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Analysis of Long Term Fertility Trials Using Split Plot Technique

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A B S T R A C T

The present study was carried out using split plot technique in secondary data obtained from All India Coordinated Research Project on Long-Term Fertilizer Experiments (AICRP-LTFE) in rice from 1998-2017. The minute changes due to time variable were studied by splitting the whole period of study into three sub periods. It was found that in *kharif* season the treatments, years and their interaction effects were significant in all the three periods. During *rabi* season, the treatments and year interaction was absent for the first period.

Key words: Split plot, LTFE, *Kharif*, *Rabi*, Interaction, Time

Long term field experiments provide valuable data that cannot be attained from short term experiments. For valid results from long term experiments primary treatments must be maintained continually for some long time, however, flexibility is necessary in secondary treatments and management aspects of the study to make it practical. Technical changes such as varietal improvement, nutrient management, pest control, complex agronomic practices etc. are in ways that cannot be foreseen.

An important role of long-term fertility trials is to provide a measure of the time on the consistency of treatment effects. However, assessing and interpretation of year-by-treatment interactions by conventional analysis of variance is an issue when more than 2 or 3 years of data are present. The unequal and unknown precision of the experiments may impair the test of significance of treatment contrasts during pooled analysis. These facts have been observed by Cochran (1937, 1954). Gomes and Guimaraes (1958) have found heterogeneous error variances in performing pooled analysis of two experiments and suggested approximate test of treatment contrasts. Bhuyan (1984 1986) has suggested a method of estimating and testing treatment contrasts in the way of combined analysis with interaction model under heterogeneous error variances based on the work of James (1951, 1954). Jamjoom and Ali (2011), Albassam and Ali(2014) have also considered the case when the individual experiments were laid out in randomized complete block designs. Split plot analysis gives better estimate of changes in yield over the year's treatment responses. The present study was undertaken to study the minute differences in the crop responses over several years by the application of same treatment throughout the years can be detected with more precision.

MATERIALS AND METHODS

The present study was based on secondary data from All India Coordinated Research Project on Long-Term Fertilizer Experiments (AICRP-LTFE) in rice, which was initiated at Regional Agricultural Research Station (RARS), Pattambi in 1997 to study changes in soil quality, crop productivity and sustainability under long term fertilizer experiments in rice. The experiment was carried out in RARS, Pattambi, Kerala using the variety Aiswarya in two planting seasons namely *kharif* and *rabi*. Aiswarya variety of rice developed at RARS, Pattambi is resistant to blast, blight and BPH. It is well suited for first and second crop seasons. The *kharif* season starts from July to October during the south-west monsoon season and the *rabi* cropping season is from October to March (winter)**.**The following are the details of the experiment:

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Number of replications: 4
Number of treatments: 12
Design: Randomized complete block design (RCBD)
Plot size: 125 m^2

Following are the fertilizer treatments
T_1: 50 percent NPK (as per POP recommendation of KAU)
T_2: 100 percent NPK (90 N: 45 P_2O_5: 45 K_2O)
T_3: 150 percent NPK
T_4: 100 percent NPK + lime @ 600 kg/ha
T_5: 100 percent NPK
T_6: 100 percent NP
T_7: 100 percent N
T_8: 100 percent NPK + FYM @5t/ha to the *kharif* rice only
T_9: 50 percent NPK + FYM @5t/ha to the *kharif* rice only
T_{10}: 100 percent NPK + *in situ* growing of *Sesbania aculeata*, as green manure crop for *kharif* rice only
T_{11}: 50 percent NPK + *in situ* growing of *Sesbania aculeata*, as green manure crop for *kharif* rice only
T_{12}: Absolute control

While conducting an experiment, some factors require larger experimental plot when compared to other factors. Sometimes our objective would be to test one factor more precisely in comparison to the other factors. In all such conditions, we adopt split plot design. The experimental units which are considered as sub-plot are nested inside the main plot. The factors which require more degree of precision are taken as sub plot.

The model for split plot experiment in randomized blocks is:

$$Y_{ijk} = \mu + r_i + m_j + e_{ij} + s_k + (ms)_{jk} + e_{ijk}$$

Where,
Y_{ijk} = the observation of i^{th} replication, j^{th} main-plot and k^{th} sub-plot
μ = overall mean
r_i = i^{th} replication effect
m_j = j^{th} main plot treatment effect
e_{ij} = main plot error or error (a)
s_k = k^{th} sub plot treatment effect
$(ms)_{jk}$ = interaction effect of main plot and subplot
e_{ijk} = error component for the sub plot or error(b)

In the present study, split plot analysis is done taking fertilizer treatments as main-plot treatment and year as sub-plot treatment. The analysis of variance for "m" main plots and "s" sub plots is given in (Table 1). Analysis is done for rice grain yield for three non-overlapping periods separately. For consistency of the results of the analysis, grain yield data is split into three periods having seven years data in first two periods (1998-2004) and (2005-2011) and six years data in period three (2012-2017).

Table 1 Analysis of variance for split-plot experiment in randomized blocks with factor A in main plots and factor B in sub plots

Source of variation	Degrees of freedom	SS	MSS	F
Replication	r-1	RSS	RMS	RMS/EMS(a)
A	m-1	ASS	AMS	AMS/EMS(a)
Error(a)	(r-1) (m-1)	ESS (a)	EMS(a)	
B	s-1	BSS	BMS	BMS/EMS(b)
AB	(m-1) (s-1)	ABSS	ABMS	ABMS/EMS(b)
Error(b)	m(r-1) (s-1)	ESS(b)	EMS(b)	
Total	rms-1	TSS		

Table 2 Assessment of the significance of year after year variation in rice yield during the *kharif* season using split plot analysis

Source of Variation	Degrees of freedom (3^{rd} period)	Period 1 (1998 to 2004)		Period 2 (2005 to 2011)		Period 3 (2012 to 2017)	
		MSS	Fcal.	MSS	Fcal.	MSS	Fcal.
Replication	3	448741.30		112939.36		21578.84	
Treatment	11	37700986.68	677.88**	55178101.42	1265.23**	96415398.68	10760.13**
Error (a)	33	55616.14		43611.01		8960.43	
Year	6 (5)	6510562.23	124.08**	640709.44	17.81**	12655824.95	1314.36**
Treatment × Year	66 (55)	537559.86	10.25**	323352.75	8.99**	927647.56	96.34**
Error (b)	216 (180)	52472.55		35967.39		9628.89	
Total	335 (287)						

**1 per cent level of significance, Values within the parenthesis indicates degrees of freedom for third period

RESULTS AND DISUSSION

In order to assess the minute variations between grain yields under treatments applied over different years, split plot analysis was carried out taking actual treatments as main plot treatments and years as subplot treatments, and the results are depicted in (Table 2, Table 3). It was observed that during *kharif* season, the effect of treatment, year and their interactions were significant at 1% level of significance. In *rabi* season, the effect of treatment, year and their interactions were significant during the second and third period. In the first period, the effect of treatment and year were significant, but the interaction effect between treatment and year was not significant. The absence of the year × treatment interaction might have resulted in non-significant trend in yield during *rabi* season.

When time was considered as subplot, the interaction effect of treatment and years over the study period was significant in both the seasons (Table 4, Table 5), i.e., the interdependency of treatments' effect over time was significant. Thus, it is evident that the variation in yield is not only due to treatment effect but also due to the responses from environmental factors over years. Due to the significance in the interaction effect, one cannot simply draw conclusion over the effectiveness of a treatment.

Table 3 Assessment of the significance of year after year variation in rice yield during the *rabi* season using split plot analysis

Source of Variation	Degrees of freedom (3^{rd} period)	Period 1 (1998 to 2004)		Period 2 (2005 to 2011)		Period 3 (2012 to 2017)	
		MSS	Fcal.	MSS	Fcal.	MSS	Fcal.
Replication	3	58837.76		142308.53		312035.75	
Treatment	11	3011386.13	32.72**	5744132.71	244.44**	6498578.74	104.53**
Error (a)	33	92028.30		23499.07		62168.66	
Year	6 (5)	5990922.92	54.62**	2419220.06	85.95**	15001872.69	179.14**
Treatment × Year	66 (55)	144002.39	1.31	180950.28	6.43**	210788.24	2.52**
Error (b)	216 (180)	109686.14		28147.68		83742.19	
Total	335 (287)						

**1 per cent level of significance, Values within the parenthesis indicates degrees of freedom for third period

Table 4 Significance of the effect of time variable (20 years) on rice yield during the *kharif* season using split plot analysis

Source of variation	Degrees of freedom	MSS	Fcal
Replication	3	78850.35	
Treatment	11	13570854.49	151.58**
Error (a)	33	89530.48	
Year	19	39309500.43	599.77**
Treatment × Year	209	365267.33	5.57**
Error (b)	684	52472.55	
Total	959		

**1 per cent level of significance

Similar findings were reported in finger millet –hybrid maize-fodder cowpea cropping sequence by Sheela (2009).

The usual practice followed in such long term experiments are joint statistical analysis by using the analysis of variance technique applied to groups of experiments on the assumption of independence of error terms which is not usually valid. Another possibility in dealing with such experiments is to consider them as special cases of split plot arrangement with years as subplot, within each treatment main plot.

Table 5 Significance of the effect of time variable (20 years) on rice yield during the *rabi* season using split plot analysis

Source of variation	Degrees of freedom	MSS	Fcal
Replication	3	250953.58	
Treatment	11	13588179.02	216.97**
Error (a)	33	62627.82	
Year	19	7753633.63	107.29**
Treatment × Year	209	245768.22	3.40**
Error (b)	684	72265.52	
Total	959		

**1 per cent level of significance

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