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Research Article

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Evaluation of the Test Unit for High Density Apple Experiments

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ABSTRACT

Proper designing of an experiment is essential to ensure that the data is valid so that proper analysis of the generated data provides valid statistical inferences keeping in view comparative economic advantage. The first step in detailing the data collection protocol is to define the type and the number of experimental units to act as test unit. In this regard the data on yield of High-Density Apple viz. Gala Redlum is analysed in a RCBD set up utilizing 3 replications to investigate the number of high density plants to be taken as the test unit within the basic plots. The evaluation is carried out by taking 6, 7, 8 and 9 sets of hypothetical treatments and separately taking 1, 2 and 3 high density plants as the test unit.

Keywords: *Experimental designs, Randomised complete block design, Hypothetical treatments, High-density plantations.*

INTRODUCTION

In experiments, a treatment is something that researchers administer to experimental units. The experimental unit should also be the unit of statistical analysis. Kuehl, 2000 defines the experimental unit as "the physical entity" or subject exposed to the treatment independently of other units. Each experiment involves a number of experimental units, which can be assigned at random to a treatment. Treatments are the set of circumstances created for an experiment based on research hypotheses, are the effects to be measured and compared in the experiment (Cochran & Cox, 1957). Some thought also should be given to the required precision of any outcomes to be measured. The required precision depends on the purpose of the experiment. If treatment effects are estimated extremely imprecisely then the experiment has no value. On the other hand, perfect precision is needlessly costly. To ensure the desired level of precision in case of high density apple experiments the number of experimental units to be taken as the test unit should be reduced to the minimum consistent with achieving the scientific objectives of the study. Inability to identify correctly the experimental unit is a common mistake which can result in incorrect conclusions as well as increase the cost of experimentation.

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The experimental unit is the physical entity which can be assigned, at random, to a treatment. Commonly it is an individual plant to which a particular treatment is applied at a given time. However, any two experimental units must be capable of receiving different treatments. In certain experiments, a group of plants/trees constituting a plot are taken as a single test unit. This implies that the p-values in the statistical analysis may be incorrect if it is assumed that a single plant/tree is the experimental unit. In this case the statistical analysis should normally be done using the mean of all the plants/trees in the plot. In other words, the choice of the sample size of the experimental units varies from experiment to experiment and proper determination of this sample size may ensure to a great extent the accuracy of the results and may also help in the reduction in the cost of the experiment that may be incurred on managing the experimental units. Usually the field experiments in HDP systems are appropriate when carried out in a randomised complete block design (Shah, et al., 2018). with the experimental material subdivided into blocks so as to ensure increase precision on treatment effects by reducing experimental error variance (Kuehl, 1994). Blocking stratifies experimental units into homogenous groups, and in field trials, plots are normally blocked according to their proximity to each other (Bhat, et al., 2018). The average of the plants within the plot can be used as a single unit or the individual plants in the plot can act as units as well. In HDP systems, the plots within the blocks may comprise of two or more than two high density trees. So a need to evaluate the number of trees to be taken as unit is HDP systems is of great concern.

MATERIALS AND METHODS

The data used comprised of the Yield of High-Density Apple viz. Gala Redlum maintained at HDP Plate-I of SKUAST-K, Shalimar comprising three columns of the high yielding variety. The high-density trial was maintained with a plant to plant spacing of 1.27 mt and column to column spacing of 2.81mt. The plan was laid out in a randomised complete block design and the trunk cross sectional area of high density trees was used as the criterion of blocking. The data was analysed using R Studio (Version 1.4.2).

RESULTS AND DISCUSSION

To assess any significant differences amongst the test units, the data was evaluated in a factorial randomized complete block design taking the hypothetical treatments as one factor and the number of plants/unit as the second factor. The experiments were repeated separately for four treatment sets viz. 6, 7, 8, and 9 treatment sets. The output from the ANOVA and table of means is given below:

Table 1: Table of means for 6 treatment set

No. of Plants/Units	Treatments						
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**Mean**
U_1: 1Plant	11.160	10.31	10.207	10.593	10.343	10.720	**10.556**
U_2: 2Plant	10.740	10.403	10.537	10.213	10.903	10.480	**10.546**
U_3: 3Plant	10.560	10.553	10.583	10.477	10.353	11.067	**10.599**
Mean	**10.820**	**10.422**	**10.442**	**10.428**	**10.533**	**10.756**	
B1: 8.019 B2: 10.890 B3: 12.792							

C.D. ($p \leq 0.05$)

- Blocks : 0.351
- Treatments : N.S.
- Units : N.S.
- T × U : N.S.

The results presented in Table 1 using a 6 treatment set, 3 replications and separately taking 1 plant, 2 plants, and 3 plants as the test unit within a single plot of a replication revealed no significant difference between the hypothesized treatments and as well the no. of plants per unit. However the blocking done using the trunk cross sectional area of the high density apple was found to be efficient in reducing the error as the block effect is significant.

Table 2: Table of means for 7 treatment set

No. of Plants/ Units	Treatments							
	T1	T2	T3	T4	T5	T6	T7	Mean
U_1: 1Plant	11.160	10.310	10.207	10.593	10.343	10.720	9.940	**10.468**
U_2: 2Plant	10.740	10.403	10.537	10.213	10.903	10.480	10.280	**10.508**
U_3: 3Plant	10.560	10.553	10.583	10.477	10.353	11.067	11.173	**10.681**
Mean	**10.820**	**10.422**	**10.442**	**10.428**	**10.533**	**10.756**	**10.464**	
B1: 8.024 B2: 10.840 B3: 12.793								
C.D. ($p \leq 0.05$)								
• Blocks : 0.286								
• Treatments : N.S.								
• Units : N.S.								
• T × U : N.S.								

The results presented in Table 2 using a 7 treatment set, 3 replications and separately taking 1 plant, 2 plants, and 3 plants as the test unit within a single plot of a replication revealed no significant difference between the hypothesized treatments and as well the no. of plants per unit. However the blocking done using the trunk cross sectional area of the high density apple was found to be efficient in reducing the error as the block effect is significant.

Table 3: Table of means for 8 treatment set

No. of Plants/ Units	Treatments								
	T1	T2	T3	T4	T5	T6	T7	T8	Mean
U_1: 1Plant	11.16	10.31	10.207	10.593	10.343	10.72	9.940	10.48	**10.564**
U_2: 2Plant	10.74	10.403	10.537	10.213	10.903	10.48	10.280	10.85	**10.537**
U_3: 3Plant	10.56	10.553	10.583	10.477	10.353	11.067	11.173	10.373	**10.704**
Mean	**10.820**	**10.422**	**10.442**	**10.428**	**10.533**	**10.756**	**10.464**	**10.568**	
B1: 8.006 B2: 10.870 B3: 12.787									
C.D. ($p \leq 0.05$)									
• Blocks : 0.285									
• Treatments : N.S.									
• Units : N.S.									
• T × U : N.S									

The results presented in Table 3 using a 8 treatment set, 3 replications and separately taking 1 plant, 2 plants, and 3 plants as the test unit within a single plot of a replication revealed no significant difference between the hypothesized treatments and as well the no. of plants per unit. However the blocking done using the trunk cross sectional area of the high density apple was found to be efficient in reducing the error as the block effect is significant.

Table 4: Table of means for 9 treatment set

No. of Plants/Units	Treatments									
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**Mean**
U_1: 1 Plant	11.160	10.310	10.207	10.593	10.343	10.720	9.940	10.480	11.327	**10.564**
U_2: 2 Plant	10.740	10.403	10.537	10.213	10.903	10.480	10.280	10.850	10.423	**10.537**
U_3: 3 Plant	10.560	10.553	10.583	10.477	10.353	11.067	11.173	10.373	11.200	**10.704**
Mean	**10.820**	**10.422**	**10.442**	**10.428**	**10.533**	**10.756**	**10.464**	**10.568**	**10.983**	
B1: 8.011 B2: 10.897 B3: 12.898										

C.D. ($p \leq 0.05$)

- Blocks : 0.273
- Treatments : N.S.
- Units : N.S.
- T × U : N.S.

The results presented in Table 4 using a 9 treatment set, 3 replications and separately taking 1 plant, 2 plants, and 3 plants as the test unit within a single plot of a replication revealed no significant difference between the hypothesized treatments and as well the no. of plants per unit. However the blocking done using the trunk cross sectional area of the high density apple was found to be efficient in reducing the error as the block effect is significant.

Thus the results from all the experiments indicated no significant differences between the treatments (hypothetical) and as well as the number of high density plants taken as an experimental unit. The results revealed that only the block effects were significant and that the blocking using TCA of high density apple could be used to control the variation in the HDP experiments. This implies no matter what number of high density plants that make a plot of given shape and size, a single plant is at par with a group of plants within the same plot.

CONCLUSION

It is possible to use a single plant/plot as an experimental unit rather than taking 2 or 3 plants as a unit in horticultural high density research trails in apple. Thereby saving the cost incurred on the research while maintaining the additional experimental units. Also, the Trunk Cross-sectional area (TCA) of the High-density plants can be used as a criterion for blocking to ensure efficient and precise results.

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