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Full Length Research Paper

Hetero-Culture Method on the Control of Stink Bugs on the Yield of Soybean: A Factorial Split Plot Analysis

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ABSTRACT: The study was prompted by the need to boost the production of food crops in order to meet the increasing demand and generate higher economic returns to Soybean. Hence, the principle of Split-plot experiment was employed to study the most effective cultivation method that can be adopted to reduce the infection of stink bugs on soybean pods to the minimum, assess the reaction of stink bugs to hetero-cultures of Soybean, assess the effect of Stink bug on Soybean when intercropped with chickpeas, cowpea, lentils and guinea corn separately and also, to assess the effect of Stink bugs on Soybean when intra-rowed with chickpeas and cowpea. Four types of intercropping; cowpea intercropped with Chickpeas, soybean intercropped with cowpea, Soybean intercropped with lentils, soybean intercropped with guinea corn. Five methods intra-row mixing one row of Soybean to one of the others, three rows of soybean to one of the others, five rows of soybean to one of others, seven rows of Soybean to one of the others. Intra-row mixing of Soybean and others were used for the experiment. After, the data collected were subjected to statistical analysis using a statistical package called SAS. The results obtained for higher yield which comes as a result of reducing the rate of infection of the bug on the Soybean pod and economic considerations of Soybean intercropped with Guinea corn will be preferred for higher yield which comes as a result of reducing the rate of infection of the bug on the Soybean pod and economic considerations of three rows of Soybean to one of the others will be preferred.

Keywords: Split-Plot design, hetero-culture, stink bugs, intercropped, intra-row and soybean

INTRODUCTION

Agriculture is central to human survival - it provides food and fuel and other ecosystem services. It is an important source of livelihood, and plays a crucial role in economic development. Agriculture is, however, also a major source of environmental degradation, contributing to climate change, depleting freshwater resources, degrading soil fertility and polluting the environment through fertilizer and pesticide use. Ironically, food production is critically dependent on the very natural resources (Nazeer, 2014). It is degrading. Sustainable food security therefore requires not only that all people at all times have access to sufficient and nutritious food, but also, that this food be produced with minimal environmental impact. Sustainable agricultural development, instead, requires that agriculture meet the needs of the present without compromising the ability of future generations to meet their own needs. Current agriculture fails in achieving these goals on numerous ends. Agriculture today is not only a leading driver of environmental degradation and a major force driving the Earth System beyond the ‘safe-operating space’ for humanity (Nazeer, 2014), it also does not feed people adequately, as currently still one in six people in developing countries are undernourished due to lack of sufficient access to nutritious food (FAO, 2010). Given that we do not achieve sustainable food security today and given that we will probably need to double food production by 2050 to feed 9 billion people with increasing demand for meat and dairy products (Foley *et al*., 2011), there is a drastic need for changes in the food system. From an agricultural perspective, we need to produce more food in the right locations at affordable prices, ensuring livelihoods to farmers and reducing the environmental cost of agriculture. Considering the huge challenge ahead of us, it is important to assess the potential contribution of different types of farming systems to sustainable food security. 'Alternative' farming systems that try to mimic ecological processes while minimizing external inputs are often suggested as more sustainable forms of food production. Hetero-Culture method is a system aimed at producing food with minimal harm to ecosystems, animals or humans. It is the most prominent of these alternative farming systems and is often proposed as a solution for more sustainable agriculture. The Canadian International Development Agency (CIDA) has committed itself to environmental sustainability and has identified the integration of development and environmental protection as one of its key strategies (CIDA, 2006). As a potentially more environmentally friendly alternative to conventional agriculture, hetero-culture agricultural method could play an important role in sustainable development. The small extent of organic agriculture in developing countries today and the likely further increase in demand for organic produce in developed as well as transition economies suggest that the organic sector in developing countries has large potential for further growth. Can hetero-culture or Co - culture method contribute to sustainable agricultural development and sustainable food and crop security? It is a method of engineering nanomaterials that are central to a range of novel technologies that may have application for the early detection and treatment of cardiovascular diseases. A range of nanotechnologies have been developed that can be used to improve the spatial and temporal resolution of cardiovascular imaging (Jennifer *et al*., 2017). It is noted that combusting-derived nanoparticles are linked to improvement in plant tissue culture in modern agriculture for generic transformation of plant; nanosilver for as antimicrobial agent; nanomaterial for callus induction, organogenesis, and titanium dioxide nanoparticles to remove bacterial contaminants through intra and inter cropping (Abd-Elsalam and Prasad, 2018) .

Factorial split-plot experiment is experiment in which all possible combinations of the levels of the factors are investigated. The primary distinguishing feature of the Randomized Complete Block design is the presence of blocks (replicates) of equal size each, and which contain all treatment combinations (Adeniran and Eyitayo, 2004). It is often inconvenient, costly, or even impossible to perform a factorial design in a completely randomized fashion - An alternative to a completely randomized design is a split-plot design. The use of split-plot designs started in agricultural experimentation, where experiments were carried out on different plots of land. Classical agricultural split-plot experimental designs were full factorial designs but run in a specific format. The key features of split-plot designs is that levels of one or more factors are assigned to entire plots of land referred to as whole plots of main plots, whereas levels of other factors are assigned to parts of these whole or main plots. These parts are called sub plots or split plots (Salkind, 2010).

Soybean (*Glycine max)* plant is a Legume. It is a plant in the family *Fabaceae,* or the fruit or seed of such a plant (also called a pulse). Legumes are grown agriculturally, primarily for human consumption, for livestock forage and silage, and as soil enhancing green manure. Well known legumes include alfalfa, clover, beans, peas, chick peas, lentils, lupins, mosquitoes carob, soybeans, peanuts, and tamarind. Legumes produce a botanically unique type of fruit called pod. Legumes are notable as a symbiotic nitrogen-fixing bacterium in structures called root modules, for that reason, they play a key role in crop rotation and mixed cropping.

Mixed cropping is defined as a system of sowing two or three crops together on the same land, one being the main crop and the others the subsidiaries. Mixed cropping is the growing of two or more plants in the same field in the same year and, at least in part, at the same time. Mixed cropping permits an intensification of the farm system, which results in increased overall productivity and biodiversity in cropped fields. It is commonly used in the tropics but are not generally used in temperate organic horticulture. Mixed cropping, particularly row intercropping and strip intercropping, could be an important tool for pest and disease management in organic farming systems (Glossary of Environment Statistics, 2001).

Report on pest control techniques rely on the fact that pests recognize a suitable crop either by sight or by smell and those mixtures can be structured so as to confuse the pest. For example, thrips are white flies which are attracted to green plants with a brown (soil) background, but they will ignore areas of complete vegetation cover including mulches and weeds. Other pests may be attracted under the opposite circumstances. Even so, the size, planting density and shape of the crop can be significant in controlling pests (Glossary of Environment Statistics, 2001). Stink bugs (*Halyomorpha halys*) are major pests of soybean in various parts of the world (Kogan and Turnipseed, 1987). Over 50 species are known to cause damage to this crop worldwide, and the Southern green stink bug, *Nezara viridula* (L.), is perhaps the most studied and economically important species. Other species such as the Neotropical brown stink bug, *Euschistus heros* (F.) and the red-banded stink bug, *Piezodorus guildinii* (Westwood), are also important pests in the neotropics (Canassa, *et al.,* 2000). A fourth species, the green-belly stink bug, *Dichelops melacanthus* (Dallas), occasionally found on soybeans, has recently become an important pest in Brazil damaging wheat and other summer crops such as corn (Panizzi *et al*., 2008). Pentatomid bugs inject salivary secretions into seeds and ingest the food slurry that salivary enzymes create. The impact of stink bug feeding on soybean seed has been studied by many authors worldwide (Brier, 1993), but only a few (Corrêa-Ferreira and Azevedo, 2002) have compared the damage to soybean seeds by different species of stink bugs. Mixing species can also assist in pest control in a number of other ways, including influencing the availability of light which can affect insect behaviour. These benefits are especially likely to include improved techniques for management of soil fertility in addition to pest and disease control. It is probable that more practically orientated long term research based in well-established organic farming systems will be necessary to achieve this. To the best of our knowledge, none have studied the possibility or employed the most effective cultivation or hetero culture method that can be adopted to reduce the infection of Stink bugs on Soybean pods to the minimum. Assess the reaction of Stink bugs to hetero-cultures of Soybean, assess the effect of Stink bug on Soybean when intercropped with Chickpeas, Cowpea, Lentils and Guinea corn separately and also, to assess the effect of Stink bugs on Soybean when intra-rowed with Chickpeas and Cowpea. Therefore, the hetero-cultural method is aimed in this study to reduce the damage of Stink bug on the yield of Soybean using the factorial split – plot analysis to boost its production in order to meet the increasing demand and generate higher economic returns to Soybean farmers.

METHODOLOGY

Variables

The research variables for this study are the subjects of the experiment are the Soybeans (*Glycine max)* plant and Stink bugs (*Halyomorpha halys*). There are two treatment factors involved in the experiment which involves different cultural method of planting Soybean, that is, Intercropping (factor A) and Intra-row mixing (factor B). The former has four levels while the latter has five levels as indicated below (Table 1):

Intercropping (Main treatment):

A_l - Soybeans intercropped with Chickpeas
A_2 - Soybeans intercropped with Cowpeas
A_3 - Soybeans intercropped with Lentils
A_4 - Soybeans intercropped with Guinea corns

Intra-row mixing (Sub-treatment)

B_1 - One row of Soybeans to one of others
B_2 - Three rows of Soybeans to one of others
B_3 - Five row of Soybeans to one of others
B_4 - Seven rows of Soybeans to one of others
B_5 - Intra-row mixing Soybeans and others

A treatment (the independent variable) in the Split-plot experiment of this nature is the different combinations of factors' levels. Hence, for this study, we shall have a total number of 20 (4X5) treatments while the 2-factors are the main effects in the experiment (Table 1).

Measuring instruments

When the subject (Soybean plant) in their respective groups (replicate) are exposed to the corresponding experimental conditions, that is; the hetero-culture methods after which the dependent variable (the yield) from each of the plant in their respective replicate are measured by screening the pod to check for infection by Stink bug by scoring. Hence, the measuring instrument is by counting of infected pods and deriving the percentage per plot.

Data analysis

The general statistical model for the 2-factor (4X5) Split-plot design is:

$$Y_{ijk} = \mu + \rho_k + \alpha_i + \delta_{ik} + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

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

where:

Y_{ijk} is the observed value for the kth block of the ith level of factor A and the jth level of factor B
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 factor A.
δ_{ik} is the whole plot random error effect, for the ith, kth combination of block and factor A.
β_j is the effect for the j^{th} level of factor B
$\alpha\beta_{ij}$ is the interaction effect of the ith level of factor A with the jth level factor B
ε_{ijk} is the subplot random error effect associated with the Y_{ijk} subplot unit (experimental error) ε_{ijk} NID $(0, \sigma^2)$ (Adeniran and Eyitayo, 2004).

RESULTS AND DISCUSSION

The study shows that only the main-plot and sub-plot used in the experiment had significant effect on the percentage infection of Stink bug on Soybean pod that corroborated Canassa *et al.* (2017) where soybean

Table 1: Statistical Analysis and the ANOVA.

Source of variation	Degree of freedom	Sum of squares	Mean square	F-ratio	F-table (5%)
Block	4	96.9994	24.2499		
Intercropping (A)	3	947.4483	315.8161	16.7360*	3.49
Error (a)	12	226.4458	18.8705		
Intra-row mixing (B)	4	467.9371	116.9843	13.9116*	2.53
Intercropping X intra-row mixing (AB)	12	33.2104	2.7675	0.3291^{NS}	1.92
Error (b)	64	538.1794	8.4091		
Total	99	2310.2204			

*Significant at 5% level of probability level and *Not significant at 5% probability level.

genotypes are of different maturity groups. The interaction effect has no significant effect on the dependent variable. Although Soybean intercropped with Guinea Corn with Three rows of Soybean to one of others showed significant effect on the rate at which it controlled the effect of Stink bugs. This is in line with Corrêa-Ferreira and Azevedo, (2002) which state the damage of Soybean seed by different species of stink bugs as a result of intercropping with maize. Soybean intercropped with chickpeas and soybeans intercropped with lentils of intercropping method used in the experiment were found to have almost the same effect on the Stink bug. But for higher yield which will come as a result of reducing the rate of infection of the bug on the Soybean pod and economic considerations, Cowpea intercropped with Guinea Corn will be preferred as in the case of Chen et al. (2019) which stated that there is yield advantage and nitrogen fate in an additive maize-soybean relay intercropping system. Also, one row of Soybean to one of others and seven rows of Soybean to one of others of intra-row mixing method used in the experiment were found to have almost the same effect on the Stink bug. But for higher yield which will come as a result of reducing the rate of infection of the bug on the Soybean pod and economic considerations, three rows of Soybean to one of others will be preferred as in the case of Panizzi *et al.(*2000) on Heteroptera of economic importance. Finally, the optimum level of the study is observed at Soybean intercropped with Guinea Corn and and Three rows of Soybean to one of others with estimated average rate of 9.02% infection on Soybean pod such as Abd–El salam and Prasad, (2018) on various protection ways.

Recommendation

Intercropping Soybean with Guinea corn is therefore recommended for higher yield.

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