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YIELD COMPONENTS IN PIGEON PEAS (Cajanus cajan)

by

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The main purpose of this paper is to present for critical examination the use of selection for various components of yield as a means of improving the quality and quantity of the crop in Pigeon peas. It is also to be used as a vehicle for the presentation of the results of some preliminary experiments on the subject.

A number of workers in the past have attacked the problem of yield through yield components. Harland (1920) working on cotton, broke lint yield into its components and investigated their inter-relationships and correlation with yield. He concluded that the yield of Sea Island cotton could be increased by selection for certain combinations of morphological characters. Woodworth (1932) and Weatherspoon, and Wentz (1934) investigated the components of soy bean yields. The latter authors found that an increase in one component was often accompanied by a decrease in another. They concluded that there was a strong physiological relationship between the components which was imposed by the existence of a physiological limit to yield.

Frankel (1942) cites an instance where two New Zealand wheat varieties were produced which gave superior yields, although they showed no improvement in any of the "limiting components" of the first group. Boyce, Copp, and Frankel (1947) found that selection for yield components in wheat was no more successful than selection for yield itself.

Powers (1945) and Griffing (1953) investigated yield components in the tomato. The former found that the interrelation of yield per plant, number of ripe fruit and size of fruit is such that it should be possible materially to increase yields by recombining greater number of fruit that ripen with larger size. He also found that the recombination of the components, number of locules and weight per locule should lend to an increase in the size of the fruit. Griffing, however, suggested that "selection for larger fruit size" will generally result in fewer numbers of fruit per cluster, fewer numbers of clusters, and therefore, fewer numbers of fruit per plant. He concluded that one set of plieotropic genes may exist which control the balance between a "growth force" tending to increase the number of reproductive parts and a similar force tending to increase the size of such parts. He thus refuted the earlier work of Powers and dismissed selection for increased yield through selection for yield components as difficult and tedious.

Thus some inconsistency exists in the findings of various workers on the usefulness of approaching the problem of yield through yield components. It often seems to be the case that an increase in one component results in decrease in one or more of the others. However, Grafius (1956) has linked the yield of wheat and oats to the volume of a box, the dimensions of which

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were the yield components. He suggests that the right combination of components must be found in order to obtain the highest possible yield.

The results presented here were obtained by preliminary recordings designed primarily to show how best the components of yield may be recorded. They do, however, allow a few tentative conclusions to be drawn.

MATERIALS AND METHODS

Materials

The recording made on fresh peas and pods was carried out on four lines, GC 12/2, GI 17/1, CH 11, 33, 34, and 03/59. The first three of these are derived from crosses made at St. Augustine, the progeny of which has been selfed for three generations. The last is an original selection which has been selfed for the same three generations. The recording made on dry peas was carried out on 57 varieties collected at St. Augustine from the Caribbean Area, India, Ceylan and East Africa.

Methods

The recordings on fresh peas and pods were carried out on the four lines which represented part of randomised blocks in a trial containing 15 lines in all.

Weekly records were taken from the commencement of cropping in October 1963 on the number of pods per tree. The number of peas per pod and the number of abortive ovules per pod were also recorded weekly on a sample of 30 pods from each line. Individual pea weights and mean pod weights were taken once for each line. Recordings were made on the first crop only.

For the dry peas the smallest dimension and the weight were recorded for individual peas.

RESULTS

Table I

Table I gives the components of yield and other data recorded for the four lines. A few points of explanation should be raised at this point.

For the number of pods per tree the variation between replications was no greater than could be accounted for by variation within replications. The lack of statistically significant differences between means, even at the 5% level may be due to the small size of the sample and/or the large coefficients of variation. The expanded trials now being recorded have 168 trees per line.

For number of peas per pod there was no statistically significant variation between weeks except in 03/59 which was significant at the 5% level. Inpection of the detailed results suggested that heteorogenetity between trees as opposed to within trees may have been the cause. The differences between lines were significant at the 0.1% level.

For weight of pea the sample size was between 50 and 70. The lines fell into two groups, GC 12/2, and GI 17/1 in the first and the others in the second. There were no significant differences within groups but the differences between each line and any line in the other group were significant at the 0.1% level.

For the number of abortive ovules per pod there were no differences between weeks except in GC 12/2. What appears to be a very high coefficient of variation is only 20-30% higher than would be expected if the abortion of ovules follows a Poisson distribution.

The regression of any yield component upon another failed to produce coefficients significant at the 5% level. Thus a full consideration of these will not be undertaken. It will, however, be pointed out that with three degrees of freedom many were significant at the 10% level. They suggest that the further investigation now in progress may show that this crop may not yet be limited physiologically and that it may be possible to improve the yield in quantity and quality by selection for yield components.

Figure I

Figure I shows the mean smallest dimension which is called the width and mean weight of samples of twenty dry peas of 57 varieties. Ten times the natural log of the parameters are plotted since it facilitates the interpretation o the exponential relationship between width and weight.

The slope of the best straight line through these points is 1.83: 1. For objects of the same density and the same shape a similar graph would give a line with a slope of 3. Thus for this sample of pigeon pea varieties, either a given increase in weight is accompanied by a disproportionally large increase in width or an increase in linear dimensions is accompanied by a decrease in density.

Both of these possible interpretations have important quality considerations. A decrease in density with increasing size would greatly hamper the canning of large seeded high yielding varieties of peas, since less food and weight could be packed in a given space. However, if a change in shape towards a more rounded pea accompanied an increase in weight, it would simplify the task of selecting for both yield and a round full pea. Preliminary measurements on three dimensions of the peas suggest that there is a considerable change in shape with weight. However, it is not yet possible to exclude the possibility of density changes.

DISCUSSION

Bearing in mind the inadequate nature of the data and the consequent reservations which must be made on their significance, a mainly theoretical discussion will be undertaken.

There are three main benefits which may accrue form the study and use of the components of yield. Firstly, there is an increase in yield, secondly, an increase in quality and thirdly, an increase in the knowledge of the biology of the crop.

On yield, Weatherspoon and Wentz working on soy beans, Frankel et al. working on wheat and Griffing working on tomatoes did not hold out much hope of increasing yield by way of selection for yield components. The opinion was that yield was limited by the physiological limit of production for the crop. It should be pointed out, however, that soy beans, wheat and tomatoes are "old" crops, that is they have been subjected to intensive breeding programmes and selection for long periods. Thus these crops may now have attained the physiological maximum of production and this would result in a close inter-dependence between yield components. On the other hand, the situation may be different in a "new" crop. Harland, working in 1920 on cotton, a tropical crop that was only at the beginning of a period of rapid improvement, stated that selection for components was a probable means of gaining increases in the quantity and quality of the crop.

The pigeon peas is now at the stage that cotton was at in 1920. Although work started as early as 1933 on pigeon peas in Trinidad, it was mainly directed towards the selection of a good deal or dry seed. The present programme was started in 1957 by H. J. Gooding, and it is still in its early stages.

Thus it may be argued that the findings for other crops, particularly "old" temperate crops may not be applicable to pigeon peas, and quantitative improvements may still be possible through selection for yield components.

On the question of the improvement of the quality of the crop, there seem to be fewer difficulties. All the authors cited have found that variation exists in the distribution of yield into its components. In pigeon peas, all the components studied show significant differences between lines except the number of pods per tree. This component is closely correlated with yield and differences in yield have been demonstrated on larger samples of trees.

Thus there is variation in pigeon peas in the apportioning of yield into its components. It is therefore probable that by applying selection directly to yield components it may be possible to rearrange the distribution in a more favourable manner. It is unfortunate that the state of knowledge of this crop is such that no clear indications exist on the subject of what would be a desirable form of crop to produce.

Thirdly, the increase in the knowledge of the biology of the crop. The necessity for this need hardly be stressed and a number of important questions which should be answered come to mind.

The cost of reaping pigeon peas by hand is one of the major problems of the crop. Higher picking rates would result in varieties with longer pods with more peas per pod, if all other factors remain constant. However, it is uncertain whether this proviso will hold. It may be that an increase in the number of abortive ovules. Experiments are currently in progress to determine if this is the case, and if it is, to estimate the optimum number of peas per pod for maximum yield.

The matter of the relationships of pea width, weight and density is another question which should be answered.

The question of the pea to pod ratio is not without complication. At present the pod "shells" have only a nuisance value to the manufacturer and consumer. An increase in the proportion of pea to "shell" would benefit both in Trinidad, since pigeon peas are sold in the pod or "unshelled" there. However, selection for an increase in the pea to "shell" ratio would result in thinner "shells" which may in turn lead to greater attack by pod borers. Insecticide protection would have to be increased and eventually a point of maximum return would have to be ascertained.

It is my opinion that the shape and form of the pigeon pea crop must be changed radically if it is to make an important contribution to the Caribbean and the general protein deficiency in the region. These changes will be most easily effected through selection and breeding in which the study and use of the components of yield and the shape and form of the tree and cropping season will play a very important part.