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Identification of potato clones of population B3C2 with durable field resistance to late blight (*Phytophthora infestans*) and high yields in Uganda

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Late blight disease caused by *Phytophthora infestans* (Mont.) de Bary is one of the major diseases of economic importance to potato production in Uganda causing yield losses of 40 to 60%. Use of host resistance is most economical and environmentally feasible solution to control this disease. This study was carried out to identify potato clones with high levels of field resistance to late blight pathogen (*P. infestans*) and high yields so that well adapted and tolerant clones could be developed and released as varieties. Sixteen potato clones of population B3C2 were accessed from International Potato Centre (CIP) in Lima Peru and evaluated for field resistance to late blight pathogen population in Uganda. Six potato clones (396027.205, 396034.103, 396026.103, 393280.82, 396038.107, and 395015.6) out of 16 clones were identified to posses high field resistance to late blight and high yields. The mean late blight disease severity measured as relative area under disease progress curve (rAUDPC) ranged between 15 to 38% for no sprayed while for sprayed it ranged from 5 to 22%. Yield performance under no spray treatment ranged from 7 to 20 T/ha while under spray treatment, yield ranged from 13 to 25 T/ha. Four of these clones (396026.103, 396034.103, 393280.82, and 396038.107) have been recommended for release as potential varieties for farmers.

Key words: Field resistance, *Phytopthora infestans*, *Solanum* potato.

INTRODUCTION

Late blight disease caused by *Phytophthora infestans* (Mont.) de Bary is one of the major diseases of economic importance to potato (*Solanum tuberosum* L.) production in Uganda and elsewhere in Sub-Saharan Africa (Gopal and Singh, 2003). Cultivation of resistant varieties is the most economical method to manage late blight (Aslam et al., 2003; Muhammad et al., 2012). World-wide losses due to late blight exceed several billion dollars annually (Kamoun, 2001). Evidence suggests that, most population of potato genotypes in Uganda which were once resistant to late blight have succumbed to the disease hence leading to substantial yield losses of 40 to 60% (Mukalazi et al., 2001; Kankwatsa et al., 2002). Kachwekano Zonal Agricultural Research and Development Institute (KAZARDI) through the National Potato Programme released two potato varieties ' Kachpot 1" and Kachport 2 (Wagoire et al., 2005) that belonged to Population B3C1 that utilized horizontal resistance to late blight (Landeo and Forbes, 2006). However, these varieties also succumbed to late blight hence the disease has continued to devastate farmer's crop. In an effort to continue to find a solution to late blight disease of potato, KAZARDI introduced 16 B3C2 potato clones from International Potato Centre (CIP) in Lima, Peru that is believed to possess quantitative genes for late blight resistance. Therefore, this study was

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carried out to assess the response of the introduced potato clones to late blight so that, well adapted and late blight tolerant varieties could be selected from these clones and developed as potential potato varieties.

MATERIALS AND METHODS

Field evaluation of B3C2 potato clones for late blight resistance

16 potato clones of population B3C2 were accessed from CIP and from Ugandan National Agricultural Research Organization (NARO), of which, released potato varieties were accessed from KAZARDI. These were planted in a randomized complete block design (RCBD) with 2 replicates at Kalegyere located at 2450 mal in kabale and Kachwekano located 2200 mas in 8 experimental plots at a spacing of 75 × 30 cm with each plot separated by 1 m distance. The design was arranged in split-split-plots replicated 3 times. The main plots were cultivars; sub-plots were fungicide sprays (Macozeb 80%) and a no sprayed control. The trials were established at Kalegyere and Kachwekano due to high disease pressure of late blight in these areas from 2010 to 2012 for a period of 4 seasons. The experimental treatment comprised of different potato clones of 366029.25, 391046.14, 393280.82, 395011.2, 395015.6, 39511.13, 395112.19, 396004.255, 396026.103, 396027.205, 396031.108, 396031.119, 396034.103, 396038.107, 396241.4, 396244.12, 'Cruza', 'Kachpot 2', 'Nakpot 5' and 'Victoria' and 2 types of fungicide spray regimes (No spray and bi weekly spray). 'Cruza' was used as resistant control variety while 'Victoria' was used as susceptible variety. The experimental trial was infected under natural late blight field conditions for a period of 4 seasons. The plants were monitored every week for late blight development.

Response of potato clones to late blight disease infection

Data on late blight disease severity plant leaf area affected (PLAA) was scored weekly starting at 30 days after planting using a scale developed by Henfling (1987) of 0 = none or very low number of lesions, 3% = more than 0% but less than 10% no infection, 10% = lesion are easily seen at close distance, 25% = about 25% of the foliage is covered, 50% - half of the foliage destroyed, 75% = 75% of each plant is affected, 90% = only top leaves are green, 97% = only very few green areas are left, 100% = foliage completely destroyed. Data was collected starting from when traces of late blight were observed and continuing until physiological maturity. Disease severity data (%) PLAA was then used to compute Area under disease progress curve (AUDPC) and relative area under disease progressive curve (rAUDPC) using procedure of Campbell and Madane (1990).

$$AUDPC = \sum_{i=1}^{n}[(X_i+X_{i-1})/2][t_i-t_{i-1}]$$

Where; X_i= present disease severity, X_{i-1} = previous disease severity, t_i-t_{i-1} = time difference between two consecutive disease severities. Upon harvesting yield data was also collected under different spray regimes.

Statistical methods

Analysis of variance was performed on the rAUDPC values of potato clones for the study; the percentage foliar late blight infection values were computed using Genstart computer package. Mean comparisons were conducted using Fisher's Least Significant Difference (LSD~ = 0.05). The sources of variability used in the statistical model were treatment (variety/potato clones), Spray regime, the blocks (replicates) and the experimental error.

RESULTS AND DISCUSSION

Field response of population B3C2 potato clones for late blight resistance

The results of the study indicate that, there is significance difference ($P < 0.005$) in severity of potato clones in response to late blight infection. The study showed that, 6 potato clones out of 16 introduced new potato clones which possess good levels of field resistance to late blight with an average disease severity rating measured as rAUDPC ranging between 10 to 15%. These clones included mainly 396026.103 (11.08%), 396027.205 (12.03%), 396034.103 (15.51%), 393280.82 (13.42%), 395111.13 (13.6%), and 396038.107 (15.56%). The other 10 potato clones were found to be susceptible to late blight for all the 4 seasons and this includes; 395011.2, 391046.14, 396031.119, 396004.255, 396241.4, 395015.6, 396244.12, 396029.250. 396031.108 and 395112.19 in addition to the local control susceptible varieties 'Victoria', 'Kachpot 2', and 'Nakpot 5'.

The disease severity measured as rAUDPC for the susceptible clones was high and ranged from 17 to 30% (Table 1). The study showed a wide variability in terms of response to late blight infection as a result of differences in genetic makeup of the clones. The identified resistant potato clone posses durable resistance (quantitative resistance) that lead to reduced disease severity when infected with late blight pathogen population in Uganda. Hence the identified resistant clones could be exploited for utilization in the seed potato system as a management option to control late blight. The above finding is in agreement with finding of Mulema et al. (2004) that indicated that, the use of potato varieties that have durable resistance to *P. infestans* is emphasized to control potato late blight.

Yield performance of population B3C2 pototo clones under late blight infection

The study showed significant differences ($P < 0.05$) in yield of potato clones under late blight. 6 potato clones yielded highly ranged from 19 to 21T/ha. These clones included 393280.82 with (20.78 T/ha), 395015.6 (19.32T/ha), 396026.103 (20.85T/ha), 396027.205 (19.56T/ha), 396038.107 (19.05T/ha), and 396034.103 (21.34 T/ha) (Table 2). The rest of the clones yielded between 10 to 17T/ha (Table 2) with exception of 396031.108 that yielded 20.48 T/ha. Though it gave a higher yield, it is highly susceptible to late blight as indicated in Table1. The yield results of the other clones was as follows; 395111.13 (15.31T/ha), 391046.14 (10.97T/ha), 395112.19 (16.81 T/ha), 396004.255 (11.71 T/ha), 396031.119 (17.36 T/ha), 396241.4 (13.47 T/ha),

Table 1. Average relative area under disease progress curve (rAUDPC) in percentage as a measure of late blight disease severity for introduced potato clones.

Potato clone	2010 season A		2010 season B		2010 Mean	2011 season A		2011 season B		2011 Mean	Grand Mean
	No spray	Sprayed	No spray	Sprayed		No spray	sprayed	No spray	Sprayed		
391046.14	26.38	10.43	32.55	11.58	20.23						20.23
393280.82**	4.49	3.21	17.44	4.70	7.46**	39.05	12.43	27.71	9.88	22.96**	13.42**
395011.2***	4.91	1.07	12.52	1.63	5.71***	37.88	21.38	26.53	14.16	24.99***	10.53***
395015.6			18.39	2.17	10.28	47.00	35.52	32.23	21.20	35.44	24.26
395111.13**	6.25	2.61	23.41	1.47	8.44**	45.25	18.50	21.59	10.37	23.93***	13.60**
395112.19	7.42	4.34	19.13	4.34	9.23	34.09	20.17	24.83	16.67	24.30	17.70
396004.255	9.07	9.02	26.32	4.73	12.29	36.88	23.88	25.47	13.27	24.87	16.48
396026.103***	3.98	1.76	11.00	3.28	5.00***	26.78	11.86	17.98	7.89	16.48***	11.08***
396027.205***			7.76	0.98	4.37***	25.83	11.50	12.41	9.10	16.41***	12.03***
396031.108	8.34	3.12	22.18	5.03	9.67						9.67
396031.119	20.73	14.38	24.35	4.16	15.90						15.90
396034.103***			9.47	1.55	5.51***	27.43	13.29	35.36	21.17	23.52***	15.51***
396038.107**	10.99	4.43	17.20	2.77	8.85**	23.59	10.79	27.95	18.39	20.45**	15.56**
396241.4	18.24	15.20	13.32	3.22	11.08	49.68	35.35	20.88	19.96	32.69	24.05
396244.12**	7.24	5.47	23.08	4.95	10.19	22.75	15.44	20.29	14.41	18.22	12.86
396029.250	14.61	7.40	13.30	4.03	9.84	35.50	21.34	25.09	19.12	24.97	18.60
CRUZA	6.82	3.53	15.94	2.13	7.10	37.45	26.62	24.75	13.40	26.28	17.25
Kachpot 2			20.38	4.36	12.37	32.04	21.63	27.51	15.04	24.36	20.67
NAKPOT5	13.29	5.57	20.12	2.19	10.29	27.65	14.55	23.71	12.19	19.70	15.27
VICTORIA	39.20	26.01	40.44	14.45	30.03			35.80	26.90	31.35	30.47
F.pr		0.013			0.046		0.013			0.046	<.001
LSD (P=0.05)		4.638			4.784		4.638			4.784	7.046

*** indicate late blight resistant potato clones, **, moderate late blight resistant potato clones, the missing gap in the table indicate that the potato clone was not evaluated in that season after succumbing to high late blight disease hence dropped in the previous season based on disease severity. rAUDPC = relative area under the disease progress curve (%) was calculated from the day of the first appearance of late blight symptoms (0 days after planting) to the last data of evaluation of late blight (max = 100) as mean of 2 replications.

396244.12 (13.47 T/ha), 396029.250 (15.79T/ha), 396236.20 (10.63 T/ha), Cruza (16.37T/ha), Kachpot 2 (17.29 T/ha), and Victoria (12.65 T/ha).

The results of the study also indicates that, most of the varieties that gave higher yields also showed lower disease severity of late blight. The difference in performances is due to differences in the genotypic make up of these potato clones. The study also showed significant differences in yield across the seasons with yield performances in season B (second rainy season) being higher than season A for all the 2 years period of the study. This was attributed to the prolonged rains in season B compared to season A (Rain fall data not shown). From yield and disease severity assessment, potato clones 396026.103, 396034.103, 393280.82, and 396038.107 have been selected and are hence recommended for

Table 2. Average yield (T/ha) of introduced potato clones under Late blight infection as influenced by different spray regimes.

Potato clones	2010 season A		2010 season B		2010 Mean	2011 season A		2011 season B		2011 mean	Grand mean
	No spray	Sprayed	No spray	Sprayed		No spray	Sprayed	No spray	Sprayed		
391046.14	13.91	18.76	10.76	17.82	15.31						15.31
393280.82***	23.91	22.50	16.51	21.49	21.10	22.59	24.48	9.85	24.49	20.35	20.78
395015.6***			20.53	24.26	22.39	14.52	20.05	12.15	22.37	17.27	19.32
395111.13	10.30	13.45	9.58	14.88	12.05			2.44	10.89	6.67	10.97
395112.19	17.69	17.50	22.24	33.28	23.40	14.01	17.33	4.28	8.00	10.22	16.81
396004.255	8.30	13.67	8.63	21.67	13.07			3.11	9.44	6.28	11.71
396026.103***	19.23	23.55	19.09	21.32	20.80	30.81	34.19	10.60	17.27	20.90	20.85
396027.205***			17.03	12.79	14.91	31.26	29.08	11.67	14.22	23.28	19.56
396031.108	19.14	21.38	18.19	23.19	20.48						20.48
396031.119	15.23	18.68	13.43	22.11	17.36						17.36
396038.107***	17.80	22.36	21.82	26.37	22.09	26.70	29.85	10.00	15.11	16.84	19.05
396241.4	13.02	16.72	18.98	32.60	22.15	7.11	9.80	3.96	8.18	6.96	13.47
396244.12	17.66	18.63	7.44	12.02	13.94			11.11	12.11	11.61	13.47
396029.250	14.03	16.62	22.24	26.72	19.90	17.34	26.05	9.11	9.82	12.80	15.79
396034.103***			15.19	21.97	18.58	28.56	31.59	13.44	22.81	24.10	21.34
396236.20	15.33	19.38	6.80	10.19	11.50			3.89	7.33	5.61	10.63
CRUZA	14.88	18.67	23.27	27.22	21.01	17.35	21.21	5.42	8.96	11.72	16.37
Kachpot2			19.23	24.62	21.93	14.36	16.39	9.98	19.47	14.97	17.29
NAKPOT5	14.30	14.62	25.45	31.36	21.43	18.56	24.52	6.56	17.82	15.69	18.56
VICTORIA	10.09	16.98	20.18	21.97	17.30			3.20	7.22	5.21	12.65
F.Pr			<0.001						<.001		
LSD (P=0.05)		1.852			1.580		1.852			1.580	3.900

*** indicate late blight resistant potato clones, the missing gap in the table indicates that, the potato clone was not evaluated in that season after succumbing to high late blight disease in the previous season. rAUDPC = relative area under the disease progress curve (%) was calculated from the day of the first appearance of late blight symptoms (30 days after planting) to the last data of evaluation of late blight (max = 100) as mean of 2 replications.

release as potential potato varieties for Uganda.

Conclusion

The identified late blight resistant potato clones (396026.103, 396034.103, 393280.82, and 396038.107) could be exploited for utilization in the seed potato system as a management option to control late blight disease in Uganda. The late blight resistant and high yielding potato clones serve as potential potato varieties for farmers if released and could save yield losses due to the disease if adopted by the farmers.

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