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Appraisal of farmers' wheat production constraints and breeding priorities in rust prone agro-ecologies of Ethiopia

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Ethiopia is the second largest producer of wheat in sub-Saharan Africa although yields remain considerably below the global average due to several production constraints. The aim of the study was to identify the primary threats to wheat production, farmers' selection criteria for wheat varieties, and disease management practices with emphasis on wheat rusts in the Arsi, Bale and West Shewa administrative zones of Ethiopia. A total of 270 wheat growing households were interviewed in the three administrative zones in 2012. Participatory rural appraisal tools, a semi-structured questionnaire and focus group discussions were used to engage with the farmers. Main wheat production constraints were wheat rust diseases, the high costs of fertilizers, shortage of improved seeds and high seed prices. The most important traits that farmers sought in wheat varieties were disease resistance (27.8%) and high grain yield (24.8%). Owing to the limited availability of rusts resistant varieties, and the emergence of virulent pathotypes, fungicide application was the main disease management practice used by 60% of respondent farmers. To enhance wheat production and productivity in Ethiopia, it is important to develop rust resistant varieties considering farmers' preferences, promote access to wheat production inputs and strengthen seed multiplication and dissemination of improved varieties.

Key words: Ethiopia, participatory rural appraisal, rust, seed source, wheat production constraints, wheat traits.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the world's leading cereal grains serving as a staple food for more than one-third of the global population. Globally, it is cultivated on approximately 218 million hectares of land (HGCA, 2014). Ethiopia is the largest wheat producer in sub-Saharan Africa (FAOSTAT, 2014). In Ethiopia wheat is cultivated on over 1.6 million hectares of land, accounting for 13.33% of the total grain crop area, with an annual production of 4.2 million tons, contributing about 15.81% of the total grain production (CSA, 2015). In terms of area of production, wheat ranks fourth after teff (*Eragrostis tef* Zucc.), maize (*Zea mays* L.) and Sorghum (*Sorghum*

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bicolor L.). In total grain production, wheat ranks third after teff and maize in the country (CSA, 2015).

Wheat is largely grown in the mid and highland areas of Ethiopia spanning at altitudes of 1500 to 3000 m above sea level (masl). However, it is mainly grown between 1800 to 2500 masl in the country (Winch, 2007). Arsi, Bale and Shewa administrative zones of the Oromia Regional State of Ethiopia are among the major wheat areas with 53.4% of the wheat produced in Ethiopia coming from these zones (CSA, 2015). The Arsi and Bale zones are included among the highest potential agro-ecologies in Eastern Africa for wheat production with 467337.42 ha under wheat (Jobie, 2007; CSA, 2015).

In Ethiopia wheat is predominantly grown by small scale farmers at a subsistence level, and these farmers experience a wide range of biotic, abiotic and socio-economic constraints. Wheat rusts, stem rust (*Puccinia graminis* Pers. f.sp. *tritici* Eriks and Hann), leaf rust (*P. triticina* Eriks) and stripe or yellow rust (*P. striiformis* Westend. f. sp. *tritici*) are the major biotic constraints in all wheat growing regions of the country. To combat yield losses due to wheat rusts and other abiotic constraints, the National Wheat Improvement Program has released more than 30 wheat varieties since 2003. However, only a few rust resistant wheat varieties are being planted by farmers in the country (DRRW, 2010).

Different reports are available on the low adoption rate of improved wheat varieties by resource poor farmers in Ethiopia. For instance, Zegeye et al. (2001), DRRW (2010) and Nelson (2013) indicated that most of the released varieties in Ethiopia had been poorly adopted by the small scale farmers because of lack of effective seed production and delivery mechanism, weak integration of variety requirements between breeders and farmers and less adaptation of the breeders developed varieties to the local environments. In Ethiopia, farmers' variety preferences is not only grain yield but also disease resistance, straw yield, seed color, baking quality and other related social values (Bishaw et al., 2010; Tesfaye et al., 2014). Therefore, in order to enhance the adoption rate of new wheat varieties, and improve wheat production and productivity in the country farmers' production constraints and varietal preferences should be well known.

Participatory rural appraisal (PRA) has been widely used to collect information on farmers' varietal preferences, production constraints and traditional knowledge and experiences to mitigate food insecurity and improve their livelihood (Chambers, 1994). Understanding farmers' preferences, attributes of wheat varieties and wheat production constraints enables breeders to set wheat breeding priorities (Weltzien and Christinck, 2009). By integrating farmers' concerns and conditions into agricultural research, research will develop technologies that become widely adopted, resulting in more productive, stable, equitable and sustainable agricultural systems (Martins et al., 2002; Owere et al., 2012). Participatory rural appraisal has been previously conducted on wheat in Ethiopia (Agidie et al., 2000; Bishaw, 2004; Bishaw et al., 2010; Tesfaye et al., 2014), however, information on presently grown varieties, farmers' key production constraints and preferences in wheat cultivars is inadequate. The objective of the current study was, therefore, to identify wheat production threats, farmers' variety selection criteria, and disease management practices with special emphasis on wheat rusts in Arsi, Bale and West Shewa administrative zones of Oromia Regional State of Ethiopia.

MATERIALS AND METHODS

Description of the study areas

The study was carried out in three selected administrative zones: Arsi, Bale and West Shewa between February and April 2012. The zones are situated in the Oromia Regional State of Ethiopia. All the zones are wheat potential areas but differ in terms of agro-ecological diversity and in the use of modern wheat production technologies. The Arsi and Bale zones are situated in the South-eastern of Ethiopia while the West Shewa zone is in the Central highlands of Ethiopia. The study zones are dominated by three major agro-ecologies: highlands (2300-3200 masl), midlands (1500-2300 masl) and lowlands (500-1500 masl). The rainfall pattern in the zones exhibits a bimodal nature: short and long rains during February to May and June to September, respectively (CSA, 2014). In all study zones mixed crop-livestock farming is the predominant mode of agricultural production (Tefera et al., 2002). Wheat, tef, barley and maize are the major cereal crops, together with pulses, oil crops and vegetables (CSA, 2015).

Data source

Both qualitative and quantitative data were collected from primary and secondary sources. Primary data were collected through semi-structured questionnaires and focus group discussions. The secondary data were obtained from the zone and district agricultural offices of the respective districts included in the study.

Sampling

A multi-stage sampling procedure was used involving the selection of zones, districts, peasant associations and wheat farmers. A non-random purposive sampling was used to select from the zones through the districts, peasant associations and farmers levels. The sampling procedure involved two districts per zone, three peasant associations per district and fifteen respondents per village. This resulted in a total of three districts, 18 peasant associations, and 270 respondents. Individual farmers were selected from each peasant association representing various socio-economic backgrounds (data not shown) and both gender (Table 1). Thus the farmers selected for the study are believed to be the representative of the wheat farmers in the three zones. Zone level agricultural experts and district agricultural development offices assisted with the identification of the sampled districts, peasant associations and respondents.

Data collection

Semi-structured questionnaire was designed on topics related to

Table 1. The selected study areas in Arsi, Bale and West Shewa zones of the Oromia Regional State in Ethiopia.

Zone	District	Male {No (%)}	Female {No (%)}	Total {No (%)}
Arsi	Tiyo	36 (80)	9 (20)	45 (16.7)
	Munisa	39 (86.7)	6 (13.3)	45 (16.7)
Bale	Sinana	42 (93.3)	3 (6.7)	45 (16.7)
	Gasera	41 (91.1)	4 (8.9)	45 (16.7)
West Shewa	Jeldu	39 (86.7)	6 (13.3)	45 (16.7)
	Dandi	41 (91.1)	4 (8.9)	45 (16.7)
	Total	238 (88.1)	32 (11.9)	270 (100)

the general socio-economic characteristics of the household, wheat varieties grown, production constraints, wheat rust diseases and their management. Enumerators were recruited for data collection who lives in the area, fluent speakers of local language (Oromifa), well acquainted with local and cultural contexts, and working within the selected districts. They were trained on the contents of the interview schedule and data collection techniques. Pre-test on non-sample respondents was also made under supervision of the researcher. Finally, the formal survey was conducted on 270 households after necessary modification and adjustments were accommodated as per the result obtained from the pre-test.

Focus group discussions were held in each district to understand farmers' varietal preferences and the specific traits that influence a farmer's decision to grow a wheat variety, and the major constraints affecting wheat production. Each group was composed of 10-15 wheat growers (both male and female). Checklists were developed and used to guide focused group discussions with farmer groups and individual key informants. The farmers were encouraged to use their local language that they were most familiar with. The development agents most familiar with the local language facilitated the group discussions. During the discussion, the farmers were asked to list wheat varieties they grow and to identify the traits that they used in selection of the varieties, and list the main constraints limiting wheat production.

Data analysis

Data (both qualitative and quantitative) obtained from sample respondents were sorted, coded and subjected for statistical analyses using the Statistical Package for Social Sciences computer software (SPSS Inc., 2005). Both descriptive (means and percentages) and inferential statistical procedures were used to analyze the data obtained from households.

RESULTS

Demographic characteristics

The sample population contained 88.2% males and 11.8% females. Almost all the respondents (99%) who participated in the study were farmers in agricultural production. The mean family size of the sampled population was 5 and about 85% of interviewed farmers had family sizes greater than 3 persons per household. In the study areas, children were contributing to farm labour significantly. Farmers who were illiterate constituted 21%. Farmers educated up to primary and secondary level constituted 62 and 17%, respectively.

Farming system

Household total crop land in the study areas ranged from 0.5 to 15 ha, with mean farm size of 2.5 ha (SD 2.43). The majority of the interviewed farmers allocate most of their land for wheat as the number one crop. Of the 2.5 hectares of mean farm size owned by individual farmers, a mean of 1.85 ha were dedicated to wheat production in the study areas. Farmers in the study areas grow different assemblage of crops. These include cereals, pulses and oilseed crops. In addition to wheat, other major crops grown by majority of farmers in the Arsi zone were barley (*Hordium vulgare* L.) (71%), maize (*Zea mays* L.) (51%), teff (*E. tef* (Zucc.) Trotter) (41%), faba bean (*Vicia faba* L.) (46%) and linseed (*Linum usitatissimum* L.) (18%). The three major cereal crops widely grown after wheat were barley (58%), maize (40%), and teff (39%) in the Bale zone. In West Shewa most farmers grow maize (67%), teff (63%), barley (41%), faba bean (38%), grass pea (*Lathyrus sativus* L.) (24%), and noug (*Guzotia abysinica* Cass.) (15%).

Wheat is grown both in the main and short rainy seasons in the Sinana and Gasera Districts of Bale zone. The main rainy season has long rains which start in June and end in September. It is the period when the largest wheat area is cultivated. In the short rainy season, the rain starts in February and ends in April. Seventy-three percent of the farmers in these districts grow wheat in both the main and the short rainy seasons, while 27% of them only utilize the main season to produce wheat. On the other hand, farmers in the Arsi and West Shewa zones only grow wheat during the main rainy season. In the study areas, wheat is produced solely under rain fed conditions.

Table 2. Farmers' sources of wheat seed in the Arsi, Bale and West Shewa zones of Oromia Regional State in Ethiopia.

Sector	Seed source	Seed source in 2011 cropping season	
		Frequency	% response
Informal	Own stock	184	68.1
	Other farmers	24	8.9
	Local markets	20	7.4
Formal	Agricultural Offices	33	12.2
	Research centers	3	1.1
	Producer cooperatives	6	2.2
Total		270	100

Table 3. Wheat varieties grown, year of release and proportion of wheat farmers in the study areas.

Variety	Year of release	% response		
		Arsi	Bale	West Shewa
Pavon 76	1982	11.10	1.15	-
Dashen	1984	-	-	31.75
Kubsa	1995	53.35	10.15	38.90
Galama	1995	-	3.35	30.55
Tusie	1997	39.75	77.20	-
Madawalabu	2000	6.80	46.20	1.15
Hawi	2000	1.10	-	-
Sofumer	2000	9.10	20.35	-
Digelu	2005	88.75	70.75	40.20
Kakaba	2010	15.85	3.40	1.10
Danda'a	2010	10.25	-	-
Local	-	-	6.75	10.70

Wheat seed source

The sources of seed for farmers are presented in Table 2. The informal sector was the source of seed for 84.4% of the farmers in the area, where 68.1% respondents used seeds retained from the previous harvest, and 8.9 and 7.4% of respondents used seeds from other farmers and local markets, respectively. The formal sector provided for only 15.5%, where 12.2% of households sourced their seed from Agricultural Offices (AO) in the respective districts, 1.1% from research centers and 2.2% from producers' cooperatives (Table 2).

Wheat varieties grown by farmers and genetic diversity

Table 3 shows the different wheat varieties grown by farmers in the study areas. Most farmers grow more than one variety, making the proportions above 100%. The most commonly grown wheat varieties in the Aris zone were Digelu, Kubsa and Tusie at 88.75, 53.35 and 39.75%, respectively. In the Bale zone, Tusie (77.2%), Digelu (70.75%) and Madawalabu (46.2%) were the dominant wheat varieties grown by the majority of households. Digelu (40.2%) and Kubsa (38.9%) were popular varieties in West Shewa zone.

Variety Digelu was grown by 88.8, 70.8 and 40% respondents in Arsi, Bale and West Shewa zones, respectively. Fifty three percent of respondents in Arsi and 39% in West Shewa grew variety Kubsa on their farms. The new bread wheat varieties, Kakaba and Danda'a that were released in 2010 were grown in Arsi by 15 and 10% of the farmers, respectively. Danda'a was grown only by 3.4% of farmers interviewed in Bale zone. None of the respondents in West Shewa grew these varieties, while 10.7% of household used local wheat varieties. Bread wheat was the principal type of wheat

Table 4. Farmers'-preferred traits required of improved wheat varieties in the study zones.

Farmers'-preferred traits	Zones						All survey	
	Arsi		Bale		West Shewa			
	Freq	%	Freq	%	Freq	%	Freq	%
Grain yield	25	27.8	15	16.7	27	30	67	24.8
Disease resistance	16	17.8	25	27.8	34	37.8	75	27.8
Grain yield and disease resistance	28	31.1	22	24.4	23	25.6	73	27.0
Environmental adaptability	7	7.8	8	8.9	2	2.2	6	6.3
Disease resistance and food quality	4	4.4	3	3.3	0	0	12	2.6
Grain yield and high market value	3	3.3	2	2.2	1	1	10	2.2
Grain yield, food quality and high market value	2	2.2	5	5.6	0	0	9	2.6
Grain yield, early maturity, disease resistance and food quality	1	1.1	4	4.4	2	2.2	7	2.6
Grain yield, disease resistance, high market value and food quality	4	4.4	6	6.7	1	1.1	11	4.1
Total	90	100	90	100	90	100	270	100

†Freq=frequency of respondents.

Table 5. Wheat varieties grown by farmers in the Arsi, Bale and West Shewa zones and their outstanding traits.

Wheat varieties	Preferred traits	Non- Preferred traits
Kubsa	High grain yield, high biomass, multiple use at home, white seed, adaptable to environment	Susceptible to disease
Digelu	High grain yield, multiple use at home, white seed, diseases resistant	Late maturity, hard straw
Galama	High biomass, multiple use at home, adaptable to environment	Susceptible to disease, late maturity
Dashen	White seed	Susceptible to disease
Kakaba	High grain yield, disease resistant, early maturity, white seed, tolerant to lodging, soft straw for animal fodder	-
Madawalabu	High grain yield, disease resistant, early maturity	-
Pavon 76	White seed, early maturity	Susceptible to disease
Tusie	White seed, tolerant to rust	-
Sofumer	High grain yield, disease resistant	Purple seed color
Danda'a	High grain yield, disease resistant, white seed, tillering capacity, bread making quality, long spike	Late maturing, less treshability

grown by farmers in all surveyed areas.

Farmers' preferred traits

In all the study areas, farmers used a combination of criteria in selecting wheat varieties. The major and common reasons behind varietal preferences are given in Table 4. The most important criteria across the areas were disease resistance (27.8%), high grain yield (24.8%) and a combination of the two (27%). In Arsi 31.1% of respondents preferred a combined high grain yield and disease resistance as the key criteria for selecting wheat varieties. Disease resistance was a key criterion for 27.8 and 37.8% farmers in Bale and West Shewa, respectively.

Environmental adaptability was a criterion for 7.8% of farmers in Arsi and 8.9% in Bale and 2.2% of respondents in West Shewa. High market value in combination with other traits was also a major selection criterion in the study areas because wheat is a major source of income in the areas.

Farmers in group discussions were also asked to associate a particular wheat variety they grow with its preferred and non-preferred traits. The most commonly grown varieties, along with their preferred traits are summarized in Table 5. Farmers in the study areas selected wheat varieties Madawalabu, Sofumer, Danda'a and Kakaba for their disease resistance. Tusie is tolerant of rust and is preferred for its market value. Kubsa and Galama are disease susceptible varieties but farmers still grew these variteis for their high grain yield and biomass which is used for animal fodder, fuel and house roofing material. White seeded varieties such as Kubsa, Dashen, Digelu, Kakaba, Danda'a, Tusie and Pavon 76 were largely grown by farmers for sale because they are preferred by urban consumers.

Farmers in group discussions stated that Kakaba is tolerant to lodging because of its semi-dwarf nature. It is early maturing variety and was preferred by farmers who

practiced double cropping. Kakaba was also preferred for its soft straw which makes it suitable for animal fodder. In contrast, Digelu has hard straw, making it little use for animal fodder. Farmers raised that variety Digelu is late maturing. However, they were convinced that this variety is high yielding and has the best fit in areas that receive extended rainfall. Danda'a was preferred by the farmers for its tillering capacity, resistance to disease and long spike. The farmers who grew Danada'a considered it as a replacement for the old susceptible wheat variety, Galama. The female famers who participated in the group discussions also stated that the variety has good bread making quality. However, the farmers indicated that Denda'a has less threshing ability and difficult for threshing using manual harvesting and threshing methods. Hence, farmers obliged to use combine harvesting.

Wheat production constraints

The farmers' perceptions of wheat production constraints and their ranks between locations are summarized in Table 6. There was a marked agreement in the identified constraints in the three survey zones, with some variation in the ranking between the zones. High seed prices were ranked fourth following a lack of access to seeds of varieties in the Arsi and West Shewa zones, whereas farmers in the Bale zone perceived high seed prices as equally important to the lack of access to seeds of improved varieties and both ranked third. Lack of credit access was perceived as an important constraint in West Shewa while it ranked lower in the Arsi and Bale zones.

Almost all sampled farmers (96%) in the three zones considered the wheat rusts as the most important production constraint. The second most important constraint in the surveyed zones was high fertilizer price (93%). Farmers in the study areas use fertilizers; however, the amount applied per unit area is often lower than the recommended rate because of the high price of fertilizer. Lack of access to seeds of improved wheat varieties (85%) was identified as the third most important limiting factor of wheat production followed by high improved seeds prices (81%). Unavailability and high cost of improved seeds were mentioned as the two most important reasons for not adopting wheat technologies by the respondents. Low market prices of wheat were also regarded as major constraints of wheat production by 66% of the farmers. Most farmers sold the produce in the local markets and were discontented with the low prices of wheat. Farmers mentioned that the low prices were due to the fact that middlemen determined the price of the produce.

Wheat rusts and farmers' management methods

Farmers in the study areas were also asked to estimate yield losses from rusts. This was done based on the differences between yields from stem rust free wheat farms and diseased wheat farms sown to the same varieties. Accordingly, yield losses of 70.7, 60.5 and 60.0% were estimated in the Aris, Bale and West Shewa zones, respectively (Table 7).

To reduce losses from rust infestations, fungicides are being used by most producers. More than 60% of interviewed farmers used fungicides for rust management (Table 8). Tilt® (Propiconazol), Bayfidan® (Triadimenol), and Mancozeb were the major fungicides used by the farmers for rust control. Only 15% of the respondents had adopted new varieties for the control of rusts. Varieties Kakaba, Danda'a and Digelu were widely adopted rust resistant wheat varieties during the study period. On the other hand, a few farmers in Bale (6.7%) were planting early to avoid rust damage. In contrast, almost 20% of the farmers did not use any control measure to protect their wheat farms from rust infection.

DISCUSSION

In Ethiopia wheat research programs to develop improved wheat varieties were initiated during the 1950s. Despite 60 years of wheat breeding in the country, most of the released cultivars had been poorly adopted by small-scale farmers (Zegeye et al., 2001; DRRW, 2010). Majority of farmers in the study areas continue to grow old varieties such as Kubsa and Galama that are often susceptible to diseases. The reasons for the persistence of old varieties were lack of farmers' preferred traits in the new cultivars, unavailability of sufficient quantity of new seed or its poor distribution in the study areas and the risk avoidance adopted by farmers who grow a mixture of varieties to spread their risks.

The continued planting of rust susceptible varieties poses a serious threat to stable wheat production in the country. The failure to distribute newly released varieties in a timely way exposes the country to an agricultural time bomb, in a scenario ominously similar to the events leading up to the 2010 and 2013 yellow rust and stem rust epidemics, respectively. Another problem with the continued use of susceptible varieties is that it increases the chances of new mutant races of rusts developing to attack presently resistant varieties (CIMMYT, 1989). To address this, the recently released rust resistant wheat varieties with diversity in genetic background, adaptation and good yield potential should be delivered to small scale farmers in time at affordable prices, to ensure increase wheat productivity.

The study also indicated the predominance of informal seed sector in seed distribution. The predominance of the informal seed systems slows down replacement of older varieties and delays the transfer of benefits from breeding research to farmers. Hence, efforts should be made to understand and solve factors in the seed system that

Table 6. Major wheat production constraints and their ranks in Arsi, Bale and West Shewa zones of Oromia Regional State in Ethiopia.

Constraints	Zones									All Surveyed		
	Arsi			Bale			West Shewa					
	†Freq.	%	Rank	Freq.	%	Rank	Freq.	%	Rank	Freq.	%	Rank
Rusts (yellow rust and stem rust)	87	96.7	1	86	95.6	1	86	95.6	1	259	96	1
Lack of seed of improved varieties	81	90.0	3	77	85.6	3	71	78.9	3	229	85	3
High seed price	78	86.7	4	77	85.6	3	65	72.2	4	220	81	4
High fertilizer price	85	94.4	2	82	91.1	2	84	93.3	2	251	93	2
Shortage of fertilizer	15	16.7	9	17	18.9	9	21	23.3	9	53	20	9
Low producer price	61	67.8	5	62	68.9	5	54	60.0	5	177	66	5
Weeds (grass weeds)	37	41.1	7	32	35.6	6	25	27.8	8	94	35	7
Poor soil fertility	11	12.2	10	10	11.1	11	12	13.3	11	33	12	11
Other diseases and pests	42	46.7	6	29	32.2	7	39	43.3	7	110	41	6
Unpredictable rain	18	20.0	8	13	14.4	10	16	17.8	10	61	17	10
Lack of access to credit	7	7.8	11	24	26.7	8	54	60.0	5	85	31	8

†Freq=frequency of respondents.

Table 7. Yield losses due to rusts in study zones.

Zone	Mean wheat productivity		Loss (%)
	Under low/no rust infestation (t ha^{-1})	Under high rust infestation (t ha^{-1})	
Arsi	4.1	1.2	70.7
Bale	3.8	1.5	60.5
West Shewa	2.0	0.8	60.0

Table 8. Wheat rusts control measures practiced in the study areas.

Control measures	Zone						All surveyed zones	
	Arsi		Bale		West Shewa			
	†Freq	%	Freq	%	Freq	%	Freq	%
None	14	15.6	15	16.7	24	26.7	53	19.6
Chemical	62	68.9	60	66.7	57	63.3	179	66.3
Resistant variety	14	15.6	9	10.0	8	8.9	31	11.5
Cultural practice (Early planting)	0	0	6	6.7	1	1.1	7	2.6
Total	90	100	90	100	90	100	270	100

†Freq= frequency of respondents.

may impede rapid varietal replacement. This effort will be instrumental in improving the current seed multiplication and dissemination pathway and widening the genetic bases of wheat that will help in buffering the rust incidence and contribute to household food security of smallholder farmers in Ethiopia. Besides, the seeds of newly developed varieties must be produced in sufficient quantities in the study areas to make the research efforts more successful.

Wheat rusts have been major threats to wheat production in Ethiopia. In recent years, novel pathotypes of the rusts fungus have overcome resistant wheat varieties (ICARDA, 2011). The study areas are among the most rusts prone areas of East Africa and the wheat farmers in these areas frequently suffer serious losses from rusts epidemics (Hodson, 2013; Periyannan et al., 2013). The yellow rust outbreak in 2010 significantly reduced the national wheat annual production. The major wheat producing regions including the study zones were seriously affected of the epidemics with losses up to 70% (Hunde et al., 2012; Yami et al., 2013). Hence, farmers in all the study areas were in agreement that wheat rusts are the most important production constraints. High prices of chemical fertilizers and improved seeds were also important production limiting factors in the study areas. An increase in fertilizer prices due to the removal of government subsidies has decreased fertilizer use in the study areas. Consequently, farmers apply chemical fertilizers below the recommended rates. Under such circumstance, it is difficult to increase the wheat yields on small scale farms. Bishaw et al. (2010) reported a serious gap between the recommended rate and the actual amount applied by the farmers.

Farmers in the study areas were well aware of the benefit of resistant varieties for the control of rust diseases. However, majority of the respondents grow old varieties for the reasons described earlier and due to high improved seed prices, and doubts about the level of resistance provided by these new varieties to rust diseases. Hence, farmers use fungicides for the control of the rusts. The producers applied fungicides at early growth stages but the application rates were below the optimum rates to get the desired level of benefits. Early planting is another important rust control measure. It reduces the time of exposure of the crop to the pathogen and hence reduces yield loss (Tolessa et al., 2014). However, early planting is not a widely adopted disease control measure by the farmers in the PRA zones.

Although farmers in the study zones had a range of preferences regarding wheat varieties and specific traits, they were in agreement that disease resistance is the most important trait compared to all other traits. This indicated that farmers were concerned about the susceptibility of the existing varieties to rust diseases. During the study period, variety Digelu which was released in 2005 was still in high demand and was being rapidly multiplied. However, Digelu developed extremely high levels of stem rust epidemic in Bale zone during the 2013 cropping season, which led to 100% yield losses (Hodson, 2013). It was resistant to stem rust at the time of its release, but become susceptible to stem rust even before its cultivation was in substantial areas. The failure of many promising cultivars such as Digelu even before its cultivation was in substantial areas, indicate disease resistance as high breeding priority (Hei et al., 2014). The farmers in the study areas also indicated grain yield as a key criterion for selecting wheat varieties after rust resistance. Breeding for disease resistant and high yielding wheat varieties should also focus on other important traits such as seed colour and early maturity that were perceived as critical by famers.

In the past, durum wheat was the most widely grown wheat type in the major wheat growing areas of Ethiopia. Ethiopia is a center of diversity for durum wheat (Zohary, 1970) and Ethiopian durum wheat land races are valuable sources of resistance to rust diseases (Denbel and Badebo, 2012). To date bread wheat has become predominant in most wheat areas of the country. Farmers in the study areas shifted to bread wheat production owing to its productivity per unit area relative to durum wheat. However, this may seriously threaten the existence of local durum wheat land races in the country if strategic seed conservation is not undertaken on a national scale.

Taking into consideration the range of attributes that farmer's use when choosing varieties for planting, selection of a large breeding population is a prerequisite when developing wheat varieties for small holder farmers. In general, to ensure a high level of variety adoption and therefore the high productivity of the crop, the wheat breeding programme in the country should put more emphasis on solving the problems of wheat farmers, increase the frequency with which it releases new varieties that resist diseases and yield well. Efforts should also be made to conserve the indigenous durum wheat landraces and make use of them in developing modern wheat varieties.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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