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SPLIT- PLOT FACTORIALANALYSIS TO INVESTIGATE THE MOST STRIGA TOLERANT GENOTYPE AMONG THE VARIETIES OF MAIZE AND THE STRIGA INFESTED ENVIRONMENT.

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ABSTRACT

This research is to investigate the most striga tolerant genotype among the varieties of maize and the striga infested environment. The goals of Agricultural Research Instituteamong others, are to increase the quantity and to improve quality of maize production .Therefore, this research seek to know the best varieties of maize that can survive under a striga infested area, examine the most tolerance variety of maiz; examineif environmental factor contributes to the yield of maize varieties and investigate whether the yield of maize varieties depends on the locations where it is been planted.

Statistical data analysis was done using Split-plot factorial experiment and comparison of treatment means was doneusing M-STAT (statistical package) to carry out the **analysis,** and the results was interpreted. The "test and results" shows that TZMi104 gave the minimum damage rate under striga infestation followed by STRTZi3.

Also, further test shows that the various varieties of maize and the various environmental factors had considerable effect in the yield when the test was performed at 5% level of significance. The

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grain yield depends on the maize genotype and the environment where it is planted, which shows that all the factors and interaction have significant effect.

Keywords; Split-Plot, Factorial Exeperiment, Maize Varieties, Striga Tolerant Genotype Design Experiment .

INTRODUCTION.

Design of Experiment is a structured, organized method that is used to determine the relationship between the different factors (Xs) affecting a process and the output of that process (Y). This method was first developed in the 1920s and 1930, by Sir Ronald A. Fisher, the renowned mathematician and geneticist.

It is a method of arranging treatments in order that their effects may be meaningfully tested (Wahua, 1999).

The basic concepts of the statistical design of experiments and data analysis were developed in the early part of the 20th century as a cost effective research design tool to help improve yields in farming. Since then, many types of designed experiments and analysis techniques have been developed to meet the diverse needs of researchers.

The specific questions that the experiment is intended to answer must be clearly identified before carrying out the experiment. We should also attempt to identify known or expected sources of variability in the experimental units since one of the main aims of a designed experiment is to reduce the effect of these sources of variability on the answers to questions of interest. That is, we design the experiment in order to improve the precision of our answers.

Building a design means, carefully choosing a small number of experiments that are to be performed under controlled conditions. There are four interrelated steps in building a design:

1. Define an objective to the investigation, e.g. better understand or sort out important variables or find optimum.

2. Define the variables that will be controlled during the experiment (design variables), and their levels or ranges of variation.

3. Define the variables that will be measured to describe the outcome of the experimental runs (response variables), and examine their precision.

Definition of Terms

- *Factors*: These are variables of interests which may be quantitative or qualitative, that are related to the response variable in an experiment.
- *Interaction Effect*: Interaction effect is said to exist between two factors when the difference in response between the levels of one factor is not the same at all levels of the other factor.
- *Main Effect*: This is the primary factors of interest in an experiment. Effect of a factor is the change in response produced by a change in the level of the factor.
- *Main-plot (Whole-plot)*: Larger experimental plot on which the main factors are applied
- *Sub-plot*: Smaller experimental plot splited within the main plot
- *Sub-Sub- plot*: Smaller experimental plot splited within the sub-plot
- *Whole-plot factors*: (the factors whose levels are hard to change) applied to the large experimental units
- *Sub-plot factors*: (the factors whose levels are easy to change) applied to the smaller experimental units
- *Sub-Sub-plot factor*: (the factors whose levels are easy to change) applied to the smaller experimental units in the sub-sub-plot

Design of Experiments The purpose of experimentation is to understand the relationship between input and output variables. By modifying the inputs and recording the changes in the response, the experimenter can identify what inputs are influential in the response. Design of Experiments is a set of procedures that are commonly used to conduct these experiments. Many statisticians have developed methods to conduct experiments and statistically identify the factors and interactions that are influential in the responses (Coleman and Montgomery, 1993). One of the more popular methods is called the Analysis of Variance (ANOVA). The ANOVA is used to identify which factors produce the greatest changes in the response.

Restricted Randomized Experiments; There are situations in which an experiment cannot be completely randomized. This can be due to limited amounts of space or time. Common restrictions can include experiments that need to be run at the same time, or when the experimental runs use several batches of materials, or when there are different operators or equipment for a set of runs. These experiments are often called Restricted Randomized Experiments. These types of experiment offer valid results for certain restrictions while sacrificing other information.By completely randomizing the experiment, the potential effects of noise and other uncontrolled variables are lessened in the experiment. This advantage may be discarded because there are other more important considerations in the experiment. It is common to see an experiment that can be conducted as a completely randomized experiment, but the experimenter chooses to purposely restrict the randomization so as to obtain other valuable information or to arrange for a less complicated experiment.Common restricted randomized experiments are blocked, Latin-squares, nested and split-plot designs. The blocked designs are used when there are different environmental or operational conditions between groups of runs in the experiment, such as: two operators each conducting a part of the experiment or an experiment that takes so long that parts of the experiment are conducted on different days. It is true that the experiment can be designed by including the operators as factors in the experiment, thus reducing this problem; however, the response due to operators in this situation is either unimportant or fairly obvious. Besides, adding the operators as a new factor, will double the size of the experiment.

According to Guillermo Lopez, 2007, When performing an experiment, it is desirable to randomize the order in which the experiment is conducted. There are, however, situations in which a complete randomization of the experiment is not feasible or recommended. Costs and time factors can constrain the experiment making it difficult to completely randomize the experiment. Whenever the experimenter is unknowledgeable about the experiment, this could lead to unreliable analysis of the experiment (Coleman and Montgomery, 1993). Techniques for coping with restrictions to randomization include blocked designs, nested designs and split-plot designs. Arvidsson and Gremyr (2003) compared how the results are affected if the experiment is done by completely randomizing the experiment or by deliberately restricting the runs.

Factorial Experiments

Montgomery (1976) defined factorial experiments as experiment in which each complete trial or replication of the experiment and all possible combinations of the level of the factors are investigated. This is the most efficient design when an experiment requires a study of the effects of two or more factors. When factors are arranged in a factorial experiment, they are often said to be crossed.Larsen (2006) defined factorial experiment as an experiment in which the interest is to investigate the effects of two or more factors on the response variable. According to him, a factor is a categorical variable with levels, indicating for each observation and from which populations it came from. For example, in pharmaceutical experiment, the treatments involved may differ in terms of the type of drug (1st factor) and the dose of the drug (2nd factor). In farming, the yield of a particular barley field may depend on the variety of barley and on the type of fertilizer. While in a social study of crime rates, factors such as level of urbanity (rural, suburban, and urban), wealth (poor, average and rich), time of year, etc may be taken into account.

Factorial experiments are more efficient than one factor at a time experiments. This design is necessary when interactions may be present, to avoid misleading conclusions. It allows effects of a factor to be estimated at several levels of the other factors, yielding conclusions that are valid over a range of experimental conditions (Montgomery, 1976).

Split-Plot Experiments

In some agronomic or horticultural fields trials, one factor sometimes require more experimental material for its evaluation than a second factor in factorial experiments. A factor such as cultural method may require the use of equipment that is best suited for large plots whereas another factor in the experiment such as cultivar or fertility level may be applied easily to a much smaller plot of land. The larger cultural treatment plot is referred to as Whole Plot and splitted into smaller plots called Subplots to which the different cultivars or fertility treatments are applied (Robert O. Kuel, 1999)

Split plot experiment is a special type of factorial experiment in which the factors (or a combination of factors) are randomized individually instead of as a unit of overall treatment combination (Wahua T.A.T., 1999)

Montgomery (2005) describes a split-plot experiment as two experiments combined or overlaid on each other: the first experiment has the whole-plot factors (the factors whose levels are hard to change) applied to the large experimental units and the second experiment has the Sub-plot factors (the factors whose levels are easy to change) applied to the smaller experimental units. Hence, split-plot experiments have three characteristics (Kowalski and Potcner (2003): the levels of all the factors are not randomly determined or reset for each experimental run, the size of the experimental unit is not the same for all experimental factors, and a restriction exists on the random assignment of the treatment combinations to the experimental units.

Research Design

Oloyo (2001) defined research as an enquiry into a problem, and the intent is to find a solution through a formulated and systematic approach involving collection, analysis and interpretation of pertinent data.

There are varieties of research and the basis for classification has been by purpose and by method adopted for conducting the research. If research is classified by purpose, we then have basic research, applied research, evaluation research and action research. While if the research is classified by method adopted for conducting research, we will have historical research, descriptive research, correlational research, causal-comparative research and experimental research. (Oloyo, 2001)

For the fact that the study data was collected through the process of field experiment which aims at establishing a cause-effect relationship, therefore the research design to be adopted is Experimental Research Design.Experimental research truly establishes cause-effect relationship. Subject to be studied are randomly divided into experimental groups, treatments are assigned to the various groups, and finally treatment effects on the subject are observed or estimated. The treatment which is manipulated and believed to be the cause is referred to as independent variable, while the effects observed on the subject is the dependent variable(s).

Research VariableThe following are the specification of the research variables for this study:

Selection of Subject: The subjects of the experiment is the maize (*zea mays*) plant (*Euthochthagaleator)*.

Treatment: There are THREE factors involved in the experiment which involves location,infected area and varieties of maize with 2 replicates

LOCATIONS (Main treatment):

A1 - BAGANDA

A2 - FERK

A3 - MOKWA

A4 - NYANPALA

INFECTION (Sub-treatment):

B1 - INFESTATION

B2 - UNINFESTATION

VARIETES (Sub-sub-treatment)

C1 - STR T2i3

C2 - STR T2Ii2

C3 - STR T2i57

C4 - Tzi1o 5057

C5 - Tzmi 104

A treatment (the independent variable) in the Split-split-plot experiment of this nature is the different combinations of factors' levels. Hence, for this study, we shall have a total number of 40 (4X2X5) treatments while the 3-factors are the main effects in the experiment.

MATERIALS AND METHODS

The experimental area was divided into 4 which make the main plot (Location) while each of the locations are later sub-divided into 2 equal experimental plots to accommodate each of the infestation treatment, that is, infested and uninfested. Each infestation level was later subdivided into 5 to accommodate the maize varieties. The experiment was replicated twice. The experimental plot within each block (replicate) is assumed to be as homogeneous as possible.

The randomization process was used to assign treatment to each of the replicate separately and independently. Location (the main plot) was randomized within each block and Infestation (sub-plot) was randomized within each Location while Variety (sub-sub-plot) was randomized within each infestation level.

Data Analysis

Proposed Initial Study Model: Based on the field layout and process taken in this experiment, the appropriate experimental design to be used for the data analysis is 4X2X5 factorial Split-split-plot experiment in a Randomized Complete Block design (RCBD).

The general statistical model for the 3-factor (4X2X5) Split-split-plot design is:

$$Y_{ijk} = \mu + \rho_k + \alpha_i + \delta_{ik} + \beta_j + (\alpha\beta)_{ij} + \gamma_{ij(k)} + \acute{\Gamma}_l + (\alpha\acute{\Gamma})_{il} + (\beta\acute{\Gamma})_{jl} + (\alpha\beta\acute{\Gamma})_{ijl} + \varepsilon_{ijlk}$$

(i = 1 to a, j = 1 to b, l = 1 to c and k = 1 to r).

where:

Y_{ijlk} is the observed value for the kth block of the ith level of location, the jth level of infestation and lth level of variety.

μ is the general mean.

ρ_k is the block effect for the kth block

α_i is the effect of the ith level of location

δ_{ik} is the whole plot random error effect, for the ith , kth combination of location and block respectively

$\beta_j$is the effect for the jth level of infestation

$\alpha\beta_{ij}$ is the interaction effect of the ith level of location with the jth level of infestation

$\gamma_{ij(k)}$ is the sub-plot random error effect, for the ith , jth and kth combination of location, infestation and block respectively.

$\acute{\Gamma}_l$ is the effect of the lth level of variety

$\alpha\acute{\Gamma}_{il}$ is the interaction effect of the ith level of location with the lth level of variety

$\beta\acute{\Gamma}_{jl}$ is the interaction effect of the jth level of infestation with the lth level of variety

$\alpha\beta\acute{\Gamma}_{ijl}$ is the interaction effect of the ith level of location with the jth level of infestation and lth level of variety

ε_{ijlk} is the sub-sub-plot random error effect associated with the Y_{ijlk} sub-sub-plot unit (experimental error) $\varepsilon_{ijlk} \sim NID(0, \sigma^2)$

Mean Separation

The F-test for any testable effect may indicate significant differences or otherwise. When significant, it suggests that, at least, one the means in question is different which needed to be investigated.

As discussed earlier, there are several methods of carrying out mean separation, such as Least Significant Difference (LSD), Bayesian Modification of LSD (BLSD), Duncan's Multiple Range Test (DMRT), Turkey's Honest Significant Difference (THSD), Scheffe's method etc. But for this study, Duncan's Multiple Range Test (DMRT) shall be usefor any significant difference.

Limitation of the Methodology/Study

RCB design becomes less efficient as the number of treatment increases; primarilybecause block (replicate) size increases proportionally with the number of treatment and the homogeneity of the experimental plots within a large block is difficult to maintain. Therefore, the experimental error of RCB design is generally expected to increase with the large number of treatments. So, with the size of the block of this study, the experimental error may be high which may affect the precision of the experiment.

On the study, due to time and resource constraint, the data to be analyzed in this study is a secondary data. Therefore, the reliability of the randomization technique used and other methods of controlling experimental error cannot be fully ascertained which may also affect the precision of the outcome of the study.

In spite of these setbacks, it is still evident that the richness and quality of this study will be achieved.

DATA ANALYSIS

The analysis of data was carried out using a statistical package called
M –STAT for the analysis. The analysis is presented below:

ANOVA Table for the Result

Sources of Variation	*Sum of Squares (SS)*	*Degree of Freedom (DF)*	*Means Square (MS)*	F_o	*Prob.*
Blocks	0.699	1	0.699	27.3730	0.0136
Location (A)	9.761	3	3.254	127.3415	0.0012
Error (a)	0.077	3	0.026		
Infestation (B)	4.278	1	4.278	655.9029	0.0000
Location X Infestation (AB)	1.172	3	0.391	59.9108	0.0009
Error (b)	0.026	4	0.007		
Variety (C)	0.889	4	0.222	8.9473	0.0001
Location X Variety (AC)	1.731	12	0.144	5.8088	0.0000
Infestation X Variety	0.705	4	0.176	7.1021	0.0003
Location X Variety X Infestation	1.432	12	0.119	4.8064	0.0002
Error (c)	0.794	32	0.025		
Total	21.564	79			

Mean Separation

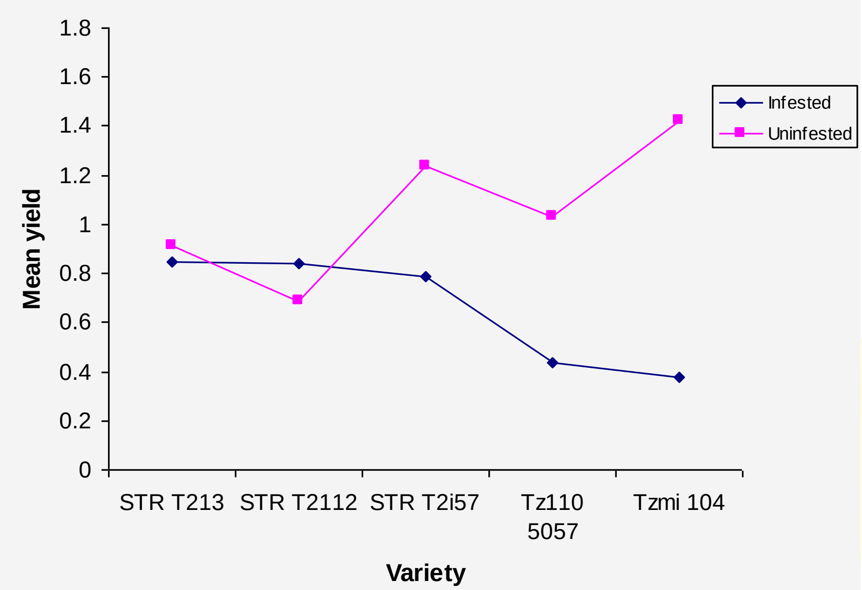

Figure 1. Mean yield of maize varieties at Babanda

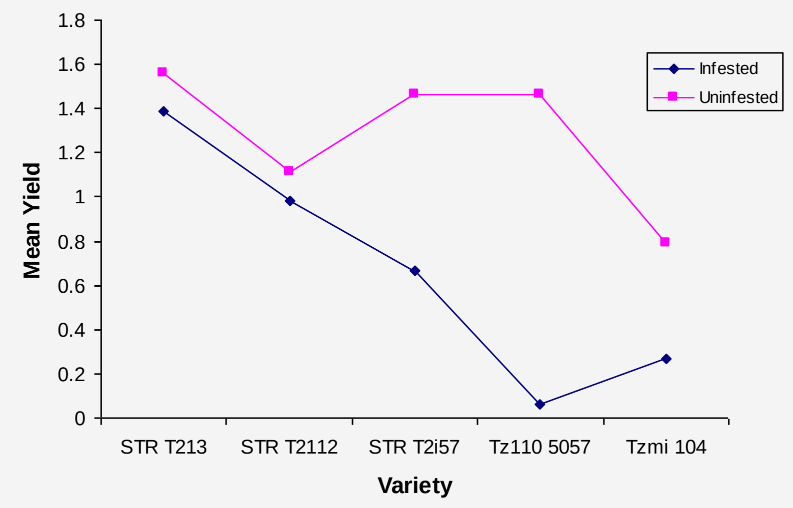

Figure 2. Mean yield of maize varieties at Ferk

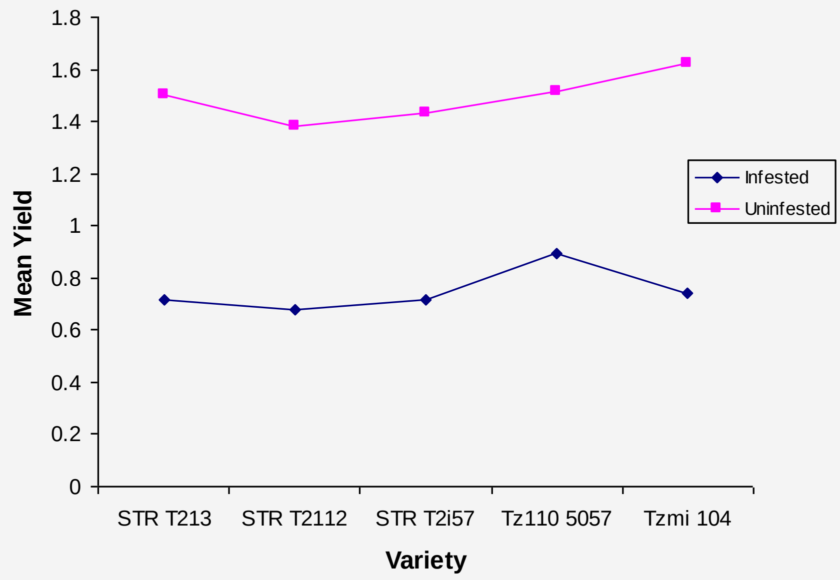

Figure 3. Mean yield of maize varieties at Mokwa

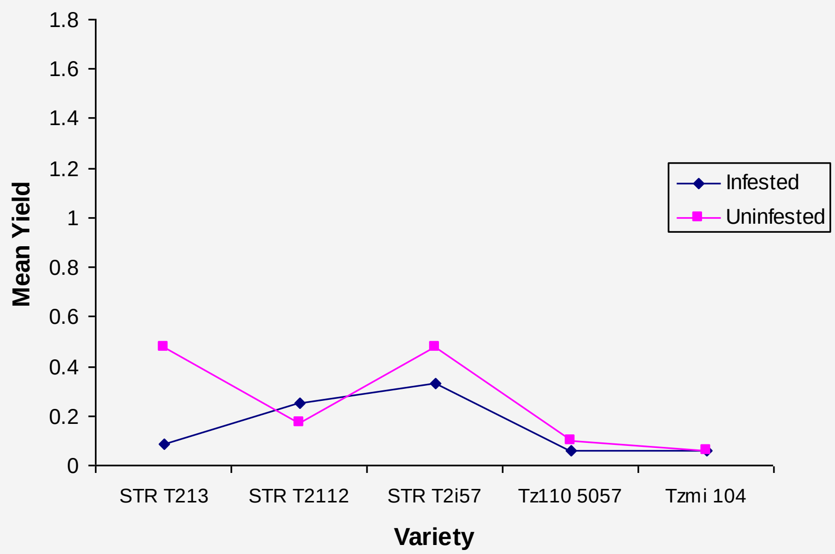

Figure 4. Mean yield of maize varieties at Nyankpala

INTERPRETATION OF RESULTS AND GENERAL CONCLUSION

The results showed that the various varieties used and the various environmental factors had considerable effect in the yield when the test was performed at 5% level of significance. The grain yield depends on the maize genotype and the environment where it is planted, which shows that all the factors and interaction have significant effect.

In conclusion, it is certain that among the varieties tried, Tzmi 104 had the highest mean yield when planted in the uninfested plot at MOKWA and STR T213 also in the uninfested plot at FERK which means it has the minimum damage rating. It is certain that it has the highest grain yield under striga infestation

Location and Variety: there is interaction effect of location and variety on the mean yield of maize irrespective of level of infestation. STRT 213 at Ferka recorded highest mean yield followed by T2 110 5057 and Tmi 104 both at mokwa. The least mean yield was recorded at Nyankpala by the same varieties.

Infestation and Variety: there is interaction effect of infested by variety on the mean yield of maize. The best three yield were recorded from the STR T213, STR T2157 and TZi10 5057 from the uninfested plot. The lowest were recorded from Tzi10 5057 and Tzmi 104 in the infested plot irrespective of location.

Location, Infestation and Variety: it was observed from the ANOVA Table that there is interaction effect of location by infestation by variety on the mean yield of maize. The highest mean yield was recorded from Tzmi 104 in the uninfested at Mokwa and STR T2i3 and TZi10 5057 in the uninfested plot at Ferka.The lowest mean yield are recorded from Tzi10 5057 in the infested plot at Nyankpala. All the plot with the lowest yield recorded a mean yield of 0.06kg.

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Among the available standard designs, choose the one that is compatible with the objective, number of design variables and precision of measurements, and with a reasonable cost.