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Path Analysis of Yield of some Potato Hybrids and their Progenitors in Northern Guinea Savanna of Nigeria

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ABSTRACT

This study on phenotypic correlation and path coefficient analysis was conducted in Toro (a warm location situated at lat. $10^0 3'$N, and Long 9^0E), Bauchi State in the northern guinea savanna of Nigeria during the rainy season of 2002 and 2003. The objectives were to determine the relationship between tuber yield and its components, and identify the most important tuber yield determinants which may be used as direct selection criteria for yield improvement in potato under high ambient temperatures conditions. The treatment consisted of one hundred and sixty potato genotypes made up of one hundred and forty nine hybrids, ten projenitors, and a check variety (Desiree). Interactions of eleven agronomic characters of potato and their correlation with tuber yield were examined. The estimates of phenotypic correlation coefficients revealed a significant positive correlation between tuber yield and each of five attributes namely average tuber weight per plant (r = 0.632), number of tuber per plant (r = 0.486), early blight severity (r = 0.123), days to tuber initiation (r = 0.128), and days to maturity (r = 0.147). However, partitioning the observed phenotypic correlations into their direct and indirect effects using path analysis showed that average tuber weight followed by the number of tubers per plant, exerted the highest direct influence on tuber yield per plant. Other attributes exerted minimal direct influence on tuber yield. The effects of early blight severity, days to tuber initiation, and days to maturity on tuber yield consisted mostly of indirect influences through average tuber weight and number of tubers. These findings, indicate that average tuber weight per plant and number of tuber per plant were the critical attributes of utmost importance which can be used successfully as indices of selection for yield improvement in potato grown in warm environment characteristic of the Northern guinea savanna of Nigeria.

Key Words: *Potato genotypes, Tuber yield, Path analysis, Selection, High temperature, Northern guinea savanna.*

Introduction

Yield is a complex character associated with many interrelated components (Murat and Vahdettin, 2004). Numerous researchers (Sidhu and Pandita, 1979; Birhman and Kang, 1993; Amadi, 2005, and Amadi and Ene Obong., 2007) have used simple correlation coefficients to study the interrelationships between tuber yield and other characters. Although information about the correlation of agronomic and morphological characters with yields is helpful in the identification of the components of this complex character, yet these do not provide precise information on the relative importance of

direct and indirect influences of each of the component characters. With increasing number of variables it becomes necessary to measure the contribution of these variables to the observed correlation and hence partition the correlation coefficient into components of direct and indirect influence (Guler et al., 2001, Onder and Babaoglu, 2001). This in turn allows separation of the direct effects of one variable (other variables are kept constant) from indirect effects of other variables, giving a clearer picture of the individual contributions of each variable to yield (Radovan, 1992). Since path analysis permits a critical examination of the specific factor that produces a given correlation, it could be successfully employed in formulating an effective selection strategy (Kumbhar, *et al*., 1980).

In the Northern guinea savanna of Nigeria with the possible exception of Jos Plateau, ambient temperatures during the rainy season are higher than the optimum requirement for potato reported to be about 15-20^{o}C (Borah and Milthorpe, 1962). Expansion of potato production into such areas requires the determination of the relationship between tuber yield and its components and identification of the most important tuber yield determinants which may be used as direct selection criteria for yield improvement under such conditions. This present work is intended to determine the inter-relationship between yield and some agronomic characters in a population of potato hybrids and their progenitors by partitioning the observed phenotypic correlation into their direct and indirect effects. This will enable the identification of characters of utmost importance which may be used as selection criteria in breeding potato for tolerance to high ambient temperature characteristic of the Northern guinea savanna of Nigeria.

Materials and Methods

This experiment was carried out during the rainy season of 2002 and 2003 in Toro -a warm location situated at lat. $10^{0}3$'N, and Long 9^{0}E in the northern guinea savanna agricultural zone of Bauchi State Nigeria. Weather data of Toro for the relevant months of study in 2002 and 2003 is presented in Fig 1.One hundred and sixty potato genotypes consisting of one hundred and forty nine hybrids (from 32 families), ten parents and Desiree, a cultivar well known for some degree of heat tolerance (Midmore, 1984) were used. The experimental design was a randomized complete block design (RCBD) replicated 2 times because of shortage of planting material. Each replication consisted of six blocks with net plot size of $3m^2$. The seed tubers were stored under diffused light storage and were sprouted before planting. They were planted at the rate of 1 tuber per stand, with inter and intra row spacing of 1m and 30cm respectively giving a plant density of 33,333 plants per hectare. Weeding was carried out manually at the 4th and 8th weeks after planting (WAP). Fertilizer was applied at the rate of 100kg N, 100kg P_20_5 and 40kg K_20 per hectare by banding two weeks after planting. No fungicide was applied. The plants were harvested when the leaves began to senesce.

Data were collected on the following attributes; seedling emergence at 4 WAP, number of stems per plant, plant height (cm), number of leaves per plant, days to tuber

initiation, days to maturity, severity of early blight, number of wilted stands, scab severity, number of tubers per plant, average tuber weight/plant, and tuber yield per plant. These attributes were measured as follows

Seedling emergence: Emergence per plot was recorded at 4 weeks after planting by counting the number of stands whose shoots have broken through the soil surface.

Number of stems per plant: Only the main stems i.e. those originating from the mother tubers were counted. The record was taken at full flowering

Plant height (cm): Plant height was obtained by measuring from the base of the plant to the apical bud. The measurement was taken at the 8th week after planting

Number of leaves per plant: The compound leaves from the base to the tip of the plants counted at 8 weeks after planting.

Days to tuber initiation: This was counted from planting to the time when the first tuber is initiated by any plant in the plot. A plant was considered to have formed tubers when the swelling at the end of the stolon was twice by visual estimates the diameter of its stolon. To observe this, beginning from 3 WAP, two plants from the boarder rows were carefully removed each week to expose the stolon for observation.

Days to maturity: This was obtained by counting the number of days from planting to the time when less than 50% of the canopy remain green.

Early blight severity: Early blight severity was recorded at 10 weeks after planting based on a scale developed by Martin and Thurston, (1987). The scale ranges from 1 to 9 with a mid point of 4.

1 = No blight spots seen on the foliage
4 = 25 –50% of the foliage infected by blight
9 = foliage completely covered/killed by blight.

Incidence of bacterial wilt: This was obtained by counting the numbers of plants with bacterial wilt symptoms per plot.

Number of tubers per plant: This was obtained by counting the whole tubers produced by all plants in the plot and dividing by the number of plants in the plot

Average tuber weight per plant: This was obtained by dividing the total weight of the tubers produced in a plot by the number of tubers

Tuber yield: The total weight of tubers/plant (g)

Statistical analyses were performed on plot means for all attributes. Combined analysis of variance, multiple correlation and regression were carried out using the STATVIEW for windows software version 4.5. Simple correlation analysis was carried out according to the method outlined by Gomez and Gomez, (1984) $r = \sum xy / \sqrt{(\sum x2)(\sum y2)}$

Path-coefficient analysis was carried out according to the method outlined by Dewey and Lu, (1959).

Results and Discussion

The correlation coefficients obtained for the relationship between yield and yield attributes are presented in Table 1. Days to tuber initiation and maturity were positively

and significantly correlated with yield. It seems that in this population and environment, delay in tuber initiation perhaps allowed for optimal foliage development before tuber initiation while delay in maturity allowed for a longer period for the storage of assimilates. These in turn ensured adequate production and storage of assimilate over a longer period in the tubers hence the positive correlation between days to tuber initiation, days to maturity and yield. However, working with a different population under a cool mid-altitude location, Amadi and Ene Obong, (2007) observed a significant negative correlation between tuber yield and days to tuber initiation; and days to maturity and suggested that early tuber initiation coupled with a sustained partitioning of assimilates to tubers invariably lead to higher yield.

Early blight severity, was positively and significantly correlated with yield in this study. Amadi and Ene Obong,. (2007) reported an insignificant negative correlation of early blight with yield under a cool mid altitude condition. Early blight disease usually appear late in the life span of the potato when the plant is almost maturing and does not adversely affect yield.

Number of tubers and average tuber weight were positively and significantly correlated with yield. This is in agreement with the report of other authors (Lopez *et al*., 1987, Ozkaynak, and Samanchi, 2005, Rasool *et al*., 2006,) and suggests that selection for increased number of tubers per plant or increased average weight per tuber will lead to yield improvement. The association between number of tubers and average tuber weight was negative and significant (r =-0.318***). Potato tuber yield is dependent on the number of tubers and average tuber weight (Birhman and Kang, 1993). Both characters compete directly for the same assimilate hence the negative correlation between them. Various authors have reported either a negative or absence of relationship between number of tubers and average tuber weight (Maris, 1969; Birhman and Verma, 1986; Amadi, 2005).

Partial correlation coefficients and coefficients of determination are shown in Table 2. These indicate that number of tubers per plant and average tuber weight had real effects on yield and were the main contributors to tuber yield in this population. Path-coefficient analysis (Table 4) showed that number of tubers per plant and average tuber weights not only exerted the highest direct influence on yield (0.772 and 0.879 respectively) but were also the major indirect means through which the other characters influenced yield. Other characters had minimal direct effects on yield.

Sidhu and Pandita (1979), and Ozkaynak et al., (2003) considered number of tubers to be more important than average tuber weight in determining tuber yield, where as Maris, (1969), and Birhman and Verma (1986) considered the contrary to be true. Lynch and Kozub (1991) observed that while number of tubers was more important for determining tuber yield in some progenies and environments, it was average tuber weight that was more important for tuber yield determination in other genotypes and environments. Results obtained from this experiment indicate that average tuber weight per plant was more important than number of tubers per plant in determining tuber yield

in this population under high ambient temperature characteristic of the Northern guinea savanna.

Multiple correlation coefficient for the relationship between tuber yield and other attributes was highly significant and positive (0.963). This means that 96.3% variation in tuber yield can be attributed to the influence of the 11 characters assessed. The multiple regression of the 11 characters on tuber yield was also very highly significant (Table 3). The very high coefficient of determination (92.8%) shows that the most important agronomic characters determining tuber yield in potato were covered in the assessment.

Results obtained from this experiment suggests that number of tubers per plant and average tuber weight are the important determinants of tuber yield and could be relied upon as indices for the selection of high yielding potato genotypes for growth in the Northern guinea savanna of Nigeria.

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Table 1: Correlation coefficient for the relationship between characters of some potato hybrids and their parents evaluated in 2002 and 2003 combined at Toro

Characters	Plant emergence (4wap)	Number of stems /plant	plant height (cm)	Number of leaves /plant	Days to tuber initiation	Days to maturity	Early blight severity	Number of wilted stands/m^2	Scab score	Number of tubers / plant	Average Tuber wt/plant
Number of stems/plant	-0.021										
plant height (cm)	0.001	0.004									
Number of leaves/plant	-0.086	0.037	0.172**								
Days to tuber initiation	-0.049	-0.006	0.109	0.415**							
Days to maturity	-0.065	-0.063	0.051	0.242**	0.637**						
Early blight severity	0.078	0.012	0.056	-0.127*	0.121*	0.064					
Number of wilted stands/ m^2	-0.07	-0.005	0.107	0.065	0.056	0.054	0.005				
Scab score	0	-0.024	-0.046	-0.03	0.149**	0.079	0.025	0.029			
Number of tubers / plant	0.043	0.165**	0.016	-0.072	0.046	-0.021	-0.003	-0.023	0.055		
Average tuber weight/plant	-0.031	-0.026	0.058	0.103	0.162**	0.202**	0.129*	-0.038	0.053	-0.318**	
Tuber yield /plant	-0.004	0.107	0.07	0.027	0.128*	0.147**	0.123*	-0.058	0.059	0.486**	0.632**

** = Correlation significant at P< 0.01, * = Correlation significant at P< 0.05

Table 2: Partial correlation coefficients and coefficient of determination (R^2), of tuber yield and some characters of potato hybrids

Characters	Partial correlation Coefficients	Coefficients of determination
Plant emergence	-.0459ns	0.000 ns
Stem number	.0094 ns	0.011 ns
Plant height	.0318 ns	0.005 ns
Leaf number	.0540 ns	0.001 ns
Days to tuber initiation	-.1927 **	0.016 ns
Days to maturity	.0791 ns	0.022 ns
Early blight	.0786 ns	0.015 ns
Bacterial wilt	-.0214 ns	0.003 ns
Scab	-.0725 ns	0.003 ns
Tuber number	.9536***	0.236***
Average tuber wt.	.9484***	0.399***

*** = Coefficient significant at P<0.001, ** =Coefficient significant at P<0.01
ns = Not significant

Table3: Multiple correlation and regression of tuber yield on some characters in potato

Source of variation	Degree of freedom	Sum of squares	Mean squares	F- value	P- value
Regression	11	681495.70	61954.1	360.92	<.0001
Residual	308	52869.47	171.65		
Total	319	734365.18			

Coefficient of determination = 0.928*** , Multiple correlation = 0.963***

Standard error of estimate = 13.10

$Y = -147.19 -0.447X_1+0.330X_2 +0.043X_3 +0.052X_4 -1.022X_5 +0.431X_6 +1.408X_7 -1.266X_8 -1.742X_9 +30.671X_{10}+5.003X_{11}$

Where X_1 = Plant emergence, X_2 = Stem number, X_3 = Plant height, X_4 = Number of leaves, X_5 = Days to tuber initiation, X_6 = Days to maturity, X_7 = Early blight, X_8 = Number of wilted stands/m^2, X_9 = Scab severity,

X_{10} = Number of tuber/pt, X_{11} = Average tuber weight

Table 4: Path analysis showing direct and indirect influences of some tuber yield of potato hybrids combined over 2 years

Character	Direct Effect	Indirect effect via											Total
		Plant emergence	Stem Number /Plant	Plant Height (cm)	Number of leaves/pt	Days to Tuber initiation	Days to Maturity	Early Blight Severity	Number of wilted stands	Scab severity	Number Of tubers /pt.	Average Tuber Weight (g)	
Plant emergence	-0.012		-.000063	.000009	-.001462	.003675	-.00182	.0017716	.00042	-.000000	.033196	-.027249	-.004
Stem Number /Plant	0.003	.000252		.000036	.000629	.00045	-.001764	.000264	.00003	.00288	.12738	-.022854	0.107
Plant Height (cm)	0.009	-.000012	.000012		.002924	-.008175	.001428	.001232	-.000642	.00092	.012352	.050982	0.070
Number of leaves/pt	.017	.001032	.001221	.001548		-.031125	.006776	-.002794	-.00039	.0006	-.055584	.090537	.027
Days to Tuber initiation	-.075	.000588	-.000018	.000981	.007055		.017846	.002662	-.000336	-.00298	.035512	.142398	0.128
Days to maturity	.028	.000780	-.000189	.000459	.004114	-.047775		.001408	-.000324	-.001580	-.016212	.177558	.147
Early Blight Severity	.022	-.000936	.00036	.000504	-.002159	-.009075	.001792		-.00003	-.0005	-.002316	.113391	.123
Number of wilted stands	-.006	.00084	-.000015	.000963	.001105	-.0042	.001512	.00011		-.00058	-.017756	-.033402	-.058
Scab severity	-.020	.00000	-.000072	-.000414	-.00051	-.011175	.002212	.00055	-.000174		-.04246	.046587	.059
Number Of tubers/pt.	.772	-.000516	.000495	.000144	-.001224	-.00345	-.000588	-.000066	.000138	-.001100		-.279522	.486
Average Tuber Weight (g)	.879	.000372	-.000078	.000522	.001751	-.01215	.005656	.002838	.000228	-.00106	-.245496		.632

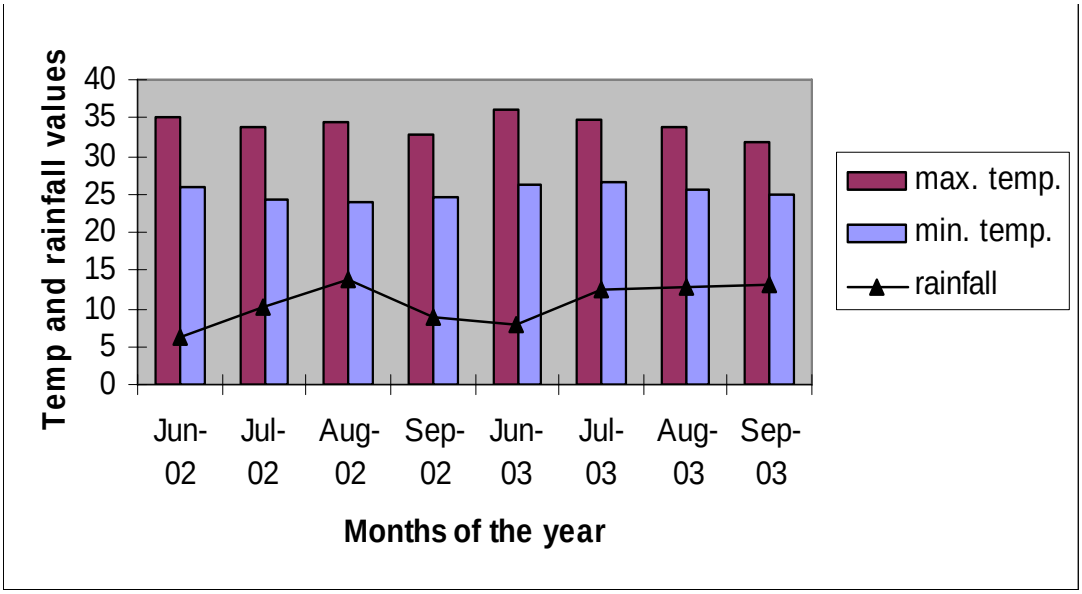

Fig. 1. Temperature and rainfall data of Toro from June to Sept. 2002 and 2003