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FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

DEPARTMENT OF CROP SCIENCE

COMPARING THE EFFECTIVENESS OF TWO SEED DRESSING METHODS, EARTHWORM POOP TEA AND CELEST TOP (A COMMERCIAL ARTIFICIAL SEED DRESSING).

By:

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A DISSERTATION SUBMITTED IN PARTIAL FULFIMENT OF THE REQUIREMENTS OF THE BACHELOR OF SCIENCE HONOURS DEGREE IN CROP SCIENCE

DECLARATION FORM

I, Kamangira Partson, do hereby declare to Bindura University of Science Education that this dissertation is my original work and all materials and academic sources of information other have been duly acknowledged. This work has never been submitted to any other academic institution for the purposes of an academic merit.

Signature  Date 02/10/24

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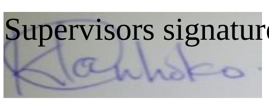

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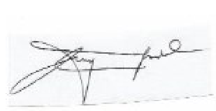
Chairperson's signature. .  ....

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DEDICATION

To Lord God Almighty (the maker of the Universe, Entirely merciful and specially merciful) Moreover, to my Family.

ABSTRACT

The study aims to evaluate the efficacy of two seed dressing methods: earthworm poop tea and Celest Top, a commercial artificial seed dressing. Earthworm poop tea, a natural and organic fertilizer, enriches soil health and supplies essential nutrients for plant growth. Celest Top, a synthetic seed dressing, contains predetermined nutrients and growth stimulants. The experiment will involve treating seeds with either method before planting them in a natural setting. The experiment was conducted in a randomized complete block design. Genstat software 7th addition was used in the analyses of the results. The results will offer insights into the potential advantages of natural fertilizers versus synthetic products in fostering plant growth and development. In general Celest top perform better than earthworm poop tea in in growth of field beans.

ABBREVIATIONS AND ACRONYMS

C; N..Carbon to Nitrogen ratio

SOM ....Soil Organic Matter

OPVs ....Open Pollinated Varieties

SAR ....System-Acquired Resistance

ANOVA.. Analysis of Variance

LSD.. Least Significance Difference

RCBD.. Random Complete Block Design

G...grams

EPT..Earthworm Poop Tea

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CHAPTER 1

INTRODUCTION

1.1 Background

Water is natural resource on the planet earth. All living creatures, including plants and animals, require it to survive. Approximately 70% of the available land is comprised of it. According to Taylor and Francis (2008), just 3 percent of them are safe to eat, while the other 67% contain high amounts of contaminants that make them unsafe. The growing world population is causing an annual increase in the rate of water use. In addition, the demand for freshwater is fueled by overexploitation, urbanization, and seasonal climatic changes. The demand for the limited supply of clean water will cause prices for water to rise, which will raise operational expenses in many sectors and agricultural fields where large quantities of water are utilized extensively—water is necessary for plant development (Anil Kumar et al, 2023). It is a necessary component of several key processes, including photosynthesis. Water is Agriculture, and without it, there is no production because all plants depend on water to carry out their physiological process. In agriculture, plants to transport chemicals and nutrients to their system for specific functions can use water; therefore, it acts as a transport medium. The water from soil moves through vascular tissues and is absorbed up until it reaches its final destination. It can be either leaves or stems.

A bean is seed that belongs to the Fabaceae family of leguminous plants. However, numerous economically significant species can be found in several genera within the family, the genera Phaseolus and Vigna both contain multiple well-known bean species. Beans are utilised in cooking all throughout the world, whether they are fresh or dried, and are high in protein, moderate in iron, thiamin, and riboflavin (Faba Bean Improvement, 2012). The majority of bean types grow as either climbing plants or upright shrubs, although a few significant cultivars have an intermediate shape. For harvesting immature seedpods, artificial supports are required when cultivating climbing types (Biddle, 2017). The immature pods of different varieties vary significantly in terms of size, shape, color, and fibrousness or softness. Moonstone Fine beans are a cultivar of the common bean (*Phaseolus vulgaris L.*), which is native to the Americas but has been introduced to many parts of the world, including East Africa. The common bean is an important crop in many countries, providing a source of protein, fiber, and other nutrients. The introduction of this bean variety to East Africa is said to have occurred in the early 1990s when the Kenya Agricultural Research Institute in collaboration with the International Center first tested the variety for Tropical

Agriculture. The variety was specifically developed for the East African market and was bred to have a sweet, tender flavor and a long shelf life.

Fine beans quickly gained popularity amongst farmers and consumers in East Africa, and since have become a major cash crop in the region, providing a source of income and nutrition to many smallholder farmers. The success of this variety of beans is largely due to its high yields, disease resistance, and excellent flavor and texture. The variety has also been promoted by organizations such as the Alliance for a Green Revolution in Africa (AGRA), which has provided support to smallholder farmers to increase their production and improve their livelihoods. However, the crop is vulnerable to pests and diseases, which can significantly reduce yields and quality. To mitigate these challenges, farmers tend to rely much on the use of pesticides, therefore the use of inorganic pesticides has been linked to environmental and health concerns. Organic pest control methods on the other hand provide a mere sustainable and eco-friendly approach to pest control and management.

Earthworms are found in a variety of soil types and make up between 60 and 80 percent of the total biomass in the soil. Their presence in the soil helps to improve its physical, chemical, and biological characteristics as well as its nutritional value, which is essential for the growth and healthy development of plants. Increased biological resistance in crop plants, the release of nutrients from broken down organic matter in the soil, the secretion of plant growth hormones, the growth of "nitrogen-fixing and phosphate solubilizing" bacteria, and soil fragmentation all help to improve crop productivity (Sinha, 2011).

1.2 Problem statement

The continuous increase in human population across the globe has made farmers use inorganic pesticides as a tactical way of producing high yields; however, inorganic pesticides contribute too many negative impacts, which include soil acidity, poor shelf life of beans, and high cost of production together with compromised nutritional value and content. The use of organic pesticides tends to counter these drawbacks by increasing soil-buffering capacity, reducing production costs, at the same time, securing nutritional value and content of beans. However, due to various sources of organic pesticides, little is known about the significance of each specific source concerning its contribution to improving bean growth and yield components.

1.3 Justification

When applying pesticides, always pick a product that will address your problem while posing the fewest threats to the environment and non-target species' health. By destroying not only the target pest(s) but also beneficial species, you can help keep overall pest pressure low. However, if many pest species are present, selective solutions may not provide complete pest control.

1.4 OBJECTIVES

Main objective
To determine the effects of Celest top and earthworm pop tea on field bean production and quality.

Specific objectives

i. To determine the effect of earthworm poop tea and celest top on the stem height of the fine beans.

ii. To count the number of leaves obtained by using worm poop tea and celest top when seed dressing before planting.

iii. To analyze the effect of poop tea and Celest top on the germination percentage of fine beans.

iv. To observe the degree of pest infestation two weeks after an emergency.

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1.5 Hypothesis

i. Organic and inorganic pesticides effect on the growth of fine beans.

ii. Organic and inorganic pesticides do not effect the yield of fine beans.

1.6 Significance of study

I. To determine which type of seed dressing promotes better seed germination.

II. To assess the impact of organic and artificial seed dressing on plant growth and development.

III. To compare the effectiveness of organic and artificial seed dressing in protecting seeds from pests and diseases.

IV. To evaluate the environmental impact of organic and artificial seed dressing on soil and water quality.

V. To understand the potential benefits of using organic seed dressing in sustainable agriculture.

VI. To analyze the cost-effectiveness of organic and artificial seed dressing for farmers.

VII. To investigate the potential health effects of consuming crops grown from seeds treated with organic or artificial dressing.

VIII. To assess the long-term effects of organic and artificial seed dressing on soil fertility

IX. To determine the shelf life of seeds treated with organic and artificial dressing.

X. To provide scientific evidence for making informed decisions about the use of organic or artificial seed dressing in agriculture.

CHAPTER 2

2.0 Literature review

2.1 Introduction

This chapter intends to highlight the work that has already been done by other researchers, their perspectives, and effective contributions in the comparison of artificial and organic seed dressing chemicals in agricultural institutes.

2.2 Biology of earthworms poop tea

Earthworm tea is produced inside a compost digester with earthworms. Compost digester is also known as “Jati” structure. Biodegradable materials are used to prepare the solution. The earthworm pop tea has many functions other than organic seed dressing chemical. It can be used as an organic fertilizer. Ginger and garlic residues are excluded in raw materials because they kill the earthworms inside the digester. It is very important to know other materials that are harmful to the earthworms. The main essence in the production of earthworm tea is to keep earthworms alive. Materials like plastics, which are biodegradable, are also excluded because they do not decay easily (Merrill, 2015).The earthworm soup is produced in 2 months depending with temperature and the nature of raw materials that have been used.

The composter is made up of 6 chambers (1-6) and small holes are present which connect all chambers. The first chamber or chamber one is where raw materials are fed in bulky and water is introduced to facilitate faster decomposition.

Table 1:characteristics of jati digester

Process factor	**Values**
C:N ratio of wastes	25:1 to 30:1
initial particle size	10 to 20mn
Moisture content	80 to 85% (limits 60% to 90%)
Oxygen	Earthworms maintain aerobic respiration

Temperature	15^0C to 25^0C
pH	>5 and <9
salt content of wastes	Low : < 0.5%

Figure 1: The JATI structure source: taken by the author

2.3 Ecology of Earthworms.

According to Edwards et al. (1996), earthworms have a body that is divided into minute sections and organized like a tube. The body is reddish-brown in colour and features a black line of blood vessels on the dorsal side and genital openings on the ventral side. Earthworms are an essential creature in agriculture and are known as soil engineers. They maintain the soil's physicochemical qualities by converting organic waste and biodegradable materials into nutrient-rich products. When they emerge from their burrows, they deposit faeces (vermicast) on the surface, functioning as a buffer and having a high content of readily accessible N, P, and K for plants (Karaca, 2006). Humic acids and plant growth hormones found in vermicast can help increase agricultural yields in both controlled and wild habitats.

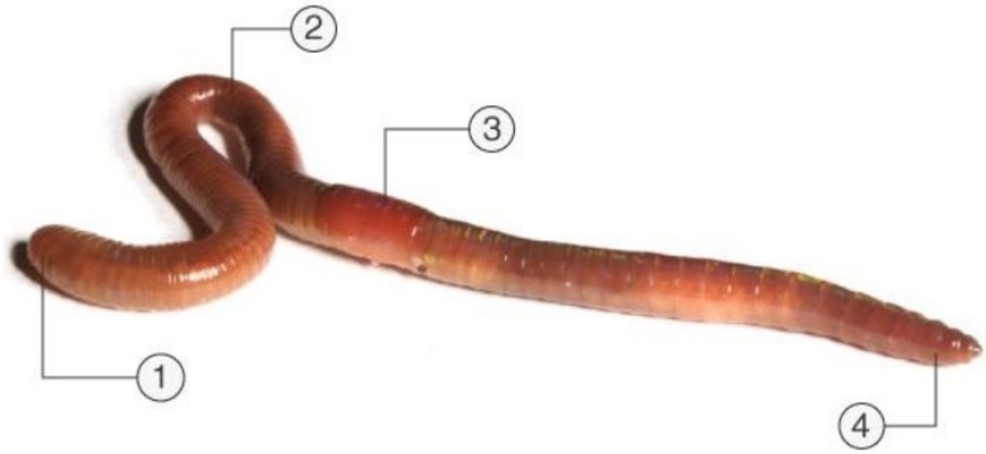

Figure 2 Earthworm structure *Clive A. (Edwards and Bohlen, 2010)*

1 posterior
2 segments
3 clitellum
4 anterior
5 The clitellum,

A glandular tissue found in segments 14-16 of an adult earthworm, helps identify the mouth and tail ends. The clitellum is divided into three segments: preclitellar, clitella, and postclitellar Because they have both male and female sex organs, earthworms are hermaphrodites. Four pairs of spermathecal apertures are found in segments 5-9, a female genital pore in segment 14, and a pair of male genital pores in segment 18. The earthworm's body is composed of S-shaped setae that help in mobility. Setae are found in all segments save the first, last, and clitellum (Edwards, 1998).

2.4 Earthworms suitable for vermicomposting (production of earthworm poop tea).

Epigeic earthworm species are distinguished by their inherent capacity to colonize waste and consume, digest, and assimilate organic substances at rapid rates. The earthworm that can withstand a broad range of environmental conditions has short life cycles, high productivity rates, and endurance and tolerance for handling. According to certain research, environmental factors influence the formation and growth of earthworms. Epigeic earthworms are relatively resistant of environmental conditions. However, these earthworms have precisely defined tolerance ranges or limits for environmental elements such as moisture, temperature, and other substances. If these restrictions are surpassed, the earthworms may relocate to more appropriate zones in the trash, abandon it, or die, resulting in the waste being digested extremely slowly.

Table 2: optimal conditions for breeding earthworms in breeding boxes

Conditions	**Requirements**
Temperature	15 to 20^{o}C
Moisture content	80 to 90%
Oxygen	Aerobics
pH	5 to 9
Salt content	Low; <0.5%

Source: (Chan 2001).

2.5 Effects of earthworms on soil fertility, plant growth, and health.

Fertility is one of the many soil processes in which soil structure has a significant effect. By creating humus, weathering minerals, and combining them to create stable aggregates that are deposited on the soil's surface or inside the soil profile, earthworm's aid in the structure and development of soil (Le Bayon et al., 2002). Burrowing is influenced by several behaviors of earthworms, including feeding, responding to drought or low temperatures, avoiding predators, and supplying oxygen to the soil. The form of a pore changes depending on the ecological group of earthworm. Under temperate and tropical soils, earthworm burrowing and casting operations generally prevent soil erosion; in temperate regions, anecic earthworm castings increased soil roughness, which was reinforced by organic wastes, creating "middens" that reduced surface runoff (Le Bayon et al. 2002). Mechanisms mediated by soil microbes are responsible for SOM breakdown and mineralization. According to Brown et al. (2004), earthworm-induced changes in soil physicochemical properties include the biocontrol of pests and parasites, stimulation of symbionts, and the production of plant growth regulators through microbial stimulation, which are some of the mechanisms involved in interactions with other organisms. Changes in soil porosity and aggregation also affect plant water and oxygen access, whereas greater SOM mineralization enhances nutrient availability.

2.6 Effects of cultural practices on earthworm communities in cropped fields.

Numerous studies have demonstrated that earthworm diversity and abundance are lower in agricultural fields than in uncropped soils (Peigne et al. 2009), and that earthworm abundance is higher in permanent pastures than in annually cropped agroecosystems. It is well known that cultural practices have an impact on earthworms in agricultural fields (Chan 2001; Roger-Estrade et al. 2010) Tillage, crop rotation, usage of organic fertilizers, and pesticide use are the cultural practices most frequently noted for their influence on earthworm populations. The sensitivity of earthworm populations to the frequency of tillage is highlighted by Ivask et al. (2007). Tillage affects earthworms in a number of ways (Chan 2001; Curry 2004; Roger-Estrade et al. 2010). The most direct effect is the mechanical harm that earthworms do to tillage tools or soil clods that are moved during tillage, which can result in bodily harm or even death. By forcing deep-living earthworms to the soil's surface, ploughing causes soil inversion, which exposes earthworms to predators. According to Birkas et al. (2004) and Rosas Medina et al. (2010), conventional tillage (ploughing and secondary tillage operations) destroys earthworm burrows, removes the insulating layer of litter, modifies the availability of organic matter due to crop residue burial, and modifies the physical characteristics of the soil, including temperature, moisture, and structure. The earthworm population is negatively impacted by soil compaction, which can happen when moist soils are farmed. As a result, the earthworms avoid compacted zones and perish from crushing by machinery (Capowiez et al. 2009; Larink and Schrader 2000). Earthworms may break down organic matter more quickly than other composts, resulting in the release of nutrients that promote the growth of fine beans. The nutrients produced in the soil also help plants grow by giving needed raw materials for the formation of nucleic acids.

2.7 Predators, parasites, and pathogens of earthworms

In addition to being preyed upon by several species of beds and animals, centipedes, and ants, earthworms are also susceptible to numerous infections, parasites, including internal parasites such as nematodes, fly larvae, and protozoa (Stirling, 2014). Bacteria like Spirochaeta sp. and Bacillus sp., as well as fungal pathogens (Satchell, 2012) parasitize earthworms. Protozoa can be found in various parts of the earthworm's body, including the alimentary tract, bloodstreams, and seminal vesicles.

2.8 Field beans

2.8.1 Importance of field beans

The Seed of the common bean (*Phaseolus vulgaris* L.) is used for human food but can occasionally be fed to livestock (Biddle, 2017). They are consumed fresh or can be dried and processed into value addition. In humans, it has many health benefits. It contains fiber that slows down the level of glucose absorption inside the body and fiber assists in the movement of food in the gut and prevents disorders like constipation. It contains vitamins, which assist in fighting against diseases and other external infections (immune boast). Environmentally, beans have a positive impact; they form a symbiotic relationship with bacteria and fix nitrogen in the soil. Bacteria fix nitrogen, which is found in the roots of the beans. Fixing nitrogen by bacteria is beneficial to the environment because fewer agricultural fertilizers are applied. Agricultural fertilizers (containing nitrogen compounds) cause soil acidity, which therefore kills soil, engineers (earthworms). In addition, beans capture carbon in the atmosphere which is an important aspect (carbon sequestration) because these gases when they increase in the atmosphere deplete the ozone layer and global warming occurs (Munn, 2013). More so field beans reduce soil erosion because they have broad leaves that provide shed and they are bushy they reduce water loss from the soil by evaporation.

2.8.2 Nutritional content of field beans

Table 3: Nutritional content of field beans

Nutrient	**content**
Protein	23.58 g
Carbohydrates	60.01g
Dietary fiber	24.9g
Iron	8.2mg
Fat	0.83g
Potassium	1406mg

Source: Uebersax and Saddiq, 2012

2.8.4. Macronutrients required

Beans requires a fertilizer with a high ratio of nitrogen (N) to potassium (K) to phosphorus (P) (Santos et al. 2016).

Table 4 macronutrients required for field bean growth

Nitrogen	200-300 kg/ha
Phosphorus	50 kg/ha,
Sulfur **(S)**	20-40 kg/ha
Calcium	50-100 kg/ha
Magnesium	20-40 kg/ha

Source: Hossain *et al* 2022.

2.8.5 Soil requirements

According to Biddle, (2017), the soil pH of fine beans ranges from 6.0 to 6.8. Fine beans require consistent soil moisture, especially during flowering and pod development. Optimal temperatures for fine bean growth range from 18-24°C (64-75). Every soil is unique in terms of its chemical, biological, and physical properties but for beans (*Phaseolus vulgaris)* to grow they require both major nutrients and minor nutrients to grow and produce. The major nutrients are NP and minor nutrients include. The optimum soil pH for Beans is 6.8. pH ranges from 6.0 to 6.8 (slightly acidic). Lime recommendations advice is over 7.5 t/ha, it is good practice to apply the lime over 3 years. This helps avoid too much lime applied at any one time, which can lead to boron and manganese deficiencies.

CHAPTER 3

3.0 Materials and Methods

3. 1 location of the field experiment

In the Chegutu District of Mashonaland West Province, Nutrifarm (NF) on the Harare-Ngezi Road, 28km from Bulawayo Road was the site of the experiment. 18° 1' 42" South and 30° 22' 24" East are the location's geographic coordinates (Selous Google map). Around 1262 metres are thought to separate the ground from sea level. In addition to an average yearly temperature of 24°C, the region receives 700–1050 mm of rainfall. With a pH range of 6.2–7.6, it is renowned for its red sandy-loam soils (Agritex, 2015).

3.2 Experimental design

The experiment was set up using a randomized block design with a 3 by 6 factorial. Three treatments total—three replications of each—were used in the arrangement. First, the area was treated negatively using natural circumstances. Next, a synthetic pesticide called Celest Top was applied to the fine bean seed dressing and earthworm poop tea was used as the second treatment. Six beds have natural therapy (neither poop tea nor Celest Top), six more have Celest top, and six more have poop tea. There were eighteen beds overall.

EXPERIMENTAL PROCEDURE

3.3.0 AGRONOMIC PRACTICES

3.3.1 Land preparation

A hand hoe was used to clean the ground. To lessen the possibility of the experimental field becoming home to pests, all weeds, and other detritus were eliminated. Since oxygen is necessary for germination, the soil was excavated to promote aeration and increase the germination percentage. To create a fine soil texture and break up tiny clods, a garden harrow was utilized. Using a garden line, hoe, and tape measure, twelve 1 x 2 m plots were made. Beds are spaced one metre apart from one another and two metres apart from one another. Since seeds are soaked for around eight hours before planting, pre-irrigation was implemented in the field to keep the soil moist for easier seed planting and to lower the soil temperature to avoid seed burn.

3.3.2 Fertilizer Application

Except for the negative control, which is in a natural setting, all treatments received both organic and inorganic fertilizers. The base dressing was compound C, and the top dressing was ammonium nitrate. Two weeks after the emergency. Three grams of ammonium are sprayed on each plant station during the first two weeks. After a fortnight, 5 grams are sprayed per plant station due to the plant's increased dry matter and the need for more nitrogen to produce nucleic acids, which are in charge of protein metabolism. Since they supply trace elements like boron, zinc, and molybdenum—, which are essential for plant physiological processes— quick start and quick growth, treatments are applied to fine beans early on.

3.3.3 Planting

Inrow, spacing was 10 cm and inter-row was 50cm, which makes 40 seeds planted per bed (1m by 2 m bed. The night before planting, the seeds are soaked in each treatment, and natural control is soaked in pure water to fasten the processes of germination. The seeds were placed in each marking plant station and the seeds were covered with fine soil. A small stick is used to drill plant stations of fine beans (2cm to 3 cm deep).

3.3.4 Pests and Diseases Control

Pests and diseases in fine beans were managed using cultural control approaches. Hand weeding was done to remove weeds that attract and harbor bugs, which can lead to illness. Weeds were burned to stop the spread of illnesses, which also helped to eliminate pests like semi-looper aphids and cutworms. Organic mixes were created and used to treat fungal rust and other pests. Aloe Vera was blended with neem leaves, water was added to promote the chemical reaction, and the mixture was sealed and stored anaerobically for two weeks. The concoction was then sprayed onto the beans. Aloe Vera successfully eliminates fungal diseases. Another blend included garlic, ginger, and chili residues. Molasses was eventually added to this combination, functioning as a binding agent throughout.

3.3.5 Weeding

Hand weeding is used to remove weeds from the field and limit competition between plants and weeds for resources like water, air, sunshine, and space. Hand hoeing was frequently used to remove tenacious plants such as runner grass. Some weeds were burnt, while others were utilized as mulch to reduce water loss from transpiration. No herbicides were used on any of the beds during the trial.

3.3.6 Harvesting of fine beans and storage.

Harvesting was conducted from day 55 up to day 65. The fine beans are harvested in two stages. The first stage is when they have green pods (green beans) and secondly, at physiological maturity when the pod is full of seeds inside the plant loses about 85 percent moisture. Due to operational expenses, most people prepare to harvest green beans. Fine beans are harvested using hands and careful handling is required because the pods can break easily. Small baskets were used to collect beans from the field. A small cold room was used to store beans.

3.4 Data collection and measurements

3.4.1 Plant height

The heights of the plants were measured from the ground level to the end of the top leaf. A measuring tape was used to measure the twelve randomly selected plants in each bed. Data on the plant was collected at two-week intervals. The measurements were in centimeters. The measurements of the plant were taken 4 times at two weeks intervals until the plant reached maturity (green beans).

3.4.2 Number of plant leaves

The number of plant leaves was counted from the 12 (each per bed) randomly selected plants and their average was expressed as the number of plant leaves at four-week intervals from germination to harvesting (week 8).

3.4.3 Pest infestation

Eye observation is conducted to measure the difference in the levels of pest infestation on different treatments. A scale is formulated measuring from zero up to seven. Zero means no pest infestation and seven is the highest rate of pest infestation. The scouting is done at two-week intervals.

3.4.4 Germination percentage

Germination was observed by counting seeds from each plot that were grown and those that germinated. The formulae of germination were used. It is a fraction number of seeds germinated total number of seeds that were grown multiplied by 100

3.5 Data analysis methods

Analysis of the results was done using the Analysis of Variance (ANOVA) model using the GENSTAT 17th edition computer package. Significant differences ($P<0.05$) among treatments were separated using the Least Significant Difference (LSD),

Chapter 4

4.0 Results

4. 1 Stem height

4.1.1 Effects of different treatments (Celest top, earthworm poop tea, and natural conditions) on field beans stem height at two weeks.

All treatments had a significant effect ($p < 0.05$) on field bean stem height after two weeks. There was a significant difference ($p < 0.05$) between treatments Celest top and natural conditions. No significant difference ($p < 0.05$) was observed between treatment Celest top and natural conditions in stem height during the first two weeks after emergence.

Table 5: the stem height at two weeks on different treatments.

Treatments	Stem height in cm (at two weeks)
1	10.867 *b*
2	13.333 *a*
3	10.450 *b*
GRAND MEAN	11.550
CV%	3.1
LSD	0.4482
SED	0.2074
P Value	0.001

Means followed by the same letter are not significantly different. Means followed by different letters are significantly different.

4.1.2 Plant height on week 4

All the treatments show a significant difference ($p<0.05$). There was a significant difference ($p<0.05$) between Celest Top and natural conditions. There was no significant difference ($p<0.05$) between earthworm poop tea and Celest Top.

Table 6; the stem height at 4 weeks on different treatments.

Treatment	Stem height (cm) 4 weeks
1	27.82 a
2	27.75*a*
3	24.97 *b*
GRAND MEAN	26.84
CV	6.6
LSD	2.213
SED	1.024
P Value	0.024

Means followed by the same letter are not significantly different ($p<0.05$).

Means followed by different letters are significant different.

4.1.3 Plant height on week 6

Plant height at six weeks indicates that treatment 2 which is Celest Top shows the highest mean followed by earthworm poop tea. Natural conditions record the lowest mean of stem height in the sixth week. Celest Top treatment is significantly different ($P<0.05$) from natural conditions. There is no significant difference between earthworm poop tea and natural conditions

Table 7; the stem height at 6 weeks on different treatments.

Treatments	Stem height (cm) 6 weeks
1	36.38 *b*
2	40.50 *a*
3	35.57 *b*
GRAND MEAN	37.45
CV%	4.4
LSD	2.041
SED	0.945
P Value	0.001

Means followed by the same letter are not significantly different ($p<0.05$).

Means followed by different letters are significant different ($p<0.05$)

4.1.4 Plant height on week 8

Celest Top treatments show the highest mean on the final week. Natural conditions record the lowest mean of stem height. There is a significant difference ($p< 0.05$) between treatment 2 (Celest Top) and earthworm poop tea. There is no significant difference ($p <0.05$) between earthworm poop tea and natural conditions.

Table 8: the stem height at 8 weeks on different treatments

Treatments	Stem height at 8 weeks
1	46.13 *b*
2	49.68 *a*
3	45.75 *b*
GRAND MEAN	47.18
CV%	3.0
LSD	1.779
SED	0.824
P Value	0.001

Means followed by the same letter are not significantly different ($p<0.05$).

Means followed by different letters are significant different ($p<0.05$)

4.2 Number of leaves

4.2.1 Effects of different treatments (Celest top, earthworm poop tea, and natural conditions) on field bean's number of leaves at two weeks.

Celest Top records the highest mean of the number of leaves and natural conditions records the lowest mean of the number of leaves two weeks after an emergency. There is no significant difference ($p<0.05$) between earthworm poop tea and Celest Top. Natural treatment shows a significant difference ($p<0.05$) with Celest top.

Table 9 Showing number of leaves at 2 weeks on different treatments**.**

Treatments	**Number of leaves at 2 weeks**
1	6 *a*
2	6.33 *a*
3	5 *b*
GRAND MEAN	5.78
CV%	8.6
LSD	0.621
SED	0.287
P Value	0.001

Means followed by the same letter are not significantly different ($p<0.05$).

Means followed by different letters are significant different ($p<0.05$).

4.2.2 Number of leaves on week 4

All the treatments show a significant difference ($p<0.05$). Treatment 2, which is Celest Top, shows the highest mean (14.83) followed by earthworm poop tea (14.50). There was a significant difference ($p<0.05$) between Celest Top and natural conditions. There was no significant difference ($p<0.05$) between earthworm poop tea and Celest Top.

Table 10: Number of leaves at 4 weeks on different treatments.

Treatments	**Number of leaves at 4 weeks**
1	14.50 *a*
2	14.83 *a*
3	8.50 *b*
GRAND MEAN	12.61
CV %	7.5
LSD	1.184
SED	0.548
Pvalue	0.001

Means followed by the same letter are not significantly different ($p<0.05$).

Means followed by different letters are significant different ($p<0.05$).

4.2.3 Number of leaves on week 6

All the treatments had an effect ($p < 0.05$) on field beans on the number of leaves at six weeks. Treatment 2, which is Celest Top, gave the highest number of leaves with a mean and the natural treatment gave the lowest mean in six weeks. There was a significant difference ($p< 0.05$) between treatments Celest top and natural conditions. There was no significant difference ($p<0.05$) between treatment earthworm soup and natural conditions in the number of leaves in the first two weeks after the emergency of the plant.

Table 11: Number of leaves at 6 weeks on different treatments.

treatments	**Number of leaves at 6 weeks**
1	21.67 *b*
2	23.17 *a*
3	13.5 *b*
GRAND MEAN	19.44
CV%	4.6
LSD	1.106
SED	0.512
P Value	0.001

Means followed by the same letter are not significantly different ($p<0.05$).

Means followed by different letters are significant different ($p<0.05$).

4.2.4 Number of leaves at week 8

Celest Top records the highest mean of number of leaves at eight weeks and natural conditions records the lowest mean on the number of leaves 8 weeks after the emergency. There is no significant difference ($p<0.05$) between earthworm poop tea and natural conditions. Natural treatment shows a significant difference ($p<0.05$) with Celest top.

Table 12: number of leaves at 8 weeks on different treatments

treatments	Number of leaves at 8 weeks
1	26.50 *a*
2	30.67 *b*
3	20.17 *a*
GRAND MEAN	25.78
CV%	4.8
LSD	1.580
SED	0.708
P Value	0.001

Means followed by the same letter are not significantly different ($p<0.05$).

Means followed by different letters are significant different ($p<0.05$).

4.3 Pest infestation

4.3.1 Aphid

Treatment 3, which is the natural treatment, records the highest rate of pest infestation. Celest Top treatment gave the lowest mean of aphid infestation. There is a significant difference ($p<0.05$) between Celest top and natural treatment. There is no significant difference between earthworm pop tea treatment and Celest Top treatment.

Table 13 Showing number of aphid infestation at the week 8

treatments	Pest infestation at 8 weeks
1	9.67 *a*
2	7.50 *a*
3	16.00 *b*
GRAND MEAN	11.06
CV%	14
LSD	1.928
SED	0.892
P Value	0.001

Means followed by the same letter are not significantly different ($p<0.05$).

Means followed by different letters are significant different ($p<0.05$).

4.3.2 Semi lopper

Treatment 3, which is the natural treatment, records the highest rate of semi-lopper infestation. Celest Top treatment gave the lowest mean of aphid infestation. Earthworm poop tea gave the second infestation mean. There is a significant difference ($p<0.05$) between Celest top and natural treatment. There is no significant difference between earthworm pop tea treatment and Celest Top treatment.

Table 14 Showing number of semi lopper infestation at the week 8.

treatments	Semi lopper infestation at 8 weeks
1	6.83 *a*
2	5.33 *a*
3	13.00 *b*
GRAND MEAN	8.50
CV%	14.3
LSD	1.514
SED	0.701
P Value	0.001

Means followed by the same letter are not significantly different ($p<0.05$).

Means followed by different letters are significant different ($p<0.05$).

4.3.3 Whitefly

Treatment 3, which is the natural treatment, records the highest rate of whitefly infestation. Celest Top treatment gave the lowest mean of aphid infestation. Earthworm poop tea gave the mean with is between natural conditions and Celest Top. There is a significant difference ($p<0.05$) between Celest top and natural treatment. There is no significant difference between earthworm pop tea treatment and Celest Top treatment.

Table 15: number of whitefly infestations at week 8

Treatments	whitefly infestation at 8 weeks
1	3 *a*
2	2 *a*
3	7.67 *b*
GRAND MEAN	4.22
CV%	19.2
LSD	1.012
SED	0.468
P Value	0.001

Means followed by the same letter are not significantly different ($p<0.05$).

Means followed by different letters are significant different ($p<0.05$).

4. 4 Germination percentage

There was no significant difference ($p<0.05$) between all treatments on germination percentages (earthworm poop tea, Celest Top and natural conditions) due to several scientific which are to be explained in chapter 5. Treatment 1, which is earthworm poop tea, gave the mean germination percentage of 83.7. Celest Top gave the highest mean on germination with 9.

CHAPTER 5

DISCUSSION

5.1 Effects of Celest top and earthworm poop tea on growth factors

5.1.1 Effects of different treatments (Celest top, earthworm poop tea, and natural conditions) on field beans stem height at two weeks.

EPT is a good source of rapidly accessible nutrients including nitrogen (N), phosphorus (P), and potassium (K), which are required for plant development (Atiyeh et al., 2000). These nutrients are essential for several physiological activities, including as photosynthesis, protein synthesis, and cell division (Marschner, 2012). The readily available nature of these nutrients in EPT allows for their rapid uptake and utilization by plants, leading to enhanced growth and development, as observed in Treatment 1 with the highest stem height. EPT contains a diverse community of beneficial microbes, including bacteria, fungi, and actinomycetes (Edwards and Arancon, 2004). These microbes can enhance nutrient uptake by plants through various mechanisms, such as nitrogen fixation, phosphate solubilization, and increased root surface area (Compant et al., 2010). Additionally, these microbes can produce plant growth hormones, such as auxins and cytokinins, which further stimulate plant growth and development (Vessey, 2003). EPT has been shown to contain plant growth hormones, such as auxins and cytokinins (Atiyeh et al., 2002). Auxins promote cell division and elongation, leading to increased stem height and root development (Davies, 1995). Cytokinins stimulate cell division and differentiation, contributing to overall plant growth and development (Mok and Mok, 2001). The presence of these hormones in EPT could explain the observed increase in stem height in Treatment 1. EPT can improve soil structure by increasing aggregation and porosity (Edwards and Arancon, 2004). This improved soil structure facilitates better water infiltration and aeration, creating a more favorable environment for root growth and nutrient uptake. EPT is an environmentally friendly alternative to synthetic fertilizers, as it reduces the need for chemical inputs and promotes sustainable agricultural practices. Celest Top, a herbicide, can significantly impact plant growth by inhibiting various physiological processes. As observed in the experiment, the shorter stem height in the Celest Top treatment group suggests that the herbicide might have suppressed cell division and elongation, leading to stunted growth. This effect could be attributed to several factors. Celest Top is known to interfere with auxin activity, a crucial plant hormone responsible for cell division and elongation (Grossmann, 2010). By disrupting auxin signaling pathways, Celest Top can hinder cell growth and development, leading to the observed reduction in stem height. Celest Top can also inhibit photosynthesis, the process by which plants convert sunlight into energy (Fuerst and Norman, 2010). This disruption in energy production can limit the plant's ability to synthesize essential compounds for growth and development, further contributing to the stunted growth observed in the Celest Top treatment group. Celest Top may also affect the availability of nutrients in the soil. By altering microbial activity and soil chemistry, the herbicide can make it difficult for plants to access essential nutrients, such as nitrogen, phosphorus, and potassium, which are crucial for growth (Smith, 2009). This nutrient depletion can further exacerbate the growth inhibition caused by Celest Top. Plants exposed to Celest Top may experience stress, leading to the production of stress hormones such as ethylene (Abeles et al., 1992). These hormones can further suppress growth and development, contributing to the observed reduction in stem height. Plants grown in natural conditions are exposed to various environmental factors, such as temperature fluctuations, rainfall patterns, and sunlight intensity. These factors can influence plant growth and development, leading to variability in stem height. In natural conditions, plants compete with each other for resources such as light, water, and nutrients. This competition could have limited the growth of the plants in the natural conditions treatment, resulting in a shorter stem height compared to the EPT treatment.

5.1.2 Plant height on week 4

The results of the experiment indicate significant differences ($p<0.05$) in plant growth among the various treatments. Earthworm poop tea (Treatment 1) exhibited the highest mean stem height (27.82 cm), followed by Celest Top (chemical herbicide). Interestingly, a significant difference ($p<0.05$) was observed between Celest Top and natural conditions, suggesting that the herbicide had a negative impact on plant growth. However, no significant difference ($p<0.05$) was found between earthworm poop tea and Celest Top. The superior performance of earthworm poop tea in promoting plant growth can be attributed to its rich content of beneficial nutrients and microorganisms. Earthworm poop tea contains a diverse array of essential plant nutrients, including nitrogen, phosphorus, potassium, and calcium, which are readily available for plant uptake (Edwards and Arancon, 2004). Additionally, earthworm poop tea harbors a rich population of beneficial microorganisms, including bacteria and fungi, which can enhance plant growth through various mechanisms like Nutrient Mobilization, hormone production, and disease suppression. Microorganisms in earthworm poop tea can solubilize and mobilize nutrients in the soil, making them more accessible to plants (Vessey, 2003). Microorganisms can produce plant growth hormones, such as auxins and cytokinins, which stimulate cell division, root development, and overall plant growth (Mok and Mok, 2001). Beneficial microorganisms can suppress plant pathogens, reducing the risk of disease and promoting healthy plant growth. The negative impact of Celest Top on plant growth aligns with its known mode of action as a herbicide. Celest Top inhibits plant growth by interfering with auxin activity, disrupting photosynthesis, and potentially affecting nutrient availability (Grossmann, 2010; Fuerst and Norman, 2010; Smith, 2009). These effects can lead to reduced cell division, stunted growth, and overall plant health decline. The lack of a significant difference between earthworm poop tea and Celest Top in terms of plant growth could be due to several factors. One possibility is that the negative effects of Celest Top were partially offset by the positive effects of earthworm poop tea. For instance, the beneficial microorganisms in earthworm poop tea might have mitigated the herbicide's impact on nutrient availability or disease suppression. Additionally, the specific plant species used in the experiment might be relatively tolerant to Celest Top, reducing the observable difference in growth between the two treatments.

5.1.3 Plant height on week 6.

The data on plant height at six weeks reveals interesting insights into the effects of different treatments on plant growth. While Celest Top (Treatment 2) exhibits the highest mean stem height (40.50 cm), followed by earthworm poop tea (36.38 cm), natural conditions show the least mean stem height (32.13 cm). Celest Top's significantly higher mean stem height compared to natural conditions ($p<0.05$) suggests a positive impact on plant growth. This aligns with Celest Top's function as a plant growth regulator, promoting cell division and elongation (Grossmann, 2010). However, it is crucial to consider the potential long-term effects of Celest Top on plant health and soil ecology. Earthworm poop tea's mean stem height, though lower than Celest Top, is still considerably higher than natural conditions. This suggests that earthworm poop tea provides beneficial nutrients and microorganisms that contribute to plant growth (Edwards and Arancon, 2004). The lack of a significant difference between earthworm poop tea and natural conditions could be due to various factors, such as the specific plant species used or the potential mitigating effects of earthworm poop tea on Celest Top's negative impacts. The lowest mean stem height observed in natural conditions highlights the potential limitations of relying solely on natural processes for optimal plant growth. This underscores the importance of exploring sustainable and environmentally friendly methods like earthworm poop tea to enhance plant growth without resorting to synthetic chemicals.

5.1.4 Stem height at 8 weeks

The final week of the study reveals a clear pattern in plant growth across the different treatments. Celest Top (Treatment 2) continues to exhibit the highest mean stem height (49.68 cm), demonstrating its sustained impact on plant growth. Natural conditions, on the other hand, record the least mean stem height, highlighting the limitations of relying solely on natural processes for optimal growth. Celest Top's significantly higher mean stem height compared to both earthworm poop tea and natural conditions ($p<0.05$) reinforces its effectiveness as a plant growth regulator. This aligns with its ability to promote cell division and elongation (Grossmann, 2010). However, it is crucial to consider the potential long-term effects of Celest Top on plant health and soil ecology. Earthworm poop tea's mean stem height, while lower than Celest Top, remains considerably higher than natural conditions. This suggests that earthworm poop tea provides beneficial nutrients and microorganisms that contribute to plant growth (Edwards and Arancon, 2004). The lack of a significant difference between earthworm poop tea and natural conditions could be due to various factors, such as the specific plant species used or the potential mitigating effects of earthworm poop tea on Celest Top's negative impacts.

5.2 Number of leaves

5.2.1 Effects of different treatments (Celest top, earthworm poop tea, and natural conditions) on field bean's number of leaves at two weeks.

The data on leaf count two weeks after emergence reveals interesting patterns across the different treatments. Celest Top (Treatment 2) takes the lead, recording the highest mean number of leaves (6.33), indicating its positive influence on leaf development. Natural conditions, on the other hand, exhibit the lowest mean number of leaves (5), highlighting the potential limitations of relying solely on natural processes for optimal leaf production. Celest Top's significantly higher mean number of leaves compared to natural conditions ($p<0.05$) reinforces its effectiveness as a plant growth regulator. This aligns with its ability to promote cell division and differentiation, leading to increased leaf production (Grossmann, 2010). Earthworm poop tea's mean number of leaves falls between Celest Top and natural conditions, suggesting that it provides beneficial nutrients and microorganisms that contribute to leaf development (Edwards and Arancon, 2004). However, the lack of a significant difference between earthworm poop tea and Celest Top could be due to various factors, such as the specific plant species used or the potential mitigating effects of earthworm poop tea on Celest Top's negative impacts.

5.2.2 Number of leaves at 4 weeks

The data on plant height four weeks after emergence reveals a more nuanced picture of the treatments' impact on growth. Similar to the two-week analysis, Celest Top (Treatment 2) maintains its leading position, exhibiting the highest mean plant height (14.83 cm), indicating its continued promotion of cell elongation and overall growth (Grossmann, 2010). Earthworm poop tea, with a mean plant height of 14.50 cm, closely follows Celest Top. This suggests that earthworm poop tea provides essential nutrients and beneficial microorganisms that contribute to plant growth and development (Edwards and Arancon, 2004). However, the lack of a significant difference between earthworm poop tea and Celest Top indicates that further research is needed to understand the specific mechanisms behind their growth-promoting effects and potential long-term impacts. Natural conditions, with a mean plant height of 13.67 cm, show a significant difference compared to Celest Top ($p<0.05$). This highlights the limitations of relying solely on natural processes for optimal plant growth. While natural conditions provide essential elements, they may not be sufficient to achieve the maximum growth potential of the plants.

5.2.3 Number of leaves at 6 weeks.

The data on leaf number at six weeks after emergence reveals a significant impact of the treatments on plant development. Celest Top (Treatment 2) once again emerges as the leader, achieving the highest mean number of leaves with 23.17. This confirms its effectiveness in promoting cell division and leaf production, contributing to overall plant growth and biomass (Grossmann, 2010). Earthworm soup, with a mean leaf number of 21.33, continues to demonstrate a positive effect on plant development. While the difference compared to Celest Top is not statistically significant, the increase in leaf number compared to natural conditions suggests that earthworm soup provides essential nutrients and beneficial microorganisms that contribute to plant growth (Edwards and Arancon, 2004). Further research is needed to understand the specific mechanisms and long-term impacts of earthworm soup on plant development. Natural conditions, with a mean leaf number of 13.50, show a significant difference compared to Celest Top ($p<0.05$). This reinforces the limitations of relying solely on natural processes for optimal plant growth. While natural conditions provide essential elements, they may not be sufficient to achieve the maximum growth potential of the plants.

5.2.4 Number of leaves at 8 weeks.

The data on leaf number at eight weeks after emergence further highlights the impact of the treatments on plant development. Celest Top (Treatment 2) continues to lead with the highest mean number of leaves at 30.67, demonstrating its sustained effectiveness in promoting cell division and leaf production (Grossmann, 2010). Earthworm poop tea, with a mean leaf number of 26.50, maintains its positive influence on plant development. While the difference compared to Celest Top is not statistically significant, the increase in leaf number compared to natural conditions suggests that earthworm poop tea provides essential nutrients and beneficial microorganisms that contribute to plant growth (Edwards and Arancon, 2004). Further research is needed to understand the specific mechanisms and long-term impacts of earthworm poop tea on plant development. Natural conditions, with a mean leaf number of 20.7, show a significant difference compared to Celest Top ($p<0.05$). This reinforces the limitations of relying solely on natural processes for optimal plant growth. While natural conditions provide essential elements, they may not be sufficient to achieve the maximum growth potential of the plants.

5.3 Pest infestation

5.3.1 Aphid

The data on pest infestation at eight weeks after emergence reveals a contrasting pattern compared to leaf number. Natural treatment (Treatment 3) exhibits the highest mean of aphid infestation (16), indicating its vulnerability to pest attacks. This could be attributed to the absence of protective measures against pests in this treatment group. Celest Top (Treatment 2) demonstrates its efficacy in pest control, recording the lowest mean of aphid infestation (7.50). This aligns with its known mode of action as an auxin herbicide, which disrupts plant growth and development, making the plants less attractive to pests (Grossmann, 2010). Earthworm poop tea, with a mean aphid infestation of 9.67, shows a moderate level of pest control. While the difference compared to Celest Top is not statistically significant, the lower infestation rate compared to natural conditions suggests that earthworm poop tea may provide some level of protection against pests.

5.3.2 Semi lopper

The analysis of semi-looper infestation at eight weeks post-emergence reveals similar trends to the aphid infestation data. Natural treatment (Treatment 3) exhibits the highest mean of semi-looper infestation (13.33), indicating its susceptibility to this pest as well. This further highlights the vulnerability of untreated plants to pest attacks. Celest Top (Treatment 2) once again demonstrates its effectiveness in pest control, recording the lowest mean of semi-looper infestation (5.33). This reinforces its potential as a protective measure against various types of pests. Earthworm poop tea, with a mean semi-looper infestation of 6.83, shows a moderate level of pest control against semi-loppers as well. While the difference compared to Celest Top is not statistically significant, the lower infestation rate compared to natural conditions suggests that earthworm poop tea may offer some level of protection against this pest.

5.3.3 Whitefly

The analysis of whitefly infestation at eight weeks post-emergence reveals similar patterns to the aphid and semi-looper infestation data. Natural treatment exhibits the highest mean of whitefly infestation, indicating its vulnerability to this pest as well. This further highlights the importance of pest control measures in protecting plants from various types of pests. Celest Top once again demonstrates its effectiveness in pest control, recording the lowest mean of whitefly infestation. This reinforces its potential as a broad-spectrum pest control solution. Earthworm poop tea shows a moderate level of pest control against whiteflies. While the difference compared to Celest Top is not statistically significant, the lower infestation rate compared to natural conditions suggests that earthworm poop tea may offer some level of protection against this pest.

5.5 Germination percentages

The lack of significant differences in germination percentages across the three treatments (earthworm poop tea, Celest Top, and natural conditions) warrants further exploration. While the absence of statistical significance might suggest that none of the treatments have a substantial impact on germination, several scientific factors could contribute to this observation**.** Plant germination is inherently variable, influenced by factors such as seed quality, environmental conditions, and genetic predisposition. This inherent variability can make it challenging to detect statistically significant differences between treatments, especially when sample sizes are limited. The observed germination percentages might reflect a complex interplay between the treatments and other environmental factors. For instance, earthworm poop tea, while not directly impacting germination, might enhance soil fertility and microbial activity, indirectly contributing to improved germination rates. Similarly, Celest Top, while potentially inhibiting some pathogens, might not have a direct impact on germination itself. The absence of significant differences in germination percentages highlights the need for further research to elucidate the complex interplay between the treatments, environmental factors, and plant biology. Future studies could investigate the specific mechanisms by which earthworm poop tea and Celest Top might influence germination, both directly and indirectly. Additionally, exploring the long-term effects of these treatments on plant growth and yield would provide valuable insights into their overall impact on plant performance.

Chapter 6

6. 1 Conclusion

During the study, it was observed that different seed dressing methods affect the growth of fine beans. It has effects on pest infestation, leaf size, stem height, and pod number. The two seed dressing methods show different results. Celest Top pesticide shows the smallest pest infection from the soil up to physiological maturity, followed by earthworm pop tea; however, Celest Top has a smaller average on stem height of the field beans than earthworm poop tea treatment.

A larger number of pods was obtained by using Celest Top as a seed dressing method in this research than all other treatments in the fourth week of the experiment, therefore, artificial Celest Top produced more pods than all other treatments. The celest top is more effective in promoting pod number and development in field beans. On the other hand, earthworms are better in pod size and appearance.

6.2 Recommendations

The first important aspect is purchasing a good seed from registered companies for example seed Co in Zimbabwe. Certified seeds already have higher germination percentages and they can tolerate certain diseases compared to OPVs (open-pollinated varieties). To add more registered seeds are free from seed-borne diseases.

To improve soil fertility and prevent nutrient depletion, farmers should implement good soil management practices, including crop rotation and cover cropping. It is also crucial to regularly conduct soil tests to determine the pH and nutrient levels of the soil. Based on the results of the soil tests, farmers should adjust their fertilization practices to ensure that their crops receive the appropriate amount of nutrients. More so, the use of integrated methods of pest control methods to reduce chemical effects on the environment. Cultural methods like crop rotation can reduce pests built up by breaking the life cycle of semi looper in field beans. Chemical pesticides can be used to control pests. Management of pesticide application is very crucial to reduce SAR (system-acquired resistance) by pests. It is recommended to use different pesticides to control pests.

The choice of seed dressing method should be tailored to the specific needs and challenges faced by the grower. For instance, if pest infestation is a major concern, a seed dressing with insecticidal properties might be preferred. Conversely, if soil fertility is a limiting factor, a seed dressing that enhances nutrient availability might be more suitable. Seed dressing should be integrated with other best management practices for optimal results. This includes proper soil preparation, irrigation, fertilization, and pest control measures. A holistic approach that addresses all aspects of plant growth and health will maximize the benefits of seed dressing. The cost-effectiveness of different seed dressing methods should be carefully evaluated. While some methods might be more expensive upfront, they could provide long-term benefits in terms of increased yields and reduced pest damage. The environmental impact of seed dressing methods should be considered. The use of synthetic pesticides should be minimized, and alternative methods, such as biopesticides or botanical extracts, should be explored. By carefully considering the specific needs and challenges faced by the grower, the choice of seed dressing method can be optimized for maximum effectiveness. Whether the primary concern is pest control, nutrient availability, environmental conditions, crop type, or cost, there's a suitable seed dressing option available to address each unique situation.

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INDEX 1

Random assignment of the treatments in blocks

T1	T2	T3	T4	T1	T2	T3	T4
T3	T1	T2	T1	T4	T3	T2	T1
T4	T3	T2	T1	T4	T1	T3	T2

APPENDIX 2:

ANALYSIS OF VARIANCE

Variate: heigh at 4 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	9.088	4.544	1.44	
block. Units stratum					
treatment	2	31.748	15.874	5.04	0.024
Residual	13	40.929	3.148		
Total	17	81.764			

Variate: height at 6 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	5.223	2.612	0.98	

block. Units stratum					
treatment	2	85.263	42.632	15.92	<.001
Residual	13	34.818	2.678		
Total	17	125.305			

Variate: height at 8 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	9.674	4.837	2.38	
block. Units stratum					
treatment	2	57.021	28.511	14.01	<.001
Residual	13	26.456	2.035		
Total	17	93.151			

Variate: height at 2 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.5033	0.2517	1.95	
block. Units stratum					
treatment	2	29.1433	14.5717	112.87	<.001
Residual	13	1.6783	0.1291		
Total	17	31.3250			

Variate: number_of_leaves at 4 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	18.1111	9.0556	10.04	
block. Units stratum					
treatment	2	152.4444	76.2222	84.53	<.001
Residual	13	11.7222	0.9017		
Total	17	182.2778			

Variate: number_of_leaves at 6 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1.4444	0.7222	0.92	
block. Units stratum					
treatment	2	324.7778	162.3889	206.52	<.001
Residual	13	10.2222	0.7863		
Total	17	336.4444			

Variate: number_of_leaves at 8 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	2.111	1.056	0.70	
block. Units stratum					
Treatment	2	335.444	167.722	111.50	<.001
Residual	13	19.556	1.504		
Total	17	357.111			

Variate: number_of_leaves at_2 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	4.1111	2.0556	8.29	
block. Units stratum					
treatment	2	5.7778	2.8889	11.66	0.001
Residual	13	3.2222	0.2479		
Total	17	13.1111			

Variate: pest_infestation_(aphid)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	13.778	6.889	2.88	
block. Units stratum					

treatment	2	234.111	117.056	49.00	<.001
Residual	13	31.056	2.389		
Total	17	278.944			

Variate: Pest infestation_(semi_lopper)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	2.333	1.167	0.79	
block. Units stratum					
treatment	2	217.000	108.500	73.59	<.001
Residual	13	19.167	1.474		
Total	17	238.500			

Variate: pest_infestation_(whitefly)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	2.7778	1.3889	2.11	
block. Units stratum					
treatment	2	109.7778	54.8889	83.40	<.001
Residual	13	8.5556	0.6581		
Total	17	121.1111			

Variate: Germintion_percentge

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	7.44	3.72	0.12	
block. Units stratum					
treatment	2	185.44	92.72	3.06	0.082
Residual	13	394.06	30.31		
Total	17	586.94			