	4	Cleanliness of field	5	5	-	-

Note: [1] Based on farmers who select seed for wheat (n=111) and barley (n=99).

For wheat farmers, freedom of standing crops from contaminating weed plants (72%), ear size (34%), grain size and absence of disease infection were important criteria in selecting seed for planting. Barley farmers considered seed size (69%; n=99) followed by freedom from weeds (56%) and ear size (22%) of standing crop, grain yield (41%) or grain color (42%) as important criteria. These criteria were used to decide which field or harvested grain should be kept for seed. Other methods and criteria have been reported, such as individual ear or head selection for maize, sorghum or pear millet; and selection based on grain yield, grain color, grain size, early maturity, drought tolerance or their combinations (Mpande and Mushita, 1996). Walker and Tripp (1997) reported seed selection in the field was practiced by <4% of maize and cowpea farmers in Ghana; and by 18 to 25% of sorghum and cowpea farmers in Zambia. In maize, field selection was based on big ear, big seed size and absence of disease and early maturity whereas post-harvest selections focus on size of grain, cob or its conditions (cleanliness, appearance, absence of insects). In cowpea on-farm storage (threshed or unthreshed) is a major criterion. In Ethiopia, it was reported that the main selection criteria for sorghum landraces are agronomic performance (adaptation, yield, stress tolerance), consumption quality (taste, color, consistency, cooking time, processing) and animal feed value (Mekbib, 2006).

Most farmers in the study area grew both wheat and barley, particularly in zone 2 where they have similar criteria. Seed selection started from choosing the right field to the conditions of the standing crops to grain quality at harvesting, threshing, storage and/or planting time based on the knowledge and perception of individual farmers. Selection of a field could be attributed to its previous history, e.g. properly rotated, fertilized, irrigated or clean field with good crop stand, grain yield and grain size. These selection criteria will not significantly change the genetic characteristics of the variety as most plants are bulk harvested and farmers may be unable to assess all the characters where selection is indirect. For example, early maturity refers to a field which escapes drought thus the crop is good in terms of grain yield or grain size. Biotic stress tolerance means rather an absence of pest or disease attack rather than actual measurement. Similarly by selecting fields with no weed infestation farmers may be indirectly selecting for plants that have some inherent weed tolerance as evidence suggests varietal differences in wheat (Rizvi et al., 2002). However, the key factor in on-farm selection is that farmers can relate each selection criterion with their knowledge and experiences to differentiate between seed of good or poor quality.

Women's role in seed selection and management appeared less visible compared to that reported for wheat in Ethiopia (Bishaw et al., 2010) and vegetables in Bangladesh (Sillitoe, 2000) and Nepal (Bajracharya, 1994). Increased use of combine harvesters substantially reduced female labor contribution in wheat and barley production while previously women were involved in manual harvesting (Tully, 1990) and therefore directly contributed to on-farm selection and maintenance of wheat and barley seed. Mazid (1994) reported that about 64% of farmers shared their barley production decision with their immediate family (including spouses). In another study women were responsible for most on-farm cleaning of barley seed (Daniela Mangione, Personal communication) although men failed to acknowledge it. Bajracharya (1994) indicated that although women's contributions to on farm work and decision making on the average was 57%, the agricultural development officers (men) perceived that the contribution of women was low (11-23%) compared to the ratings of female development officers (62%), a clear reflection of a gender bias. In practical terms, women directly or indirectly contributed to plant and/or seed selection both in wheat and barley crops despite a generally held view which underestimates their roles.

Plant and/or seed selection practices can be summarized as follows: (i) no methodological approaches were observed in plant selection in either wheat or barley; (ii) farmers' seed selection was anecdotal and not systematic, largely influenced by observation in the field or at harvesting or planting time; (iii) intensification and commercialization of production is leading to loss of traditional plant/seed selection practices; (iv) high seed renewal rate and varietal turnover resulting from availability of new wheat varieties has reduced farmer's need to 'improve' existing varieties; (v) plant and/or seed selection in wheat and barley is roughly similar, although almost all barley farmers still used landraces.

Seed cleaning and treatment

Wheat and barley seed is commonly cleaned, whether sourced locally from farmers, traders or retained on the farm. This may include all post-harvest operations like drying (removing excess moisture), cleaning (removing impurities), grading (improving quality), treating (protection against pests) and packaging. In certain circumstances, on-farm seed cleaning is no more than winnowing the seed after harvesting; this does not guarantee selection of uniform grain sizes (Mpande and Mushita, 1996). In other cases, detailed seed cleaning techniques are employed to maintain seed quality (Mugedza and Musa, 1996) or an elaborate traditional seed treatment techniques are used against storage pests (Monyo et al., 2000).

All wheat growers surveyed reported using cleaned and treated seed either from the formal sector or through on-farm seed cleaning and treatment (Table 10). Forty-five farmers (22%) used cleaned and treated certified seed sourced from the formal sector. About 161 farmers (78%) sourced seed from other farmers, traders or used their own seed; most of the seed was cleaned and/or treated by farmers themselves. Similarly, 91% of farmers (n=200) cleaned their barley seed obtained from local sources or saved on farm (Table 10). The majority of wheat/barley farmers used manual cleaning with wire mesh sieves (78%/87%) while the remaining used locally manufactured mobile cleaners. The main purpose of cleaning was to remove weeds, inert matter, broken seeds, other crop seeds (e.g. barley), facilitate machine planting or removing insect infested grains. Most farmers who used cleaning machines were in Hasakeh where the service is easily available, through small-scale mobile cleaners fabricated in one of the nearby towns. This has emerged as an important rural enterprise.

The striking observation in wheat seed management was the extent of chemical treatment used by farmers in Syria. The availability of chemicals induced most wheat growers to use seed treatment, probably influenced by the practices of the formal sector. On-farm seed treatment was widely used. Almost all farmers treated their seed before planting (76%) except those who purchased treated seed (24%). In Jordan, 64 and 62% of seed sourced informally was cleaned and treated on the farm, respectively (Hasan, 1995). Stanelle et al. (1984) reported that seed treatment was practiced by 36% of wheat farmers, but more targeted towards areas with disease problems due to high rainfall and humidity. Surprisingly, fewer farmers used chemical seed treatment in barley (7%) compared to wheat. Although 56 farmers (27%; n=206) planted barley as a second crop along with wheat none reported chemical treatment for barley seed. In Ethiopia, nearly 90% of barley growers who retained seed on the farm or purchased seed from neighbors cleaned their seed using traditional hand tools (Woldeselassie, 1999); but these were found inefficient in removing weeds and inert matter. None of the farmers also used seed treatment as well.

Table 10. On-farm wheat and barley seed processing and management in Syria (n=161).

	Wheat (n=161)		Barley (n=200)	
Seed cleaning and treatment	Farmers	%	Farmers	%
Not clean seed	-	-	12	6
Purchased clean seed	13	8	6	3
Cleaned seed	148	92	182	91
Method of cleaning				
Hand sieving	125	78	174	87
Machine cleaning	23	14	8	4
Purpose of cleaning				
Remove inert matter	61	38	146	73
Remove weed/crop seeds	90	61	74	37
Remove small seeds	24	15	20	10
Remove broken seeds	54	34	21	11
Facilitate planting	4	3	29	15
Remove insect infested seeds	-	-	8	4
Seed treatment				
Not treat seed	-	-	169	85
Purchased treated seed	5	3	-	-
Treat seed	156	97	13	7
Check germination	9	6	6	3

A number of chemicals, local or imported, were available for seed treatment in Syria. From 156 wheat farmers who treated their seed on farm most used broad-spectrum fungicides like Quinolate (69%) followed by Agrospor 60 (19%). The main purpose of seed treatment was for control of smuts (73%), but only 3% applied Vitavax a systemic fungicide. The chemical, usually in powder form, is first diluted in water and then mixed with seed manually on tarpaulins in the open using shovels (87%) whereas mobile cleaners were used to treat the rest. Only one-third of farmers applied the seed treatment at recommended rates, and only 12% used the necessary safety measures while treating seed. Most farmers did not have adequate knowledge of the chemicals (could not identify the name) and their application and efficacy. Inadequate formulation of chemicals; lack of knowledge on methods and rates of application; lack of adequate equipment and knowledge in handling; and lack of safety precautions are matters for concern. Sub-standard chemicals without proper formulation and of unknown origin were available on the market. Adequate quality assurance and appropriate extension would help ensure safety, increase efficacy, target pests more effectively, reduce costs and lessen environmental pollution.

Seed storage and management

Among 206 wheat and 200 barley farmers surveyed, 64% and 76% respectively, stored seed and grain separately (Table 11). Almost all grain/seed was primarily stored in jute or polypropylene bags, showing the disappearance of traditional storage facilities reported elsewhere. Walker and Tripp (1997) found that farmers in Zambia tend to separate sorghum, bean and groundnut seed whereas in Ghana they are less predisposed to such practice for maize and cowpea seed; jute/polypropylene sacks were widely used in both countries. Traditional storage structures much quoted elsewhere (Mpande and Mushita, 1996; Walker and Tripp, 1997) are uncommon because they are irrelevant for wheat and barley where large quantities are stored.

Table 11. On-farm wheat and barley seed storage and management in Syria.

Seed storage practices	Store seed separately[1]				Seed storage practices	Not store seed separately[1]			
	Wheat (n=132)		Barley (n=152)			Wheat (n=74)		Barley (n=48)	
	Farmers	%	Farmers	%		Farmers	%	Farmers	%
Separate seed store	132	64	152	76	*Not separate seed store*	74	36	48	24
Polypropylene bag	52	39	-	-	Polypropylene bag	24	32	1	2
Jute bag	75	57	143	94	Jute bag	48	65	45	94
Poly & jute bag	5	4	-	-	Poly & jute bag	2	3	-	-
Local bins	-	-	5	3	Local bins	-	-	1	2
Bulk	-	-	4	3	Bulk	-	-	1	2
Control of storage pests					*Control of storage pests*				
No infestation	48	36	44	29	No infestation	28	38	10	21
Sun drying	15	11	27	18	Sun drying	6	8	13	27
Cleaning	42	32	57	38	Cleaning	20	27	14	29
Change/dispose seed	15	11	13	9	Change/dispose seed	14	19	-	-
Chemical spraying	28	21	2	1.3	Chemical spraying	10	14	-	-
Fumigation	32	24	-	-	Fumigation	17	23	-	-
Others	-	-	9	6	Others	-	-	2	4
Responsibility for storage					*Responsibility for storage*				
Men	111	84	134	88	Men	68	92	38	79
Women	6	5	9	6	Women	3	4	4	8
Both (men & women)	15	11	9	6	Both (men & women)	3	4	6	13

Note: [1] Percentages are calculated based on 206 and 200 wheat and barley growers, respectively; and then adjusted accordingly based on farmers who store seed and grain separately or not.

Generally pests were reported as major constraints for on-farm grain and/or seed storage by wheat (64%) and barley (74%) producers. Weevils, khapara beetle and rodents were reported as serious storage pests in wheat and barley. A survey of grain and seed storage facilities found that khapara beetle was the most widespread and destructive storage pest in northwestern Syria (Niane, 1992). Most wheat farmers changed their seed frequently (particularly formal sector seed), and/or sold their produce directly to government depots with relatively less on-farm seed storage and therefore experienced less pest problems.

Wheat and barley farmers used both traditional (cleaning, sun drying, changing, disposing) and modern (spraying, fumigation) control measures to manage storage pests. There is an increasing trend to use contact insecticides or fumigants, even by farmers who store seed and grain together. Similarly combination of traditional (heat treatment, sun drying, cleaning, changing storage structures or disposing infested seed) and modern (contact insecticides, fumigants) chemicals was commonly used to control grain storage pests for barley in Ethiopia (Woldeselassie, 1999) and for cereals and legumes in Ghana and Zambia (Walker and Tripp, 1997). Farmers in Ghana are more inclined to use protectants on cowpea than on maize. Farmers in Zambia apply little or no chemical on sorghum, although insects cause substantial damage to seed.

There was widespread use of chemicals (contact or fumigant) for wheat storage pests. The type, rate and application method and equipment raise fundamental questions of efficacy and safety. Inappropriate use of chemicals has led to the development of pesticide resistance worldwide. Likewise, the strains of kahpra beetle collected from various grain/seed storage facilities have shown different levels of pesticide resistance (Niane, 1992).

Conclusions

Awareness and adoption of modern wheat varieties and associated technologies has increased spectacularly in Syria. Within a short period the country has become self-sufficient in wheat, producing surpluses for export in good years. Availability of modern wheat varieties with high and stable yield, generation and transfer of appropriate agronomic packages for different agro-ecological zones and expansion of irrigation are the main driving forces behind this achievement. The success also hinges on the existence of a strong wheat seed system where certified seed is available, affordable and regularly used by farmers. The wheat case demonstrates how linkages between research and the seed sector can help achieve national food security if properly backed by government commitment and an enabling policy environment in providing inputs, marketing and price incentives. Such a strategy is important if the wheat success is to be replicated in other crops in Syria or elsewhere.

Barley is a typical crop of marginal environments where yield is limited by severe abiotic and biotic stresses. Farmers in the major production areas grow landraces and depend on informal seed sources. Several improved varieties have been released but none has been widely adopted; possibly because of lack of adaptation or farmers' preferences. This has led to researchers exploring alternative strategies, for example exploring participatory plant breeding (PPB) methods which show some promise. Greater effort is needed to combine research with farmers' knowledge to identify new barley varieties adapted to marginal environments, with traits acceptable to farmers. More flexible policy options are also needed, in addressing crop improvement, technology transfer, seed provisions, price incentives, etc and enhance barley production and productivity in the country.

Farmers have clearly articulated perceptions of wheat and barley varieties they were growing; and identified several technological and socio-economic criteria that determine adoption. High yield, grain size, food quality, and tolerance to lodging, drought and frost are the traits that farmers seek in new bread and durum wheat varieties. Barley growers seek grain yield, grain size, grain color, feed quality, marketability, drought tolerance and disease resistance in new varieties. Plant breeders need to combine agronomic traits desired by famers and grain quality that matches the needs of industry.

In reality, the informal sector remains the major source of new varieties and the 'default' seed supplier for botyh wheat and barley. Most farmers recognize the difference between seed for planting and grain for consumption and as a result used different management practices to maintain seed quality such as on-farm selection, cleaning, treatment, separate storage or seed quality assessment. The majority of farmers have shown a considerable degree of sophistication in introducing new technology such as cleaners, treatment, etc. The government should recognize the role of the informal sector, and provide adequate policy, regulatory and technical support in order to integrate it with the formal sector.

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