Research Application Summary

Evaluation and selection of drought and pod borer (*Helicoverpa armigera*) tolerant chickpea genotypes for introduction in semi-arid areas of Kenya

Mulwa, R.M.S.[1], Kimurto, P.K.[1] & Towett, B.K.[1]
[1]Egerton University, P.O. Box 536-20115, Egerton, Kenya
Corresponding author: rmulwa@egerton.ac.ke

Abstract

This study evaluated 289 chickpea lines for drought tolerance, and 30 for pest resistance. Several promising genotypes have been identified (ICC 2580, ICC 7272, ICCV 92311, ICC 3362, ICCV 95311, ICC 506, EC 583311, ICCVX 906183-1), and these will be evaluated further in multi-location trials.

Key words: *Cicer arietinum,* drought tolerance, pest resistance

Résumé

Cette étude a évalué 289 lignées de pois chiches tolérance à la sécheresse, et 30 pour la résistance aux ravageurs. Plusieurs génotypes prometteurs ont été identifiés (ICC 2580, ICC 7272, ICCV 92311, ICC 3362, ICCV 95311, ICC 506, CE 583311, 906183 à 1 ICCVX), et celles-ci seront évalués dans les essais en outre à plusieurs endroits.

Mots clés: *Cicer arietinum*, tolérance à la sécheresse, la résistance aux ravageurs

Background

Chickpea (*Cicer arietinum* L.) is a good alternative food-security legume crop in semi-arid tropics since it is more drought tolerant than other legumes currently grown. Chickpea yields have however remained stagnant for the past 2-3 decades due largely to biotic and abiotic stress factors during production (ICRISAT, 2007). Amongst biotic factors, flower and pod feeding Lepidopterans (*Helicoverpa armigera, Maruca testulalis*, *Etiella zinckenella*, and *Lampides* spp) account for up to 85% loss in grain yield in Eastern and Southern Africa (Minja, 2001). *Helicoverpa armigera* (pod borer) alone causes 25-40% loss amounting to $325 million annually (ICRISAT, 1992; Sharma *et al.*, 2005). Widespread use of insecticides to control *Helicoverpa armigera* in the recent past has made the pest develop considerable levels of resistance (Kranthi *et al.*, 2002) and is causing concern due to fears of increased environmental pollution.

Among abiotic factors, drought stress is the single most important constraint to yield of chickpea accounting for 40-50% yield reduction globally (FAOSTAT, 2003). Several strategies to screen for drought tolerance have been proposed (Kashiwagi *et al.*, 2006) and breeding efforts are underway to develop drought tolerant varieties. This is made even more urgent by the declining rainfall levels due to climate change with consequent crop failures and famines.

In these scenarios, development of chickpea varieties with drought and *Helicoverpa armigera* tolerance would be a welcome intervention to overcoming these production challenges, especially since this costs little to farmers. Therefore, the objective of this study was to evaluate and select drought and *Helicoverpa armigera* tolerant chickpea genotypes from reference and mapping populations of chickpea germplasm grown in marginal rainfall areas of Kenya.

Literature Summary

Chickpea is the third most important legume crop in the world after dry beans (*Phaseolus vulgaris*) and field pea (*Pisum sativum* L.) (Kumar *et al.*, 2005; FAOSTAT, 2008). In Asia, chickpea is second in importance to rice (ICRISAT, 2005). The global annual production is 9.24 million tons grown on 12.03 million hectares with average yields of 818 kg/ha (FAOSTAT, 2006; ICRISAT, 2007). About 90% of the global area and 88% of production is concentrated in Asia. India is the leading chickpea growing country with over 68% share in hectarage and production followed by Turkey (11%), Pakistan (8%), Iran and Syria. In Africa, the annual production is approximately 430,000 tons which accounts or about 5% of global production. The leading producers are Ethiopia (168,000 tons), Tanzania (63,000 tons) and Kenya (55,000 tons). In Kenya, chickpea is a relatively new crop that is currently expanding to new areas from the original semi arid areas to the Rift Valley highlands and mid altitudes as a relay crop during the short rains. Preliminary investigations show that chickpea is highly adapted to varied agro-ecozones (Kimurto *et al.*, 2004; Kibe and Onyari, 2006; ICRISAT, 2008).

Chickpea is a key component in the diets of resource-poor people in Asia and Africa especially those who are vegetarians because of choice or cannot afford to supplement their diets with meat. It is a rich source of essential vitamins, minerals, and important amino acids like lysine and other secondary metabolites (Grusak, 2002). It is also an important component of animal feed. Chickpea can fix up to 140 kg of N/ha in cereal-legume fallow relay systems, conserve soil moisture through addition of organic matter, act as a 'break-crop" that facilitates control of diseases, pests and weeds and also improves the physical characteristics of various soil types (Cheruiyot *et al.*, 2001; Cheruiyot *et al.*, 2002), hence useful in maintaining and improving soil health, long term fertility and sustainability of the crop ecosystem. Recently chickpea has also gained popularity in large scale cropping systems in developed countries particularly Australia, Canada and USA as a rotational and relay crop with cereals, mainly wheat (Turner *et al.*, 2001; ICRISAT, 2008). In the semi arid tropics chickpea is an important crop for the poor resource farmers because of its drought resistance; it has the ability to utilize low rainfall and complete its lifecycle early and requires minimum input amounts. For example, in Kenya and Ethiopia, chickpea is mainly grown towards the end of the long rainy season with receding soil moisture or during the short rain seasons.

Study Description

The study was conducted at Agricultural Training Centre (ATC)-Koibatek, Eldama Ravine, Kenya, which lies in Agro-ecozone UM4, with low agricultural potential. The mean annual rainfall is 767mm while the mean minimum and maximum temperatures are 10.9 and 28.8^{o}C, respectively. Two sets of reference and mapping population of chickpea germplasm (289 lines for drought and 30 lines for pest resistance) were screened for two seasons in 2008/09. The drought stress trial was laid in a Lattice design (17 blocks) while the 30 lines for pest tolerance screening were planted in a randomized complete block design (RCBD). The test genotypes consisted of both Desi and Kabuli chickpea types. The treatment crop lines were spaced 40 x 10cm and were 2m long. Both trials were replicated twice. Data collected in both experiments included days to 50% flowering and physiological maturity, plant height (cm), number of pods/plant, number of seeds/pod, total number of seeds/plant, 100-seed mass (gm), and grain yield (kg/ha). In the *Helicoverpa armigera* trial, additional data taken were pod damage, larval counts and pod damage rating.

All data were analyzed using Analysis of Variance (ANOVA) with the SAS software (SAS 2005). Mean separations were done using Duncan Multiple Range Test (DMRT, $P<0.05$). Data on larval counts, percent pod damage and percent damage leaf weights were transformed using arcsine transformation before analysis.

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Mean rainfall received was 222 mm in season I (short rains) and 262 mm in season II (long rains), however there was better general performance of the genotypes in season I than in season II. There were highly significant differences (P<0.05) amongst test germplasm for the traits measured (Table 1). The number of days to flowering and maturity ranged between 44-74 and 82-144 days, respectively. The earliest flowering genotypes were ICC 4814, ICCV 92311, ICC 9862, ICC 7323, Annigeri and ICC 506, while those which matured earliest were ICC 9586 and IG10500. Genotype ICC 16487, ICC 9137 and ICC 1915 flowered latest as compared to IG 7078, ICC 1205 and 1923 which matured latest. Mean plant height ranged from 14-42 cm, with genotypes IG 71005 producing the tallest plants and moderate biomass (3.9 tons/ha) and lower harvest index (HI), an indication that genotypes which do not remobilize biomass into the sinks are not useful despite large biomass production. There was wide diversity in HI amongst tested genotypes, with mean harvest index (HI) ranging from 0.18-0.67, with a mean of 0.43 in both seasons. Genotypes ICC 2580, ICC 7272, ICCV 92311, ICC 3362, ICCV 95311 and ICC 9895 had the greatest HI (0.63-0.69) (Table 1).

Table 1. Selected elite lines from the drought screening trials.

Genotype	DFF (days)	DPM (days)	Yield (kg/ha)	HI	100 seed mass (gm)
ICC7272	57	98	2410	0.62	35
ICC2580	50	91	2872	0.6	24.4
ICCV95311	50	87	2211	0.6	34.6
ICCV92311	44	93	2087	0.59	35.9
ICC9895	57	91	2489	0.57	25.8
ICC4814	42	90	1977	0.56	17.3
ICCV10	52	85	2130	0.54	21.2
ICC12155	65	99	2600	0.53	26.4
IG6044	53	89	2467	0.5	23.8
ICC7255	55	89	2599	0.49	31.4
ICCV97105	56	96	567	0.48	32.9
ICC10399	50	87	2430	0.48	31.4
IG74036	56	88	2659	0.48	24.9
CC7315	57	89	2870	0.47	29.5
IG10500	68	85	2737	0.44	32.7
Mean	60	95	2026	0.45	18.9
SE±		5.2	10.6	1066	0.12
P<0.05	*	*	**	*	**

Key: DFF = days to 50% flowering; DPM = days to 75% physiological maturity; HI = Harvest index.

Great genetic diversity in grain yield among tested genotypes was observed, ranging from 219-2872 kg/ha (Table 1). The highest yielding genotypes were ICC 2580, ICC 7315, IG10500, IG 74030 and ICC 12155. Genotypes with high HI and high grain yield were ICC 2580, ICC 7272, ICCV 92311, ICC 3362, ICCV 95311 and ICC 9895 (>2.1tons/ha). These genotypes also had high 100-seed mass (20-35 gm) which could have contributed to high grain yield (Table 1).

In experiment II, insect pod damage ranged between 10-30% (Table 2) which is similar to figures earlier reported by Sharma *et al.* (2005) in India. This indicates that *Helicoverpa armigera* is also an important chickpea pest in Kenya. Insect infestation was lower in season II due to high rainfall amounts during the growing period, which contributed to washing off of noctuid eggs from the plant and breaking down of the pupation chambers in the soil, thus preventing adult emergence. The fourth and fifth instars observed were found to be feeding mainly on pods. The lowest larval population was recorded in genotypes EC 583318, ICC 4958, ICCVX 960186-1, ICCVX 960-28 and ICCVX 960183-69, which were comparable with those of the tolerant check (ICC 506), suggesting that the mapping and reference sets have genetic potential for pest resistance. Similar findings were reported during evaluation of the mini-core samples at ICRISAT, India (Sharma *et al.*, 2006). These genotypes also had lower leaf damage scores and suffered low pod damage (Table 2). Characteristically, the genotypes had deep green colour, small leaflets and also tended to be more hairy which could have made them less preferred by the pest. The highest larval population and pod damage scores were

Table 2. Selected elite lines from *Helicoverpa armigera* screening trials.

Genotype	Larvae count at podding	Pod damage score	Pod damage (%)	Pods/ plant	Grain yield (kg/ha)	100-seeds weight (g)
EC 583311	0.39	1.33	10.64	40	2660	20.6
ICCVX960183-28	0.36	1.33	11.78	46	1795	17.2
ICCVX960 183-69	0.4	1.33	14.24	40	1966	17.3
ICC 4958	0.47	1.33	14.91	40	2191	19.6
ICCVX96 186-1	0.37	1	15.07	40	1651	20.3
ICC 506	0.44	1	15.33	41	1772	18.8
ICCCX 960183-72	0.59	1	15.1	40	2342	17.6
EC 583264	0.5	1.67	16.43	36	2544	27.6
EC 583250	0.51	1.33	16.94	40	1856	17.7
ICC 14402	0.61	1.33	17.61	37	1734	18
ICCV10	0.45	1.35	15.7	42	1385	18.3
ICC3137	0.72	2.34	25.4	33	1309	21.7
ICC37	0.71	2.43	29.2	36	2163	21.2
ICC4973	0.68	2.35	18.7	37	1442	20.3
SE ±	1.55	0.99	8.59	3.62	569.8	4
P<0.05	*	**	*	*	**	*

recorded on ICC4973, ICC1356 and ICC 14402 which were comparable to those of the susceptible checks (ICC3137 and ICCC37) (Table 2). In contrast, these genotypes had larger leaflet area, spreading canopy structures and were less hairy.

Overall, mean grain yield ranged between 394-2660 kg/ha, with better yields realized in season II (Table 2). Genotypes EC 583311, EC 583318, ICC 506, ICCV 10, ICCVX 960183-69 and ICCVX 960186-1 had the highest grain yield ranging between 1500-2600 kg/ha (Table 2). Late maturing genotypes (e.g. ICC3137) were attacked more by the pest than early maturing genotypes like ICC506 and ICCV10, suggesting that they could have escaped heavy infestation during the poding stage when the fifth instar larval population was high. Genotype ICC 4859 also had high yield under drought screening, an indication of its potential as a drought and insect pest tolerant genotype as earlier postulated (Kashiwagi *et al.*, 2006; Varshney *et al.*, 2009).

Recommendation

From the results, several genotypes are promising candidates (ICC 2580, ICC 7272, ICCV 92311, ICC 3362, ICCV 95311, ICC 506, EC 583311, ICCVX 906183-1), with high HI, grain yield and/or pest resistance. They should be evaluated further for future release as commercial chickpea varieties for growing in the semi-arid lands of Kenya and for use as breeding material.

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