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Comparing efficiency of on-farm experiments relative to designed experiments in complete blocks

***Siraj Osman Omer*[1] *and Babiker M. Mahgoub*[2]**

[1]Experimental Design and Analysis Unit, Agricultural Research Corporation (ARC), P.O. Box 126, Wad Medani, Sudan

[2]Faculty of Agriculture University of Bahri, Sudan

ABSTRACT: The aim of this study was to estimate the relative efficiency (RE) of an On-Farm Experiment conducted in randomized complete block design (RCBD) compared with a completely randomized design (CRD). An on-farm experiment was carried out at Noralhuda, Gezira, Sudan during season 2010. A set of six varieties of sorghum were evaluated in this study and data was collected on flowering period (FP), number of plant (NP), plant height (PH, cm), head length (HL, cm)), 100 seed weight (SW, g), forage weight (FW, kg) and productivity (P, t/ha). Relative efficiency to RCBD, of on-farm experiment was about 91%, 2.04%, 1.22% , 0.91% , 0.88% , 0.99% and 0.89 for FP, NP, PH, HL, 100SW, FW, and P respectively. The coefficients of variation (CV), coefficient of determination (R2) and relative efficiency (RE) were 7.70%, 78% and 1.12% for RCBD respectively. The relative efficiency of on-farm trials show the same efficiency comparing to RCBD, as can be expected. It would have attained the same sensitivity as in RCBD or CRD with about approximately 100% of replication used. The use of completely randomized design was most suited on farms where blocks might be difficult to be formed and impractical to maintain, it was found that experimental design efficiency compared to RCBD is not too low on-farming experimental.

KEYWORDS: RCBD, On-farm trials, Relative efficiency.

1 INTRODUCTION

The statistical analysis of on-farming experimental to experimental design efficiency are generally characterized by low coefficient of determination, R2 and high coefficient of variation (CV), due to varying farmer management levels from one technology to another within a farmer Kashif et al. (2011). CV provides a measure of inherent variation in the field for given atrait and is expressed as a percentage, it is referred to as experimental error Bellon and Reeves eds (2002). A high CV make treatment differences less likely to be detected statistically significance with less number of replications, while with a low CV it is highly likely Johnston et al. (2003). Efficient experimental design is essential when planning research trials Asheber (2010). For a small number of treatments, the completely randomized design (CRD) and randomized complete block design (RCBD) are the most frequently applied, and , practically, the CRD is the simplest of all designs (Shelton et al., 2009). The randomized block experiment is inefficient for large number of treatments, due to of their failure to reduce the effect of soil heterogeneity Muhammad et al. (2008).

On-farm experiments are planned in the fields of representative farmers and examine a small number of experimental materials SSC (1998). Efficiency of on farm experiments an essential of well-studied statistical tools in design of experiments, and ANOVA can be incorporated in its framework Kashifa et al (2011). The purpose of each on farm experiment to study the effect of measurements taken before, during, and after the growing season in this case the efficiency is widely accepted relative precision as measure purported to evaluate the relative efficiency in terms of the ratio of error variances of both designs Ingrand et al. (2006).

There are several experimental-design procedures that are quite amenable to simulation experiment such as on- farm experiment Ingrand et al. (2000). These simulation experiments present unique opportunities not present in physical experiments Kelton (2000). The designing simulation experiments deserves the capitalize in modeling effort and unplanned, hit-or-miss course of experiments unlikely to yield much solid insight Parsad e et al. (2009).The assessment of on-farm trail is commonly based on measures of coefficient of variation (CV) coefficient of determination (R2) and experimental error due to varying farmer management levels Timothy et al. (1997). The aim of this study was to estimate the relative efficiency (ERE) of an On-Farming Experimental simulated to RCBD compared with a CRD.

2 ON-FARM RESEARCH

On-farm research is in fact that looks in combination with a scientific approach. An on-farm trial aims at testing a technology or a new idea in farmer's fields, under farmer's conditions and controlling the farmer's practice Pierre et al. (1999). On-farm research is a powerful decision-making tool for organic farmers. A lot of work goes into doing high-quality research, but the confidences one has in the results are worth it. Analyses of different farming practices may be generated by replication, randomization, and use of a control in designing an experiment because they help to separate out treatment effects from natural levels of background variation Sooby (2001). On-farm trials differ from classical on-station trials in various ways Nokoe (2003). The mostly commonly used method for analyzing on-farm trials is the conventional analysis of variance (ANOVA) for the relevant design of the trial John (2003). Some basic principles for on-farm research are:

- Address experiments problems that are important to farmers
- Limit your experiment to a comparison of two (or maximum three)
- Treatments
- Help to adopt entire new systems of production
- The results should not be turn out as you planned

On-Farm research helps in testing the technologies developed at the research stations by taking into account the realistic environment the on-farm trials can be classified into three categories(i), designed experiment and managed by researchers (ii) designed experiment by researcher and managed by farmers, and (iii) designed experiment and managed by farmers. Primarily on-farm research is suffering from lack of control on variability due to (a) variation in farmers' managerial skills and resources, (b) variation in plot etc. In this case resolvable block designs are quite helpful in On-Farm research to take care of variation due to management skills of the farmers or plot to plot variation (Meertens, 2008). The use of design of experiment (DOE) and data farming techniques is critical to effectively planning, and subsequently evaluating, tests of complex adaptive systems in a joint mission environment (Cheng et al., 2003). On-farm research is a problem-directing approach to agricultural research that begins by diagnosing the environmental conditions, practices and problems of farmer's users Tripp and Woolley (1989).

3 JUSTIFICATION OF THE STUDY

Most agricultural research was carried out on-station, where conditions can be controlled and single treatments applied. The scientists have replaced the RCBD on investigating experimental trails in many fields, however over location and seasons due to their understudying its layout and simplest statistical analyses. The on farm trails are widely used in plant breeding and variety testing around the world and are more efficient than RCBD. These designs are restricted to very limited number of treatments and the field layout is very CriticalKashifa et al. (2010).

4 MATERIAL AND METHODS

On farm experimental field was carried out at Noralhuda location, Gezira scheme experimentation using randomized complete block design (RCBD) layout, Wad Medani during season 2010-2011. a set of six verities of sorghum cultivars were use in this study on flowering period (FP), number of plant (NP), plant height (PH) (cm), head length (HL) (cm), 100 seed weight (g) (SW), forage weight (kg) (FW) and productivity(P), respectively. The mean square error from each analysis was used to estimate the relative efficiency of an (RCBD) compared with a CRD according to the relative efficiency equation. The results were statistically analyzed using Cropstat version7.2.

4.1 RELATIVE EFFICIENCY

Efficiencies are measures of goodness of the design Kuhfeld et al. (1994). Relative efficiency is often used to indicate how much saving in cost and land can be envisaged from a design. Efficiency measures and the relative precision are described in an attempt to provide some guidance in the choice of appropriate measure of effective blocking in RCBD. The results for the obtained by the proposed measures are presented Gwowen (2004).

$$\text{Efficiency of RCBD vs. CRD} = \frac{(b-1)\text{MS.B}+b(t-1)(\text{MS.E})}{(bt-1)\text{MS.E}}$$

Where

b and r are the number of blocks and treatments respectively
MS.B is the mean square of block /replication under RCBD
MS.E is the mean square of error under RCBD

Efficiency of RCBD relative to CRD can be interpreted as the number of times as many replicates would be needed for CRD to have the same precision of estimates of treatment means as in case of RCBD.

4.2 RELATIVE EFFICIENCY OF THE RCBD

RCBD and CRD may lead to different conclusions, how much more (less) efficient is the RCBD compared to a CRD?, The relative efficiency (R) of the RCBD with respect to the CRD is

$$R = \frac{(\text{dfb}+1)(\text{dfr}+3)}{(\text{dfb}+3)(\text{dfr}+1)} \cdot \frac{\sigma_r^2}{\sigma_b^2}$$

Where σ_r^2 is the CRD error variance, $\sigma_b^2$is the RCBD error variance dfr is the CRD error degree freedom and dfb is the RCBD error degree freedom.

R is the factor by which the number of replications of a CRD needs to be increased for a CRD to achieve the same precision as a RCBD. From Table 1, an estimated relative efficiency (ERE) less than 1 indicates that a CRD is a more efficient design, while value nearly equal to 1 suggests that the two designs yield similar results. Value greater than 1 suggests that RCB design is more efficient design than CRD. In this study, the efficiency of complete randomized designs (CRD) and randomized complete block design (RCBD) was compared in this research experiment conducted during season 2010 in a Gazira scheme, Wad Medani, Sudan.

5 RESULTS AND DISCUSSION

The results of this work are based on data collected from Gezira Scheme by sampling chosen at three times.

Table 1. Cultivation of 6 sorghum cultivars in Galoka Managil in Gezira scheme, Sudan

Variety	Flowering Period	No of Plant	Plant height (cm)	Head length (cm)	100 seed weight (g)	Forage weight (kg)	Productivity (t/ha)
Panar	73 ab	39000 ab	77 ab	33 a	3.45a	924 b	4.6 d
Alfa2	62 bc	41000 bc	86 ab	31 a	2.63 a	1118 b	8.1 b
W.Ahmed	77 a	41000 a	95 ab	28 ab	3.71 a	1235 b	5.8 c
Pac 501	56 c	46000 c	154 a	22 b	3.05 a	2464 a	11.6 a
Tabat	79 a	30077 a	98 b	28 ab	3.05 a	1274 b	3.5 e
Pac 537	61 bc	43000 bc	157 a	31 a	2.85 a	2512 a	5.8 c
SE±	2.83	2444.81	5.22	1.45	0.48	162.92	0.23
Sig	0.0003	0.0179	0.0001	0.0027	0.6541	<.0001	<.0001
Mean	68	40013	111	29	3.12	1588	6.57
CV% under CRD	7.2	10.5	8.1	8.7	26.8	18.1	5.9
CV% under RCBD	7.8	7.6	7.6	9.4	29.3	18.7	6.5

Means with the same letter are not significantly different; the means comparison was performed by Tukey's HSD (honest significant difference) test

Table 1 shows the yield and yield components on sorghum cultivars, there were statistical significant for all parameters, in this section statistical information is needed such as CV%, standard error of means and significant level to illustrated the means of relative efficiency, regarding the results show that there were not statistical difference between the coefficient of variation (CV %)of CRD and RCBD at (p>0.959). The overall CV% was 12.19 and 12.41 for CRD and RCBD respectively. It is evident that there was efficiency in experimental form trials. In general results of on- farm trials either simulated as CRD or RCBD, It's given highly efficiency due to the experimental management and farmers conditions, which accrued depend on accuracy of coefficient of variation.

Table 2.Results of Coefficient of variation (CV %) and Coefficient of determination (R2)for all parameters of CRD and RCBD

Parameters	CV %		R2	
	CRD	RCBD	CRD	RCBD
FD	7.2	7.8	0.832	0.826
NP	10.5	7.6	0.846	0.642
PH	8.1	7.6	0.964	0.952
HL	8.7	9.4	0.755	0.747
SW100	26.8	29.3	0.22	0.218
FW	18.1	18.7	0.893	0.881
PROD	5.9	6.5	0.986	0.986

Tables 1 and 2 shows the summary of analysis of variance for all parameters, which were analyzed as simulated RCBD. The results showed that there were highly statistical significant expect the 100 seed weight (SW) there were approximately equality of coefficient of variation and coefficient determination. The above result indicated, the CV% of CRD is slightly lower (10%) than RCBD.

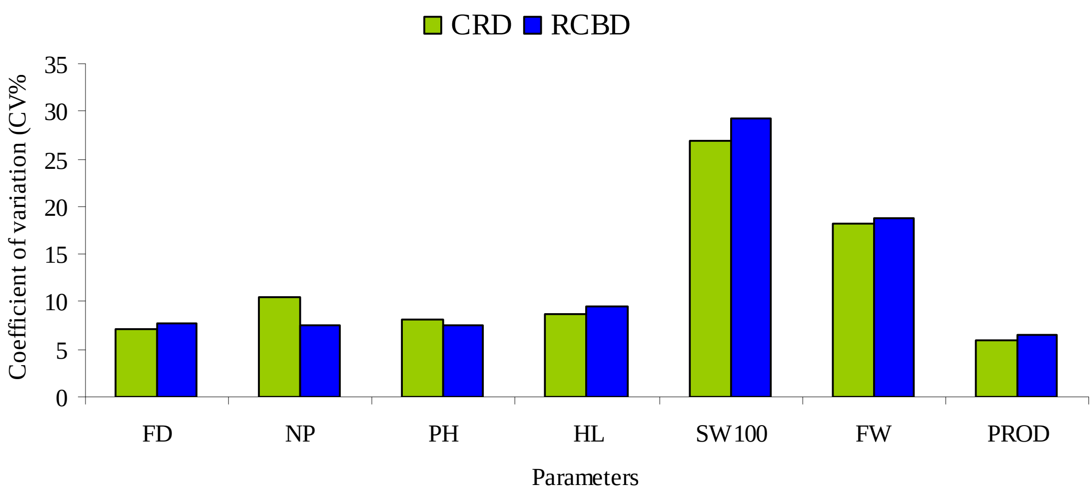

Figure 1. Comparison of estimated coefficients of variation (CV) between CRD and RCBD

The figure1 has shown no statistically significant for CV % and R2over all parameters at (p> 0.263) for all parameters of CRD and RCBD. The coefficient of variation (CV) calculated for all parameters to preliminary yield trials are (12.19 and 12.41) for CRD and RCB design respectively. The standard deviation (StDev) calculated for these simulated trials are (7.58 and 8.53) for CRD and RCB design.

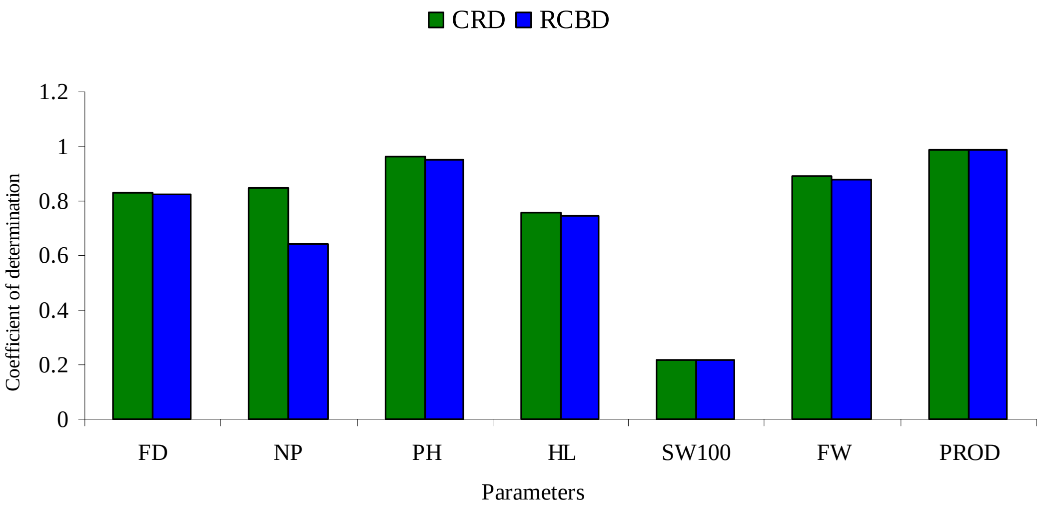

Figure 2. Comparison of estimated coefficients of determination (CV) between CRD and RCBD

The figure 2 show there were no statistical significant over all parameters (p>0.929). The coefficients of determination (R2) were calculated for all parameters to preliminary yield trials are (0.785 and 0.751) for CRD and RCB design respectively. The standard deviation (StDev) calculated for these simulated trials are 0.2615and 0.2627) for CRD and RCB design.

Table3. Expectation of mean squares (EMS) of complete randomized design (CRD) and randomized complete block design (RCBD)

Parameters	MSE of RCBD	MSB(Replication) of RCBD	MSE of CRD	Relative Efficiency
FD	27.87	4.67	24	91%
NP	9255556	6.106E7	17888889	2.04%
PH	70.9	135.50	81.7	1.22%
HL	7.37	1.17	6.3	0.91%
SW100	0.84	0.01	0.7	0.88%
FW	85222.22	50555.56	79444.4	0.99%
PROD	0.18	0.01	0.2	0.89%

Where MSE=Mean square error

Thus the CRD is the more efficient design in this case. It would have attained the same sensitivity as the RCBD with about 84% of the replications used. The results of the experiments show that there is small difference between error mean squares (EMS) under CRD and RCB design. The coefficient of variation (CV) of RCB design is comparatively low as compared to CRD. In study the on farm experiment indicated good index of reliability due to Low value of CV. The effectiveness of this design, relative to the more traditional design (RCBD). The results showed that, the RE of on-farm experimental about 91%, 2.04%, 1.22%, 0.91%, 0.88% , 0.99% and 0.89 for FP, NP, PH, HL, 100SW, FW, and P respectively . The overall coefficient of variation (CV) and relative efficiency (ER) are (7.70 and 13.6) for RCBD to CRB. The relative efficiency of on farm trials shows that was more efficient than RCBD. The value of relative efficiency (12.41 and 1.12%) indicates that the use of CRD or (RCBD) has the some precision, thus the RCBD is the more efficient design in this case. It would have attained the same sensitivity as the CRD with about 1.12% and approximately 100%. The error mean squares (EMS) under RCB design was smaller as compared to RCB design. It is also noted that the coefficient of variation (CV) RCB design was comparatively low as compared to CRD. Historically agronomists have relied heavily on the CV as a measure of trial's reliability. This increase in precision resulted in RCB design better detected significant differences than CRD. The value of relative efficiency greater than one for both the experiments shows that RCBD was clearly more efficient than CRD (table1). Relative efficiency indicates that the use of RCBD will increase experimental precision in general.

6 CONCLUSIONS

The results highlighted that, RCBD On-farm experiment appeared more efficiency than CRD. The relative efficiency of on-farm trials shows that was same efficiency to RCBD, as can be expected. It would have attained the same sensitivity as the RCBD or CRD with about approximately 100% of replication used. The use completely randomized design was most suited on farms where blocks might be difficult to form and impractical to maintain, it was found that experimental design efficiency compared to RCBD is not too low on-farming experimental. The use completely randomized design was most fundamental and useful in effectiveness and an appropriate measure of relative efficiency of on-farm experiment. The benefit of use on farm experiment will be in evaluating specific cultivars in share of environmental and economic condition with highly precisian to have parricidal in the provision of time and effort together. Investigation of efficiency of On-farm experiments as requirement of good experimental trials and precision of agricultural field research, because part of the farm is controlled and measured in order to make projections about how the whole farm will respond. Similarly, in making measurements it would take a prohibitively long time to the results of the study may be used in advising agricultural communities that sustainability of agro-ecosystem will ensure more efficient agricultural production.

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