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Improving Production and Productivity of Chickpea (*Cicer arietinum* L.) Through Scaling-up of Improved Technologies in the Vertisol Highland Areas of Amhara Region, Ethiopia

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ABSTRACT

Background: Chickpea seed supply is limited for a local level farmer to the farmer seed exchange systems. The scale-up was conducted in the vertisol potential areas of North Shewa Zone of Amhara Region to create wider demand for improved chickpea varieties, strengthen the linkage among the possible actors and enhancing technology multiplication and dissemination to improve its productivity.

Methods: Naatolii, Mastewal, Arerti and Habru improved chickpea varieties were introduced and more than 393ha of land was covered and about 826 farmers were accessed through delivering more than 49.3 tons of improved seed.

Result: The productivity of chickpea in the area was boosted to 2.61tons ha^{-1} and yield advantage of 73% to 97.7% was obtained from improved varieties compared to the local cultivar. As a result of this intervention, many farmers benefited easy access to improved seeds of different chickpea varieties through direct seed marketing and farmer to farmer seed exchange.

Key words: BBF, Crop rotation, Innovation, Naatolii, Sowing date.

INTRODUCTION

Background: chickpea production in Ethiopia

Chickpea *(Cicer arietinum* L.) is the third-largest produced legume in the world, next to faba bean and field pea (Gaur *et al*., 2010). Ethiopia is the largest producer of chickpeas in Sub Saharan Africa accounting for over 90% of chickpea production in the region (Kassie *et al*., 2009) and is ranked seventh globally. It is a multi-purpose legume and an excellent source of protein for rural people in the developing countries (Malunga *et al*., 2014; Sarker *et al*., 2014). Chickpea is valued for its nutritive grain with high protein content, 25.3-28.9% (ICRISAT, 1991). Also, it improves soil fertility by fixing atmospheric nitrogen in soils (Gaur *et al*., 2010). Chickpea fits well in the production system as a rotational crop with teff and wheat where other optional crops for crop rotation in the vertisol areas are limited.

Chickpea is one of the major pulse crops grown in Ethiopia next to faba bean and haricot bean. In 2017/18 nationally, 683,814 farmers were engaged in growing chickpea and it covers 1.91% of the grain crop area and 1.63% of grain production (CSA, 2018). The National and Amhara Regional productivity of chickpea is 2.06 and 19.00 tons/ha, respectively (CSA, 2018). About 26 improved chickpea varieties have been released so far through the national research system (MoA, 2018). However, the adoption of improved varieties was low mainly due to insufficient seed production and limited availability of quality seeds (Alene *et al*., 2000; Asfaw *et al*., 2011; Dadi *et al*., 2005; ICARDA, 2008; Shiferaw *et al*., 2007). Access to high-quality seeds of improved varieties are among the limiting factor in large-scale adoption of chickpea. Improved chickpea varieties hold a key for improving production and productivity of the crop (Kassie *et al*., 2009; Patil and Ramesha, 2018). Besides, according to Kumar *et al*. (2019) the technological yield gaps affecting yield in pulses were highest in chickpea. This paper is, therefore, aimed to provide an insight into scaling up of chickpea technologies and documenting best approaches to maximize production and productivity of the crop through improving the availability of improved quality seeds to farmers.

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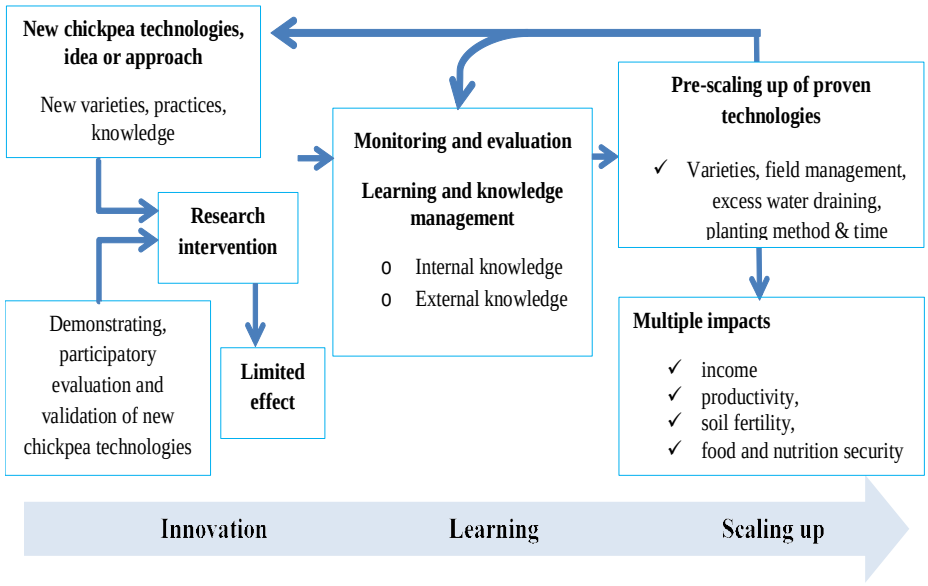
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Conceptual framework of the study

This scaling-up activity was based on Linn *et al*. (2010), scaling-up model which involves three phases (Fig 1). The innovation phase, which is the first phase of the model, involves testing, verification and validation of chickpea technologies. In this study, participatory technology evaluation and pre extension demonstration activities fell



Source: Adopted from Linn *et al.* (2010).

Fig 1: Illustration of the innovation, learning and scaling up phases.

under the innovation phase. Demonstrations are a critical tool for extension promotion allowing the farmer to evaluate, test and learn about the new technologies. Farmers are more likely to test new technologies with higher expected beneûts and relatively lower risky (Pannell *et al*., 2006). During the learning phase, farmers were learned by directly observing the demonstration plots and as group dynamics learned each other. In the scaling-up phase, the innovations or technologies which were demonstrated and tasted during the innovation and learning phases are brought to large scaling up.

MATERIALS AND METHODS

The experiment was conducted at four districts namely Ensaro, Merhabete, Moretina jiru and Siyadebrna wayu districts of North shewa Zone of Amhara Region for more than eight consecutive growing seasons since 2011. The area is characterized by a unimodal rainfall pattern and The area receives an average annual rainfall of 929 mm while the annual average temperatures range between 9.0 and 21.4°C, respectively. Vertisol is the dominant soil type in the areas and the altitude ranging between 1500 and 2800 masl. The production system in the study area is characterized as a mixed crop-livestock agricultural system.

Three improved chickpea varieties including Naatolii, Habru and Arerti varieties were tested and evaluated using a local variety as a check. The experiment was conducted on six farmers' farm fields as replication with a plot size of 10 x 10m for each variety per each district. About 130 and 30kg ha^{-1} seed rate and Di-Ammonium phosphate (DAP) were applied, respectively. Meanwhile, through the small pack approach, these three varieties were introduced and evaluated on the farmer's field. Farmers' research and extension group **(**FREG) were organized each consisting of 25-30 members to enhance participatory evaluation. The group members were selected in consultation with development agents to represent different social segments of the community. The groups had chairman and secretary to facilitate the FREG tasks as well as they had an action plan and meeting schedule to evaluate the experiment following the physiological growth stages. Trial plots were for free, while the research center covered other experimental costs. Before the implementation of the trials, all FREG members were trained on the basic agronomic practices and technology package components embracing both theoretical and practical sections.

RESULT AND DISCUSSION

During the first phase, three improved varieties namely Naatolii, Arerti and Habru varieties were demonstrated. These varieties were evaluated by farmers and other stakeholders against farmers' local cultivar. After thorough discussion farmers were identifying their most important selection parameters of improved varieties as early maturity, tolerant to disease, number of pods per plant, number of primary branches and adaptation to the local environment, grain color and yield. Based on their identified selection attributes farmers were selecting Naatolii variety first followed by Arerti variety second. Similarly as revealed below in (Table 1) the yield obtained from Naatolii was found better

Table 1: Mean grain yields of the three improved chickpea varieties.

	Chickpea varieties			
	Naatolii	Arerti	Habru	Local
Average productivity tons /ha in 2011/12	2.61	2.29	2.40	1.32
Farmers selection	1st	3rd	2nd	4th

compared to the other two varieties. Compared to the local cultivar, Naatolii, Arerti and Habru varieties had yield advantage of 97.73%, 73.48% and 81.82%, respectively.

Based on the premising results found during the demonstration phase improved varieties were entered into the scaling-up phase based on farmers' preference. Hence, Naatolii, Habru and Arerti varieties were introduced to different districts based on farmer's preference and productivity potential of the varieties on a wider scale through the farm clustering approach.

Amount of improved chickpea seed supplied

Improved seeds of Naatolii, Mastewal, Arerti and Habru varieties were used for the scaling up based on farmers' preference. Totally 49.37 tons of improved seed for those varieties were delivered and more than 393.5ha of land was covered (Fig 3). About 826 (69 female) farmers were addressed directly through the dissemination of improved chickpea seed. Most importantly the technology was spread out over chickpea production potential areas through farmer to the farmer seed exchange. During the implementation period more than 1306 ha of land were covered with improved varieties of chickpea seed through farmer to farmer seed exchange systems and 4168 (568 female) farmers were the indirect beneficiary of the seed access.

Capacity building of farmers and extension workers through training

Capacity building of various stakeholders has a vital role in transferring of innovations among the farming community by the extension systems. Farmer's attitudes and opinion towards the introduced improved varieties of chickpea and seed production and marketing were remarkably changed from time to time due to continuous training, field monitoring, partnership strength, market linkage, access to improved seed and experiences of production and marketing activities. Before implementation each year, training was organized on full production packages of chickpea for farmers and experts. A total of 1055 (105 female) farmers and 74 (20 female) experts from all districts were trained on chickpea agronomy, seed production, post-harvest handling and marketing during the implementation period (Fig 4).

Field days and promotion

At the end of the trial, field days were organized involving model farmers, development agents and farmers from the trial sites, experts from other seven potential districts, unions, local NGOs and administrative officials. Field day has a vital role in technology diffusion and adoption process to popularize the new technologies and innovations on a wider scale easily to end-users. A total of 1110 (164 females) participants visited the trial and applaud to the improved

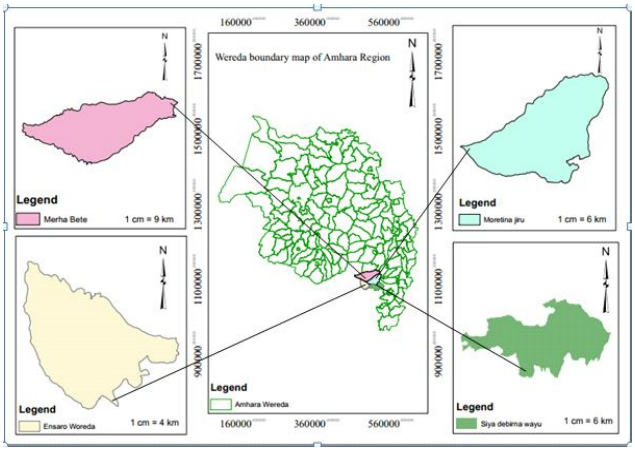


Fig 2: Map of the study areas.

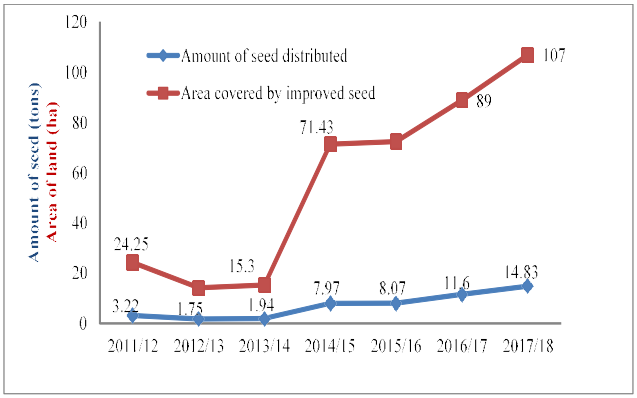


Fig 3: Amount of seed supplied and the area covered by improved seed.

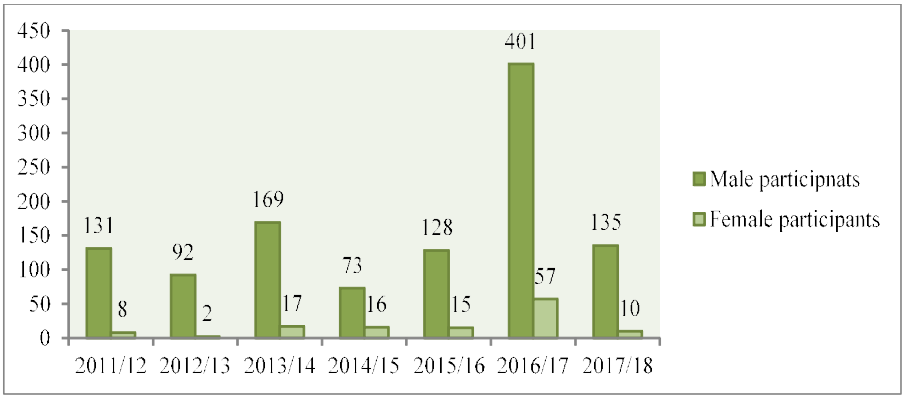


Fig 4: No. of training participant farmers and agricultural experts.

varieties for its good vegetative performance (Fig 5). Participant farmers were very happy and thanking all concerned bodies involved in the scaling up and they were expressing their interest to continue growing these improved varieties. During the field visit, farmers were observed that early planting was essential and help the crop to escape from frost to increase the yield obtained. "The improved variety has a great yield compared to local variety and also the improved practice help farmers to increases production as well as productivity of chickpea in our locality," said participant experts during the field visit.

Women participation, access to technology and extension services

In many developing countries including Ethiopia women who are accounted for half of the community that holds a key role in the rural economy, face more severe constraints than men in access to productive resources (Patil and Babu, 2018; Raney *et al*., 2011). Despite, many efforts have been made to achieve more sustainable development through mainstreaming gender related issues in the agriculture sector huge productivity difference exists between male and female farmers in Ethiopia. As reported in many of the previous findings, in Ethiopia the agricultural productivity differences between male and female-headed households generally range from 33 to 67% (Aguilar *et al*., 2015; Challa and Mahendran, 2015; Gezimu *et al*., 2019; Tiruneh *et al*., 2001) probably due to gender inequality in productive resources endowment and limited access to agricultural extension services. In the study area especially in chickpea production most of the farm activities were handled by women. Bed preparation during planting, weeding and harvesting of chickpea were mainly operated by women. During the entire period efforts have been made to improve the participation of women in access to improved seed and agricultural extension services. From the total 3006 participant farmers in training, field visit and farmers who were directly addressed through the provision of improved seed, women constitute about 10.03%.



Fig 5: Taken during field visit.

Multiple impacts of the scaling up activity

The productivity of the crop was boosted by draining excess water through adopting the new broad-based in-furrow (BBF) the drainage system and through shifting planting time from Late-September to Mid-August as revealed in Fig 6 and 7. Due to the sticky and unworkable nature of vertisol when it is saturated with water, farmers were usually planting chickpea at the end of the main season after the drainage of excess water. Given that major chickpea-producing areas in Ethiopia are prone to waterlogging and the crop's sensitivity to waterlogged conditions, drainage of excess water is of particular importance in seedbed preparation. This practice of late planting is a major yield-limiting factor as it causes the crop to experience terminal drought (Rashid *et al*., 2010). Findings have shown high yield was harvested during early to mid-September and up to 45% from planting on BBF compared to the flatbed (Agegnehu and Sinebo, 2012). Similarly, Varoglu and Temperature (2019) suggest that the sowing date is an important yield-limiting factor.

Chickpeas have been recognized as a good source of dietary protein because of their balance of amino acids and high protein bioavailability. Chickpea serves as a source of proteins for the rural farm households with 25.3-28.9% protein content (ICRISAT, 1991). Chickpea helps to improve the nutritional status of the rural poor households (Malunga *et al*., 2014; Sarker *et al*., 2014) as it contains good quality of protein, all the essential amino acids, compared to other legumes (Jukanti *et al*., 2012). The intervention of chickpea technologies and farmers participating in chickpea production provides access for di*et al*ternatives and improvement of diet combination. Crop rotation with pulse crops resulted in significant improvement in dietary



Fig 6: Farmers traditional chickpea production practice.

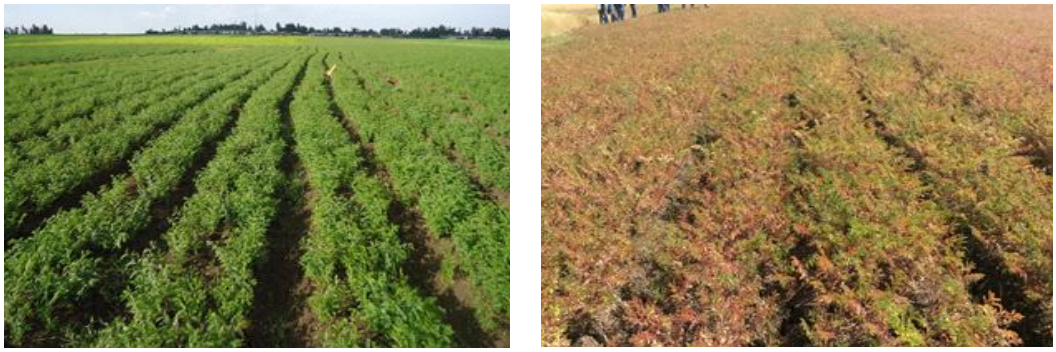


Fig 7: Improved management practices introduced to the area.

diversification improves their gross income from crop sales (Sauer *et al*., 2018). The production improvement of chickpea both in area coverage and productivity, improved the market supply of chickpea and the communities are benefited from the intervention by getting relatively sufficient market access of chickpea in their locality. Chickpea can be consumed as raw green locally known as *Eshet*, used in stews (locally known as *Shiro*, a common dish in Ethiopia) and consumed in roasted and boiled forms.

Chickpea is a versatile crop with multiple benefits for integrated crop-livestock smallholder farming systems. It improves soil fertility through fixating atmospheric nitrogen and is easily incorporated into crop rotations to ensure the sustainability of farming systems (Gaur *et al*., 2010). In the vertisol areas, chickpea is grown in rotation with teff and wheat. Hence, in the intervention area, the area of land allocated for improved chickpea varieties was drastically increased after the intervention which plays a key role in breaking the wheat-teff production system as a rotation crop.

The improved seed is an integral part of increasing crop productivity (Kassie *et al*., 2009) and all the other inputs largely depend on the quality of seed used. More than 90% of the annual seed demand for chickpea production was covered by the informal seed system either by own saved seed or through farmer to farmer seed exchange system (Atilaw and Korbu, 2011; Bishaw and Van Gastel, 2008). The formal seed system of the country supplies below 10% of the seed demand and when disaggregated over 90% was focused on maize and wheat seed production. As of the forgoing gaps in the formal seed system, this scaling up activity was done to promote improved chickpea technologies coupled with seed multiplication and delivery. Therefore to expand the area coverage of improved seed, to ensure its sustainability and market participation of smallholder farmers establishing farmer seed producer and marketing cooperative is the best alternative. Based on this intervention three local chickpea seed producers and marketing cooperatives with a member of 505 farmers were established.

CONCLUSION AND RECOMMENDATIONS

The production and productivity of chickpea improved in the intervention areas due to the introduction of improved varieties and the provision of better extension services. Naatolii, Mastewal, Arerti and Habru varieties were adopted and preferred by farmers in the area. Compared to the local cultivar, Naatolii, Arerti and Habru improved varieties had a yield advantage of 97.73%, 73.48% and 81.82%, respectively. Farmers were shifting planting time from late-September to mid-August in most intervention areas through draining excess water using BBF. Participatory approaches to technology expansion for newly introduced technologies enhance the rate of technology adoption through improving access of farmers to quality and sufficient improved seeds at an affordable cost. Supporting and strengthening of local seed producer and marketing cooperatives and linking them with markets; technical backstopping and supplying of early generation seed is very crucial for sustained production and productivity improvement of the crop.

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