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Inbreds, Inbreeding Depression and Tuber Qualities of S1 and S2 Progenies in Taro (*Colocasia esculenta* L. Schott)

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Abstract

Taro is a perennial herbaceous tuber bearing plant belonging to the family Araceae. The tubers are a good source of starch and dietary fiber (4.3 g per 100 g fresh tuber). Preliminary work on selfing indicated that variation was less in the selfed progeny than in open pollination and it was possible to concentrate resistance genes towards leaf blight. Hence inbreeding was done in taro to identify the extent of selfing possible and to develop good genetic stocks for different characters. Three hundred and fifty accessions of germplasm and 10 breeding lines from Central Tuber Crops Research Institute, 42 collections from North-Eastern Hill region of India and six local collections were screened for flowering for two crop seasons. The flowering accessions ranged from 1.72–9.83% only in various seasons. Twenty five first generation selfed progenies (S1) and five second generation selfed progenies (S2) were obtained and 16 S1 and five S2 progenies were raised and analyzed for inbreeding depression, cooking quality, starch and sugar content. The phenotypic characters of the progenies, except for cormel shape, did not show remarkable variation. The S1 progenies were evaluated for yield and 12 inbreds were selected with cormel yield > 400 g plant^{-1}. Among 97 selected S1 lines with yield above 100 g plant^{-1} and good cormel shape, 35.1% were having non-acrid and soft tubers. In S1 progenies, starch content on fresh weight basis ranged from 11.8–33.1% and sugar 1.1-3.2%. Inbreeding depression was evident in the weight of corm (1.62%) and weight of cormel (4.72%). The number of corms showed significant negative inbreeding depression (-) 14.44% and the same in the case of cormel number was (-) 4.59%. There was varietal difference with respect to inbreeding depression which can be made use of for production of superior inbreds.

Key words: Inbreeding, inbreds, inbreeding depression, selfed progenies, corm, cormel, taro

Introduction

Taro is a perennial herbaceous tuber bearing plant belonging to the family Araceae and widely distributed in the tropical and sub-tropical regions of the world. The tubers are a rich source of starch. Most of the cultivated varieties in the taro growing countries are selections from germplasm. Flowering and seed setting are scanty and erratic in taro (Sreekumari and Thankamma Pillai, 1994). Preliminary work on selfing showed variation in selfed progeny but the variation was less than that in open pollination (Thankamma Pillai and Unnikrishnan, 1992). There is a possibility of getting homozygous population by continuous selfing and it is possible to concentrate resistance genes (Santha Pillai et al., 1993). Heterotic vigour can be exploited by hybridization of superior inbreds. Hence a breeding programme was undertaken to develop good genetic stocks for different characters, identify the extent of

selfing/inbreeding possible in a shy flowering crop like taro and to arrive at an ideal plant type with high yield, good tuber shape, non-acridity and good cooking quality. A study was also conducted on seasonal flowering behaviour.

Materials and Methods

Three hundred and fifty accessions of taro, 10 breeding lines from Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, India, 42 accessions collected from North-Eastern Hill region (NEH) of India (Meghalaya) and six local collections were screened for flowering at CTCRI, Thiruvananthapuram, India. Observations were recorded for two crop seasons viz., the first crop season was April to September and the second was October to March. Pollination was carried out by brushing fresh pollen on the female flowers, mostly on the day of female anthesis. However, accessions with low pollen shedding were pollinated according to the availability of pollen and exploiting the protogyny. Seeds obtained were sown in trays with river sand and powdered cow dung in 3:1 ratio. Seedlings with three to four leaves were transferred to polybags (16 cm x 12cm) filled with soil, river sand and powdered cow dung in 2:1:1 ratio. After 40-45 days, seedlings were transferred to the field at a spacing of 60 cm between ridges and 40 cm between seedlings and maintained as per package of practices (Kerala Agricultural University, 1993) at CTCRI.

The quantitative characters viz., number of corms plant^{-1}, number of cormels plant^{-1}, corm weight plant^{-1} and cormel weight plant^{-1} were recorded at the time of harvest and data were analysed statistically. Inbreeding depression, if any, in the inbred lines was analysed by comparing the percentage difference in the parameters between inbred population and open pollinated population. Cooking quality viz., softness and acridity were recorded following organoleptic tests. The starch and sugar was analysed and reported on fresh weight basis (Moorthy and Padmaja, 2002).

Results and Discussion

Germplasm collection from NEH

Forty two accessions of taro, mostly cultivars, were collected from NEH region; Meghalaya, India (Table1). The collections were made from Gharo, Khasi and Jawai hills in Meghalaya. Taro was cultivated as a mixed crop along with rice, legume, ginger etc. under the 'Jhum' system of cultivation. Wide variability for color, size and shape of tubers was observed. Majority of the collections were 'Dasheen' type with few or no cormels.

Table 1. Taro collections from Meghalaya (NEH)

Location	Number of accessions collected
Garo hills	6
Tura	3
Bhagmara	3
Shillong	1
Barapani	6
Umroi	3
Jawai Hills	4
Kanduli	5
Laitkore	5
NBPGR regional station (Shillong)	2
Konjoi	4

Flowering

Screening for flowering showed that, 33 out of 350 accessions of taro germplasm, two out of 42 taro collections from NEH region, 10 breeding lines from CTCRI and five local collections produced inflorescence. The frequency of flowering accessions in the first crop season; April to September, ranged from 6.03% to 9.83% and in the second crop season; October to March, it was 1.72% to 2.46%. Sreekumari and Thankamma Pillai (1994) reported low frequency of flowering in two crop seasons in earlier collections of taro germplasm. Germplasm accessions viz., C-57, C-164, Baranandi and the two breeding lines, H-67 and H-142 were found to be flowering prolifically irrespective of crop seasons.

Pollination

Pollination based on protogyny was successful (Jos and Vijaya Bai, 1977; Paradales, 1980). Twenty five S1 and five S2 were obtained and the percentage seed set showed wide variability ranging from low to very good. The seed set was significantly good in selfed population done at the time of female anthesis and was comparable with that in open pollinated fruits. Seeds germinated 7–10 days after sowing and 16 S1 and five S2 lines were raised along with its respective open pollinated seedlings. The field establishment of seedlings were very satisfactory.

Phenotypic characters of parents and progenies

The yield characters of parents are given in Table 2. Out of 16 parents, six were dwarf statured (<50 cm), nine were medium tall (50-100 cm) and one was tall (>100 cm). With regards to the color of the plants, 13 parents were green, 'Baranandi' was dark green, H-142 was light green and H-93-175 was deep purple. The phenotypic characters of the progeny, except for cormel shape, did not show remarkable variations from their respective parents. C-57 a dwarf parent produced only dwarf plants with slight variation among them in terms of height. In C-214, the tall parent did not produce any offspring exceeding the height of the parent (average height: 106.3 cm) and the progeny height ranged from 59–84 cm.

Very high variability was observed in the corm and cormel characters. The number of cormels per plant in the different progenies varied from 1–40 and its shape varied from semi stolon to club shape, conical, cylindrical and round (IPGRI, 1999). The number of corms per plant ranged from 1–6 and its shapes were conical, round or dumb-bell.

Cooking quality

The cooking quality was tested in 170 selected lines having an yield of above 100 g plant^{-1}, from S1, S2 and OP populations. The flesh colour of cooked tubers varied from white to greyish–white. Out of the 97 S1 lines, 34 (35.1%) were having non-acrid and soft tubers. In S2 lines and OPs, seven and 27 were non-acrid and soft, espectively (Table 3). Twelve S1 lines with non-acrid and soft tubers were having yield above 400 g. Thankamma Pillai and Unnikrishnan (1993) reported that those yielding above 400 g were considered as high yielders. Hence the results are promising with respect to the frequency of S1 lines for non-acrid and soft tubers as well as good yield.

Table 2. The yield characters of parents selected for selfing

Parent	Average number of corms	Average weight of corm (g)	Average number of cormels	Average weight of cormels (g)
C-12	1.7	63.0	20.3	203.0
C-25	1.7	86.0	10.0	248.3
C-57	2.7	61.3	12.7	176.7
C-68	2.0	55.0	15.7	226.7
C-164	1.3	72.5	12.3	170.0
C-214	1.0	181.7	9.3	241.7
N-214	1.3	135.0	10.7	243.3
DP-26	2.0	51.7	8.0	116.7
C-303	2.0	47.5	16.5	190.0
C-398	3.6	95.4	11.7	266.7
Baranandi	1.7	56.0	22.0	260.0
H-67	1.7	58.0	13.7	206.7
H-107	1.3	106.2	12.3	240.0
H-142	2.6	75.0	19.0	316.7
H-93-175	2.0	39.2	13.7	146.7
H-93-182	1.3	51.2	11.3	196.7

Each value is mean of three plants

Starch and sugar content in breeding lines

Starch content on fresh weight basis showed wide variability and ranged from 11.8% -33.1% in S1 lines and 17.8%-30.4% in S2 progenies (Table 4). Out of 34 non-acrid and soft tuber type S1 lines, nine were having above 25% starch. The sugar content varied from 1.1%-3.2% in S1 and 1.2%-2.5% in S2 progenies. Gautham et al. (2000) reported wide variability for starch and sugar contents in taro.

Performance of inbreds and estimation of inbreeding depression

Data on tuber characters of inbreds and open pollinated (OP) seedlings of 16 parents were compared to study inbreeding depression, if any, in the inbreds. The difference in the mean of each character was found out and the percentage was calculated (Table 5).

In general, weight of tuber showed inbreeding depression; + 4.72% for cormel weight and +1.62% for corm weight, whereas the number of tubers was not affected by inbreeding. Moreover, corm number showed significant negative inbreeding depression (-14.44%) and the same in cormel number was (-) 4.59%. For cormel number, 10 inbred progenies showed inbreeding depression and in six progenies, negative inbreeding depression was observed. In five out of 16 parents there was no deviation at all and in nine parents, inbreds showed better performance with regard to corm number. Similar results were reported by Easwariamma et al. (1985) in another tuber crop, cassava, where 50% of the parents showed negative inbreeding

Table 3. Cooking quality of S1, S2 and OP progenies (I clonal stage)

Progeny	Cooking quality	Number of seedlings	Average weight of corm (g)	Average weight of cormel (g)	Percentage of breeding lines based on *Cq.
S1	*na./s.	34	112.6	264.1	35.1
S1	na./*ms.	15	129.7	256.0	15.5
S1	*ma./s.	20	129.3	271.5	20.6
S1	ma./ms.	14	174.3	346.7	14.4
S1	ma./*h.	07	159.3	280.0	7.2
S1	*ha./h.	01	300.0	250.0	1.0
S1	ha./s.	03	91.7	333.3	3.1
S1	ha./ms.	03	136.7	328.3	3.1
Total S1		97			
S2	na/s.	07	128.6	247.1	53.8
S2	ma/s.	05	136.0	270.0	38.5
S2	ma/ms.	01	110.0	180.0	7.7
Total S2		13			
OP	na/s.	27	111.7	242.3	45.0
OP	na/ms.	13	160.8	340.4	21.7
OP	na/h.	02	100.0	300.0	3.3
OP	ma/s.	05	81.0	217.0	8.3
OP	ma/ms	11	189.1	340.0	18.3
OP	ma/h	02	60.0	192.5	3.3
Total OP		60			

*Cq: cooking quality; na: non-acrid; ma: medium acrid; ha: highly acrid; s: soft; ms: medium soft; h: hard

Table 4. Starch and sugar content in na/s progenies

	Starch (% on FW basis)	Sugar (% on FW basis)	Starch <20%	Starch 20-25%	Starch >25%
S1	11.87-33.1	1.1-3.2	14	11	9
S2	17.8-30.4	1.2-2.5	2	2	3
OP	9.2-29.6	1.7-3.4	10	10	7

FW: Fresh weight

Table 5. Percentage inbreeding depression for tuber characters

Parent	Cormel weight	Cormel number	Corm weight	Corm number
C-12	-19.07	-40.00	-16.67	-30.00
C-25	-11.72	-63.60	+3.59	0.00
C-57	+1.19	-55.78	-13.13	-15.00
C-68	+12.52	+4.00	-2.28	-27.00
C-164	+29.35	+6.00	+30.46	-10.00
C-214	-21.05	-38.00	-41.56	0.00
N-214	-4.40	+18.00	-35.16	-8.00
DP-26	+22.32	+17.80	+15.81	0.00
C-303	-24.55	-42.00	+6.50	0.00
C-398	+11.54	+20.00	-15.58	-18.00
Baranandi	-10.30	+0.80	+14.58	-27.00
H-67	+2.23	-5.00	-7.81	-20.00
H-107	-13.24	+8.00	+11.23	0.00
H-142	+35.01	+48.00	-4.34	-33.33
H-93-175	+20.00	+29.20	+27.55	+15.00
H-93-182	+45.70	+37.00	+52.57	+23.00
Mean	+4.72	-4.59	+1.62	-14.44

depression for number of tubers. Kawano et al. (1978) have also reported that notwithstanding the general inbreeding depression, superior inbreds can be produced in some genotypes of cassava. Thankamma Pillai and Unnikrishnan (1992) reported that the general performance of the inbred lines was inferior to that of OP and hybrids. This might be due to the limited number of progenies handled and varietal difference with respect to inbreeding depression. Inbreeding depression is expected from a crop, which is highly adapted to cross-pollination. Nonetheless, the varietal difference in taro can be made use of for production of superior inbreds.

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