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Original article

Managing the Menace of Late Blight Disease of Potato Using Field Resistance in Jos Plateau, Nigeria

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Abstract

Late blight disease caused by *Phytophthora infestans* is the most destructive of all potato diseases and is recorded as responsible for the famous global famine in the middle of the 19th century in Ireland. It affects leaves, stems and tubers in the field and can absolutely destroy the crop producing up to 100% crop loss. Jos Plateau is noted for favourable cultivation of potato which is an economic crop grown in over 250,000 hectares of land area annually. However, this prospect is hindered by the ravaging late blight which has led to colossal losses in the past three years. Reports from current production suggests great loss has already been recorded this year; so far about 30% of the total harvest is lost due to the severity of the disease. Though farmers attempt to control late blight by spraying fungicides, the use of resistant varieties in combination with other control measures such as proper cultural management and growing potato outside the blight danger period is still the best approach and feasible to small scale farmers. A research was carried out in Kuru (a location in Jos-Plateau well noted for late blight attacks). Sixteen (16) advance varieties and clones from CIP were used to screen for their resistance.

Keywords: Late Blight, Field Resistance, Jos Plateau, Nigeria.

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INTRODUCTION

Potato (*Solanum tuberosum* L) belongs to the tuber crops and the crop belongs to the family solanaceae. The colonial tin miners introduced potato on the Jos-Plateau in the early 19th century toprovide food for their European expatriate population (Kwon-Ndung and Ifenkwe, 1993). The production was encouraged by the British Colonial Government during the second world war as the tubers were needed to feed their armed forces in West Africa. Since then, the importance of potato has been widely realized such that it is now an important commodity in both local and international trade (Ugonna et al., 2013). More so, the crop has become an integral part of the farming system of the local farmers who are responsible for producing over 1,500,000 metric tonnes and 92% of Nigerian's annual output (NRCRI annual Reports, 2012 and Chuwang, 2014). The rainy season crop which accounts for 82% of Nigeria's total annual production is prone to various diseases, the most economically important being late and early blights caused majorly by *Phytophthora infestans* (Mont) DeBary and *Alterania solani* respectively (Capital Post Magazine, 2014). These by no means, are not the only pathogens but they are the most important.

The pathogen of potato late blight, *Phytophthora infestans* on a wide scale is considered to be the most important potato disease because the yield loss under favourable (cool and rainy) weather conditions may even reach 80 – 100%, due to complete defoliation and subsequent tuber rot (Gergely, 2004). The incidence of late blight has always been observed, but the severity and frequency of the cases had never really exceeded the economic threshold to the extent which warranted the drastic control measures that were taken in the past few rainy seasons (2012, 2013 and 2014). This disturbing development and increase in the attack predisposes the entire population of the Jos-Plateau to food insecurity, economic deterioration and environmental pollution. This statement is justified when we consider the fact that the potato crop, which is usually harvested early, holds the key to bridging the hunger gap during the critical period between July and August (Chuwang, 2014). Similarly, the potato business in Nigeria is conservatively estimated to be worth 300 billion Naira (FAO, 2008 and NRCRI, 2012) and the demand for fresh tubers had never been fully met. And so, the demand deficit in Nigeria can only be effectively supplied from the Jos-Plateau given the favourable climatic conditions like cool temperature due to high altitude.

A yearly report from the National Root Crop Research Institute of potato late blight on potato farms in Plateau State is a concern with records of 100% loss (Amadi et al., 2008).

One of the major changes in the spread of *Phytophthora infestans* races with complex virulence, altering the strategy in breeding for field resistance have gained priority in current breeding programmes (Gergely, 2004). The physical environment influences the development of an epidemic through effects on various phases of the pathogen's life cycle as the pathogen interacts with specific phases in the development of the host plant (Gopal et al., 2003).

Cool, wet weather with rainfall and ambient relative humidity (RH) above 90% and temperatures of 7-21^{o}C favours late blight development (Forbes et al., 2014). Natural epidemics of *Phytopthora infestans* in the field can be used advantageously for screening large population of potato genotypes for resistance to this disease and this will also contain the emerging threat posed by potato late blight and other diseases.

Materials and Methods

The experimental plant materials of this research comprised of sixteen potato varieties and clones (both CIP advanced lines, European varieties and two local varieties) sourced from the germplasm collection of National Root Crops Research Institute Umudike, Potato Programme Kuru, which is a location well noted for late blight disease. Kuru has a latitude of 09.7N and longitude of 08.85E, with an annual rainfall of about 1795mm. the temperatures are highest on average in November, at around 20.8C and lowest in July around 17.9C (Ambrose et al., 2013).

The experiment was conducted in 2016 in Randomized Complete Block design with three replications. Each experimental unit was made up of two ridges measuring 3m in length and 2m wide, planting was done 30cm within row and 90cm between rows. Fertilizer was applied at planting at the rate of 600kg per ha NPK 15:15:15. Weeds were controlled by pre-emergence application of the herbicides Primextra^{R} and Altrazine^{R} (4l/ha) using a knapsack sprayer (20 liters) and subsequently controlled manually at 8WAP using a small hoe.

Data were recorded on emergence count (4WAP), percentage of potato foliage damage by late blight, vigour score, leaf area index, plant height, ground cover (canopy), plant growth habit, total tuber weight and average under disease progress curve (AUDPC), (CIP, 1996 and Forbes et al., 2014).

Statistical analysis, analysis of variance (ANOVA) was carried out on mean plot basis from the mean of the cultivars across replications according to Snedocor and Cochran (1980). Coefficient of variation, correlated response, broad sense heritability and phenotypic and genotypic coefficient of variation were calculated for all the sixteen varieties and clones measured (John, 1978).

Results and Discussion

The analysis of variance (data not shown) revealed that the potato cultivars were highly significant for all the traits studied. This could be attributed to their genetic make-up. This is because the seed tubers used in the experiment were of the same size grade, physiological age and received the same treatment before and after planting.

Table 1. Range, Mean, Standard Error, Coefficient of variation and Heritability for eight characters of 16 potato genotypes grown in Kuru

Traits	Range	mean$\pm$S.E	H%	CV%	
				genotypic	Phenotypic
Leaf area index	6.11 - 25.06	14.78 $\pm$ 3.17	97	69.73	12.39
Vigour score	1.67 - 9.00	5.63 $\pm$ 1.18	97	68.01	12.09
Emergence count	13.67 - 20.00	17.85 $\pm$ 1.23	93	14.02	3.99
Plant height	14.12 - 39.21	26.64 $\pm$ 5.59	95	52.84	12.1
AUDPC	0.00 - 1611.33	737.62 $\pm$ 24.17	99	17.41	6.89
Canopy cover	19.03 - 58.00	33.95 $\pm$ 6.76	97	66.89	11.9
Growth habit	1.30 – 2.30	1.76 $\pm$ 0.39	85	26.02	12.87
Total tuber weight	2.96 - 9.97	7.38 $\pm$ 2.20	99	56.26	4.46

The mean, range, phenotypic, genotypic coefficient of variation and heritability are presented in Table 1. For all the morphological and yield traits, the widest range was recorded for late blight resistance (AUDPC), followed by plant canopy cover and plant height in that order. On a whole, range of values were recorded for each trait as showed (Table 1). As would be expected, the traits with high range also indicated the highest coefficient of variation. For morphological, late blight resistance and yield traits, genotypic coefficient of variation (GCV) were higher than the corresponding phenotypic coefficient of variation (PCV) for all characters. The highest GCV and PCV were recorded for leaf area index and vigour score (69.73 and 12.39; 68.01 and 12.09), respectively. The least estimate for both the PCV and GCV was in emergence counts.

Broad sense heritability estimates ranged between 85% (for growth habit) and 99% (for area under disease progress curve and total tuber weight). Heritability values were higher for all the traits. All characters measured were influenced by environmental factors and their genetic characteristics have been reported to vary from one genotype to another (Demo, 1997).

Table 2. Phenotypic correlation coefficient between characters and yield in 16 potato genotypes grown in Kuru

Traits	**Leaf Area Index**	**Vigour Score**	**Emergen ce Count**	**Plant Height**	**Late Blight Resistanc e (AUDPC)**	**Canopy Cover**	**TTW**	**PGH**
Leaf Area Index	1.0000	0.7131**	-0.1250	0.6779**	-0.6112**	0.7457	0.3904	0.3519
Vigour Score	0.7131**	1.0000	-0.3485*	0.7582**	-0.8226**	0.75910**	0.6474**	0.3886**
Emergence count	-0.1250	-0.3485*	1.0000	-0.3435*	0.4411**	-0.2213	-0.5673**	0.1488
Plant Height	0.6779**	0.75917*	-0.3435*	1.0000	-0.6909**	0.7869**	0.5907**	0.3788*
Late Blight Resistance (AUDPC)	-0.6112**	-0.8226**	0.4411*	-0.6909**	1.0000	-0.8423**	-0.8310**	-0.4460**
Canopy Cover(CM^2)	0.7458**	0.7591**	-0.2214	0.7861**	-0.8423**	1.0000	0.6840**	0.5960 **
TTW (t/ha)	0.3904**	0.6674**	-0.5672**	0.5908 **	-0.8318**	0.6839**	1.0000	0.3553*
Plant Growth Habit (PGH)	0.3520*	0.3389*	-0.1488	0.3588*	-0.4460*	0.5916**	0.3553*	1.0000

*,** Significant at P<0.05, 0.01, respectively

Table 2 shows the phenotypic correlation coefficient between the characters measured and the yield in 16 potato genotypes. Most of the correlation coefficients were significant. Significant coefficient between leaf area index and vigour score of high magnitude (r_p = 0.7131). Phenotypic correlation coefficient between leaf area index and late blight resistance estimates (AUDPC) were significant (-0.6112), plant height and vigour score (0.7582). Leaf area index and tuber yield 0.3904, leaf area index and canopy cover (r_p = 0.7458) vigour score and plant height (r_p = 0.75917). Vigour score and canopy cover (r_p= 0.7591), vigour score and late blight (r_p= -0.8226) vigour score and total tuber weight (r_p= 0.6674). Emergence counts recorded non-significant correlation coefficient with almost all the characters. Emergence counts and leaf area index (r_p= -0.1250), emergence counts and late blight resistance (0.4411). Emergence counts and plant growth habit (r_p = 0.1488). Late blight resistance correlation coefficients were negative and significant with all the traits. Late blight and leaf area index (r_p = -0.6112), late blight resistance and vigour score (r_p = -0.8226), late blight and plant height (r_p = -0.6909), late bright resistance and canopy cover (r_p = -0.8423), late blight resistance and tuber yield (r_p = -0.8318). Late blight and plant growth habit (r_p = -0.4460). Canopy cover recorded positive and significant correlation with leaf area index (r_p = 0.7457), plant vigour (r_p = 0.75910), plant height (r_p = 7869), tuber yield (r_p = 0.6839) and plant growth habit (r_p = 0.5916). Tuber yield exhibited high and positive correlation coefficient with vigour score (r_p = 0.6474), plant height (r_p = 0.5907) and canopy cover (r_p = 0.6840).

The high positive correlation between tuber yield and most of the characters observed in this study are in agreement with previous research which reported correlation values of 0.74 (Danbaba and Aba, 2011). The positive high correlations between these pairs indicate that a change in one is accompanied by a corresponding change in its components, that is vigour score and canopy cover. Late blight resistance was negatively correlated with all the traits except emergence counts. Such a negative association arises primarily from developmentally induced relationships since they attack all parts of the plants especially the leaves that manufacture food for the plants. This agrees with Danbaba et al. (2012) whose work showed that if one structure is more favoured than the other, a negative correlation arises. Another reason could be the activities of late blight pathogen that limit proper functioning of these traits (Kwon-Ndung, 1990). In conclusion, the result of the present study has shown that most of the traits evaluated showed significant differences across traits. Variety Gembu local gave the highest tuber yield and also exhibited highest resistance to late blight. Late blight disease also showed a negative relationship with all the traits evaluated indicating that it can attack and destroy every part of the plant.

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