Jour. Ind. Soc. Ag. Statistics
Vol. XXXVIII, No. 1 (1986), pp. 120-127

SYMPOSIUM ON 'BREEDING AND OTHER STRATEGIES FOR MINIMISING CROP LOSSES DUE TO PESTS AND DISEASES'

The Symposium on "Breeding and other strategies for minimising crop losses due to pests and diseases" was held during the 39th Annual Conference of the Indian Society of Agricultural Statistics at Punjabrao Krishi Vidyapeeth, Akola on 29th December, 1985 under the Chairmanship of Dr. A. B. Joshi, Former Vice-Chancellor, Mahatma Phule Krishi Vidyapeeth, Rahuri and former Director of I. A. R. I., New Delhi. The conveners for this Symposium were Prof. Prem Narain, Director, I. A. S. R. I. and Prof. S. K. Roy of the Indian Statistical Institute, Calcutta. Six papers were contributed to the Symposium out of which five were actually presented. The relevant extracts from the papers read at the Symposium are given in the following paragraphs.

PREM NARAIN*

Breeding Strategy to Minimise Losses due to Diseases and Pests

2. Plant breeders usually concentrate on genetic principles and breeding methods which lead to better crop varieties from the point of view of yield characteristics. Breeding for resistance to diseases and pests is adopted in isolation when improved varieties show susceptibility to diseases and pests. For greater economic returns, however, what is required is to have varieties which are not only better yielders but also are resistance to pathogens. Resistance is a state of less disease with immunity as the limiting case. The relation between yield and resistance being usually nonlinear, it is a waste of time and money to try for perfect resistance. The breeding strategy to minimise losses due to diseases and pests should aim at a breeding programme which pay attention to multiple characters. This necessity, however, puts a ceiling on the intensity of selection which

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can be applied since with multiple objectives, different characters get unequal weightage in selection. It is essential to look into the nature of ecological zones, the type of pathosystems which co-evolve with the crop species in the zones, the various crop breeding systems in vogue and the types of resistance before a suitable breeding strategy could be planned.

3. The breeding strategy for durable disease and pest resistance involves a number of pre-requisites such as whether the concerned disease/pest is economically worth breeding against, establishing resistant scales, quantitative assessment methods and examining the joint biology of host and pathogen. The experimental design and the choice of inoculum for expression to the various gradation in disease response particularly in Horizontal Resistance (HR) is very important. Susceptible controls are valuable for evaluating what may be already a considerable level of resistance. The performance in the field should be the final criterion of success which means laboratory tests should have relationship to the conditions existing in the farmers' fields. The breeding principles are virtually the same for diseases and pests and therefore, a common strategy should be adopted for both. The crop improvement is ultimately holistic in nature aimed at an entire ecosystem so that breeding for resistance should not be an activity separate from breeding better crop varietias but should be fully integrated with it. This means diverse disciplines such as breeding, pathology, entomology, statistics, etc. are to be integrated. This discipline integration requires that different expertise should be involved from the beginning to the end. In short, all this means bringing about crop improvement with a sound ecological understanding so as to provide stable food production over time.

R.K. KHOSLA*

Statistical Analysis for Estimation of Crop Losses due to Pests and Diseases

4. The paper was presented by Prof. Prem Narain as the author could not attend the Symposium due to ill health.

5. It is a well known fact that considerable crop losses are incurred at pre-harvest and post-harvest stages which makes a great hinderance in the corp production and protection programme. The occurrence of such losses at the pre-harvest stage might be due to incidence of pests and diseases, nematodes, birds and animals, floods, droughts, hail-storm, etc. However, the reliable and objective estimates of losses of foodgrains at this stage are hardly available in this country. But such estimates are very

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important rather pre-requisite for Planners, Policy Makers, Administrators, Scientists, etc. for developing and adopting efficient and economical control measures to minimise these losses. Several attempts for assessing such losses have been made in this country and abroad in the past but those were either limited in scale or the methods followed were not very scientific. Keeping the importance of the problem in view, IASRI has been engaged in developing the statistical methodology for estimation of those losses.

6. For evolving a suitable methodology for the estimation of the crop losses due to incidence of pests and diseases and its relationship with the yield, it is necessary to understand the terminologies, viz. concepts, definitions and measurement techniques in regard to incidence/infestation of pests and diseases, yield and losses. Uniform concepts would help the research workers to compare the results obtained in various Regions/States without any ambiguity. Such common and acceptable concepts, definitions and measurement techniques may also help in increasing the reliability of data.

7. The sampling design for estimation of crop losses should be as simple as possible so as to spare maximum time for the field staff for recording the periodical observations and thus increasing the reliability of data collected. Stratified multistage random sampling technique should be adopted. The country or the region under coverage may be divided into a number of strata, keeping in view of the homogeneity of the area in respect of soil type, climate, irrigation, cropping pattern, accessibility and other administrative and field survey conveniences, etc. Within each stratum, (1) number of first stage units (say villages) growing crop under survey may then be selected at random, (m) second-stage units (say fields within villages) then be selected within each selected first-stage unit and so on. These stages may be two, three or more till we reach the field level. Supposing fields are the second-stage units then (m) number of fields in each first-stage units are taken. In each field we may select (n) number of plots of $1m \times 1m$ size each in case of paddy and wheat crops, and $2m \times 2m$ size in each in case of sorghum and maize crops. Actually the plot size should be determined on the basis of carefully planned pilot survey. For the purpose of assessing the avoidable loss in yield two or more additional fields may be selected where plant protection measures could be used to control pests and diseases. These two or more fields could be selected at random out of (m) fields, already selected in each first-stage unit as mentioned above, then two more fields similar to these fields in respect of crop variety, fertilizer and manure application, topography soil type, irrigation, cultural practices, etc., may be selected. These two pairs of similar fields are found in each first-stage unit besides (m−2) extra fields. One field from each such pairs may be selected at

random, in which the pests and diseases would be controlled by chemical plant protection measures as recommended by the team of experts and may be called, 'protected field'. The other field of each pair may be exposed to natural infestation and referred to as 'unprotected field'. In each of the (n) selected plots, 5 plants, 4 corner and a central one may be selected for recording the detailed observations in case of measuring the severity of diseases and pests as it is not possible to observe all the plants in a plot for such purposes. The observations on the major pests and diseases may be recorded at an interval of about 4 weeks or a fortnight, beginning with the first observation taken 4—6 weeks after transplanting or sowing and ending with the last observation at the time of harvest. The plots in the fields may be fixeld for recording the periodical observations for whole of the season.

8. For investigating the suitable sample at each stage, it is necessary to estimate the variation between the units at each stage. These estimates are calculated for the incidence of major pests and diseases and used in working out the number of sampling units required at different stages for a pre-assigned degree of precision using the usual formula.

C. S. RAO, A. P. K. REDDY, M. B. KALODE AND A. V. RAO*

Breeding and other Strategies for Minimising Losses due to Pests and Diseases in Rice

9. Rice is grown in India under diverse agro-climatic conditions. Rice production in India during 1964-65 was 39.3 million tonnes which increased to 60 million tonnes during 1983-84. The increase in production was mainly due to the spread of high yielding varieties and fertilizer consumption. With the advent of high yielding varieties and new production technology the insect and disease problems also increased. Although accurate figures are not available, it is estimated that insects and diseases reduce the yield to the extent of 8 to 12 per cent. At the Directorate of Rice Research efforts have been made to develop disease and insect resistant varieties and also other strategies for minimising losses in Rice yield due to pests and diseases.

10. An attempt has been made to review the available information on the extent of losses due to pests and diseases and current breeding strategies employed to develop insect and disease resistant varieties. Currently grown commercial varieties having resistance to more than one insect/disease/multiple resistant varieties are enumerated. Also available resistant cultures/promising varieties against major insects and diseases are listed.

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11. Other strategies for minimising losses including integrated pest management are described.

SRIVENKATARAMAN T. GURUMURTHY* AND N. SUNDARARAJ**

Estimation of Crop Loss—A New Approach

12. The conventional method of estimating the crop loss usually involves the maintenance of protected plot unaffected by either the disease or the pest. The yield of this protected plot is generally compared with the yield of the affected plot for estimating the loss due to the condition (pests or diseases) affecting the crop. As the protected as well as the affected plots have a mixture of both the healthy and the affected plants, this method of comparison may not represent the true situation in estimating the loss due to the condition in question. A new approach of estimating the crop loss is suggested here which considers the individual plant yields of only the affected plot by treating it as a problem of estimating relevant parameters in a mixture population.

13. The problem has been considered under three different sampling schemes.

14. *Scheme 1*: A SRSWOR of a fixed size n is drawn from a plot having N plants with an unknown proportion of affected and healthy plants. The plants are identified as either healthy or diseased only after the selection and measurements on yield (y) are recorded. In this scheme the number n_1 of the diseased plants and n_2 of healthy plants ($n_1 + n_2 = n$, being fixed) are obviously random numbers. Relevant formulae for the estimation of the crop loss and its precision are obtained in terms of the estimators of the parameters of the mixture of two populations namely $\bar{y}$ (diseased), $\bar{y}_2$ (healthy) P, S_1^2 and S_2^2.

15. *Scheme 2*: This scheme employs inverse sampling of drawing units one by one until a preselected number of r_1 diseased plants are drawn. In such a case the number of units namely n_2 drawn from the healthy group is a random variable, and hence the total sample size $n = r_1 + n_2$ is also a random number. The relevant formulae for the estimator of the crop loss and its precision in terms of the parameters P, $\bar{y}_1$, $\bar{y}_2$, S_1^2, S_2^2 are obtained.

16. *Scheme 3*: This is an extension of the inverse sampling which imposes a requirement of a continuing the drawing of the units one by one under SRSWOR until at least a preselected number of r_1 units from group 1 and r_2 units from group 2 are realised. Two situations may arise in this case. Situation 1 is that while drawing items one by one the number r_1 may be reached first and the scheme may require continuing drawing

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until r_2 units are realised in group 2. Finally this may end up with (r_1 + x) units (x random) from group 1 and exactly r_2 units from group 2. Situation 2 is the reverse of this which may result in exactly r_1 units from group 1 and ($r_2 + x$) units from group 2. This makes the total units $n = (r_1 + r_2 + x)$ also a random variable. The estimation of the parameters of the mixture population viz. P, $\bar{y}_1$, $\bar{y}_2$, S_1^2, S_2^2 is considered and the relevant formulae for the crop loss estimator and its precision are also derived.

17. While Scheme 1 and Scheme 2 are partially familiar in the literature, there does not seem to be any reference in the literature to Scheme 3. The present paper develops for the first time the new estimators for the estimation of the parameters P, $\bar{y}_1$, $\bar{y}_2$, S_1^2, S_2^2 of the mixture population along with their precision. It also presents the relevant formulae for the estimation of crop loss and its precision in terms of these new estimators.

S. K. ROY*

Multiline Cultivars and Intercropping Systems as Measures of Pest and Disease Control

18. The tolerances of disease and pest attack by mixtures of crops consisting either of varieties of the same crop species ('multilines') or of different crop species ('intercrops' or 'mixedcrops') and that by the pure cultures of the individual components have been reviewed. In reviewing the literatures, it has been indicated that the susceptible plants become less infested by Pests and fungal pathogens when grown with resistant plants than when grown in pure stand and that with increase in the relative proportion of resistant plants in 'multilines' and 'intercropping' systems the level of infestation of the susceptible plants is reduced. The reasons for this difference have been traced to reduced imigration rate, reduced population growth rate, and increased imigration rate. These are substantiated by experimental evidences.

19. The available evidences on the types of interactions within a multiline variety of wheat attacked by rust disease and multiline rice variety attacked by brown-spot disease have been discussed and include competition between races of the parasite, crossprotection of hosts, host adaption and mutation.

20. Results suggest that stabilizing selection can contribute signifieantly to the horizontal resistance of a multiline and thus reduce crop losses. Similar situation presumably exists in intercropping systems.

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21. The review as well as the data presented in this paper suggest a strong case for advocating the practice of multiline cultivars and intercropping systems in reducing crop losses due to pests and diseases.

*M. N. HAQUE

Breeding and other Strategies for Minimising Crop Losses due to Pests and Diseases

22. The evolution of new races in micro-organism (insects, pests, fungi, nematodes, bacteria and viruses) takes place at a much faster rate than breeding of matching resistant varieties. Fortunately among the new races only few are of virulent type and the most virulent types are not always the fittest to survive. For breeding of long lasting resistance a full understanding of the host parasite relationship is a must. Till the breeding of long lasting resistance in all crops are attained we have to resort to the system of integrated pest and disease control. Of the several methods of pests and diseases control (cultural, mechanical, physical, biological, chemical etc.), the chemical method though most effective is not free from health hazard and environment pollution. Allelochemicals, a compound obtained from plants being easily biodegradable seems to be insecticides of coming furure. Breeders, entomologists and pathologists face several problems, the solution of which is possible by active involvement of statisticians. The statisticians should adopt some of these as their own problems and conduct experiments on field. Mendel could not have discovered the laws of inheritance had he not conducted his own experiments on pea.

23. A method for identifying suitable genotypes to act as parents in breeding for pest and disease has been suggested.

24. Winding up the symposium, the Chairman, Dr. Joshi thanked the Society for organising the symposium on a topic which should recieve greater attention in the field of crop production. He stated that the present topic takes care of the crops at two stages, one while introducting the crop variety resistance to pests and diseases and the other when the crop is standing in the field by taking various preventive measures to avoid and to minimise losses. He mentioned that although various measures are being taken to minimise the crop losses due to pests and diseases but suitable techniques to measure quantitatively the extent of losses are yet to be worked out. To this end, the statisticians should take steps so that both policy makers and the farmers can benefit from their findings.

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25. He also thanked the various speakers and hoped that the deliberations would be of immense benefit from the practical point of view for the plant breeders as well as the statisticians interested in such problems.

26. The following recommendations emerged out of this Symposium:

(i) There is an urgent need of integrating diverse disciplines such as breeding, pathology, entomology, statistics, etc. for bringing about crop improvement with a sound ecological understanding so as to provide stable food production over time.

(ii) The practice of multiple cultivars and intercropping systems should be advocated for reducing crop losses due to pests and diseases.

(iii) The crop varieties resistant to pest and diseases to be developed must be tested under field conditions before general adoption. Prior to field conditions, the laboratory tests should have relationship to the conditions existing in the farmers' fields.