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CONTROL OF VARIABILITY IN EXPERIMENTS WITH RUBBER USING COVARIANCE TECHNIQUE: A REVIEW

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ABSTRACT

Comparatively little has been published on experimental techniques and statistical methods in rubber. This paper is a review of available literature on the use of covariates in experiments falling into immature and mature stages of rubber. The main objective is to encourage researchers to collect appropriate pre-treatment records to adjust the post treatment variables so as to obtain high precision of results. In this connection, the effectiveness of rubber yield, girth and panel variables as pre-treatment records during the mature stages; seed and budded stump weights as covariates during the immature stages are discussed. The use of double covariance and other possible approaches to minimize initial variability in fertilizer, pest and disease, weed and green house experiments are also discussed.

Key words: covariance, rubber, variability

INTRODUCTION

Perennial crops such as rubber have longer lifespan and generally occupy a larger space in the field. Hence, experiments on such crops last for several years. Moreover, they are of greater interest as individuals compared to annual crops. The variation observed in a tree crop experiment is a combination of the variation inherent in the material at planting (genetic and stock effect), the positional variation caused by the soil heterogeneity and variation due to different extents of shock experienced by each tree at planting. The inherent variation of individuals is of little importance when compared to positional variability which builds up steadily with time in case of perennial crops (Pearce, 1976; Dospekov, 1984).

Paardekooper (1971) has reported that the relative portion of these two sources of variation differ with the age of rubber. At the time of planting the variation is mainly dependant on the condition of the stumps but the position in the field has little influence. However, with the growth of tree, the variation due to environment dominates the other sources of variation.

It is a common observation that the high variability in experiments with perennial crops continues to present problems, in spite of the recent advances in methods of field experimentation. Different ways of blocking may reduce unexplained variability in experiments in the presence of environmental variation but is not regraded as an effective measure in the presence of variability inherent to individual trees. The idea of 'calibration' *viz*. the use of supplementary information provides a satisfactory means of reducing the unexplained variability. This method known as the analysis of covariance was introduced by Sir Ronald Fisher in 1934 and has been widely used, consequently in the field of crop experimentation. However, Finney (1989) reported that the adjustment of means by the use of covariates is a much under exploited technique. Pearce *et al.* (1988) were of the view that the method of covariance analysis worked more effectively with perennials.

As reported by Paardekooper (1971), covariance analysis can be successfully used in tapping and stimulation experiments in rubber, where the variation inherent to the tree is more important. The value of pre-treatment yield records as a covariate in fertilizer trials was investigated by Narayanan (1966). The gain in precision was considerable but gradually decreased with time. Narayanan (1968), used both girth and pre treatment yield in a double covariance analysis and obtained high precision with some of the trials. The effectiveness of girth as a covariate was observed to be better sustained, increasing over the first 3 years of the experiments.

According to Paardekooper (1971), the major disadvantage of using pre-treatment yield records in calibration is the undue delay in the experiment caused by the collection of pre-treatment records. However, it was stressed by many researchers that the gain in precision usually outweighs the loss in time. The problem is left to the experimenter to decide whether to continue the pre-treatment recording and weigh it against expected gain in precision.

Presently, several variables are being measured as pre-treatment records in field experiments with rubber conducted by the Rubber Research Institute of Sri Lanka. This article is a collection of some results and possible suggestions on the use of covariates on improvement of precision in experiments with rubber.

Effectiveness of pre-treatment rubber yields as covariates

Yields recorded before the commencement of the experiment are most effective as a covariate during the early years of experimentation. But, the effectiveness declines with time and depends mainly on the length of time over which the pre-treatment records were taken (Narayanan, 1966; 1968; 1970). However, there is not enough information to decide on the optimum length of calibrating period to obtain a reliable estimate of the inherent yield variations.

Recent studies have shown considerable gain in precision in analysis by the utilization of pre-treatment yield records for the first 2-3 years of experiments. However, declining behaviour of the efficiency was observed with the lapse of time for all experiments (Wijesuriya and Thattil, 1996). Greater reduction in error would have resulted if the preliminary records had lasted for longer periods.

In field experiments of rubber, it would not be feasible to delay the commencement of experiments too long to obtain the necessary preliminary data. However, for major fertilizer response experiments lasting for 5 or more years, a delay of at least 12 months would be advisable because most fertilizer response studies have ended up with no apparent effect on response to yield. Moreover, it is important to reduce the standard errors of treatment comparisons so that even small but economic responses can be detected. Perhaps, the number of replications needed would be higher to achieve the same degree of accuracy in the absence of pre-treatment records.

The current practice in fertilizer experiments is to obtain pre-treatment yield records for about 3 to 6 months. However, it is advisable to obtain a full year's data with 08 test tappings according to the schedule suggested by Wijesuriya and Thattil (1995) to capture the seasonal fluctuations in tree performance. It is also advisable to keep records of bulk yields of smaller blocks in research sites, so that the experimenters will be able to design their experiments with previous information such as. gradients in the field and tree performances.

Effectiveness of pre-treatment trunk girth and tapping panel variables

Trunk girth is an important growth measurement in experiments with rubber even during the immature stages. A considerable gain in precision can be obtained when yield records are adjusted using pre-treatment girth records since significant relationships were found between yield and girth for various rubber clones (Thattil *et al.*, 1991; Wickramasinghe and Abayapala, 1980; Ong Seng Haut, 1981; Narayanan and Ho Chai Yee, 1970). However, when girth is very uniform in a stand, no significant gain in precision was observed, which is true for any pre-treatment variable. Pre-treatment girth can be successfully used to reduce the initial variability in post-treatment girth, girth increment and rubber yield (Wijesuriya and Thattil, 1996). The improvement in precision in the adjustment of post-treatment girth records from pre-treatment girth is obvious, since such records are inter-dependant.

As stated by Narayanan (1968), the effectiveness of girth as a covariate is more consistent and can be used effectively during the first three years to adjust yield. There were certain instances where pre-treatment girth could be effectively used in adjusting yield for 3 consecutive years (Wijesuriya and Thattil, 1996). However, further evidence is needed before making firm conclusions.

Tapping panel variables such as: bark thickness, tapping cut length and tapping cut height also can be used as pre-treatment records since they have significant relationships with post-treatment yield and girth. However, none of the tapping panel variables showed an improvement when compared to girth as a covariate in adjusting rubber yields . Gain in precision when tapping cut length was used as a covariate compared well with trunk girth but the efficiency was 10% less (Wijesuriya and Thattil, 1996). Nevertheless, measurement of girth is easier and can be accurately taken when compared to the tapping panel variables. Therefore, girth records are statistically sound and practically acceptable as a covariate in adjusting rubber yields.

Double covariance analysis

The use of double covariance analysis using pre-treatment yield and girth as simultaneous calibrating variates for improving the precision of post-treatment yield has been assessed by Narayanan (1970) for fertilizer experiments of *Hevea*. However, no firm conclusions were made in favour of double covariance compared to single covariance analysis.

On several occasions, double covariance proved to be superior to single covariance analysis; however, no marked differences in precision were obtained. The efficiency index declined with time, but more consistent compared to single covariance analysis (Wijesuriya and Thattil, 1996).

Although double covariance analysis will not necessarily further increase the precision of post-treatment comparisons compared to one or the other of the covariates separately, the choice of the analysis depends on the circumstances of the experiment. For instance, double covariance can be effectively used in reducing initial variability with the lapse of time. Therefore, whenever possible it is desirable to collect adequate records of all possible pre-treatment variables *viz.* girth, yield and tapping panel variables before application of treatments.

Effectiveness of seed weight and budded stump weight as pre-treatment records

As stated by Panse and Sukhatme (1978), genetic heterogeneity among trees grown from seedlings, physiological causes and effects of pest disease damages are responsible for inherent differences between trees. Clonal material are expected to produce uniform stands. Several studies have been carried out on clonal variability in rubber under Sri Lankan conditions. These studies revealed that considerable variation exists between monoclonal blocks (Senanayake, 1975). The author suggest that this could be due to soil heterogeneity and to the variability of root stock seedlings.

Approaches such as visual selection of seedlings during the nursery stage are usually carried out to minimize the root stock variability. However, the existence of root stock variability was reported by Senanayake *et al.*, (1975). Studies on identifying identical genetic material by isozyme studies have been carried out in Malaysia (Chevallier, 1988; RRIM, 1994). This kind of approach is also applicable in identifying homogenous seedlings to minimize stock variability. However, this may not be practical since the results of such experiments raised from identical stocks are not applicable to actual field conditions of rubber plantations unless similar measures are taken to produce planting material for commercial plantations.

Selection of uniform planting material can be practiced successfully to control the unexplained variability in experiments. Another possibility is to obtain budded stump weights and seed weights before field establishment. A considerable gain in precision was found when seed and budded stump weights were used as covariates in analyses of variance (Wijesuriya and Thattil, 1996). Hence, these two can be successfully used in reducing initial variability in experiments mainly confined to the immature stage of rubber.

Other possibilities of minimizing initial variability in fertilizer trials of rubber

Use of pre-treatment soil nutrient data in experiments with rubber have been used in characterization of soils (Yogaratnam and Weerasuriya, 1984). However, no attempt has been made to adjust post-treatment soil nutrient data by pre-treatment records. Collection of pre-treatment soil data will not cause undue delays when compared to pre-treatment yield recording. Therefore, it is advisable to record pre-treatment soil nutrient values; at least a few samples per plot which may be very useful to reduce positional variability in rubber soils. One problem is that the cost of soil analysis is high.

The use of block effect as a covariate in response surface analysis also can be used effectively in reducing the unexplained variability in experiments with rubber. A considerable gain in precision was observed in a fertilizer response study carried out to obtain optimum levels of N, P and K under mulched and normal conditions (Wijesuriya and Thattil, 1996).

Residual effects of previous experiments as covariates

When the trees are uprooted after the completion of an experiment, the effects on the soil last for a long time. Therefore, it is necessary to take such effects into account in any future use of this site for experimental purposes. Therefore, information on previous performance of crops is useful. These residual effects can be corrected by effective blocking. Moreover, the plot yields of the previous experiment, a pseudo-variate or an index can be used as covariates to control initial variability (Gomez and Gomez, 1984; Pearce *et al.*, 1988).

Analysis of covariance in experiments with pest or disease incidence and weed research

The distribution of pest or disease incidence is usually spotty and the pattern of occurrence is difficult to predict which makes blocking ineffective in such experiments. A possible covariate may be the disease or pest incidence before application of treatments. In weed control studies, a possible covariate may be the weed population before application of treatments.

Analysis of covariance in green house experiments

In green house trials, the competition effects between adjacent units are large and the standard remedial measures such as removal of border plants are not feasible. Under these circumstances, the performance of surrounding plants may be used to adjust the treatments concerned. This idea known as 'nearest neighbor methods' was originally proposed by Papadakis in 1937 and subsequently modified by several researchers (Pearce, 1978; 1980).

CONCLUSIONS

According to many reports, pre-treatment yield is most effective as a covariate in adjusting post-treatment yield during the early years, but the efficiency declined with time. Pre-treatment girth which can be accurately and easily measured is comparatively more consistent in terms of efficiency with lapse of time. Seed and budded stump weights can be used to reduce the initial variability in experiments during initial stages to a substantial extent. No firm conclusions can be made in favour of double covariance compared to single covariance analysis. Although not yet confirmed, the residual effects, pest, disease or weed counts and nearest neighbor analyses would help to reduce initial variability of experiments to a substantial extent. Therefore, the researchers are always encouraged to collect possible pre-treatment data whenever the cost involved is not high.

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