Research Application Summary

Inheritance and stability of earliness in solanum potato

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Abstract

Potato is an important food and cash crop in Uganda. Recent climatic variability characterised by erratic rainfall and elevated temperatures have been recognised as a major threat to potato production and productivity. Breeding for adaptation to these conditions will be imperative to sustain potato productivity. This will require developing high yielding, short growth cycle genotypes with in both high and low elevations. Breeding strategies to guide development of such genotypes require understanding the mode of inheritance of earliness and its impact on potato tuber yield and quality. In order to address this, five late-maturing potato clones with partial resistance to late blight were crossed with five early-maturing but low yielding lines using a North Carolina 2 (NC2) design, F_1 plants are being evaluated for the combining abilities of parents and the relative importance of additive and non-additive gene effects. In addition, nine advanced potato clones are being evaluated across three sites located at different altitudes, from 1400 m to 2450 m above sea level for 2 seasons to determine the magnitude of genotype by environment interactions for early maturity and tuber yield. Studies are on-going and preliminary data suggest that there is a strong G x E interaction for growth and yield, implying that there will be location specific selection programmes for potato.

Key words: Climate change, combining ability,early-maturity, wide adaptability

Résumé

La pomme de terre est un aliment important et une culture de rente en Ouganda. La variabilité climatique récente caractérisée par des précipitations irrégulières et les températures élevées ont été reconnues comme une menace majeure pour la production et la productivité des pommes de terre. La sélection pour l'adaptation à ces conditions sera impérative pour maintenir la productivité des pommes de terre. Il faudra pour cela un haut rendement en développement, les génotypes de cycle de croissance court avec à la fois des faibles et hautes altitudes.

Les stratégies de reproduction pour guider le développement de tels génotypes exigent de comprendre le mode de transmission de la précocité et son impact sur la qualité et le rendement en tubercules de pomme de terre. Afin de résoudre ce problème, cinq clones de pommes de terre à maturation tardive avec une résistance partielle au mildiou ont été croisés avec cinq à maturation précoce, mais des lignées à faible rendement en utilisant une conception en Caroline du Nord 2 (NC2). Les plantes F1 sont en cours d'évaluation pour les capacités de combinaison des parents et l'importance relative des effets des gènes additifs et non-additifs. En outre, neuf clones de pommes de terre avancés sont en cours d'évaluation à travers trois sites situés à des altitudes différentes, à partir de 1400 m à 2450 m au-dessus du niveau de la mer pendant 2 saisons pour déterminer l'ampleur du génotype par des interactions de l'environnement pour la maturité précoce et le rendement des tubercules. Des études sont en cours et les données préliminaires suggèrent qu'il existe une forte interaction G x E pour la croissance et le rendement, ce qui implique qu'il y aura des programmes de localisation de sélection spécifique pour la pomme de terre

Mots clés: Changement climatique, aptitude d'association, maturité précoce, large adaptabilité

Background

Most potato varieties in Uganda attain their physiological maturity and hence their full yield potential (>15t ha^{-1}) at more than 90 days after planting. Additionally, most are best adapted to elevations above 1800 masl where the environment is cool with more rainfall compared to mid-elevation and lowland areas. Recent climatic change characterised by erratic rainfall and elevated temperature (Miyashita *et al*., 2005; Majaliwa *et al*., 2010) implies that potato variety yields in the highlands is likely to reduce with a posiibility of total failure in mid-altitudes and lowlands (<1700 masl). This calls for developing varieties that can tolerate the current climatic changes. This can be partly achieved in potato by developing cultivars that mature early, are adapted to elevated temperature but still produce high yields. Further more, those with stable yields will be most desirable. This study attempts to determine the stability of selected advanced potato clones for earliness and high fresh tuber yield spanning altitudes from 1400 to 2450masl.

Literature Summary

Potato is a cash and food security crop in Uganda and is mainly grown South Western highlands. About 300,000 households in

Uganda are involved in potato production (Ferris *et al*., 2001). Potato yields in Uganda are among the lowest by world standards, estimated at 7.0 t ha^{-1} (FAOSTAT, 2010). Crop breeding has been used to improve cultivars for resistance to biotic and abiotic stresses, earliness, quality and high yield (Razukas and Jundalas, 2006; Azhar *et al.*, 2007). Among these, earliness in potato is very important especially in areas with land scarcity, multiple cropping systems or short rainy seasons. Earliness would also make potato more adaptable to mid-elevations and lowlands which are characterised by short rainy seasons. Early maturity, in shorter rainy seasons would facilitate drought escape (Banziger *et al*., 2000). Breeding for Earliness in potato is also advantageous since it leads to disease escape (Razukas and Jundalas, 2006). However, breeding for earliness in potato has not been purposely pursued in Uganda.Achieving this however, requires understanding the mode of inheritance conditioning earliness (El-Bramawy and Shaban, 2007). It is also important to understand whether the genetic control of earliness is due to additive, non-additive, dominant or epistatic effects and the interaction of these effects with the environment.

Study Description

Two studies are being undertaken to i) determine the mode of inheritance of earliness in potato and ii) determine the magnitude and pattern of GxE interactions for maturity period and tuber yield in potato.A field experiment was conducted at Kalengyere Research Station (01^0 13.2S, 029^0 47.8E; 2,450 masl) during the September-December season of 2011. Five late maturing, late blight resistant and five early- maturing but low yielding potato clones were used as parents. The F_1 progenies were produced during 2011B after parental crossing following North Carolina 2 (NC2) design. Mature berries from each cross were harvested, bulked and ripened for true seed extraction. The extracted seeds of each cross were germinated in the nursery to raise heterogeneous F_1 plants. Ten (10) plants of each of the 25 crosses (families) were transplanted into an open field in 3 replicates. They were then evaluated along with the parents. Data were collected on growth (flower bud initiation, tuber initiation, 50%Anthesis, duration of anthesis, onset of leaf ripening) and yield (number of tubers per plant, average tuber weight and total fresh tuber weight) parameters. The magnitude and significance of general and specific combining abilities will be were tested using analysis of variance. The relative importance of additive and non-additive gene effects were estimated using Baker's ratio. Mid-Parent-offspring regression analysis will also be generated to determine heritability.

Field experiments were also conducted determine the magnitude and pattern of G x E interactions for maturity period and tuber yield. Field trials were set up at Kalengyere Research Station (2450 masl), Kachwekano Zonal Agricultural Research and Development Institute (ZARDI) (2200 masl) and Mbarara ZARDI (1400 masl). potato clones were planted and tested for stability of earliness and high fresh tuber yield. The experiment is still on-going. Data is being collected on and yield parameters. The significance of cultivars, sites and their interactions among measured parameters are being tested using ANOVA. Data is available for one season and for the G x E study.

Research Application

For both growth and yield parameters, G x E interactions were highly significant at P<0.05 (Table 1 and 3). This implies that

Table 1. ANOVA table for growth parameters of potato grown in 3 environments during the second rainy season, 2011.

Source of variation	d.f.	Bud initiation	Tuber initiation	50% anthesis	Duration of anthesis	Onset of senescence
Env.	2	269.15	66.92	1019.84	2152.55	888.5
Rep/Env.	3	0.24	0.52	0.02	1.98	0.5
Genotype	10	11.61^{ns}	45.57^{ns}	25.81^{ns}	3247.89***	593.5***
G X E	20	8.12***	23.52***	14.45***	670***	32.7***
Pooled error	30	0.14	0.58	0.02	0.68	0.1

Table 2. Mean values for growth parameters of potato genotypes evaluated in 3 environments during the second rains, 2011.

Variety	Bud initiation	50% anthesis	End anthesis	Senescence	Tuber initiation
395011.2	33.3	46.7	79.3	78.3	41.3
396244.12	33.3	45.7	77.3	74.8	37.5
Nakpot 1	33.7	44.7	63.8	70.7	36.3
396029.25	33.8	46.3	87.3	89.7	42.5
396026.1	34.8	51.3	81	84	42.7
391046.14	35.3	46.7	82.5	73.5	38.8
Victoria	35.3	47.8	60.4	70	35.7
396031.12	35.7	48.7	91	92	40.7
395112.19	36.3	49.7	83.8	95	43
393280.82	36.7	50.3	85	93.3	42
396241.4	37.3	48.7	66.2	70.7	37.2
Grand mean	35.1	47.9	78	81.1	39.8
LSD	3.4	4.6	15.2	6.9	5.8
CV%	5.7	5.8	11.3	5	8.6

Table 3. ANOVA table for yield parameters of selected potato genotypes evaluated during the second season of 2011 in 3 environments.

SOV	df	Mean tuber weight (g)	Number tubers per plant	Tuber yield (t/ha)
		m.s	m.s.	m.s.
Environment	2	1545.9	109.5	414.9
Rep/Env.	3	437.5	2.0	2.5
Genotype	10	4435.9***	12.5ns	296.1***
G X E	20	739.1***	5.9**	58.1**
Pooled error	30	166.6	2.6	17
Total	65			

Table 4. Mean values for yield parameters of potato genotypes grown in 3 environments during the second rainy season, 2011.

Variety	Mean tuber weight/g	Number of tubers/plant	Total yield t/ha
395011.2	58.7	8	14.0
396244.12	66.0	7	14.5
396241.4	85.1	8	21.3
Victoria	86.3	11	29.6
393280.82	87.7	11	32.1
396029.250	88.9	10	25.8
391046.14	93.2	10	26.8
395112.19	106.8	9	27.5
396026.103	115.7	10	33.4
396031.119	117.5	9	28.3
Nakpot 1	157.6	8	35.2
Grand mean	96.7	9	26.2
LSD	32.74	3	9.2
CV%	19.9	18	20.6

genotype performance was not consistent across locations. For example, 396026.103 was the earliest to initiate flower buds in Kachwekano and Mbarara, but second last at Kalengyere. Total fresh tuber yield among test varieties showed that G x E was also highly significant across locations, implying that selection of genotypes may need to be specific for a specific environment. Based on initial results, entries 391046.14 and 396029.250 seem to be the most promising genotypes for earliness and yield. Entry 391046.14 reached maturity at 73 days after planting with a yield of 26.8 tha^{-1} whereas 3960029.250 matured at 89 days after planting with a yield of 25.8 tha^{-1}.

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