A study on nitrogen, phosphorus, and biofertilizer levels' effects on rabi green gram quality, yield, and growth, as well as their lasting effects on succeeding summer maize under middle Gujarat conditions

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Abstract

This study set out to compare the efficacy of all randomized complete block designs (RCBDs) to the VBD, as well as to examine the discrepancies between the general combining ability effect and the specific combining ability effect across a range of environmental designs. Six brinjal parents (GOB 1, JBGR 1, KS 331, AB 15-06, AB 17-17, and AB 17-28) were used to produce fifteen different crosses using the diallel technique IV. Late Kharif 2019 saw the crossing take place at the Main Vegetable Research Station, with late 2020 seeing the assessment of crosses at the Agronomy Farm. Fifteen hybrids were planted in two different types of environments (RCBD and VBD). Because of the small sample size, we only looked at four instances for RCBD.

Keywords: *Nitrogen, Phosphorus, Biofertilizer, Rabi Green Gram, Growth.*

1. Introduction

Experimental errors may be reduced by adequate design, replication, randomization, and local control in field studies using agronomic treatments and/or crop genotypes (plant breeding materials). This allows us to get more accurate results from our experiments. The challenge for experimentalists is to choose a design that is suitable for the therapies being tested. Environmental designs such as the Completely Randomised Design (CRD), the Randomised Complete Block Design (RCBD), the Latin Square Design, the Split Plot Design, the Strip Plot Design, and the Incomplete Block Design are common in the agricultural sector. So are plant breeding designs like the Dialel Design, the Partial Dialel Design, the Line x Tester Design, and others. Both types of designs are used by plant breeders nowadays. Common in agriculture and biology, mating design is a cross diagrammatically drawn between groups or strains of plants during plant breeding. The experimental breeding material (lines or crosses) is produced by mating designs, and then the materials' performance is evaluated in the field.[1-2]

The field of environmental design is concerned with the methodical submission of data gained via the matching of design to environmental circumstances and the subsequent extraction of useful information. In the context of diallel cross experiments, environmental design concerns have received much attention in the literature. Large experimental space is required for diallel studies since more parents means more crossings, which means more plots. When planning mating designs, soil heterogeneity in the experimental material is the primary consideration. RCBD solely accounts for homogeneity in one direction across experimental units. high data variations occur when a high number of treatments must be handled in a relatively small block size (RCBD). The use of smaller blocks in an incomplete block design helps in this respect, allowing for more accuracy. For diallel studies, the literature provides two more environmental designs, the row-column design and the variance balanced design. One disadvantage of the row-column layout is the considerable resource overhead involved with doing several replications. Diallel studies using a variance balanced design (VBD) save space since the number of replicates is always two.[3-4]

The current study takes into account Diallel Approach IV, one of the four approaches described above. Diallel crosses are conducted to estimate the heritability of all the variables under consideration. Both the general and the particular combining skills of the inbred lines utilised in the crosses may be estimated using these. The typical efficiency of a line in a hybrid configuration is denoted by the symbol gca. The term sca is used to describe situations in which a hybrid's performance deviates significantly from what would be predicted based on the average performance of its parents.[5]

In 2016–17, 125,100 metric tonnes (MT) of brinjal were harvested in India, making the country the world's second biggest producer behind China. The most brinjal came from the states of West Bengal, Odisha, Gujarat, Bihar, and Madhya Pradesh. With 74,34,000 hectares (ha) and 1,486,55,000 metric tonnes (MT) produced, Gujarat ranked third in the world in brinjal output, behind only West Bengal and Odisha. For the 2016–17 agricultural year in Gujarat, the Anand district produced the most brinjal (166.94 thousand metric tonnes), followed by the Vadodara and Surat regions.[6]

The brinjal crop is one of several vegetable crops that have benefited from the work done at AAU's Main Vegetable Research Station. Twenty-one trials were carried out in 2019–20 and 2020–21 to assess various brinjal entries. From 5 to 24 entries were submitted. No other environmental design has been employed to perform field trials, hence the current research is warranted by the fact that RCBD was used for all of them.[7]

2. Literature review

Goulden, C. H. (2019)provided an evaluation of p-2 diallel offspring with p parents. Jinks and Hayman (1953) provided a broad strategy, which Hayman developed further. Six presumptions underpinned the methodology used. The study was a hybrid of regression theory and graphical methods. Environment (E), genetic additive variance (D), genetic dominance variance component (H1), symmetry/asymmetry of alleles (H2), mean of covariance of additive and non-additive effects (F), and dominance effects (h 2) are the six genetic components for which estimate methods were provided. Heritability, the frequency of dominant and recessive alleles, and the degree of dominance might all be inferred from these genetic features. An illustration was produced to better illustrate the analysis and approach.[8]

Ding, X. & Gao, S. G. (2018)examined the idea of hybrid vigour in depth as it relates to the diallel mating system. Based on the offspring in the investigation, four distinct diallel experimental designs were proposed. On the basis of the parents' sampling nature, two models, the fixed effect model and the random effect model, were explored. There were 8 examples total, 4 diallel experimental procedures used, and 2 distinct sample nature assumptions used. As a potential environmental design, a randomised block design was investigated. The question of what kind of model should be used in what kind of situation was discussed. Each of the eight scenarios has its own computation technique, anticipated mean square, and illustrations.[9]

Fares, W. M. & Morsy, A. R. (2017) the optimality of a nested balance incomplete block design for generating full diallel crossings was examined. During the research, the researchers gave the effects of gca more weight than those of the parents did, and they gave less importance to the impacts of sca. Instructions on how to build the thing were provided. We obtained a set of 16 optimum designs and compared their efficacy to that of a randomized full block design. Some of the suggested designs were as effective as the randomized whole block design, while others were not as effective. Because it was believed that sca impacts would be small, the suggested design is not likely to be used by breeders.[10]

Gadhiya, A. D. & Bhamini, V. P. (2016) determined by analysing direct crossings between eight parents and twenty-eight F1 offspring at the College of Agriculture in Vellayani. Analysis was performed using Griffing's Model I (Method II). Non-additive components have a role in the expression of fruits per plant, average fruit weight, and yield per plant, as shown by the ratios of gca to sca variance of 0.24, 0.44, and 0.21, respectively. Good general combiner for characteristics was observed in the parent strain, Wardha Local. Significant sca effects were seen in the crosses Wardha Local x Vellayani Local, Wardha Local x Palakurthi Local, NBR-38 x Vellayani Local, and Swetha x Vellayani Local.[11]

Ghosh, D. K., & Ahuja, S. (2015) evaluated 50 wheat entries using the alpha lattice design and 25 potato entries using the randomized full block design. Two replicates of 50 entries were planted in 10 blocks of five rows each for the wheat crop. A total of 25 individual plants were planted in 5 blocks of 5 plots each to form the potato crop design. The relative efficiency was measured against the standard error of the difference and the coefficient of variation. In a randomized full block design for wheat, the coefficient of variation was 7.70%, while in an alpha lattice design it was 8.54%, and in both designs it was 13.60% and 16.39% for potatoes. For both crops, the alpha lattice design had a lower standard error of difference than the randomized whole block design. Alpha lattice design outperformed randomized whole block design for both the wheat and potato crops, with efficiencies of 1.24 and 1.46, respectively. [12]

3. Methodology

Data from diallel crosses produced using Griffing's technique IV was used to compare the efficacy of RCBD and VBD as environmental design strategies.

3.1Experimental material

Diallel crossings were carried out using six different brinjal genotypes (Table 3.1). Crossing blocks were created by sowing the seeds of the parents in a nursery and then transferring them to the field 30 days later. In the crossover block, we crossed both sets of parents 15 times, producing 15 offspring. Dialel crosses were constructed using Griffing's Strategy 4. All of the hybrids' seeds that were harvested from the ripe fruit were saved.

Table 3.1 Specifics of the studied families' lineages

Notation	Genotypes	Source
P_1	GOB1	MainVegetableResearchStation,AAU,Anand
P_2	JBGR1	VegetableResearchStation,JAU,Junagadh
P_3	KS331	CSAUK,Kanpur,UttarPradesh
P_4	AB15-06	MainVegetableResearchStation,AAU,Anand
P_5	AB17-17	MainVegetableResearchStation,AAU,Anand
P_6	AB17-28	MainVegetableResearchStation,AAU,Anand

Table 3.2: Crosses between dialel pairs

Notation	Crosses
C1	GOB1 xJBGR 1
C2	GOB1 xKS 331
C3	GOB1xAB15-06
C4	GOB1xAB17-17
C5	GOB1xAB17-28
C6	JBGR1xKS331
C7	JBGR1 xAB15-06
C8	JBGR1 xAB17-17
C9	JBGR1 xAB17-28
C10	KS331 xAB15-06
C11	KS331 xAB17-17
C12	KS331 xAB17-28
C13	AB15-06 xAB17-17
C14	AB15-06 xAB17-28
C15	AB17-17 xAB17-28

3.2Experimental details

In Late Kharif, 2019, the hybrid seeds were sowed at the Main Vegetable Research Station, AAU, Anand in the nursery, and transplanting was done at the Agronomy Farm, AAU, Anand five months later on October 5, 2019. Two environmental designs, the randomized complete block design (hereafter RCBD) and the variance balanced design, were applied to the diallel crosses. Three RCBD replicates were used to transplant all diallel crosses. All fifteen crosses were laid out in six blocks of five, with two replicates each block, in VBD. Both environmental layouts had a double row of plantings at each end. Eight plants were planted in a row across each plot. The distance between rows was 90 centimetres, while inside a row it was 60 centimetres. We took all the necessary agronomic and plant protection precautions to ensure a healthy crop, from the nursery to the field.

3.3 Analysis of data

Two environmental designs, RCBD and VBD, were applied to the resulting diallel crossings.

3.4 Comparison of environmental designs

The success of a field experiment relies heavily on the environmental designs used. The nature of the research, the nature of the experimental materials, the level of accuracy necessary, the number of elements to be examined, etc. all have a role in determining the optimal design. Consequently, it's crucial to choose for energy-saving layouts. In the past, researchers have examined the effectiveness of various design criteria via several studies. Coefficient of variation and relative efficiency were the main two factors evaluated.

3.5 Comparisons of GCA and SCA effects

There is a need for in-depth research into how the combined impacts of gca and sca in various environmental designs vary from one another. This will make it easier to examine the importance and significance of the dependence of gca and sca distributions on environmental designs. Chi-square tests are used to examine the correlation between environmental design and three attributes.

Gca impacts of characteristics on environmental design (randomized full block design and variance balanced design) may be evaluated using a Chi-square test.:

Particulars	**RCBD**	**VBD**
Significant*gca* effects	a	b
Non-significant*gca*effects	c	d

4. Results

The results of the current experimentation on a number of fronts. The results of a randomized complete block design (RCBD) and a variance balanced design (VBD) were analyzed using the techniques described in Chapter III. RCBD had three replications, whereas VBD had two replications due to its six blocks of size five. The RCBD data was evaluated in four different ways: using all three replications (RCBD I), using a combination of two replications of RCBD (RCBD II and RCBD III), using a combination of two replications of RCBD (RCBD IV), and using replications 1 and 3.

4.1 Analysis of variance for different environmental designs

Table 4.1 summarizes the results of an ANOVA performed on the average fruit weight (g), average fruit output (kg), and number of fruits produced per plant for RCBD I, II, III, IV, and VBD.

Table 4.1: Analysis of variance

Trait	Sources	DF	RCBDI	DF	RCBDII	RCBDIII	RCBDIV	DF	VBD
NFPP	Rep/Block	2	808.50**	1	100.41	824.60**	1500.49**	5	110.11*
	Crosses	14	189.94**	14	109.28*	164.01*	142.40**	14	70.96*
	Error	28	35.80	14	36.91	32.46	38.03	10	22.22
FYPP	Rep/Block	2	12.84**	1	3.72	9.52**	25.24**	5	0.97*
	Crosses	14	1.26**	14	0.91	1.11*	0.92*	14	1.05**
	Error	28	0.43	14	0.60	0.33	0.37	10	0.17
AFW	Rep./Block	2	1482.82**	1	1287.09**	307.76	2853.61**	5	887.89**
	Crosses	14	910.13**	14	542.38**	661.06*	777.73**	14	685.05**
	Error	28	160.89	14	125.59	222.27	134.81	10	40.60

With the exception of RCBD II for number of fruits per plant and fruit production per plant and RCBD III for average fruit weight, the analysis (Table 4.1) demonstrated substantial or very significant block effects for VBD and replication effect for the characteristics evaluated of all RCBD designs. Except for RCBD II fruit output per plant, all other designs and attributes tested showed substantial or extremely significant changes when diallel crosses were used. The results showed that for all RCBDs and VBDs except for RCBD II for fruit yield per plant, the diallel crosses exhibited substantial or extremely significant genetic differences in terms of number of fruits per plant, fruit yield per plant, and average fruit weight.

4.2 Efficiency comparison of RCBD with VBD

Estimates based on error mean squares, such as SEm and CV, were used to determine if one design (layout) was more effective than another. The relative effectiveness of VBD and RCBD for the three qualities examined in this study are shown in Table 4.2. Using equation 25 (page 23), we evaluated relative efficiency based on error mean square, and using SEm and CV, we assessed relative efficiency by dividing the SEm of RCBD by the SEm of VBD, and the CV of RCBD by the CV of VBD. The efficiency increase was determined by taking relative efficiency and subtracting 100.

When comparing the number of fruits per plant, fruit yield per plant, and average fruit weight across all RCBD designs, VBD had lower error mean square, standard error of mean (except for RCBD I for number of fruits per plant), and coefficient of variation.

The relative efficiency and increase in efficiency of VBD in contrast to RCBDs were positive, as seen by the CV (Table 4.2) found under RCBD I, II, III, and IV and VBD for the quantity of fruits per plant characteristic. VBD was more effective and accurate than RCBD with two or three replications, with efficiency gains ranging from 23.56% (RCBD III) to 40.24% (RCBD I and RCBD IV).

Table 4.2: Environmental design comparisons using a variety of statistical measures

Particulars	RCBDI	RCBDII	RCBDIII	RCBDIV	VBD
Numberoffruitsperplant					
ErrorMeanSquare	35.80	36.91	32.46	38.03	22.22
#RelativeEfficiency%	92.05	142.37	125.20	146.70	-
#Gaininefficiency%	-7.95	42.37	25.20	46.70	-
StandardErrorof Mean	3.45	4.30	4.03	4.36	3.60
#RelativeEfficiency%	95.83	119.44	111.93	121.11	-
#Gaininefficiency%	-4.17	19.44	11.94	21.11	-

CV%	16.31	18.65	14.37	16.31	11.63
#RelativeEfficiency%	140.24	160.36	123.56	140.24	-
#Gaininefficiency%	40.24	60.36	23.56	40.24	-
Fruityield(kg)perplant					
ErrorMeanSquare	0.44	0.60	0.33	0.37	0.18
#RelativeEfficiency%	141.25	291.83	160.32	179.18	-
#Gaininefficiency%	41.25	191.83	60.32	79.18	-
StandardErrorof Mean	0.38	0.55	0.41	0.43	0.32
#RelativeEfficiency%	118.75	171.87	128.12	134.37	-
#Gaininefficiency%	18.75	71.87	28.12	34.37	-
CV%	19.88	27.49	15.38	17.99	10.51
#RelativeEfficiency%	189.15	261.56	146.33	171.17	-
#Gaininefficiency%	89.15	161.56	46.33	71.17	-
Averagefruitweight (g)					
ErrorMeanSquare	160.89	125.59	222.27	134.81	40.60
#RelativeEfficiency%	226.45	265.14	469.25	284.60	-
#Gaininefficiency%	126.45	165.14	369.25	184.60	-
StandardErrorof Mean	7.32	7.92	10.54	8.21	4.87
#RelativeEfficiency%	150.30	162.62	216.42	168.58	-
#Gaininefficiency%	50.30	62.62	116.42	68.58	-
CV%	13.95	12.94	15.48	12.93	6.33
#RelativeEfficiency%	220.37	204.42	244.54	204.26	-
#Gainin efficiency%	110.37	104.42	144.54	104.36	-

From 126.45% (RCBD I) to 369.25% (RCBD III) for error mean square, from 50.30% (RCBD IV) to 116.42% (RCBD III) for SEm., and from 104.36% (RCBD IV) to 144.54% (RCBD III) for CV, the efficiency gain of VBD was measured when comparing average fruit weight to all RCBDs (Table 4.2). Again, VBD was shown to be more effective and accurate in the field than RCBD.

In conclusion, when comparing the average fruit weight, fruit production per plant, and the number of fruits produced by each plant, VBD outperformed all of the RCBD with two replications. When just two copies need to be made, VBD performs better than RCBD. Three replicates showed that VBD increased both plant productivity and average fruit weight compared to RCBD.

Table 4.3 Efficiency increase using VBD (averaged across two replicates)

Traits	Averagegaininefficiency(%)onbasisof			Average (%)
	EMS	SEm	CV%	
NFPP	38.09	17.49	41.38	32.32
FYPP	110.44	44.78	93.02	82.74
AFW	236.66	82.54	117.74	145.64
Average	128.39	48.27	84.04	86.90

Table 4.3 presents the results of the analysis, which show that the VBD, an incomplete block design, improved the precision (judged by relative gain) of the experimental information, i.e., treatment (crosses) effect, with an overall gain/precision of 86.90%; the lowest being 32.32% for number of fruits per plant and on parameter basis, 48.27% for SEm. Incomplete block designs have the unique property of reducing variance across experimental units inside a sub-block, which in turn improves the accuracy of VBD. In the RCBD model, this is impossible.

One might look at the current result from a different angle. Thanks to VBD's efficiency boost, we may be able to conduct field experiments at a cheaper cost. The fruit production of brinjal crops is of interest to researchers and farmers. With two replicates, the average gain for VBD ranged from 44.78 percentage points (SEm estimate) to 110.44 percentage points (EMS estimate) over RCBD (Table 4.3). In other words, if you want the same accuracy in your estimations as RCBD but at a much lower price (the minimum level is desired here), VBD is your best option. Results show that VBD is superior to RCBD for testing brinjal crop performance in the field. More field experiments with a wider variety of crops over a longer period of time are need to corroborate this finding, however.

4.3 GCA and SCA effects deviations observed in environmental designs

The 2 test was used to compare the differences in sign and significance between gca and sca from various designs. Here, "deviation" refers to the gaps in the rates at which gca and sca estimations are positive and negative. Each design has 18 values, with 6 gca's representing the traits under study. Table 4.4 displays the 2 values and the frequency distribution of positive and negative signs of gca and sca values across three attributes. Table 4.4 also displays the frequency distribution of 45 sca estimates and 2 values, organized by design.

To learn how much positive and negative estimate frequencies deviate from one another across designs (from the combined 2 test) and between RCBDs and VBD (from the 2 test between each RCBD and VBD), we calculated the 2 test for each RCBD and VBD and also combined the results.

Table 4.4: Positive and negative gca and sca values as a function of design frequency

Particulars	RCBD				VBD	Combined χ^2
	I	II	III	IV		
			***gca*effects**			
Positive	4	4	8	9	7	5.14 (0.27)
Negative	14	14	10	9	11	
Individual χ^2 testwithVBD	1.18 (0.28)	1.18 (0.28)	0.11 (0.74)	0.45 (0.50)	-	
			***sca*effects**			
Positive	21	23	24	21	25	1.14 (0.88)
Negative	24	22	21	24	20	
Individual χ^2 testwithVBD	0.71 (0.40)	0.18 (0.67)	0.04 (0.83)	0.71 (0.40)	-	

Table 4.4 displays the results of a 2 test for frequency distributions, which demonstrated no statistically significant impact of the variables in any of the comparisons. This showed that the gca/sca estimations might be either positive or negative regardless of the methods of comparison.

Table 4.5 shows the percentage of RCBD and VBD with statistically significant gca and sca estimations. Additionally, Table 4.5 provides the 2 values.

Table 4.5 displays the results of a 2 test comparing the frequency distributions of significant and non-significant gca estimates. This test revealed that the distributions of significant and non-significant gca estimates were not significant for the RCBD I v/s VBD; RCBD III v/s

VBD; and for the overall combined test. The number of insignificant gca estimations was higher in RCBD II (15) than in VBD (10).

Table 4.5: Measures of significance for gca and sca, broken down by design type and frequency

Particulars	RCBD				VBD	Combined χ^2
	I	II	III	IV		
***gca*effects**						
Significant	5	3	7	4	10	7.83 (0.09)
Non-significant	13	15	11	14	8	
Individualtest χ^2withVBD	2.85 (0.09)	5.90* (0.01)	1.01 (0.32)	4.21* (0.04)	-	
***sca*effects**						
Significant	7	0	3	8	12	16.54**(0.002)
Non-significant	38	45	42	37	33	
Individualχ^2test with VBD	1.67 (0.20)	13.84** (0.0002)	6.48** (0.01)	1.03 (0.31)	-	

Table 4.5 displays the sca impacts, showing that the non-significant sca estimates were higher for all designs, but that the RCBD II vs. VBD, RCBD III vs. VBD, and combination test all deviated significantly. Significant or non-significant sca estimations in the current research are generally design-dependent (environmental factors may have had a role in the RCBD II and III estimates).

P2 (JBGR 1) and P4 (AB 15-06) are good combiners for fruit yield per plant and average fruit weight, and P4 (AB 15-06) is also good for number of fruits per plant, according to an overall statistical analysis of these three variables presented in separate tables. The crosses C2 (GOB 1 x KS 331), C7 (JBGR 1 x AB 15-06), C9 (JBGR 1 x AB 17-28), C14 (AB 15-06 x AB 17-28), and C15 (AB 17-17 x AB 17-28) show promise based on mean performance and sca estimations.

5. Conclusion

There were a total of fifteen different cross-pollination attempts across two different environmental designs (a randomized complete block design (RCBD) and a variance balanced design (VBD)). Due to the small sample size, only four instances were evaluated for RCBD. RCBD I has three copies, whereas RCBD II and III each have two copies, and RCBD IV has two copies of both copies. Counts were taken of how many fruits each plant produced, how much fruit each plant produced in kilogram's, and how heavy an average fruit was.

6. References

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