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DISTRIBUTION OF MISSING PLANTS AND ITS EFFECT ON THE NEIGHBOURING PLANTS

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SUMMARY

The distribution of missing plants and its effect on the yield of neighbouring plants were studied. The former aspect was studied following both parametric and non-parametric procedures. The theory of doublets (Vander Plank [6]) and subsequent test criterion evolved by Sunderaraj [2], [3] and [4] in another study, have been employed for studying the nature of distribution. A test based on multi-variate hypergeometric distribution showed that the distribution was random. Further, the effect of the missing plant on its neighbour seems to be dependent on the distance enjoyed because of missing plant. The beneficial effect was more for the plant in the different adjoining rows, rather than in the same row. The effect of the missing plants on the community appeared to be slight, when missing plants are of the order of 8 percent and the distribution is random. Because of compensating mechanism, this study advocates, as desirable, the study of distribution of missing plants, before any adjustment of the yield in experimental plots by ANOCV.

Missing plants in a community are common both in field experimentation and in farmers' fields. As plants in a community are known to compete for light, moisture and nutrients, any absence of plants would have an effect on the neighbouring plants. The neighbouring plants are known to benefit from such missing plants. So that the loss in yield due to missing plant may offset to some extent, though not completely. Gomez and Dedatta [1] found such beneficial effect on the neighbouring hills in rice, by inducing artificial situation of missing hills, in seven different patterns.

But in the present investigation, the purpose was to study the effect of missing plants as observed in a bulk plot, without inducing any such artificial situations. Here, the randomness or otherwise of distribution of missing plants is also of importance, as the effect may vary in different patterns. As such, initially the distribution of missing plants was studied in a bulk plot, and after identifying the pattern the effect of missing plants on the yields of neighbouring ones was studied. Further, the cumulative effects of these effects on the neighbouring ones, were compared with the loss in yield because of missing plants.

Material and Methods

In a bulk plot of GKVK, wherein sunflower was grown during kharif 1977, yield data of sunflower constituted the basic raw material for the study. The data was in respect of the 960 plants spaced 60 cm between rows and 30 cms within row. In twelve rows of 80 plants, 75 plants were absent, at the time of harvest. The location of missing plants in each row was noted, before the harvest, and the yields of plant were individually recorded.

In order to study the distribution of missing plants, i.e. to study whether the missing plants were random in their distribution or exhibited any systematic pattern, two approaches were used. The first one was based on the theory of doublets suggested by Vander Plank [6] in the context of disease spread and studied further by Sunderaraj and others [2], [3], [4]. The second approach was based on non-parametric test viz. Sign test [5].

In the first approach, three models have been proposed by Sunderaraj, for testing whether the spread of disease in plants is within or not (i.e. a random phenomenon). The same models have been tried to test whether the incidence of missing plant is a random phenomenon or not. In the first model, considering the community as a whole, assuming the probability of incidence of missing, remains the same, both an asymptotic test and exact test have been evolved. For large '*n*' (the number of plants), the asymptotic test is reasonably a good approximation to the exact test. For the present study as '*n*' was large, asymptotic test was preferred.

The second model which assumes Poisson probability, could not be tried, as the fitting of Poisson law showed that this incidence on number of missing plants did not follow Poisson distribution.

The third model introduces another statistical criterion based on multivariate hypergeometric distribution for the distribution of missed plants $m_1, m_2, \ldots m_k$ in K plots, each having exactly n plants. The number of missed plants m_i is a random variate, and the joint distribution of these independent d_1's given $\Sigma m_i = t$ as fixed, has a multivariate hypergeometric distribution. Under these conditions, an asymptotic test has been devised by Sundararaj and the same has been used. Here the null hypothesis to be tested is that the incidence of missing plants is a random phenomenon.

Apart from these parametric tests, a non-parametric test viz. sign test was also used to test whether the distribution was random or not.

Effect on the Neighbouring Plants

The effect of missing plants on the yield of neighbouring ones, would also depend on the pattern of missing plants i.e. one plant missing, two plants missing consecutively or alternatively etc. But as the number of sample points was not many, only the first pattern, wherein one plant missing was studied. Here while studying the effect on its neighbours, seperate identity for the immediate plants in the same row, in different rows and the diagonal ones were kept. This was so in order to study the effect of distance, on the competition effect.

The effect of a missing plant on the neighbouring plant was computed as the difference in yield from the yield of normal plant. Here normal plant means the plant which has no neighbour missing. For this purpose the yield of normal plant with close proximity to the missing plant but having all the immediate two neighbours (at least) in tact, was considered.

Students' t-test for testing whether the two means belong to the same population or not, was followed to find out the effect of neighbouring plants. The equality of variances was also tested before the application of t-test.

This effect was studied separately for neighbouring plants i.e. in the same row of missing plant, adjoining rows but in the same position, and for the diagonal ones.

Results and Discussions

(a) Distribution of Missing Plants

(1) The first model (Sunderaraj, [2]), assumes the probability of incidence of a missing plant would remain the same. Considering 960 plants as a whole plot, the number of doublets were counted. The number of doublets expected was computed assuming (i.e. Null hypothesis to be true) i.e. the incidence of missing was a random phenomenon. The asymptotic test was applied, using the following formula:

$$E(x) = \frac{d(d-1)}{n}$$

$$V(x) = \frac{d(n-d)(d-1)(n-d+1)}{n^2(n-1)}$$

where d = number of missing plants; X = Number of doublets

75 = 19

Then, the asymptotic test $Z = \frac{X - E(x)}{V(x)} = 3.9$

follows Z distribution. The probability of getting a 3.9 or more is less than 1%. Hence the hypothesis that distribution of missing plants is a random phenomenon, cannot be accepted.

(2) As mentioned earlier, this method could not be followed. Fitting the Poisson model for the number of missing plants, and testing for goodness of fit by χ^2 test showed that the same did not follow Poisson law.

(3) For fitting a multi-variate hypergeometric distribution, the 12 rows were considered as 12 plots (m), each having 80 number of plants (n), thus accounting for a total of 960 plants (N). Assuming the missing plants in each row as an independent variate, and $\Sigma d_i = t$ is fixed, joint distribution of d_i's is given by a multivariate hypergeometric distribution. Following Sunderaraj [4], an asymptotic test-criterion has been used as follows :

$$E(\bar{x}) = \text{No. of doublets} = \frac{\alpha_2 - \alpha_1}{n}$$

$$V(\bar{x}) = \frac{V(x)}{m} + \frac{2(m-1)}{m} \frac{(n-1)^{(2)}\, t^{(4)}}{N^{(4)}} - \frac{(\alpha_2 - \alpha_1)^2}{n^2}$$

where

$$\alpha_1 = \frac{nt}{N} \quad \text{and} \quad \alpha_2 = \alpha_1 + \frac{t^{(2)}\, n^{(2)}}{N^{(2)}}$$

where x is the number of doublets and $\bar{x}$ is its mean on simplification $E(\bar{x}) = 0.4763$, $V(\bar{x}) = 0.3845$

$$T = \frac{\bar{X} - E(\bar{x})}{V(\bar{x})} = \frac{1.5873 - 0.4763}{0.3845} = 1.7852$$

This T has an asymptotic normal distribution and the observed T of 1.7852 is less than the expected at $\alpha = 0.05$ (As such N.H. has to be accepted). That is the distribution of d_i's cannot be assumed to be other than random.

Besides these, the sign test also showed that the missing plants did not exhibit any tendency on pattern. From these, there appears to be some contradiction on the nature of the distribution of missing plants while the study indicated that the distribution was not random as turned out by employing model I, but it was not so, (i.e. the distribution was random when model III was employed). Here importance may be given more to the III model, rather than the first, as the latter seems to be more practical and scientific, it considers each row as a plot and not taking the complete set as one plot. That is the III model takes into account the directional aspect but the I model has no such provision.

(*b*) *Effect on the Neighbouring Plant*

As mentioned earlier, the effect was studied as the difference from normal plant. The yield of the plant neighbour to missing plant in the same row (12.92 g/pl) was significantly more, compared to the normal plant yield (12.12 g/pl). When one plant is missing the plant gets a benefit of 60 cms on one side, while the normal plants get the space benefit of 30 cms. But the effect of the plant on a different row would be different, as this plant would get a benefit of 120 cms on one side. The yield of such plants was comparatively more i.e. the average being 13.45 g/pl.

The effect of missing plant on the diagonal plants was not consistent and it was erratic.

These are the effects on individual plant and the effect as such on the community as a whole is also discussed.

It is often a point of controversy, whether the yield of a plot should be adjusted for missing plants or not especially in experimental plots. The point in favour of adjustment is that as the number of plants will be less, the treatment under study will be under-estimated because of less number of plants. But there is always a compensating mechanism, so that the neighbouring plants benefit from extra space, light and nutrients, and this may offset the loss in yield due to missing plants. Any further adjustments for variation in plant stand will only exaggerate the effect of the treatment. These aspects were studied in the present situation.

It appears as though, that when the number of missing plants is less than 10 percent, the bulk plot yield seems to be made good almost (about 95%) because of compensating mechanism, as observed in the present study. This is so because the occurrence of missing plant was random in nature. When the missing pattern is not random, such type of compensating mechanism may not work, because then there would be a tendency of cluster of missing plants. In such situations adjustment of yields for variation in plant stand may be necessiated for analysis in experimental data. In other words, it may be necessary to study the distribution of missing plants, before adjustment of yield for variation in plant stand, by covariance analysis.

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