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Variation and Correlation Studies on Some Adapted Genotypes of Potato *(Solanum Tuberosum.*L*)* in Kuru, Jos, Nigeria

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Abstract

Sixteen genotypes of potato *(Solanum tuberosum* L.) were grown during the rainy seasons of 2006 and 2007 in Kuru to estimate genetic variability and interrelationship between yield and some traits as well as heritability of some traits. The experiment was laid out in a randomized complete block design (RCBD) in three replications. Analysis of variance indicated that significant variation existed in all the traits studied. Tuber yield showed significant genotypic correlation with emergence count, plant height, internode length, days to maturity and number of tubers per plant. Tuber yield showed a significant negative genotypic association with vigor score and number of main stems per plant. It was found that there were highly significant positive correlations between tuber yield and vigor score, plant height, internode length and number of tubers per plant, indicating that improvement in any of these characters will lead to indirect improvement in tuber yield. The high negative values of correlation coefficients recorded between tuber yield and vigor score and tuber yield and number of stems per plant signify that selection for those traits would have effect in the opposite direction in respect of tuber yield in the crop.

Key words: Genotypes, correlation, quantitative characters, yield.

Introduction

Yield, being a complex quantitative trait, is influenced by various component traits. For effective improvement, simultaneous selection of the most important yield components is necessary. For this reason, knowledge of the magnitude and nature of the association between yield and the related characters is important. Crop improvement depends upon the magnitude of genetic variability present in the base population. Once genetic variability has been ascertained in a crop, improvement is possible by using an appropriate selection method. This involves the knowledge of correlation between traits and commercial yield (Rasmusson and Cannel, 1970; Singh and Gupta, 1990; Lynch and Kozub, 1991). Correlations studies between characters have been of great value in the determination of the most effective procedures for selecting superior genotypes.

Correlations studies are very important because they indicate the important determination of potato tuber yield production (Omoruwa *et al.*, 1987). The fraction of the phenotypic variation in a trait that is due to genetic effects can be measured by the heritability of the trait. Heritability in conjunction with genetic coefficient of variation will give a more reliable index of selection (Burton, 1952). Gopal *et al* (1999) and Gaur *et al* (1978) observed strong and positive association between tuber yield and tuber number per plant in potato. Amadi *et al* (2008) also observed a high correlation between tuber yield and tuber number per stand. The objectives of this study were to determine the genetic variability for various characters evaluated and the inter-relationship among these characters with tuber yield in 16 adapted genotypes of potato.

Materials and Methods

The experimental materials consisted of sixteen genotypes of potato (*Solanum tuberosum* .L). The materials were obtained from the germplasm collection of potato programme, National Root Crops Research Institute, Kuru, Nigeria, during the 2006 and 2007 wet seasons in Kuru, Jos, which is located on Latitude $09^0 44^/$ N and Longitude $08^0 44^/$ E, and on mid-altitude elevation of 1257m above mean sea level. It has an annual rainfall of 1289.8 mm with total rainy days of 103. Planting was done on the 17^{th} May, 2006 and 23^{rd} May, 2007 on ridges spaced at 100cm by 30cm between and within rows respectively, giving a plant population of 33,333 plants per ha. Fertilizer (NPK 15:15:15) application was done by banding method at the rate of 550Kg per ha immediately after planting. The experimental design used was a randomized complete block replicated three times. The sixteen genotypes were randomized in each block. Gross plot size of 4m x 3m and a net plot size of 2m x 3m were used in the experiment. Each of the gross plots contained four rows and the boarder rows formed the discards. Ten plants in each plot were randomly selected for recording observations.

Emergence score was determined as the number of plants that emerged at 4 weeks after planting (WAP) per plot. Number of stems per plant and plant height (from ground level) were recorded when the top-most shoot of some genotypes turned into a flower. Internode length was estimated by measuring the internode length of the main stem only. Days to maturity was recorded as the number of days from planting to the date when 50% of the leaves senesced. Vigor was determined by visual assessment on the scale of 1 to 7, 7= high vigor, 1= low vigor. Tubers were harvested at maturity and the number counted and weighed to the nearest 0.01kg.

Analysis of variance (ANOVA) was carried out for each character and a covariance analysis was calculated for each pair of characters studied using the plot means according to the procedure outlined by Snedecor and Cochram (1967) and Kem phorne (1973). Genotypic, phenotypic and environmental correlations were estimated using the formula described by Singh and Chaudhary (1985). Broad sense heritability was calculated according to the method by Allard (1990).

$$\text{Genotypic correlation } (r_g) = \frac{\sigma_{gx.y}}{\sqrt{(\sigma^2_{gx})(\sigma^2_{gy})}}$$

Where:

$\sigma^2_{gx.y}$ = genotypic covariance between two traits, x and y

σ^2_{gx} = genotypic variance of trait x

σ^2_{gy} = genotypic variance of trait y

$$\text{Phenotypic correlation } (r_{ph}) = \frac{\sigma^{2phxy}}{\sqrt{(\sigma^2_{ph}x)(\sigma^2_{ph}y)}}$$

Where:

$\sigma^2_{ph}xy$ = phenotypic covariance of traits x and y.

$\sigma^2_{ph}x$ = phenotypic variance of trait x.

$\sigma^2_{ph}y$ = Phenotypic variance of trait y.

$$\text{Environmental correlation } (r_e) = \frac{\sigma^2_e xy}{\sqrt{(\sigma^2_e x)\,(\sigma^2_e y)}}$$

Where:

$\sigma^2_e xy$ = environmental covariance between traits, x and y.

$\sigma^2_e x$ = environmental variance of trait x.

$\sigma^2_e y$ = environmental variance of trait y.

Results and Discussion

The combined mean performance of the genotypes is shown on Table 1. Significant difference ($p<0.05$) existed among the genotypes in most of the traits studied. This may be due to genetic differences by the genotypes. This indicates that genetic variability exists in all the traits in the genotypes evaluated. Improvement of weak genotypes can thus be done by breeding and selection. Two genotypes, Nicola and 392226.4, had the highest emergence count among all the genotypes with a mean of 20 stands each, while genotype 93.4 recorded the lowest emergence counts with a mean of 11 stands. Vigor score differed among all the genotypes studied. The genotypes, Machembe and 93.4 were the most vigorous, while Bertita and Accent were the least vigorous. Plant height varied significantly for all the genotypes. Genotypes Machembe, 2001-5 and B9430.9 were the tallest, while genotypes 3908459, 392226.4 and Desiree were the shortest. Desiree had the highest internode length, while genotype 2001-5 had the highest number of main stems per plant.

Furthermore, genotype RC762-2 took the longest time to mature with a mean maturity period of 83.00 days. Number of tubers per plant differed significantly among all the genotypes studied (Table 1).

Table 1: Combined Mean performance of potato genotypes at Kuru, Jos (2006-2007).

	Genotype	EC	VS	PH	IL	NS	DM	NT	TW	NL
1.	Accent	19.66	4.13	77.73	4.27	2.47	70.40	8.50	0.87	51.73
2.	Desiree	17.00	4.40	66.53	6.97	2.80	75.13	6.60	0.41	64.87
3.	Nicola	20.00	4.40	79.40	4.40	3.67	75.23	9.50	0.58	79.40
4.	R. Ruaka	18.33	4.30	74.07	5.00	3.03	81.20	5.73	0.48	68.67
5.	Bertita	19.33	4.00	72.00	4.50	3.07	72.16	8.37	0.51	72.23
6.	B9430.9	19.66	4.73	57.67	4.37	3.33	72.16	9.83	0.63	44.73
7.	390845.9	19.00	4.80	53.87	5.20	2.47	79.93	8.27	0.56	47.83
8.	392257.09	18.66	4.86	76.20	3.37	2.43	69.30	5.77	0.45	63.67
9.	RC762.2	19.66	4.60	61.33	5.43	2.27	83.43	7.13	0.60	43.53
10.	Machembe	17.66	5.13	96.33	3.73	3.63	73.20	7.47	0.77	74.53
11.	2001.5	17.00	4.86	93.93	4.20	4.43	78.33	8.67	0.56	43.67
12.	93.5	11.33	5.20	64.47	3.57	2.77	80.30	8.27	0.54	46.40
13.	392287.040	16.66	4.60	69.33	4.90	3.00	74.06	8.23	0.45	61.47
14.	392010.045	17.33	4.46	67.33	5.20	2.83	82.40	8.30	0.56	47.20
15.	390430.010	19.66	4.36	67.35	5.40	2.97	73.60	11.53	0.41	39.13
16	392226.4	20.00	5.00	66.73	4.83	2.43	73.86	9.97	0.49	73.30
	Grand Mean	18.18	4.61	74.03	4.77	2.98	75.97	8.26	0.55	57.65
	CV	6.2	11.47	21.00	19.00	27.00	12.00	31.6	12.00	7.800

Key: EC = Emergence counts, VS = Vigor score, PH = Plant height (cm), IL = Internode length (cm), NS = Number of stems, DM = Days to maturity (days), NT = Number of tubers, NL= number of leaves per plant, TW= tuber weight (kg), TY = Tuber yield (t/ha).

Genotypes 392226.4, Nicola and B9430.9 produced the highest number of tubers with a mean of 9.97, 9.50 and 9.83, respectively. The genotype, Accent had the highest tuber weight per plant with a mean of 0.87kg, while Nicola (the check), had the highest number of leaves per plant with a mean of 79.40. Similarly, tuber yield ranged from 6.80t/ha to 14.50t/ha for genotypes Machembe and 390430.010 respectively. This highly significant variation in plant attributes within a population suggests that selection is possible for each character. Days to maturity had a wide range of 69.30 to 83.43, which means that genotype selection for different maturity regimes that will be suitable to the different ecological zones is possible. This finding is in agreement with Amadi *et al* (2008).

Estimates of mean, range, standard error, mean square, genotypic and phenotypic coefficient of variation, combined across years (2006 and 2007) are presented in Table 2. For all the agronomic traits, the widest was recorded for plant height, followed by number of leaves. For emergence counts, the mean of all the genotypes was 18.18, which ranged from 11.33-20.00 (Table 2). Mean vigor score and plant height was 4.67 and 74.03cm, respectively. On an average, 3.17cm stem girth was recorded.

Table 2: Mean, Range, Standard Error, Mean Square, Genotypic and Phenotypic Coefficient of Variation

Character	Mean	Range	Standard Error	Mean square	Coefficient of variation	
					GVC(%)	**PVC(%)**
Emergence count	18.18	11.33-	0.42	14.1319**	11.39	12.96
Vigour score	4.67	20.00	0.08	0.7930**	10.88	11.29
Plant height (cm)	74.03	4.00-	6.02	426.0195**	7.08	26.03
Stem girth (cm)	3.17	5.13	0.22	0.6419NS	13.38	11.42
Days to maturity	75.96	53.87-	5.41	212.44**	3.45	11.85
Number of	57.65	96.33	4.80	542.32*	18.32	30.99
leaves/plant	4.77	2.83-	0.28	1.9483*	12.94	23.16
Internode	3.04	3.44	0.48	1.9893**	25.83	28.50
length(cm)	8.26	69.30-	1.51	7.029NS	3.09	31.79
Number of	0.55	83.43	0.06	0.04589NS	9.90	36.40
stems/plant	9.42	39.13-	0.04	1.7642NS	6.73	35.28
Number of		79.40				
tubers/plant		3.57-				
Tuber yield (t/ha)		6.99				
Tuber		2.43-				
weight/plant(kg)		4.43				
		5.77-				
		11.53				
		0.41-				
		0.89				
		68-14.5				

*, ** = Significant at 1% and 5% levels of probability

NS = Not significant

The mean days to maturity, number of leaves per plant and internode length were found as 75.96, 57.65 and 4.77cm, respectively. Number of stems per plant ranged between 2.43 and 4.43 with a mean value of 3.04. Number of tubers per plant, fresh tuber weight and tuber yield had mean values of 8.26, 0.55kg and 0.94kg, respectively. Low standard errors of means for all the traits were obtained, thereby, indicating that these traits are less influenced by the environment, therefore these traits are amenable to improvement through selection. Phenotypic coefficient of variation was larger than genotypic coefficient of variation, but in some cases the two values differed only slightly, indicating small environmental effects in estimating these parameters. Number of stems per plant showed the largest genetic coefficient of variation while number of tubers per plant showed the smallest genetic coefficient of variation combined across the years. These findings are in agreement with Gopal *et al* (1999). However, genetic variation alone cannot determine the amount of variation that is heritable. Heritability estimates must accompany the genetic coefficients of variation to make it meaningful.

The estimates of genotypic variance, phenotypic variance, environmental variance, heritability and genetic advance combined across the years (2006 and 2007) are presented in Table 3. The phenotypic variance components were generally higher in magnitude than those of genotypic variance. The highest genotypic variance was recorded for number of leaves per plant (111.547) while the lowest was recorded for fresh tuber weight per plant (0.003). Phenotypic variances ranged from 0.040 for fresh tuber weight to 319.247 for number of leaves per plant. The genotypic variance exceeded error variance estimate only on emergence counts and number of main stems per plant. When traits with high phenotypic variances also have high genotypic variance, selection for these traits based on the phenotype is likely to result in appreciable genetic advancement in line with the findings of Sharma (1980).

Table 3: Genotypic, phenotypic and environmental variances, heritability and expected genetic advance.

Characters	Genotypic variance σ^2_g	Phenotypic variance σ^2_{ph}	Environmental variance σ^2_e	Heritability broad sense h^2B	Expected genetic advance% of mean
Emergence	4.290	5.551	1.261	91.00	44.24
count	0.258	0.278	0.2868	97.00	11.04
Vigour score	11.640	247.58	343.691	19.30	14.74
Plant height	0.018	0.131	0.149	56.20	0.66
Stem girth	6.859	81.051	87.910	30.60	5.70
Days to maturity	111.547	319.247	207.710	50.00	199.28
Number of	0.381	1.220	0.804	58.70	9.66
leaves/plant	0.617	0.753	0.137	93.10	38.92
Internode length	0.065	6.899	6.838	2.70	0.04
Number of	0.003	0.040	0.038	18.70	0.21
stems/plant	0.004	0.110	0.107	93.3	0.08
Number of					
tubers/plant					
Tuber					
weight/plant					
Tuber yield					

Heritability values were lower for number of tubers per plant, plant height and days to maturity, this indicates that these traits are considerably influenced by environmental factors, hence, they offer limited hope for successful selection. The low broad sense heritability estimate observed for number of tubers per plant was in agreement with Danbaba (2011) who also reported low heritability for number of tubers per plant in potato. Number of stems per plant, emergence counts and number of leaves per plant showed high heritability along with high expected genetic advance in percentage of the mean (Table 3), indicating that, improvement of tuber yield in potato would be effective through phenotypic selection for these characters.

Estimates of phenotypic, genotypic and environmental correlations combined across the years (2006 and 2007) are presented in Table 4. Significant and negative genotypic correlation was observed between vigor score and tuber yield (r = -0.45), number of main stems and tuber yield (r = -0.56), number of tubers per plant and tuber yield (r = -0.73) and fresh tuber weight per plant (r = -0.45). Significant and positive genotypic correlations were observed between tuber yield and emergence count, (r = 0.35), plant height and tuber yield (r = 0.82), tuber yield and internode length (r = 0.65) and days to maturity with tuber yield (r = 0.71). Tuber yield showed significant and positive phenotypic correlation coefficient with emergence counts (r = 0.34), vigor score (r = 0.59), plant height (r = 0.39), internode length (r = 0.32) and number of tubers per plant (r = 0.53). Stem diameter, number of main stems and fresh tuber weight per plant had low and negative phenotypic correlation with tuber yield.

Table 4: Genotypic, phenotypic and environmental correlation between tuber yield and nine characters of potato.

Character	Genotypic correlation coefficient with tuber yield	Phenotypic correlation coefficient with tuber yield	Environmental correlation coefficient with tuber yield
Emergence count	0.35*	0.34	0.01
Vigour score	-0.45*	0.59**	0.56**
Plant height	0.82**	0.39*	0.30
Internode length	0.65**	0.32	0.20
Stem diameter	-0.02	-0.09	0.14
Number of	-0.56**	-0.04	0.12
mainstems	0.71**	0.05	0.11
Days to maturity	-0.73**	0.53**	0.56**
Number of	-0.45*	-0.23	-0.13
tubers/plant			
Tuber weight/plant			

*** = Significant at 5% and 1% level of probability

Environmental correlations with tuber yield had both negative and positive values depending on characters. Significant positive environmental correlation coefficients with tuber yield were exhibited by plant vigor and number of tubers per plant. Negative and low environmental correlation coefficient was recorded between tuber yield and fresh tuber weight per plant. Low and positive environmental correlation coefficient were recorded between plant height, internode length, stem diameter, number of main stems and days to maturity and tuber yield.

The values of genotypic correlation coefficients were, in most cases, greater than phenotypic correlation coefficient between various pairs of characters, indicating a fairly strong association between the characters studied (Table 4) Johnson *et al* (1955). Tuber yield was positively and significantly correlated with plant height and days to maturity. Theoretically, it means that plant height and days to maturity could be used as selection index to improve tuber yield. The negative and significant genotypic correlation observed between number of main stems and fresh tuber weight suggests that number of main stems and fresh tuber weight will have less activity in tuber yield.

The significant positive genotypic correlation between days to maturity and tuber yield indicates that high yielding genotypes will usually be late in maturity. This finding agrees with that of Marris (1988). Characters, which are phenotypically correlated but not genotypically correlated, will not produce repeatable estimates of inter-character association and any selection based on the relationship is likely to result in little, if any genetic gain. This is true of the association between tuber yield and plant vigor and both plant height and number of tubers per plant.

The significant positive environmental correlation coefficient between plant vigor and tuber yield and number of tubers per plant and tuber yield shows that the effect of environmental factors on the expression of the relationship between the characters was so strong as to alter it markedly. However, environmental correlation coefficient between tuber yield and fresh tuber weight per plant was negative, indicating that the effect of environment on this character was weak.

Conclusion

In conclusion, it was observed across years that some yield attributes or traits were positively correlated with yield. Therefore, selection for any of these traits can lead to indirect selection for tuber yield. Simultaneous selection for these traits can also be made for genetic improvement of tuber yield in potato. Tuber yield, which is quantitatively inherited, is the most economically important trait in potato and is influenced by soil, fertility and other factors, thus making direct selection difficult. Consequently, to improve the tuber yield, it is important to select for one or more yield related traits such as plant height, internode length and days to maturity. Therefore, simultaneous selection using these traits could result in genetic improvement of tuber yield in the crop.

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