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Statistical Analysis on Effect of Organic and Inorganic Fertilizers for the Yield of Sorghum

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Abstract: The study probed into the statistical analysis of the effect of organic and inorganic fertilizer on the yield of sorghum; which was carried out at Abubakar Tafawa Balewa University (ATBU) School Farm, Bauchi State. The study relied on secondary data from ATBU school farm structured using a single variety of sorghum at three level of organic (0, 1 and 2t/kg) and four level of inorganic (0, 15, 30, 45kgN/ha) fertilizer. Cow dung and NPK were sources of fertilizer used in the secondary data. SPSS version 20 software was employed to analyze the data obtained. Each variable considered was subjected to univariate analysis of variance (ANOVA) and comparison of the means by employing Duncan Multiple Range Test (DMRT). The result indicated that the effect of fertilization on yield and weight of sorghum were significant at p=0.001. Application of 45kgN/ha of NPK gave the highest yield of 3.6t/ha among sole application of NPK, while 1t/ha of cow dung recorded the highest yield (2.37t/ha) among sole application of cow dung. It was observed that a combination of 2t/ha of cow dung + 45kg/ha of NPK significantly (P=0.001) gave the highest yield of 4.4t/ha of sorghum. However, it was not significantly better than sole application of 45kg/ha of NPK and a combine application of 2t/ha of cow dung + 30kg/ha of NPK. Similarly, 2t/ha of cow dung + 45kg/ha of NPK significantly gave the highest weight of 418kg/ha of sorghum.

Keywords: Soghum; Organic fertilizer; Inorganic fertilizer; Yield; Application.

1. Introduction

Agricultural investigations are based on the application of statistical methods and procedures which are helpful in testing hypotheses using observed data, in making estimations of parameters and in predictions. The application of statistical principles and methods is necessary for effective practice in resolving different problems that arise in many branches of agricultural activities. Because of the variability inherent in agricultural data, knowledge of statistics is necessary for the understanding and interpretation. Numerous activities in agriculture are very different from each other, resulting in different branches of agricultural science like: crop production, plant production, livestock, animal production, agricultural mechanization, water resources, agricultural economics and so on [1].

The importance of statistics in agriculture is obvious, regarding the collection, analysis and interpretation of numerical data. Statistical principles are applied in all areas of experimental work and they have important roles in agricultural experiments. Statistics plays an important role in experimentation while many scientific problems in agriculture could be solved by different statistical procedures [2].

Sorghum is an indigenous crop to Africa, and though commercial needs and uses may change over time, sorghum will remain a basic staple food for many rural communities. The latter is especially true in the more drought prone areas of South Africa, where this crop provides better household food security than maize. Sorghum is mainly cultivated in drier areas, especially on shallow and heavy clay soils. In recent years, there has been a shift in sorghum production from the drier production areas to the wetter areas. This change has resulted in the identification and development of cultivars which are more tolerant to lower temperatures [3].

Agricultural research has played a key role in the development of statistical methods. The presence of wide heterogeneity in the experimental material that is often used in agricultural research, led to the application of statistical tools and consequently many refinement and newer developments in statistics followed. Many interrelated factors, both natural and managerial, causes soil fertility decline. This decline may occur through leaching, soil erosion and crop harvesting [4].

Proper application of organic and inorganic fertilizers can increase the activities of soil micro-organisms and enzymes and soil available nutrient contents [5, 6]. He and Li [5] indicated that combined application of organic and inorganic fertilizers can increase the activities of soil and available nutrient content.

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In addition, application of organic manure could improve the soil quality and is more profitable in environmental protection when compared with application of chemical fertilizer alone The soil with organic manure continually applied had lower bulk density and higher porosity values, porous and buffering capacities [7]

The use of fertilizer is virtually inevitable in crop production due to the nature of our soils which is inherently low in fertility. Thus, the increasing use of inorganic fertilizer (NPK, Urea, Single Super phosphate etc.) and organic fertilizer (cow dung, poultry manure, farm yard manure etc.).

Over 70% of sorghum in Africa is produced by resource poor small-scale farmers [8] and the average sorghum yield in Africa stood at 1.3 t/ha compared to 3.0 t/ha elsewhere. This low grain yield can be attributed to a number of constraints which include both biotic stress (diseases, pests, and lack of suitable varieties) and abiotic stress (low soil fertility and lack of capital to purchase farm inputs).

Examples of inorganic fertilizers are chemical additives that are designed for plants to directly absorb, such as nitrogen (N), phosphorus (P) and potassium (K). These three essential elemental nutrients should naturally occur in healthy soil, but some plants require more of them. Other chemicals that might be included in inorganic fertilizers include calcium, sulfur, iron, zinc and magnesium [9].

Hence, it is important to carry out statistical analysis on the effect of organic (cow dung) and inorganic (NPK) fertilizer combination on the weight and yield of sorghum to find out combinations that will give economic yield.

2. Objectives of the Study

The main aim of this study is to examine the effect of organic and inorganic fertilizers on the yield of sorghum while specific objectives are to:

i determine the optimum combination of organic and inorganic fertilizer for the yield of sorghum.

ii determine the mean for the total weight and yield of sorghum.

iii. compare the mean on the effect of organic and inorganic fertilizer on the yield of soghum.

3. Methodology

This study was carried out at Abubakar Tafawa Balewa University School Farm, Bauchi State. The study area is located between 9° 00’- 10° 30’ N and 9° 30’ - 10° 30’E in Nigerian Northern Guinea Savannah of Bauchi State at an altitude of 600m above sea level.

The data collected for this study was secondary data from ATBU school farm using a single variety of sorghum at three level of organic (0, 1 and 2t/kg) and four level of inorganic (0, 15, 30, 45kgN/ha) fertilizer. Cow dung and NPK were sources of fertilizer used in the secondary data.

SPSS version 20 software was employed to analyze the secondary data collected. Each variable considered was subjected to univariate analysis of variance (ANOVA) and the means comparison using Duncan Multiple Range Test (DMRT).

4. Computation Procedure and Data Analysis

4.1. Analysis of Variance (ANOVA)

ANOVA is a statistical method that stands for analysis of variance. A statistical analysis tool that separates the total variability found within a data set into two components: random and systematic factors. The random factors do not have any statistical influence on the given data set, while the systematic factors do. Analysis of variance (ANOVA) is a collection of statistical models used to analyze the differences among group means and their associated procedures (such as "variation" among and between groups), developed by statistician and evolutionary Biologist, Ronald Fisher.

In the ANOVA setting, the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are equal, and therefore generalizes the *t*-test to more than two groups.

4.2. Randomized Complete Block Design

The randomized complete block design (RCBD) is one of the most widely used experimental designs in agricultural research. The design is especially suited for field experiments where the number of treatments is not large and there exists a conspicuous factor based on which homogenous sets of experimental units can be identified. The primary distinguishing feature of the RCBD is the presence of blocks of equal size, each of which contains all the treatments.

4.3. Blocking Technique

The purpose of blocking is to reduce the experimental error by eliminating the contribution of known sources of variation among the experimental units. This is done by grouping the experimental units into blocks such that variability within each block is minimized and variability among blocks is maximized. Since only the variation within a block becomes part of the experimental error, blocking is most effective when the experimental area has a predictable pattern of variability. An ideal source of variation to use as the basis for blocking is one that is large and highly predictable. An example is soil heterogeneity on a fertilizer or provenance trial where yield data is the primary character of interest. In the case of such experiments, after identifying the specific source of variability to be used as the basis for blocking, the size and the shape of blocks must be selected to maximize variability among blocks.

Schematic Representation of ANOVA for RCBD

Source of variation	**Degree of freedom (*df*)**	**Sum of squares (*SS*)**	**Mean square $\left(MS = \frac{SS}{df}\right)$**	**Computed *F***
Replication	$r - 1$	*SSR*	*MSR*	
Treatment	$t - 1$	*SST*	*MST*	*MST/MSE*
Error	$(r - 1)(t - 1)$	*SSE*	*MSE*	
Total	$rt - 1$	*SSTO*		

Compute the correction factor and the various sums of squares (*SS*) given in the above table as follows.
Let y_{ij} represent the observation made from *j*th block on the *i*th treatment;
$i = 1,\ldots t$;
$j = 1,\ldots,r$.

4.4. Duncan Multiple Range Test (DMRT)

In statistics, Duncan's Multiple Range Test (DMRT) is a multiple comparison procedure developed by David B. Duncan in 1955. Duncan's MRT belongs to the general class of multiple comparison procedures that use the studentized range statistic q_r to compare sets of means. The exact definition of the test is:

The difference between any two means in a set of n means is significant, provided the range of each and every subset which contains the given means is significant according to an $\alpha_p$level range test where$\alpha_p = 1 - \gamma_p$, $\gamma_p = (1 - \alpha)^{(p-1)}$ and $p$is the number of means in the subset concerned.

5. Results and Discussion

The yield parameter as influenced by different rate and combination of cow dung (Organic) and NPK (Inorganic) fertilizer are shown in Table 1. Significant (P≤0.05) difference was observed from the ANOVA Table (Table 2) on the yield of sorghum as affected by the different rate and combination treatment. However, 2t/ha of cow dung + 45kg/ha NPK significantly (P≤0.05) gave the highest yield of 4.4t/ha of sorghum. Although cow dung 2t/ha of cow dung + 45kg/ha NPK gave the highest yield, it was however not significantly (P≤0.05) better than 2t/ha of cow dung + 30kg/ha NPK and 0t/ha + 45kg/ha NPK which gave a yield of 3.8 and 3.6t/ha respectively. The control which had no application of either cow dung or NPK gave the lowest yield of 1.06t/ha of sorghum. The combination of cow dung and NPK generally gave better yield than the sole application of either cow dung or NPK.

The result generally revealed that there was significant effect of both cow dung and NPK fertilizer application on the yield of sorghum. The effect may be adduced to low soil fertility of the experimental site. Tisdale and Nelson [10], Ndaeyo, *et al.* [1], Makinde, *et al.* [11] and Uko, *et al.* [12] noted that crop response to fertilizer application is affected by nutrient reserve in the soil.

According to them, crops respond more to fertilizer application in soils with very low nutrient content than soils with high nutrient reserve. Organic fertilizer apart from releasing nutrient elements to the soil, has also been shown to improve other soil chemical and physical properties which enhance crop growth and development [4, 13].

This may be responsible for the better performance recorded in the yield of sorghum that had combination of cow dung and inorganic fertilizer than crops that received either only cow dung or only inorganic fertilizer treatments. This agrees with results obtained in other crops [1, 12-15]. Dei [16] attributed this to increased efficiency in the utilization of inorganic fertilizers as a result of reduced leaching losses of nutrients.

It was shown in Table 3 that better yield was observed with the combination of cow dung and NPK which could be due to the fact that inorganic fertilizer component of the mixture provided early nutrient to the growing crops during the early vegetative growth stage, while the organic component provided nutrient at the later stage of the crop development.

Table-1. Means of Yield as influence by NPK and Cow dung

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Cow Dung = 0 & NPK = 0	1.067	.292	.464	1.669
Cow Dung = 0 & NPK = 15	1.900	.292	1.297	2.503
Cow Dung =0 & NPK = 30	2.300	.292	1.697	2.903
Cow Dung = 0 & NPK = 45	3.600	.292	2.997	4.203
Cow Dung = 1 & NPK =0	2.367	.292	1.764	2.969
Cow Dung = 1 & NPK = 15	2.100	.292	1.497	2.703
Cow Dung = 1 & NPK = 30	2.933	.292	2.331	3.536
Cow Dung = 1 & NPK = 45	3.067	.292	2.464	3.669
Cow Dung = 2 & NPK = 0	2.200	.292	1.597	2.803
Cow Dung = 2 & NPK = 15	2.967	.292	2.364	3.569
Cow Dung = 2 & NPK = 30	3.833	.292	3.231	4.436
Cow Dung = 2 & NPK = 45	4.400	.292	3.797	5.003

Table-2. ANOVA for Yield of Sorghum

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	28.272[a]	11	2.570	10.046	.000
Intercept	267.868	1	267.868	1047.040	.000
CWNPK	28.272	11	2.570	10.046	.000
Error	6.140	24	.256		
Total	302.280	36			
Corrected Total	34.412	35			

Table-3. Mean Comparism on the Effect of Cow Dung and Npk on the Yield of Sorghum (Kg/Ha)

	Treatment	N	Subset				
			1	2	3	4	5
Duncan[a,b]	Cow Dung = 0 & NPK = 0	3	1.067				
	Cow Dung = 0 & NPK = 15	3	1.900	1.900			
	Cow Dung = 1 & NPK = 15	3		2.100	2.100		
	Cow Dung = 2 & NPK = 0	3		2.200	2.200		
	Cow Dung =0 & NPK = 30	3		2.300	2.300		
	Cow Dung = 1 & NPK =0	3		2.367	2.367		
	Cow Dung = 1 & NPK = 30	3			2.933	2.933	
	Cow Dung = 2 & NPK = 15	3			2.967	2.967	
	Cow Dung = 1 & NPK = 45	3			3.067	3.067	
	Cow Dung = 0 & NPK = 45	3				3.600	3.600
	Cow Dung = 2 & NPK = 30	3				3.833	3.833
	Cow Dung = 2 & NPK = 45	3					4.400
	Sig.		.055	.322	.050	.061	.078

Means for groups in homogeneous subsets are displayed.
Based on observed means
The error term is Mean Square (Error) = .256.
a. Uses Harmonic Mean Sample Size = 3.000.
b. Alpha = .05.

Means in the same subsets are significantly the same and differ significantly from means in other subsets.

Table-4. Means of total weight as influenced by NPK and Cow dung

CWNPK	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Cow Dung = 0 & NPK = 0	108.000	32.143	41.660	174.340
Cow Dung = 0 & NPK = 15	189.667	32.143	123.327	256.006
Cow Dung =0 & NPK = 30	214.000	32.143	147.660	280.340
Cow Dung = 0 & NPK = 45	358.333	32.143	291.994	424.673
Cow Dung = 1 & NPK =0	237.000	32.143	170.660	303.340
Cow Dung = 1 & NPK = 15	214.333	32.143	147.994	280.673
Cow Dung = 1 & NPK = 30	292.000	32.143	225.660	358.340
Cow Dung = 1 & NPK = 45	274.333	32.143	207.994	340.673
Cow Dung = 2 & NPK = 0	219.333	32.143	152.994	285.673
Cow Dung = 2 & NPK = 15	283.000	32.143	216.660	349.340
Cow Dung = 2 & NPK = 30	384.000	32.143	317.660	450.340
Cow Dung = 2 & NPK = 45	418.333	32.143	351.994	484.673

Table-5. ANOVA for Total Weight of Sorghum

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	257616.972[a]	11	23419.725	7.556	.000
Intercept	2547748.028	1	2547748.028	821.987	.000
CWNPK	257616.972	11	23419.725	7.556	.000
Error	74388.000	24	3099.500		
Total	2879753.000	36			
Corrected Total	332004.972	35			

The results in Table 4 showed the effect of cow dung and NPK on the total weight of sorghum. The ANOVA Table (Table 5) revealed that, the different rate and combination of cow dung and NPK significantly ($P \leq 0.05$) affected the total weight of sorghum. A combination of 2t/ha of cow dung + 45kg/ha gave the highest weight of 418kg/ha of sorghum which was significantly higher when compared with other treatment with exception of 2t/ha of cow dung + 30kg/ha NPK and 0t/ha + 30kg/ha NPK. The control (0t/ha of cow dung + 0kg/ha NPK) had the lowest weight of 108.00kg/ha of sorghum.

6. Conclusion and Recommendations

The analysis suggested that sorghum yield and its component can be raised significantly by modifying agronomic practices. Yields were increased, by application of cow dung and inorganic fertilizer. In addition, the integrated application of cow dung and inorganic fertilizer performed better than the application of inorganic fertilizer or cow dung only. Also, cow dung combined with inorganic fertilizer is more beneficial to the environment because with decrease in the use of chemical fertilizer and use of organic manure such as cow dung; can bring about sustainable agriculture. However, it is imperative to apply the right statistical tools in order to achieve this aim and ensure reliability of any research geared towards agricultural sustainability and economic development.

Based on the statistical analysis in this study, it is therefore recommended that a combined application of 2t/ha of cow dung and 45kg/ha of NPK be used by farmers and other associated agencies for the optimum production of sorghum. However, in order to minimize cost, 2t/ha of cow dung and 30kg of NPK could be adopted by farmers.

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