

Full Length Research Paper

Yield gaps, adoption and seed commercial behaviour: Implications for chickpea seed system in Ethiopia

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The paper presents the yield gaps, adoption of improved varieties and the commercial behaviour in seed of smallholder chickpea producers based on the primary data collected from 612 randomly selected farmers covering 36 kebeles from 18 chickpea-producing districts, in 2017. The results indicate that the estimated average yield gaps were lower by 37.97 and 49.17% for desi chickpea and by 29.62 and 40.97% for kabuli chickpea, than the yields achieved on farmers' fields with improved variety and recommended practice and on-research stations, respectively. Overall, 43% of the chickpea producers were full-adopters, 9.5% partial adopters and the remaining 47.5% are non-adopters of improved varieties. Given the recent introduction of kabuli chickpea, all respondents reported the use of improved varieties (42.5%). Of the total 57.5% desi chickpea producing farmers, only 9.6% were full adopters. The commercial behaviour in chickpea seed use indicates that 55.4% of the farmers were autarkic who did not engage in chickpea seed markets, whereas 22% used purchased seed, 11.4% sold seed, and the remaining 11.1% were engaged in the seed market both as buyers and sellers. These results imply that there is a huge potential to narrow the yield gaps provided that the national seed system responds adequately to the key factors of adoption along with the smallholder farmers' commercial behaviour in chickpea seed system.

Key words: Chickpea, yield gap, adoption, commercial behaviour, seed system.

INTRODUCTION

The historical developments of organized seed sector were summarized in Ethiopia (Bishaw and Atilaw, 2016). Accordingly, we recognize at least three stages of seed sector development in the country: (i) emergence of formal sector characterized by ad hoc seed production and delivery (1940-1978); (ii) Establishment of formal sector and consolidation of public sector (1979-1990); and (iii) Diversification and expansion of the formal sector with entry of the private sector (since 1991). Currently, the seed sector is considered as one of the key

agricultural transformational agenda of the government and subsequently a national seed system development strategy was prepared by the Agricultural Transformation Agency through broader consultation of the stakeholders (MoA and ATA, 2013).

However, the development and performance of the seed systems followed different paths depending upon the nature of the crop, the commercialization process, and the type and networks of different stakeholders engaged in the commodity value chains of the crops

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(Spielman et al., 2010; Bishaw et al., 2010; Strasberg, et al., 1999). These development paths are highly linked to the formal, intermediate and informal seed systems, where for some crops, the formal seed system plays crucial role while for others the informal seed system dominates which translates to the difference of the performance in terms of adoption, yield gaps and diversity of actors engaged.

Chickpea is one of the most important legumes growing in the highlands and semi-arid regions of the country by about 1.2 million smallholder farmers with area coverage of about 260 thousand ha and production of 472,611 tonnes (CSA, 2016). Despite its importance, the productivity is low owing to low yield potential of land races and their susceptibility to diseases and pests, and poor cultural practices. To address these constraints, tremendous efforts have been made to develop improved technologies including new varieties and associated crop management practices. Accordingly, 12 desi and 11 kabuli improved chickpea varieties were released by NARS in collaboration with CG centers such as ICARDA and ICRISAT (MoANR, 2016).

The promotion of these improved varieties has been facilitated through the chickpea national extension package combining improved varieties, agronomic practices and targeting potential production areas in the country (MoA, 2014). Given the importance of chickpea in generating foreign currency through export, the extension package focuses on use of improved varieties that meet minimum international standard of hundred-grain weight (34 g).

With the focus of national formal seed system on few cereal crops primarily on maize and wheat there is relatively more information on their performance (Alemu and Bishaw, 2016). However, there is limited information on the performance and status of formal seed sector for key legume crops like chickpea specifically on varietal adoption, use of certified seed and commercial behaviour of producers that are crucial for proposing better options to align with on-going policy and development interventions targeted to enhance the overall performance of the national seed system. Accordingly, this study aimed at understanding the key characteristics of chickpea seed system, its performance, key actors and farmers' commercial behaviours.

MATERIALS AND METHODS

Study area, sampling and sample size

About 52 and 40% of area allocated to chickpea in the country is found in Amhara and Oromia regions, respectively (CSA, 2016). Accordingly, the study targeted potential chickpea production zones and districts in Amhara and Oromia regions. Considering the importance of the crop, three zones in Oromia (East Shewa, West Shewa, and North Shewa) and six zones (North Gonder, South Gonder, South Wollo, North Shewa, East Gojjam, and West Gojjam) from Amhara region were selected. A total of 612 chickpea producers were interviewed, which were allocated to districts

(*woredas*) and *kebeles* (the lowest administration unit) based on proportion to population size of chickpea producers.

Data sources and collection

Both primary and secondary data were collected in 2017. The primary data was collected from the sampled chickpea producers using a pre-tested questionnaire in March 2017. The questionnaire considered key questions about socio-demographics, resource ownership, access to services, production practices including varietal use, certified seed use, and commercial behaviour in chickpea seed. Similarly, additional primary information was collected through Key Informant Interviews (KIIs) using a checklist prepared for relevant actors at federal and regional levels, farmer's cooperatives, and agricultural research centres. The check list covers questions related with roles in chickpea seed system and challenges faced in delivering their respective roles. The secondary data on trends in production and productivity, number of farmers involved, certified seed production, chickpea seed actors, policies and directives relevant to the chickpea seed system were collected from CSA, Inputs Marketing Directorate of MoANR, and published documents.

Methods of data analysis

Estimation of yield gaps

The comparison of yield gaps was based on yield achieved at research stations, yield at farmers' fields with improved varieties and recommended packages or farmers' practices, and the national yield from CSA data. The yield estimates at research station were based on data from the national variety register for recently released varieties, the yields on farmers' field with recommended practice are from either demonstration or popularization trials, which are commonly reported in the variety register. The national yield estimate is from the annual crop production reports of the Central Statistical Agency (CSA).

Estimation of adoption rates

The adoption rate of improved chickpea varieties was estimated at household level, where a household is categorized into non-adopter, partial adopter, and full adopter since data was collected at plot level. Non-adopters are those households who do not use any improved variety in any of the plots where chickpea was grown. Partial adopters are those who used in one or more of the plots of chickpea field both local and improved varieties. Full adopters are those who used seed of improved variety of chickpea in all the plots. The adoption rates were estimated considering the two chickpea types (desi and kabuli).

Estimation of seed commercial behaviour

From household's market participation perspectives, the commercial behaviour can be defined in relation to Net Market Position (NMP) or Absolute Market Position (AMP) of a household either from agricultural outputs or inputs side. For output side, NMP is defined as the ratio of the value of agricultural outputs sold to the total value of agricultural outputs produced by a household; and from the input side, it is defined as the ratio of the value of agricultural inputs acquired from the market to the total value of agricultural production of a household (Von Braun et al., 1994). On the other hand, AMP is quantified using directly the quantities of sales and purchases of outputs and inputs.

Table 1. Yield gaps in chickpea production in Ethiopia.

Category	Use of technologies and practices	Chickpea type	Yield range (tonnes/ha)	Gaps against national yield (percentage)
Research field on-station	(i) Improved variety	Desi	2.5 - 4.7 (~3.60)	49.17
	(ii) Recommended practices	Kabuli	2.3 - 3.6 (~3.10)	40.97
	(iii) Researcher managed			
Farmers' field with recommended practice	(i) Improved variety	Desi	2.3 - 3.6 (~2.95)	37.97
	(ii) Recommended practices	Kabuli	2.5 - 2.7 (~2.6)	29.62
	(ii) Farmer managed			
Average national yield*	(i) CSA estimate (CSA, 2016)	Chickpea	1.83	-

Source: MoANR (2016).

In this study, the commercial behaviour in chickpea seed is described based on the market position estimated using Absolute Market Position (AMP), which is quantified by comparing the quantity of chickpea seed sold and purchased over a year. The possible market positions identified were categorized into four as (i) autarky, neither buyers nor sellers (ii) sellers only, (iii) buyers only, and (iv) both as buyers and sellers.

RESULTS AND DISCUSSION

Chickpea production, productivity and yield gaps

Chickpea productivity and yield gaps

The survey results indicate statistically significant difference in the productivity between desi and kabuli chickpea. Farmers reported that on average they achieved a yield of 2.29 and 1.36 tonnes ha⁻¹ for kabuli and desi chickpea plots, respectively with total average of 1.78 tonnes ha⁻¹. The Central Statistical Agency estimate for the same production season was 1.83 tons ha⁻¹ (CSA, 2016), which is slightly higher than the average survey estimate.

Yield gaps based on comparison of productivity levels achieved at national level; on-farm with recommended practices; and on-station at research centers may serve as indicators on the availability of and access to technologies, knowledge and information (Table 1). It also reflects on the performance of a seed system, extension services, and other input delivery systems (van Ittersuma et al., 2013; Spielman et al., 2010).

In estimating the average yield gaps, we use the national average chickpea yield data of 1.83 tonnes ha⁻¹ for all chickpea types (CSA, 2016). Table 1 presents the yield gaps in chickpea production due to variety and application of recommended crop management practices. The estimated national average yields were 37.97 and 49.17% lower for desi type and by 29.62 and 40.97% for kabuli type than the yields achieved on farmers' fields with improved variety and recommended practices and at research stations, respectively. These yield gap figures

indicate the potential of bridging the yield gaps through improved access to varieties and quality seed along with associated recommended agronomic practices and adequate extension services on providing the necessary information.

Adoption, seed source and certified seed use

Chickpea varieties

The national agricultural research system has released 23 improved chickpea varieties, where 12 are desi and 11 are kabuli type. The first improved variety for desi chickpea was released in early 1970s by the Debre Zeit ARC. For kabuli chickpea, the first variety was released in 1990s showing its recent introduction in the country (MoANR, 2016).

Adoption of improved varieties

Overall, 43% of the chickpea producers were full adopters, 9.5% partial adopters and the remaining 47.5% were non-adopters (Table 2). The overall adoption seems to be relatively high, which is highly associated with increased production of kabuli chickpea, which is a recent introduction into the production system in the country. Among the respondents about 42.5% produce kabuli chickpea whereas 57.5% produce desi chickpea. All kabuli chickpea producers reported the use of improved variety. Of the total 57.5% desi chickpea producing farmers, only 9.6% were full adopters where all plots of chickpea were planted with improved chickpea varieties and close to 1% are partial adopters where improved variety of chickpea was used in one of the chickpea plots and 46.9% are non-adopters.

From among 11 kabuli chickpea varieties released, farmers reported using only four varieties dominated by Arerti variety (57.7% of kabuli chickpea producers). Of the 12 desi chickpea varieties released, eight improved

Table 2. Adoption of improved chickpea varieties in 2016 cropping season.

Adoption	Chickpea type			Total	N
	Desi	Kabuli	Both		
Full adopter	16.8	100.0	6.7	43.0	263
Partial adopter	1.4	-	88.3	9.5	58
Non-adopter	81.8	-	5.0	47.5	291
Total	100.0	100.0	100.0	100.0	612
N	352	200	60	612	-

Source: Own survey (2017).

Table 3. Improved chickpea varieties adopted and their characteristics

Chickpea type	Variety grown	N	%	Year of release	Weighted average age (years)
Kabuli (four of 11 improved varieties)	Arerti	150	57.7	1999	17.29
	Shasho	73	28.1	1999	
	Habru	36	13.8	2004	
	Chefe	1	0.4	2004	
	Total adopters	260	100		
Desi (eight of 12 improved varieties)	Natolii	27	7.7	2007	17.55
	Mariye	19	5.4	1985	
	Mastewal	11	3.1	2006	
	Dalota	4	1.1	2013	
	Teketay	3	0.9	2013	
	DZ -10-4	3	0.9	1974	
	Akaki	2	0.6	1995	
	Worku	2	0.6	1994	
	Total adopters	71	20.2		

Source: Survey 2017 and MoA (2016)

varieties were identified by the farmers, the dominant variety reported being Natoli with 7.7% of desi chickpea producers (Table 3). The weighted average of varieties was 17.29 for kabuli and 17.55 for desi chickpea showing older varieties are being used by farmers.

Adoption and seed source

Chickpea producers, whether using local landraces or improved varieties obtain their seed for planting from different resources. The survey result indicates that chickpea producers use either saved or purchased seed or in combination. The purchased seed can be either certified seed of improved varieties or non-certified seed of landraces or improved varieties. Of the total respondents of chickpea producers, about 23% purchased certified seed of improved varieties whereas about 18% purchased seed from local sources of landraces or improved varieties and 59.2% used own seed from previous harvest of landraces or improved varieties (Figure 1).

Figure 1 presents the proportion of chickpea producers by chickpea type, adoption status, participation in the seed market, and use of certified seed. All kabuli chickpea producers are full adopters of improved varieties with use of different seed sources. The result indicates that from the chickpea producers, (32.7%) are engaged only in the production of kabuli type, of which 20.1% used purchased and 12.6% saved seeds. From the 20.1% users of purchased seed of improved kabuli varieties, 13.7% purchased certified seed and the rest 6.4% purchased seed from local sources. The results further show that 54.7% of chickpea producers are engaged in the production of desi type chickpea. Of the desi type producers, 10.5% were users of improved varieties, of which 8.3% used purchased and 2.2% saved seeds. From the 8.3% users of purchased seeds of improved desi varieties, 5.2% purchased certified seeds and the rest 3.1% purchased seeds from local sources. From the 47% non-adopting desi producers, 6% reported the use of non-certified purchased seed and the rest 41% reported the use of saved seed.

Farmers who produce both kabuli and desi chickpea

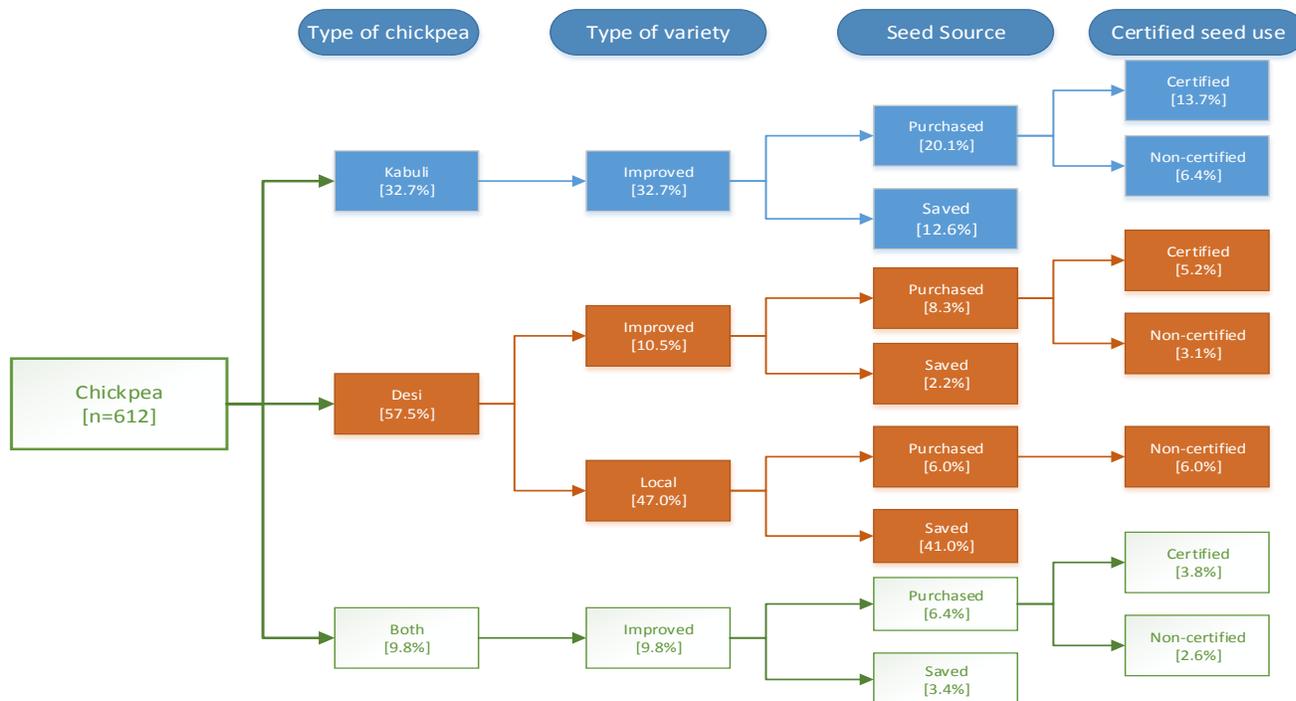


Figure 1. Seed source by chickpea type, adoption and certified seed use. Note: In case of both producers, it implies partial adopters who use both improved varieties and landraces. Source: Own survey (2017).

are partial adopters, because of the fact that kabuli seed available is only for improved varieties. For the 9.8% of the chickpea producers engaged in the production of both types, 6.4% of the farmers reported the use of purchased seed and the rest 3.4% reported the use of saved seed. Among the 6.4% purchased seed users, 3.8% purchased certified seed and the rest 2.6% purchased non-certified seed.

Note: respondents who used both saved seed and purchased certified seed were considered as those who purchased certified seed, and respondents, who used both saved and purchased non-certified seed are considered as those who purchased non-certified seed.

According to official statistics about 1,913.8 tonnes of chickpea certified seed was produced out of which 10.8 tonnes (0.6%) a carry-over seed in 2016 was cropping season. Considering the volume of certified seed supplied in the country, the CSA data of chickpea area and the number of farmers engaged in chickpea production, the average landholding of 0.22 ha and chickpea seed rate of 100 kg ha⁻¹, the total certified seed supplied (1903 tonnes) could reach merely 86,500 smallholders (7.38%) of the total 1.17 million chickpea farmers. Moreover, the certified seed supplied estimated to cover only 19, 030 ha (7.46%) compared to the total area of 258,486 ha which is less than the desired level of 25% seed replacement rate for self-pollinated crops such as chickpea.

Trends in adoption of improved chickpea varieties

To understand the patterns of chickpea adoption, respondent farmers were asked when they have started using improved varieties of chickpea. Based on their responses, the estimated patterns of adoption for desi and kabuli chickpea producers, respectively are depicted in Figure 2. The trend for kabuli indicates the start of kabuli chickpea production as a recent introduction, whereas for desi producers, it shows the trend in adoption trends over years.

Commercial behaviour in chickpea seed

The commercial behaviour in chickpea seed use indicates that 55.4% of the farmers were autarkic where they did not engage in chickpea seed markets both as buyers or as sellers, where as 22% used purchased seed, 11.4% sold seed, and the remaining 11.1% were engaged in chickpea seed market both as buyers and as sellers. Given this, commercial behaviour actors of the chickpea seed market can target about 33% of chickpea producers, who are in seed buying position. Majority of chickpea producers, who are in autarkic seed market position, requires awareness for creating seed demand through different mechanism if they are to be engaged in the seed market. There was statistically significant difference in the

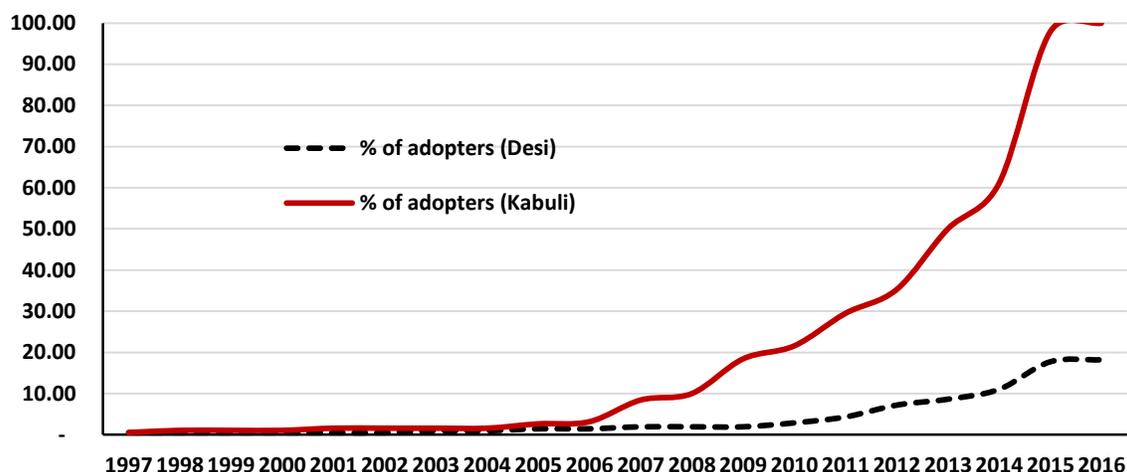


Figure 2. Patterns of adoption of improved desi chickpea varieties.

Table 4. Commercial behaviour of smallholders in chickpea seed use and adoption by chickpea type produced (2016 cropping season).

Chickpea type	Commercial behaviour	Adoption of improved chickpea varieties								Chi-square
		Full adopter		Partial adopter		Non adopter		Total		
		%	n	%	n	%	n	%	n	
Desi	Only buy	9.9	35	0.9	3	7.7	27	18.5	65	132.85***
	Only sell	1.4	5	-	-	12.8	45	14.2	50	
	Both buy and sell	2.8	10	0.6	2	2.0	7	5.4	19	
	Autarkic	2.6	9	-	-	59.4	209	61.9	218	
	Total	16.8	59	1.4	5	81.8	288	100.0	352	
Kabuli	Only buy	26.0	52	-	-	-	-	26.0	52	-
	Only sell	8.0	16	-	-	-	-	8.0	16	
	Both buy and sell	15.5	31	-	-	-	-	15.5	31	
	Autarkic	50.5	101	-	-	-	-	50.5	101	
	Total	100.0	200	-	-	-	-	100.0	200	
Both	Only buy	3.3	2	23.3	14	3.3	2	30.0	18	5.50
	Only sell	-	-	6.7	4	-	-	6.7	4	
	Both buy and sell	3.3	2	26.7	16	-	-	30.0	18	
	Autarkic	-	-	31.7	19	1.7	1	33.3	20	
	Total	6.7	4	88.3	53	5.0	3	100.0	60	
All	Only buy	14.5	89	2.8	17	4.7	29	22.1	135	121.08***
	Only sell	3.4	21	0.7	4	7.4	45	11.4	70	
	Both buy and sell	7.0	43	2.9	18	1.1	7	11.1	68	
	Autarkic	18.0	110	3.1	19	34.3	210	55.4	339	
	Total	43.0	263	9.5	58	47.5	291	100.0	612	

Source: Own survey (2017)

Note: *** indicates significance at 1%.

commercial behaviour between farmers of the different chickpea types (Table 3).

Looking at the commercial behaviour in seed use in relation to adoption of improved chickpea variety, there is a trend that among full adopters there is a tendency of

being in a buying market position for desi chickpea, where about 12% from the total desi producers are in seed buying position. For kabuli chickpea, most of the farmers are in autarkic position followed by buying (Table 4). The chi-square test shows statistically significant

difference in the distribution of farmers in adoption and commercial behaviour for desi chickpea producers. Of the total 43% of full adopters of chickpea, about 22% are in buying position and 18% in autarkic and the rest 3% in selling market position for chickpea seed. On the other hand, from the total 47.5% non-adopters, about 5% are in buying, about 7% in selling and the rest about 34% are in autarkic position.

Conclusion

The study indicates that 57.5% of producers are engaged in desi production, 32.7% in kabuli and the rest 9.8% are engaged with both types. The average productivity level between desi and kabuli chickpea shows significant difference, where farmers on average achieved 2.29 and 1.36 tons ha⁻¹, respectively. The yield gap assessed indicates that there is substantial difference between national average yield and the yields achieved on farmers' fields with improved variety and recommended practice and at research stations. The estimated yield gaps indicate the potential to boost productivity if appropriate measures are put in place in terms of use of quality seed of improved varieties and associated recommended agronomic practices.

The overall adoption was 43% for chickpea producers with considerable difference by type of chickpea. All kabuli chickpea producers are full adopters whereas only 16.8% of desi chickpea producers are adopters. Farmers reported the use of few and old kabuli and desi chickpea improved varieties. The weighted average age of varieties was about 17 years for both chickpea types implying low varietal replacement rates and limited use of recently released varieties among chickpea producers.

The commercial behavior between farmers was found to be quite different among producers of different chickpea types. About 55% of chickpea producers do not engage in chickpea seed market as they use only own seed, the remaining 45% are engaged either as buyers, sellers or both either in the formal and/or informal chickpea seed market. In terms of the commercial behaviour in seed use in relation to adoption of improved chickpea variety, there a tendency of being a buying market position for desi chickpea among full adopters, where about 12% from the total desi producers are in seed buying position. For kabuli chickpea, most of the farmers are in autarkic position followed by buying. These trends indicate the huge market potential for certified seed for both desi and kabuli chickpea, if chickpea producers with respective market positions are treated accordingly like demonstration and popularization of improved varieties for those in autarkic position and creating access to certified seed for those in buying position. The estimated yield gaps, adoption rates particularly of desi chickpea and commercial behavior in seed demand, the formal seed system need to improve

its performance in terms of enhancing access to seed of recently released varieties considering the identified smallholders commercial behavior in seed to narrow the huge yield gap in chickpea production.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

- Alemu D, Bishaw Z (2016). Commercial Behavior, Varietal Preferences and Wheat Seed Markets in Ethiopia. Working Paper 30. ICARDA, Beirut, Lebanon 45 p.
- Bishaw Z, Atilaw A (2016). Enhancing Agricultural Sector Development in Ethiopia: the Role of Research and Seed Sector. *Ethiopian Journal of Agricultural Sciences* 27:101-130.
- Bishaw Z, Struik PC, van Gastel AJG (2010). Wheat seed system in Ethiopia: Farmers' varietal perception, seed sources and seed management. *Journal of New Seeds* 11(4):281-327.
- Central Statistical Agency (CSA) (2016). Area and production of major crops. Agricultural Sample Survey 2015/2016 (2008 E.C.). Statistical Bulletin 584. Central Statistical Agency. Addis Ababa, Ethiopia.
- Ministry of Agriculture (MoA) (2014). National extension packages for pulse crops. MoA, Addis Ababa. Ethiopia.
- Ministry of Agriculture (MoA) and Agricultural Transformation Agency (ATA) (2013). Seed System Development Strategy: vision, systemic challenges, and prioritized interventions. MoA and ATA, Addis Ababa, Ethiopia.
- Ministry of Agriculture and Natural Resources (MoANR) (2016). Crop Variety Register. ISSUE No. 18 and No 19. Plant Variety Release, Protection and Seed Quality Control Directorate. MoANR, Addis Ababa, Ethiopia
- Spielman D, Byerlee D, Alemu D, Kelemework D (2010). Policies to Promote Cereal Intensification in Ethiopia: The Search for Appropriate Public and Private Roles. *Food Policy* 35:185-194.
- Strasberg PJ, Jayne TS, Yamano T, Nyoro J, Karanja D, Strauss J (1999). Effects of agricultural commercialization on food crop input use and productivity in Kenya. Michigan State University International Development Working Papers No. 71. Michigan, USA.
- van Ittersuma MK, Cassman KG, Grassini P, Wolf J, Tittonell P, Hochman Z (2013). Yield gap analysis with local to global relevance-A review. *Field Crops Research* 143:4-17.
- Von Braun J, Bouis H, Kennedy E (1994). Conceptual framework. 11-33. In: Von Braun, J. and E. Kennedy (eds.). In: *Agricultural Commercialization, Economic Development and Nutrition*. Washington DC: IFPRI. 441 p.