International Journal of Farm Sciences **2(2)** :17-27, 2012

Increasing productivity of sweet potato, *Ipomoea batatas* (L) Lam through clonal selection of ideal genotypes from open pollinated seedling population

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ABSTRACT

Understanding interrelationship among various agronomic traits is vital to plan an effective breeding programme in sweet potato, *Ipomoea batatas* (L) Lam. This study was undertaken at Horticultural Experimental Farm, Indira Gandhi Agricultural University, Raipur, Chhattisgarh to determine association among yield and yield related traits in the crop plant so as to identify the major traits of importance that could be used as bases for clonal selection. The experimental material consisted of thirty three sweet potato genotypes along with one standard check (Sree Ratna) which were replicated thrice in a randomized block design during Rabi 2003-04. The data on vine length, vine weight per plant, total tuber yield per plant, harvest index, biological yield per plant, total tuber yield per hectare, marketable tuber yield per plant, marketable tuber yield per hectare, number of tubers per plant, total soluble solids, tuber length, neck length and diameter of tuber, weevil infested tubers per plant, dry weight of tuber and dry weight of vine were recorded and analyzed to workout the genetic variability, heritability, genetic advance, correlation and path coefficient analysis for all the characters. Correlation coefficient analysis revealed that tuber yield per plant had positive correlation with biological yield per plant, harvest index, marketable tuber yield per plant and diameter of tuber suggesting that selection for component characters may increase the tuber yield of sweet potato. Path coefficient analysis revealed that biological yield per plant and harvest index were important traits influencing tuber yield and could be utilized as election criteria in sweet potato improvement programme for Chhattisgarh plains.

Keyword: Clonal selection; sweet potato; yield; crop

INTRODUCTION

Sweet potato, *Ipomoea batatas* (L) Lam locally known as *Shakarkand* is one of the most popular tuber crops in India and abroad because of its yield potential and high calorific value. It is mainly cultivated almost in all the tropical and subtropical countries as well as in the warmer regions of temperate countries. It is heterozygous cross-pollinated, hexaploid (2n=90) and vegetatively propagated tuber (modified

root) crop in which many of the traits show continuous variation (Jones et al 1986). Sweet potato is the world's seventh most important food crop after wheat, rice, maize, potato, barley and cassava. It contains raw protein in fresh storage roots which ranges from maximum 49 to minimum 2.24 per cent on wet basis (Walter and Catignani 1981). The starch content in raw sweet potato storage roots varies from 33-73 per cent on dry basis (Truong et al 1986). In addition to protein and starch some of the sweet potato varieties provide 1-12 mg carotene per 100 gm of tuber making the tubers more nutritious (Lila 1988). According to Grafuis (1959) increasing total yield would be made easier by selecting for components because the components are more simply inherited than the total yield itself. Thus studies on correlation enable the breeder to know the mutual relationship between various characters and determine the component characters on which selection can be used for genetic improvement. Although correlation coefficients are helpful in determining the component of complex traits like yield they do not provide an exact picture of relative importance of direct and indirect influence of each component character. The ultimate storage root yield depends upon a large number of factors that influence the final expression of the traits. Such a complex scheme of relationship could be partitioned by path coefficients analysis as suggested by Wright (1921) and adopted by Dewey DR and Lu (1959). In agriculture path analysis can be used to assist plant breeders in identified traits that are useful as selection criteria to improve crop yield.

MATERIAL AND METHODS

The present study was conducted at the Horticultural Experimental Farm, Indira Gandhi Agricultural University, Raipur, Chhattisgarh during Rabi season of 2003-04. The material used in the present study was developed through open pollinated breeding method. The true open pollinated seeds of five sweet potato lines viz IGSP-4, IGSP-12, IGSP-17, POL-21-1 and 56-2 were sown in the primary nursery during 2002-03. On the basis of tuber formation in seedling population 33 clones were selected for further evaluation (Table 1).

The experiment was arranged in a randomized complete block design with three replications. Each genotype was planted on a 2.4x2.2 m size plot. A distance of 50 cm was maintained between the plots. Since the seed coat of sweet potato is very hard seeds were treated with concentrated Hydrochloric acid (HCl) for one hour in beakers and repeatedly washed with running tap water for removal of the acid residue completely before sowing in nursery beds. Five well pulverized nursery beds measuring 1.5 m wide and 3.0 m long were prepared and seeds were sown in miniature furrows at 2.0 cm depth and covered with

Table 1. Morphological features of the selected genotypes

S No	Genotype	Notation	Storage root skin colour	Storage root flesh colour
1.	IGSP-12-02-3	C_1	Pink	Orange
2.	IGSP-17-02-6	C_2	Pink	White with purple dots
3.	IGSP-12-02-2	C_3	Cream	Cream
4.	IGSP-12-02-1	C_4	Pink	Light orange
5.	56-2-02-17	C_5	Cream	Cream
6.	IGSP-17-02-7	C_6	Cream	Cream with purple dots
7.	IGSP-02-7	C_7	Cream	Cream with purple dots
8.	56-2-02-5	C_8	Cream	Cream
9.	IGSP-4-02-1	C_9	Cream	Cream
10.	IGSP-12-02-5	C_{10}	Cream	Light orange
11.	IGSP-17-02-3	C_{11}	Cream	Cream with purple pigmentation
12.	56-2-02-20	C_{12}	Cream	Cream
13.	IGSP-02-13	C_{13}	Dark pink	White
14.	IGSP-12-02-6	C_{14}	Cream	Cream
15.	56-2-02-23	C_{15}	Dark pink	White
16.	56-2-02-3	C_{16}	Cream	Cream
17.	IGSP-02-17	C_{17}	Dark pink	Cream
18.	IGSP-02-18	C_{18}	Cream	Light orange
19.	IGSP-02-19	C_{19}	Cream	Cream
20.	IGSP-02-20	C_{20}	Cream	Cream
21.	IGSP-02-21	C_{21}	Dark pink	White
22.	IGSP-17-02-10	C_{22}	Dark pink	Cream
23.	56-2-02-9	C_{23}	Cream	Cream
24.	IGSP-17-02-1	C_{24}	Pink	White
25.	IGSP-02-25	C_{25}	Pink	White
26.	IGSP-02-20	C_{26}	Pink	White
27.	IGSP-02-27	C_{27}	Pink	White
28.	IGSP-4-02-2	C_{28}	Pink	Cream
29.	56-2-02-2	C_{29}	Dark pink	White
30.	POL-21-02-8	C_{30}	Cream	Cream
31.	56-2-02-18	C_{31}	Cream	Cream
32.	POL-21-02-6	C_{32}	Cream	Cream
33.	56-2-02-7	C_{33}	Dark pink	Orange
34.	Sree Rethna (Standard check)	C_{34}	Dark pink	Orange

well rotten farm yard manure. The watering, weeding and plant protection operations were carried regularly as and when required. After the 90 days of sowing of true seeds in nursery beds clones having thick roots were selected by visual observation. Top and middle portion of vine cuttings of selected clones with 3-4 nodes and about 20-30 cm long were clipped off and planted in primary nursery as single progeny rows with 60x20 cm spacing. On the basis of shape, size, colour of tubers and flesh, weevil infestation and growth habit superior clones were selected from the seedling population in primary nursery after the 100 days of planting. The tubers of selected clones were treated with monocrotophos @ 1ml/l of water and planted as three progeny rows in secondary nursery with 60x20 cm spacing for multiplication. The experimental field was prepared finally by giving three criss cross tractor ploughings followed by harrowing. Before transplanting pulverizing operation was done by rotavator. The experimental plot was divided into three replications with the help of measuring tape, rope and bamboo pegs. In total 34 plots of 2.4x2.2 m size in each replication were prepared. NPK @ 75:50:75 kg/ha in the form of urea, single super phosphate and muriate of potash was applied. Urea was applied in two split doses first as basal dose and second after 45 days of vine transplanting in main field as top dressing. Full quantities of phosphorus and potash along with FYM 10 tonnes/ha were applied as basal doses. The upper and middle portions of vines of the finally selected clones multiplied in the secondary nursery were vertically planted in the well prepared field at 60x20 cm spacing on the ridges. Five random competitive plants were selected and harvested from each plot at four different maturity dates viz 90, 100, 110 and 120 days after planting. Characters like vine length, vine weight per plant, number of tubers per plant, tuber weight per plant, marketable yield of tubers per plant, weevil infested tuber yield per plant, total tuber yield, marketable tuber yield, tuber length, diameter of tubers, neck length of tubers, biological yield per plant, harvest index, dry matter percentage of tubers, dry matter percentage of foliage, total soluble solids (%) and organoleptic evaluation were studied during the study.

RESULTS AND DISCUSSION

Correlation analysis

The correlation studies enable the breeder to simplify a complex trait like tuber yield into its component parts. Direct selection for complex traits like tuber yield is often not very effective hence indirect selection for some of the component traits associated with tuber yield may be rewarding. Thus knowledge of the nature and extent of inter relationship between yield and its attributes is of great utility to the breeders in formulating selection strategies which aims at improving tuber yield in sweet potato. The yield components may not

always be independent in their action and may be interlinked. The selection practiced for one character may simultaneously bring change in the other related traits. Thus to bring change in any character especially in tuber yield in desired direction proper understanding of association btween the tuber yield and its contributing characters is essential which determines the component characters on which selection can be made for improvement. Positive correlation accelerates the rate of genetic progress but such correlations are desirable for selecting early and high yielding genotypes.

During the present study correlation analysis of different morphological characters with tuber yield and its components was investigated (Table 2).

The total tuber yield per plant was positively correlated with biological yield per plant (0.912), harvest index (0.633), marketable tuber yield per plant (0.795) and diameter of tuber (0.634) at phenotypic levels. However biological yield per plant (0.918), harvest index (0.647), marketable tuber yield per plant (0.958), diameter of tuber (0.75) showed positive correlation with yield at genotypic level only.

The diameter of tubers was positively correlated with biological yield per plant (0.581) and marketable tuber yield per plant (0.581) at phenotypic level only. Harvest index (0.684) and marketable tuber yield per plant (0.820) were positively correlated with diameter of tubers at genotypic level only. Marketable tuber yield was positively and significantly correlated with biological yield per plant at phenotypic (0.753) and genotypic (0.919) levels. Harvest index was negatively and significantly correlated with number of tubers (-09.44) and vine weight per plant (-0.795) at environmental level. Vine weight was positively and significantly correlated with tuber length (0.625) and biological yield per plant (0.617) at genotypic level whereas biological yield per plant (0.918) was positively correlated at both phenotypic and environmental levels.

Tuber yield had positive and significant correlation with harvest index, biological yield, marketable tuber yield per plant and diameter of tubers at phenotypic level only. Similar findings were also reported by Thamburaj and Muthukrishnan (1976), Kamalam et al (1977), Ibrahim (1987), Thankamma and Easwari (1990), Nanda (1994), Kumar et al (1996), Alam et al (1998), Parida et al (1999), Hossain et al (2000) and Chaudhary et al (2000) whose studies indicate that tuber yield in sweet potato was highly and positively correlated with tuber diameter. Harvest index was negatively and significantly correlated with number of tubers per plant and vine weight per plant at environmental level. Similarly vine weight was positively and significantly correlated with number of tubers per plant and biological yield at genotypic level. This is in accordance with

Table 2. Correlation coefficient of tuber yield and its components in sweet potato

Character		Biological yield per plant (g)	Vine weight per plant (g)	No of tubers per plant	Vine length per plant (cm)	Harvest index (%)	Total soluble solids (%)	Marketable tuber yield per plant (g)	Neck length of tubers (cm)	Diameter of tubers (cm)	Total tuber yield per plant (g)
Tuber length (cm)	P	0.169	0.294	-0.034	0.185	-0.147	-0.134	0.036	0.017	0.046	0.060
	G	0.391	0.625*	0.068	0.467	-0.252	-0.297	-0.025	0.086	-0.218	0.173
	E	0.259	0.301	-0.071	0.086	-0.276	-0.122	0.086	-0.086	0.123	-0.043
Biological yield per plant (g)	P		0.169	0.037	0.100	0.268	-0.288	0.753**	-0.060	0.581*	0.912**
	G		0.617*	0.066	0.122	0.301	-0.302	0.919**	-0.063	0.099	0.919**
	E		0.918**	-0.025	-0.070	-0.795**	0.004	-0.136	0.055	-0.033	0.279
Vine weight per plant (g)	P			0.052	0.316	-0.575	-0.079	0.258	-0.051	0.164	0.245
	G			0.099	0.404	-0.551	-0.087	0.339	-0.055	-0.033	0.279
	E			-0.020	-0.138	-0.944**	0.020	-0.090	0.013	-0.019	-0.111
No of tubers per plant	P				0.107	-0.011	-0.019	-0.070	-0.311	-0.033	0.023
	G				0.144	-0.039	-0.016	-0.089	-0.523	-0.332	0.040
	E				0.080	0.066	-0.042	-0.058	-0.027	0.130	-0.004
Vine length per plant (cm)	P					-0.278	0.084	-0.013	0.091	0.066	-0.032
	G					0.353	0.084	-0.030	0.104	0.101	-0.043
	E					0.162	0.101	0.030	0.036	0.037	0.159
Harvest index (%)	P						-0.216	0.449	-0.026	0.407	0.633*
	G						-0.233	0.540	-0.027	0.684*	0.647*
	E						0.024	0.070	-0.014	0.074	0.325
Total soluble solid (%)	P							-0.101	0.016	-0.119	-0.309
	G							-0.122	0.018	-0.231	-0.322
	E							-0.025	-0.024	0.054	-0.010
Marketable tuber yield per plant (g)	P								-0.090	0.581*	0.795*
	G								-0.095	0.820**	0.958**
	E								-0.126	0.174	-0.135
Neck length of tubers (cm)	P									-0.063	-0.048
	G									-0.087	-0.049
	E									-0.092	0.103
Diameter of tubers (cm)	P										0.634*
	G										0.750**
	E										-0.007

*Significant at 5% level (0.576); **Significant at 1% level (0.708)

the findings of Huett (1976) and Bhagsari and Harmon (1982). Gasura (2008) also reported that there was a positive correlation ($r = 0.58$; $P<0.05$) between yield and tuber number. However the regression line accounted for 53 per cent of the total variance. Cultivars like Beauregard, Tanzania, Buliribwamese, Kisakyamaria and Tar are high yielding almost at par with NASPOT 1 improved variety. Rees et al (2003) to have relatively low dry matter content (less than 18%) local landraces can make a significant contribution either as varieties per se or progenitors in breeding programmes for the farmer preferred traits. Storage roots with high dry matter and high starch content are more suitable for secondary processed products such as starch and flour.

Path coefficient analysis

The concept of path analysis was originally developed by Wright in 1921 but the technique was first used for plant selection by Deway and Lu in 1959. This is simply a standardized partial regression coefficient which splits the correlation coefficient into direct and indirect effects and measures the direct and indirect contribution of independent variables on dependent variable. They are free from units and as such it is easy to make interpretation. Path analysis is of immense value for the vegetable breeders in two ways. It helps in judging the direct influence of the various characters on the tuber yield as dependent trait and in explaining the total correlation between dependent and independent traits.

The genotypic character correlation coefficients observed between tuber yield and its components were partitioned into direct and indirect effect and are mentioned in Table 3 taking yield per plant as a dependent variable. The biological yield per plant (1.164) had highest positive direct effect on tuber yield followed by harvest index (0.077), number of tubers per plant (0.01), vine length per plant (0.009), total soluble solids (0.009), neck length of tubers (0.007) and diameter of tubers (0.005). Negative direct effects were found for vine weight per plant (-0.415), marketable tuber yield per plant (-0.015) and tuber length (-0.005). Tuber length had positive indirect effects on tuber yield through biological yield (0.455). It had negative indirect effect on vine weight per plant (-0.260) and harvest index (-0.019). Biological yield had positive indirect effects on tuber yield through harvest index (0.023) and diameter of tubers (0.005). It had negative indirect effect on vine weight per plant (-0.256), marketable tuber yield (-0.013) and number of tubers per plant (-0.002). Vine weight per plant had positive indirect effects on tuber yield through biological yield (0.718) whereas it had negative indirect effect through harvest index (-0.042). Number of tubers per plant had positive indirect effect on tuber yield through biological yield per plant (0.077) and negative indirect effect on vine weight (-0.041), harvest index (-0.003) and neck length of tubers (-0.003). Vine length per plant had positive indirect effect on tuber yield through biological yield per plant

Table 3. Path coefficients of the characters contributing towards tuber yield (tonne/ha) in sweet potato

Character	Tuber length (cm)	Biological yield per plant (g)	Vine weight per	No of tubers per plant (g)	Vine length per plant (cm) plant	Harvest index (%)	Total soluble solids (%)	Marketable tuber yield per plant (g)	Neck length of tubers (cm)	Diameter of tubers (cm)
Tuber length (cm)	**-0.005**	0.455	-0.260	0.001	0.004	-0.019	-0.003	0.000	0.001	-0.001
Biological yield per plant (g)	-0.002	**1.164**	-0.256	0.001	0.001	0.023	-0.003	-0.013	0.000	0.005
Vine weight per plant (g)	-0.003	0.718	**-0.415**	0.001	0.003	-0.042	-0.001	-0.005	0.000	0.002
No of tuber per plant	0.000	0.077	-0.041	**0.010**	0.001	-0.003	0.000	0.001	-0.003	-0.002
Vine length per plant (cm)	-0.002	0.142	-0.168	0.001	**0.009**	-0.027	0.001	0.000	0.001	0.001
Harvest index (%)	0.001	-0.350	0.229	0.000	-0.003	**0.077**	-0.002	-0.008	0.000	0.004
Total soluble solid (%)	0.001	-0.352	0.036	0.000	0.001	-0.018	**0.009**	0.002	0.000	-0.001
Marketable tuber yield per plant (g)	0.000	1.069	-0.141	-0.001	0.000	0.042	-0.001	**-0.015**	-0.001	0.005
Neck length of tubers (cm)	0.000	-0.073	0.023	-0.005	0.001	-0.002	0.000	0.001	**0.007**	0.000
Diameter of tubers (cm)	0.001	1.159	-0.123	-0.003	0.001	0.053	-0.002	-0.015	-0.001	**0.005**

Residual effect = 0.000; Bold figures denote the direct effect

(0.142). Harvest index of plant had positive indirect effect on tuber yield through biological yield per plant (0.350), vine weight (0.229) and tuber diameter (0.004) whereas it had negative indirect effect on vine length per plant (-0.003), total soluble solids (-0.002) and marketable tuber yield per plant (-0.008). Total soluble solids had positive indirect effect on tuber yield through vine weight per plant (0.036). It had negative indirect effect through biological yield per plant (-0.352) and harvest index (-0.018). Marketable tuber yield per plant had positive indirect effect on tuber yield through biological yield per plant (1.069), harvest index (0.042) and tuber diameter (0.005). It had negative indirect effect through vine weight per plant (-0.141). Neck length of tubers had positive indirect effect on tuber yield through vine weight (0.023), vine length (0.001) and marketable tuber yield per plant (0.001). But it had negative indirect effect on biological yield per plant (-0.073), number of tubers per plant (-0.005) and harvest index (0.002). Diameter of tubers had positive indirect effect on tuber yield through biological yield per plant (1.159), harvest index (0.053) and tuber diameter (0.005) whereas it had negative indirect effect on vine weight per plant (-0.123).

The path analysis study reveals that biological yield per plant had highest positive direct effect on tuber yield and harvest index followed by number of tubers per plant, vine length, total soluble solids, neck length of tubers and diameter of tubers. This indicates true relationship of these characters with tuber yield. The highest negative indirect effect on tuber yield was observed by vine weight per plant, marketable tuber yield per plant and tuber length. In the present study positive direct effects of number of tubers per plant on tuber yield are in conformity with the finding of Thamburaj and Muthukrishnan (1976), Kamalam et al (1977), Amarchandra and Tiwari (1983), Alam et al (1998), Parida et al (1999) and Nedunzhiyan and Reddy (2000).

Negative direct effect on tuber yield through vine weight per plant is in agreement with the results of Amarchandra and Tiwari (1983), Nanda (1994) and Parida et al (1999) who reported that girth length and neck length of tubers exhibited negative direct effects. While making selection for marketable tubers the traits like yield per plant, biological yield per plant, harvest index, number of tubers, vine length, total soluble solids, neck length and diameter of tubers should be given importance for getting ideal plant types in sweet potato.

CONCLUSION

The data on vine length, vine weight per plant, total tuber yield per plant, harvest index, biological yield per plant, total tuber yield per hectare, marketable tuber yield per plant, marketable tuber yield per hectare, number of tubers per plant, total soluble solids, tuber length, neck length and

diameter of tubers, weevil infested tuber yield per plant, dry weight of tubers and dry weight of vines were recorded and analyzed to workout the correlation and path coefficient analysis for all the characters. On the basis of correlation studies it may be concluded that selection based on biological yield per plant, harvest index, marketable tuber yield per plant and diameter of tubers can be utilized for making improvement in tuber yield of sweet potato. Study on path analysis reveals that direct selection for higher yield of tubers per plant will be helpful to select the genotypes having higher yield potential. However higher biological yield per plant, harvest index, number of tubers per plant, vine length, total soluble solids, neck length of tubers and diameter of tubers may also be considered for selecting genotypes to obtain higher tuber yield.

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Received : 19.1.2012 *Accepted :* 27.2.2012