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CROP SCIENCE DEPARTMENT

Effect of combined foliar application of humuson and D.I Grow on the growth performance of soybeans under Sub humid conditions in Zimbabwe

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DECLARATION

I Shalom Tambe (B211806B) declares that this research project is a result of my original work and has not been presented somewhere for any degree or any institute. All other supplementary sources of information have been acknowledged by means of references.

CERTIFICATION OF THE DISSERTATION

Bindura University of Science Education

Department of Crop Science

The undersigned certify that they have read and recommend to the Bindura University to accept a dissertation entitled: **The Effects of the combined foliar application of humuson and D.I Grow on the growth performance of soybeans under Sub humid conditions in Zimbabwe.**

Submitted by

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In partial fulfilment of the requirements for the Bachelor of Science Honors Degree in Agriculture.

SUPERVISOR:

DATE:07/07/2025

DEDICATION

I dedicate this project to the Almighty God for granting me strength, wisdom, and good health throughout the course of this study. To my dear parents, whose unwavering support, love, and encouragement have been the cornerstone of my academic journey this achievement is as much yours as it is mine. To my lecturers and supervisors, thank you for your guidance and patience. Lastly, to all smallholder farmers in Zimbabwe who continue to pursue sustainable farming practices despite limited resources may this work contribute in some small way to your efforts and success.

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ABSTRACT

Soybean (*Glycine max*) is a vital legume crop valued for its high protein content and economic significance. However, in Zimbabwe, smallholder farmers face challenges in accessing and affording recommended rates of inorganic fertilizers, leading to sub-optimal soybean yields. This study was conducted to evaluate the effect of combined foliar application of Humuson and DI Grow on selected growth parameters of soybean under sub-humid conditions. The experiment was carried out at New Retreat Farm in Beatrice, using a Randomized Complete Block Design (RCBD) with six treatments replicated three times. Treatments included various combinations of Humuson and DI Grow, along with positive (100% Humuson and 100% DI Grow) and negative (no fertilizer) controls. Foliar applications were conducted at the V4 (vegetative) and R1 (flowering) stages. Data on plant height, leaf area index, and number of leaves were collected 30 days after crop emergence from five randomly selected plants per plot. Results from the analysis of variance (ANOVA) revealed significant differences ($p<0.05$) among treatments for all measured parameters. Treatments combining Humuson and DI Grow, particularly T1 (50% Humuson + 50% DI Grow) and T2 (75% Humuson + 25% DI Grow), demonstrated superior performance in promoting plant growth compared to the control and single-product applications. The findings suggest that the combined foliar application of Humuson and DI Grow enhances soybean vegetative growth and offers a viable, cost-effective alternative to conventional fertilizers for smallholder farmers. This practice could contribute to improved yields, income generation, and food security in Zimbabwe.

Table of Contents

CHAPTER 1: INTRODUCTION

1.1 Background of the study

Soybean (*Glycine max*) crop was first domesticated in ancient China, followed by the surrounding region of Southeast Asia (Jung *et al*., 2020). Soybean due to its high protein content, it became a major food source for people in Southeast Asia and earned the nickname "Cow of the field" (Dong *et al*., 2021). Soybeans, do best in well-drained soils that include a minimum of twenty percent clay (Bagale, 2021). Soybeans offer a variety of health assistances due to their nutritional composition and bioactive compounds. Soybean crop was first domesticated in ancient China, followed by the surrounding region of Southeast Asia (Anderson *et al*. (2019). It was primarily consumed for its oil and protein-based products. Due to its high protein content, it became a major food source for people in Southeast Asia and earned the nickname "Cow of the field" (Hymowitz, 2008). In the modern world, soybeans are cultivated globally, with major production hubs located in the North-South America region, including the USA, Argentina, and Brazil (Wilcox, 2004; USDA-FAS, 2018). Although the origins of the Soybean plant are unknown, many botanists think that domestication of the plant began in central China around 7000 BC (Anderson *et al*. (2019).

According to (Jung *et al*., 2020), soybeans are an old crop that have been used for thousands of years as food and a component of medicines in China, Japan, and Korea. After being brought to the country in 1804, soybeans gained significant importance in the Midwest and South by the middle of the 20th century. Argentina and Brazil are also significant producers. Soybeans became successful as a new crop in the United States due to an immediate need for soyabean oil and meal. The soyabean plant was introduced to the United States in the 18th century as an experimental crop. Its cultivation in the U.S. has evolved over time, from being used as a Civil War coffee substitute to becoming a major agricultural commodity. Soybeans were first grown in America in the 19th century and were not grown in Iowa until the 20th century. The domestication of soyabeans likely occurred between 6,000 and 9,000 years ago. The commonly accepted hypothesis is that soyabeans were domesticated in East Asia, particularly in China. The genetic, genomic, and geographic evidence supports the idea of a single origin for domesticated soyabeans. Soyabeans are now grown in many countries around the world, with the largest producers being the United States, Brazil, Argentina, China, and India. The United States is the leading producer and exporter of soyabeans globally.

Soyabeans, do best in well-drained soils that include a minimum of twenty percent clay. The crop responds to manure but does not fare well on light or poor sands. Because the bacteria that fixes nitrogen only flourishes in a specific ideal pH range and is particularly sensitive to low pH (acidic soils), the crop is likewise sensitive to soil acidity. The ideal pH range, according to the $CaCl_2$ scale, is 5.5 to 7. Usually, farmers are encouraged to collect soil samples for pH (acidity or basicity) analysis in the winter, as soyabeans are susceptible to soil acidity. If required, lime should be added to the soil at the suggested or mandated rates in order to raise its pH to the ideal level. The results of a thorough soil analysis will specify the type and rate of basal dressing to be applied as well as the soil's nutritional status. Application of 200 to 300 kg per ha of compound L or soya blend is generally advised in Zimbabwe. However, most farmers in Zimbabwe are resource constrained and apply sub-optimal amounts resulting in suppressed growth of the crop. Farmers may also opt to apply organic manure which also has a positive effect on soyabean. Unfortunately, most farmers especially the smallholder ones do not have access to adequate quantity and quality manures for soyabean crop production. It is therefore suggested that foliar fertilizers maybe an alternate for nutrient supply in soyabean production.

Foliar nutrition refers to the practice of applying fertilizer solutions directly to the leaves of plants. It is a beneficial method for addressing specific plant requirements because foliar fertilizers are absorbed directly at the site of application. While foliar fertilization does not replace the need for soil-applied fertilizers, it can enhance nutrient uptake and improve plant performance, particularly in challenging conditions such as diseases or unfavourable soil conditions like flooding or drought. Well-nourished plants are better equipped to resist pathogens, and even if their nutrient transport system or roots are compromised by diseases, they can still produce reasonably normal yields. Therefore, this study will be conducted to determine the effect of using different foliar fertilizers on selected growth of soyabean in Zimbabwe.

1.2 Problem statement

The majority of soybean growers in Zimbabwe are small-scale farmers with limited financial means. These farmers often cannot afford the recommended dosages of fertilizers needed for optimal crop growth, which results in reduced yields. Inadequate nutrition not only stunts plant development but also decreases the crop’s resistance to disease and environmental stress. In addition, the overreliance on traditional inorganic fertilizers has introduced long-term environmental issues, including water pollution and degradation of aquatic ecosystems. The combination of economic barriers and environmental sustainability concerns underscores the need for alternative, cost-effective, and environmentally friendly nutrient delivery systems such as foliar fertilization.

1.3 Justification

Research on the impact of foliar fertilizers on soybean performance under Zimbabwean conditions is still insufficient. According to Leif (2019), foliar nutrition, involving the spraying of nutrients directly onto leaves, is highly effective for correcting nutrient deficiencies and is especially beneficial when the soil has properties that limit root uptake. It enables plants to rapidly absorb the required elements without undergoing extensive processing through the soil matrix. Furthermore, foliar fertilization allows for targeted application during critical developmental stages of the crop, increasing its effectiveness. It also allows for a lower quantity of materials to be used, making the method cost-efficient while maintaining crop productivity.

Humuson and D.I Grow are two foliar fertilizers known for enhancing plant vigor, chlorophyll content, and resistance to stress. Humuson is derived from humic substances, promoting microbial activity and nutrient availability, while D.I Grow is a plant stimulant with trace elements that support cell division and overall plant health. Their combined application may present a synergistic effect on crop development. Therefore, it is essential to assess whether these foliar treatments can address the nutritional challenges faced by smallholder farmers and whether they offer a practical solution for boosting soybean growth. A positive outcome could reduce the nation's dependency on imported soybean and strengthen food and income security for farming communities.

1.4: Objectives of the study

1.4.1: Main Objective:

To determine the effect of combined foliar application of Humuson and DI Grow on the growth performance of soybean under sub-humid conditions in Zimbabwe.

1.4.2: Specific Objectives:

1. To evaluate the effect of different combinations of Humuson and DI Grow on the plant height of soybean.
2. To determine the impact of foliar application of Humuson and DI Grow on the leaf area of soybean.
3. To assess the influence of the foliar treatments on the number of leaves per plant in soybean.

1.5 Hypotheses

1. The application of different combinations of Humuson and D.I Grow significantly increases the plant height of soybean.
2. The foliar application of Humuson and D.I Grow significantly enhances the leaf area of soybean.
3. The number of leaves per plant in soybean is significantly improved by the use of Humuson and D.I Grow.

CHAPTER 2: LITERATURE REVIEW

2.1 Origin of Soyabeans

Soyabeans (*Glycine max*) were first cultivated in ancient China, and their use eventually spread to areas across Southeast Asia (Jung *et al.,* 2020). Owing to their rich protein composition, soyabeans gained prominence in Southeast Asia, earning them the nickname "Cow of the field" (Dong *et al*., 2021). This leguminous plant exhibits extraordinary adaptability and versatility. It was first grown around 1100 BC in northern China, making it one of the earliest cultivated food sources. Its wild ancestor, a vine-like plant, bore small, hard seeds that were unpalatable unless adequately cooked. Over time, the domesticated soyabean, *Glycine max*, became widely distributed across East Asia. Unlike its wild variant, the cultivated form grew upright and produced more substantial, tastier seeds. A wide range of food items such as sprouts, steamed or roasted beans, soy milk, sauces, fermented paste and cake, flour, and tofu were derived from soyabeans. It is estimated that 6000–9000 years ago, in East Asia, wild soybeans (*Glycine soja*) were domesticated to produce soyabeans (*Glycine max*), a major legume crop (Carter *et al.,* 2004; Kim *et al*., 2012b). Although the precise date of soyabean domestication has long been disputed, new developments in whole-genome sequencing and archaeological findings have shed light on the crop's past. According to one theory, the Huang-Huai Valley in Central China, which is situated between the Huai and Yellow rivers, is the is the most probable region where Soyabean domestication took place (Han *et al*., 2016). Comparing this region's soybean accessions to those from other regions, genetic investigations reveal a higher number of genetic introgressions from wild soybean (*G. soja*). Additionally, compared to other regions, the Huang-Huai Valley's soybean accessions show a higher level of genetic variety. According to a different theory, soybean may have originated in several locations throughout East Asia (Xu *et al*., 2002; Abe *et al*., 2003). The presence of several maternal lineages in domesticated soybeans has been revealed by phylogenetic studies employing nuclear or chloroplast microsatellite markers, suggesting the likelihood of distinct domestication processes in various places. According to recent genome resequencing research, all currently grown soyabeans are descended from a single domestication event, supporting the single origin theory (Zhou *et al.,* 2015b; Han *et al*., 2016). All domesticated soyabeans are descended from a single cluster of wild soybeans (*G. soja*), according to resequencing of several types of soybeans, including wild, landrace, and improved cultivars.

2.2 Uses of Soyabeans

According to Signh (2023), soyabean has the potential to reduce kidney diseases and function as an antidiabetic medication. By substituting soybean plant proteins for animal proteins, soybeans may aid in lowering the elevated protein level. Plant protein from soyabeans may aid in renal hyper filtration and lessen kidney damage in people with type 2 diabetes. Because they target glucose transporters, the isoflavonoids and stigmasterol found in soybeans may have anti-diabetic effects. Consuming soyabeans on a daily basis as part of a diet may help lower the risk of cancer. One isoflavone found in soyabeans may be the source of its anti-cancer properties. Because of its anti-proliferative characteristic, which prevents the growth of malignant cells, soybeans may be used to treat breast, prostate, and colon cancer.

According to (Antony *et al* 2011) cardiovascular diseases are those that impact the heart and blood vessels. Cardiovascular disease includes conditions like hypertension, coronary artery disease, and coronary heart disease. Because they reduce cholesterol, soyabeans' isoflavone and phytosterols may be particularly important in the development of cardiovascular illnesses. Weaker, brittle bones and joints are referred to as osteoporosis, and they typically affect elderly women. Because Soyabean isoflavones may preserve bone mineral density, they may be utilized to treat osteoporosis (Messina, 2016)

Soyabeans are high in protein, and their frequent consumption may lead to a reduction in overall food intake, potentially helping in controlling obesity. Both human and animal studies have linked soy protein with possible decreases in body weight and fat mass. The rich protein content of soybeans might also support healthy blood pressure levels. Since soy protein has hypotensive properties, it might be useful in reducing blood pressure. Isoflavones found in soybeans may promote skin health by enhancing collagen production, which improves elasticity and hydration. This could result in fewer wrinkles and less pigmentation. Moreover, the isoflavones in soybeans may also exhibit antidepressant activity, potentially alleviating symptoms of depression through regular consumption.

2.3 Economic Use of Soyabeans

According to (Shah *Et...al* 2020) The cultivation and utilization of soyabeans contribute significantly to various economic benefits at local, national, and global levels. International Trade: Leading producers of soyabeans', including the United States, Brazil, and Argentina, are prominent players in the world market, making soyabeans' a valuable commodity in international trade. A nation's economic standing is improved by exporting soybeans, which increases foreign exchange revenues.

Job Creation: Employment opportunities are created by the soybean business, from planting to processing and distribution. Many people's livelihoods are supported by the jobs produced in transportation, agriculture, processing, and other associated industries.

Income Generation for Farmers: Growing soyabeans may be a lucrative endeavor for farmers. Soyabeans sales and other soy-based goods give rural communities a source of income and improve their financial situation.

Diversification of Agriculture: Farmers can incorporate soyabeans into crop rotation systems as a flexible crop. By reducing the risks involved in depending just on one crop, diversification promotes the stability of agricultural economies.

Support for Animal Agriculture: The growth and production of animals are increased when Soyabean meal is used in animal feed. As a result, the livestock industry is able to maintain its financial stability by producing healthy and fed animals that are used for meat and dairy production.

Sustainable Agricultural Practices: By fixing nitrogen in the soil, soyabeans help to lessen the requirement for artificial fertilizers. This helps farmers save money on inputs and encourages sustainable agricultural methods, both of which improve farmers' bottom lines.

Industrial Applications and Innovation: The development of alternative energy sources and innovation are aided by the industrial uses of soyabeans, such as the manufacturing of biodiesel from soybean oil. This usage diversity promotes technical breakthroughs and strengthens economic resilience.

Market for Goods Made of Soya: The market created by the manufacturing of several soy-based products, such as soy milk, tofu, and meat substitutes made from soy, goes beyond traditional agriculture. By increasing the value of soybeans, this market diversification promotes economic expansion.

Global Economic Interdependence: Trade and economic cooperation between countries are encouraged by the interconnectivity of the world's Soyabean markets. Major soybean-producing and exporting nations are important players in the world economy.

Development of the Rural Area: Soyabean growing is a common practice in rural regions, and its economic advantages go beyond farming to support the general development of the region. Successful agricultural operations are generally associated with enhanced infrastructure, healthcare, and education.

Investments in Research and Development: To increase crop yields, increase resistance to disease, and create new soya-based products, the Soyabean sector draws funds for research and development. This investment strengthens the industry's economic impact and advances technology.

2.4 Fertilizer Requirements for Soyabeans Production

According to (Ferguson *et al*., 2018), increases in Soyabean yield potential have been fueled by developments in the agronomic, genetic, biological, and crop protection elements of production. Soyabean fertility analysis and maintenance are becoming more and more crucial in order to optimize its yield potential. This is caused by rising soybean yields in addition to rising maize yields, environmental issues, and budgetary constraints. If the corn crop is higher than anticipated, there may be a nutritional shortage in the next soybean crop because of the nutrients taken during the harvesting process.

According to (Pedersen 2007), Nutrients provide the building blocks for maintaining biological processes, shielding the plant from illness and other environmental challenges, and eventually boosting production (soybean plants need 16 components for growth and seed development). Soyabeans need three macronutrients: potassium (K), phosphorus (P), and nitrogen (N). Calcium (Ca), magnesium (Mg), iron (Fe), boron (B), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), Sulphur (S), and chlorine (Cl) are examples of secondary and micronutrients that support soybean growth. To assist maintain overall soil nutrient availability, soybean soil pH levels should be kept between 5.5 and 7.0; however, the ideal range is between 6.3 and 6.5. The pH of the soil, a measurement of its acidity or alkalinity, influences the elements that are available.2. Additionally, studies have revealed that Soyabean cyst nematode (SCN) populations at harvest are likely to be higher when the soil pH exceeds 6.5.3. Fernandez (2018).

Phosphorus and potassium are the two most vital nutrients soyabeans depend on for optimal development. Although soyabeans, as legumes, fix nitrogen from the atmosphere naturally, external inputs such as compost, organic manure, or commercial fertilizers like ammonium nitrate can further enhance yields. Farmers conduct soil tests to determine nutrient levels and apply phosphorus and potassium accordingly. Yield improves when essential nutrients are provided timely and in proper amounts. Ideal soils for soyabean cultivation are well-aerated, rich in organic matter, drain well, and have a nearly neutral pH between 6 and 6.8. Acidic, waterlogged soils hinder soyabean growth. Researchers, including Davidson (2016), have confirmed that well-drained soils are the most suitable for soyabean farming due to the crop's intolerance to standing water.

2.5 Inorganic Fertilizer Use on Soyabean Production

According to (Scherer *et al*. 2009), "Any material, synthetic or natural, applied to soil or plant tissues to supply one or more plant nutrients essential to plant growth is a fertilizer." Over the past 50 years, inorganic fertilizers have been at the core of numerous scientific fields (Smil, 2001). A number of global issues, including population expansion, food security, and economic advancement, depended on their discovery—or more accurately, their formulation (Cakmak, 2002). The need for more food production to meet the growing population determines the importance of fertilizers and plant nutrition (Cakmak, 2002). Inorganic fertilizers, often known as mineral fertilizers, are mostly composed of synthetic-organic or inorganic substances (Scherer *et al*., 2009).

Although widely used by farmers today, nitrogen (N), phosphorus (P), and potassium (K)—the three primary nutrients—are often overlooked in soyabean production. Nitrogen is the most dominant macronutrient in fertilizers, yet its availability in soil remains poorly understood (Baties, 1996). It plays a fundamental role in the structure of proteins, nucleic acids, and amino acids, and also supports enzyme formation (Scherer *et a*l., 2009). A deficiency in nitrogen results in low chlorophyll levels and protein synthesis, visibly affecting the plant through pale leaves and weak growth (Scherer *et al.*, 2009). According to Gryphon (2015), plants typically take it as NO-3 or NH+4, which results in increased crop yields. (Massignam *et al*., 2009). Furthermore, it plays a significant role in the creation of leaf area (Ahmad et al., 2009) and the improvement of food quality (Arshadullah *et al*., 2010). This opinion is supported by a number of studies compiled by Leghari *et al*. (2016), who noted that nitrogen boosts the yield of common plants like wheat, rice, cotton, and sugarcane. It also plays a part in vegetable gardens and fruit plants like citrus or mango trees (Leghari *et al.,* 2016). In summary, the darkening and growth of leaves, stems, and roots are the primary indicators of its significance (Leghari *et al.,* 2016).

Phosphorus, another key nutrient, is vital for the synthesis of nucleic acids and phospholipids, and is integral to the formation of ATP (Scherer *et al.,* 2009). The presence of phosphorus molecules attached to ATP supports key plant functions like glucose activation and phosphorylation. Plants suffering from phosphorus deficiency often show reduced growth and dark green or grey coloration (Scherer *et al*., 2009). Phosphorus is commonly absorbed as H2PO4- or HPO4-2 and is present in fertilizers as P2O5. (Gryphon, 2015). Furthermore, when it comes to metabolic processes and the rise in photosynthesis that occurs when leaf-P is abundant, there is a considerable association between N and P (Reich *et al*., 2010). Furthermore, root length and width as well as P concentration have an impact on biomass concentration (Bindraban *et al*., 2020). The same authors emphasize that just a small portion of phosphorus is absorbed by plants and declare it an essential nutrient. In the end, they conclude that phosphorus appears to be mycorrhization's foe in roots.

Potassium, the third essential macronutrient, is absorbed mainly as K+ ions and is found in fertilizers commonly as K2O (Scherer *et al*., 2009). It is highly concentrated within plant cells and influences various physiological processes like membrane potential and cellular depolarization. The respiration of carbohydrates to maintain ATP at appropriate levels is a prominent indicator of K insufficiency, resulting in low energy status in plants, which leaves them vulnerable to many illnesses and attacks. It is important to recognize that K+ plays a crucial molecular role in the processes of water intake, osmotic adjustment, drought stress route, and stomatal regulation (Wang *et al*., 2013). Resistance to biotic stress can be strengthened by potassium. It has been demonstrated that most cultivations are vulnerable to disease attacks, and that a K deficit tends to exacerbate this condition. As a result, using K-rich fertilizers is a relatively easy way to raise yields (Wang *et al.,* 2013). Potassium is most frequently found in fertilizers as K2O, also known as potash, although plants absorb it as K+ (Gryphon, 2015). Additionally, potash is favorably correlated with resistance to salt stress; as osmotic changes are a K+-related function, understanding their relationship to salt stress resistance, we comprehend the importance of potassium (Wang *et al*., 2013). To continue, K has a connection to water-logging resistance and is also significant to the alleviation of low-temperature stress, which is a common cause of yield losses (Wang *et al.,* 2013). Lastly, potassium is essential for the development of flowers and fruits, both in terms of quantity and quality (Zekri & Obreza, 2020). In conclusion, the majority of conventional agricultural schemes strongly advise the use of fertilizers and particular macronutrients have several functions.

2.6 Potential Use of Foliar Fertilizers on Soyabeans Production

According to (Dang, 2022), one common method for giving crops mineral nutrients is foliar treatment. Additionally, it improves nutrient use efficiency, particularly in situations with low soil fertility or constrained environmental circumstances. The foliar application of P, K, and Mg or P, K, Mg, and Zn increased plant nutrition, which enhanced the productivity and fruit quality of pomelo grown in alluvial soils. Fruit quality was improved with the application of foliar fertilization, which also increased the concentrations of P, K, and Mg in fruits. These elements are strongly correlated with fruit quality. Pomelo production was increased by these components, which were found in both leaves and fruits, as they showed a positive association with fruit output. Enhancing the quality of pomelo fruits is mostly dependent on the foliar feeding method...The objective of this study was to assess the effects of foliar application of zinc (Zn), potassium (K), magnesium (Mg), and phosphorus (P) on the uptake, yield, and quality of soyabean nutrients. Foliar fertilization lowers fertilizer application volumes and losses to the environment [10], particularly in cases of compaction or soil degradation. For instance, phosphorus readily precipitates in low pH soil; plants can use just 20% of the phosphorus accessible to them, with the remainder becoming insoluble compounds. Due to its high mobility, potassium readily leaches from the soil solution. Furthermore, low soil pH reduces the availability of certain vital elements like zinc and magnesium that affect citrus fruit growth and yield.

The macronutrients phosphorus, potassium, and magnesium play key roles in improving citrus fruit yield and quality. Citrus trees are especially dependent on phosphorus, which is a critical factor limiting their growth and productivity. Phosphorus supports a wide range of plant processes, including cellular division, photosynthesis, sugar movement, enzyme activation, and overall metabolism. In the same way, potassium plays a pivotal role in the synthesis of sugars and starches, stomatal regulation, protein formation, enzyme activity, acid metabolism in juice, and cell division. Foliar application of potassium enhances nutrient absorption, boosts juice quantity, and reduces fruit drop while improving total soluble solids (TSS). (Khalid et al., 2015) concluded that applying potassium and phosphorus topically to the "Kinnow" mandarin fruit greatly increased its ascorbic acid concentration and titratable acidity.

Magnesium facilitates chlorophyll synthesis, phosphorus uptake, carbohydrate metabolism, and sugar production. Inadequate magnesium diminishes both yield and fruit quality, as noted by Morton et al. On the other hand, even though zinc is only needed in trace amounts, it is vital for several physiological functions such as chlorophyll synthesis, enzyme activation, photosynthesis, auxin production, and metabolism. Foliar zinc spraying corrects micronutrient shortages and enhances fruit quality. Zinc foliar spraying corrects micronutrient deficits, improving the quality of the fruit. Zinc spraying enhanced the quality and production of pomegranate fruit. A very successful crop, soybeans are important for the production of food and animal feed worldwide. It is widely grown in nations like the United States, Brazil, and Argentina, which along with Paraguay, Canada, Uruguay, and Ukraine are significant soybean exporters.

The method of applying nutrient-rich solutions directly onto plant foliage is referred to as foliar nutrition. This technique allows nutrients to be quickly absorbed at the application site, making it particularly suitable for addressing specific plant needs. While soil-based fertilization is still essential, foliar feeding can improve nitrogen intake. Plants in good health are better able to resist diseases and can still yield well even if root systems or nutrient uptake pathways are impaired. When designing a foliar fertilizer plan for soyabeans, several aspects must be considered. Nutrients must be provided either through soil or leaf sprays for plants to absorb them. When applied to foliage, these nutrients must penetrate through the leaf surface to enter the plant's tissues. Like many plants, soyabean leaves have a waxy layer called the cuticle, which helps protect against environmental stressors such as pests and moisture loss. Foliar fertilizers serve as a fast, targeted nutrient supply that enhances yields, complements soil-based fertilization, and quickly addresses deficiencies. Applying foliar sprays at certain growth stages boosts both yield and quality. Foliar-application fertilizers offer quick, on-the-spot feeding for large, superior crops. It serves as an affordable supplemental feed for thorough soil fertilization and quick nutrient deficiency correction. Applying foliage to crops at particular phases of growth boosts yields and enhances quality.

According to (Liu, 2023), the following five situations need to spray foliar fertilizer. Use foliar fertilizer when the crop's root system is aging and its ability to absorb nutrients is being compromised. Both the root vitality and the capacity to absorb fertilizer decrease in annual crops throughout their late development phase. The method of root application is insufficient to meet the needs of the crops if you wish to top-dress them with fertilizer. It is appropriate to apply foliar spray fertilizer at this time.

Use foliar fertilizers on crops that are deficient. When crops are growing and certain nutrients are lacking, fertilizing the soil won't cure the deficiencies in the crops right away. Instead, it will take some time for the crops to absorb the nutrients and develop symptoms of the deficiencies.

At this point, foliar fertilization can completely take use of the benefits of rapid foliar fertilizer absorption, allowing nutrients to swiftly reach the plant through the leaves and resolving the issue of nutrient insufficiency. For instance, if you apply foliar fertilizer to the leaves at this time to veggies that are lacking in specific trace elements, the plants will be shorter and the leaves will become yellow and lose their green color.

Foliar fertilizer should be used when unfavorable environmental conditions hinder crop growth. Crops must recuperate rapidly when the soil environment is unsuitable for their growth, such as excessive moisture or drought, or when the soil is excessively acidic or alkaline, which will prevent the roots of the plants from absorbing nutrients. Fertilizer needs to be sprayed on the leaves right now. To swiftly add more nutrients to crops in order to meet their growing and development needs.

Provide medium and trace element supplements as soon as possible, and make extensive use of foliar fertilizer. When applied to roots, certain fertilizers like those containing phosphorus, iron, manganese, copper, zinc, etc. are quickly fixed by soil colloidal adsorption, which lessens their effectiveness. The benefits of foliar spraying include low fertilizer consumption, rapid results, high utilization rate, safety, and no pollution. Its application is not restricted by the characteristics of the soil.

Use foliar fertilizer when administering soil fertilization is challenging. When there is not enough base fertilizer, it is challenging to apply soil topdressing to crops protected by plastic film and areas without drip watering. Foliar spray fertilizer is required at this time to enhance the plant's nutritional needs.

On the other hand, some crops with deep roots absorb some nutrients relatively little. When applying fertilizer using conventional methods, it is challenging to reach the root system's absorption portion and the fertilizer impact is not fully realized. Foliar spraying, on the other hand, has superior effects. By improving crop uptake and use, foliar fertilization helps minimize the quantity of fertilizer needed and lowers contamination of water and soil resources. This efficient method of fertilization accomplishes two goals at once.

CHAPTER 3: MATERIALS AND METHODS

3.1 Research site

The experiment was conducted at New Retreat Farm located in Beatrice, a rural farming area situated within the Mashonaland East Province of Zimbabwe. Beatrice lies approximately 54 kilometres south of Harare along the Harare to Masvingo highway. This site is situated in Agro-Ecological Region II, which is classified as a high potential farming zone. The region receives moderate to high rainfall ranging between 750 and 1,000 millimetres per year. The climate is sub-humid, with average summer temperatures ranging from 25°C to 30°C, creating positive conditions for soybean cultivation. The soils at New Retreat Farm are well-drained sandy loams with moderate clay content, ideal for supporting leguminous crops such as soyabeans. These soils generally maintain a slightly acidic to neutral pH range of 5.5 to 6.5, which supports effective nodulation and nutrient availability, particularly for nitrogen-fixing crops. The geographic coordinates for the site are approximately 18.2290 degrees south latitude and 31.0855 degrees east longitude. This location was selected for its representativeness of the typical farming conditions faced by smallholder and commercial farmers in Zimbabwe. Additionally, the farm has a history of agricultural experimentation, making it an appropriate site for assessing the performance of foliar fertilizers under real-world field conditions.

3.2 Experimental design

A Randomized Complete Block Design (RCBD) was used for the experiment, with 6 treatments replicated 3 times to give a total 0f 30 experimental units. Each treatment was randomly assigned within each block. Each plot measured 3 meters by 3 meters hence 9 m^2, with a planting spacing of 45 centimetres between rows and 10 centimetres between plants within each row. This layout allowed for proper plant growth and minimized competition for light, nutrients, and water. The use of the RCBD was essential for accounting for environmental heterogeneity and ensuring that treatment effects could be clearly observed.

3.2.1 Treatment Description

The treatment combinations are shown in Table 3.1. Some of the treatments comprised a combination of humuson and DI Grow foliar fertilizers whilst others were the positive and the negative controls. The positive controls used in the study were 100 % Humuson, 100 % DI Grow The negative control was the treatment with nothing added to it. These treatments were chosen to investigate the individual and synergistic effects of the foliar fertilizers on soybean growth under field conditions.

Table 3.1: Experiment treatment combinations

Treatment	Foliar Fertilizer
T1	50% humuson + 75% D.I Grow
T2	75% humuson + 25% D.I Grow
T3	25% humuson +75 D.I Grow
T4	100% humuson
T5	100% D.I Grow
T6	Control (no foliar application)

3.3 Trial management

3.3.1 Planting and spacing

Planting of the crop was done after receiving the effective rains which enables germination to occur with minimal problems. The spacing used was 45 cm interrow and 10 cm inner-row. The soyabean variety used in this study was solitaire which is an early maturing cultivar. Solitire is also noted for its good germination, vigorous early growth and moderate resistance to common field pests and diseases.

3.3.2 Pest management

Pest management started as soon as the crop emerges. Pest scouting was done early in the morning and evening on daily basis as they are many diseases and insects that attack soyabean. Pest control was implemented as per the occurrence of the pests in the field using the relevant pesticides.

3.3.3 Weeding in soyabeans

Weeding was done as early as crop emerges in-order to control pest and diseases. Weeding can be done manually and chemically.

3.3.4 Foliar Fertilizer Application

Humuson and D.I Grow were applied at the vegetative stages starting from 22 days after emergence (DAE) stages using a knapsack sprayer. Application was done early in the morning to reduce volatilization losses.

Dosages:

• Humuson: 30 ml per 10 litres of water

• D.I Grow: 30 ml per 10 litres of water

• Mixed treatments were prepared in appropriate ratios (1:1 and 3:1) before spraying

3.4 Data Collection

Measurements were taken from five randomly selected plants per plot at 2-week intervals starting from 30 days after emergence (DAE) until 60 DAE (Table 3.2).

Table 3.2: Parameters measured

Parameter	Measurement Method
Plant Height	Measured from soil level to tip using a tape measure
Number of Leaves	Manual counting per plant
Leaf Area	Measured using a leaf area meter calculation formula (Leaf area (cm^2): Calculated using the formula: Leaf Area = Length × Width × 0.75.

3.5 Data Analysis

The data obtained was subjected to Analysis of Variance (ANOVA) using the Genstat software 13 version statistical package to test the significant effect of combined foliar fertilizers on selected growth parameters of the soyabean crop. Least Significant Difference (LSD) tests at the 5% significance level were used to separate treatment means.

CHAPTER 4: RESULTS

4.1 Effect of combined foliar application of humuson and D.I Grow on leaf area

The results showed that foliar combinations of humuson and D.I Grow had highly significant effect on leaf area ($p < 0.001$ Leaf area changed significantly over time (30, 45, and 60 DAE). Across all sampling dates, the 75% Humuson + 25% D1 Grow treated had highest leaf area whilst the Control (no foliar application) treatment had the lowest leaf area (Table 4.1).

Table 4.1: Effect of combined foliar fertilizers Humuson and D.I Grow on leaf area (cm^2)

Treatment	30 DAE	45 DAE	60 DAE
100% D1 Grow	98.5^{b}	124.6^{b}	153.47^{b}
100% Humuson	102.7^{b}	128.7^{b}	155.50^{b}
25% Humuson + 75% D1 Grow	107.9^{b}	136.7^{c}	166.33^{c}
50% Humuson + 50% D1 Grow	107.1^{b}	140.5^{cd}	166.87^{c}
75% Humuson + 25% D1 Grow	117.5^{c}	146.8^{d}	181.03^{d}
Control (no foliar application)	80.4^{a}	105.7^{a}	126.23^{a}
Grand mean	102.3	130.5	158.24
F-prob	<0.001	<0.001	<0.001
LSD	12.47	8.86	6.637
CV%	6.7	3.7	2.3

4.2 Effect of combined foliar application of Humuson and D.I Grow on number of leaves

There was highly significant effect ($p < 0.001$) of different foliar fertilisers on number of leaves across all the sampling periods (30, 45, and 60 DAE). Across all sampling dates, the 75% Humuson + 25% D1 Grow treated had highest number of leaves whilst the Control (no foliar application) treatment had the lowest leaf number (Figure 4.1).

4.3 The Effects of combined foliar application of humuson and D.I Grow on plant height (cm)

There was highly significant effect ($p < 0.001$) of different foliar fertilisers on plant height across all the sampling periods (30, 45, and 60 DAE). Across all sampling dates, the 75% Humuson + 25% D1 Grow treated had highest plant height whilst the Control (no foliar application) treatment had the lowest plant height (Figure 4.2).

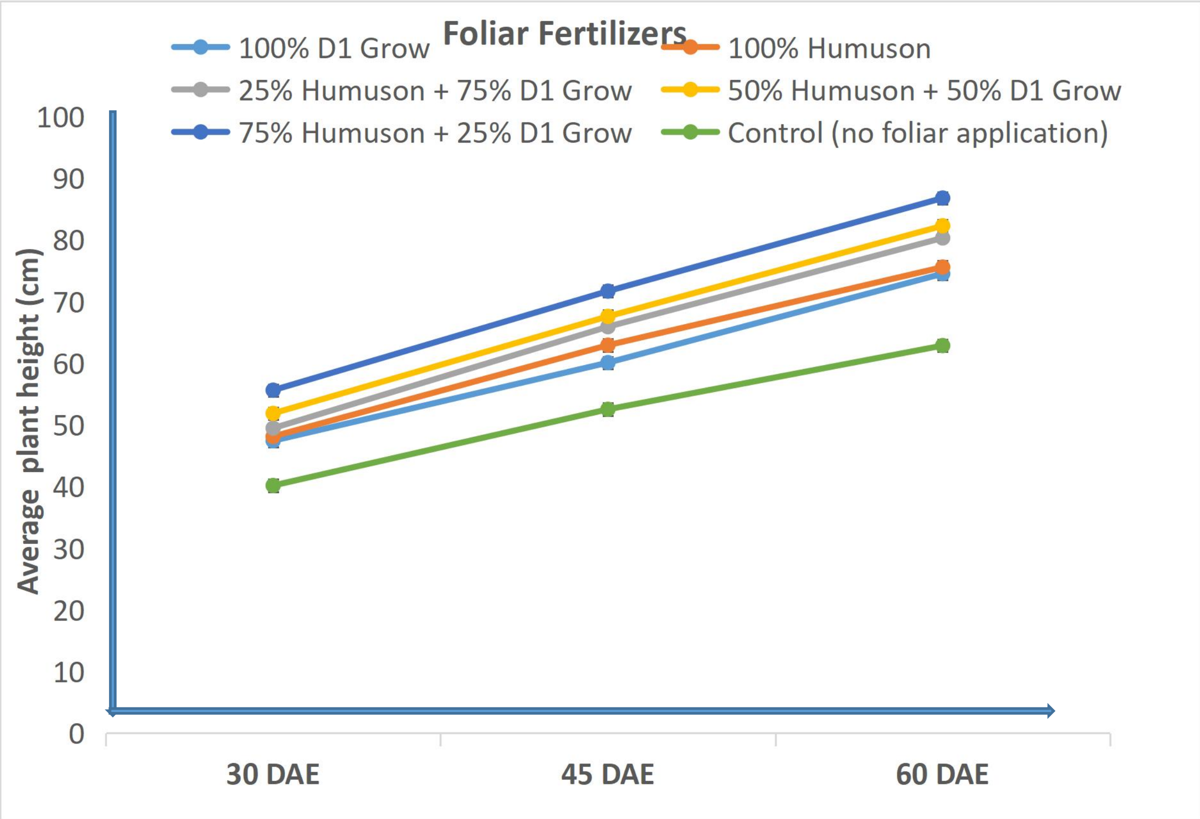

Figure 4.3: The Effects of combined foliar application of Humuson and D.I Grow on plant height (cm)

CHAPTER 5: DISCUSSION

5.1 Effect of Foliar Application of Humuson and D.I Grow on Leaf Area

The results demonstrated that foliar application of Humuson and D.I Grow significantly influenced leaf area at all growth stages. The combination of 75% Humuson and 25% D.I Grow consistently produced the highest leaf area, while the untreated control recorded the lowest. This suggests a synergistic interaction between the two fertilizers enhancing leaf expansion and overall vegetative growth.

Humic substances like those in Humuson improve nutrient uptake, root development and cell membrane permeability which promote leaf growth (Canellas *et al.,* 2015). D.I Grow containing essential macro and micronutrients, likely complemented this by directly supplying nutrients necessary for leaf cell division and expansion (Saa *et al*., 2015). The increasing trend in leaf area over time aligns with normal soybean development stages where leaf expansion is a primary indicator of vegetative vigor (Board & Kahlon, 2011).

Moreover, the superiority of combined treatments over sole applications supports the findings of Yakubu *et al*. (2020), who reported that combining organic and inorganic foliar fertilizers can enhance photosynthetic area and thus biomass accumulation more effectively than individual applications.

5.2 Effect of Foliar Application of Humuson and D.I Grow on Number of Leaves

The number of leaves also responded significantly to foliar treatments, with the 75% Humuson + 25% D.I Grow treatment producing the highest leaf count. Leaf number is critical in determining the photosynthetic capacity of a plant and directly influences its productivity.

Humic acid has been reported to stimulate cytokinin-like activity, enhancing meristematic activity and the formation of new leaves (Nardi *et al*., 2002). D.I Grow contributes essential nutrients such as nitrogen and potassium, which are involved in vegetative growth and leaf development (Taiz *et al*., 2015). The synergy observed may be due to Humuson enhancing nutrient uptake efficiency while D.I Grow provides the immediate nutrient supply needed for rapid leaf formation.

These findings agree with those of Muhammad et al. (2018), who found that foliar application of humic acid combined with balanced nutrients increased the number of leaves in soybean and other leguminous crops. The control plants lacking external nutrient supplementation exhibited the slowest leaf development highlighting the importance of foliar feeding in nutrient-deficient soils.

5.3 Effect of Foliar Application of Humuson and D.I Grow on Plant Height

Plant height was significantly influenced by the foliar fertilizer treatments with the 75% Humuson + 25% D.I Grow treatment again outperforming all other treatments. Increased plant height indicates vigorous vegetative growth and a better capacity to intercept light.

Humic acid contributes to hormonal regulation and root elongation, which improves water and nutrient absorption, indirectly promoting shoot elongation (Canellas & Olivares, 2014). Meanwhile, the D.I Grow supplement likely provided readily available nitrogen, a key driver of cell elongation and internodal growth (Marschner, 2012). The interaction between organic acids and nutrient supply likely optimized physiological processes such as chlorophyll synthesis and energy metabolism, leading to taller plants.

This supports the findings by El-Shabrawy *et al*. (2019), who observed that a combination of humic acid and mineral fertilizers significantly increased plant height in legume crops. The control treatment had the shortest plants, emphasizing the need for external foliar nutrients to maximize crop height under suboptimal soil fertility.

Overall, the study confirms that foliar application of Humuson and D.I Grow significantly enhances soybean vegetative growth. The combined treatment of 75% Humuson + 25% D.I Grow consistently produced the most favorable results across all measured parameters leaf area, leaf number, and plant height demonstrating a complementary effect of organic and mineral nutrient sources on soybean development.

CHAPTER 6: CONCLUSION AND RECOMENDATIONS

6.1 Conclusion

This study has demonstrated that the application of foliar fertilizers significantly enhances the vegetative growth of soybean, particularly in terms of plant height, number of leaves, and leaf area. The use of combined fertilizers, especially the treatment containing 75% Humuson and 25% D.I Grow, consistently resulted in superior plant performance compared to other treatments and the untreated control. This indicates a synergistic effect between the humic acid-based bio stimulant (Humuson) and the mineral based foliar fertilizer (D.I Grow), which likely improved nutrient uptake efficiency, stimulated hormone activity, and enhanced photosynthetic capacity.

The one-way ANOVA results confirmed that both Days After Emergence (DAE) and foliar fertilizer treatment affected the parameters, with additional interaction effects for plant height and leaf area. These findings suggest that not only the type of nutrient but also the timing of its application is crucial for optimizing growth responses. The control group, which received no foliar treatment, consistently showed the lowest performance across all metrics, highlighting the importance of supplemental foliar nutrition for improving soybean growth under standard field conditions.

Overall, the findings underscore the potential of integrating bio stimulants with conventional foliar fertilizers to achieve more effective and sustainable nutrient management strategies in soybean cultivation.

6.2 Recommendations

Based on the findings of this study, several practical and research-oriented recommendations can be proposed to enhance soybean production through effective foliar fertilization strategies.

- The consistent benefit of the treatment comprising 75% Humuson and 25% D.I Grow suggests that this specific combination should be adopted as an optimal foliar fertilizer procedure, particularly during the early vegetative stages of soybean growth. This blend appeared to deliver a balanced supply of organic and mineral nutrients, resulting in significant improvements in plant height, leaf area, and number of leaves.

Therefore, its use is strongly recommended for farmers aiming to boost early plant vigor and establish a strong foundation for high yield potential.

- Furthermore, the timing of foliar fertilizer application should be carefully aligned with key developmental phases of the crop. The period between 30 and 60 days after emergence (DAE) emerged as critical for nutrient uptake and biomass accumulation, and foliar feeding during this window was shown to be most effective. Hence, it is advisable to schedule foliar applications during this growth phase to maximize nutrient utilization and physiological response.
- In addition to recommending specific treatments and timings, it is important to consider the integration of foliar feeding with conventional soil fertilization practices. Such a combined approach can lead to improved nutrient use efficiency, reduce the total amount of soil-applied fertilizers required, and contribute to more sustainable agricultural practices. This is particularly beneficial in scenarios where soil nutrient availability is suboptimal due to pH imbalances, drought stress, or other environmental constraints.
- Future research should aim to extend the scope of this study beyond the vegetative stage. While significant growth improvements were observed, further investigation is needed to determine whether these early benefits translate into enhanced reproductive development and final yield. Additionally, conducting similar studies under varied environmental conditions, soil types, and cropping systems would help validate the robustness and general applicability of the results.

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APPENDECIES

Analysis of variance

Variate: Avg_Leaf_Area_cm^2_30_DAE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	2	8.34	4.17	0.09	
Replicate.*Units* stratum					
Treatment	5	2338.84	467.77	9.96	0.001
Residual	10	469.63	46.96		
Total	17	2816.80			

Analysis of variance

Variate: Avg_Leaf_Area_cm^2_45_DAE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	2	81.52	40.76	1.72	
Replicate.*Units* stratum					
Treatment	5	3168.24	633.65	26.73	<.001
Residual	10	237.04	23.70		
Total	17	3486.80			

Analysis of variance

Variate: Avg_Leaf_Area_cm^2_60_DAE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	2	181.94	90.97	6.84	
Replicate.*Units* stratum					
Treatment	5	5142.53	1028.51	77.29	<.001
Residual	10	133.07	13.31		
Total	17	5457.54			

Analysis of variance

Variate: Avg_No_of_Leaves_45_DAE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	2	1.000	0.500	0.25	
Replicate.*Units* stratum					
Treatment	5	169.833	33.967	17.27	<.001
Residual	10	19.667	1.967		
Total	17	190.500			

Analysis of variance

Variate: Avg_No_of_Leaves_60_DAE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	2	13.444	6.722	5.99	
Replicate.*Units* stratum					
Treatment	5	289.611	57.922	51.61	<.001
Residual	10	11.222	1.122		
Total	17	314.278			

Analysis of variance

Variate: Avg_Plant_Height_cm_30_DAE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	2	6.543	3.272	2.40	
Replicate.*Units* stratum					
Treatment	5	400.165	80.033	58.60	<.001
Residual	10	13.657	1.366		
Total	17	420.365			

Analysis of variance

Variate: Avg_Plant_Height_cm_45_DAE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	2	5.063	2.532	1.23	
Replicate.*Units* stratum					
Treatment	5	666.340	133.268	64.77	<.001
Residual	10	20.577	2.058		
Total	17	691.980			

Analysis of variance

Variate: Avg_Plant_Height_cm_60_DAE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	2	0.408	0.204	0.06	
Replicate.*Units* stratum					
Treatment	5	1029.016	205.803	62.49	<.001
Residual	10	32.932	3.293		
Total	17	1062.356			

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