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Selection in Arecanut Palm (*Areca catechu* Linn.)

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THE ARECANUT industry in India is of considerable size, the crop occupying a total area of 118,000 hectares. Four million people are reported to be associated with this industry. The per hectare yield is not generally satisfactory even though gardens giving yields as high as 4,250 kg. per hectare are not uncommon. Research on arecanut is hardly half a decade old. While considerable work has been initiated for the improvement of the crop through manurial, cultural and pest and disease control measures, the improvement of the crop by selection and breeding has received practically no attention. The cross breeding nature of the palm, the perennial habit and the time lag involved in the study of progenies are the major barriers in undertaking genetical and breeding investigations in the crop. In recent years breeding and selection programmes on coconut palm, which has more or less similar problems have been discussed at length (Harland, 1957; Sakai, 1960; Liyanage and Sakai, 1961; Charles, 1961). Breeding work in arecanut being still in pioneering stage, a breeding or selection programme incorporating known theoretical principles so as to achieve the desired crop improvement and also to elucidate information on refinement of some of the techniques will be most welcome. Results of correlation and heritability studies taken up and a mass-pedigree selection programme developed for the crop are discussed in this paper.

Patel (1957) recommended growing seednuts collected from open pollinated highly productive and well isolated gardens and growing seedlings from the crossed nuts obtained through controlled cross pollination of highly productive trees as a means of improvement. A scheme for production of elite seeds in arecanut has been suggested by Murthy and Bavappa (1961). Based on progeny tests and correlation and heritability studies, Bavappa and Ramachander (1967 a, b) have observed that heritability for yield is comparatively low and that positive phenotypic and genotypic correlations exist between number of leaves at the time of planting, girth at collar one year after planting and number of

nodes two years after planting with yield during the first four years of bearing. They also found that the transmitting ability in regard to yield is different for mother palms of uniform standards. The limitations of the present method of selection have also been discussed

MATERIALS AND METHODS

A total of 2,966 palms raised from open-pollinated seednuts in 41 families was under study at this Research Station since 1957 under uniform field conditions. Information on yield and various yield attributes of both progenies and mother palms were being regularly recorded. Correlation and heritability studies, family and individual palm evaluations and other appropriate statistical tests were undertaken.

RESULTS

Mother palm selection

Heritability for yield being very low (0.20) practically no improvement in yield could be achieved by resorting to selection for this character. Search was, therefore, made for characters having high heritability as well as correlation with yield. Values in respect of 11 characters examined are given in Table 1.

It will be observed from the above that out of the 11 characters considered, only age at first bearing and percentage of inflorescences to leaves shed have high heritability, genotypic correlation of the latter with yield, however, being very low. Percentage of nut set has medium heritability and high correlation with yield.

Since age at first bearing alone had a high heritability and significant correlations with yield, the yield pattern of palms of different bearing ages was examined. The results are given in Table 2.

It is seen from the above table that palms which come to bearing early are consistantly better yielders.

Even though mean weight of nut has negative genotypic, phenotypic and environmental correlation with number of nuts harvested, it has been observed that number of nuts produced has positive correlation with total weight. In order to examine whether there is a threshold value for number of nuts and mean weight of nut, data available were examined. The results obtained are given in Table 3.

From the above table it can be seen that inspite of considerable reduction in mean weight of nut, the total weight of nuts produced increases with increase in number of nuts.

Effect of seedling selection on age at first bearing

It had been established that in the case of seedlings, number of leaves at the time of planting, girth at collar one year after planting and number of nodes two years after planting have positive phenotypic and genotypic correlations with yield and that these characters have high heritability. Correlations were worked out between these three characters and age at first bearing. The results are given in Table 4.

The negative correlations go to show that exercising selection of seedlings for the above characters will aid in bringing down the age at first bearing of the population concerned.

In order to critically examine the effect of selection of seedlings (five leaves and above at the time of planting, 20 cm. and above girth at collar one year after planting and four nodes and above two years after planting) on age at bearing, data in respect of the population under study were tabulated. The results are given in Table 5.

It can be seen from the above that plants which commence bearing late are totally eliminated when selection standards are applied.

Transmitting ability of different yield attributes

It had been observed earlier that mother palms of uniform standards have differential transmitting ability in regard to yield. In order to examine the variability in transmitting ability of different yield attributes, mean data for 10 families classified into three yield groups of high (20 per cent above garden mean), medium and low (20 per cent below garden mean) were examined. The results are given in Table 6.

From the above it may be seen that percentage of set and the accompanying number of nuts and their total weight are the characters which show wider variability in regard to their transmitting ability.

Selection for higher yield by mass-pedigree system

The primary objective of arecanut crop improvement is the attainment of increase in yield. Even though certain seedlings and mother palm selection standards have been worked out improvement in yield by

other methods also deserve consideration. With this objective in view a selection programme as detailed below was initiated.

1. Gardens grown under average conditions were selected and palms yielding more than 60 per cent. of the garden mean were marked out for collection of seednuts as mother palms.

2. Plants numbering 2,966 belonging to 41 such mother palms were grown under uniform conditions.

3. A norm of 30 per cent. above the mean yield of the progeny garden was fixed and families screened. Three families out of the 41 which satisfied the above norm (bulk norm test) were selected.

4. All the palms of the selected three families were screened for yield using a norm of 30 per cent. above the mean of that particular family. They were also screened for their age at first bearing (5 years after transplanting) and for the established selection criteria of seedlings. Twenty palms which were found to satisfy these standards were selected.

5. Seedlings from the above plants are being grown in adequately replicated progeny rows along with two controls, (1) phenotypically high yielding mother palms (original selection) and (2) phenotypically high yielding mother palms (first generation) for assessing the improvement achieved. Seedlings will be subjected to the standard selection procedures at planting and in subsequent two years except in control plots.

6. The bulk norm test will be applied to eliminate undesirable families.

7. The seeds from families passing the norm test will be bulked after eliminating such of those plants whose yields fall below the family mean/ whole population mean of lines.

8. Direct distribution of the seeds as well as simultaneous multiplication in isolation, with regular emasculation of palms yielding less than garden mean will be taken up.

Taking into account the perennial nature of the crop and consequent limitations imposed in handling of large number of generations for achieving genetic gain by Mass-pedigree selection, superimposition of the technique of screening of individual plants for characters having high heritability has been attempted. A modified mass-pedigree system proposed for seed propagated, out-bred perennial crops is given in Fig. 1.

DISCUSSION

The necessity of ascertaining characters having high heritability values which can be considered in the selection of mother palms and the progress in the genetical constitution for yield that could be attained if selection is made on each of these characters has been brought out by Liyanage and Sakai (1961). Though characters such as age at first bearing, percentage of nut set, percentage of inflorescences to leaves shed, and number of inflorescences produced have fairly high heritability it is only the first two characters which have high phenotypic and genotypic correlations with yield and to this extent selection for these two characters alone will be advantageous. By confining selection of seednuts to 62 per cent palms which come to bearing at fifth year an increase in yield of 8 to 15 per cent can be expected depending upon the extent of selfing or nature of crossing taken place. This yield increase can be further enhanced by combining selection for age at bearing with selection of seedlings. Of the female flowers set a loss of about 20 per cent takes place due to tender nut shedding. The fact that the number of nuts set has a very high phenotypic and genotypic correlation (value being 0 97 and 1.08 respectively) with yield shows that almost the same set of genes control both these characters. Thus the difference observed between number of nuts set and number of nuts harvested (yield) is mostly due to environmental variation and there exists no genetic barrier between these two characters. This is also further supported by the low heritability (0.03) obtained for the percentage of nuts harvested to nut set. It, therefore, appears that by providing optimum environmental conditions yield in arecanut can be increased by about 20 per cent by preventing the tender nut shedding.

Even though mean weight of nut has negative genotype, phenotypic and environmental correlation with number of nuts harvested, number of nuts produced has positive correlation with yield. Thus inspite of the considerable reduction in the mean weight of nut, total weight of nuts increases with increase in number of nuts produced In breeding programmes selection of parents having larger number of nuts will be advantageous whatever may be the mean weight of nuts.

The differential yielding behaviour of the families seems to be only due to the widely different percentage of set and the accompanying variability in the number of nuts and yield. This finding is of considerable practical and fundamental importance due to the fact that it throws some light on the character of "prepotency" and will aid

in the selection of mother palms. The transmitting ability of yield of "prepotent" palms seems to be due to the transmissibility of percentage of set. It should thus be possible to use this character for identifying "prepotents". The heritability of this character being better than that of yield, direct selection for the same will also be useful. It may also be necessary that in the efforts to improve the fruit setting by methods such as assisted pollination, hormones spray, etc., the families with differential setting are treated separately.

Since the average effects of genes and not its genotype determine the breeding value of a palm, progeny testing is an important aspect in breeding programme. In cotton a final increase in yield of about 40 per cent has been achieved by progeny testing and selection of progenies based on a fixed norm (Harland 1949 a. b). The norm method of selection is appropriate for any character irrespective of the estimates of heritability and is particularly true in out breeding materials where recombination between the selected members can be forced and the released variability exploited for further improvement (Murthy, B R., personal communication, 1967). The introduction of characters having high heritability estimates and correlation with yield in the Mass-pedigree selection programme should improve its efficiency.

SUMMARY

Studies on the heritability of different characters and their correlation with yield were undertaken. Age at first bearing was found to have high heritability and significant correlation with yield during the first four years of bearing. Percentage of nut set was also found to be highly correlated with yield but the heritability of the same was relatively low. Even though the mean weight of nut is negatively correlated with yield, in the absence of a threshold value, the total weight of nuts produced increased with number of nuts. Selection of seedlings for number of leaves, girth at collar and number of nodes at the appropriate stage was found to eliminate totally the late bearing plants. The high yield of the progenies of "prepotent" palms was found to be due to the transmissibility of percentage of set. A selection programme initiated for arecanut has been outlined and a modified mass-pedigree system for out bred seed propagated perennial crops suggested.

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TABLE 1.—Correlation of Different Characters with yield (Number of nuts) and their Heritability

	Pheno-typic	*Genotypic*	*Environ-mental*	h^2
1. Age at first bearing	–0.45	–0 55	-0.65	0 72
2. Number of leaves shed	0.19	0.53	0.35	0 32
3. Number of inflorescences produced	0 41	0 02	0.59	0.46
4. Number of bunches harvested	0 72	0.27	0 77	0 10
5. Number of female flowers produced	0.55	-0.44	0 65	0 08
6. Number of nuts set	0.97	1 08	0 97	0.03
7. Percentage of nut set	0.78	0.88	0 75	0 33
8. Mean weight	-0.28	–0 58	–0 24	0 07
9. Number of nuts per bunch	0.84	0.86	0 82	0.22
10. Percentage of bunches to inflorescences	0.60	0 42	0.63	0.16
11. Percentage of inflorescences to leaves shed	0.42	0.04	0.69	0.60

TABLE 2.—Yield Pattern of Palms having different Age at First Bearing

Age at first bearing	*Percentage of occurrence*	*Yield (No. of nuts) in different years*				*Mean*
		I	II	III	IV	
5	62	109	211	255	305	220
6	32	—	139	148	208	165
7	4	—	—	58	95	76
8	1	—	—	—	34	34
9	1	—	—	—	—	0

TABLE 3.—Relationships between Number and Mean Weight of Nuts

No. of Nuts per Tree	*Percentage of occurrence*	*Total weight of nuts per tree (gm.)*	*Mean Weight of Nuts (gm.)*
0-50	20	904	39
51-100	16	2,953	39
101-150	18	4,796	38
151-200	13	6,540	37
201-250	10	8,681	37
251-300	7	9,295	35
301-350	5	11,412	35
351-400	6	12,715	34
401-450	2	12,178	36
451-500	2	14,967	33
501-550	1	16,975	33
551-600		19,200	33
751-800		21,810	28

TABLE 4.—Correlation between Seedling Characters and Age at First Bearing

Characters	*Correlations*	
	Phenotypic	*Genotypic*
1. No. of leaves at the time of planting	-0.16*	-0.25
2. Girth at collar after one year's growth	-0.30†	-0.21
3. Number of nodes after two years' growth	-0.23†	-0.41†

*Significant at 5 per cent level.
†Significant at 1 per cent level.

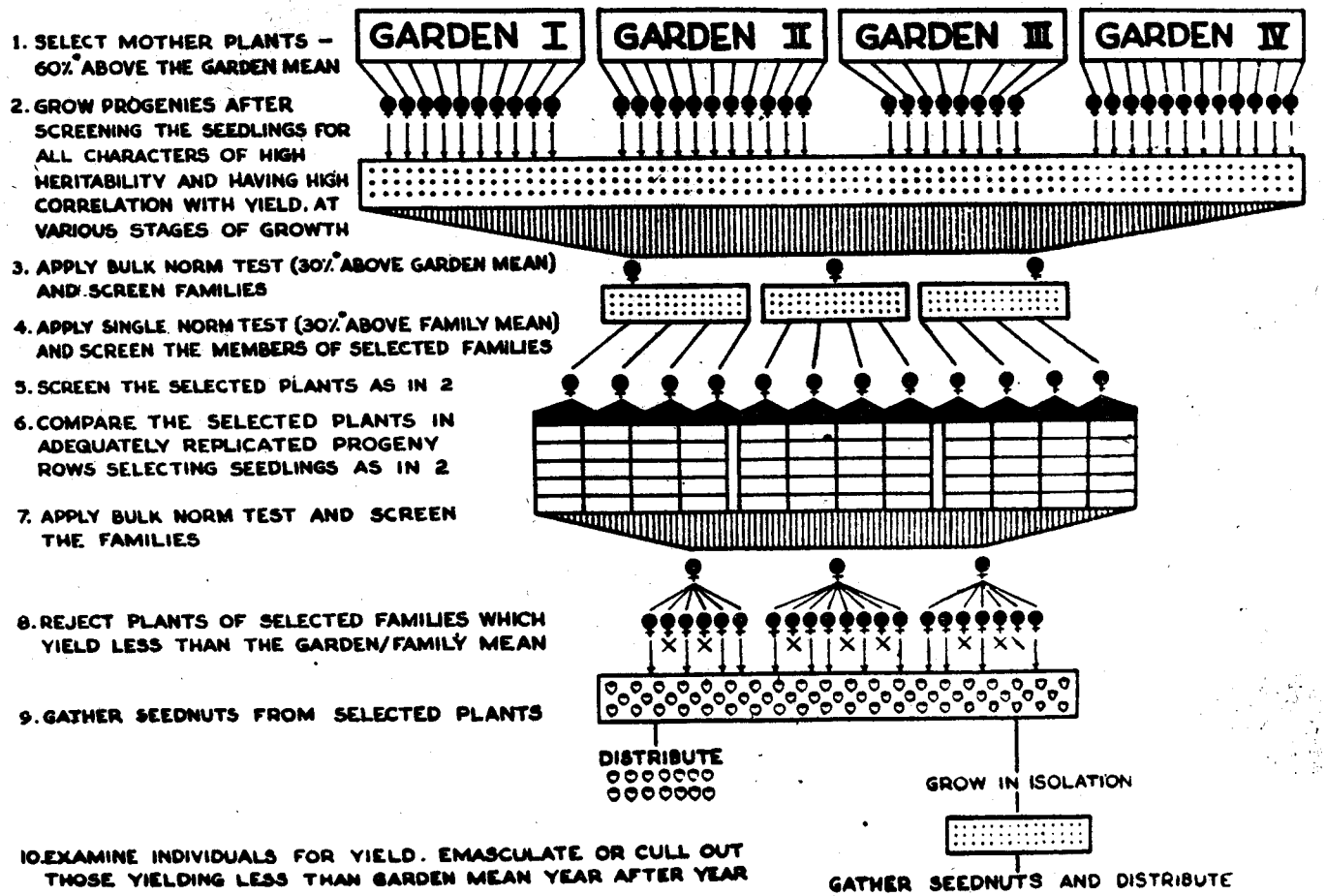
TABLE 5.—Effect of Selection of Seedlings on Age at First Bearing

Age at First Bearing	*Precentage of palms in different age groups*	
	Present stand	*After exercising selection*
5	62	74
6	32	25
7	4	1
8	1	0
9	1	0

TABLE 6.—Variability in Yield and Yield Attributes of Ten Families

	High	*Medium*	*Low*
1. No. of leaves shed ...	7.5	7.6	7.4
2. No. of inflorescences ...	5.2	6.0	5.1
3. No. of bunches ...	3.1	3.1	2.8
4. No. of flowers ...	1,043.6	1,172.2	1,045.0
5. Total No. set ...	328.0	291.4	145.0
6. Percentage of set ...	32.0	23.2	18 0
7. No. of nuts ...	271.7	222.6	159 8
8. Total weight (gm.) ...	9,731.3	8,662.6	6,071 5
9. Mean weight of nut (gm.)	37.7	40.2	38.0
10. Number of nuts per bunch	78.3	65 2	50 5
11. Percentage of bunches to inflorescences	57.6	49.0	51.5
12. Percentage of inflorescences to leaves shed	69.3	78.4	69.5
13. Percentage of nuts harvested to nut set	78.6	73.2	71.5

MODIFIED MASS-PEDIGREE SYSTEM FOR OUT BRED SEED PROPAGATED PERENNIAL CROPS



10. EXAMINE INDIVIDUALS FOR YIELD. EMASCULATE OR CULL OUT THOSE YIELDING LESS THAN GARDEN MEAN YEAR AFTER YEAR

* TO BE FIXED AS PER REQUIREMENTS