“GENETIC VARIABILITY, CORRELATIONS AND PATH ANALYSIS IN SWEET POTATO [*Ipomoea batatas* (L.) Lam.]”

M.Sc.(Ag.) THESIS

by

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"GENETIC VARIABILITY, CORRELATIONS AND PATH ANALYSIS IN SWEET POTATO [*Ipomoea batatas* (L.) Lam.]"

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CERTIFICATE – I

This is to certify that the thesis entitled **"GENETIC VARIABILITY, CORRELATIONS AND PATH ANALYSIS IN SWEET POTATO [*Ipomoea batatas* (L.) Lam.]"** submitted in partial fulfilment of the requirements for the degree of "Master of Science in Agriculture" of the Indira Gandhi Agricultural University, Raipur, is a record of the bonafide research work carried out by **GHANSHYAM DAS SAHU** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

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CERTIFICATE - II

This is to certify that the thesis entitled **"GENETIC VARIABILITY, CORRELATIONS AND PATH ANALYSIS IN SWEET POTATO [*Ipomoea batatas* (L.) Lam.]"** submitted by **GHANSHYAM DAS SAHU** to the Indira Gandhi Agricultural University, Raipur in partial fulfilment of the requirements for the degree of **M.Sc. (Ag.)** in the **Department of Horticulture** has been approved by the Student's Advisory Committee after oral examination in collaboration with the external examiner.

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LIST OF ABBREVIATIONS

Abbreviations	Description
%	Per cent
^0C	Degree Celsius
ANOVA	Analysis of variance
CD	Critical difference
cm	Centimetre
df	Degree of freedom
Fig.	Figure
g	Gram
GA	Genetic advance
GCV	Genotypic coefficient of variation
ha	Hectare
HI	Harvest index
mm	Millimeter
NS	Non significant
PCV	Phenotypic coefficient of variation
SEm	Standard error due to mean
SS	Sum of square

CHAPTER-I

INTRODUCTION

Sweet potato [*Ipomoea batatas* (L.) Lam.] is an important starchy food crop of the tropical and sub-tropical countries. Which is being grown over a wide range of environment between 40^{o}N (North) to 32^{o}S (South) and 2200 metres above the Mean Sea Level (Key, 1973).

It is a member of the convolvulaceae and hexaploid with chromosome number 2n=90. It is a cross-pollinated and vegetatively propagated tuber (modified root) crop. The tuber and tender leaves of this crop are very nutritious and used as boiled or baked product, cooked with rice as snack or desert as well as prepared into dried chunks and chips (Alkino and Truong, 1987).

Sweet potato is thought to have originated from America, although the precise location remains unknown. O'Brien (1972) stated that its origin is to be Central America or North-West of South America which is about 3000 B.C. The countries Guatemala, Columbia, Equador and Peru have the greatest diversity in sweet potato germplasm. Whereas, secondary centres of genetic variability are Papua New Guinea, Philippines and part of America (Yen, 1982). European explorers introduced this crop into Africa and India by the early 1500's, China by 1594's, Taiwan by 1657 and Japan by 1698's (Yen, 1974, 1982).

Approximately 80 per cent of the world sweet potato is grown in Asia. Just under 15 per cent in Africa and about 5 per cent in rest of the world. Among the Asian countries, China is the largest producer leaving far behind Indonesia.

It is sixth most important food crop in the world with an annual production of 138.4 million tonnes from 9.2 million hectares with a productivity of 15.0 t/ha (FAO, 1992).

China occupies first position in area globally accounting for 68.3 per cent of the world area, producing 87 per cent of world sweet potato (Anon, 2000). Remaining area is Uganda, Vietnam, India and some other countries. In India it covered an area of 0.14 million hectares producing 1.71 million tonnes tubers with a productivity of 8.3 t/ha (Edison, 2002), which is concentrated mainly in Orissa, Bihar, West Bengal and Uttar Pradesh. Whereas, Chhattisgarh covered an area of 2041.8 hectares producing 10965.6 tonnes with a very low productivity of 5.3 t/ha (Chhattisgarh Horticultural Development Plan, 2001).

The area, production and productivity of sweet potato in the state is very low as compared to national level which is due to unavailability of suitable variety with wider adaptability and stability to the farmers. Although, it is an important tuber crop in India as well as in Chhattisgarh but very little attention has been given so far on its improvement. For any crop improvement programme, genetic variability is very important to know the inheritance pattern of the characters. Studies on the entire spectrum of variability regardless of its commercial value are necessary to obtain the knowledge of inheritance pattern (Jones, 1966). So far sweet potato is concerned, very scanty information is available with regard to spectrum variability for tuber yield and its components with reference to Chhattisgarh situation.

Looking to the above facts, the present investigation was undertaken with the following objectives:

To identify the suitable high-yielding genotypes of sweet potato for Chhattisgarh plains.

To study the genetic variability in sweet potato for higher tuber yield and its components.

To work out heritability and genetic advance for tuber yield and its components.

To estimate the coefficient of correlation for tuber yield and its components

To find out direct and indirect influence of components on tuber yield.

CHAPTER-II

REVIEW OF LITERATURE

Sweet potato is an important starchy food crop of tropical and sub-tropical countries. According to O'Brien (1972), sweet potato has been cultivated probably from 3000 B.C. The genus *Ipomoea* consists of 175 species, among which *Ipomoea batatas* (L.) is the only cultivated species. Sweet potato is found to be a hexaploid with somatic chromosomes 2n = 90; the basic chromosome number for the genus *Ipomoea* is 15 (Jones, 1965). It is the only natural hexaploid morning glory (Austin, 1977 and Jones, 1965). The genetic improvement of this crops largely depends on the magnitude of genetic variability and the extent to which desirable characters are heritable. Sweet potato is such a crop having wide range of variability in tuber skin, flesh colour, tuber shape, time of maturity, resistance to disease, leaf shape and several other morphological characters which can be exploited for the development of desirable genotypes. Knowledge of the total genotypic variance in a plant population is of great importance to the breeder to manipulate the variance for the improvement of the characters. Hence, an attempt has been made to collect back ground information on the amount of genetic variability present in the sweet potato genotype in order to prepare a guideline for selection of parents as a donor which will be further utilized in the breeding programme for the development of desirable varieties for agro-climatic conditions of Chhattisgarh plains.

Genetic Variability and Heritability

Burton (1952) suggested that genetic variability alongwith heritability should be considered for assessing the maximum and accurate effect of selection. Studies on the variability using genetic parameters like genotypic coefficient of variation, heritability and genetic advance is essential for initiating an efficient breeding programme. Johnson *et al*. (1955) suggested that heritability estimate in combination with genetic advance would be more reliable than heritability alone for predicting the effect of selection.

Several workers observed wide range of genetic variability for vine and tuber characters in sweet potato (Steinbauer *et al.*, 1943; Mc. Lean, 1955; Jones *et al.*, 1969; Hayneys and Wholey, 1971; Lowe and Wilson, 1975; Kamalam *et al.*, 1977; Kamalam, 1990; Vimala and Lakshmi, 1990 and Rao *et al.*, 1992).

The phenotypic and genotypic coefficients of variation (PCV and GCV) for length of vine, length of petiole, number of branches, length of internode and length to girth ratio of tubers, showed very little differences indicating less influence of environment on these characters which suggested the presence of sufficient genetic variability and hence ample scope for effective selection (Singh *et al.*, 1988). High genotypic coefficient of variation and phenotypic coefficient of variation coupled with high heritability estimates for vine length, number of branches, number of leaves and tuber yield were observed by Kumar *et al*. (1996) and Alam *et al*. (1998). High heritability and high genetic advance for vine length was recorded by most of the workers (Singh and Mishra, 1975; Kamalam *et al.*, 1977; Rao *et al.*, 1992 and Sankari *et al*., 2000). However, low heritability estimates for vine length was also observed by Vimala and Lakshmi (1990). High estimates of heritability for vine traits than for root traits were reported by Jones *et al.* (1969) and Singh and Mishra (1975). The traits such as number of roots per vine, root yield per vine, starch and total carotenoids content could be considered for improvement through selection as advocated by Sankari *et al.* (2000).

Jong (1974) suggested that the additive genetic variance was more important than the non-additive genetic variance in determining tuberous root weight and top weight in contrast to the number of tuberous roots where the main genetic variance was non-additive type. However, Sakai (1964), Li (1967), Jones (1977) and Jones *et al*. (1969a, 1978) reported low heritability for root yield suggesting the importance of non-additive genetic variance. Thamburaj and Muthukrishnan (1967) observed high genetic advance and high heritability estimates for girth of tubers and number of tubers. High heritability estimates for tuber character like tuber length, tuber weight and tuber girth were also obtained by Vimala and Lakshmi (1990).

Character Association

Tuber yield is one of the complex quantitative characters and greatly influenced by various characters. Relationship among tuber yield and other associated characters could be obtained by simple correlation studies. Hence, correlation coefficients have got immense practical value in revealing the magnitude of relationship between different characters. Estimation of genotypic and phenotypic correlation between various characters may provide information, which is necessary in a breeding programme when selection is based on two or more characters simultaneously. Such study would help us to know the suitability of various characters for indirect selection, because selection for one or more traits results in correlated response in several other traits. (Searle, 1965).

Tuber Yield and Components

Ibrahim (1987) and Pushkaran *et al.* (1976) observed that the root characters as a whole were more strongly correlated to the tuber yield in sweet potato than shoot characters and further, these characters had significant positive association among themselves. Xiang *et al*. (1995) also suggested that high yielding genotypes of sweet potato should have more root, vigorous growth, heavy leaves and short vines. In sweet potato, yield is positively associated with the harvest index (Huett, 1976; Lowe and Wilson, 1974 and Bhagsari and Harman, 1982) and high yielding genotypes generally had high harvest index (Huett, 1976 and Vimala *et al.* 1988). The results of many studies indicated that tuber yield of sweet potato was highly and positively correlated with number of tubers (Pillai and Easwari Amma, 1990; Zhan, 1994; Kumer *et al.*, 1996; Alam *et al*., 1998 and Parida *et al*., 1999), tuber width (Alam *et al.*, 1998; Kurup *et al.*, 1996; Kumer *et al.*, 1996; Naskar *et al.*, 1986 and Thamburaj and Muthukrishnan, 1976a), weight of tuber (Pillai and Easwariamma (1990), Alam *et al.*, 1998; Kumar *et al.*, 1996; Kurup *et al.*, 1996), length of tuber (Naskar *et al.*, 1986 and Thamburaj and Muthukrishnan, 1976a and 1976b), petiole length (Hrishi and Nair, 1973; Kamalam *et al.*, 1977;

Thamburaj and Muthukrishnan, 1976a and 1976b; Naskar *et al.*, 1986 and Pillai and Easwariamma, 1990), number of branches (Thamburaj and Muthukrishan, 1976b; Saladage *et al.*, 1981 and Naskar *et al.*, 1986), root size & dry matter percentage of tuber (Gerpacio, 1994 and Zhan, 1994). Thamburaj and Muthukrishnan (1976a) observed significant and positive correlation between weight of foliage and number of US grade-1 roots and total yield of fleshy roots were positively correlated with stem length, stem diameter and internode length.

However, negative correlation with tuber yield and other component characters like length of vine was reported by Thamburaj and Muthukrishnan (1976b), Kamalam *et al*. (1977), Naskar *et al.* (1986), Ibrahim (1987), Gerpacio (1994), Kumar *et al*. (1996), Alam *et al.* (1998) and Pillai and Easwariamma, (1990). Similar trend for number of branches (Kumer *et al.,* 1996 and Thankamma and Easwari Amma (1990), internode length (Thamburaj and Muthukrishnan, 1976b), weight of vine (Kamalam *et al.*, 1997) and root dry matter content (Gerpacio, 1994) were also observed.

Path coefficient analysis

Yield being a complex polygenic character, direct selection may not be reliable approach on account of being influenced by environmental factors. Linear correlation between yield and various structural or growth components, because of the inter-relationship among the component themselves, can present a ambiguous picture. Therefore, it becomes essential to identify the component characters through which yield improvement could be obtained, Though correlations give information about the components of a complex character like yield, it could not provide the information regarding the relative importance of direct and indirect contribution of the component characters to yield. Path coefficient analysis developed by Wright (1921) is a standardized partial regression analysis which specifies the relative importance and measures the direct influence of one variable upon another, besides partitioning of the correlation coefficients in to direct and indirect effects (Dewey and Lu, 1959).

Methodology of path co-efficient has been developed by Wright (1921, 1935). This method is based on construction of a qualitative diagram, in which variables whether actually measured or not are represented as additively and completely determined by others, and these often inturn by more remote ones until an array of ultimate factor is arrived at, all correlation among which are assumed to be known (Weight, 1954). Dewey and Lu (1959) for the first time applied it in plants to analyze inter correlation in a cause and affect system in crested wheat grass. The work on path coefficient studies in sweet potato *(Ipomoea batatas* L.) were done by various scientists are mentioned here.

Ibrahim (1987) reported that root characters viz. tuber girth, number of tubers and tuber length showed higher path values than shoot characters and finally concluded that in a breeding programme for yield, based on component characters, the shoot characters will be of little importance. The results of many studies indicated that tuber yield of sweet potato is influenced by the maximum positive direct effect on girth of tuber (Thamburaj and Muthukrishnan, 1976; Kumar *et al*, 1996; Alan *et al.*, 1998), number of tuber per vine (Thamburaj and

Muthukrishnan, 1976 tuber (Naskar *et al.,* 1986) length of petiole (Kamalam *et al.,* 1977), weight of tuber (Mohankumar *et al.,* 1990; Kumar *et al.,* 1996), marketable tuber yield (Parida *et al.*, 1999).

Thamburaj and Muthukrishnan (1976) indicated that weight of the foliage contributed maximum direct effect on tuber yield. Kumar *et al.,* 1996, noticed moderately high positive direct effect of number of branches on tuber yield. But number of branches had negative genotypic correlation with yield. So the positive value of direct effect was nullified through the negative direct effect via vine length, tuber width and tuber weight.

Tuber yield in sweet potato is also influenced indirectly through number of tubers (Kamalam *et al.,* 1977), vine yield and average tuber weight per plant (Parida *et al.,* 1999).

Some workers have also reported negative direct effects of vine length (Alam *et al.,* 1998), girth to tubers (Naskar *et al.,* 1986), number of leaves, length of petiole and length of tuber (Thamburaj and Muthukrishnan, 1976) on tuber yield in sweet potato.

Xiang *et al.*(1995) suggested that high yielding genotypes should have more roots, vigorous growth, heavy leaves and short vines. Several other workers suggested that, number of tubers per plant, length of petiole, tuber weight, tuber width and to a lesser extent weight of vine should be the criteria for selection of a high yielding plant type in sweet potato.

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled **"Genetic variability, correlations and path analysis in sweet potato [*Ipomoea batatas* (L.) Lam.]"** was conducted at Horticultural Research Farm, Indira Gandhi Agricultural University, Raipur (C.G.) during *Rabi* season of 2002-03. The material used and the methodology adopted in the investigation are described below:

3.1 Location and climate

Raipur is situated at 21°11'N latitude, 81°36'E longitude and at an altitude of 289.56 metres from Mean Sea Level. The climate of Raipur is hot and sub-humid type. The average of 50 years of data showed that the annual rainfall ranges between 1200-1400 mm mostly received from middle of June to end of September, with occasional light showers during winter and summer season. The average maximum and minimum temperature are 42.8°C and 10.1°C in the month of May and December, respectively.

The weather data recorded during the period of investigation *viz.*, maximum and minimum temperature, rainfall, relative humidity and evaporation rate have been depicted in Fig.3.1.

3.2 Soil of the experimental field

The soil of the experimental field was sandy loam in texture which is locally known as "*Matasi*" and is neutral in reaction with pH 7.5. The physico-chemical analysis of soil sample has been summarised in Table 3.1.

Table 3.1 : Physico-chemical properties of the soil

Particulars	Values	Rating	Method used
A. Physical properties			
1. Mechanical composition			
Sand (%)	54.18	-	International Pipette method (Black, 1965)
Silt (%)	21.34	-	
Clay (%)	24.48	-	
Texture class		Sandy loam (*Inceptisols*)	
B. Chemical composition			
1. Organic carbon (%)	0.50	Medium	Walkley and Black's rapid titration method (Jackson, 1967)
2. Available N (kg/ha)	330.0	Medium	Modified Kjeldahl method (Jackson, 1967)
3. Available P (kg/ha)	20.00	High	Olsen's method (Olsen, 1954)
4. Available K (kg/ha)	400.00	High	Flame photometric method (Jackson, 1967)
5. pH (1:2.5 soil:water)	7.5	Neutral	Glass electrode pH meter (Piper, 1967)
6. EC (dSm^{-1} at 25^oC)	0.19	Normal	Solubridge method (Black, 1965)

3.3 Treatment details and layout plan

Treatment details consisted of 24 genotypes of sweet potato. The details of the treatment is given in Table 3.2.

Table 3.2 : Details of the treatments

S. No.	Genotypes	Notation	Source
1.	Sree Bhadra	V_1	CTCRI, Thiruvananthpuram
2.	IGSP-4	V_2	IGKV, Raipur
3.	Shree Rethna	V_3	CTCRI, Thiruvananthpuram
4.	IGSP-12	V_4	IGKV, Raipur
5.	IGSP-17	V_5	IGKV, Raipur
6.	IB-90-15-9(S)	V_6	IGKV, Raipur
7.	Pol-2101	V_7	RCCTCRI, Bhubaneswar
8.	Bastar Local (IGSP-15)	V_8	IGKV, Raipur
9.	IGSP-31	V_9	IGKV, Raipur
10.	NDSP-16	V_{10}	NDUAT, Faizabad
11.	Kalyani Local	V_{11}	BCKV, Kalyani
12.	IGSP-11	V_{12}	IGKV, Raipur
13.	56-2	V_{13}	CTCRI, Thiruvananthpuram
14.	IB-90-11-1	V_{14}	CIP, New Delhi
15.	IGSP-26	V_{15}	IGKV, Raipur
16.	IGSP-10	V_{16}	IGKV, Raipur
17.	IGSP-13	V_{17}	IGKV, Raipur
18.	Balaghat Local (IGSP-18)	V_{18}	IGKV, Raipur
19.	IGSP-9	V_{19}	IGKV, Raipur
20.	IGSP-8	V_{20}	IGKV, Raipur
21.	Kalmegh	V_{21}	ANGRAU, Hyderabad
22.	H-633	V_{22}	CTCRI, Thiruvananthpuram
23.	Gouri	V_{23}	RCCTCRI, Bhubaneswar
24.	IB-90-10-20	V_{24}	CIP, New Delhi

3.4 Experimental material

The experimental material comprised of 24 genotypes of sweet potato maintained at the Department of Horticulture, IGKV, Raipur were used as planting material. The vine cutting of all 24 genotypes of sweet potato were planted in a randomized block design with three replications. The planting of experimental material was done on 27th September, 2002. Recommended fertilizer and other cultural package of practices were adopted for better crop growth. Five random competitive plants were selected from each plot and following observation were recorded. The average value of each observation were calculated on the basis of five plants for each genotype in every replication.

3.5 The morphological features of experimental material are given in Table 3.3.

Table 3.3 : Details of the treatments (genotypes)

S. No.	Genotypes	Storage root shape	Storage root skin colour (Predominant)	Storage root flesh colour (Predominant)
1.	Sree Bhadra	Round elliptic	Dark pink	White yellow
2.	IGSP-4	Long irregular	Red	Cream
3.	Shree Rethna	Round elliptic	Red	Orange
4.	IGSP-12	Elliptic	Dull white	White cream
5.	IGSP-17	Elliptic	Red	White yellow
6.	IB-90-15-9(S)	Long elliptic	Red	Orange
7.	Pol-21-1	Round elliptic	Dull white	Cream
8.	Bastar Local (IGSP-15)	Long oblong	Yellowish pink	Dull white
9.	IGSP-31	Obovate	Light red	Light yellow
10.	NDSP-16	Long Elliptic	Dark red	White
11.	Kalyani Local	Elliptic	Dark red	Light orange
12.	IGSP-11	Long elliptic	Dull white	Cream
13.	56-2	Round elliptic	Dull white	Cream
14.	IB-90-11-1	Long elliptic	Red	White
15.	IGSP-26	Long elliptic	Dull white	White
16.	IGSP-10	Round elliptic	Dull white with purple tinge	Light yellow
17.	IGSP-13	Long elliptic	Yellowish red	Light orange
18.	Balaghat Local (IGSP-18)	Long irregular	Dark red	White
19.	IGSP-9	Long elliptic	Dark red	White
20.	IGSP-8	Elliptic	Light brown	Orange
21.	Kalmegh	Long elliptic	White purple	Cream
22.	H-633	Elliptic	Dark red	White
23.	Gouri	Round elliptic	Dark red	Dark orange
24.	IB-90-10-20	Round elliptic	Red	Yellow

3.6 Observations recorded

3.6.1 Vine length (cm)

Length of vine (cm) of five randomly selected plants from each replication was measured at maturity, using scale from ground level to tip of the largest vine and their mean value was taken to denote mean vine length of each entry in centimetres.

3.6.2 Vine weight per plant (g)

After harvesting of the crop (at maturity 130 DAP), the vegetative portion above the tuber neck and plant joint was weighed for each of the plant and their mean value was taken to get the mean vine weight per plant (g) of each genotype

3.6.3 Number of tubers per plant

Randomly selected plants were harvested at maturity and their tubers were counted for each plant separately and their mean value was calculated to denote number of tuber per plant of each entry.

3.6.4 Number of marketable tuber per plant

Number of marketable tuber (excluding weevil infested and very small tubers) were counted from five plants of each genotype and mean value was calculated.

3.6.5 Neck length of tuber (cm)

The neck length of five randomly selected plants (three tubers from each plant) in each plot were measured in centimeter in between vine stem and tuber head.

3.6.6 Tuber length (cm)

Three mature tubers from each selected plant were taken and their length was measured in centimeter and mean value was calculated to denote mean value of tuber length (cm) of each genotype.

3.6.7 Tuber diameter (cm)

Three mature tubers from each selected plant from each plot were taken and their diameter (upper, middle and lower) was measured by using vernier callipers and mean value is used to denote tuber diameter (cm) of each genotype.

3.6.8 Biological yield per plant (g)

The weight of the whole plant including the vine, leaves and tubers was recorded at the time of harvest and men value was calculated from each genotype.

3.6.9 Tuber yield per plant (g)

All tubers of each randomly selected plants were weighed by ordinary balance individually and their mean value was calculated to get the weight of tubers per plant of each genotype.

3.6.10 Marketable tuber yield per plant (g)

Only good quality tuber (excluding weevil infested and very small tuber) from each plant were selected and weighed.

3.6.11 Tuber yield (t/ha)

The tuber yield of all genotypes in each replication was recorded on net plot basis and the mean value was calculated as tuber yield tonnes per hectare.

3.6.12 Marketable tuber yield (t/ha)

The marketable tuber yield (excluding weevil infested and very small tuber) of all genotype in each replication was recorded on net plot basis and the mean value was calculated as marketable tuber yield tonnes per hectare.

3.6.13 Harvest index (%)

Ratio between net tuber weight and gross weight of plant was calculated and recorded in terms of percentage by the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Net tuber weight}}{\text{Gross weight of plant}} \times 100$$

3.6.14 Total Soluble Solids (TSS, %)

It was estimated by Erma hand refractometer. Fresh tuber extract from each randomly selected plant of each genotype was estimated and expressed in percentage.

3.6.15 Dry matter per cent of foliage

Three green foliage samples each of 100 g were taken from the noted foliage of five randomly selected plants. Then it was sundried for seven days and thereafter kept in the electric oven at $60^{o}C$ for 8 hours. Finally, dry weight of foliage was measured and calculated in per cent.

3.6.16 Dry matter per cent of tuber

Three fresh tuber samples (chips form) each of 100 g were taken from the noted tuber of five randomly selected plants. Then it was sundried for seven days and kept in the electric oven at 60^{o}C for 8 hours for drying. Finally, dry weight of tuber was noted and calculated in per cent.

3.7 Statistical and genetical analysis

3.7.1 Analysis of variance

The analysis of variance was carried out for each character separately as per method of Panse and Sukhatme (1967). Significance of differences among genotypes was tested using the following skeleton.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F value	
				Calculated	Table at 5%
Replication	(r-1)	RSS			
Treatment	(t-1)	TrSS	M_1	M_1/M_2	
Error	(r-1)(t-1)	ErSS	M_2		

Where,

r	=	Number of replications
t	=	Number of treatments
RSS	=	Sum of squares due to replication
TrSS	=	Sum of squares due to treatment (genotypes)
ErSS	=	Sum of squares due to error
M_1	=	Mean sum of squares due to treatment
M_2	=	Mean sum of squares due to error

3.7.2 Genetic parameter of variation

3.7.2.1 Range

The range of distribution was expressed by the limit of the smallest and the largest value of each observation.

3.7.2.2 Mean

This mean was found by summing up all the observations and dividing the sum by the number of observations.

3.7.2.3 Heritability

Heritability in broad sense (h^2b) defined as the proportion of the genotypic variance to the total variance (phenotypic variance), was estimated by using the following formula given by Hansan *et al.* (1956).

$$h^2b = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

3.7.2.4 Genetic advance

Expected genetic advance (GA) was calculated as per the method suggested by Johnson *et al.* (1955)

$$GA = K.\ \sigma p\ h^2$$

where,

K	=	Constant (standard selection differential) having value of 2.06 at 5% selection intensity
σp	=	Phenotypic standard deviation
h^2	=	Heritability estimates

3.7.2.5 Genetic advance as percentage of mean

Genetic advance as percentage of mean was calculated by the following formula:

$$\text{Genetic advance as \% of mean} = \frac{\text{G.A.}}{\text{X}} \times 100$$

Where,

GA = Genetic advance

X = Mean of the character

3.7.2.6 Genotypic and phenotypic coefficient of variation

The genotypic and phenotypic coefficient of variation were calculated using formula as suggested by Burton (1952).

$$\text{GCV(\%)} = \frac{\sqrt{\text{Genotypic variance}}}{\text{X}} \times 100$$

$$\text{PCV(\%)} = \frac{\sqrt{\text{Phenotypic variance}}}{\text{X}} \times 100$$

Where,

GCV = Genotypic coefficient of variation

PCV = Phenotypic coefficient of variation

X = Mean of the character

3.7.3 Character association (Correlation coefficient)

Correlation coefficient (r) between the variable was estimated by using the formula proposed by Millar *et al.* (1958).

$$r_{(xy)} = \frac{\text{Cov. (xy)}}{\text{Var(x) . Var(y)}}$$

where,

$r_{(xy)}$ = Correlation coefficient between character x and y

Var(x) = Variance of x character

Var(y) = Variance of y character

The significance of correlation coefficient (r) was tested by comparing 't' value at (n-2) degree of freedom (Snedecor and Cochran, 1956).

$$t = \sqrt{r\,(n-2 / 1-r^2)}$$

If calculated 't' is greater than tabulated 't' at (n-2) degree of freedom at given probability level, the coefficient of correlation is taken as significant.

3.7.4 Path coefficient analysis

The genotypic correlation coefficients were further partitioned into direct and indirect effects with the help of path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959). Path coefficient was calculated separately for all important character considering tuber yield and total soluble solids (TSS) as dependable variable.

Path coefficient was estimated using, simultaneous equations, the equations showed a basic relationship between correlation coefficient and path coefficient. These equations were solved by presenting them in matrix notations.

$$A = B.C$$

The solution for the vector 'C' may be obtained by multiplying both sides by inverse of 'B' matrix i.e. $B^{-1} A = C$

After calculation of values of path coefficient i.e. ‘C’ vector, it is possible to obtain path values for residual (R). Residual effect was calculated using formula referred from Singh and Chaudhary (1985).

$$R = \sqrt{1 - \Sigma di \times r_{ij}}$$

where,

Di = direct effect of i^{th} character

rij = correlation coefficient of i^{th} character with j^{th} character

Direct and indirect effects of different characters on tuber yield was calculated at genotypic level.

CHAPTER-IV

RESULTS

The experimental findings with respect to all important biometrical parameters on 16 characters of 24 genotypes of sweet potato [*Ipomoea batatas* (L.) Lam.] have been described under the following heads:

4.1 Range and mean performance tuber yield and its components

4.2 Analysis of variance

4.3 Genetic variability

4.3.1 Genotypic and phenotypic coefficient of variation

4.3.2 Heritability

4.3.3 Genetic advance

4.4 Character association

4.5 Path coefficient analysis with tuber yield

4.1 Range and mean performance of tuber yield and its components

Range and mean performance of genetic parameters of variation for tuber yield and its components have been presented in Table 4.1.

4.1.1 Vine length (cm)

Vine length varied from 88.60 cm (IGSP-4) to 330.66 cm [Bastar Local (IGSP-15)] with mean value of 160.40 cm.

4.1.2 Vine weight per plant (g)

Vine weight per plant ranged from 111.3 g (Gouri) to 415.0 g [Bastar Local (IGSP-15)] with the mean value of 258.45 g.

4.1.3 Number of tuber per plant

Number of tuber per plant varied from 3.00 [Bastar Local (IGSP-15)] to 5.23 (IGSP-4) and the mean value was 3.99 tuber per plant.

4.1.4 Number of marketable tuber per plant

Number of marketable tuber per plant ranged from 2.40 (Kalmegh) to 4.53 (IGSP-12) and the mean value was 3.31 tuber per plant.

4.1.5 Neck length of tuber (cm)

Neck length ranged from 7.33 cm (IGSP-13) to 46.66 cm (H-633), whereas, the mean value was 30.44 cm.

4.1.6 Tuber length (cm)

Tuber length ranged from 13.55 cm (NDSP-16) to 24.66 cm (IGSP-17) with the mean value of 18.24 cm.

4.1.7 Tuber diameter (cm)

Tuber diameter ranged from 8.39 cm [Balaghat Local (IGSP-18)] to 15.15 cm (Sree Bhadra) with the mean value of 11.49 cm.

4.1.8 Biological yield per plant (g)

The lowest biological yield per plant 539.66 g was recorded in genotype Gouri and the highest 1146.66 g in genotype Sree Bhadra with the mean value of 796.73 g.

4.1.9 Tuber yield per plant (g)

The tuber yield per plant was ranged from 392.33 g (H-633) to 825.33 g (Sree Bhadra) whereas the mean value was 543.90 g.

4.1.10 Marketable tuber yield per plant (g)

The lowest marketable tuber yield per plant 281.33 g was recorded in genotype IB-90-11-1 and the highest 731.90 g in genotype Shree Rethna, with the mean value of 456.37g.

4.1.11 Tuber yield (t/ha)

Tuber yield (t/ha) ranged from 22.34 [Balaghat Local (IGSP-18)] to 47.17 (Sree Bhadra). While, mean value was 31.08 tonnes per hectare.

4.1.12 Marketable tuber yield (t/ha)

Marketable tuber yield ranged from 16.05 tonnes per hectare (IB-90-11-1) to 41.80 tonnes per hectare (Shree Rethna). The mean value was 26.07 tonnes per hectare.

4.1.13 Harvest index (%)

Minimum harvest index 54.33 per cent was recorded in IB-90-11-1 and maximum 80.06 per cent in IGSP-31 with the mean value of 67.97 per cent.

4.1.14 Total Soluble Solids (TSS, %)

Total Soluble Solids ranged from 10.40 per cent in genotype Balaghat Local (IGSP-18) to 17.10 per cent in genotype IB-90-15-9(S) with the mean value of 12.68 per cent.

4.1.15 Dry matter per cent of foliage

Dry matter per cent of foliage ranged from 16.00 per cent (56-2 and H-633) to 30.00 per cent (IGSP-26) with the mean value of 21.6.

4.1.16 Dry matter per cent of tuber

Dry matter per cent of tuber ranged from 20.00 per cent (Gouri) to 36.00 per cent (IGSP-9 and H-633) with the mean value of 29.2.

4.2 Analysis of variance

Analysis of variance of all the characters under study are presented in Table 4.2 which showed that variances due to genotypes were highly significant.

4.3 Genetic variability

4.3.1 Genotypic and phenotypic coefficient of variation

To get clearer picture of variability among genotypes, the coefficient of variation was estimated at genotypic and phenotypic levels for each character (Table 4.1 and Fig. 4.1 & 4.2). In the present study, phenotypic coefficient of variation in general were higher in magnitude than the genotypic ones for genotypes.

The genotypic coefficient of variation was found highest for vine length (38.95%) followed by neck length of tuber (38.04%), vine weight per plant (30.72%), marketable tuber yield per plant (22.47%), marketable tuber yield tonnes per hectares (22.39%) and total tuber yield tonnes per hectares (21.02%).

4.3.2 Heritability in broad sense

Heritability in broad sense is given in Table 4.1 and Fig. 4.3. Heritability estimates in general, were high for most of the characters except number of marketable tubers per plant (8.6%). Characters possessing high estimates of heritability were dry matter per cent of foliage (89.5%), neck length of tuber (89.3%), dry matter per cent of tuber (88.7%), vine length (86.0%), vine weight per plant (82.8%), total soluble solid (81.8%), harvest index (81.5%), tuber length (79.1%), biological yield per plant (72.5%) and tuber yield per plant (71.2%).

4.3.3 Genetic advance

Genetic advance as percentage of mean (Table 4.1) was high for vine length (74.37%), neck length of tuber (73.91%), vine weight per plant (57.57%), tuber yield per plant (36.51%), tuber yield tonnes per hectare (36.35%), biological yield per plant (32.84%), marketable tuber yield per plant (32.62%), tuber length (32.34%), marketable tuber yield tonnes per hectare (32.22%), tuber diameter (24.36%) whereas, low for dry matter per cent of foliage (0.05) and dry matter per cent of tuber (0.03%).

4.4 Correlation coefficient analysis

Correlation coefficient analysis is a statistical measure which is used to find out the degree and direction of relationship between two or more variables. Association among different yield attributing characters with tuber yield was calculated in all possible phenotypic (P), which is presented in Table 4.3.

Characterwise results of the correlation study is explained only at phenotypic level:

Tuber yield had shown significant and positive correlation with marketable tuber yield tonnes per hectare (0.82), tuber yield per plant (0.99), marketable tuber yield per plant (0.82), biological tuber yield per plant (0.87), tuber diameter (0.73) and harvest index (0.49), at phenotypic level only.

Vine weight per plant had positive and significant correlation with vine length (0.47).

Number of marketable tuber per plant had positive and significant association with number of tuber per plant (0.64).

Biological yield per plant had significant and positive association with vine weight per plant (0.62), tuber diameter (0.50) as well as with tuber length (0.41), respectively.

Tuber yield per plant had significant and positive association with biological tuber yield per plant (0.87) and tuber diameter (0.73).

Marketable tuber yield per plant had positive and significant association with tuber yield per plant (0.82), biological tuber yield per plant (0.77), tuber diameter (0.55) and number of marketable tuber per plant (0.52).

Marketable tuber yield tonnes per hectare had positive and significant association with biological tuber yield per plant (0.77), tuber diameter (0.55) and number of marketable tuber per plant (0.53).

Harvest index had significant and positive association with tuber diameter (0.59), tuber yield tonnes per hectare (0.43) and tuber yield per plant

(0.43) whereas, it was significant and negatively associated with vine weight per plant (-0.78) only.

Dry matter per cent of foliage had significant and positive association with vine length (0.41).

4.5 Path coefficient analysis

The genotypic character correlation coefficients observed between tuber yield and its components were partitioned into direct and indirect effect (Table 4.4), taking tuber yield tonnes per hectares as a dependant variable.

The data revealed that tuber yield per plant (0.99) had the highest direct positive effect towards number of marketable tuber per plant (0.008) whereas, negative direct effects were estimated for marketable tuber yield tonnes per hectare (-0.48).

Vine length had positive indirect effect via marketable tuber yield per plant (0.04) and vine weight (0.002) and negative indirect effect through tuber yield per plant (-0.06) and marketable tuber yield tonnes per hectare (0.04).

Vine weight per plant had positive indirect effect via tuber yield per plant (0.19), marketable tuber yield per plant (0.14) and number of marketable tuber per plant (0.006), while, negative indirect effect through marketable tuber yield tonnes per hectare (-0.14) and number of tuber per plant (-0.003) was observed.

Number of tuber per plant had positive indirect effect via tuber yield per plant (0.24), marketable tuber yield per plant (0.03) and number of marketable tuber per plant (0.01) whereas, negative indirect effect through marketable tuber yield tonnes per hectare (-0.33) was estimated.

It was estimated that number of marketable tuber per plant exhibited positive indirect effect via vine weight per plant (0.002). Whereas, negative indirect effect through marketable tuber yield tonnes per hectare (-0.15), number of tuber per plant (-0.017) and biological yield per plant (-0.008) was observed.

Neck length of tuber exhibited positive indirect effect via marketable tuber yield per plant (0.11), tuber yield per plant (0.045) and number of marketable tuber per plant (0.004), while marketable tuber yield tonnes per hectare (-0.114) showed negative indirect effect.

Tuber length had positive indirect effect via tuber yield per plant (0.34) and marketable tuber yield per plant (0.20), while negative indirect effect through marketable tuber yield tonnes per hectare (-0.20) and biological yield per plant (-0.004) was exhibited.

Tuber diameter had positive indirect effect via tuber yield per plant (0.83), marketable tuber yield per plant (0.36) and vine length (0.001) whereas, negative indirect effect through marketable tuber yield tonnes per hectare (-0.38) and biological yield (-0.005) was observed.

Biological yield per plant had positive indirect effect via tuber yield per plant (0.91), marketable tuber yield per plant (0.44) while, negative indirect effect through marketable tuber yield tonnes per hectare (-0.46).

Tuber yield per plant had positive indirect effect via marketable tuber yield per plant (0.46) and number of marketable tuber per plant (0.005) whereas, a negative indirect effect through marketable tuber yield tonnes per hectare (-0.49), biological yield (-0.009) and tuber diameter (-0.004) was observed.

Marketable tuber yield per plant had positive indirect effect via tuber yield per plant (0.99) and number of marketable tuber per plant (0.003) while, negative indirect effect through marketable tuber yield tonnes per hectare (-0.48) and biological yield per plant (-0.009) was exhibited.

Marketable tuber yield tonnes per hectares had positive indirect effect via tuber yield per plant (0.99) and marketable tuber yield per plant (0.46) but negative indirect effect through biological yield per plant (-0.009) and tuber diameter (-0.004) was observed.

Harvest index had positive indirect effect via tuber yield per plant (0.39) and marketable tuber yield per plant (0.13) and negative indirect effect through marketable tuber yield tonnes per hectare (-0.14) and tuber diameter (-0.004) was estimated.

Total soluble solids exhibited positive indirect effect through tuber yield per plant (0.15) and marketable tuber yield per plant (0.09) but negative indirect effect through marketable tuber yield tonnes per hectare (-0.09) and biological yield (-0.005) was observed.

Dry matter per cent of foliage had positive indirect effect via tuber yield per plant (0.09) and marketable tuber yield per plant (0.03) while, a negative indirect effect through marketable tuber yield tonnes per hectare (-0.03), number of marketable tuber per plant (-0.002) and was exibited.

The positive indirect contribution of dry matter per cent of tuber was estimated via marketable tuber yield per plant (0.02) and number of tuber per plant (0.003) whereas, a negative indirect effect through tuber yield per plant (-0.10) and tuber yield tonnes per hectare (-0.10) was observed.

CHAPTER-V

DISCUSSION

The present study was conducted to find out some important genetic information based on 24 genotypes, which could enlighten the breeding strategy to be adopted in the genetic improvement of sweet potato [*Ipomoea batatas* (L.) Lam.] for Chhattisgarh plains.

A sound genetic information has been an indispensable prelude for modifying the arrangement of gene frequencies to enable stable genetic improvement in a genotype. Genetic variability and heritability which measure the relationship between genotypic and phenotypic appearance for the success of a breeding programme is essential and pre-requisite for an effective improvement in crop species. It is well-known that the selection is based on phenotypic observation and the success would naturally depend upon the relationship between phenotype and the genotype. Hence, the estimates of heritability and genetic advance are also useful in prediction of genetic improvement following selection and deciding suitable breeding procedures for sweet potato improvement. Similarly, the knowledge of association between tuber yield and its components are useful in determining suitable selection scheme to get maximum genetic gain. This information can also be effectively used for locating the most important tuber yield components by path coefficient analysis.

The purpose of the present investigation was to extract the basic information which can throw light on the strategies to be adopted for sweet potato improvement with reference to Chhattisgarh plains.

Hence, the discussion pertaining to different aspects of the present study has been discussed under the following heads:

5.1 Genetic variability and heritability

The phenotypic coefficient of variation (PCV) in sweet potato was higher as compared to genotypic coefficient of variation (GCV) as presented in Table 4.1 for all the characters. This indicates that, the apparent variation is not only genotypic but also due to environment. However, the phenotypic coefficient of variation (PCV) and genotypic coefficient of variance (GCV) showed very little difference for vine length, vine weight per plant, neck length of tuber, tuber length, harvest index and total soluble solids indicating less influence of environment on these characters (Table 4.1). This suggests the presence of sufficient genetic variability and hence, ample scope for effective selection of these characters. The characters like number of marketable tuber per plant and marketable tuber yield per plant showed larger difference between phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) indicating the large influence of environment on these characters (Table 4.1). Similar findings have been reported by Singh *et al.* (1988).

High genotypic coefficient of variation and phenotypic coefficient of variation with high heritability and high genetic advance were observed for vine length, vine weight per plant and tuber yield which is in accordance with findings of Kumar *et al.* (1996), Alam *et al.* (1998), Singh and Mishra (1975), Kamalam *et al.* (1977), Rao *et al.* (1992) and Sankari *et al.* (2000). However, Sakai (1964), Li (1967) and Jones *et al.* (1978) reported low heritability for root yield (Table 4.1) suggesting the importance of non-additive genetic variance. High estimates of heritability for vine traits than for root traits were reported by Jones *et al.* (1969) and Singh & Mishra (1975). On the other hand, Vimala and Lakshmi (1990) reported low heritability estimates for vine length. In contradiction to the present experimental results, Kumar *et al.* (1996) and Alam *et al.* (1998) reported high genotypic coefficient of variation coupled with high heritability estimate for number of branches per plant. Similarly, Thamburaj & Muthukrishnan (1976) and Vimala & Lakshmi (1990) observed high genetic advance with high heritability for tuber diameter, number of tuber and tuber length. Difference in experimental materials and environment would like to generate different expression of characters. Moderate values of heritability, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and genetic advance as percentage of population mean (Table 4.2) have been reported for internode length and vine length.

The pre-requisite of any vegetable improvement underlines the emphasis and need about the nature and extent of inherent capacity of any genotype for characters under improvement. As it is obvious that the variability in a biological population is the result of genetic constitution of the genotype on the prevailing environment. The vegetable breeder can attain maximum selection response if existence of variance is greater due to additive genes and estimated in terms of heritability.

In the present investigation, an attempt has been made to estimate the heritability in broad sense by variance component analysis. The prediction regarding this aspect was made on the basis of percentage viz., low (<50%), moderate (50-70%) and high (>70%) as suggested by Robinson (1966).

Heritability estimates are influenced by method of estimation, generation under study, sample size and the environmental factors which is useful in the study of inheritance of quantitative traits. Whereas, the magnitude of genetic advance is influenced by unit of measurement. In order to avoid this and to facilitate the comparision of progress in various characters of different genotypes in sweet potato, genetic advance was calculated as percentage of mean.

The summary of heritability and genetic advance as a percentage of mean in sweet potato obtained from the present study are presented in Table 5.1.

5.2 Character association studies (Correlation coefficient analysis)

Association analysis of different morphological characters with tuber yield and its components were investigated through this study. The correlation studies enable the vegetable breeder to simplify a complex trait like tuber yield into its component parts.

The tuber yield is a complex and highly variable character which is a result of cumulative effect of its component characters. Therefore, direct selection for tuber yield *per se* may not be very effective. Hence, correlation among component association will be very useful for effective selection.

Table 5.1 : Summary of heritability, genetic advance as per cent of mean and genetic advance (GA) for tuber yield and its components in sweet potato.

S. No.	Characters	H^2(b)	GA as % of mean	GA
1.	Vine length (cm)	H	H	H
2.	Vine weight per plant (g)	H	M	H
3.	Number of tuber /plant	H	L	L
4.	No. of marketable tuber/ plant	L	L	L
5.	Neck length of tuber (cm)	H	H	L
6.	Tuber length (cm)	H	L	L
7.	Tuber diameter (cm)	M	L	L
8.	Biological yield per plant (g)	H	L	H
9.	Tuber yield per plant (g)	H	L	H
10.	Marketable tuber yield / plant (g)	L	L	H
11.	Tuber yield (t/ha)	H	L	L
12.	Marketable tuber yield (t/ha)	L	L	L
13.	Harvest index (%)	H	L	L
14.	Total soluble solid (%)	H	L	L
15.	Dry matter per cent of foliage (%)	H	L	L
16.	Dry matter per cent of tuber (%)	H	L	L

Where; H = High; M = Medium; L = Low

The yield components may not always be independent in their action and they may be interlinked. The selection practiced for one character may simultaneously bring change in the other related trait. Thus, to bring change in any character especially in tuber yield in desired direction, proper understanding of association among the yield and its contributing characters are essential which determines the component characters on which selection can be made for improvement.

If association is positive, it considerably will accelerate the rate of genetic progress, while correlation in negative direction, will reduce the genetic progress but such correlations are desirable for selecting early and high yielding genotypes. Here, only significant correlation is being discussed:

Tuber yield had positive and significant correlation with biological yield per plant, tuber diameter, vine weight per plant, number of tuber per plant, neck length of tuber, tuber length, harvest index, total soluble solids and dry matter per cent of foliage at phenotypic levels. Similar finding was reported by Ibrahim (1987) and Pushkaran *et al.* (1976) in sweet potato. Present findings are supported by Thamburaj & Muthukrishnan (1976a & 1976b), Kamalam *et al.* (1977), Thankammapillai & Easwari Amma (1990), Zhan Liya (1994), Kumar *et al.* (1996), Alam *et al.* (1998) and Parida *et al.* (1999) whose studies indicated that tuber yield in sweet potato was highly and positively correlated with number of tuber per plant.

Vine weight per plant had positive and significant correlation with vine length. Similar finding was reported by Thamburaj and Muthukrishnan (1976), Kamalam *et al.* (1977) and Naskar *et al.* (1986).

Biological yield per plant had significant and positive association with vine weight per plant, tuber diameter and tuber length.

Harvest index had significant and positive association with tuber diameter. Whereas, it was significant and negatively associated with vine weight per plant which is in accordance with the findings of Hueh (1976) Bhagsari and Harman (1982).

Dry matter per cent of foliage had significant and positive association with vine length. Which is supported with the results of Gerfacio (1994) and Zhan Liya *et al.* (1994).

Significant and positive correlation of petiole length, vine yield per plant internode length, vine length, biological yield per plant and harvest index were in support with the results obtained by Hrishi and Nair (1973), Kamalam *et al.* (1977), Thamburaj and Muthukrishnan (1976a and 1976b), Naskar *et al.* (1986), Thankamma Pillai and Easwari Amma (1990), Gerpacio (1994), Zhan Liya (1994) and Saladaga (1981); Whereas, vine length is negatively correlated with tuber yield. Similar findings was reported by Kumar *et al.* (1996) and Thankamma & Easwari Amma (1990).

In contrast to the present investigation positive correlation was observed between vine weight per plant and tuber yield per plant and length of vine, while internode length and vine yield was negatively associated with tuber yield which is in accordance with the findings of Thamburaj and Muthukrishnan (1976b), Saladaga *et al.* (1981), Naskar *et al.* (1986), Kamalam *et al.* (1977), Ibrahim (1987), Gerpacio (1994), Kumar *et al.* (1996), Alam *et al.* (1998) and Thankamma Pillai & Easwari Amma (1990). Genotypic variability and different agroclimatic environments might be responsible for complexity of the situation as well as expression of check.

The correlation studies among different characters revealed that selection for tuber yield per plant should be based on biological yield per plant, tuber diameter and harvest index. Hence, these characters should given weightage while making indirect selection for the improvement of dependent variable i.e. tuber yield.

5.3 Path coefficient analysis

The path coefficient analysis are standardized for partial regression coefficients. They are free from unit and as such it is easy to make interpretation. It is of immense value for the vegetable breeders in two ways viz., one is to judge the direct influence of the various characters on the tuber yield on dependent trait and secondly, it also helps in explaining the total correlation between dependent and independent traits. To measure the direct and indirect effect Lenka and Mishra (1973) used the following scale and the same scale is being used in the present investigation as given below:

Value of direct and indirect effect	Rate/Scale
0.00 to 0.09	Negligible
0.10 to 0.19	Low
0.20 to 0.29	Moderate
0.30 to 0.99	High
More than 1.00	Very high

The path analysis would help to identify those important components of tuber yield by establishing the cause and effect relationship among yield and its contributing characters.

The result in Table 4.3 which revealed that vine length had positive indirect effect via vine weight per plant, number of tuber per plant, tuber diameter and negative indirect effect through biological yield per plant and tuber length.

Vine weight per plant had positive indirect effect via tuber diameter and number of marketable tuber per plant.

Neck length of tuber exhibited positive indirect effect via tuber diameter and number of tuber per plant.

Tuber diameter had positive indirect effect via vine length and dry matter per cent of tuber and negative indirect effect through biological yield per plant and vine weight per plant.

Biological yield per plant had positive indirect effect via vine weight per plant and negative indirect effect through tuber diameter, tuber length and number of tuber per plant.

Harvest index had positive indirect effect via biological yield per plant, vine length and dry matter per cent of tuber.

The positive direct effect of number of tuber per plant on tuber yield was in agreement with the findings of Thamburaj and Muthukrishan (1976), Kamalam *et al.* (1977), Alam *et al.* (1998) and Parida *et al.* (1999).

Similarly, Thamburaj and Muthukrishnan (1976) also noted the direct effect of vine yield on tuber yield, whereas, positive direct effect of length of petiole on tuber yield was in accordance with the finding of Kamalam *et al.* (1977). While, tuber yield indirectly affected by vine yield. Similar results was obtained by Parida *et al.* (1999). On the other hand, Thamburaj and Muthukrishnan (1976) also reported negative direct effect of petiole length on tuber yield in sweet potato.

Path coefficient analysis of various tuber yield contributing attributes revealed that vine weight per plant, number of marketable tuber per plant and tuber yield per plant had maximum direct effect on productivity. Hence, these components should be considered while making selection strategies to develop suitable varieties for Chhattisgarh plains.

CHAPTER-VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

The present investigation entitled **"Genetic variability, correlations and path analysis in sweet potato [*Ipomoea batatas* (L.) Lam.]"** was carried out at Horticultural Research Farm, College of Agriculture, Indira Gandhi Agricultural University, Raipur (Chhattisgarh) during *Rabi* 2002-03. Twenty four genotypes were grown separately in randomized block design, with three replications to estimate the genetic variability, heritability, genetic advance, correlations and path analysis. Observations on 16 important characters *viz.*, vine length (cm), vine weight per plant (g), number of tubers per plant, number of marketable tubers per plant, neck length of tuber (cm), tuber length (cm), tuber diameter (cm), biological yield per plant (g), tuber yield per plant (g), marketable tuber yield per plant (g), tuber yield (t/ha), marketable tuber yield (t/ha), harvest index (%), total soluble solids (%), dry matter per cent of foliage and dry matter per cent of tuber were recorded on five competitive randomly selected plants from each replication.

1. Analysis of variability and heritability

Analysis of variance revealed significant differences for all the characters (except number of marketable tubers per plant) under study. Relative magnitude of phenotypic coefficient of variation was higher than the genotypic coefficient of variation in general but genotypic coefficient of variation was higher for vine length, neck length of tuber, vine weight per plant and marketable tuber yield per plant in particular, while low for number of marketable tuber per plant, total soluble solids and harvest index.

Heritability estimate was high for almost all the characters except number of marketable tubers per plant and tuber diameter.

High heritability coupled with high genetic advance were recorded for vine length, vine weight per plant, tuber yield per plant and biological yield per plant. Hence, selection for these traits will be rewarding towards higher tuber yield.

2. Study on correlation coefficients

Correlation coefficient analysis revealed that tuber yield tonnes per hectare showed significant positive correlation with biological yield per plant, tuber diameter and harvest index. While, vine weight per plant had positive and significant correlation with vine length. Similarly, biological yield per plant was positively and significantly associated with vine weight per plant, tuber diameter as well as with tuber length indicating that selection criteria should be based on these component traits for the improvement of sweet potato tuber yield for Chhattisgarh plains.

3. Path coefficient analysis

Path coefficient analysis revealed that vine weight per plant, number of marketable tuber per plant and tuber yield per plant had positive direct effect on tuber yield tonnes per hectare whereas, negative direct effects were estimated for vine length, number of tuber per plant, neck length of tuber, tuber length, tuber diameter, biological yield per plant, harvest index and dry matter per cent of tuber. Hence, selection should be based on these component traits for the improvement of higher tuber yield in sweet potato for Chhattisgarh plains.

Conclusion

It could be concluded from the present findings that considerable variability exists among the genotypes for most of the traits showing possibilities of genetic improvement.

Genetic coefficient of variation were moderate to high for tuber diameter, tuber length, biological yield per plant, vine weight per plant, neck length of tuber and vine length indicating prevalence of genetic variability for these traits, which can successfully be utilized through selection for the improvement of tuber yield.

Occurrence of high heritability coupled with high genetic advance for vine length, vine weight per plant, tuber yield per plant and biological yield per plant indicated preponderance of additive genetic variance in the genetic control of these traits. Direct selection would be more effective for these characters towards the improvement of tuber yield in sweet potato.

The correlation studies among different characters revealed that selection for tuber yield per plant should be based on biological yield per plant, tuber diameter and harvest index. Hence these characters should be given weightage while making indirect selection for the improvement of dependent variable e.g. tuber yield.

Path coefficient analysis of various tuber yield contributing attributes revealed that vine weight per plant, number of marketable tuber per plant and tuber yield per plant had maximum direct effect on productivity. Hence, these components should be considered while making selection strategies for the development of suitable varieties for Chhattisgarh plains.

Genotypes identified for desirable traits were Sree Bhadra (for tuber yield, tuber diameter and biological yield), Shree Rethna (for marketable tuber yield), Bastar Local (IGSP-15) (for vine length and vine weight). IGSP-4 (for number of tuber), H-633 (for neck length), IGSP-17 (for tuber length) IGSP-31 (for harvest index) and IB-90-15-9 (S) (for total soluble solids) in sweet potato for Chhattisgarh plains (Table 6.1).

Table 6.1 : Desirable genotypes for tuber yield and its components.

S. No.	Genotype	Desirable characters
1	Sree Bhadra	Tuber yield, tuber diameter and biological yield
2	Shree Rethna	Marketable tuber yield
3	Bastar Local (IGSP-15)	Vine length and vine weight
4	IGSP-4	Number of tuber
5	H-633	Neck length
6	IGSP-17	Tuber length
7	IGSP-31	Harvest index
8	IB-90-15-9 (S)	Total soluble solids

Suggestions for future work

Further studies may be taken up with a view for the development of suitable varieties for Chhattisgarh Plains. Some of the important lines of approaches are outlined below:

1. To carry out regional trial to isolate improved genotypes suitable for different agro-climatic conditions of Chhattisgarh.
2. To develop early maturing high-yielding genotypes coupled with good nutritional status.
3. To screen out genotypes having high starch, alongwith low sugar and crude fibre content for industrial point of view.
4. To identify desirable types from seedling segregates through poly-cross nursery.
5. To characterize and evaluate the field gene bank of sweet potato to identify and install large number of duplicates.
6. To select drought tolerant/ resistant genotypes of sweet potato from available germplasm.
7. To develop carotene rich genotypes coupled with higher total soluble solids and sugar content.

“Genetic variability, correlations and path analysis in sweet potato [*Ipomoea batatas* (L.) Lam.)”

by

Ghanshyam Das Sahu

ABSTRACT

The present investigation was carried out at Horticultural Research Farm, IGAU, Raipur (C.G.). The experimental material consisted of 24genotypes of sweet potato which were replicated three times in a randomized block design during *Rabi* 2002-2003.

The data of 16 characters were recorded and analysed to workout the variability, heritability, genetic advance, correlation and path analysis for vine length, vine weight per plant, number of tuber per plant, number of marketable tuber per plant, neck length of tuber, tuber length, tuber diameter, biological yield per plant, tuber yield per plant, marketable tuber yield per plant, tuber yield tonnes per hectare, marketable tuber yield tonnes per hectare, harvest index, total soluble solids, dry matter per cent of foliage and dry matter per cent of tuber.

Analysis of variance revealed that the mean sum of squares due to genotypes were significant for all the characters (except number of marketable tuber per plant). Estimates of genetic parameters for various characters revealed that relative magnitude of genotypic coefficient of variation in general, was higher for vine length followed by neck length of tuber, vine weight per plant, marketable tuber yield per plant, total soluble solids and harvest index.

Heritability estimates in general were high for most of the traits showing preponderance of additive genetic variance. High heritability coupled with high genetic advance as percentage of mean was in general, high for vine length, vine weight per plant, tuber yield per plant and biological yield per plant indicated that direct selection for these characters is very effective.

Correlation coefficient analysis revealed that tuber yield tonnes per hectare had positive significant correlation with biological yield per plant, tuber diameter and harvest index, suggesting that indirect selection for these characters may increase the tuber yield of sweet potato traits.

Path coefficient analysis revealed vine weight per plant, number of marketable tuber per plant and tuber yield per plant were important traits influencing tuber yield and could be utilized as selection criteria in sweet potato improvement programme for Chhattisgarh plains.

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Table 4.1 : Genetic parameters of variation for tuber yield and its components in sweet potato.

S. No.	Parameters → / Characters ↓	Range		Mean	Coefficient of variation (%)		h^2(b) (%)	Genetic advance	G.A. as % of mean
		Minimum	Maximum		Genotypic	Phenotypic			
1.	Vine length (cm)	88.60	330.66	160.40	38.95	42.01	86.00	119.30	74.37
2.	Vine weight per plant (g)	111.33	415.00	258.45	30.72	33.75	82.80	148.80	57.57
3.	Number of tuber per plant	3.00	5.23	3.99	13.44	17.52	58.80	0.85	21.30
4.	No. of marketable tuber per plant	2.40	4.53	3.31	7.21	24.56	8.60	0.14	4.22
5.	Neck length of tuber (cm)	7.33	46.66	30.44	38.04	40.25	89.30	22.50	73.91
6.	Tuber length (cm)	13.55	24.66	18.24	17.79	19.99	79.10	5.90	32.34
7.	Tuber diameter (cm)	8.39	15.15	11.49	14.93	18.34	66.30	2.80	24.36
8.	Biological yield per plant (g)	539.66	1146.66	796.73	18.73	22.01	72.50	261.70	32.84
9.	Tuber yield per plant (g)	392.33	825.33	543.90	21.01	24.90	71.20	198.60	36.51
10.	Marketable tuber yield / plant (g)	281.33	731.90	456.37	22.47	31.87	49.70	148.90	32.62
11.	Tuber yield (t/ha)	22.34	47.17	31.08	21.02	24.91	71.20	11.30	36.35
12.	Marketable tuber yield (t/ha)	16.05	41.80	26.07	22.39	31.89	49.30	8.40	32.22
13.	Harvest index (%)	54.33	80.06	67.97	11.15	12.35	81.50	14.00	20.59
14.	Total soluble solid (%)	10.40	17.10	12.68	10.97	12.13	81.80	2.50	19.71
15.	Dry matter per cent of foliage (%)	16.00	30.00	21.60	15.39	16.27	89.50	0.01	0.05
16.	Dry matter per cent of tuber (%)	20.00	36.00	29.20	13.70	14.55	88.70	0.01	0.03

Table 4.2 : Analysis of variance for tuber yield and its components in sweet potato.

Source of variation	df	Mean sum of square														
		Vine length	Vine weight / plant	No. of tuber / plant	No. of marke-table tuber / plant	Neck length of tuber	Tuber length	Tuber diameter	Bio-logical yield/ plant)	Tuber yield/ plant	Marke-table tuber yield/ plant	Tuber yield	Marke-table tuber yield	Harvest index	Dry matter per cent of foliage	Dry matter per cent of tuber
		(cm)	(g)	(No.)	(No.)	(cm)	(cm)	(cm)	(g)	(g)	(g)	(t/ha)	(t/ha)	(%)	(%)	(%)
Replication	2	20.42	2533.29	0.042	0.176	418.48	12.58	0.449	5286.00	3379.00	13911.00	11.07	46.60	26.21	0.000	0.000
Genotypes	23	12343.71**	20212.02**	1.066**	0.778	3.17**	34.37**	10.33**	75296.98**	44464.87**	42180.81**	145.30**	137.33**	185.36**	0.000**	0.000**
Error	46	637.08	1305.58	0.202	0.606	16.05	2.77	1.497	8467.62	5283.08	10640.98	17.26	35.04	13.04	0.000	0.000

* Significant at 5%
** Significant at 1%

Table 4.4 : Path coefficients of the character contributing towards tuber yield (t/ha) in sweet potato.

Characters	Vine length (cm)	Vine weight / plant (g)	No. of tuber / plant (No.)	No. of marke-table tuber / plant (No.)	Neck length of tuber (cm)	Tuber length (cm)	Tuber diameter (cm)	Bio-logical yield/ plant (g)	Tuber yield/ plant (g)	Marke-table tuber yield/ plant (g)	Marke-table tuber yield (t/ha)	Har-vest index (%)	Total soluble solid (%)	Dry matter per cent of foliage (%)	Dry matter per cent of tuber (%)	Genotypic correlation with tuber yield) (t/ha)
Vine length (cm)	**-0.003**	0.002	0.002	0.001	0.000	-0.001	0.001	-0.002	-0.058	0.040	-0.040	0.001	0.000	0.000	0.000	-0.056
Vine weight per plant (g)	-0.001	**0.003**	-0.003	0.006	0.000	-0.001	0.001	-0.006	0.191	0.140	-0.146	0.002	0.000	0.000	-0.001	0.185
Number of tuber /plant	0.000	0.001	**-0.014**	0.010	0.000	0.000	-0.001	-0.002	0.239	0.030	-0.033	0.000	0.000	0.000	0.001	0.231
No. of marketable tuber/ plant	0.000	0.002	-0.017	**0.008**	-0.001	-0.001	-0.002	-0.008	0.675	0.153	-0.157	0.001	0.000	0.000	0.000	0.654**
Neck length of tuber (cm)	0.000	0.000	0.001	0.004	**-0.001**	0.000	0.001	-0.001	0.045	0.109	-0.114	0.000	0.000	0.000	0.000	0.044
Tuber length (cm)	-0.001	0.001	0.000	0.003	0.000	**-0.002**	0.000	-0.004	0.339	0.200	-0.209	0.000	0.000	0.000	0.001	0.329
Tuber diameter (cm)	0.001	-0.001	-0.002	0.004	0.000	0.000	**-0.005**	-0.005	0.826	0.359	-0.375	-0.002	0.000	0.000	0.001	0.801**
Biological yield per plant (g)	0.000	0.002	-0.003	0.007	0.000	-0.001	-0.003	**-0.010**	0.912	0.440	-0.459	0.000	0.000	0.000	0.000	0.885**
Tuber yield per plant (g)	0.000	0.001	-0.003	0.005	0.000	0.000	-0.004	-0.009	**0.999**	0.466	-0.486	-0.001	0.000	0.000	0.000	0.999**
Marketable tuber yield / plant (g)	0.000	0.001	-0.001	0.003	0.000	-0.001	-0.004	-0.009	0.999	**0.466**	-0.485	-0.001	0.000	0.000	0.000	0.999**
Marketable tuber yield (t/ha)	0.000	0.001	-0.001	0.003	0.000	-0.001	-0.004	-0.009	0.999	0.466	**-0.485**	-0.001	0.000	0.000	0.000	0.999**
Harvest index (%)	0.001	-0.003	0.001	-0.002	0.000	0.000	-0.004	0.001	0.393	0.136	-0.142	**-0.002**	0.000	0.000	0.001	0.381
Total Soluble Solids (%)	0.000	0.000	0.000	0.001	0.000	0.000	-0.001	-0.001	0.150	0.087	-0.091	-0.001	**0.000**	0.000	0.000	0.145
Dry matter per cent of foliage (%)	-0.001	0.001	0.000	-0.002	0.001	-0.001	0.000	-0.001	0.090	0.027	-0.027	0.000	0.000	**-0.001**	0.000	0.087
Dry matter per cent of tuber (%)	0.000	0.001	0.003	0.000	0.000	0.000	0.001	0.000	-0.108	0.023	-0.021	0.001	0.000	0.000	**-0.004**	-0.104

Residual effect = 0.000 **The bold figures denotes the direct effect**

Table 4.3 : Correlation coefficients of tuber yield and its components in sweet potato.

Characters	Vine weight / plant (g)	No. of tuber / plant (No.)	No. of marke-table tuber / plant (No.)	Neck length of tuber (cm)	Tuber length (cm)	Tuber dia-meter (cm)	Bio-logical yield/ plant (g)	Tuber yield/ plant (g)	Marke-table tuber yield/ plant (g)	Tuber yield (t/ha)	Marke-table tuber yield (t/ha)	Harvest index (%)	Total soluble solids (%)	Dry matter per cent of foliage (%)	Dry matter per cent of tuber (%)
Vine length	0.471*	-0.083	0.077	-0.157	0.316	-0.185	0.189	-0.013	0.103	-0.013	0.100	-0.393	-0.131	0.413*	0.094
Vine weight per plant (g)		0.178	0.231	0.061	0.365	-0.163	0.624**	0.198	0.235	0.198	0.235	-0.779**	-0.064	0.127	0.224
Number of tuber /plant			0.640**	-0.015	0.009	0.109	0.224	0.199	0.077	0.199	0.081	-0.054	-0.058	0.027	-0.151
No. of marketable tuber/ plant				0.208	0.165	0.054	0.279	0.192	0.524**	0.192	0.528**	-0.100	0.063	-0.026	0.026
Neck length of tuber (cm)					0.015	-0.030	0.074	0.064	0.210	0.064	0.212	-0.007	0.073	-0.356	0.005
Tuber length (cm)						0.029	0.412*	0.288	0.355	0.288	0.353	-0.135	-0.093	0.275	-0.111
Tuber diameter (cm)							0.505*	0.734**	0.551**	0.734**	0.550	0.591**	0.270	-0.020	-0.174
Biological yield per plant (g)								0.873**	0.767**	0.873**	0.767**	-0.041	0.104	0.103	0.034
Tuber yield per plant (g)									0.817**	0.999**	0.817**	0.428*	0.173	0.085	-0.112
Marketable tuber yield/ plant (g)										0.817**	0.999**	0.288	0.206	0.044	0.040
Tuber yield (t/ha)											0.817**	0.428*	0.173	0.085	-0.112
Marketable tuber yield (t/ha)												0.288	0.206	0.043	0.035
Harvest index (%)													0.212	-0.030	-0.316
Total soluble solid (%)														0.048	0.026
Dry matter per cent of foliage (%)															-0.760

* : Significant at 5% level

** : Significant at 1% level

Appendix II : Mean performance of different sweet potato genotypes

Genotypes \ Characters	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Sree Bhadra	140.33	321.33	3.96	2.73	29.33	22.11	15.15	1146.66	825.33	640.16	47.17	36.56	71.95	12.40	20.00	26.00
IGSP-4	88.60	311.33	5.23	4.13	43.00	17.63	10.26	810.33	499.00	389.90	28.51	22.61	61.49	12.50	20.00	22.00
Shree Rethna	158.00	332.00	4.63	4.20	37.66	16.05	14.83	1139.33	807.33	731.90	46.14	41.80	70.88	12.00	20.00	32.00
IGSP-12	199.00	330.33	4.73	4.53	41.33	21.62	12.49	1080.00	749.66	718.96	42.84	41.04	69.39	13.20	20.00	30.00
IGSP-17	125.66	209.66	4.80	3.93	33.66	24.66	13.59	814.66	605.00	494.90	34.57	28.27	73.99	12.80	24.00	26.00
IB-90-15-9(S)	137.00	288.00	3.80	3.53	35.00	15.56	12.34	846.66	558.66	512.26	31.92	29.24	65.64	17.10	22.00	32.00
Pol-2101	115.33	141.66	4.46	3.46	23.33	15.31	12.06	620.00	478.33	363.06	27.33	20.71	77.23	14.10	20.00	32.00
IGSP-15	330.66	415.00	3.00	3.06	44.00	24.51	9.17	862.00	482.33	492.60	27.57	28.12	56.01	13.40	26.00	30.00
IGSP-31	137.00	153.33	3.40	3.06	44.66	16.83	14.13	776.66	623.33	567.10	35.62	32.38	80.06	14.50	20.00	30.00
NDSP-16	244.33	273.33	3.46	3.00	25.00	13.55	12.51	763.66	490.00	419.80	28.00	23.95	64.15	12.36	22.00	32.00
Kalyani Local	223.33	332.33	5.20	3.50	20.00	15.13	11.15	812.00	546.33	364.83	31.22	20.82	62.29	12.03	24.00	30.00
IGSP-11	95.90	330.33	3.40	2.83	44.00	21.12	10.46	948.00	617.66	519.83	35.30	29.68	65.01	12.03	24.00	32.00
56-2	110.66	157.00	3.26	3.03	26.66	19.63	12.46	653.00	496.00	461.03	28.34	26.32	75.71	12.13	16.00	30.00
IB-90-11-1	113.66	333.33	4.00	2.80	17.33	16.41	10.82	729.66	396.33	281.33	22.64	16.05	54.33	11.50	20.00	34.00
IGSP-26	218.66	169.00	4.00	3.13	12.33	21.43	12.23	770.00	601.00	496.50	34.34	28.34	78.04	11.06	30.00	28.00
IGSP-10	132.66	190.00	3.53	2.73	8.33	15.43	11.97	781.66	591.66	458.13	33.81	26.17	75.66	14.26	28.00	30.00
IGSP-13	224.66	350.00	4.26	3.73	7.33	22.38	10.93	873.33	523.33	454.63	29.90	25.96	59.72	13.53	22.00	27.00
IGSP-18	291.00	275.00	3.73	3.20	29.66	19.05	8.39	666.00	391.00	331.30	22.34	18.89	58.85	10.40	24.00	28.00
IGSP-9	150.33	302.00	3.73	3.33	24.00	19.47	8.90	766.33	464.33	430.53	26.53	24.57	60.39	11.00	20.00	36.00
IGSP-8	152.00	293.33	4.26	3.60	37.00	19.61	8.84	693.00	433.00	365.16	24.74	20.83	59.53	12.56	22.00	30.00
Kalmegh	135.33	191.66	3.60	2.40	24.66	17.69	11.57	796.66	605.00	421.26	34.57	24.23	75.86	12.43	18.00	22.00
H-633	113.00	191.66	3.80	3.06	46.66	13.96	8.98	584.00	392.33	315.16	22.42	17.97	66.92	12.80	16.00	36.00
Gouri	96.20	111.33	3.86	2.93	32.33	14.72	11.36	539.66	428.33	319.33	24.47	18.23	79.36	13.43	22.00	20.00
IB-90-10-20	116.66	200.00	3.66	3.33	43.33	13.98	11.29	648.33	448.33	403.20	25.62	23.01	68.82	10.73	18.00	26.00
Grand mean (X)	160.40	258.45	3.99	3.30	30.44	18.24	11.49	796.73	543.90	456.37	31.08	26.07	67.97	12.68	22.00	29.00
CV(%)	15.73	13.98	11.24	24.12	13.16	9.14	9.14	10.64	11.55	13.36	22.60	13.37	22.70	5.31	5.28	4.90
SE(Diff)	5.51	7.38	0.09	0.16	0.82	0.34	0.34	0.25	18.78	14.83	21.06	0.85	1.21	0.74	0.20	0.30
CD (at 5%)	14.63	20.95	0.26	0.46	2.32	0.97	0.97	0.71	53.34	42.11	59.80	2.41	3.43	2.09	0.57	0.85

1. Vine length (cm), 2.Vine weight per plant (g), 3. Number of tuber per plant, 4.Number of marketable tuber per plant,
5.Neck length of tuber (cm), 6.Tuber length (cm), 7.Tuber diameter (cm), 8.Biological yield per plant (g),
9.Tuber yield per plant (g), 10.Marketable tuber yield per plant (g), 11.Tuber yield (t/ha), 12. Marketable tuber yield (t/ha),
13.Harvest index (%), 14.Total Soluble Solids (%), 15.Dry matter percentage of foliage, 16.Dry matter percentage of tuber

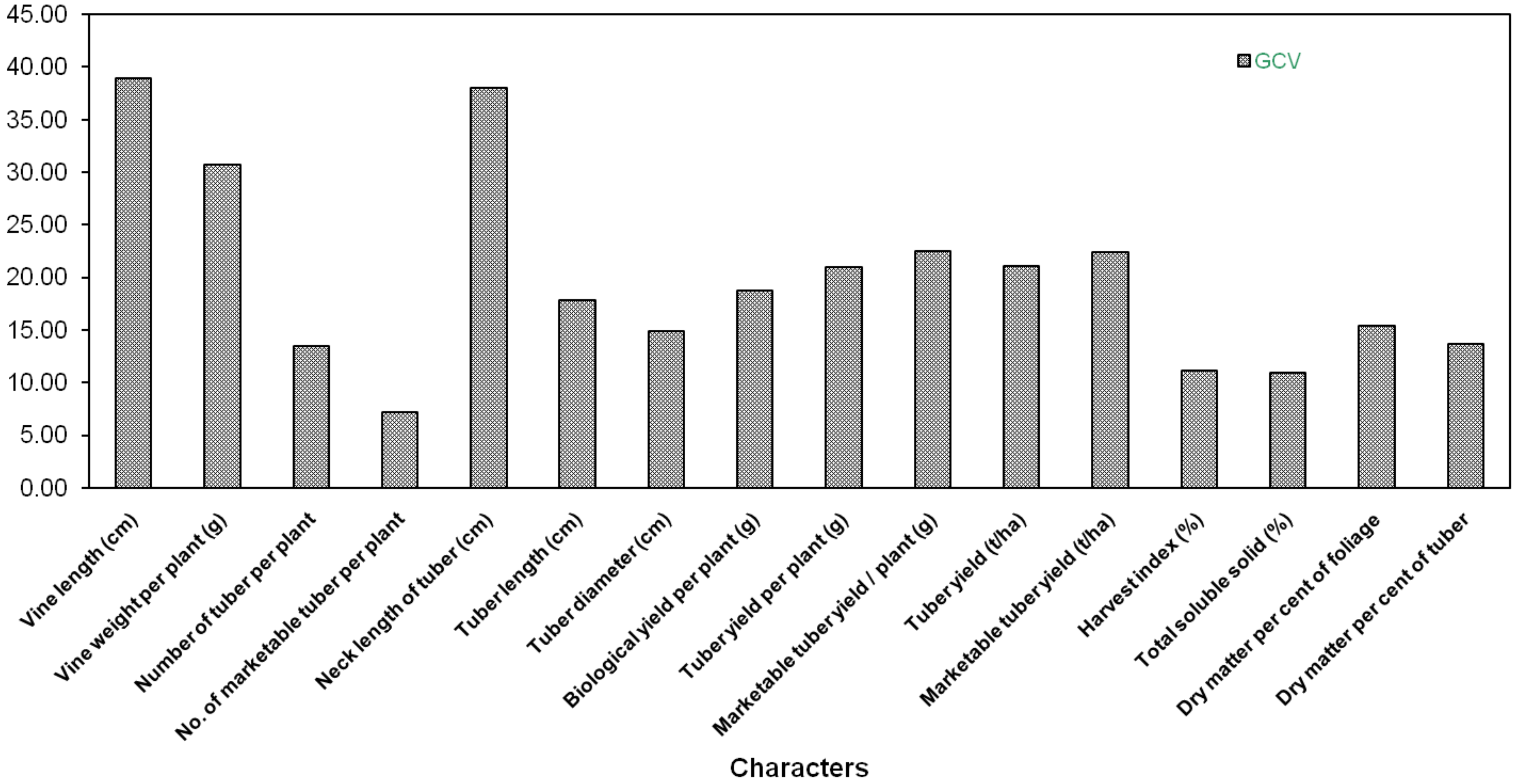
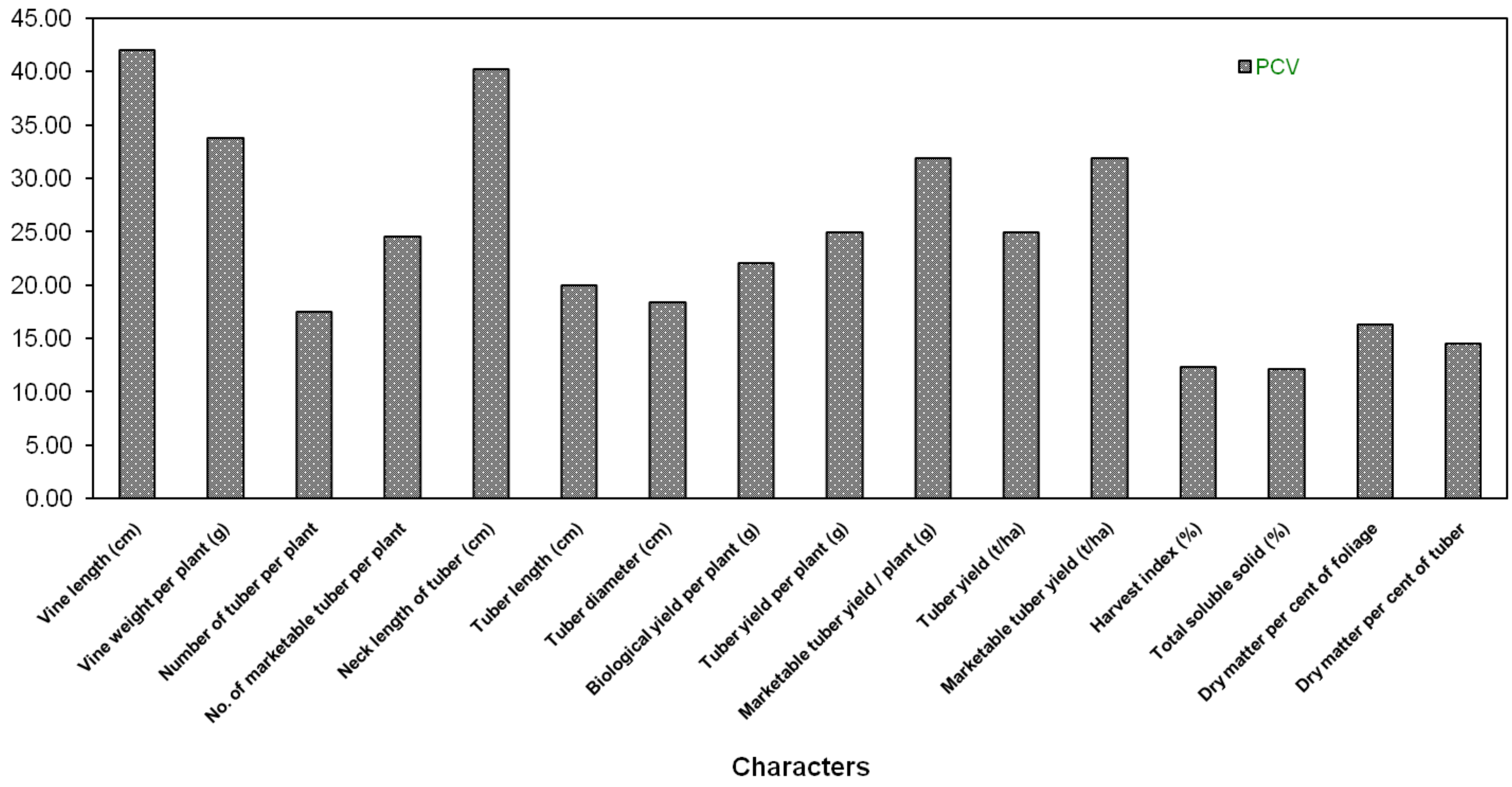


Fig 4.1 : Graphical presentation of genotypic coefficient of variation (GCV) of tuber yield and its components in sweet potato.



45.00
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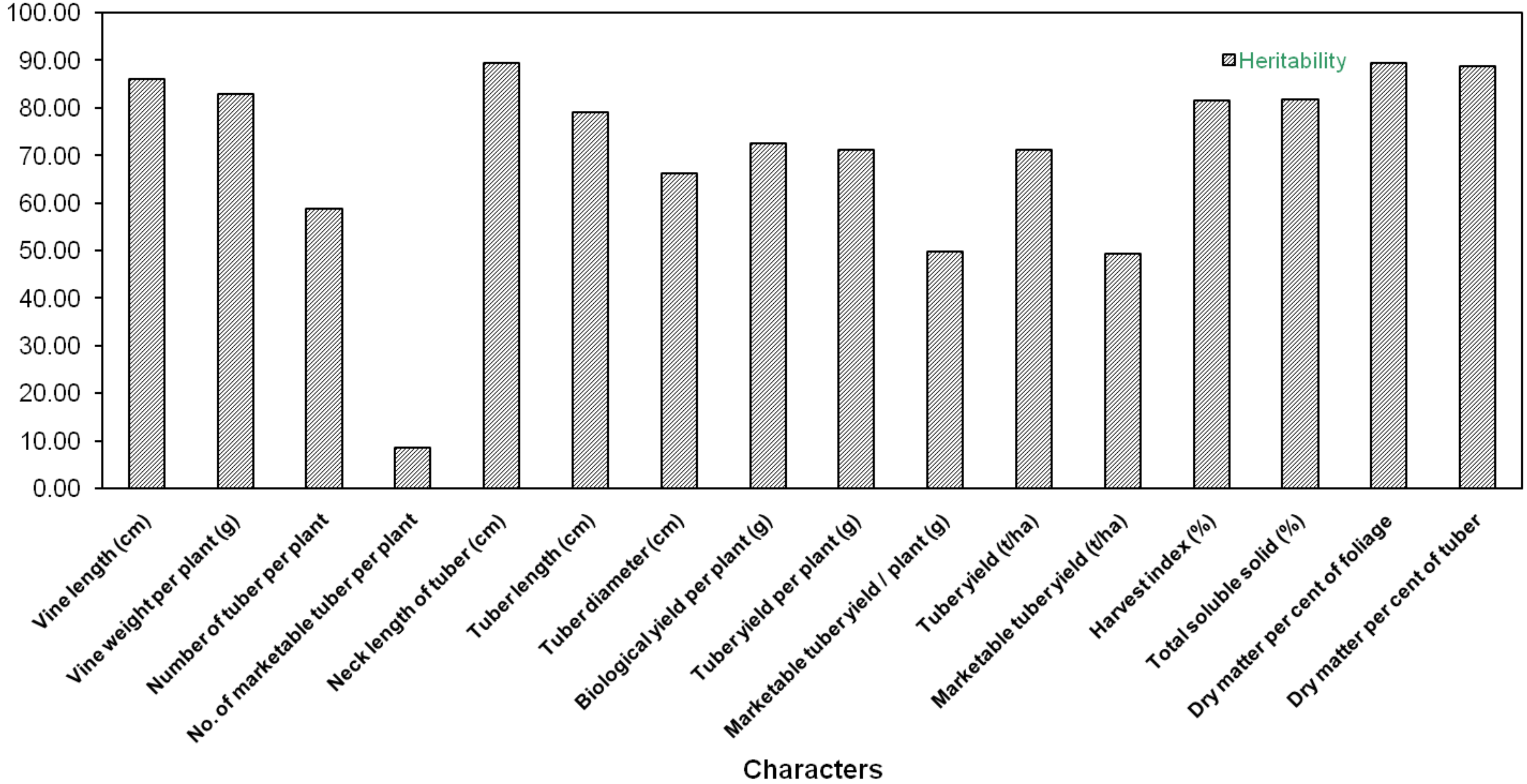
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
PCV
Vine length (cm)
Vine weight per plant (g)
Number of tuber per plant
No. of marketable tuber per plant
Neck length of tuber (cm)
Tuber length (cm)
Tuber diameter (cm)
Biological yield per plant (g)
Tuber yield per plant (g)
Marketable tuber yield / plant (g)
Tuber yield (t/ha)
Marketable tuber yield (t/ha)
Harvest index (%)
Total soluble solid (%)
Dry matter per cent of foliage
Dry matter per cent of tuber
Characters



100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Heritability
Vine length (cm)
Vine weight per plant (g)
Number of tuber per plant
No. of marketable tuber per plant
Neck length of tuber (cm)
Tuber length (cm)
Tuber diameter (cm)
Biological yield per plant (g)
Tuber yield per plant (g)
Marketable tuber yield / plant (g)
Tuber yield (t/ha)
Marketable tuber yield (t/ha)
Harvest index (%)
Total soluble solid (%)
Dry matter per cent of foliage
Dry matter per cent of tuber
Characters