Cytotypes in Sweet Potato: Pentaploid and Heteroploid Types

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Abstract

Pentaploid plants obtained through hybridization between synthesized tetraploid and cultivars of the hexaploid sweet potato, exhibited variation in plant growth and tuber development. Yield and quality were comparable to those of the hexaploid cultivars of sweet potato.

The heteroploids obtained by back crossing the pentaploids with sweet potato are hypohexaploids as well as hyperpentaploids with chromosome numbers ranging from 80 to 87. In respect to tuber quality, yield and plant type, some of these heteroploids are similar to the cultivated sweet potato.

These observations suggest that wild tetraploid species having genes for desirable agronomic attributes can be transferred to sweet potato cultivars. These heteroploid lines will be utilized to study the genetic control of important agronomic characters.

Introduction

Sweet potato *(Ipomoea batatas)*, is a hexaploid with 90 somatic chromosomes and is the only species in the genus reported so far with such a high number. Though *I. trifida* is also a hexaploid with 90 chromosomes, its specific status has been disputed Jones, 1967; Martin and Jones, 1972; Nishiyama *et al.*, 1961). The wild species consisting of diploid and few tetraploid species possess genetic variability which could be introduced with advantage into the cultivated species (Jones, 1968; Martin *et al.*, 1974; Vijaya Bai *et al.*, 1969 and Sakamoto, 1970; 1976). Gene transfer in the hexaploid group does not involve overcoming strong sterility/compatibility barriers. However, the transfer of desirable genes from diploid and tetraploid species into the cultivated sweet potato is hampered by the isolation of these species of lower ploidy from the hexaploids.

The crossability of a naturally occurring tetraploid species and a synthesized tetraploid species has been studied. Some observations on the pentaploid plants obtained from the latter crosses, and also of heteroploid plants derived by back-crossing the pentaploids with the hexaploid sweet potato are presented here.

Materials and Methods

The synthesized "Tetraploid Sweet Potato" plants were raised from the seeds obtained from Drs. Miyazaki and Kobayashi of Japan. The pentaploids were evolved by crossing the "Tetraploid Sweet Potato" with the cultivated sweet potato. The heteroploids were raised by back-crossing the pentaploids with the hexaploid sweet potato. In all crosses, the plant with lower chromosome number were used as the female parent. The percentages of dry matter, starch and sugar were estimated by adopting the standard procedures.

Results

(A) "Tetraploid Sweet Potato"

Only two morphologically distinguishable plants could be raised. Their chromosome number has been determined as $2n = 4x = 60$. Of the two plants designated as 4x S^P -1 and 4x S^P –2, the former is with entire or subtrilobed or rarely trilobed leaves spread profusely. Its plant parts are green without any pigmentation, whereas in plant 2, the stems are purplish-green with trilobed and purplish-green veins on the dorsal side. It is also equally vigorous as 4x S^P -1 but the stems are stouter. Plant -2 produces small tubers if retained in the field for a longer duration whereas plant-1 produces only fibrous roots which do not even sprout. The plants flower only during October-February. The chromosome association and pollen fertility of these plants are given in Table 2.

(B) "Pentaploid Sweet Potato"

The "Tetraploid Sweet Potato" plants, 4x S^P -1 and 4x S^P -2 as female parents were crossed with a cultivar of sweet potato (Vijaya Bai and Hrishi, 1977). About 146 pollinations were made in the former combination producing 19 fruits with 23 seeds. In the latter combination, 195 pollinations were made producing 20 fruits with 20 seeds. A total of 16 cytologically identified pentaploid plants (9 + 7) with $2n = 5x = 75$ chromosomes were raised. They are morphologically distinguishable from each other. All these plants are partially fertile. The pentaploids derived from 4 x S^P -1 were numbered serially as 5x -1 to 5x -9 and those from 4x S^P -2 as 5x-10 to 5x-16. The chromosome number, chromosome association and pollen fertility of these plants are given in Table 2 and data on crossability is given in Table 1.

Barring 5x - 1, 5x - 7, 5x - 8, 5x - 9, 5x - 10 and 5x- 13 in the other plants, the vines exhibit the spreading nature of their female parent. Morphologically, all the plants were distinguishable from each other and none of them were similar to either of the parents. All the plants flowered profusely throughout the year except 5x - 3, 5x -4 and 5x -5 which flowered only in November to February. 5x-13 and 5x-16 are very shy-flowering types.

Well-developed edible tubers were produced by all except 5x-3, 5x-4, and 5x-5 which produced only thickened roots and small fibrous tubers during certain seasons. The initial observations on the average yield potential of these pentaploid plants which is a 3 to 4 season performance are presented in Table 3.

The tuber quality in respect to dry matter, starch and sugar percentage has been analyzed during 3-4 seasons and an average value of these are presented in Table 3. These

values are well comparable with the sweet potato cultivar used as the pollen parent.

Critical yield trials are being undertaken.

(C) "Heteroploid Sweet Potato"

The pentaploids, 5x-1, 5x-7 and 5x-8 were backcrossed with sweet potato. The data on crossability is given in Table 1. From the three plants, only 48 seeds were obtained. Though 18 seeds germinated, only 15 survived and reached maturity. From the pentaploid plant 5x-7, 36 open pollinated seeds were collected and sown, of which 11 germinated but only five plants reached maturity.

The twenty plants originating from the OP seeds have been numbered serially as Ht-1 to Ht-20, Ht-16 to Ht-20. The chromosome number, chromosome associations and pollen fertility of these heteroploids are given in Table 2.

These heteroploids consisting of both hypohexaploids and hyper-pentaploids are morphologically, like the hexaploid sweet potato cultivar with respect to vine growth. But A6t-9, Ht-12 and Ht14 exhibited more spreading of vines. These plants varied in their nature of flowering. Ht-14 and Ht-12 are shy-flowering; Ht-10 and Ht-15 are moderately flowering and all the remaining heteroploids flowered profusely throughout the year.

In tuber formation, considerable variation was observed. Five heteroploids viz., Ht-8, Ht-12, Ht-15, Ht-17 and Ht-20 produced tubers during certain seasons only and at other times produced only thickened roots. The other heteroploids produced good edible tubers. The preliminary data on the yield of these heteroploids are represented in Table 3.

The tubers were analyzed for their dry matter, starch and sugar content and the data are given in Table 3.

Conclusion

As sweet potato can be vegetatively propagated, any chromosomal race with desirable agronomic attributes can be isolated for cultivation. Wild species are now being used in the breeding programme of sweet potato (Kobayashi and Miyazaki, 1976; Sakamoto, 1970, 1976). Pentaploids obtained from crossing tetraploid species are partially fertile and can be back-crossed with the cultivars of sweet potato. The observations on the BC_1 generation with sweet potato reveals that heteroploids are more fertile than pentaploids and they can be further back-crossed to obtain plant types with desirable agronomic characters. Besides, the heteroploid lines are important in cytogenetic structure studies of the species and genetic control studies for agronomic characters. Isolation and classification of these heteroploids is being carried out to get a whole series of heteroploids.

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Table 1. Data on the crossability of tetraploid and pentaploid sweet potato

Crosses (♀ x ♂)	No. of pollinations	No. of fruits collected	% fruit set	No. of seeds obtained	No. of seeds sown	No. of seeds germinated	% seed germination
4x-SP-1 x SP	146	19	13.01	23	20	10	50.00
4x-SP-2 x SP	195	20	10.26	20	19	9	47.37
5x-SP-1 x SP	92	16	17.39	16	14	5	35.71
5x-SP-2 x SP	229	–	–	–	–	–	–
5x-SP-7 x SP	207	29	14.01	30	30	12	40.00
5x-SP-8 x SP	158	4	2.53	4	3	3	100.00

SP = sweet potato cultivar

Figure 2. Chromosome number, Chromosome association and pollen fertility.

Material	Somatic chromosome	Chromosome Associations						Number of PMCs	Pollen fertility (%)
		VI	V	IV	III	II	I		
4x-SP-1	60	–	–	1-6	–	18-28	–	20	44.5
4x-SP-2	60	–	–	0-4	0-1	22-30	0-2	24	22.6
5x-SP-1	75	–	–	0-2	1-8	30-33	5-9	24	14.9
5x-SP-2	75	–	0-1	0-3	0-7	22-31	7-14	22	24.2
5x-SP-3	75	–	–	0-2	0-5	21-30	5-10	10	48.3
5x-SP-4	75	–	–	0-3	1-7	29-32	4-9	8	12.5
5x-SP-5	75	–	0-1	0-2	1-5	21-31	6-10	10	17.4
5x-SP-6	75	0-2	0-2	0-3	2-5	22-31	6-11	16	0.0
5x-SP-7	75	–	–	0-1	0-5	23-35	5-10	15	24.3
5x-SP-8	75	–	0-2	0-3	0-8	16-31	4-18	18	15.1
5x-SP-9	75	–	–	0-1	1-5	20-32	5-10	12	2.5
5x-SP-10	75	–	–	0-2	0-11	19-30	2-12	21	36.0
5x-SP-11	75	–	–	–	0-7	23-26	2-8	12	51.5
5x-SP-12	75	–	–	0-3	4-10	18-21	6-9	12	35.1
5x-SP-13	75	–	–	0-1	2-7	22-26	3-7	10	21.4
5x-SP-14	75	–	–	0-1	3-6	19-28	2-9	15	16.7
5x-SP-15	75	–	–	0-2	2-8	16-22	3-8	8	20.5
5x-SP-16	75	–	–	0-1	2-7	21-25	2-6	10	23.5
Ht-1	85	–	–	0-2	0-5	29-38	1-19	25	28.1
Ht-2	86	–	–	0-2	0-2	37-42	2-8	19	74.2
Ht-3	81	–	–	0-2	2-6	28-34	3-7	21	52.5
Ht-4	84	0-1	–	0-3	0-2	26-29	4-6	10	57.4

Ht-5	80	0-1	0-2	0-4	0-8	19-33	1-15	28	38.4
Ht-6	87	0-1	–	0-6	0-4	29-41	0-7	16	68.6
Ht-7	83	–	–	0-2	0-3	31-37	1-9	11	54.7
Ht-8	83	–	–	0-1	1-6	30-38	3-12	20	29.4
Ht-9	81	–	–	0-1	0-5	28-38	3-12	6	51.1
Ht-10	86	–	–	0-2	0-4	31-40	2-15	30	43.1
Ht-11	82	–	–	0-1	1-5	29-35	2-9	11	66.7
Ht-12	81	–	–	0-2	0-3	29-33	4-8	10	55.5
Ht-13	83		–	0-2	0-7	27-38	3-14	25	52.3
Ht-14	83	0-2	–	0-3	0-4	26-35	3-9	8	55.4
Ht-15	83	–	–	0.1	0-4	23-35	10-31	12	5.5
Ht-16	83	–	–	–	0-1	36-38	4-8	5	9.5
Ht-17	84	–	–	0-3	0-3	30-35	5-14	10	3.2
Ht-18	87	–	–	0-2	1-6	28-38	2-4	5	34.7
Ht-19	82	–	–	0-3	0-5	27-35	2-12	30	44.2
Ht-20	80	0-1	–	1-5	3-6	18-27	6-11	6	1.5
SP-1*	90	–	–	0-4	0-3	35-43	1-3	10	60.4
SP-2*	90	–	–	1-5	0-2	31-40	2-3	12	53.3
SP-3*	90	0-1	–	0-4	0-2	28-41	1-4	15	65.3

* Cultivars of sweet potato

Table 3. Tuber yield and quality

Variety	Average yield/plant (g)		Dry matter %	Starch %	Sugar %
	(a)	(b)			
4x-SP-1	–	–	–	–	–
4x-SP-2	–	–	–	–	–
5x-SP-1	159.25	214.00	34.40	22.20	2.80
5x-SP-2	268.75	281.50	30.20	20.92	2.88
5x-SP-3	159.00	NA	30.20	20.28	2.50
5x-SP-4	137.50	NA	NA	NA	NA
5x-SP-5	188.50	NA	NA	NA	NA
5x-Sp-6	187.50	122.00	33.00	23.87	3.61
5x-SP-7	217.75	109.50	34.00	23.78	3.06
5x-SP-8	202.00	126.50	33.73	21.20	2.98
5x-SP-9	306.50	203.50	33.60	20.80	3.79
5x-SP-10	275.00	245.00	35.20	23.65	3.32
5x-SP-11	760.00	235.00	33.80	20.89	2.89
5x-SP-12	608.25	360.00	29.90	17.61	2.66
5x-SP-13	216.50	226.00	33.40	21.50	2.63
5x-SP-14	462.50	261.50	26.80	15.16	3.05
5x-SP-15	225.00	250.00	35.20	24.20	2.42
5x-SP-16	533.50	200.00	40.40	27.40	2.71
Ht-1	188.70	NA	28.13	17.48	2.89
Ht-2	253.00	286.00	26.93	16.48	3.19
Ht-3	330.67	234.00	26.13	14.42	3.18
Ht-4	376.67	230.50	30.00	17.17	4.31
Ht-5	250.00	NA	29.73	30.30	3.58
Ht-6	189.00	196.50	29.73	18.05	3.15
Ht-7	208.33	166.50	32.60	25.73	2.39
Ht-8	100.00	NA	29.20	19.27	2.04
Ht-9	111.00	90.00	32.53	21.34	3.23
Ht-10	205.33	159.00	29.06	18.73	3.12
Ht-11	650.00	NA	31.60	18.21	3.76
Ht-12	210.50	100.00	30.00	16.88	3.80
Ht-13	458.33	250.00	32.13	21.53	3.69
Ht-14	194.67	NA	32.93	20.39	2.88
Ht-15	100.00	NA	28.00	18.00	2.60
Ht-16	299.00	NA	27.20	40.96	1.78
Ht-17	106.50	NA	32.80	19.56	2.37
Ht-18	500.00	NA	31.80	22.11	2.19
Ht-19	116.50	NA	29.20	19.53	1.14
Ht-20	170.00	NA	30.80	20.32	1.95
SP-1	450.00	205.00	31.20	20.84	4.03
SP-2	344.67	267.50	34.40	23.34	3.37
SP-3	421.75	NA	23.60	14.04	3.47

NA = Not available
a = 2-4 vines planted on mound
b = 8-11 vines planted in beds