Research Application Summary

Inheritance of tolerance to intermittent drought from selected potato (*Solanum tuberosum*) cultivars in south western Uganda

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Abstract

The study objective of this study is to characterise new potato clones for drought tolerance under Ugandan conditions. Study genotypes were subjected to three water stress levels and also crossed with susceptible, locally adopted varieties to estimate the combining ability of the tolerant genotypes. Results for yield and for indicators of drought tolerance showed greater tolerance to drought in the new clones than in the local varieties. Four of the promising clones were crossed with three of the varieties susceptible to drought to determine their combining ability for yield and drought related traits, and to generate segregating materials for further evaluation.

Key words. Drought tolerance and combining ability, genotype, *Solanum tuberosum*, watering regime

Résumé

L'objectif de cette étude est de caractériser les nouveaux clones de pommes de terre pour la tolérance à la sécheresse dans des conditions ougandaises. Les génotypes de l'étude ont été soumis à trois niveaux de stress hydrique et aussi croisés avec des variétés sensibles, adoptés localement pour estimer l'aptitude de combinaison des génotypes tolérants. Les résultats pour le rendement et pour les indicateurs de la tolérance à la sécheresse ont montré une plus grande tolérance à la sécheresse dans les nouveaux clones que dans les variétés locales. Quatre des clones prometteurs ont été croisés avec trois des variétés sensibles à la sécheresse afin de déterminer leur aptitude à la combinaison des caractères de rendement et ceux se rapportant à la sécheresse, et de générer des matériaux compartimentés pour une évaluation ultérieure.

Mots clés: Tolérance à la sécheresse et aptitude de combinaison, génotype, *Solanumtuberosum*, régime d'arrosage

Background

Potato is the most important staple food and source of income in the highlands of Uganda. However, its production is affected by drought as a result of fluctuations in timing and amount of rainfall. Drought prevents crops from realising their full genetic potential, and results in great losses in production. This is aggravated by Uganda's dependence on rain-fed agriculture. Due to the current global warming, drought is already severe in many regions, expected to continue, and predicted to become very severe (Rijsberman 2006). Also, in Uganda the area of substantial potato production is expanding into locations at lower altitudes, where drought is more common. This study is aimed at developing source materials that are tolerant to drought and can be crosses with locally-preferred cultivars in order to develop cultivars with drought tolerance combined with other desired traits, and thus to increase potato production even in water-stressed conditions.

Literature Summary

Abiotic environmental stresses, such as drought, soil salinity and extreme temperatures, are factors that limit the growth of plants and cause huge crop losses worldwide (Rodriguez *et al*., 2005). Due to potato's sparse and shallow root system, it is very sensitive to water stress (Jefferies, 1993), so tuber yield may be considerably reduced by soil moisture deficits (Porter *et al.*, 1999). Although irrigation would counteract the effects of soil moisture deficits (Fabeiro**,** Santa & Juan, 2001), the majority of Uganda's production areas have no access to water for irrigation, and even where available, its use is limited by high costs. Water deficit results in decreases in tuber yield, and the plant's water potentials, number of leaves, leaf area, plant height, ground coverage and number of tubers (Hassanpanah, 2010). Continuous water stress produces small or cucumber-shaped tubers, while periodic deficiency produces knobby or bottlenecked potatoes (Nolte *et al*., 2003). Water stress also makes the plants more susceptible to a number of diseases, such as potato early death (*Verticillium dahliae*), early blight (*Alternaria solani*), black dot (*Colletotrichum coccodes*), common scab (*Streptomyces scabies*) and powdery mildew (Nolte *et al*., 2003). Plants respond to drought by inducing several morphological, physiological and molecular mechanisms that enable them to withstand the stress. These can be grouped into three categories, - escape, avoidance and tolerance (Weisser, 2010).

For most crops, conventional breeding and marker-assisted selection have been important mechanisms for achieving yield improvements under drought-prone environments (Bennett, 2003). Both field and green house experiments have been used in this study.

Study Description

This study was carried out in a green house in Kabale, Uganda, at Kachwekano Zonal Agricultural Research and Development Institute (KAZARDI), from mid-October, 2011 to mid-February, 2012. KAZARDI is situated at 2200 masl, and has a bi-modal rainfall pattern, separated by a short dry spell. Eight genotypes were characterised for drought tolerance under Ugandan conditions for one season. These included five new ones from CIP (International Potato Center, Lima, Peru) that had been bred for drought tolerance, and three locally-adapted varieties whose reaction to drought was not known. The experiment was conducted in a split- plot design with three watering regimes (field capacity, ½ of field capacity and ¼ of field capacity) as the main-plot treatment factor, and the eight genotypes as the sub-plot treatment, replicated four times. Field capacity was determined by oven drying soil samples at 105^{o}C to a constant mass after saturating 1m^2 of soil with water and leaving it to drain freely. The amount of water at field capacity was determined, and that amount was applied to optimally watered plots, while those plants in the second treatment were given half this amount, and the others one-quarter. Wooden boxes measuring 3.0m x 1.1m were used as main plots, divided into eight partitions of 0.75m x 0.55m each to accommodate all eight genotypes. Data were collected on plant height, leaf area, ground cover, number of stems per plant, main stem diameter, stress score, dry matter content, days to 50% flowering, chlorophyll content, relative leaf-water content, water-use efficiency, and yield traits. The parents were replanted on 1st April, 2012 for the second season screening, and data collection is on-going.

Research Application

Significant differences were obtained among the genotypes for all the observations made. The new varieties produced higher yields than the local varieties (apart from Victoria), and showed less reduction due to water stress. Severe stress reduced yield. The least yield was recorded in genotype 393315.1 (45.4%), followed by 394034.7 (50%) and 395077.242 (56.1%). The local checks were affected much more: Rutuku (by 70.6%), Victoria (by 71.7%) and Kachpot1 (by 75%). Plant height and relative leaf-water content were reduced under drought conditions, while plant wilting and number of days to 50% flowering were increased. Genotype x drought interaction was significant only for relative leaf water content, stress score, number of days to 50% flowering, and the increase in plant height after the imposition of stress. Also, drought stress did not have much effect on tuber shape in drought-tolerant genotypes, apart from 391591.96, which with Rutuku and Kachpot1, produced small and malformed tubers in stressed plots. However, Victoria maintained its shape and tuber quality, though the size of tubers and yield were reduced, and 391691.96 and Kachpot1 produced many tubers, although mainly small, non-marketable ones.

Four promising parents (used as males) were crossed with three susceptible, locally-adapted parents (females), to generate 12 F1 families. These were planted in nursery beds, and seedlings were transplanted into boxes in the screen house on the 2nd of May 2012. They will be subjected to three stress levels as were the parents, to determine how much of the drought tolerance from the parents had been genetically transferred to the F1's.

Table 1. Means for total number of tubers per plot, and yield in tonnes per hectare for potato genotypes tested under three watering regimes.

Genotype	Total number of tubers			Y T ha^{-1}		
	WRI	WR2	WR3	WRI	WR2	WR3
391533.1	30.0	31.0	28.5	20.1	12.2	11.0
391691.96	62.0	44.3	28.8	18.3	9.8	6.7
393077.159	34.5	22.5	23.3	26.8	14.0	9.5
394034.7	23.8	19.5	21.5	26.8	14.0	13.4
395017.242	21.8	23.0	25.0	25.0	14.0	11.0
Kachpot1	44.5	26.3	16.3	19.5	6.1	4.9
Rutuku	38.0	26.8	20.5	20.7	10.4	6.1
Victoria	24.3	27.0	19.8	28.1	11.0	7.9
Mean	34.8	27.5	22.9	23.2	11.4	8.8
LSD		6.6			2.9	

TNT (total number of tubers), Y T/ha (yield in tones per hectare), WR1 (watering regime 1, full watering), WR2 (watering regime 2, ½ the full watering amount), and WR3 (watering regime 3, ¼ the full watering amount).

Acknowledgement

We thank AGRA for sponsoring this study, Kachwekano ZARDI for use of the laboratory facilities, and RUFORUM for designing the MSc. Programme which is providing quality training for MSc. students in Plant Breeding and Seed Systems.

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