An overview of chickpea breeding programs in Kenya

by Paul K. KIMURTO[1]*, Bernard TOWETT[1] Richard S. MULWA[1], Nancy NJOGU[1], Alice KOSGEI[1], Serah SONGOK[1], Moses OYIER[1], Daniel RUTTO[4], Paul KORIR[1], Gangarao RAO[2], Said SILIM[2], Peter KALOKI[2], Ruth MURUIKI[1], Grace BARMAO[3] and Joseph K. MACHARIA[1]

Abstract: Chickpea is a new crop in Kenya and its potential has not been fully utilized. The chickpea grain yields generally range between 1.2 to 3.5 tons/ha at farmers' fields, indicating that chickpea has a potential of becoming an important export crop in Kenya. The chickpea breeding program in Kenya is still at infant stage and being established with support from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Four chickpea varieties have been recently released from the breeding material supplied by ICRISAT. Efforts are being made on evaluation of germplasm and breeding lines, application of modern molecular breeding tools and techniques in chickpea breeding and establishment of effective seed system for establishing a sustainable chickpea production system in the country.

Key words: abiotic stress, biotic stress, drought tolerance, Aschochyta blight, *Helicoverpa armigera*

[1]Egerton University, Faculty of Agriculture, Department of Crops, Horticulture and Soils, Egerton, Kenya (kimurtopk@gmail.com)
[2]International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Nairobi, Kenya
[3]Kenyatta University, Department of Biological Sciences, Nairobi, Kenya
[4]Chepkoilel University college, School of Agriculture, Eldoret, Kenya

Current status of chickpea production and distribution in Kenya

Chickpea is a relatively new crop grown in Eastern and Rift valley provinces of Kenya, though the landraces have been under cultivation in coastal and Eastern parts of Kenya for over 40 years. The current chickpea area in Kenya is about 55,000 ha and production is approximately 15,000 t to 18,500 t (2). Chickpea is widely consumed in Kenya, mainly by the large population of Asian origin living in urban cities (Nairobi, Kisumu, Mombasa, etc) and for whom chickpea is an important source of protein. Kenya also has highly developed processing industries for chickpea. Kenya imports approximately 100,000 t of chickpea annually mainly from Tanzania, Sudan and Ethiopia (5) which is processed (dehulled) and then either consumed locally or exported to Asian markets (mainly India and Pakistan).

In large cities, chickpea is now considered as functional food with low fat, cholesterol free and ideal cheap source of protein and energy to the affluent and vegetarian populations with major food-related health problems like diabetes, cancer or coronary heart diseases. For the rural poor populations mainly in the arid and semi-arid lands (ASALs) of Kenya, chickpea is considered as an alternative drought tolerant legume which can replace bean, which is known to be more susceptible to heat and drought stresses than chickpea. Chickpea is considered as a cheap source of protein and also recognized as appetite suppressant because it is digested slowly and hence delay the reappearance of hunger for several hours, a characteristic highly valued by poor communities who leave on one meal per day.

Chickpea has become attractive to cereal farmers (maize, finger milet and wheat) due to its ability to improve soil fertility and yield of following cereal crops by 24-68% in a cereal-legume relay cropping system (1). As a green manure crop, chickpea improves soil structure of acidic soil (8). Chickpea is also known to reduce incidence of fusarium wilt in passion fruit it preceded passion fruit in the rotation (7). Currently over 270,000 households derive their livelihoods from the from chickpea both in dry highlands and ASALs of Kenya. The government of Kenya currently recognizes chickpea as mitigation strategy for climate change effects (5) and has embarked on a campaign to promote the crop countrywide. The crop also has potential of reducing crop losses caused by the new devastating Maize Lethal Necrotic Disease (MLND) when sown in rotation with maize in major maize producing areas affected by the disease in parts of Kenyas' Rift valley region like Bomet, Kilgoris, Naivasha, Narok and Nakuru.

Key constraints to chickpea production

Several biotic and abiotic constraints limit chickpea production in Kenya. Amongst the biotic factors, pod borers (*Helicoverpa armigera*), ascochyta blight (caused by *Ascochyta rabiei*) and fusarium wilt (caused by soil borne fungus, *Fusarium oxysporum* f. sp. *ciceris*) are major causes of yield losses. Pod borer causes yield losses of up to 80% especially in ASALs areas where insect severity is high, but can be as low as 30% - 50% in cooler areas (6). Due to limited sources of resistance, application of insecticides remains the only option for controlling this pest. Aschochyta blight is a widespread major foliar disease that causes extensive grain yield losses (up to 100%) and reduces grain quality especially in dry highlands of Kenya. High chickpea yields can be achieved if chickpea is sown in long rains in the highlands, but this is rarely adopted by the farmers because the cool and wet weather favors the development of Aschochyta blight epidemics. Intergraded disease management (IDM) protocol, which include use of tolerant cultivars adapted to early sowing, seed dressing with fungicides, and foliar application at different growth stages (seedling or early vegetative growth stages), is being standardized for management of ascochyta blight.

Terminal drought is a major abiotic constraint limiting chickpea production in most growing areas since the crop is largely sown on residual soil moisture after long rains (in relay cropping with cereals) and experiences moisture stress towards the end of the crop season (summer in the dry season. In ASALs where crop is sown during long rains, the crop can still experience drought if the rains are low in amounts (250 - 450 mm), poorly distributed, and short (40 - 60 days). Several other socio-economic constraints, like access of farmers to credit, agricultural inputs (seed, fertlizers, fungicides, pesticides, etc.) and market affect adoption and production of chickpea by farmers.

Major aims in breeding programs

Chickpea breeding program in Kenya was non-existent until recently (last 10 years ago) when collaborative efforts between Egerton University (EU), Kenya Agricultural Research Institute (KARI) and ICRISAT through funding support from Generation Challenge Program (GCP), Tropical Legumes I (TL-I) and Tropical Legumes II (TL-II) projects, and other donors resulted in establishment of a functional breeding program. ICRISAT has been the major source of advanced breeding lines for release as commercial varieties or germplasm for crop improvement in Kenya and within the Eastern and Southern Africa Region (ESA). The major target of chickpea improvement includes high yield potential, adaptability to different agro-eco zones, early maturity, large seed size (100 seed weight of 30 - 55 g) in kabuli type, and resistance/tolerance to key abiotic (terminal drought) and biotic (pod borer, ascochyta blight and fusarium wilt) stresses. Germplasm nurseries for these attributes have been sourced from ICRISAT and multi-location evaluation trials carried out to identify potential candidates for release or use in breeding program. Under TL-I project, novel breeding approaches, like marker-assisted backcrossing (MABC) and marker-assisted recurrent selection (MARS), are being used for improving drought tolerance (4).

Salient achievements

A functional chickpea breeding program is currently being developed in Kenya at Egerton University and KARI. However, recent efforts on evaluating breeding lines received from ICRISAT have led to release of four varieties for commercial production in Kenya. These include Chania Desi 1 (ICCV 97105) and LDT 068 (ICCV 00108) in desi type and Saina K1 (ICCV 95423) and LDT 065 (ICCV 00305) in kabuli type. LDT 065 and LDT 068 were released in 2009, while the remaining two varieties were released in 2011. These varieties are early maturing and have moderate to high resistance to fusarium wilt. LDT 065 and Chania Desi 1 have moderate resistant to ascochyta blight. The desi varieties are suitable for making splits (*dhal*) and *Githeri*, while kabuli varieties are suitable for salads and harvest of green pods. LTD 068 has upright growth habit and can be harvested by combine harvesters. There are several other desi (e.g. ICCV 92944, ICCV 94954, ICCV 01507) and kabuli advanced breeding lines (ICCV 97306, ICCV 96329) being evaluated under national performance trials and some of these may be released in near future. Concerted efforts are being made under TL-II project to enhance seed availability of the recently released improved varieties by bringing together several seed companies and local seed traders.

Pod borer causes yield losses ranging between 20-40% and sometimes up to 80% (6). Field evaluations and laboratory screening have shown that no genotype is completely resistant to its infestation. This suggests that integrated pest management (IPM) is the only option for management of pod borer.

Chickpea yield losses of up to 100% has been reported due to ascochyta blight in the crop grown during the rainy, wet and cool long rain season (May-August) (3). Farmers often use very expensive fungicides to contain this disease, which increases cost of production. Thus, use of resistant varieties is the most sustainable solution for managing asochyta blight. Sources of resistance to ascochyta blight have been identified and need to be introgressed in the current commercial varieties.

Among abiotic factors, drought stress is the single most important constraint to yield of chickpea in Kenya. Efforts are being made to develop varieties with deeper and vigorous root system. A genomic region controlling root traits has been introgressed from ICC 4958 or ICC 8261 into several varieties (Chania Desi 1, Saina K1, LDT 068, ICCV 10, ICCV 92944 and LDT 065) using MABC. In addition, MARS is being used in two crosses (ICCV ICCV 04112 × ICCV 93954 and ICCV 005107 × ICCV 94954) for developing improved lines (4).

The ongoing research and developmental efforts on chickpea are expected to enhance area and productivity of chickpea in Kenya and improve income and food and nutritional security to the farmers.

Future prospects

The foundations of future prospects of breeding program in Kenya have been laid with strong support from ICRISAT, Generation Challenge program (GCP), national partners and other international partners. The ongoing work on large scale germplasm characterization and evaluation, modernization of facilities, application of modern molecular breeding tools and techniques, establishment of effective seed system and capacity building efforts will ensure that a a sustainable chickpea production system is established in the country. The breeding program will continue to make efforts on improving resistance tolerance to terminal drought, pod borer, ascochyta blight and fusarium wilt. ■

References

(1) Cheruiyot EK, Mumera LM, Nakhome LN, Mwonga AM (2002) Effect of legume-managed fallow on weeds and soil nitrogen in succeeding maize and wheat crops in the Rift valley highlands of Kenya. Crop Past Sci 43:24-34

(2) KARI (2011) Annual Report 2011. Kenya Agricultural Research Institute (KARI), Nairobi

(3) Kimurto PK, Towet BK, Mulwa RS, Njogu N, Kosgei AJ, Songok SJ, Oyier MO, Jeptanui L, Gangarao NR, Silim S, Kaloki P, Macharia JK, Gaur PM, Sivakumar C, Thudi M, Varshney R (2012) Application of marker-assisted breeding to improve drought tolerance in elite Kenyan chickpea genotypes. Abstract Book, VI International Conference on Legume Genetics and Genomics, 2-7 October 2012, Hyderabad, India

(4) Kimurto PK, Towet BK, Mulwa RS, Njogu N, Jeptanui L, Gangarao NR, Silim S, Kaloki P, Macharia JK (2013) Evaluation of chickpea genotypes for resistance to Aschochyta blight (*Aschochyta rabiei*) disease in dry highlands of Kenya. J Phytopathol Mediterr 52:212-221

(5) MOA (2011). The Ministry of Agriculture (MOA) Annual Report 2011 at a glance. Government Printers, Nairobi

(6) Mulwa RMS, Kimurto PK, Towett BK (2010) Evaluation and selection of drought and pod borer (*Helicoverpa armigera*) tolerant chickpea genotypes for introduction in semi-arid areas of Kenya. Proceedings, Second RUFORUM Biennial Meeting, Entebbe, Uganda, 20-24 September 2010, 34-39

(7) Mwangi HG, Gethi M, Mumera F (2009) Evaluation of strategies for management of Fusarium wilts in passion fruits in central Rift of Kenya. Proceedings, KARI Biennial Conference, Nairobi, Kenya, 57-71

(8) Wakindiki IIC, Yegon R (2011) Effect of decomposition intensity of incorporated chickpea manure on stability and saturated hydraulic conductivity of a clay loam and clay soil. Afr J Agric Res 6:1120-1127