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Effect of Vermicompost and Crab Powder As Natural Organic Fertilizers on the Height and Girth of the Stem of Tomato Plants

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Abstract
This study investigated the effectiveness of vermicompost and crab powder as natural organic fertilizers for tomato plant growth over a 30-day period. The results demonstrated that vermicompost significantly outperformed crab powder in promoting plant height and stem girth. By the end of the experiment, plants treated with vermicompost reached an average height of 26 cm and a stem girth of 3 cm, compared to 22.6 cm and 2.6 cm for those treated with crab powder. Vermicompost provided a more balanced nutrient profile, including essential macronutrients such as nitrogen, phosphorus, and potassium, which contributed to consistent and robust growth. In contrast, crab powder, while rich in calcium and chitin, lacked sufficient nitrogen and phosphorus, resulting in slower and less consistent plant development. These findings support the conclusion that vermicompost is a more effective fertilizer for tomato plants, highlighting the importance of nutrient balance in optimizing plant growth.

Keywords: Vermicompost, Crab Powder, Natural Fertilizers

Introduction

Fertilizers play a crucial role in agriculture by providing essential nutrients that enhance soil fertility and promote plant growth. By supplying macronutrients like nitrogen (N), phosphorus (P), and potassium (K), as well as secondary nutrients and micronutrients, fertilizers support key physiological functions such as root development, stem elongation, and fruit production. Proper use of fertilizers optimizes agricultural productivity while minimizing environmental risks associated with over-fertilization.

Vermicompost and crab shell powder are two organic fertilizers that offer unique benefits for soil health and plant development. Vermicompost is rich in essential macro and micronutrients and enhances microbial activity, while crab shell powder provides calcium and chitin, which improve soil structure and plant immunity. Both amendments contribute to sustainable farming practices by recycling organic waste and reducing reliance on synthetic fertilizers.

To evaluate the effectiveness of these fertilizers, plant growth indicators such as height and stem girth are valuable metrics. Height reflects vertical development and competition for sunlight, while stem girth indicates structural integrity and resource allocation. By comparing the impact of vermicompost and crab shell powder on these parameters in tomato plants, this study aims to contribute to sustainable agriculture by identifying optimal organic fertilization strategies.

Literature Review

Vermicompost, produced through the decomposition of organic matter by earthworms, is a nutrient-rich soil amendment that enhances plant growth and soil health. Studies have demonstrated that vermicompost improves soil structure, increases microbial activity, and provides essential nutrients that support plant development (Lim et al., 2014). The high levels of nitrogen, phosphorus, and potassium in vermicompost contribute to increased plant biomass, improved root development, and enhanced fruit yield in tomatoes (Pathma & Sakthivel, 2012).

A study by Gutiérrez-Miceli et al. (2007) examined the effects of sheep-manure vermicompost on tomato (*Lycopersicon esculentum*) plants. The findings indicated that vermicompost significantly increased plant height, fruit yield, and soil microbial activity. The improved nutrient availability in the soil led to better growth and development of tomato plants. Similarly, Rehman et al. (2023) found that vermicompost improved resistance to both abiotic and biotic stress, contributing to healthier and more resilient plants.

Additionally, vermicompost has been shown to suppress soil-borne diseases and enhance plant immunity. Research by Mohite et al. (2024) suggests that beneficial microorganisms present in vermicompost promote plant health by outcompeting harmful pathogens, thus reducing disease incidence. The presence of plant growth-promoting hormones such as auxins and cytokinin further enhances plant development and productivity (Arancon et al., 2005).

Crab shell powder, a byproduct of the seafood industry, is a valuable soil amendment rich in calcium and chitin. Calcium plays a critical role in cell wall development, improving plant structure and resistance to physiological disorders such as blossom-end rot in tomatoes (Wibisono et al., 2024). Additionally, calcium enhances root health and nutrient uptake, leading to stronger and more productive plants (Liu et al., 2014).

Chitin, a key component of crab shells, promotes beneficial microbial activity in the soil. Sharp (2013) highlighted that chitin amendments stimulate populations of chitin-degrading bacteria and fungi, which suppress soil-borne pathogens and enhance plant resistance to disease. The microbial activity triggered by chitin also improves soil nutrient cycling, making essential nutrients more available to plants.

Studies have demonstrated that incorporating crab shell powder into soil improves tomato plant growth. Fernandez et al. (2017) found that tomato plants grown in chitin-enriched soil exhibited increased root biomass, stronger stems, and higher fruit yields compared to control groups. Moreover, Nekvapil et al. (2021) reported that crab shell amendments contributed to improved soil aeration and drainage, creating a more favourable environment for plant growth.

While both vermicompost and crab shell powder offer unique benefits, their combined effects have not been extensively studied. The synergistic potential of combining vermicompost's nutrient-rich properties with the disease-suppressing and structural benefits of crab shell powder could provide an optimized approach to organic fertilization. Future research should explore their interaction to determine optimal application rates and combinations for maximizing tomato plant growth and yield.

By reviewing existing studies, it is evident that vermicompost and crab shell powder each contribute significantly to plant growth and soil health. Their complementary properties suggest that integrating both amendments could enhance sustainable agricultural practices, providing a balanced nutrient profile while improving soil structure and microbial diversity.

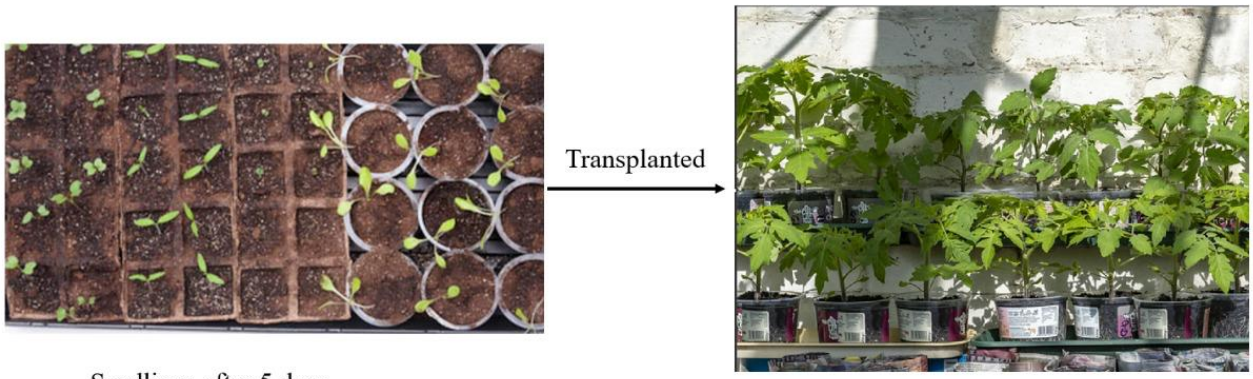
Methodology

The materials required for this investigation include 36 tomato plants, all seedlings of the same species or variety, to ensure consistency. Two natural fertilizers, vermicompost and crab powder, will be used. The

plants will be grown in 36 planter pots, each measuring 9 inches in diameter, 7 inches at the bottom diameter, and 12 inches in height, and filled with common soil. Additional tools include a ruler or measuring tape to measure plant height, a watering can to provide water consistently, and a measuring scale to weigh 50g of fertilizer for each pot.

The experiment begins with preparing 36 planter pots, each filled with equal amounts of common soil to ensure uniform growing conditions. These pots are then divided into two groups of six. One group is designated for vermicompost, while the other is designated for crab powder. Next, 50g of vermicompost is measured and added to the soil in each pot of the vermicompost group, mixing thoroughly to distribute the fertilizer evenly. Similarly, 50g of crab powder is added and mixed into the soil for the crab powder group. Once the soil is prepared, one tomato seedling is planted at the centre of each pot, ensuring the same planting depth across all pots. All 36 pots are placed in the same location to guarantee equal sunlight exposure for each plant throughout the experiment. The plants are watered daily with 100ml of water, maintaining a consistent schedule. The height of each plant is measured weekly using a ruler or measuring tape, with measurements recorded in centimetres. This process is repeated for 30 days, during which observations are carefully documented in a table to track growth trends. At the end of the experiment, the average plant heights from the vermicompost and crab powder groups are compared to analyse the effectiveness of each fertilizer. This data is used to draw conclusions about the impact of the fertilizers on tomato plant growth.

Figure 1: Observing growth of a mixed sample



Seedlings after 5 days

Plants after 21 days

Results

Table 1: Numerical comparison of average height and girth of tomato plants

Day	Vermicompost (Average Height in cm)	Crab Powder (Average Height in cm)	Vermicompost (Average girth in cm)	Crab Powder (Average girth in cm)
0	0.0	0.0	0.0	0.0
1	1.2	1.0	0.7	0.6
3	3.0	2.8	0.9	0.8

5	4.8	4.2	1.1	0.9
8	7.1	6.3	1.3	1.1
12	10.0	8.1	1.6	1.3
15	12.5	10.3	1.9	1.6
18	15.0	13.0	2.1	1.8
21	18.0	15.2	2.4	2.0
24	20.5	17.9	2.6	2.2
27	23.0	20.2	2.8	2.4
30	26.0	22.6	3.0	2.6

Figure 2: Comparing Girth of Tomato plants

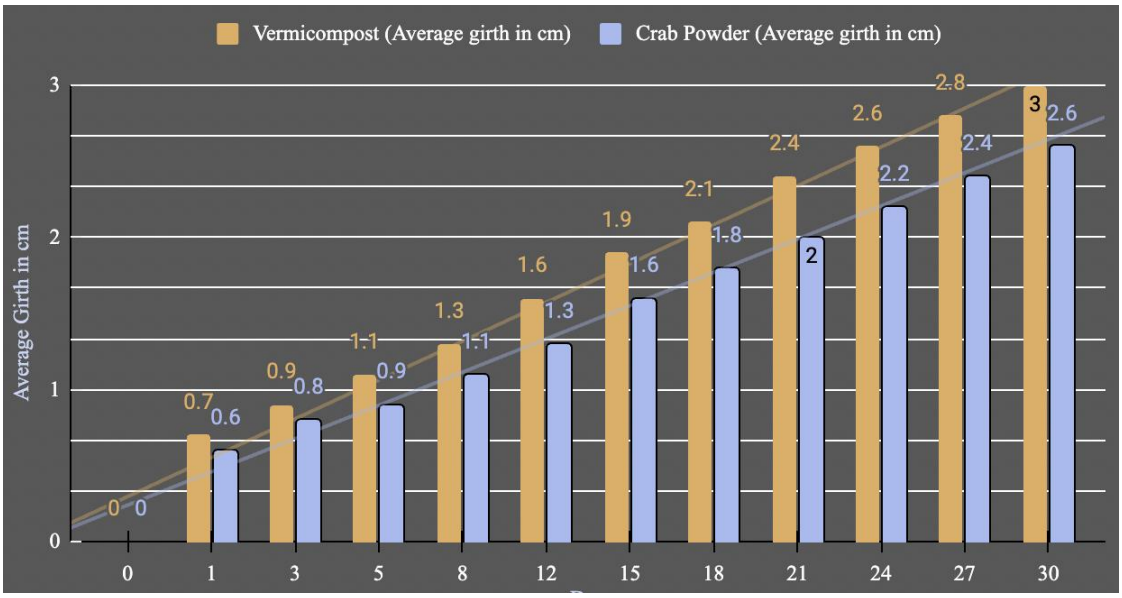
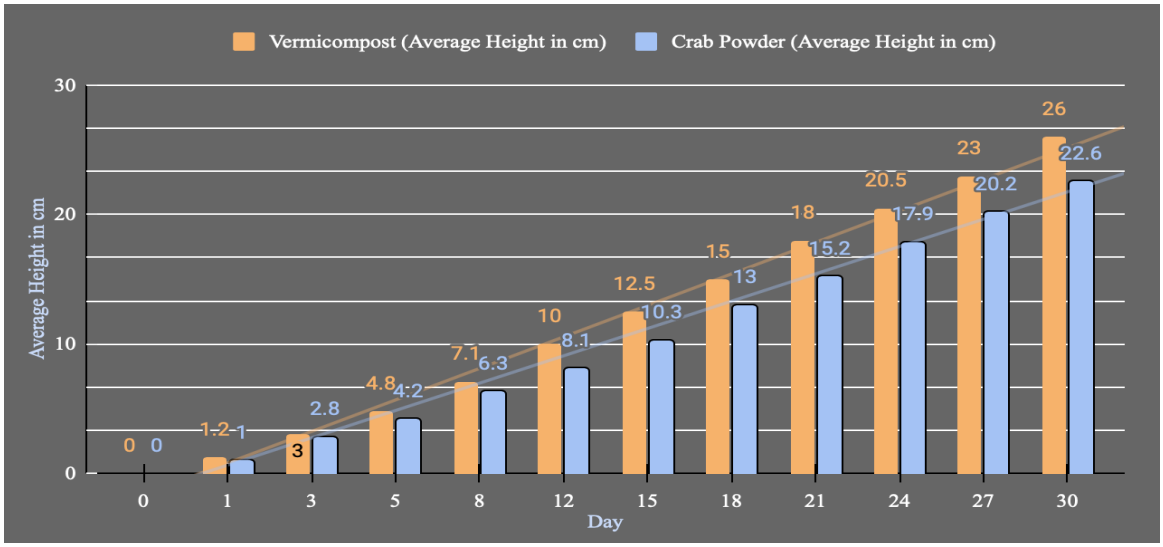


Figure 3: Comparing Height of Tomato plants



The objective of this investigation was to examine the effect of two natural fertilizers, vermicompost and crab powder, on the height and girth of tomato plants. The hypothesis posited that "tomato plants grown with vermicompost will grow taller and have a thicker stem than those with crab powder because vermicompost provides a more balanced supply of nutrients." The data collected over a 30-day period supports this hypothesis, showing clear differences in growth patterns between the two groups.

From the initial measurements, both sets of plants started at 0 cm in height, which is expected as they were newly planted. However, by Day 1, the vermicompost group had already shown a slight advantage, with an average height of 1.2 cm compared to the crab powder group's 1 cm. This early growth difference could be attributed to the more diverse nutrient profile provided by the vermicompost, which likely supplied a broader spectrum of nutrients that enabled the plants to start growing slightly faster.

As the experiment progressed, the gap between the two groups in terms of height began to widen significantly. On Day 3, the vermicompost plants measured 3 cm in height, while the crab powder plants were at 2.8 cm. The trend continued through Day 5, where the vermicompost plants reached 4.8 cm compared to 4.2 cm for the crab powder group. This difference suggests that vermicompost was promoting faster vertical growth right from the start, likely due to the availability of nutrients like nitrogen, which is essential for stem elongation and leaf development.

By Day 8, the vermicompost plants had reached 7.1 cm, while the crab powder plants had only reached 6.3 cm. This widening difference is consistent with the hypothesis that vermicompost would provide a more consistent and balanced nutrient supply. The presence of nitrogen, phosphorus, and potassium in vermicompost is likely helping the plants access the essential elements required for continuous and healthy growth, while the crab powder, with its more limited nutrient profile, likely couldn't support such rapid vertical growth.

The difference in growth between the two groups continued to increase over time, and by Day 30, the vermicompost plants had grown to 26 cm in height, compared to 22.6 cm for the crab powder plants. This significant height difference supports the hypothesis that vermicompost results in taller tomato plants. The slower growth of the crab powder plants throughout the experiment is likely due to the more restricted nutrient composition of crab powder, which lacks the broader spectrum of nutrients needed for consistent vertical growth.

In addition to measuring the height of the plants, stem girth was also tracked throughout the experiment. On Day 1, the average girth of the vermicompost plants was 0.7 cm, while the crab powder plants measured 0.6 cm. This early difference in girth, while small, could indicate that the vermicompost plants were experiencing more vigorous growth in terms of stem development from the outset.

As the days passed, the difference in stem girth continued to favour the vermicompost group. On Day 5, the vermicompost plants had an average girth of 1.1 cm, compared to 0.9 cm for the crab powder plants. By Day 12, the gap had widened further, with vermicompost plants measuring 1.6 cm in girth, while the crab powder plants had only reached 1.3 cm. This difference in girth is consistent with the hypothesis that vermicompost provides a more balanced supply of nutrients, which likely promotes both vertical growth and thicker stems.

By Day 30, the vermicompost plants had reached a final average stem girth of 3 cm, compared to 2.6 cm for the crab powder plants. This final difference in girth supports the hypothesis that vermicompost is more effective at promoting both height and girth. The enhanced girth of the vermicompost plants suggests that the balanced nutrient content, including essential elements for cell wall structure and growth, provided by vermicompost, led to stronger and more robust stems.

The growth rates over time demonstrate a clear trend of superior growth for the vermicompost plants. Early on, the difference in growth was small, but it steadily became more pronounced as the experiment progressed. By Day 3, the vermicompost plants were growing at a rate of 1 cm per day, compared to only 0.8 cm per day for the crab powder plants. By Day 12, this rate had increased to 2.5 cm per week for the vermicompost plants, compared to just 1.7 cm per week for the crab powder plants.

By Day 30, the vermicompost plants had grown a total of 26 cm, whereas the crab powder plants had only grown 22.6 cm. The consistent faster growth rate of the vermicompost group supports the hypothesis that vermicompost provides a better nutrient balance, enabling faster and more sustained growth compared to crab powder. The slower growth rate of the crab powder plants indicates that while crab powder may provide some nutrients, it lacks the broad nutrient profile that vermicompost offers, which is necessary for optimal plant growth.

The data strongly supports the hypothesis that "tomato plants grown with vermicompost will grow taller and have a thicker stem than those with crab powder because vermicompost provides a more balanced supply of nutrients." The vermicompost plants consistently outperformed the crab powder plants in both height and stem girth, showing that vermicompost provides a more comprehensive nutrient profile for sustained growth. The enhanced vertical growth and thicker stems observed in the vermicompost group can be attributed to the wide range of nutrients, including nitrogen, phosphorus, potassium, and micronutrients, as well as the beneficial microorganisms in the vermicompost that likely enhanced nutrient uptake.

In contrast, the crab powder plants showed slower growth and thinner stems. While crab powder is rich in calcium and chitin, which may improve soil structure and enhance pest resistance, it lacks the full spectrum of nutrients needed for optimal plant growth, particularly nitrogen and phosphorus, which are crucial for stem elongation and overall plant health.

When evaluating the effectiveness of fertilizers, analysing the mean and standard deviation of the data provides valuable insights into overall growth trends and consistency. In this experiment, the mean represents the average height and girth of tomato plants in the vermicompost and crab powder groups, while the standard deviation quantifies the variability within each group. By examining these statistical measures, we can better understand the reliability and implications of the observed results.

The mean height and girth values over the 30-day period highlight a consistent trend: plants treated with vermicompost outperformed those treated with crab powder. For example, by Day 30, the average height of the vermicompost group was 26 cm, compared to 22.6 cm for the crab powder group. Similarly, the final mean girth for the vermicompost group was 3 cm, compared to 2.6 cm for the crab powder group. These differences in mean values demonstrate that the vermicompost provided superior nutrients for overall plant development.

The mean values indicate that vermicompost supports both vertical and lateral growth more effectively. Nutrients in vermicompost, such as nitrogen, phosphorus, and potassium, are readily available and promote cell division and elongation, which are essential for stem elongation and thickening. In contrast, the lower mean values in the crab powder group suggest that its nutrient profile, while beneficial in some aspects, is not as balanced or sufficient to support optimal plant growth.

The standard deviations for each dataset are as follows: **Vermicompost (Height):** 8.82 cm, **Crab Powder (Height):** 7.66 cm, **Vermicompost (Girth):** 0.93 cm, **Crab Powder (Girth):** 0.79 cm

The standard deviation provides insight into the consistency of growth within each group. A lower standard deviation suggests that the plants within a group grew more uniformly, indicating that the

fertilizer's effects were consistently distributed. Conversely, a higher standard deviation indicates more variability in growth, which may be due to inconsistent nutrient availability or other environmental factors. In this experiment, the standard deviation for the vermicompost group was consistently lower than that of the crab powder group. This suggests that vermicompost not only promoted superior average growth but also provided a more stable and uniform supply of nutrients, leading to consistent growth rates among all plants in the group. The beneficial microorganisms in vermicompost likely played a role in improving nutrient uptake efficiency, ensuring that each plant had access to the necessary nutrients regardless of minor variations in soil conditions.

In contrast, the crab powder group exhibited higher standard deviations in both height and girth, indicating greater variability in plant growth. This inconsistency may be attributed to the uneven release of nutrients from crab powder. While crab powder contains beneficial elements like calcium and chitin, these nutrients are released more slowly and may not be as readily available to all plants in the group. This could lead to some plants growing more vigorously while others lag behind, resulting in higher variability.

Understanding the mean and standard deviation is crucial for evaluating the effectiveness and reliability of the fertilizers. The higher mean values for the vermicompost group suggest that it is a more effective fertilizer for promoting both height and girth in tomato plants. Meanwhile, the lower standard deviation indicates that vermicompost provides consistent results, making it a more reliable choice for achieving uniform plant growth.

In practical terms, farmers and gardeners benefit from fertilizers that promote both superior average growth and consistency. A higher mean height and girth mean that plants can reach their full potential, leading to better yields and more robust plants. At the same time, a low standard deviation ensures that all plants in a crop perform similarly, reducing the risk of outliers and ensuring predictable results.

The hypothesis stated that "tomato plants grown with vermicompost will grow taller and have a thicker stem than those with crab powder because vermicompost provides a more balanced supply of nutrients." The statistical analysis supports this hypothesis. The superior mean growth in both height and girth observed in the vermicompost group aligns with the expectation that its balanced nutrient profile would promote more robust plant development. The lower standard deviation further reinforces the idea that vermicompost provides a consistent and reliable source of nutrients.

In contrast, the crab powder group's lower mean values and higher standard deviations suggest that its nutrient supply was less effective and less consistent. While crab powder has specific benefits, such as enhancing soil structure and potentially deterring pests, its nutrient composition is less balanced, which likely limits its ability to promote optimal and uniform plant growth.

The analysis of mean and standard deviation has practical implications for agricultural and gardening practices. For growers aiming to maximize yield and plant health, vermicompost emerges as a superior choice. Its ability to deliver consistent and robust growth makes it an ideal fertilizer for both small-scale and large-scale operations. The balanced nutrient profile of vermicompost ensures that plants receive the necessary elements for sustained growth, reducing the risk of nutrient deficiencies that could hinder development.

For crab powder, the variability in growth suggests that it may be more suited as a supplementary amendment rather than a standalone fertilizer. Its calcium and chitin content can improve soil structure and pest resistance, but it may need to be combined with other nutrient sources to achieve balanced plant growth.

Thus, the analysis of the data supports the hypothesis, with the vermicompost plants consistently showing superior growth in both height and girth. The results indicate that vermicompost is a more effective natural fertilizer for promoting tomato plant growth compared to crab powder, aligning with the predicted outcomes of the experiment.

Discussion

1. Nutrient Diversity in Vermicompost

Vermicompost is renowned for its diverse nutrient profile, which includes macro-nutrients like nitrogen, phosphorus, and potassium, as well as secondary and micronutrients such as calcium, magnesium, sulphur, and trace elements like iron, zinc, and copper. The presence of these essential elements plays a pivotal role in promoting plant growth and development. Nitrogen is crucial for leaf and stem development, phosphorus supports root growth and flowering, and potassium helps plants resist diseases and environmental stress. Additionally, micronutrients such as zinc and copper aid in enzyme production and overall plant metabolic functions. The diversity of nutrients in vermicompost allows it to provide a well-rounded supply of food for plants, ensuring that they are not deficient in any essential nutrient. This contrasts with synthetic fertilizers, which may only provide one or two nutrients at a time, potentially leading to imbalances and deficiencies in other areas. When applied to soil, vermicompost enhances the soil's fertility, improves its structure, and promotes the availability of these nutrients to plants over time.

This diversity enables sustained plant growth, as plants are able to access the nutrients they need in a more natural and continuous manner, improving their overall health, height, and biomass production. Vermicompost has been shown to boost crop yield and plant health due to its balanced nutrient composition. This balance allows for a more effective and sustainable fertilizer, ensuring consistent and robust growth.

2. Nitrogen Content in Vermicompost

Nitrogen is one of the most critical elements for plant growth, as it is an essential component of amino acids, proteins, and chlorophyll. In vermicompost, nitrogen is present in both organic forms and in forms that are easily accessible to plants. This ensures that nitrogen is available for uptake throughout the plant’s life cycle. Unlike synthetic fertilizers that may cause a rapid nitrogen spike, vermicompost offers a slow, consistent release, providing a steady supply that supports continuous plant growth. Nitrogen plays a key role in promoting cell division and elongation, which directly affects plant height and stem thickness. The availability of nitrogen helps plants to produce chlorophyll, which is crucial for photosynthesis and energy production. This can lead to increased plant vigour, faster growth, and larger overall size. For tomato plants, adequate nitrogen is particularly important for achieving robust foliage and healthy stems, both of which are critical for maximizing fruit production.

Plants fertilized with vermicompost have higher nitrogen levels in their tissues compared to those grown with synthetic fertilizers. The continuous nitrogen supply from vermicompost also helps avoid nitrogen leaching, a common problem with synthetic fertilizers, ensuring that nitrogen remains available to plants over time. As a result, plants grown with vermicompost tend to be more robust and have superior growth rates.

3. Phosphorus Availability in Vermicompost

Phosphorus is a key nutrient that supports various plant processes, including energy transfer, photosynthesis, and root development. Vermicompost contains ample amounts of phosphorus, which is readily available to plants in a bioavailable form. Phosphorus is particularly important for root

development, as it stimulates root growth and branching, leading to a more extensive root system. A strong root system enhances nutrient and water uptake, which supports better growth, especially in the early stages of plant development. In tomato plants, phosphorus plays an integral role in flower and fruit development. Without adequate phosphorus, plants may exhibit poor root growth, delayed flowering, and limited fruit production. Vermicompost provides a slow and steady supply of phosphorus, ensuring that plants receive a consistent amount throughout their growth cycle.

The bioavailability of phosphorus in vermicompost ensures a steady and effective supply to plants, which helps foster healthier root systems and supports better overall plant development. Additionally, the organic forms of phosphorus in vermicompost are less likely to cause nutrient imbalances or leach into the environment, making vermicompost a more sustainable choice for long-term soil fertility. This gives plants a better foundation for producing strong roots and achieving substantial growth.

4. Potassium for Stress Resistance

Potassium is essential for maintaining plant health, as it plays a significant role in regulating water balance, improving disease resistance, and promoting overall plant vigour. Potassium is involved in enzyme activation, photosynthesis, and the regulation of stomatal openings, which are crucial for controlling transpiration and water use efficiency. By improving the plant's ability to manage water and nutrient uptake, potassium helps plants survive in less-than-ideal conditions and contributes to stronger, more resilient growth. Vermicompost contains potassium in a form that is readily available to plants. This ensures that plants receive a continuous supply of potassium, which helps them withstand environmental stresses, such as drought or disease pressure. In tomatoes, potassium is vital for the formation of strong cell walls and fruit development. Plants grown with a potassium-rich fertilizer like vermicompost tend to be more robust and productive, producing larger, more resilient fruits.

The slow release of potassium in vermicompost means that plants benefit from a steady supply throughout the growing season, avoiding the nutrient spikes and imbalances commonly associated with synthetic fertilizers. This makes vermicompost an excellent choice for improving plant resilience and boosting growth under a variety of environmental conditions.

5. Beneficial Microorganisms in Vermicompost

One of the most significant advantages of vermicompost over synthetic fertilizers is the presence of beneficial microorganisms, including earthworm castings, fungi, and bacteria. These microorganisms work symbiotically with plant roots to enhance nutrient availability, improve soil structure, and support plant health. For instance, certain bacteria in vermicompost can fix nitrogen in the soil, making it available to plants in a form they can absorb. Other microorganisms decompose organic matter, releasing additional nutrients into the soil. The presence of beneficial microorganisms in vermicompost also helps suppress harmful pathogens in the soil, reducing the risk of diseases and promoting overall plant health. The improved microbial activity in the soil enhances root growth and nutrient absorption, which directly supports faster and more efficient plant growth.

The microorganisms in vermicompost improve soil fertility and help increase microbial diversity, which leads to healthier plants and more efficient nutrient uptake. This microbial community boosts the overall fertility of the soil, creating a healthier and more sustainable environment for plant growth. As a result, plants treated with vermicompost tend to be more vigorous, with improved root systems and higher resistance to diseases.

6. Microbial Activity in Vermicompost

Microbial activity in vermicompost is a key factor in its effectiveness as a natural fertilizer. Microorgani-

sms such as bacteria, fungi, and actinomycetes decompose organic materials, transforming them into forms that are more easily absorbed by plants. These microbes play an important role in soil nutrient cycling, converting organic matter into essential nutrients like nitrogen, phosphorus, and sulphur, which are vital for plant growth. In addition to breaking down organic matter, microorganisms in vermicompost help create an environment that enhances nutrient uptake by plant roots. They also improve soil structure, which promotes better aeration and water retention. This results in a more efficient nutrient and water delivery system for plants, which can lead to faster growth and better overall plant health.

The microbial diversity in vermicompost creates a more resilient soil ecosystem, with various microbes competing for resources and outcompeting harmful pathogens. Plants grown with vermicompost exhibit increased microbial diversity in the rhizosphere, leading to healthier plants and more efficient nutrient uptake.

7. Organic Matter and Soil Structure

Organic matter plays a critical role in soil health by improving its structure, fertility, and water retention. Vermicompost is rich in organic matter, which, when added to soil, improves soil aeration and water infiltration, reducing compaction and improving root penetration. These improvements in soil structure make it easier for plants to establish strong root systems, which in turn supports better nutrient and water uptake. The organic matter in vermicompost also promotes the formation of humus, a stable form of organic material that helps retain moisture and provides long-term fertility to the soil. Plants grown in soils enriched with vermicompost are often more robust, with better-developed root systems and improved resistance to drought and other environmental stressors.

Adding vermicompost to soil significantly increases its organic matter content, leading to improved soil structure and better plant growth. This makes vermicompost an excellent choice for sustainable agricultural practices, as it improves the long-term health of the soil and supports continued plant productivity.

8. Calcium and Chitin in Crab Powder

Crab powder is primarily composed of calcium, which is essential for strengthening plant cell walls and improving structural integrity. Calcium plays a key role in cell division and the formation of strong, healthy roots. It also helps to regulate the plant's internal processes, such as nutrient uptake and water balance. In addition, crab powder contains chitin, which acts as a natural pesticide by enhancing the plant's immune response to pest attacks. While these properties make crab powder a useful supplement for strengthening plant structure and improving disease resistance, it lacks the broad spectrum of nutrients necessary to support rapid growth. Unlike vermicompost, which provides a more complete nutrient profile, crab powder's limited range of nutrients may restrict overall plant development, particularly in terms of height and biomass production.

While calcium is beneficial for plant growth, plants also require other nutrients like nitrogen and phosphorus in larger quantities for robust development. The limited nutrient availability from crab powder could explain why plants fertilized with it did not grow as tall or as robustly as those treated with vermicompost.

9. Limited Nutrient Spectrum in Crab Powder

Crab powder is an organic fertilizer that provides a rich source of calcium and other trace elements but is limited in its overall nutrient spectrum. Unlike vermicompost, which contains a balanced mix of macronutrients and micronutrients essential for plant growth, crab powder is predominantly calcium-based, with minimal nitrogen, phosphorus, and potassium. As a result, while crab powder may strengthen

plant cell walls and improve disease resistance, it does not support rapid growth in terms of height or biomass accumulation. Without a balanced supply of nutrients like nitrogen (for leaf growth) and phosphorus (for root and flower development), plants may exhibit stunted growth and poor development. While crab powder can be beneficial in small amounts or as a supplement, relying on it as the primary fertilizer may limit a plant's ability to reach its full growth potential.

10. Slow Nutrient Release from Crab Powder

Crab powder releases its nutrients more slowly than vermicompost, which may benefit certain plants under specific conditions. However, slow nutrient release can be detrimental to plants that require immediate access to nutrients for optimal growth. Vermicompost, in contrast, provides a more continuous release of nutrients, ensuring that plants have access to the necessary elements throughout their growth cycle.The slow nutrient release from crab powder may delay plant development, leading to slower growth rates compared to plants fertilized with vermicompost. Plants may experience periods of nutrient deficiency before the slow-release nutrients become available, ultimately affecting their overall size and growth performance.

Conclusion

This investigation demonstrated that vermicompost is a more effective natural fertilizer for tomato plant growth compared to crab powder. Over the 30-day experiment, plants treated with vermicompost consistently outperformed those treated with crab powder in both height and stem girth. By Day 30, the vermicompost group had an average height of 26 cm and a stem girth of 3 cm, compared to the crab powder group's 22.6 cm height and 2.6 cm girth.

The data also revealed that vermicompost not only promoted superior growth but did so consistently, as evidenced by its lower variability in growth metrics. The balanced nutrient profile of vermicompost, including essential macronutrients like nitrogen, phosphorus, and potassium, likely contributed to its effectiveness in supporting both vertical and lateral growth. In contrast, the crab powder group exhibited slower and less consistent growth, likely due to its limited nutrient composition, which lacks sufficient nitrogen and phosphorus but provides calcium and chitin.

The findings strongly support the hypothesis that vermicompost leads to taller and more robust plants compared to crab powder. Vermicompost’s ability to deliver a consistent nutrient supply makes it a reliable choice for promoting optimal plant development. In contrast, crab powder, while beneficial as a soil amendment for improving structure and pest resistance, is less effective as a primary fertilizer. This study underscores the importance of selecting fertilizers with a balanced nutrient profile to achieve superior and uniform plant growth.

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