An analysis of successful cases and the factors responsible for these successes have proved without doubt that success has always been in proportion to the effort spent on tackling a problem. In general, the amount of money spent on biological control hitherto has been relatively very little. A recent investigation in the state of California has revealed amongst others the fact that in a period of about 36 years, the returns with respect to biological control were $ 30·00 for each dollar invested, while in the case of chemical control, the nationally accepted figure was $ 5·00 for each dollar invested. This should be sufficient inducement for any developing nation to divert more funds and attention for research in biological control. I do not mean to say that chemical control should be entirely abandoned, because considering the extent and type of agriculture that we have in the world today, it would be ridiculous to suggest such an idea. Rather, attempts must be made to combine or integrate the two methods judiciously and with long-range effects in mind and an ecological approach to pest control be pursued. A country such as ours certainly has the potential to do this, if only we can find dedicated scientific workers trained adequately in the fields of ecology and biological control.

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A Study of Variation Pattern in the Progenies of an Amphiploid of *Pennisetum* *

by

K. SREE RAMULU [1] and B. W. X. PONNAIYA [2]

Introduction: The study of cytogenetical behaviour of the natural polyploids and the evaluation of the breeding behaviour of their derivatives have been of particular interest to the geneticists and breeders in crops like *Sorghum, Allium, Triticum, etc.* The evaluation of the amphiploid progenies also throw much light on the nature of true genetic relationships (Grant, 1956). In this paper an account of morphological variation of the progenies of a colchicine induced amphiploid of F_1 of *P. typhoides* x *P. purpureum* is presented and the genetic segregation has been interpreted. The scope for the use of amphiploid progenies is indicated.

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[1] Ph. D. Scholar, Faculty of Cytogenetics and Plant Breeding, Agricultural College and Research Institute, Coimbatore-3. [2] Dean and Professor of Cytogenetics and Plant Breeding, Agricultural College and Research Institute, Coimbatore-3.

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Materials and Methods: The material comprised two species of *Pennisetum*, namely, *P. typhoides* Stapf et Hubb (2n : 14) and *P. purpureum* Schum. (2n : 28) and the hybrid of *P. typhoides* x *P. purpureum* (2n : 21), amphiploid of F_1 (*P. typhoides* x *P. purpureum*) (2n : 42) and the selfed progenies of amphiploid. The amphiploid was secured by vegetative treatment of the setts of F_1 with colchicine by Krishnaswamy and Raman (1949). The amphiploid gave sufficient seed set on selfing. A total number of 96 selfed progenies secured from the amphiploid was studied in detail for qualitative and quantitative characters. Anderson's (1949) methods of pictorialised scatter diagram and scoring of "Hybrid index" were adopted to evaluate the variation pattern and also for the simultaneous presentation of several variables in order to understand as to how the variation of each of the characters is more or less associated with that of the other in the amphiploid progenies.

Experimental Results: (a) *Plant Characters:* Out of 2860 seeds sown only 714 germinated, the percentage of germination being 24·9. At fourth leaf stage, majority of the plants showed retarded growth and reduced vigour. The final survival was 33·3 per cent. The seedlings showed segregation for albinos, green, purple and greenish purple colour.

At maturity, the progenies could be grouped into open, semi-open and erect types. The height of plants ranged from 150–500 cm. among which, seven plants were taller than amphiploid parent and 50 plants were shorter than *P. typhoides*. The progenies also showed variation for tillering and thickness of stem. The qualitative features indicated segregation for pigmentation of stem, bristle, and anther, nature of leaf margin such as serrate, dentate and texture of leaf. The activity of adventitious buds was found to be variable. In 44 plants the activity was maximum. Greater variation was noticed in length of leaf than in width. In most of the plants the length of spikelet exceeded *P. typhoides* and only 27 plants gave values exceeding that of *P. purpureum*. The number of tillers, length of panicle, bristles were of high expressivity while that of thickness of stem and width of leaf exhibited wide variation. The mean values of quantitative attributes of the amphiploid and their parents along with the selfed progenies are given in Table 1.

(b) *Variation Pattern:* The metroglyph analysis method of Anderson's (1949) was adopted to study the morphological variation in the selfed progenies. Eight morphological features, viz., height of plant, number of tillers, thickness of stem, length and width of leaf, length of panicle, length of bristles and spikelets were considered. The pictorialised scatter diagram was ploted by using the length of spikelet and length of leaf as the ordinate

TABLE 1. *Comparative behaviour of Quantitative characters in parents, amphiploid, and its progenies of P. typhoides × P. purpureum combinations (Mean values)*

All measurements in cm.

	Pennisetum typhoides (2n : 14)	*P. purpureum* (2n : 28)	F_1 hybrid (2n : 21)	Amphiploid (2n : 42)	Amphiploid progeny Mean/Range
Plant height	250	442	430	460	311·3 + 7·26 / 151 — 500
Number of tillers	1·2	38	34	39	14·82 + 0·75 / 2 — 45
Stem diameter	1·55	2·80	2·40	2·80	1·69 + 0·51 / 0·6 — 3·2
Leaf length	73·35 ± 1·24	109·00 ± 1·58	106·88 ± 1·83	101·36 ± 1·36	57·35 + 1·67 / 16 — 125
Leaf width	3·54 ± 0·9	4·50 ± 1·01	3·10 ± 0·06	3·66 ± 0·61	4·10 + 0·9 / 1·0 — 45
Leaf panicle	24·2 ± 0·08	25·1 ± 0·06	22·7 ± 0·03	23·60 ± 0·10	28·0 + 0·04 / 11 — 45
No. of groups of spikelets per cm axis	32	21	25	28	33·34 ± 0·86 / 16 — 55
No. per involucre	3·92	2·13	2·16	2·26	......
Length of spikelet	0·392 ± 0·05	0·802 ± 0·02	0·589 ± 0·01	0·612 ± 0·01	0·780 ± 0·01 / 0·5 — 1·1
Length of long bristle	0·61 ± 0·02	1·63 ± 0·02	1·20 ± 0·02	1·41 ± 0·03	1·73 ± 0·07 / 1·3 — 2·6
Length of short bristle	0·41 ± 0·010	0·75 ± 0·01	0·64 ± 0·04	0·62 ± 0·01	0·793 + 0·01 / 0·5 — 1·1
Pollen diameter (microns)	10·92 ± 0·05	8·54 ± 0·15	10·15 ± 0·12	15·57 ± 0·19	....
Pollen fertility (percent)	97	96	2	75	64·71 ± 0·06 / 16 — 100
Length of stomata (microns)	11·18 ± 0·09	8·55 ± 0·10	10·30 ± 0·12	11·44 ± 0·12	......
No. of stomata/ Unit area (1 mm. square)	3·87 ± 0·09	7·14 ± 0·21	4·59 ± 0·11	0·13	......

and abscissa, respectively. (Fig. 1). The other five characters were represented as rays emerging from each metroglyph and the height of plant was represented within the metroglyph. The score values assigned to the expression of each character are indicated in table 2.

The metroglyph of *P. typhoides* with five rays each with minimum score occupied a position much nearer to the point of intersection of the ordinate and abscissa while *P. purpureum* occupied a position farther away

TABLE 2. *Score Values for Morphological Characters*

S. No.	Characters	Marks		
		0	1	2
1.	Height (cm.)	Below 250	251—450	451 and above
2.	Number of tillers	1—5	6—10	11 and above
3.	Stem thickness (cm.)	0·6—1·5	1·6—2·5	2·6 ,,
4.	Length of leaf (cm.)	Below 75	76—100	101 ,,
5.	Width of leaf (cm.)	Below 3·5	3·6—4·5	4·6 ,,
6.	Length of panicle (cm.)	Below 20	21—30	31 ,,
7.	Length of bristle (cm.)	0·60–1·00	1·01—1·50	1·51 ,,
8.	Length of spikelet (cm.)	Below 0·45	0·46—0·75	0·76 ,,

from *P. typhoides* with the longest rays for all characters. The hybrid, *(P. typhoides* x *P. purpureum)* and the amphiploid occupied positions intermediate to both the parents (*vide* Fig. 1).

The pictorialised diagram revealed a total of 70 and 26 towards the top right of the diagram and 26 towards the top right of the diagram and those distributed towards top left showed increased values for spikelet length and decreased values for leaf length/breadth. Equal values for length of leaf as well as spikelets were exhibited by those scattered at right position of the diagram. There was a tendency for the leaf width always to be associated with leaf length and also frequently with spikelet length. The behaviour of the individual rays of the progenies exhibited a wide variation with respect to the expression of the characters in relation to one another thereby revealing the variation pattern of the amphiploid progenies. In general, a distinct skewedness was noticed in the amphiploid progenies towards *P. purpureum* in expression of many of the morphological features.

(c) *Hybrid Indices:* The hybrid index scores or marks (Anderson, 1949) allotted to different morphological characters of the amphiploid progenies of *P. typhoides* x *P. purpureum* are indicated under metroglyph analysis. The variation pattern is shown in Fig. 2. The hybrid index value of the amphiploid-progenies ranged from 4 to 15 (mean 9·39 ± 0·24) while that of F_1 hybrid (*P. typhoides* x *P. purpureum*) and its amphiploid possessed values of nine and twelve respectively. The scores assigned to *P. typhoides* and *P. purpureum* were 0 and 16 respectively. The indices of the amphiploid progenies confirmed the variation in the progenies as inferred

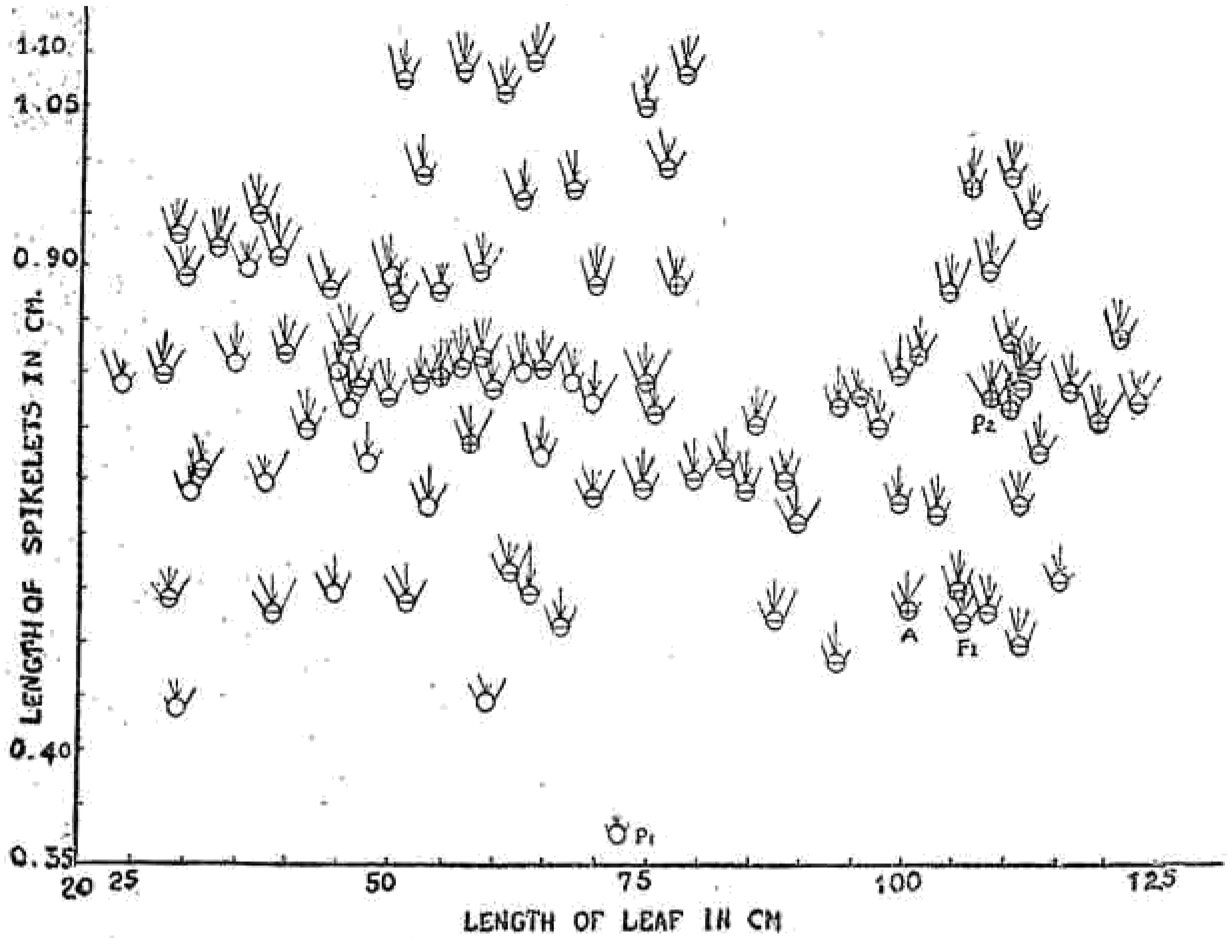

FIG 1.

Pictorialised scatter diagram showing the association of eight morphological characters in the progenies of amphiploid represented by short, medium and long rays.

(i) Plant height (cm.) Below 250 ○ 250—440 ⊖ 440 and above ⊕ ;

(ii) Number of tillers 1—5 short 6—10 medium 10 and above long ;

(iii) Stem thickness (cm.) 0·6—1·5 short 1·6—2·5 medium 2·5 and above long ;

(iv) Width of leaf (cm.) Below 3·5 short 3·5—4·5 medium 4·5 and above long ;

(v) Length of panicle (cm.) Below 25·0 short 25·0—30·0 medium 30 and above long ;

(vi) Length of bristles (cm.) 0·6—1·00 short 1·01—1·50 medium 1·50 and above long.

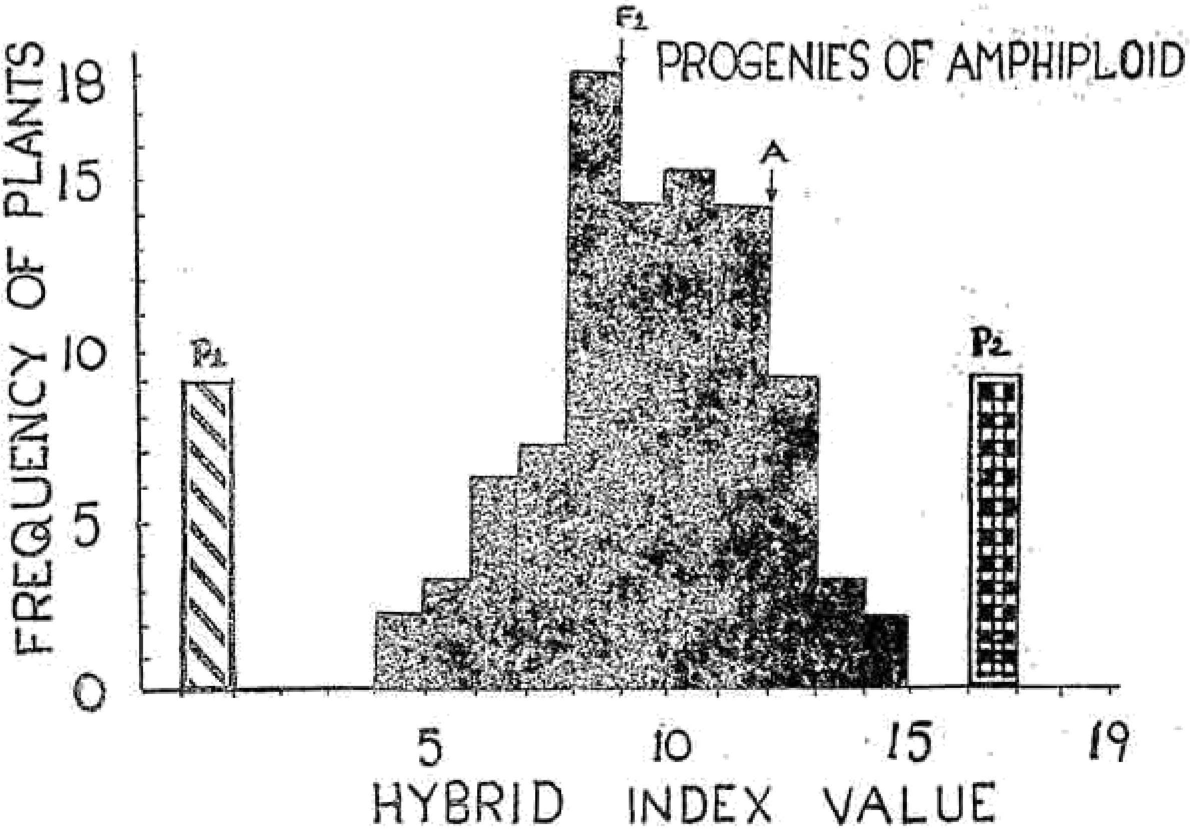

FIG. 2

The frequency distribution hybrid Index values of the progenies of amphiploid of F_1 (*P. typhoides* x *P. purpureum*) compared with parents, F_1 (*P. typhoides* x *P. purpureum*) and amphiploid.

P_1	— *P. typhoides*
P_2	— *P. purpureum*
F_1	— F_1 of *P. typhoides* x *P. purpureum*
Amphiploid-A	— Amphiploid of *P. typhoides* x *P. purpureum*

from the metroglyph analysis. The transgressive variation was also evident from the indices value that ranged from 4 to 15. A consideration of the individual rays also indicated that each character also showed variation in the progenies (Fig. 1).

Discussion: The selfed amphiploid progenies were secured from the somatically induced amphiploid of the *Cumbu-Napier* hybrid. The amphiploid and the selfed A_3 progenies were of autoallohexaploid nature (Krishnaswamy and Raman, 1954) and represented hexaploid status while the immediate hybrid parent was of triploid nature (allotriploid AA'B) derived by hybridization of allotetraploid *P. purepureum* (A'A'BB) x diploid *P. typhoides* (AA). The selfed progenies exhibited, albino and retarded growth probably due to variable expression of growth factors or due to genic unbalance as a consequence of selfing the amphiploid which is of outbreeding nature. In respect of many characters, contributed by *P. purpureum* a condition of intermediate expression with obvious dominance bias for

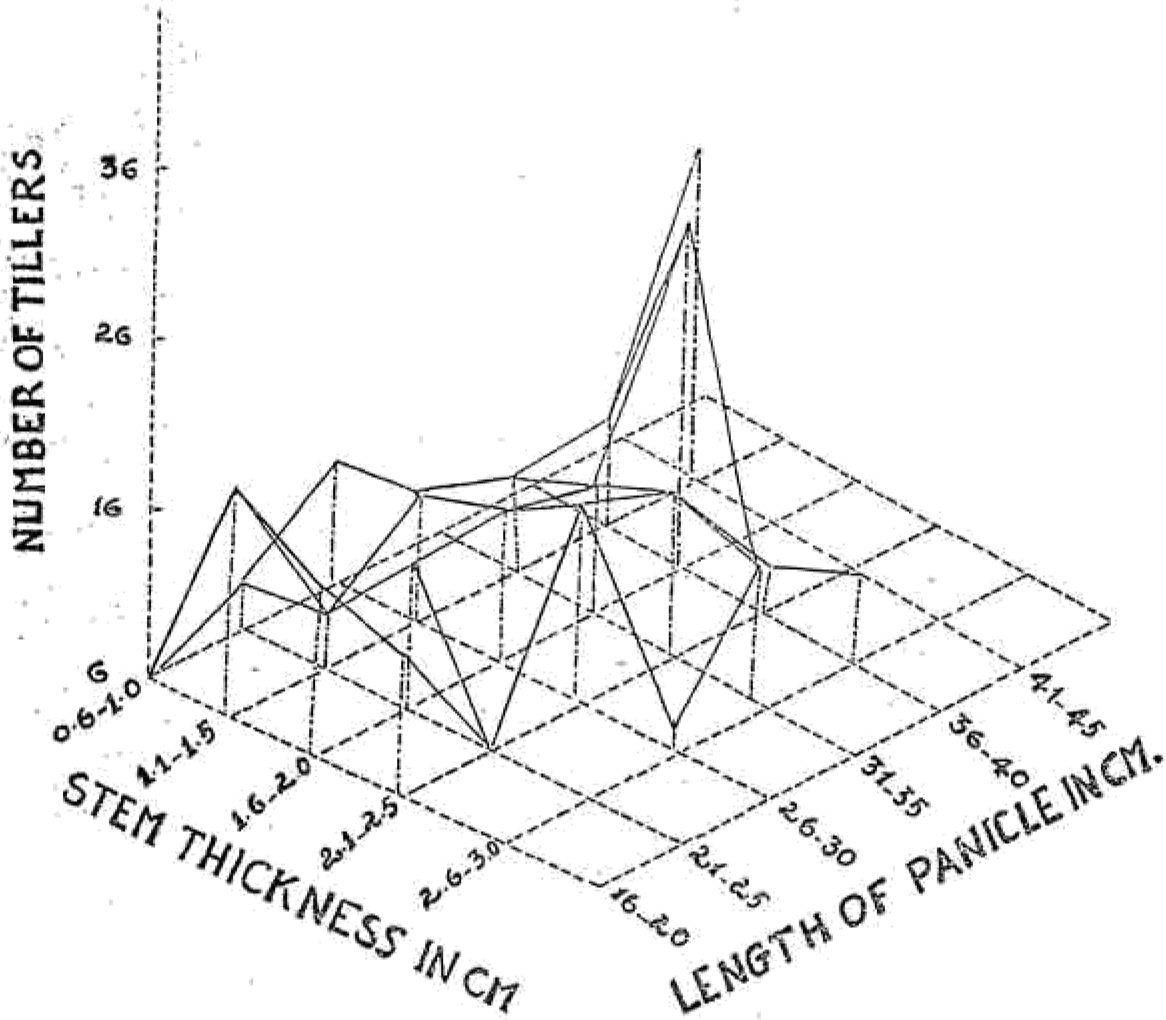

FIG. 3

The diagram showing the segregation pattern for tillering in relation to the stem thickness and length of panicle in the progenies of amphiploid of *P. typhoides* x *P. purpureum*
The skewed distribution for the number of tillers may be seen.

characters such as hairiness and tillering has also been noticed. This was also evident from the individual metroglyphs and their rays. Among the progenies transgressive segregation was noticed for tillering and stem thickness while the qualitative factors showed smooth segregation. All the segregants did exhibit random association of characters as inferred from the different rays of each glyph in the pictorialised scatter diagram.

The progenies showed stability for the 2n chromosome number (2n : 42) and also exhibited multivalents (Sree Ramulu, 1965). The amphiploids and their progenies would represent the genomic constitution of AA A'A' BB according to Krishnaswamy and Raman (1954). Hence the variability in the progenies might be thus due to genetic segregation resulting from the heterogenetic associations and also due to the heterozygosity *per se* of the parents that are cross pollinated. The segregation was also reported to be simple for pigmentation by Krishnaswamy and Raman (1954).

Quantitative variation in amphiploid progenies has also been pointed out by Bell *et al.* (1955) in the nature of transgression the amphiploid progenies of *Aegilops–Triticum.* The influence of polyploidy as related to the level of expression of characters, especially those of quantitative factors in modifying the variation pattern need also be mentioned.

Stapf (1934) has placed both *P. typhoides* and *P. purpureum* in the section *penicillaria* of *Pennisetum* by virtue of similarities and this has been confirmed from the segregation of the selfed A_2 progenies evaluated in the persent study. Among the parental species *P. purpureum* is a wild one and its phenotypic influence was also predominant in amphiploid and its progenies. Grant (1952, 1956) has pointed out the segregation in the raw allopolyploid derivatives as the best indication of genic differentiation. The interspecific differences are segregated. For polygenic characters also, the segregation in alloploids has proved useful. A certain extent of disharmony as a species differentiating factor was also evident from the appearance of lethal factors in A_2 progenies.

The amphiploid progenies which incorporated the genomes, namely, AA and A'A' BB of the two parental species that were cross-fertilised have shown variable pattern of morphological characters as result of selfing. However, the inbreeding differences of the genomes that were originally heterozygous were not either marked or probably being marked possibly due to the heterozygosity *per se* for many genic factors. The great store of potential genetic variability associated with the increased number of genes in the progenies of amphiploid provides an opportunity for developing new genotypes. Some of the desirable segregants in the progenies of amphploid obtained in the present study resembled the cultivated diploid in habit, stature, tillering, leaf and in a few panicle characters. These progenies may advantageously be utilised in backcrossing programmes for improvement of the cultivated species. The progenies with open, short, bushy and compact nature with some what smooth leaves resembling amphiploid can be utilized for forage purposes. The progenies might also possess entirely a new range of adaptability and testing of the adaptability and performance may lead to the selection of ideal types.

Summary: A total of 210 selfed progenies from the raw allopolyploid (2n : 42) of the parentage, *Pennisetum typhoides* (2n : 14) x *P. purpureum* (2n : 28) was analysed for the qualitative and genome variation. The method of metroglyph analysis was employed. Segregants showing transgression in certain attributes over the values for the parental species were observed in the progenies as a consequence of genic segregation arising from the heterogenetic association of chromosomes of the constituent genomes.

In spite of fairly high degree of recombination the population in general showed skewness in distribution towards *P. purpureum* as judged by the morphological characters studied. It is also inferred that for few attributes contributed by *P. purpureum* occurred more frequently. None of the morphological attributes of the progenies secured the maximum frequency for O' value class which represented the level of expression of characters of *P. typhoides*. The progenies showed a range of hybrid indices of four to fifteen with the mean score of $9{\cdot}39 \pm 0{\cdot}24$. The weak and lethal populations studied may be due to disharmony brought in by deleterious recombination of genes from the parental species.

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REFERENCES

Anderson, E. 1949 *Introgressive Hybridization* John Wiley & Co., New York.

Bell, G. D. H., M. Lupton and R. Riley 1953 Investigations in the *Triticinae* III. The morphology and field behaviour of the A_2 generation of interspecific and intergeneric amphidiploids. *J. agri. Sci*, **43**: 105-15.

Grant, V. 1956 The genetic structure of races and species in *Gilia*. *Adv. Genet.*, **8**: 55-84.

Krishnasamy, N., and V. S. Raman 1949 A note on the amphidiploid of the hybrid of *Pennisetum typhoides* x *P. purpureum* *Curr. Sci.*, **18**: 15-6.

—— and —— 1954 Studies on the interspecific hybrid of *Pennisetum typhoides* x *P. purpureum*. III. The cytogenetics of colchicine induced amphidiploid. *Genetica*, **27**: 253-72.

Sree Ramulu, K. 1965 Studies on the cytomorphology of the progeny of a raw allopolyploid in *Pennisetum*. *Diss.* M. Sc., Ag. Madras (Unpubl.)

Stapf, O. 1934 *Flora of Tropical Africa* L. Reeve & Co., Kent.