IMPROVED TECHNIQUES IN BREEDING AND INHERITANCE OF SOME OF THE CHARACTERS IN THE SWEET POTATO, *IPOMOEA BATATAS* (L.)

— *by* —

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Since the inception of a breeding program in Louisiana by Miller (12, 13), new techniques have been developed and several genetic characters studied. The incompatibility system of varieties and seedlings in the United States and others is better understood (5, 6, 11, 14, 16, 17).

The sweet potato is a hexaploid with a basic number of 15 chromsomes (8, 9, 10) and like most vegetatively propagated crops it is very heterozygous. Several new varieties of great commercial significance (4) have been developed. One of the latest Louisiana varietal introductions, Centennial, is the leading variety grown in the United States. Several research workers have reported on the behaviour of some of the genetic characters in the sweet potato (1, 2, 3, 4, 7).

MATERIAL AND METHODS

A total of 28 sweet potato breeding parents was selected for these studies. The compatibility behaviour and phenotype of each parent was known. The varieties and seedlings were developed at Louisiana State University except Kandee from Kansas State Experiment Station; Whitestar; and seedlings P. I. 213321 and P. I. 227890 which are USDA introductions.

Controlled pollinations were made in field plot breeding nursery and in a greenhouse 20 x 120 feet where the sweet potato plants were trained on to a six foot netted wire trellis. The sparse flowering clones were cleft-grafted on to morning glory (Ipomoea spp.) root stock. Pollinations were begun in August and continued until October 25 of each year. Large soda straws were used after removing the corollas of the flower and subsequent emasculation to protect the pistils from contamination before and after pollinations. The controlled pollinations were made daily between 5:00 and 9:00 a.m. Pollen of each male parent was collected each morning from flowers protected by soda straws.

In January of each year the seeds were scarified in concentrated sulfuric acid for 25 minutes and thoroughly washed in tap water and dried. The seeds were then planted in greenhouse benches filled with a mixture of shredded sphagnum moss and silt loam soil. The seedlings were allowed to grow for approximately 4 months at which time they were pulled and transplanted to a field where the plants were spaced 5 feet apart on rows 4 feet wide. The seedlings were allowed to grow for another 4 months and then each seedling was classified as to plant characters and the roots harvested, bagged and labeled for further study.

RESULTS AND DISCUSSION

The objectives of the sweet potato breeding program are to continue a study of incompatibility systems, inheritance of genetic characters, and to develop new varieties with the following major characteristics: high yield, desirable skin and flesh color, good keeping quality, well shaped roots, good culinary quality, favourable sprout production, good adaptability, and resistance to several diseases, Fusarium wilt (*Fusarium oxysporum f. batatas*), soil rot (*Streptomyces ipomoea*), internal cork and root knot nematodes (*M. incognita*).

A total of 30 breeding parents were tested as to cross and self compatibility. There were 6 groups (5 incompatible and one self compatible) identified (5, 6).

The genetic characters studied are as follows:

Skin and Flesh Color. Control crosses between parents having different fleshy root skin color were made (Tables I and III). The skin colors were classified as white, cream, tan, copper, rose and purple. Seedling progenies of crosses between parents having fleshy roots of a cream and white skin color produced seedlings with roots of a white or cream skin (3). Segregates from progenies of cream x copper parents produced seedlings with fleshy roots that were predominantly copper as shown in Table III. Seedlings from crosses of copper x copper skinned parents were predominantly copper and tan. Copper x rose skinned parents produced seedlings that were also mostly of a copper skin color. Seedlings of crosses of rose x rose skin colored parents were predominantly copper and rose. In crosses of rose x purple skinned parents the resulting seedling progenies were mostly of a purple skin color. Colored skin color is incompletely dominant over white or cream skin color.

Flesh Color. Data from seedling progenies of crosses between parents containing varying amounts of carotenoid pigments were (Tables I and II). White fleshy root color was found to be incompletely dominant over the character for carotenoid pigments, which is mostly beta-carotene. A progeny of 195 seedlings between a cross of a white flesh and one having 18 mg. of carotenoids per 100 gm. fresh weight of root tissue produced 84.1 percent of the seedlings with little or no pigments. The progeny mean for carotenoids was 1.3 mg.

Crosses between parents having 6 and 12 mg. of carotenoids produced seedlings with a progeny mean of 8.3 mg. However, a cross between parents having 6 and 18 mg. of carotenoids had a progeny mean of 12.9 mg.

White flesh color is incompletely dominant over orange flesh color. The latter behave as a typical quantitative character. There are several genes controlling carotenoids (possibly 6) which have additive effects.

Dry Matter Content. Data from crosses between parents containing fleshy roots with varying amounts of dry matter showed that seedling progeny means were intermediate between the two parents. Transgressive segregation occurred in seedling progenies studied. This quantitative character shows in most cases additive genic effect. Transgressive inheritance is also suggested.

Fusarium Wilt Resistance. Fusarium wilt or stem rot is caused by the fungus, *Fusarium oxysporum f. batatas.* Since chemical fungicides and crop rotation offer no effective control of this soil-borne disease, breeding for resistance seems to be the best means of controlling this problem. The progenies of 29 crosses were evaluated as to Fusarium wilt resistance and statistical analysis of data shows large genetic differences for resistance transmitted by various parents.

Each seedling in each progeny was tested by cutting fresh ends of vine cuttings of each plant and dipping them in a spore suspension of Fusarium inoculum. Four treated cuttings planted in each of three 4-inch pots filled with clean sand constituted 3 replications. The variety Heartogold was treated and planted with each group of seedling progenies to use as a susceptible check; whereas, Goldrush treated the same as Heartogold was used as the resistant check. Crosses between parents represented: Resistant x highly resistant; moderately resistant x highly resistant; moderately resistant x moderately resistant: and moderately resistant x moderately susceptible parents.

Fusarium wilt index was computed for each seedling. Twelve plants from 3 replications of each seedling were placed in one of five categories as follows: 0 – stem of cutting showing no vascular discoloration; I – trace of vascular discoloration; II – moderate vascular discoloration; III – severe vascular discoloration; and IV – severe vascular discoloration. An index of each seedling was computed by using formula:

Summation of category numbers x No. of plants in each

Wilt index – category x 100

Number of plants tested x 4 (total no. of classes — 1)

The results in general indicated that crosses involving resistant x highly resistant and moderately resistant x moderately resistant parents gave the best results as a large percentage of seedlings of each progeny were resistant to Fusarium wilt. Crosses involving susceptible parents gave a very few resistant seedlings. Selfed progenies of Centennial and Kandee had a large number of resistant seedlings in each progeny. The selfed progeny of L130 had only a few moderately resistant seedlings. The parents Julian, Whitestar, and L21 carried several genes for resistance. Some parents transmitted considerable resistance and Julian was outstanding. This quantitative character is controlled by possibly six genes that are additive. Transgressive inheritance is indicated in crosses between some parents.

Quality Studies. The major characters affecting the culinary qualities of sweet potatoes are: flesh color, flavor, texture, fiber content, sweetness, moistness, and general acceptability of sweet potato roots baked or processed (Tables I and IV). A baking index was obtained by calculating a mean score rating of all seven factors. Scoring was based on a range of 0 to 10; 10 representing the maximum favorable expression for each above character with the exception of fiber in which 10 represented an absence of fiber. Since white flesh color is incompletely dominant, the seedlings from crosses using a white flesh parent produced seedlings that rated poorly in color after processing or baking. In crosses of parents that rated medium to good in baking quality, the majority of the seedlings rated fair to good in quality.

Seedling progeny means from crosses of parents of acceptable culinary quality were intermediate between parents or acceptable.

Breeding Technique. The following technique of this highly heterozygous crop has been successfully used at Louisiana State University. Breeding parents are selected on the basis of field performance and genotype as indicated by expression of phenotypic characters. The parents selected are of as many different incompatibility groups as possible and have two or more of the following characters: high yielding ability; well shaped roots; copper or rose skin color; all parents having orange flesh with 3 or more mg/100 gm. of carotenoids per 100 gm. fleshy roots; moderate to good plant production; good culinary quality; profuse flowering; and disease and/or insect resistance. These parents are placed in an isolated nursery, trained onto a wire trellis and allowed to pollinate at random by honey and bumble bees. The seeds are identified as to maternal parent and scarified in sulfuric acid for 25 minutes, washed in water and dried. The seeds are planted in a greenhouse bench in a good medium, spacing seed 2 inches apart. They are allowed to grow for four months. By that time each seedling has produced a fleshy root approximately one inch in diameter. The seedlings are pulled, and using high selection pressure, best seedlings are saved. This includes seedlings having colored skin, preferably tan, copper or rose, orange flesh, and well shaped roots. The white flesh seedlings are discarded as well as seedlings with irregularly shaped roots. Using this basis for selection, approximately 10 percent of the seedlings are saved and transplanted to the field. After 4 months of growth each seedling is harvested and approximately 15 percent of these are saved for subsequent testing. The roots of each seedling are bagged and labeled. The numbering system in each year includes the last number of the year and adding a selection number of 1 to infinity, e.g., in 1966 the first seedling would be 6-1 and the second 6-2, etc. Every 10 years a recurrence of this number would occur; however, generally all seedlings have been discarded or named as varieties.

For genetic studies, controlled crosses are made as indicated earlier in this paper.

The above method of varietal improvement permits a genotype that possesses a balanced genic system that allows maximum expression of desirable quantitative characters and at the same time allowing a vigorous plant that yields well. This method is called the Polycross system.

SUMMARY

Several major horticultural characters were studied as follows: skin and flesh color, culinary quality, dry matter content and resistance to Fusarium wilt. These behave as quantitative genetic characters. White flesh color is incompletely dominant. Transgressive inheritance is indicated in some crosses.

Crosses between parents having an acceptable culinary quality produced progenies that had most of the seedlings that were acceptable and the progeny means were intermediate between the two parents.

The breeding parents are classified as to incompatibility groups and a search is being made for more self fertile or self compatible parents.

A breeding technique was described.

Table I. Characters of Sweet Potato Breeding Parents

Parent	Skin Color	% Dry Matter	Carotenoids mg/100 gm	Baking Quality
Julian	Copper	28.4	18.5	Good
L8-67	Rose	27.2	17.5	Good
L1-80	Copper	29.4	18.0	Good
Centennial	Copper-Tan	29.0	16.1	Good
L0-240	Purple	27.0	16.5	Medium
L3-7	Copper	36.5	11.7	Medium
L3-64	Rose	30.8	11.0	Good
L3-80	Rose	30.8	10.4	Medium
L2-61	Purple	30.6	8.6	Poor
L131	Cream	29.6	7.0	Medium
Georgia Red	Rose	29.3	5.2	Good
Porto Rico	Copper	29.4	5.2	Good
Kandee	Light Copper	28.7	4.6	Poor
L130	Rose	31.3	4.2	Medium
L21	Light Copper	32.6	1.2	Poor
Whitestar	Cream	34.3	0.4	Poor
Pelican Processor	White	38.4	0.0	Poor
P.I. 213321	White	29.5	0.0	Poor
P.I. 227890	Purple	36.6	0.0	Poor

Table II. Frequency Distribution of Sweet Potato Seedlings into Different Total Carotenoid Pigment Classes.

Parental Combination	Total No. Seedlings	Number of Seedlings into Each Class									Progeny Mean
		0	0.1-3	3-6	6-9	9-12	12-15	15-18	18-21	21+	
Centennial (X)	164	21	19	5	9	14	11	24	37	24	13.0
Kandee (X)	67	23	14	9	3	4	4	6	4	0	5.1
Julian x L21	229	15	8	11	16	19	17	24	76	43	15.2
L3-7 x L1-80	116	11	4	5	8	6	9	17	28	29	15.6
L2-61 x Ga Red	100	16	11	8	8	6	10	24	16	1	10.4
L2-61 x L131	339	26	32	7	14	26	68	109	55	2	12.7
L8-67 x L131	128	8	2	1	3	4	10	30	60	10	16.4
P. I. 213321 x L1-80	258	160	57	24	7	5	4	1	0	0	1.5
P.I. 213321 x L21	239	221	16	0	1	1	0	0	0	0	0.1
P.I. 227890 x L21	179	170	6	2	1	0	0	0	0	0	0.1
Centennial x L1-80	98	7	3	6	4	8	9	13	19	29	15.7

Table III. Frequency Distribution of Sweet Potato Seedlings into Different Skin Colour Classes.

Parental Cross	No. of Seedlings	Percentage of Seedlings into each Skin Color					
		White	Cream	Tan	Copper	Rose	Purple
Copper (X)	57	0.0	5.3	22.8	43.9	7.0	21.0
White x Copper	357	13.4	17.4	27.5	22.7	11.2	7.8
Cream x Copper	166	1.2	7.2	33.1	37.3	12.7	8.5
Cream x Rose	27	0.0	0.0	33.3	29.6	11.2	25.9
Cream x Purple	32	0.0	0.0	15.6	21.9	21.9	40.6
Copper x Copper	373	0.3	7.8	25.2	45.3	13.1	8.3
Copper x Rose	443	0.2	3.6	20.3	51.5	16.0	8.4
Copper x Purple	18	0.0	0.0	16.7	5.6	44.4	33.3
Rose x Rose	58	0.0	5.1	17.2	32.8	25.9	19.0
Rose x Purple	21	0.0	0.0	0.0	4.8	9.5	85.7

Table IV. Inheritance of Baking Quality in Sweet Potatoes

	Characters* of Fleshy Roots								
Parental Combination	Cross	Color	Flavor	Texture	Fiber	Sweet-ness	Moist-ness	General Accept-ability	Progeny Mean Baking Index
P. I. 213321 x L21	Poor x Poor	0.4	2.2	3.9	6.4	2.7	3.0	0.8	2.8
P. I. 213321 x L1-80	Poor x Good	1.7	3.0	4.6	6.2	3.3	3.7	2.0	3.5
Centennial x L1-80	Good x Good	6.3	5.6	6.1	5.7	5.6	6.2	5.5	5.9
Centennial x L3-80	Good x Med.	4.7	5.0	5.4	5.9	4.9	5.3	4.3	5.1
L3-7 x L3-80	Med. x Med.	5.0	5.2	5.4	5.9	5.2	5.2	4.7	5.2
L3-7 x L1-80	Med. x Good	5.8	6.0	6.3	6.1	6.0	6.3	5.8	6.1
L130 x L1-80	Med. x Good	4.8	5.4	5.7	5.2	5.5	6.0	4.7	5.3
L130 x L8-67	Med. x Good	4.9	5.0	5.8	5.6	5.2	6.2	4.5	5.3
L1-80 x L3-80	Good x Med.	5.6	5.4	5.9	5.6	5.4	5.6	5.0	5.5
L1-80 x L3-64	Good x Good	5.7	5.2	5.8	5.8	5.3	6.1	5.1	5.6

*Scored on the basis of 0–10; 10 representing the maximum favourable expression of each factor.

Table V. Inheritance of Fusaium Wilt Resistance in Sweet potatoes

Parental Cross	Wilt Index of Parents	No. of Seedlings	Progeny Mean Wilt Index	Percentage* R.	M. S.	S.
L1-80 x L3-80	50 x 55	60	56.5	71.7	28.3	—
P. I. 213321 x L1-80	49 x 50	236	52.0	49.2	36.0	14.8
L8-3 x L1-80	37 x 50	42	58.5	26.2	59.5	14.3
Centennial x L1-80	60 x 50	118	60.4	46.6	39.8	—
L3-7 x L1-80	53 x 50	165	49.6	85.5	10.9	3.6
L130 x L1-80	60 x 50	67	56.2	70.1	25.4	4.5
L131 x L1-80	67 x 50	55	52.1	78.2	21.8	—
L3-93 x L1-80	83 x 50	99	67.8	22.2	66.7	11.1
L130 x L1-80	60 x 50	67	56.2	70.1	25.4	4.5
L131 x L1-80	67 x 50	55	52.1	78.2	21.8	—
L2-61 x L131	34 x 67	361	70.5	22.2	44.5	33.3
L8-67 x L131	60 x 67	106	67.7	25.5	59.4	15.1
Centennial x L131	60 x 67	43	63.7	32.6	46.5	20.9
L3-93 x L131	83 x 67	86	69.3	24.4	53.5	22.1
Tanhoma x L131	71 x 67	94	77.6	—	44.7	55.3
Whitestar x L21	30 x 20	41	47.9	80.5	19.5	—
P. I. 213321 x L21	49 x 20	215	65.0	37.6	42.5	19.6
P. I. 227890 x L21	45 x 20	180	52.1	76.7	19.4	3.9
Julian x L21	37 x 20	226	30.3	100.0		
Centennial x L21	60 x 20	84	61.5	45.3	45.3	9.4
Centennial x Kandee	60 x 80	59	66.4	27.1	45.8	27.1
Centennial x L1-80	60 x 50	118	60.4	46.6	39.8	13.6
Centennial x L21	60 x 20	84	61.5	45.3	45.3	9.4
Centennial x L3-80	60 x 55	213	69.7	17.8	46.0	36.2
Centennial (X)	60 x 60	142	54.7	69.6	15.5	4.9

*R — Resistant; M.S. — Moderately Susceptible; S — Susceptible.

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