Journal of Genetics, Genomics & Plant Breeding 7(4)76-83 (October, 2023)
ISSN (Online): 2581-3293

RESEARCH ARTICLE

Evaluation of kabuli chickpea varieties for adapting under irrigation production at Kobo, Ethiopia

A. Mohammed, A Misganaw, S. Bisetegn, A. Desale, T. Alemnew, M. Tefera, G. Kebede, A. Tefera, S. Assefie

Sirinka Agricultural Research Center, P. O.Box 74, Woldia, Ethiopia

Corresponding authors email: awolmoha1966@gmail.com

Manuscript received: September 1,2023; Decision on manuscript:September 29,2023; Manuscript accepted: October 5, 2023

Abstract

The experiment was executed during the 2019 -2020 irrigation cropping season to evaluate the adaptability and yield performance of *kabuli*-type chickpea varieties with the involvement of farmers based on their preference criteria. Ten improved varieties were laid out in RCB design with three replications for the mother trial and the baby trial, a single rep of the mother trial, which was used for farmers' preference selections. The farmers evaluated and selected the varieties depending on their criteria from the baby trial. The criteria were grain productivity, earliness, seed size, and freedom from any diseases. Farmers' selection was analyzed by pair wise and matrix ranking method. The analysis of variance showed a significant difference for grain yield and most of the traits. The result showed that variety Akuri was the best yielder with a seed yield of 2558kg/ha, followed by Harbu (2300.5kg/ha) and Kobo (1922.5kg/ha), respectively. Grain yield was the first prioritized trait to farmers for selecting the best adaptable chickpea variety under irrigation. Akuri was the best variety statistical calculation was visually selected by the farmers as good for grain yield under irrigation followed by Harbu and Kobo. Therefore; based on researchers' and farmers' perceptions Akuri and Harbu varieties will be recommended and pre-scale up for producing areas in the district and similar agro ecological zones under an irrigation production system.

Key words: *Kabuli* chickpea, irrigation, grain yield, farmers' preferences, adaptability

Introduction

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world, after dry common bean and field pea (Padmavathiv *et al.,* 2013). India is the largest chickpea producing country accounting for 72 % of the global chickpea production (Dudhe and Kumar, 2016; Ojiewo, 2016). Ethiopia is considered one of the secondary centers of diversity for chickpeas (van der Maesen, 1987). In Ethiopia, chickpea is the third largest legume crop in the area and production next to faba bean and common bean (CSA, 2019).

There are two types of chickpeas depending on seed color, shape, and size; *desi* and *kabuli*. The *kabuli* type has large, round or ram head and cream-colored seeds, and is grown in temperate regions (Dudhe 2008; Nigusie *et al.,* 2017). In Ethiopia, the *kabuli* type of chickpea covers 25% of the whole area coverage (Asnake, 2014). Mostly it is produced based as a source of foreign currency or export purposes. Chickpea is important for protein source and soil fertility improvement. It is also known as a risk avoidance crop.

Besides being an important source of human food and animal feed, it also plays an important contributor to soil fertility as it provides nitrogen to soil due to nitrogen fixation ability with the help of bacteria (Gul *et al.*, 2011). Ecologically, chickpea is known to be an efficient N2-fixing crop due to its capability of symbiotic nitrogen fixation. Chickpea meets 80% of its nitrogen (N) requirement from symbiotic nitrogen fixation and can fix up to 140 kg N per ha from the atmosphere (ICRISAT, 2010; Dudhe and Kumar, 2017). In Ethiopia, chickpeas are produced by rain-fed and irrigation production systems. Ethiopia is one of the few African countries endowed with relatively abundant water resources, a favorable climate, and potentially huge irrigable land (Tilahun *et al.*, 2008). The country has potential suitable land and water resources for irrigation-based chickpea production surpasses many thousand hectares (Nigusie *et al.*, 2017). In most of the irrigation potential areas in the country, farmers produce triple crops per season. Based on this, Kobo is one of the potential areas that have a high irrigation potential for crop production including chickpeas. According to Kobo Girana Valley Programe, in Kobo district there is more than 2100ha of land cultivated by farmers under irrigation. They produce triple crops per season, tef or maize-chickpea- onion. Not only regionally but also nationally, there is no released chickpea variety for irrigation production systems, especially the *kabuli* type which can increase farmers' income more than that of the desi type. Due to this, farmers produce local chickpea variety which is low yielder (0.7-1t/ha) and fetches low income. To increase the production and productivity of chickpeas in this area under irrigation there is a need to recommend improved *kabuli*-type chickpea variety. Therefore; the objective of this experiment was to evaluate and recommend the best adaptable, high-yielding, and early maturing of *kabuli*-type chickpea varieties with the involvement of farmers based on their preferences for producing areas under the irrigation production system in the district.

Materials and methods

Description of experimental site and material

The experiment was executed under the irrigation production system at Kobo, which is located at 11008'21", 39 18'21", and 1450masl latitude, longitude, and altitude; respectively. The annual rainfall of the site is 637mm with 15.80c minimum and 29.10c maximum temperature. According to Sirinka Agricultural Research Center soil classification, it is classified as Eutric fluvisol.

About 10 *kabuli*-type improved chickpea varieties were evaluated for their adaptation and yield performance under irrigation during 2019 and 2020 in the Kobo district. These varieties were improved and released by Sirinka and Debre Zeyt Agricultural Research Centers under rain-fed conditions. The experiment was done by mother and baby trial form. The Mother trial was done by Random Complete Block Design with three replications. Each variety was sown in six rows at 40 cm, 10 cm, and 1m spacing between, rows, plants, and plots, respectively; with 4m row length. The baby trial, a single replication of the Mother Trial, was done on three different farmers' fields to help farmers select the best varieties based on their preferences. Totally 27 farmers who produce chickpeas under irrigation participated variety selection process. All agronomic practices were carried out uniformly for all varieties as required without fertilizer application. For controlling the pod borer, the insecticide Karate at the rate of 200ml/300 liters of water per hectare was applied at the branching stage (two times within a 15-day interval). The irrigation frequency was applied before sowing, at seedling, at branching, and at the pod setting stage similar to Fitsume *et al.*, (2015).

Data collection and analyses

The data of several pods per plant, number of seeds per pod, hundred seed weight, plant height, biomass yield, and grain yield were collected from the harvestable plot area of the mother trial. Biological data like biomass yield (kg/ha) and seed yield (kg/ha) were collected from the harvestable plot area of the mother trial. In addition to these disease data was also scored. Farmers participated in the best variety selection process in 2020. In total, 27 farmers who produce chickpea under irrigation participated variety selection process. Farmers' criteria to select the best variety were grain productivity, earliness, seed size, and freedom from any diseases. The ranking procedure was explained for participant farmers and each selection criteria was ranked from 1 to 5 (1= very good, 2= good, 3= average, 4= poor, and 5= very poor). Then farmers were given the chance to rank each variety based on the attributes listed by them. The agronomic data were subjected to the analysis of variance (Gomez and Gomez, 1984) using Gen stat software eighteenth editions from the mother trial. According to Ceccarelli (2012), two methods by which farmers can evaluate varieties in the PVS trials are the Pair-wise ranking and the matrix ranking method. The selection data were analyzed by the Pair-Wise ranking method.

Results and discussion

According to the analysis of variance (ANOVA), the variability between varieties showed a significant difference ($P<0.05$) for the number of pods per plant, hundred seed weight in gm., grain yield, and biomass in kg per hectare in the results of the two years (Table 2 and 3). The analysis showed variety Akuri was the best yielder in both years with a grain yield of 2558kg/ha, followed by variety Harbu (2300.5kg/ha) (Table 3). The lowest grain yield was scored by the Dhera variety (840.5kg/ha). The influence of disease is minimal under an irrigation production system (Nigusie *et al.,* 2017). The same result also occurred in this study, there was no any disease occurrence in both years of the trial (Tables 2 and 3). In general, the grain yield of chickpeas under irrigation production is highly increased than in a fed production system. Similar to this study, an increase in grain yield of chickpeas under irrigation has been reported by many authors (Anwar *et al.,* 2003; Pacucci *et al.,* 2006; Kang *et al.,* 2008; Vinayak *et al.,* 2012 and Mansur *et al.,* (2010).

Table 1: Mean performance of *kabuli* type chickpea varieties under irrigation condition

Varieties	Days to maturity	Plant height	Number of pods per plant	Number of seeds per pod	Number of branches	Biomass Kilo gram per hectare	Hundred seed weight	Adjusted grain yield kilo gram / hectare
Kobo	98bcd	46.2	35.3a	1c	14.1	6859a	38.5a	1736cd
Akuri	94d	40	26.5b	1.1c	10.1	4899bc	35.3ab	2653a
Kassech	101abc	42.2	26.7b	1.14bc	12.1	4681bc	30.6bcd	1651cde
Yelbie	101abc	42.2	26.7b	1.14bc	12.1	4681bc	30.6bcd	1651cde
Teji	101abc	46.5	33.3a	1.1c	15.4	4595c	35.5ab	1988bc
Ejeri	102abc	42.8	34.1a	1.13	11.3	5341b	33.2abc	2234ab
Harbu	96cd	39.5	26.6b	1.13	7.7	5030bc	33.8abc	2462a
Chefe	101abc	39.5	17.8c	1.13	9.8	3785d	27.4cd	1026fg
Hora	106a	42.4	25.7b	1c	13.3	4757bc	27.9cd	1368def
Dhera	104ab	46.6	20.5c	1c	11.3	3630d	25.7e	722g
GM	101	42.2	26.8	1.14	12.1	4680.8	30.6	1650.5
DMRT 5%	*	ns	**	**	ns	**	**	**
CV%	5.3	8.0	9.0	8.4	10.7	17.8	11.6	15.9

There was also a substantial difference between the varieties for hundred seed weight. The hundred seed weight of the varieties varied in both year's trial with range between 38.5gm for Kobo and 25.7gm for Dhera variety (Table 1 and 2). The maximum hundred seed weight for Kobo was 38.5gm followed by Teji (35.5gm) and Akuri (35.3gm) (Table 1). The days to maturity of the varieties were range 88 - 106 days, this indicate all varieties were early maturing. Participatory variety selection (PVS) was also done as an option to increase productivity and production in terms of users' preferences under irrigation. A very important advantage of PVS is that the adoption of new cultivars is much faster than under the formal system, in which farmers are confronted with only a very restricted range of new cultivars (Mohammed *et al.*, 2016).

Table 2: Mean performance of *kabuli* type chickpea varieties under irrigation condition

Varieties	Days to maturity	Plant height	Number of pods per plant	Number of seeds per pod	Number of branches	Biomass Kilo gram per hectare	Hundred seed weight	Adjusted grain yield kilo gram / hectare
Kobo	85	51.1bc	43.2a	1.4	15ab	5620b	33.3a	2109b
Akuri	86	51.3bc	45.4a	1.6	13.5abc	6313a	29.2bc	2463a
Kassech	88	46.6bc	23.2bc	1.6	12.9bcd	3633e	30.7ab	1444cd
Yelbie	86	63.6a	43.2b	1.6	15.7a	4030d	27cd	1707c
Teji	90	47bc	24bc	1.6	8f	4400d	29.4bc	1524cd
Ejeri	90	51.1bc	18.6d	1.2	9.1ef	4968c	27.9cd	1348d
Harbu	88	54.6b	46a	1.4	14.8ab	5611b	26.5d	2139b
Chefe	88	44c	45.4a	1.2	11.5cde	4257d	27.1cd	1671c
Hora	92	45c	24bc	1.2	7.3f	3513e	26.4d	836e
Dhera	93	49.9bc	20.4cd	1	10.6de	3073f	29.4bc	959e
GM	88	50.3	31.5	1.4	11.8	4542	28.8	1619
DMRT 5%	Ns	*	**	Ns	**	**	*	**
CV	7.3	9.8	17.8	13	12.3	15.4	7.6	10.2

Table 3: Mean performance of *kabuli* type chickpea under irrigation condition

Varieties	Mean grain yield	Mean grain yield	
	2019	2020	Mean
Kobo	1736	2109	1922.5
Akuri	2653	2463	2558
Kassech	1651	1444	1547.5
Yelbie	1651	1707	1679
Teji	1988	1524	1756
Ejeri	2234	1348	1791
Harbu	2462	2139	2300.5
Chefe	1026	1671	1348.5
Hora	1368	836	1102
Dhera	722	959	840.5
GM	1650.5	1619	1634.75

During the 2019 trial season, farmers participated to select the best variety based on their criteria. Totally 27 farmers who produce chickpeas under irrigation participated variety selection process. For chickpea variety selection farmers focused on the traits of grain productivity, earliness, seed size, and free from any diseases (Table 4). All the criteria were set by farmers without contributing to the research. According to Ceccarelli (2012), two methods by which farmers can evaluate varieties in the PVS trials are the Pair-wise ranking method and the Matrix ranking method. The ranking procedure was explained for participant farmers and each selection criteria was ranked from 1 to 5 (1= very good, 2= good, 3= average, 4= poor, and 5= very poor). Before the selection process, farmers had given weight to their criteria. Based on this, grain yield productivity was the most prioritized farmers' criteria to select the best variety followed by seed color, earliness, seed size, and disease free which had given 1, 2, 3, 4, and 5 weights; respectively (Table 4). Abebe *et al.*, 2005 reported that farmers have their selection criteria for new varieties which largely depend on the importance of the crop in the farming system and uses. Matrix ranking was used to assess farmers' opinions and perceptions of the varieties. According to Amhara Agricultural Research Institution's unpublished Guideline for Participatory Varietal Selection, (2018), the variety that has the least rank index, is the most desirable variety. The ranking of *kabuli*-type chickpea varieties based on the perception of the farmers is presented in Table 5.

Table 4 Pair-wise ranking of the criteria for *kabuli* type chickpea variety by farmers

Criteria	Productivity	Disease resistance	Earliness	Seed size	Total	Rank
Productivity (Prod)	X	Prod	Prod	Prod	3	1st
Diseases resistant (DR)		X	ER	SS	0	4th
Earliness (ER)			X	ER	2	2nd
Seed size (SS)				X	1	3rd

Table 5: the selected *kabuli* type varieties' rank index based on farmers preferences

Varieties	Traits with their weights				Total	Rank
	Productivity (1)	Disease resistance (4)	Earliness (2)	Seed size (3)		
Kobo	7	31	8	19	65	3rd
Akuri	15	7	14	11	47	1st
Kassech	17	32	10	21	80	4th
Yelbie	32	29	19	14	94	7th
Teji	28	13	23	24	88	5th
Ejeri	35	26	28	22	111	6rd
Habru	9	10	7	30	56	2nd
Chefe	31	8	30	32	101	8th
Hora	22	18	34	17	91	10th
Dhera	23	21	32	26	102	9th

As per the selection criteria set farmers ranked the overall preference ranking of varieties based on four criteria was in the order Akuri, Harbu, Kobo, Kassech, Teji, Ejeri, Yelbie, Chefe, Dhera, and Hora; respectively. Farmers prefer varieties that meet multiple objectives; on chickpea (Yasin G and Mathios A, 2016), on sorghum (Tulole *et al.*, 2010); and on ground nut (Tulole *et al.*, 2008). That means that in this study Akuri (2558kg/ha), Harbu (2300.5kg/ha), and Kobo (1922.5kg/ha) best varieties under irrigation could be introduced in the farming systems based on various subjective preference criteria. Farmers preferred the variety Kobo thirdly as it produced attractive seed size and grain yield.

Pre-scale up of recommended *kabuli* type chickpea variety at Kobo

We used Akuri and Harbu varieties which were the selected varieties by farmers through participatory variety selection trial. This activity was done at Kobo on 5ha of land covered by Akuri and 18ha of land covered by Harbu variety. Ninety-two farmers participated in both selected varieties. For all participant farmers, we gave 3.22 tons of seed to cover 23ha of land. Farmers agreed to give seed after harvesting and threshing to the other five farmers to popularize the technology. The training was given to districts' participant farmers, development agents, and office of Agricultural professionals. From both varieties participant farmers produced 80.5 tons seed which can be important for the district to popularize. Also, all farmers agreed to give this variety seed to other farmers which are very important for scaling up this variety technology.

General feedback is given by participant farmers

Chickpea under irrigation was not usual practice around focused district, but after this activity most of farmers very interested to produce chickpea under irrigation because its production cost is very low compare to others crop under irrigation. Their chickpea variety is so susceptible to chickpea important diseases under irrigation due to this its productivity is very poor. Seed boldness is very important for the market so these two varieties have bold seed.

Conclusion and recommendation

Ten improved *kabuli*-type chickpea varieties were evaluated for yield and adaptation under irrigation at Kobo for two years. Differences among varieties were significant for grain yield and some of the traits. Grain yield was the first prioritized trait for farmers for selecting the best adaptable kabuli-type chickpea variety under irrigation. Akuri was the best variety based on the ANOVA result and was visually selected by the farmers as good for grain yield under irrigation followed by Harbu and Kobo. This study also indicated that proper selection of varieties with improved management can increase farmers' income under irrigation. Therefore; based on researchers' and farmers' perceptions Akuri and Harbu varieties will be recommended and pre-scale up for producing areas in the district and similar agroecological zones under an irrigation production system.

Acknowledgements

First of all, the author's deepest gratitude and acknowledgment goes to Amhaera Agricultural Research Institute and/or Sirinka Agricultural Research Center for providing the research budget and facilitating the process. We would like also to express sincere thanks to the Sirinka Agricultural Research Center pulse case team members for contributing their great effort to this successful accomplishment of the experiment.

References

1. Abebe, G, Assefa, T. Harrun, H.,Mesfin T., Al-tawaha A.M. 2005.Participatory selection of drought tolerant maize varieties using mother and baby methodology: a case study in the semi-arid zones of the central rift valley of Ethiopia. World J. Agri.Scie.1:22-27.
2. Asnake F., 2014. Overview of chickpea improvement research program in Ethiopia. The Journal of the International Legume Society Issues 3, June 2014
3. Anwar, M. R., McKenzie, B. A., and Hill, G. D. 2003. Water-use efficiency and the effect of water deficits on crop growth and yield of Kabuli chickpea in a cool-temperate sub-humid climate. J. Agric. Sci., 141: 285-301.
4. CSA(Central Statistical Agency) 2019. Agricultural sample survey 2018, report on area and production for major crops (private peasant holdings, main season), Addis Ababa, Ethiopia.
5. Ceccarelli, S. 2012. Plant breeding with farmers – a technical manual. ICARDA, PO Box 5466, Aleppo, Syria. pp xi + 126. ISBN 92-9127-271-X.
6. Dudhe, M. Y. and Kumar J. 2016. Screening of chickpea genotypes against salinity stress. Bioinfolet. 13 (2): 298-302.
7. Dudhe, M. Y. 2008. "Genetic studies on salt tolerance in chickpea". Ph.D. thesis, Indian Agriculture Research Institute, New Delhi (India).
8. Dudhe, M.Y., Kumar J. 2017. Combining ability studies under salinity stress and unstressed condition in chickpea. Legume Res., 41(2):239–245.
9. Desta, F., Bissa, M., and Korbu, L.2015. Crop water requirement determination of chickpea in the central vertisol area of Ethiopia using FAO CROPWAT model. African J. Agril., Res., 10(7): 685 – 689.
10. Gomez, K.A., Gomez, A.A. 1984. Statistical procedures for agricultural research 2nd Edn. John Willey and Sons, New York.
11. Gul, R., Khan, H., Sattar, S., Farhatullah, Munsif, F., Khan, S., BSA, Khattak, S.H., Arif, M., Ali, A. 2011. Comparison among nodulated and non-nodulated chickpea genotypes. Sarhad J. Agri., 27(4): 577-581
12. International Crop Research Institute for Semi-Arid Tropics (ICRISAT) 2010. Pooran M. Gaur, Shailesh Tripathi, C.L. Laxmipathi Gowda, G.V. Ranga Rao, H.C. Sharma, Suresh Pande and Mamta Sharma, Patancheru 502 324 Andhra Pradesh, India (2010), Chickpea Seed Production Manual.
13. Kang, S., B. A. McKenzie and G. D. Hill. 2008. Effect of irrigation on growth and yield of Kabuli chickpea (*Cicer arietinum* L.) and narrow-leafed lupin (*Lupinus angustifolius* L.). Agron. New Zealand 38: 11-32.
14. Mansur, C. P., Palled, Y. B., Salimath, P. M., and Halikatti, S. I. 2010. An analysis of dry matter production, growth, and yield in Kabuli chickpea as influenced by dates of sowing and irrigation levels. Karnataka J. Agric. Sci., 23(3): 457-460.
15. Maqbool, M.A., Aslam, M., and Ali, H. 2017. Breeding for improved drought tolerance in chickpeas (*Cicer arietinum* L.). Plant Breed., 136(3): 300- 318.
16. Mohammed, A., Asefie, S., Dagnachew, W., and Seyum N.2016. Participatory evaluations of field pea (*Pisum sativum* L.) varieties in Wollo, Ethiopia. World J. Agric. Sci., 1 (2): 1-6.
17. Girma, N., Fikre, A., and Ojiewo, C. O. 2017. The Genotypic and phenotypic basis of chickpea (*Cicer arietinum* L.) cultivars for irrigation-based production in Ethiopia. J. Agril., Sci., 9 (8). 229-236.
18. Ojiewo, C. 2016. Presentation of chickpea production, technology adoption and market linkages in Ethiopia on Pan-African Grain Legume and World Cowpea Conference Livingstone - Zambia Feb 28 – Mar 4, 2016.
19. Pacucci, G., Troccoli, C., and Leoni, B. 2006. Supplementary Irrigation on Yield of Chickpea Genotypes in a Mediterranean Climate. Agricultural Engineering International: The CIGR E J., VIII (1), Manuscript LW 04005.

20. Hordofa, T.,Menkir, Michael, Awulachew, Seleshi Bekele, Erkossa, T. 2008. Irrigation and rain-fed crop production system in Ethiopia. In Awulachew, Seleshi Bekele; Loulseged, Makonnen; Yilma, Aster Denekew (Comps.). Impact of irrigation on poverty and environment in Ethiopia: draft proceedings of the symposium and exhibition, Addis Ababa, Ethiopia, 27-29 November 2007. Colombo, Sri Lanka: International Water Management Institute (IWMI). pp.27-36.
21. Bucheyeki, T.L., Shenkalwa, E.M., Manpunda,T.X., Matata, L.W. 2008. On-farm evaluation of promising ground nut varieties for adaptation and adoption in Tanzania. African J. Agril., Res., 3 (8):531-536
22. Bucheyeki, T.L., Shenkalwa, E.M., Manpunda,T.X., Matata, L.W., Matata, L.W. 2010. Yield performance and adaptation of four sorghum cultivars in Igunga and Nzega districts of Tanzania International Journal of the Faculty of Agriculture and Biology, Warsaw University of Life Sciences, Poland. Commun. Biometry Crop. Sci., 5(1): 4-40.
23. Vinayak, N., Halepyati, A. S., and Koppalkar, B. G. 2012. Growth and yield of late sown chickpeas as influenced by irrigation methods, genotypes, and planting densities. Karnataka J. Agric. Sci., 25(2): 267-269.
24. Goa, Y. and Ashamo, M. 2016. Yield performance and adaptation of desi chick pea varieties in selected districts of Wolayta and Hadiya zones of South Ethiopia. Int. J. Res. GRANTHAALAYAH, 4(3): 33-41.
25. Van Der Maesen, L. J. G. 1987. Origin, history, and taxonomy of chickpea. In M. C. Saxena & K. B. Singh (Eds.), The Chickpea. UK: CAB International Publications.