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THE BIONOMICS OF THREE SHORT-DURATION VARIETIES OF RICE

(With reference to effecting economy in the cost of cultivation.)

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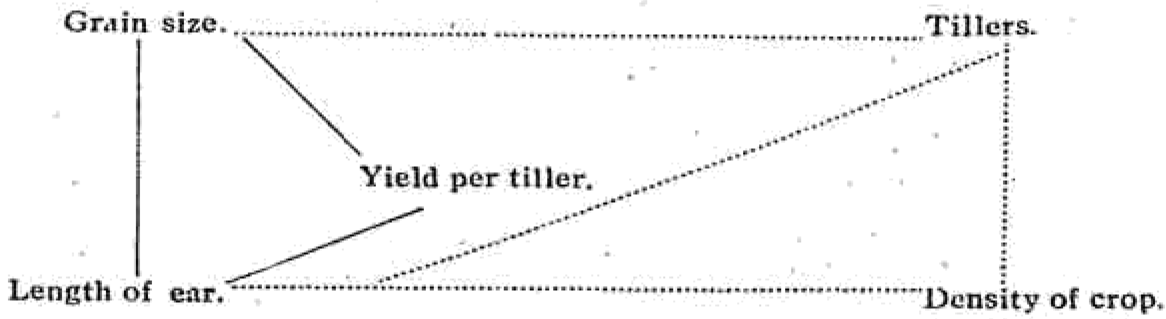
Introduction. In the evolution of high-yielding strains of a variety, a study of the latter to find out its response under varied conditions of farming is of the utmost importance. Unless its behaviour is previously known the selection will have to be based only on the empirical methods of selecting well tillered and long eared plants.

Popular requirements may vote for an attractive ear while tillering may carry weight with considered judgment. But this cannot be said to hold true as a general principle in all varieties of the same duration and much less in those of different durations. The nature, number and mode of tillering though partly a genetic manifestation are a function of the life-period. It has always been the experience in cereals that to make a selection for high yield is no easy task, though many useful characters are correlated. Some of the important correlations are diagramatically represented below.



Lines denote positive correlation while dotted lines indicate negative correlation.

The number and intensity of correlations and the number of factors interacting will be increased in a segregating population, thus adding to the already existing difficulties of the plant breeder. Further this behaviour is common to all cereals. Hunter (1931) states that in oats, large seeded varieties do not usually possess high tillering propensities. This is in conformity with the observations in rice. Myers in wheat finds only a slight correlation between the number of culms and weight of grain per culm. Leighty found in oats that as the number of ears borne by the plants increased the amount of grain from each culm would also increase.

It is therefore obvious that the ordinary ryot is fairly justified in having his own apprehensions about the prospects of a variety newly introduced into his tract.

The peculiarities of the local climate are important factors in determining the suitability or otherwise of a new variety; but in the case of strains of a local variety, considerations on this score are not expected to be of much moment unless the strains be remarkably divergent from the parent variety, in being either very early or very late or in some other character of agricultural importance. The study of the bionomics of a strain therefore becomes immediately important.

But nevertheless the economic aspect of raising a crop should not be lost sight of and efforts should be made as far as possible to economise material and expenditure at every stage.

Material. In view of the above work on three short duration varieties, viz., *Wateribune*, *Swarnalu*, and *kasi pichodi* was started as a preliminary to further studies on strains and new varieties. The experiment was conducted at the Agricultural Research Station, Maruteru. A brief description of the habits of the three varieties will not be out of place.

Wateribune is a variety imported from New South Wales. Though it was a 4 to 5 months variety in its home, change of habitat reduced its duration to about 3 months. A primary flush of poor ears and a rich bountiful crop of secondary good sized ears on taller culms is a feature of this variety.

Swarnalu is a local variety grown in both the seasons—main and second crop seasons—wherever a short duration crop is required. The number of tillers in this variety is great and they are set wide as opposed to the scanty and close set tillers of *Wateribune*.

Kasi Pichodi is a variety with a fine grain and with a larger number of erect tillers set close together.

Details of the experiment. Though it is a common belief that closer planting tends to give greater yields with short duration varieties, attempts at reduction of cultivation expenses without impairment of yield necessitate the finding out of methods to economise seedlings. The experiment was designed as below:

Treatment.	Particulars.
I.	4″ × 4″—Single seedling per hole.
II.	7½″ × 7½″— „ „ „
III.	do. —Three seedlings „
IV.	12″ × 12″— Six „ „
V.	15″ × 15″— Ten „ „

Excepting the last treatment in *Wateribune* all the treatments were tried in the three varieties.

Economy effected.—The number of seedlings planted out in an unit area of 5′ × 5′ works out in the five treatments as below.

Treatment.	Number of seedlings planted.	Percentage economy in seedlings.
I.	256	—
II.	81	68·4
III.	243	5·1
IV.	216	15·6
V.	250	2·4

It is obvious that in treatments I, III and V, there is practically no economy in the number of seedlings required. Treatment II is again a drastic economy in the number of seedlings by two-thirds while treatment IV embodies economy in labour and in about one-sixth of the seedlings required.

Characters studied. (i) General.—The close planted units were lighter in foliage colour and grew taller than the wide planted ones. The latter bushed out very well and presented a sturdier appearance without any lodging as distinguished from the others.

(ii) *Tillering.*—(a) *Number of tillers.*—For purposes of this study only ear-bearing tillers were considered. The following gives the number of plants studied in the several treatments.

Treatments.	Number of plants in 5′ × 5′.		No. of blocks observed.	Total.
I.	256	×	2	512
II.	81	×	2	162
III.	81	×	2	162
IV.	36	×	4	144
V.	25	×	4	100

As the sample is pretty large, random errors due to fluctuation are reduced tc a minimum.

The tiller counts were reduced to a uniform plot size of 5′ × 5′ foı facility in comparsion and are set out in table 1.

Table 1. *Number of tillers per unit area, per hole and plant.*

Particulars.	Treatments.				
	I	II	III	IV	V
Wateribune.					
Tillers per 5′ × 5′.	744	583	705	698	
per cent.	100	78·3	94·8	93·8	
,, per hole.	2 9	7·2	8·7	19·4	
,, per plant.	2 9	7·2	2·9	3·23	
Space enjoyed per plant in sq. in.	16	56 25	18·72	24	2[illegible]·5
Proportionate no. of tillers per 16 sq. in.	2·9	2·05	2·48	2·15	
Per cent.	100	70·7	85 5	74·1	
Swarnalu.					
Tillers per 5′ × 5′.	1036	770	900	874	854
,, per cent.	100	74·3	86·9	84·4	82·4
,, per hole.	4 05	9·51	11·11	23·44	34·16
,, per plant.	4·05	9·51	3 70	3 91	3·42
Proportionate no. of tillers per 16 sq. in.	4·05	2·70	3·16	2·61	2·43
Per cent.	100	66·6	78·02	64·1	60·0
Kasi Pichodi.					
Tillers per 5′ × 5′.	1231	894	1145	1052	1126
,, per cent.	100	72·6	93·0	85·5	91·5
,, per hole.	4 81	11·04	14·13	29·14	45·0
,, per plant.	4·81	11·04	4·71	4·84	4·5
Proportionate no. of tillers per 16 sq. in.	4·81	3·14	4·03	3·23	3·23
Per cent.	100	65·3	83·7	67·1	67 1

It is clear from the table that (i) no other treatment yields as many tillers as the 4" planted singles; (ii) economy in the number of seedlings result in the reduction of total number of tillers per unit area as restated in Table 2.

Table 2. *Economy in seedlings and reduction in the number of Tillers per unit area.*

Treatment.	Percentage economy in seedlings.	Percentage reduction in the total number of tillers in		
		Wateribune.	Swarnalu.	Kasi Pichodi.
II.	68·4	21·7	25·7	27·4
III.	5·1	5·2	13·1	6·9
IV.	15·6	6·2	15·6	14·5
V.	2·4		17·6	8·5

Though direct proportion cannot be strictly applied, the number of tillers per plant expressed to a uniform space of 16 sq. in. in the several treatments indicates their relative merit. The percentage loss of tillers per plant in an unit space is set out as below.

Table 3. *Percentage loss of tillers per plant on unit area basis.*

Treatment.	Percentage economy in seedlings.	Percentage loss in			Tillers per plant in Trt. I.
		Wateribune	Swarnalu	Kasi Pichodi	
II.	68·4	29·3	33·4	34·7	Wat. 2·9
III.	5·1	14·5	22·0	16·3	Swar. 4·05
IV.	15·6	25·9	35·6	32·9	Kasi P. 4·81
V.	2·4		40·0	32·9	

(iii) Tables II and III bring out that the amount of loss in the number of tillers per unit area and number of tillers per plant depend on the percentage economy effected and on the tillering capacity of the varieties. This is amply illustrated by comparing the amount of loss in *Wateribune*, a poor tillerer, against that in *Swarnalu* or *Kasi Pichodi*.

It will therefore appear that the tillering suffers more in profusely tillering varieties than in poor tillering ones under any unfavourable conditions. It will also be observed from Treetment II that greater spacing affords scope for greater loss in the number of tillers per unit area and the occurence of gaps in a field will further add to the loss in the tillers per unit area. The yield will consequently be reduced though it is believed that the neighbouring plants will make up for the gaps to some extent.

(b) *The composition of the population.* The composition of the population in the different treatments according to the tiller classes—1-tillered plants, 2-tillered plants, etc.—merits consideration. On the dissection of some stools it has been found that the constitution of the same tillered class varied to some extent. For instance, a 5-tillered plant may be of the constitution of—

$$\text{(i) } T_0 - T_1 - T_2 - T_3 - T_4 .$$

$$\text{(ii) } T_0 - T_1 - \underset{t_1}{T_1} - \underset{t_2}{T_1} - T_2 .$$

$$\text{(iii) } T_0 - T_1 - \underset{t_1}{T_1} - T_2 - T_3 .$$

$$\text{(iv) } T_0 - T_1 - T_2 - \underset{t_1}{T_2} - T_3 .$$

(*Note:* T_0 — Primary tiller.
$T_{1,2,3,4.}$ — Secondary tiller.
$\underset{t_{1......4}}{T_{1......4}}$ — Tertiary tillers).

The different constitutions have obviously different yield potentialities in as much as a daughter tiller of a secondary tiller (say $\underset{t_1}{T_2}$) may not yield as much as that of a late secondary tiller, say T_4 or T_6. A most important point that remains unattempted is whether a 5 tillered plant for instance will have the same constitution in the different treatments of spacing and crowding. Ordinarily, spacing will encourage tertiary tillers, while crowding in a hole, resulting in the lengthening of the bottom internodes may encourage tillers of only the secondary phase. The data gathered on the composition of the population is set out in Table 4.

Table 4. *Details of the tillering composition of the population.*

Particulars.	Treatments.				
	I	II	III	IV	V
Wateribuns.					
Range from—to.	1—4	4—16	3—12	7—26	
No. of classes in the range.	4	13	10	20	
Mean tillers per hole.	2·9	7·2	8·7	19·4	
P. E.$_m$	±·057	±·174	±·150	±·314	
C. V.	30·7	36·1	28·9	32·8	
Swarnalu.					
Range from—to.	1—8	3—13	5—19	15—36	21—45
No. of classes in the range.	8	11	15	22	25
Mean tillers per hole.	4·05	9·51	11·11	23·44	34·16
P. E.$_m$	±·115	±·164	±·270	±·312	±·509
C. V.	49·1	29·0	34·9	20·6	21·9
Kasi Pichodi.					
Range from—to.	1—13	5—15	4—22	23—40	23—48
No. of classes in the range.	13	11	19	18	26
Mean tillers per hole.	4·81	11·04	14·13	29·14	45·04
P. E.$_m$	±·153	±·199	±·226	±·303	±·481
C. V.	57·2	29·5	30·5	15·9	17·6

The probable error of the mean, as may be seen from the table, is relatively small in all cases thereby giving greater confidence in the averages obtained.

It will be noted here that the observations of Mitra (1924) on the variation of tillering in broadcasted *aus* (short duration varieties) confirm those arrived at in these varieties. The variation in tillering in about 56 to 59 varieties observed for three years in broadcasted *aus* was found by him to vary between 19·0 and 25·7 % with a mean tillering of 2·7.

(c) *Effect of crowding on tillering.* Previous experiments at Aduturai, on short duration varieties, [Srinivasa Ayyangar, 1925] have shown, that, given the same spacing, crowding in a hole reduced the number of tillers per plant as per data given below.

Treatment.	No. of tillers per hole.	No. of tillers per plant.	n	σ	P. E. m	P. E. d	D / P. E. d
3"×3" — singles.	2·13	2·13	987	0·82	·018	0·034	$\frac{0·305}{0·034}$ 9·0
6"×6" — 4 plants per hole.	7·30	1·83	483	0·95	·029		

Note:—Differences between means highly significant.

Dionisio Calvo (1927) arrived at the same conclusion in a study of the Philippine varieties. An observation of the same fact made Londsdale (1909) to surmise "that due to this practice of planting most varieties in bunches the varieties lose their power of tillering but this can be regained if the seedlings are planted singly year after year." An analysis of the effect of crowding on tillering is given in Table 5.

Table 5. *Effect of crowding on tillering.*

Particulars	Treatments. III	IV	V	Remarks.
Wateribune.				No. of tillers in 4"×4" is 2·9 per plant. Calculated according to the above rate of tillers for plant.
No. of tillers observed.	8·7	17·4		
do. calculated.	8·7	19·4		
Deviation.	—	+2·0		
Std Dev.	2·24	4·69		
D/S. D.	·–	0·43		
Swarnalu.				
No. of tillers observed.	11·11	23·44	34·16	No. of tillers per plant in 4"×4" is 4·05.
do. calculated.	12·15	24·30	40·5	
Deviation.	–1·04	–0·86	–6·34	
Std. Dev.	4·03	4·96	7·60	
D/S. D.	0·26	0·17	0·83	
Kasi Pichodi.				
No. of tillers observed.	14·13	29·14	45·04	No. of tillers per plant in 4"×4" is 4·81.
do. calculated.	14·43	28·86	48·1	
Deviation.	–0·30	+0·28	–3·06	
Std. Dev.	3·35	4·5	7·14	
D/S. D.	0·09	0·06	0·43	

Reviewing Table 5 it will be noted that in all cases the deviations of the observed from the calculated number of tillers per hole are not significant. It will therefore follow that the plants in wider spacings of treatment III, IV, and V have behaved as regards the tillering aspect as though they are the members of a field of 4"×4" spacing. Whether this will also amount to mean that the increased spacings of 18·72, 24·0 and 22·5 sq, inches (Table I) per plant in treatments III, IV and V have compensated for any depressing effects is not clearly known. Hence the crowding and the increased spacings per plant in the above treatments have apparently counteracted each other.

(iii) *Flowering.* A note of passing mention may be made with reference to flowering. The closer planted units flowered earlier than the wider planted ones the range being shorter in the former than the latter.

Table 6. *Mean and Range of flowering dates.*

Particulars.	Treatments.				
	I	II	III	IV	V
Wateribune.			August		
Range of flowering.	8–14	8–20	8–23	8–24	
,, ,, in days.	7	13	15	17	
Mean flowering date.	9th	12th	10th	13th	
Swarnalu.					
Range of flowering.	8–16	9–21	8 26	9–25	9–25
,, ,, in days.	9	13	19	17	17
Mean flowering date.	11th	14th	13th	15th	15th
Kasi Pichodi.					
Range of flowering.	9–16	9–21	9–21	9–21	12–24
,, ,, in days.	8	13	13	13	13
Mean flowering date.	12th	13th	13th	15th	17th

With the wider planted units the flowering occured in two to three spells at intervals of two to three days. Much can be said in favour of a short flowering period; but generally the prolonged flowering is not viewed with the same spirit of welcome as the former. Sharpness of flowering in good weather ensures uniform ripening and a clean harvest; while prolonged flowering does not result in uniform ripening. Consequently losses occur due to shedding of over ripe grain when the crop is detained on the field for the under ripe grains to mature. In inclement weather sharpness of flowering has equal chances to escape loss due to weather or to get badly affected. But prolonged flowering ensures good harvest of at least a portion of the crop. This is the ryot's point of view who always wants to risk the least by avoiding "to put all the eggs into one basket to hatch." This appears to deserve some notice especially in these days of 'Economic Depression'.

(iv) *Length of ear.* The length of ear is an important attribute in all studies of yield. Though the "weight of ear" is the one that is directly concerned with the yield, the handling of this attribute entails more labour and involves other difficulties as the sheding of grain etc. The weight of ears will be seen below, is proportionate to the length of ear. Srinivasa Ayyangar arrived at the following figures in the Kuruvai variety.

Table 7. *Density of Ear.*

Spacing.	Mean length of ear. in cm.	Mean weight of grain per ear in gm.	Density.	Remarks.
3″×3″	17·8	1·18	0·0669	
4″×4″	18 7	1·62	0·0866	
6″×6″	20·0	1·54	0 0770	
8″×8″	20·8	1·64	0·0778	
6″×12″	21·6	1·78	0 0824	
12″×12″	23·4	1·98	0·0846	
No. of plants per hole, spaced 6″×6″				
2	20·0	1·54	0·0770	
3	20·5	1·46	0·0712	
4	19·1	1·36	0·0712	
5	18·7	1·32	0·0706	
6	19·1	1·24	0·0649	

Examining the density of ear in the three varieties in this experiment with reference to the length of ear, the coefficients of correlation in two of the varieties are

Wateribune + 0·34 ± 0·05
Swarnalu + 0·36 ± 0·05

Though the coefficient of correlation obtained denote a tendency to positive relationship between the two factors it is not high enough to warrant serious consideration. The third variety *Kasi Pichodi* could not be handled as the grains were shedding when the ears were kept for drying. The figures of Srinivsa Ayyangar (loc. cit) also show that the density of ear remains constant within limits except when the environment, eg. space, has been economised too much as in the case of very close planting or too much crowding in the hole. Therefore the density of the ear has been found to be constant under the usual spacing. Thus the "length of ear" appears adequate for the study of yield in this problem.

(*a*) *Mean length of ear.*—The mean length of ear along with the statistical coefficients is given in table 8.

Table 8. *Mean length of ear.*

Particulars.	Treatments.					Remarks.
	I	II	III	IV	V	
Wateribune.						
Mean in cm.	20·5	20·7	20·6	20·4		
Per cent.	100	100·97	100·6	99 3		
P. $E._m$	± ·184	± ·187	± ·219	± ·171		
C. V.	13·9	14·1	15·5	12 8		
Swarnalu.						
Mean in cm.	19·7	22·4	20·4	21·1	20·4	
Per cent.	100	113·7	103·5	107·1	103·5	
P. $E._m$	± ·207	± ·179	± ·289	± ·223	± ·241	
C. V.	15 6	12·0	13·6	15·5	13 3	
Kasi Pichodi.						
Mean in cm.	21·2	22·4	21·9	21·7	21·8	
Per cent.	100	106·7	103·3	102·3	102 8	
P. $E._m$	± ·199	± ·186	± ·171	± ·187	± ·178	
C. V.	13·8	12·3	11·4	12·7	12·05	

It will be noted that the mean length of ear does not vary significantly in general except in the case of *Swarnalu* treatment II and IV, and *Kasi Pichodi* treatment II.

The range of ear length with the corresponding mean minimum and maximum is given in table 9.

Table 9. *Range of ear length in cm.*

Variety.	Treatments.				
	I	II	III	IV	V
Wateribune.					
Mean, min. and max. range.	18·2–22·6 4·4	16·6–24·4 7·8	16·3–24·0 7·7	15·6–24·5 8·9	
Swarnalu.					
Mean, min. and max. range.	16·8–22·1 5·3	18·2–25·6 7·4	16·2–24·3 8·1	14·3–25·7 11·4	13·7–25·6 11·9
Kasi Pichodi.					
Mean, min. and max. range.	18·4–23·8 5·4	17·9–25·5 7·6	16·9–24·9 8·0	16·3–25·8 9·5	15·9–26·1 10·2

From the table it will be observed that as the spacing increases the range also increases ; and it will be interesting to note that the wider range in increased spacing is brought by the lowering of the minimum with a simultaneous rise of the maximum.

(*c*) *Tillering and the range of ear length.*—The range of ear length is next studied with reference to the several tiller classes in the population as given in Appendix A (i, ii, and iii). On working out the relationship between the tillering and the range of ear length in each of the treatments the following coefficients of correlation are obtained.

Table 10. *Coefficient of correlation between the number of tillers and the range of ear length.*

Treatments.	Wateribune.	Swarnalu.	Kasi Pichodi.
I	+0·94±·045	+0·88±·062	+0·89±·049
II	+0·74±·092	+0·41±·186	+0·38±·173
III	+0·67±·113	+0·29±·179	+0·73±·091
IV	+0·47±·136	+0·63±·134	+0·45±·189
V			+0·59±·155

It is obvious from the table that the range of ear length bears in general a fairly high positive correlation with tillering, i.e., with the increase of tillering per hole the range of ear length is also increased. Further it is of interest to note that the same high positive correlation is obtained with plants crowded in a hole as with plants planted singly wide apart. This will therefore give an impression that plants crowded in a hole behave collectively and as regards earing are comparable to a well-tillered plant. It will be recalled that these plants crowded in a hole have behaved, as regards tillering like plants of 4" × 4" spacing, as regards ear length and its relationship with tillering, they resemble a single plant spaced wide apart.

Significance of the co-efficient of correlation. Working out the probable error of *r*, we find that *r* is significant in 9 cases out of 13. But the application of Fisher's table 16 reveals a level of significance between P=·05 and P=·01 in only 5 cases out of 13. The probable causes of such a discrepancy may be due to (i) limitation of the attribute under study, (ii) errors of random sampling.

(d) *Tillering and mean ear length.* Before we proceed to analyse the range of ear length in greater detail it may be incidentally observed that the mean-ear length bears no significant relationship to tillering,

Table 11. *Coefficient of correlation between tillers and mean ear length.*

Treatment.	r. Tillers. Mean ear length.		
	Wateribune.	Swarnalu.	Kasi Pichodi.
I	−0·48±·297	+0·20±·263	+0·32±·213
II	−0·05±·202	−0·37±·194	+0·28±·188
III	−0·11±·200	+0·51±·144	+0.54±·137
IV	−0·01±·174	+0·56±·153	−0·33±·211
V		+0·39±·202	−0·39±·199

(e) *Relation of the components of range of ear length with tillering.* It is found that the range increases with spacing and with tillering as well. The fact that increased range is brought by lowering the minimum and raising the maximum keeping the mean almost unaffected, has also been observed.

Analysing the range into its components, their relation with tillering is obtained by the following coefficients of correlation.

Table 12. *Tillering related to maximum and minimum ear-lengths.*

Treatments.	r. Tillers Minimum.			r. Tillers Maximum.		
	Wateribune.	Swarnalu.	Kasi Pichodi.	Wateribune.	Swarnalu.	Kasi Pichodi.
I.	−0·77±·158	−0·76±·114	−0·64±·141	+0·19±·376	+0·79±·103	+0·81±·080
II.	−0·50±·152	−0·37±·195	−0·10±·201	+0·64±·119	−0·04±·225	+0·70±·103
III.	−0·43±·166	+0·30±·178	−0·52±.141	+0·53±·146	+0·58±·129	+0·76±·081
IV.	−0·53±·126	−0·46±·177	−0·19±·229	+0·17±.169	+0·76±·094	+0·34±·211
V.		+0·06±·237	+0·26±·218		+0·50±·238	−0·58±·155

It is obvious from the table that increase in tillering is associated with lowering of the minimum and raising of the maximum ear length.

Yield. The several treatments were laid out for comparison of yield in randomised blocks. The yield results are set out in the following table.

Table 13. *Plot yields of treatments*

Variety.		Treatments. I	II	III	IV	V	Fisher's Z.
Wateribune	Mean yield of four repetitions	496·5	442·75	459·5	424·25		Observed=0·4457 Expected at P=0·05 is 0·6757
	Expressed as percentage	100	89·2	92·5	85·4		
Swarnalu	Mean yield of four repetitions	446·5	481·0	477·0	420·5	402·25	Observed=0·0999 Expected at P=0·05 is 0·5907
	Expressed as percentage	100	107·8	106·9	94·2	90·1	
Kasi Pichodi	Mean yield of two repetitions	618	510·5	520·5	548·5	462·5	
	Expressed as percentage	100	82·7	84·2	88·8	74·8	

Since the number of replications in the third variety, *Kasi Pichodi*, is inadequate for statistical purposes the calculations have not been attempted. It is presumed that the same amount of error exists in this experiment as in the case of the other two varieties,

A glance at the table given above shows that the differences between the treatments are not statistically significant, as the observed Z is much less than that expected at P='05 level of significance. But on the other hand the variation in yield from treatment to treatment closely follows the variation in the percentage of the total number of tillers per unit area (Table I) in the case of *Wateribune* and *Kasi Pichodi* and length of ear (Table 8) in the case of *Swarnalu*.

Conclusion. The fact that differences in yield between the several treatments are not significant obviously explains how a substantial economy can be effected (1) in the labour required for planting and subsequent operations by planting in bunches at wider spacing as per treatment IV and V and (2) in the number of seedlings required as per treatment II with its attendant savings in the seedbed facilities of a holding.

But yield is the resultant of complex interactions between the environment and the plant. The effects of environment are reflected in the different attributes of "yield of the plant" which itself bears a further set of complex relations with the "yield per acre" with which the ryot is concerned. Economy of labour and material result in more space per plant. Spacing promotes the tillering capacity of the plant to the extent to which tillering is inhibited by the competition of plants in the same or adjacent holes. It has further been shown in

Table 5 that the plants in a hole are no more benefitted by extra space per plant available in wider spacings than they are affected by crowding. Consequently conclusions in Table 2 indicating that the percentage reduction in the total number of tillers per unit area closely follows the percentage economy effected in the number of seedlings planted, are quite valid, while varietal differences regulate the amount of loss in the tillers per plant per unit area in the several treatments.

Adverting to the attributes of the ear, though the mean length in the several treatments is not statistically different, it has been observed that the range between the longest and the shortest ears increased with the spacings adopted. The " tillers per hole " have been found to bear a significant positive correlation with the range between the ear lengths, thereby showing that the individual plants in a hole act conjointly as if they were a single well tillered plant.

Percival says " Thus tillering may result either in an increase or decrease in the yield per acre when compared with a crop in which each plant has produced a single ear on account of being thickly planted. While increased tillering leads to the production of more straw per plant, the number of straws per acre decreases with tillering, a paradoxical statement which depends for its truth upon the fact, that the smaller the number of plants the greater the tillering, at the same time this does not compensate for the loss of plants incurred by wide planting."

Inspite of the fact that under special circumstances, wide planting may succeed in practice, it is found to be less hazardous to attempt to obtain an adequate number of ears per acre by close planting. It will therefore be seen that the yield of short duration varieties is at its best in close spacing. The important factor in yield appears therefore to be the number of tillers per unit area.

Therefore, in all efforts towards improvement of yield, endeavour must be made to increase the number of tillers per unit area either by close planting or by increasing the tillering capacity of the individual plant. Since the latter cannot be improved beyond a certain limit the improvement of individual tillers either by planting in proper season, manuring, or most fundamentally by 'breeding' demands the most immediate attention.

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Appendix A (i). *Range of ear length in tiller classes in Wateribune.*

No. of tillers per hole.	Range of ear length cm. in treatments.			
	I	II	III	IV
2	3·3			
3	3·9		2·0	
4	6·5	4·5	4·5	
5		6·7	7·5	
6		9·7	8·8	
7		7·9	8·0	6·0
8		8·4	7·5	7·0
9		6·9	5·8	5·5
10		5·8	7·9	—
11			7·0	6·2
12		10·0	7·9	7·5
13		10·0	10·0	5·0
14				13·5
15		10·0		10·0
16		11·0		6·5
17				12·5
18				9·9
19				8·0
20				
21				
22				9·5
23				9·0
24				
25				
26				10·0

Appendix A (ii). *Range of ear length in tiller classes in Swarnalu.*

No. of tillers per hole.	Range of ear length cm. in treatments.				
	I	II	III	IV	V
2	4.5				
3	5·2	4·1			
4	4·1	—			
5	6·4	—	6·4		
6	8·2	6·0	—		
7		6·6	6·0		
8	8·4	8·0	13·0		
9	—	9·5	7·0		
10		7·8	8·2		
11			8·5		
12		8·2	7·0		
13		7·5	9·0		
14			7·0		
15				9·5	
16			9·5		
17			7·1		
18					
19			11·3		
20				11·2	
21				9·0	12·0
22				12·7	
25				8·8	
26		7·5		12·2	
27				14·0	13·0
29					10·0
31				11·5	
32					12·5
35					10·0
36				14·3	
37					13·0
44					12·2
45					11·5

Appendix A (iii). *Range of ear length in tiller classes in Kasi Pichodi.*

No. of tillers per hole.	Range of ear length cm. in treatments i				
	I	II	III	IV	V
2	4·5				
3	5·2				
4	4·8		5·3		
5	6·7	4·4			
6	7·0	5·2	6·0		
7	5·0	11·0	4·6		
8		4·6	4·6		
9	7·2	7·0	7·6		
10		8·1	7·7		
11		6·5	8·8		
12		9·5	7·0		
13	12·3	11·0	7·0		
14		8·0	8·2		
15		6·3			
16			9·8		
17					
22			10·0		
23				8.2	11·0
29				11·2	
28				8·9	
29				10·1	
30				9·6	
31				8·5	
32				9·0	
36					10·5
40				11·2	12·0
41					10·5
44					10·0
45					8·6
47					8·2
48					10·0

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