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Farmers' perceptions on improved bread wheat varieties and formal seed supply in Ethiopia

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Abstract

The paper presents smallholder farmers' perceptions on attributes of bread wheat varieties based on primary data collected from 524 households in four major wheat growing areas of Ethiopia. The results indicated high value of attainment indices for improved varieties compared to landraces, which shows how the demanded attributes are embodied more in improved ones. Grain yield and yellow and stem rust resistance are attributes that are desired most compared to others. However, there is high variability in attainment indices among improved varieties for the different attributes, which suggests the need to target varieties for the different environments including disease and drought tolerance. The results also showed inconsistency between the value of attainment indices of varieties and the amount of seed supplied by the formal sector, which resulted in mismatch between demand and supply leading to considerable carryover seed. The formal sector needs to consider diversifying its bread wheat varietal portfolio and increase its capacity for seed supply to respond to emerging challenges and effectively address farmers' preferences.

Keywords: Attainment indices; Farmers' perception; Formal seed system; Varietal attributes; Wheat.

Introduction

Bread wheat (*Triticum aestivum* L.) is one of the major crops predominantly grown by small-scale farmers under rainfed condition in the highlands of Ethiopia. It ranks fourth in terms of area and production and second in terms of productivity among cereal crops (CSA, 1999; 2000). Despite substantial increases in wheat area, 33% of the national demand is fulfilled by imports and food aids. The national average wheat yield of 1.8 tones ha^{-1} is below Sub-Saharan Africa and world averages (Dixon et al., 2009). There are several biophysical and socio-economic constraints affecting wheat production and productivity in the country.

The main objectives of wheat breeding in the country are to develop varieties with high and stable grain yield and quality and resistant to biotic and abiotic stresses. The national agricultural research system has developed diverse improved bread wheat varieties with key attributes such as high grain yield and quality, resistance to rusts, tolerance to drought and consumer preferences (taste, baking and nutritional quality). Farmers however have subjective preferences for different varietal attributes and their varietal demand is significantly affected by their perceptions (Alemu and Mamo, 2007; Adesina and Jojo, 1995; Bishaw et al., 2011).

In order to sustain increased agricultural production and productivity, the agricultural transformation agenda of the country has prioritized improving the efficiency of national seed system. The Growth and Transformation Plan of 2010-2015 targets increasing overall wheat seed supply from 80,000 tonnes in 2012 to 102,290 tonnes in 2015, an increase of 28%. This is sufficient to cover 681,000 ha equivalent to 40% of current wheat area of about 1.7 million ha. The top-down state directives focused on public sector driven seed supply without due consideration of farmers' demand for seed. The discussion about how to match wheat seed supply and demand becomes intense mainly because of the considerable amount of carry-over seed every year on one side and the complaints of shortage of supply on the other side. In order to understand the underlining causes of demand and supply gap, we tried to assess farmers' perceptions on the important attributes of bread wheat varieties and their demand for seed in four major wheat growing areas of the country. The study investigated farmers' perceptions about key attributes of bread wheat varieties, the mismatch between farmers' varietal preferences and the formal seed supply and suggested the future direction for seed delivery.

Methods

Sampling methods and sample size

The respondents were selected using multi-stage sampling procedures: (i) first, major production zones were selected using data from the Central Statistical Authority (CSA, 2000) and only zones (11) with more than three percent of farmers producing wheat were considered from four regions; (ii) second, in each zone two districts with the highest number of wheat producers were selected; (iii) third, in each district, two *kebeles* (lowest administrative unit) with the highest number of wheat producers were selected; and (iv) fourth, in each *kebele*, respondent farmers were selected randomly and the sample sizes were determined based on the proportion to population size to have a total of 524 respondents (Table 1).

Table 1. Number of sample farmers in different zones.

Regions	Zones	Sample size
Amhara	South Gondar	56
	South Wolo	46
	North Shewa	81
	East Gojam	46
Oromia	West Shewa	81
	Arsi	37
	Bale	56
	South West Shewa	37
Southern Nations and Nationalities and Peoples (SNNP)	Guraghe	28
	Hadiya	28
Tigray	South Tigray	28
Total		524

Assessment of farmers' varietal perceptions

In order to elicit farmers' preferences, we followed two steps. First we identified the list of attributes that helps farmers to characterise the different varieties of bread wheat. This was done first by consulting wheat breeders and agronomists and then validating with farmers. The identified attributes were grain yield, seed size, seed colour, early maturity, drought tolerance, resistance to rusts (*Puccinia striiformis* f. sp. *tritici* and *P. graminis* f. sp. *tritici*), threshability, field establishment (germination, seedling emergence and growth) and crop stand, bread making quality, marketability, straw yield and straw quality. Second we elicited farmers' perceptions using these attributes for the local and improved bread wheat varieties currently under cultivation. This was done first by assessing the importance of each attribute to the famers and second by assessing how the attribute is embedded in each variety that the farmer grows.

Farmers' perceptions of bread wheat varieties using the above attributes were elicited using an empirical approach (Sall et al., 2000). The approach uses an index that provides how well a certain variety attribute meets farmers' preferences. It involves application of quasi-arbitrary ordinal weights in which farmers rank the importance of each attribute and how well these attributes are embodied in different varieties. Accordingly, each farmer was asked to judge each attribute for each variety on two scales: first, what is the importance of a given attribute to them (very important, important, not so important) and second, how they judge the quality of the attribute of a given variety (very good, good and poor). Accordingly, the response matrix for N farmers was calculated (Table 2).

Each entry in the matrix, n_{ij}, represents the number of farmers who ranked a particular attribute based on their perception of its importance, j and their satisfaction with the quality provided by the variety, i. The bottom row entries, C_j, are the total number of farmers who ranked the characteristics according to its importance. The row total, r_i, are the total number of farmers who ranked the characteristics as embodied in a variety at a certain level of satisfaction. Therefore, following holds:

$$\sum C_j = \sum r_i = \sum\sum n_{ij} = N$$

where: n_{ij}, = number of farmers who ranked a particular attribute based on their perception of its importance, j= satisfaction with the quality provided by the variety, i= The bottom row entries, C_j, are the total number of farmers who ranked the characteristics according to its importance. The row total, r_i, are the total number of farmers who ranked the characteristics as embodied in a variety at a certain level of satisfaction.

Table 2. The response matrix of farmers' perception of varietal attributes.

Attribute → / Variety ↓	Very important	Important	Not so important	Row total
Very good	n_{11}	n_{12}	n_{13}	r_1
Good	n_{21}	n_{22}	n_{23}	r_2
Poor	n_{31}	n_{32}	n_{33}	r_3
Column total	c_1	c_2	c_3	N

The weighting matrix is presented in Table 3. The use of quasi-arbitrary ordinal weights helps in meeting required conditions that makes the estimated indices are robust (Sall et al., 2000). Accordingly, weights were given, where the row totals (S_i) present the supply weights, which are weights assigned to the farmers' perception of how well a specific attribute is being embodied in a given variety. The column totals (d_i) present the demand weights, which are assigned to the farmers' perception of how important the specific attribute is. Each cell in the matrix is then calculated as:

$$W_{ij} = S_i d_j$$

Table 3. The weighting matrix.

	Very important	Important	Not so important	Row total
Very good	w_{11}	w_{12}	w_{13}	s_1
Good	w_{21}	w_{22}	w_{23}	s_2
Poor	w_{31}	w_{32}	w_{33}	s_3
Column total	d_1	d_2	d_3	

Reed et al. (1991) and Sall et al. (2000) propose certain restrictions to be imposed on the weights, so that the following inequalities hold:

a) $w_{1j} > w_{2j} > w_{3j}$ for all j. This implies that regardless of how important a characteristic is, the more favourably the farmer perceives that characteristic being present in the variety under evaluation, the higher the weight is.

b) $w_{i1} > w_{i2} > w_{i3} > 0$ for all i which is rated good or better. This inequality implies that whenever a characteristic embodied in a variety is rated as good or better, the weight should be positive and increase in value as its level of importance increases.

c) $w_{i1} < w_{i2} < w_{i3} < 0$ for all i which is rated poor. This implies weights for characteristics rated as poor should be negative and decreasing as their importance increases.

d) The above inequalities imply the following restrictions when constructing the supply and demand weights: $S_1 > S_2 > 0 > S_3$ and $d_1 > d_2 > d_3 > 0$.

All demand weights (d_i) are positive, while the supply weight for a characteristic ranked as poor is negative. The stated weighting scheme ensures that the highest (lowest) weights will be given to those characteristics considered very important and embodied very well (poor).

Given the response weighting matrices, the following indices can be calculated as follow:

$$D = \frac{1}{d_1 N} \sum_{j-1}^{3} d_j c_j$$

The demand index (D) is a measure of how important the farmers perceive a particular characteristic to be. A value of 1 indicates that all farmers perceive the characteristic to be very important. The minimum value of the index is $(d_3/d_1)>0$ and is attained when all farmers perceive the characteristic to be of little importance.

$$S = \frac{1}{s_1 N} \sum_{i=1}^{3} s_i r_i$$

The supply index (S) is a measure of the perception of farmers on how well a characteristic is being embodied in a variety. A maximum value of 1 indicates that all farmers perceive the characteristic supplied as being very good quality. The minimum value will be attained if all farmers perceive the quality of the characteristic being supplied as poor.

$$W = \frac{1}{w_{11}N}\sum_{j=1}^{3}\sum_{i=1}^{3} w_{ij}n_{ij}$$

The attainment index (W) provides a measure of how well farmers' perception of the importance of the characteristic matches farmers' perceptions of how well it is being supplied in the variety. The maximum value of W is 1, which implies a perfect match. In such a situation, all farmers rank a particular attribute as very important and rank the quality supplied by the variety as very good. The minimum value of the index depends on the supply weight S_i, chosen and is calculated to be $(s_i/s_1) < 0$.

Results and Discussion

Bread wheat varieties cultivated by farmers

According to survey results about 11 improved and 20 local bread wheat varieties were grown by farmers across the four major wheat production regions. Sixty nine per cent of the respondents grew improved varieties while the remaining grew local varieties (Table 4). Among improved bread varieties the prominent ones were *Digalu, Tuse, Kubsa, Galema, ET13, Madda Walabu, Danda'a, Pavon, Kakaba, Hawi* and *Dure.* All farmers in the study area of SNNP used only improved varieties. The landraces were *Bani* and *Wofiche* in Tirgay; *Enate, Kinikina, Kontem, Kuchibiye, Kurest, Logawshebo, Qebetu, Qeye Sende, Qurshet, Shamax, Sesse, Tekure Sende, Trifical Thogoshob* and *Zembolela* in Amhara; and Abebe and *Danshure* in Oromia.

The highest proportion of farmers reported growing *Digalu* (12.6%) followed by T*use* (11.6%) and *Kubsa* (9.5%) as shown in Table 4. Though, older improved varieties like *ET13* and *Pavon76* persisted, the adoption of newly released varieties like *Kakaba* and *Danda'a* was increasing. The data for 2011 showed that the proportion of users was 23.9% for *Kubsa*, 10.3% for *Galema*, 8.2% for *Dashen*, 5.1% for *Madda Walabu* and 3.7% for *Tusie* (Yirga et al., 2013). There was considerable decline in the proportion of farmers using popular varieties like *Kubsa* because of its attack by yellow rust during the 2010 epidemics. The proportion of farmers using different improved varieties appeared to be well spread, with no dominant varieties during the survey year, probably owing to decline in the variety *Kubsa*. Earlier studies showed higher varietal concentration where the five top varieties were planted by 66% of farmers and occupied 80% of area where *ET13* and *Pavon76* were prominent among them (Bishaw et al., 2010).

Table 4. Modern bread wheat varieties grown by farmers.

Variety	Year released*	Proportion of farmers growing (%)
ET13	1981	3.4
Pavon	1982	1.5
Kubsa	1995	9.5
Galema	1995	6.3
Tuse	1997	11.6
Madda Walabu	2000	1.7
Hawi	2000	0.4
Dure	2001	0.2
Digalu	2005	12.6
Kakaba	2010	1.1
Danda'a	2010	1.3
Others (improved)		19.2
Total		69.0

Source: Survey (2012), MoA (2012).

Farmers' perception of bread wheat varieties

We presented here the results on farmers' perceptions embodied in local and improved bread wheat varieties grown by them during the 2012 crop season (Tables 5 and 6). What farmers wanted in terms of the different varietal attributes is reflected in the demand indices. The results indicated that grain yield and resistance to yellow and stem rusts were attributes that were desired most compared to other attributes. It was evident from the supply and attainment indices that what was demanded by the farmers was more supplied and attained by improved varieties than the local ones. However, it was found that for attributes like field establishment, crop stand, straw yield and quality, local varieties had better attainment indices compared to some improved varieties.

Yield and grain characteristics

Farmers' perceptions about grain yield, size and colour showed considerable difference among local and improved bread wheat varieties. All improved varieties demonstrated better attainment index compared to local varieties. Moreover, all improved rust resistant varieties have better attainment compared to improved rust susceptible varieties. *Digalu* and *Danda'a* have the highest attainment indices for yield among rust resistant varieties showing farmers' preferences. For grain size, the most preferred was *Madda Walabu* followed by *Digalu* among rust resistant varieties. In terms of grain colour, the highest attainment was recorded for *Pavon76* among resistant varieties and for *Tuse* among susceptible varieties. However, *Pavon7*6 was rated for its high yield, but less so for grain size and colour (Bishaw et al., 2010). *Pavon76* and *Kubsa* were widely adopted and found important in suitability scoring

by farmers (Gebeyehu et al., 2002). Moreover, *Kubsa* and *Galema* were broadly adapted and found superior in grain yield, yield stability and seed characteristics (Yalew et al., 1997).

Field establishment, crop stand and earliness

In terms of field establishment, crop stand and earliness, *Pavon76* demonstrated the highest attainment index compared to other varieties. Some improved varieties like *ET13* has even lower attainment index compared to the local varieties for field establishment and crop stand.

Disease and drought resistance

All resistant varieties had higher attainment indices compared to local varieties for yellow and stem rusts. The highest attainment index was recorded for *Madda Walabu* among resistant improved wheat varieties. All susceptible improved varieties had lower attainment indices compared to local varieties. Bishaw (2004) reported that about 79% of farmers considered rusts as important wheat-production constraints and had concerns for short longevity of rust resistance of modern varietiess (Yirga et al., 1992). For example, some of resistance varieties now succumb to yellow (*Kakaba*) or stem (*Digalu*) rusts.

Food quality and marketability

All improved varieties demonstrated better attainment indices for food quality and bread taste (except *Millennium*) and marketability compared to landraces and the highest attainment index is recorded for *Pavon76* in both cases. Earlier reports showed that *Pavon7*6 and *Kubsa* were rated high for food quality and marketability (Bishaw et al., 2010). In Ethiopia, there is strong preference for grain colour where white grain varieties fetch better prices and consumer preferences for food preparation (Gebremariam et al., 1991; Agidie et al., 2000).

Threshability, straw yield and quality

The attainment indices of threshability is better for all improved varieties compared to landraces except for Millennium, which has low attainment index compared to landraces. *Digalu* demonstrated the highest attainment index of threshability compared to other varieties.

Farmers preference for straw yield and quality showed that *Danda'a, ET13* and *Millennium* varieties demonstrated lower attainment indices compared to local varieties. The highest preference for straw yield and quality was *Madda Walabu*. It was reported earlier that *ET13* was favoured by farmers because of its straw yield and quality and tolerance to diseases (Bishaw et al., 2010; Agidie et al., 2000).

Table 5. Demand, supply and attainment indices for rust resistant bread wheat varieties.

Variety attributes	Local			Highland agro-ecology												Mid-highland agro-ecology					
				Danda'a			ET13			Madda Walabu			Digalu			Kakaba			Pavon76		
	DI	SI	AI	DI	SI	AI	DI	SI	AI	DI	SI	AI	DI	SI	AI	DI	SI	AI	DI	SI	AI
Grain yield	0.99	0.18	0.18	0.97	0.94	0.91	0.99	0.35	0.35	1	0.89	0.89	0.99	0.91	0.91	1	0.88	0.88	0.99	0.86	0.86
Grain size	0.96	0.37	0.36	0.93	0.83	0.75	0.94	0.4	0.37	0.99	0.98	0.97	0.97	0.91	0.89	0.99	0.86	0.85	0.99	0.89	0.88
Grain colour	0.84	0.29	0.26	0.8	0.71	0.55	0.66	0.53	0.36	0.95	0.89	0.84	0.93	0.88	0.82	0.88	0.86	0.81	0.97	0.94	0.92
Field establishment & crop stand	0.8	0.51	0.42	0.78	0.91	0.72	0.64	0.59	0.4	0.93	0.91	0.85	0.89	0.94	0.84	0.93	0.88	0.87	0.94	0.97	0.93
Early maturity	0.83	0.18	0.15	0.71	0.8	0.57	0.7	0.41	0.29	0.91	0.72	0.66	0.89	0.73	0.66	0.97	0.86	0.84	0.93	0.94	0.88
Drought tolerance	0.88	0.47	0.41	0.84	0.74	0.62	0.82	0.38	0.3	0.87	0.89	0.77	0.88	0.87	0.77	0.9	0.86	0.79	0.93	0.89	0.83
Yellow rust resistance	0.91	0.32	0.3	0.86	0.71	0.6	0.96	0.36	0.34	0.93	0.95	0.89	0.92	0.85	0.79	0.88	0.74	0.66	0.88	0.72	0.63
Stem rust resistance	0.92	0.33	0.31	0.87	0.83	0.71	0.94	0.37	0.34	0.95	0.93	0.89	0.95	0.85	0.81	0.9	0.74	0.67	0.9	0.69	0.63
Threshability	0.83	0.32	0.29	0.71	0.88	0.6	0.68	0.53	0.37	0.91	0.89	0.8	0.89	0.94	0.85	0.87	0.88	0.77	0.92	0.89	0.81
Bread taste/food quality	0.89	0.51	0.45	0.84	0.8	0.65	0.86	0.55	0.47	0.92	0.79	0.74	0.88	0.74	0.66	0.88	0.86	0.77	0.85	0.94	0.81
Marketability	0.87	0.2	0.18	0.9	0.86	0.75	0.71	0.56	0.4	0.94	0.75	0.71	0.94	0.73	0.69	0.9	0.86	0.78	0.96	0.97	0.94
Straw yield	0.86	0.64	0.56	0.81	0.65	0.53	0.78	0.59	0.48	0.9	0.91	0.8	0.87	0.81	0.72	0.84	0.91	0.78	0.89	0.81	0.71
Straw quality	0.87	0.65	0.57	0.83	0.68	0.58	0.79	0.52	0.44	0.92	0.98	0.9	0.89	0.9	0.82	0.86	0.88	0.8	0.93	0.86	0.8

Note: Weights used to calculate indices are S (3, 1, -1), D (3, 2, 1); DI= Demand Index; SI= Supply Index; AI= Attainment Index.

Table 6. Demand, supply and attainment indices for rust susceptible bread wheat varieties.

Variety attributes	Local			Mid-highland agro-ecology									Highland agro-ecology		
				Millennium			Kubsa			Tuse			Galema		
	DI	SI	AI	DI	SI	AI	DI	SI	AI	DI	SI	AI	DI	SI	AI
Grain yield	0.99	0.18	0.18	0.93	0.47	0.40	0.99	0.74	0.73	0.99	0.84	0.83	0.98	0.59	0.58
Grain size	0.96	0.37	0.36	0.93	0.38	0.36	0.96	0.67	0.64	0.98	0.87	0.84	0.95	0.69	0.66
Grain colour	0.84	0.29	0.26	0.64	0.29	0.20	0.73	0.85	0.63	0.95	0.94	0.89	0.77	0.73	0.60
Field establishment and crop stand	0.80	0.51	0.42	0.64	0.69	0.45	0.68	0.87	0.60	0.90	0.92	0.83	0.73	0.80	0.61
Early maturity	0.83	0.18	0.15	0.69	0.51	0.38	0.76	0.86	0.66	0.89	0.91	0.82	0.77	0.69	0.56
Drought tolerance	0.88	0.47	0.41	0.82	0.16	0.17	0.85	0.50	0.44	0.87	0.88	0.75	0.84	0.51	0.45
Yellow rust resistance	0.91	0.32	0.30	0.87	0.16	0.13	0.92	0.30	0.27	0.90	0.79	0.72	0.92	0.31	0.27
Stem rust resistance	0.92	0.33	0.31	0.87	0.20	0.17	0.91	0.33	0.29	0.92	0.80	0.76	0.91	0.33	0.29
Threshability	0.83	0.32	0.29	0.80	0.33	0.28	0.77	0.90	0.69	0.87	0.89	0.77	0.79	0.73	0.59
Bread taste/food quality	0.89	0.51	0.45	0.84	0.42	0.36	0.88	0.83	0.74	0.84	0.78	0.66	0.90	0.50	0.63
Marketability	0.87	0.20	0.18	0.87	0.33	0.30	0.81	0.86	0.70	0.94	0.92	0.87	0.85	0.75	0.66
Straw yield	0.86	0.64	0.56	0.87	0.24	0.21	0.83	0.73	0.64	0.85	0.90	0.76	0.86	0.73	0.64
Straw quality	0.87	0.65	0.57	0.84	0.33	0.31	0.83	0.69	0.60	0.87	0.94	0.82	0.84	0.68	0.60

Note: Weights used to calculate indices are S (3, 1, -1), D (3, 2, 1); DI= Demand Index; SI= Supply Index; AI= Attainment Index.

In Ethiopia, farmers identified as many as 26 technological and socioeconomic factors for growing a particular modern variety or a local landrace of wheat (Bishaw et al., 2010). Varietal attributes such as grain yield, colour, grain size, food quality and marketability appeared to be most important in both durum and bread wheat and across all regions substantiating earlier results in central (Negatu et al., 1992; Negatu and Parikh, 1999), southeastern (Alemayehu et al., 1999; Kotu et al., 2000) and northwestern (Agidie et al., 2000) Ethiopia. It was also reported that farmers' perceptions of key attributes of modern varieties have positive influence on adoption (Negatu and Parikh, 1999; Kotu et al., 2000; Bishaw, 2004).

Farmers' varietal preferences and seed supply

Table 7 presents farmers' preferences for key attributes of bread wheat varieties such as grain yield, yellow rust resistance and drought tolerance; and trends in formal seed supply. Accordingly, all six resistance bread varieties have shown high attainment index (AI) for the three key attributes except *ET13*. On the other hand, all four susceptible varieties have shown lower AI for rusts except *Tuse* although *Kubsa* and *Tuse* have better AI for grain yield and *Galema* for drought.

Theoretically, farmers' varietal preference as indicator of demand is expected to be reflected in the volume of formal seed supplied. During 2008-13, on average 42,454 tonnes of certified seed of 10 improved bread wheat varieties were supplied (Table 7). The analysis of five year average showed that the top five wheat varieties occupied about 90% of the total seed supply. These include *Kubsa* (44%) and Galema (12%) among susceptible varieties and *Digalu* (13%), *Pavon76* (12%) and *Kakaba* (9%) among resistant varieties, although some of them now succumb to yellow or stem rust. Farmers' preferences led *Kubsa* to dominate the seed supply, but the yellow rust epidemics in 2010 resulted to its gradual decline in subsequent years.

Further analysis of five year data revealed many interesting observations regarding the mix and seed supply of resistant or susceptible wheat varieties. Until 2010/11, yellow rust susceptible varieties appeared to dominate the formal seed supply occupying 73 to 92% and this gradually declined to 29% in 2012/13. *Kubsa* is a yellow rust susceptible predominant variety but gradually declined from 77% in 2008/09 to 56% in 2010/11 to 26% in 2012/13 crop season. On the other hand, the formal seed supply of rust resistant varieties had increased from 8% in 2008/09 to 27% in 2010/11 and 71% in 2012/13 crop season. *Digalu* and *Pavon76* with high AI for grain yield, rust resistance and drought however maintained a low average of about 12-13% over the five year period although *Digalu* increased from 1 to 18% during the same period. *Danda'a* and *Kakaba* were two newly released varieties with combined resistance to stem and yellow rust and expected to replace *Kubsa* and *Galema*, respectively. In 2012/13, *Danda'a* and *Kakaba* occupied 19% and 23% of formal seed supply, respectively. Both varieties appeared to have comparable AI for grain yield among resistance varieties though rated relatively moderate for yellow rust resistance which require some precaution in the future. *Madda Walabu* was rated equally well among resistant varieties but seed availability from formal sector appears non-existent clearly demonstrating lack of varietal choices.

Interestingly *Kubsa* continue to dominate formal seed supply following the aftermath of yellow rust epidemics despite its lower AI in grain yield, rust resistance and drought tolerance. The reason for continuous supply of seed of varieties which does not meet farmers' demands is manifold, hence the problem of carry-over seed. First, there is limited capacity of the formal sector to shift immediately to new varieties and respond to emerging biotic stresses. Most NARS have limited physical, financial and human resources capacity for accelerated early generation seed multiplication and make available basic seed to initiate certified seed production and marketing by public or private sector. Second, there is lack of clear responsibility in promoting new varieties to create awareness and demand for seed guiding the seed production planning. Moreover, there is insufficient consultation with extension services and seed suppliers. Third, *Kubsa* still remains popular in the absence of rust epidemics which does not occur every year under Ethiopian condition.

It should also be noted that the formal wheat seed supply has increased dramatically, from 20,201 tonnes in 2008/09 to 64,844 tonnes in 2012/13, an increase of over three-fold. The continued increase in certified seed production brought the challenge of seed demand and supply to forefront. First, the formal seed supply could not commensurate with seed demand from farmers in terms of varietal choices. Second, there was substantial amount of carry over seed remained unsold every year despite a continued increase in seed demand. For example, about 5151 tonnes (12.1%) of wheat seed was carried over in 2012/13 crop season. Third, wheat accounted for nearly 64% of total seed supply and most importantly few wheat varieties (e.g. *Kubsa*) occupy the major share (Bishaw and Louwaars, 2012). The situation could be exacerbated with rust epidemics where new resistant varieties are urgently demanded and accelerated seed multiplication is highly desired.

The analysis of farmer's varietal preferences and formal sector seed supply can be summarized as follows:

- The formal sector was not able to provide certified seed of wheat that commensurate with farmer's varietal choices. *Madda Walabu* was rated high for key attributes preferred by farmers where seed production is negligible;
- There is a fluctuation in the amount of seed produced for each variety. *Pavon76* seed production was inconsistent although the variety rated reasonably high for grain yield, rust resistance and drought tolerance.
- The formal sector continued to produce certified seed of wheat varieties which are already susceptible to rusts. *Kubsa* dominated formal seed supply even after it was found susceptible to yellow rust for several years.
- There is a time lag between variety release and seed availability in farmers' field. The formal sector was rather slow in responding to varietal changes and new seed demand.

Table 7. Bread wheat varieties and formal seed supply (tonnes) from 2008/09-2012/13 crop seasons.

Wheat rust	Variety	Year released	Attainment index			Cropping season					Average	%
			Grain yield	Yellow rust resistance	Drought tolerance	2008/09	2009/10	2010/11	2011/12	2012/13		
Resistant	Danda'a	2010	0.91	0.60	0.62				2,252	12,363	2,923	7
	Kakaba	2010	0.88	0.66	0.79			245	3,370	14,654	3,654	9
	Digalu	2005	0.91	0.79	0.77	226	1,151	5,616	9,173	11,740	5,581	13
	Madda Walabu	2000	0.89	0.89	0.77	151	458	1,155	20		357	1
	Pavon76	1982	0.86	0.63	0.83	1,147	4,416	8,323	5,213	7034	5,226	12
	ET13	1981	0.35	0.34	0.30			35	58		18	0.04
	Sub-total					1,523	6,024	15,374	20,086	45,790	17,760	42
Susceptible	Millennium	2007	0.40	0.13	0.17	173	406	244			165	0.4
	Tuse	1997	0.83	0.72	0.44	467	604	1,496	1,214	832	923	2
	Galema	1995	0.58	0.27	0.75	2,462	5,447	8,063	7,503	1,298	4,955	12
	Kubsa	1995	0.73	0.27	0.45	15,576	19,885	31,407	9,472	16,924	18,653	44
	Sub-total					18,678	26,341	41,210	18,189	19,054	24,694	58
	Total					20,201	32,366	56,585	38,275	64,844	42,454	100

Source: National Seed Committee, 2013 and own data.

Conclusion and Recommendation

Recognizing the importance of farmers' subjective preferences and the perceptions of the attributes of the varieties for effective seed demand, an assessment was made to elicit how farmers' preferences for important attributes are embodied in the different bread wheat varieties currently under commercial seed production. The results indicated that (i) grain yield, yellow and stem rust resistance and drought tolerance are attributes that are most preferred by farmers, (ii) the high value of supply indices that was demanded by farmers are more supplied by improved varieties than landraces; (iii) the high value of attainment indices shows the demanded characteristics are embodied more in improved ones compared to local varieties; (iv) there is high variability in attainment indices among improved varieties for different attributes, which suggests the need to target varieties for different circumstances. This also implies for wheat breeders to further improve varieties for less attained attributes.

The value of attainment indices compared with the volume of seed supplied by the formal sector is not consistent resulting in mismatch between demand and supply and considerable carryover seed. For effective matching of demand and supply for seed, farmers' preferences as an important indicator of demand needs to be aligned with seed supply for each variety. The results indicated two important issues. The first issue is supply of seed of varieties which does not meet farmers' demand, hence the problem of carry-over seed. This implies the problem of the formal sector to shift immediately to new varieties (time lag between variety release and seed availability), which is highly associated with lack of responsibility who should invest in the initial promotion of new varieties. The second issue is the limited capacity of responsiveness of the formal sector to emerging biotic and abiotic stresses. For instance, although *Kubsa* was the most popular variety because of high yield it was succumbed to yellow rust in 2010 but continue to dominate wheat seed production.

Despite a long list of released wheat varieties few of them entered large-scale seed production and made available to farmers. The prominence of mega varieties (e.g. *Kubsa*) showed the vulnerability of wheat production exposing it to eminent danger of emerging threats like stem rusts. The federal and regional research systems should address the diverse local needs to meet farmers' preferences and varietal choices. With the establishment of regional seed enterprises, there will be more scope to manage these more specific varieties. An alternative strategy also lies in decentralized community seed production schemes to deliver these locally adapted varieties.

Ethiopia's diverse agro-ecology is one of the fundamental challenges for breeders in developing 'niche' varieties. In principle, this would require a very extensive and costly testing system to identify a large number of 'pocket varieties' which is very difficult for the formal sector to regularly supply certified seed. The results indicated that no one variety has the best traits for all production areas. Therefore, for effective consideration of farmers' preferences, the formal sector needs to diversify seed supply of bread wheat varieties and also improve its capacity to respond to emerging challenges.

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