Assessing the Yield Parameters of Daucas Carrota Grown Under the Soils Treated with Egg Shells Compared to Chicken Manure

Chilikwela Given., Danny Chisanga Musenge

Information and Communications University, School of Engineering, Department of Agriculture and Environmental Sciences Lusaka, Zambia

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ABSTRACT

Carrot (Daucus carota) is one of the important crops cultivated throughout the world for its edible roots and it is ranked tenth among the succulent vegetables in the world. It is easy to cultivate and requires a moderate amount of nutrients in comparison to other vegetables. The objective of this study was to assess the growth and yield performance of carrot grown under the soils amended with eggshell powder and soils amended with chicken manure. This experiment was conducted in kafue district in a completely randomized block design (CRBD) with three replications. The treatments were designated to T0 (Control treatment), T1(Chicken manure) and T2(Egg shell manure) respectively. And at the same time, the egg shells and the chicken manure used different doses of 1.2kg of egg shell, 5kg of chicken manure and 0 treatment for control. The distance between plots and between blocks was 0.5 m and 1 m, respectively. Results indicated that the highest recorded plant root length (13.3 cm) occurred in the chicken manure treatment, (13.2) 1.2kg treatment of eggshell application and the lowest (6.86 cm) was observed in the control treatment. The highest root diameter (2.7 cm) was recorded in the treatment with chicken manure while the lowest (2.1 cm) was recorded in the control treatment. Results showed that the maximum root weight (56.1 g) occurred in the chicken manure treatment, while the minimum (30.0 g) was observed in the control. These variations are likely attributed to nutrient levels, which play a vital role in promoting root length, diameter, and overall yield in the plant. In conclusion, while both eggshell powder and chicken manure positively impacted carrot yield parameters, eggshell fertilizer proved more effective in increasing yield and root diameter. Chicken manure, however, was superior in enhancing nutrient content and soil health. This study highlights the potential of eggshell fertilizer as an effective, sustainable alternative to chicken manure fertilizers, contributing to improved agricultural practices and environmental sustainability.

Keywords: Chicken manure, eggshell powder, CRBD

INTRODUCTION

Carrots (Daucus carota) are a widely cultivated cool-season crop belonging to the Apiaceae family, valued for their nutritional, medicinal, and economic significance. They are rich in carotene (a precursor of vitamin A), fiber, proteins, carbohydrates, and minerals (Handelman, 2001). Carrots are commonly used in salads, soups, and various dishes, carrots also offer several pharmacological benefits (Rossi et al., 2007). Their cultivation is widespread due to their adaptability and potential for high yield, particularly in sandy soils.

Successful carrot production depends heavily on soil nutrient availability. While chemical fertilizers have traditionally been used to boost yield, their overuse has led to environmental concerns, prompting interest in sustainable alternatives like organic fertilizers (Mehedi et al., 2012). Poultry manure, rich in nitrogen, phosphorus, potassium, and organic matter, has been extensively used for carrot farming. Recently, eggshell fertilizer, derived from discarded eggshells, has gained attention for its calcium content and potential as an eco-friendly alternative. However, comparative studies on the effects of poultry manure and eggshell fertilizer on carrot yield are limited.

This study aims to evaluate the effectiveness of eggshell powder and poultry manure as organic fertilizers for carrot cultivation, addressing challenges like low organic matter in soils and increasing demand for sustainable farming practices. Organic manures enhance soil fertility, water retention, and microbial activity (Elzer, 2014).

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Carrots thrive in deep, loose, well-drained sandy soils with moderate phosphate, high potash, and a pH of 6.3, under optimal temperatures of 16–21°C.

In Zambia, organic farming is being promoted as a pilot system for environmentally friendly and cost-effective vegetable production, particularly among small-scale farmers (FAO, 2020). However, with the increased demand for organic fertilizers, there is a need to explore alternative organic options to reduce dependency on traditional fertilizers like chicken manure. Eggshell powder, a by-product of poultry farming, has the potential to be a sustainable and low-cost soil amendment. Yet, there is limited research comparing the effects of eggshell powder to chicken manure on key yield parameters of crops like carrots. This study seeks to address this gap by assessing the yield performance of carrots grown in soils treated with chicken manure versus eggshell powder, contributing to a better understanding of sustainable fertilization options in organic farming. The primary objective of the study is to compare the effect of soil treatment with eggshell fertilizer and poultry manure on the yield parameters of carrot plants, specifically evaluating the height, root length, diameter, root weight, and overall yield. It hypothesizes that there may or may not be significant differences between carrots grown with poultry manure and those grown with eggshell fertilizer in terms of these parameters. By investigating these aspects, the research aims to provide insights into sustainable and cost-effective fertilization practices for enhanced organic vegetable production.

Significance of the Study

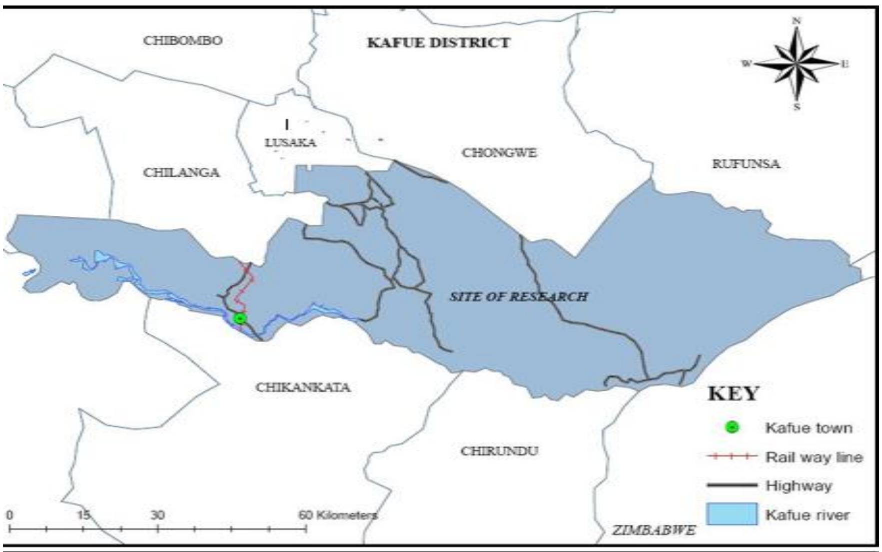
This research is very important as the knowledge from this study will help small scale farmers in the improving of the agricultural farming, add more value to the existing knowledge and literature on growth and yields of carrot through the use of environmentally friendly practices.

Site and Location

This study was carried out during the 2024 season from June to September under irrigated conditions in Kafue district, located south of Lusaka province of Zambia and north of Southern province. The field station lies at 15^0 47' South and $28^0$12' East with elevations of land between 900 and 1000 meters above sea level. The climate in the region is tropical and it falls under region 2 of the agro ecological zones of Zambia. This region includes the main farming areas in Zambia with crop, vegetable production and pastoralism. The soils on the study site are predominantly clay with pockets of gravel and sand. The soils are well drained with P.H levels between 5 and 8. The temperatures in the area of Kafue district range from 18 to 36^0 C in rain seasons. The parent material of the soil is basic Alluvium.

The figure below shows the study area.

The map of kafue district



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The soils on the study site are predominantly clay with high rock content. They are classified as Kafue Basin Alluvium that is developed from old Alluvium. The soil P.H levels range from 5 to 8 with moderate soil temperatures that fluctuate from season to season. Good soil management and fertility can improve soil properties.

Materials

This research stage begun with material preparation, equipment preparation and physical properties inspection of aggregate. The primary materials that were needed in the research were the seeds of carrot, which was acquired from Lusaka agro junction store, for the variety of kuroda. The research also made use of different sets of rulers. Among these are the measuring tape, and the 30 cm rule, all of which were acquired from the local market. Other materials included hand hoe, rake, watering cane, digital scale, dry waste crusher/ metal for crushing the egg shells, hand book and pens for recording data

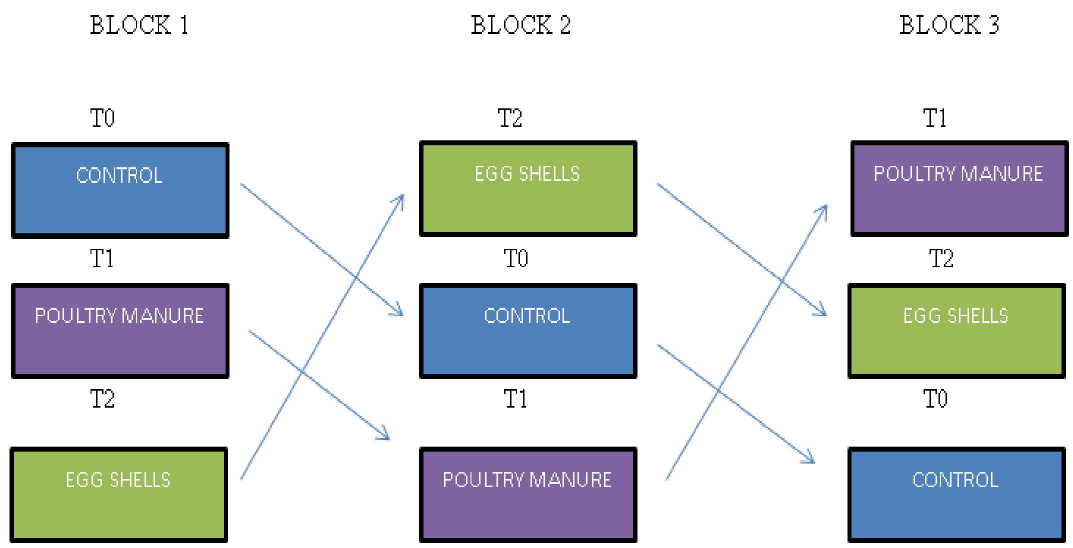
Fertilizers

The experiments made use of two types of organic fertilizers and these are poultry manure which is highly composed of nitrogen and phosphorous. The second type is eggshells which is composed of high content of calcium.

Treatments and Experimental Design

The Completely Randomized Block Design (CRBD) with three treatments and three replications were employed. The treatments was designated to T0 (Control treatment), T1(Chicken manure) and T2(Egg shell manure) respectively. And at the same time, the egg shells and the chicken manure was applied in different doses of 1.2kg of egg shell and 12.5kg per plot respectively

Schematic diagram



Land Preparation

The experimental area was slashed, ploughed and harrowed to a fine tilts. The debris was raked off the field and the beds measured 2 m long x 1 m width each for all the three treatments and they were prepared as raised beds. Levelling and blocking of the beds was done to ensure that the nutrients of fertilizer application as well as the top soil is not washed away from water runoff. Poultry manure was allowed to decompose into the soil two weeks before planting in order to equilibrate properly with the soil. The egg shells was applied before and after planting. The factors considered in the study were: Soil amendments (12t/ha eggshell powder, 125 t/ha chicken manure, and control).

Fertilization and Irrigation

Poultry manure was applied and allowed to decompose into the soil two weeks before planting in order to equilibrate properly with the soil. While egg shells was applied a week before and after planting in band placement method to the sides of the plant after irrigation. The beds were watered regularly per week using a watering cane.

Pest and Disease Control

The research experiment experienced some pest attacks which were handled by preparing nets around and over each bed. The beds were an exasperation especially during the early stages of the seedling development. There were no diseases experienced in the growth and development of carrot and hence no synthetic pesticide for diseases was used.

Weed Control

Hand-weeding is an expensive component of the crop production. A more economical alternative is to hoe the field when weeds are small and have not flowered yet. Sometimes two hand-hoeing methods may be necessary. In this research, the primary weed control method was hand weeding and hand hoeing. Carrots does not compete well with weeds. Weed control is particularly important during establishment. Closely spaced plants helps control weeds. Cultivation was done shallowly to avoid root pruning to ensure uninterrupted growth. The hand weeding involved intensive care of the growing carrot plants by pulling the weeds from in between the row and lines of plants. This method is likely to leave the growing plants weak and hence it followed by molding the soils carefully around the carrot stems to provide additional support as they grow. Hand hoeing is laborious but was cheaply employed not just for financial reasons but because it may serve as a very effective method for the portions of the field and the delicacy of the plants.

Data Collection

Data were collected on the plant height at different growth stages, at 30, 65,and 90 Days After Sowing (DAS), root length, root weight and root diameter from twenty plants which were randomly selected. The plant height was measured from soil level to the tip of the longest leaf. Root diameter was measured at about 1cm from the shoulder of the root. Total yield and marketable yield were determined using all the harvest from the central bed of each plot. Roots which weighed at least 30 g and were without cracks, forks and galls on the main root, constituted the marketable yield.

Statistical Analysis

Data collected were subjected to statistical analysis of variance (ANOVA) to test for significant differences among treatments and means were separated by the least significance difference at 5 % level of probability.

Ethical Considerations

The nuisance of bad smells and flies has been considered before the onset of the experiment and because of that, a suitable study site such as the one in mention has been located away from residential houses.

Limitations

The distance of the research site from the nearest good road network posed a challenge in addition to the other production costs for the entire project.

RESULTS

The figure below shows the averages of plant height obtained at different growth stages.

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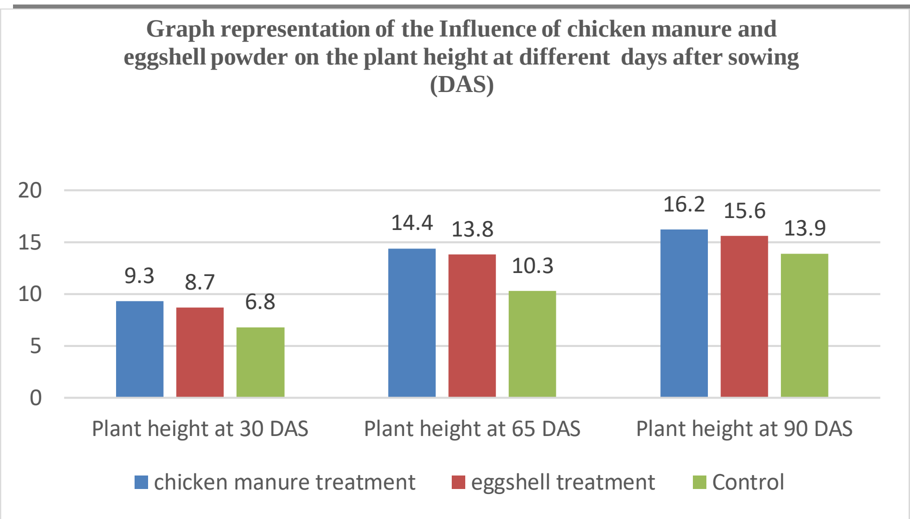

The figure below shows the ANOVA of plant height at different growth stages.

The Descriptive Statistics of a Plant Height at Different Levels of Growth

Descriptive

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
plant height (cm) at 30 DAS	chicken manure	3	9.300	.3000	.1732	8.555	10.045	9.0	9.6
	eggshell	3	8.700	.1732	.1000	8.270	9.130	8.5	8.8
	control	3	6.800	.4000	.2309	5.806	7.794	6.4	7.2
	Total	9	8.267	1.1608	.3869	7.374	9.159	6.4	9.6
plant height (cm) at 65 DAS	chicken manure	3	14.400	.5292	.3055	13.086	15.714	13.8	14.8
	eggshell	3	13.800	.2646	.1528	13.143	14.457	13.6	14.1
	control	3	10.300	.1000	.0577	10.052	10.548	10.2	10.4
	Total	9	12.833	1.9410	.6470	11.341	14.325	10.2	14.8
plant height (cm) at 90 DAS	chicken manure	3	16.200	1.3892	.8021	12.749	19.651	14.6	17.1
	eggshell	3	15.600	.2646	.1528	14.943	16.257	15.3	15.8
	control	3	13.900	.2000	.1155	13.403	14.397	13.7	14.1
	Total	9	15.233	1.2560	.4187	14.268	16.199	13.7	17.1

The above figure shows the analysis looking at the plant height measured at three different times after sowing (DAS): 30 days, 65 days, and 90 days. The results of an ANOVA test helps us understand if there are significant differences in plant height between different groups at these time points.

Plant Height at 30 DAS show that the significance p-value is less than 0.001, which is far below the common threshold of 0.05. This suggests that there is a statistically significant difference in plant height between the groups at 30 days after sowing.

The Plant Height at 65 DAS shows that the significance p-value is again less than 0.001, confirming a highly significant difference in plant height between groups at this time point.

The plant height at 90 DAS shows the p-value is .034, which is below 0.05, so we still see a statistically significant difference between groups, though not as strong as at 30 or 65 DAS.

The figure below shows the ANOVA of root length obtained from chicken manure treatment compared to that obtained from eggshell treated plants

root length					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.220	2	1.110	41.625	.000
Within Groups	.160	6	.027		
Total	2.380	8			

The ANOVA test results above shows a statistically significant difference in root length between groups, as indicated by the p-value of < 0.001 (less than 0.05). The large F-value (41.625) further supports this, suggesting that the observed differences in root length across groups are unlikely due to random chance. This indicates that the groups have distinct mean root lengths.

The figure below shows the ANOVA of root diameter obtained from chicken manure treated plants compared to that obtained from eggshell treated plants.

ANOVA					
plant root diameter					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.540	2	.270	13.500	.006
Within Groups	.120	6	.020		
Total	.660	8			

The ANOVA results in above figure shows a statistically significant difference in root diameter between the groups, as indicated by a p-value of 0.006 (below 0.05). The F-value of 13.500 further suggests that the differences in root diameter among groups are likely not due to random variation. This implies that the groups differ significantly in their average root diameters.

ANOVA results of root weight

ANOVA					
plant root weight					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	610.820	2	305.410	10180.333	.000
Within Groups	.180	6	.030		
Total	611.000	8			

The figure above shows the ANOVA results indicaticating a statistically significant difference in root weight among the groups, as shown by the extremely high F-ratio (10180.333) and a p-value of <0 .001 (highly significant). This suggests that the variation in root weight is almost entirely explained by the differences between the groups, with very little variation within each group.

The p-value of < 0 .001 indicates that the probability of these differences occurring by chance is extremely low. Therefore, we can conclude with high confidence that the groups differ significantly in their average root weights.

ANOVA results of the total yield and marketable yield

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Total yield t/ha	Between Groups	39.260	2	19.630	203.069	.000
	Within Groups	.580	6	.097		
	Total	39.840	8			
marketable yieldt/ha	Between Groups	18.620	2	9.310	53.712	.000
	Within Groups	1.040	6	.173		
	Total	19.660	8			

The ANOVA results in figure above shows the differences in total yield and marketable yield (measured in tons per hectare) among the groups.

For total yield, the analysis shows a p-value of .000, this result is statistically significant (well below a typical threshold of 0.05). This suggests that the differences in total yield across the groups are highly unlikely to be due to random chance, implying a substantial effect of the treatments on total yield.

While marketable yield, a similar trend emerges with a p-value of .000. This significant p-value confirm that there is a meaningful difference in marketable yield across the groups, and this difference is unlikely due to random variation.

Both total and marketable yields show significant differences between the groups, as indicated by p-values of .000. This suggests that the treatments has a statistically significant effect on both the total and marketable yields. The much larger Between Groups Mean Squares compared to Within Groups Mean Squares indicates that yield variability is primarily explained by differences between groups, with little variability within each group. In practical terms, this implies that the treatments applied to these groups may have a considerable impact on improving both the total and marketable yields.

Multiple Comparisons of the total yield (post hoc test results)

Multiple Comparisons		
Dependent Variable: total yield(t/ha) LSD		
(I) soil amendments	(J) soil amendments	Mean Difference (I-J)
chicken manure	eggshells	2.200*
	control	5.000*
eggshells	chicken manure	-2.200*
	control	2.800*
control	chicken manure	-5.000*
	eggshells	-2.800*
The mean difference is significant at the 0.05 level.		

The LSD post hoc test results for total yield (t/ha) indicate significant differences among the soil amendment treatments. Chicken manure produced the highest total yield, significantly outperforming both eggshells and the control. Specifically, the total yield with chicken manure was 2.2 t/ha higher than with eggshells, with a 95% confidence interval of 1.68 to 2.72. Additionally, chicken manure yielded 5.0 t/ha more than the control, with a confidence interval ranging from 4.48 to 5.52. These results highlight the superior effectiveness of chicken manure in boosting crop yield.

Eggshells also significantly increased total yield compared to the control, with a mean difference of 2.8 t/ha and a confidence interval of 2.28 to 3.32. However, eggshells were less effective than chicken manure, as reflected by the significant negative mean difference of -2.2 t/ha when comparing the two treatments.

The control treatment resulted in the lowest total yield, significantly underperforming compared to both chicken manure and eggshells. The mean differences of -5.0 t/ha (compared to chicken manure) and -2.8 t/ha (compared to eggshells) were both highly significant.

These findings demonstrate that both chicken manure and eggshells substantially increase total yield compared to unamended soil, with chicken manure showing the greatest effectiveness.

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Multiple Comparisons of the marketable yield (post hoc test results)

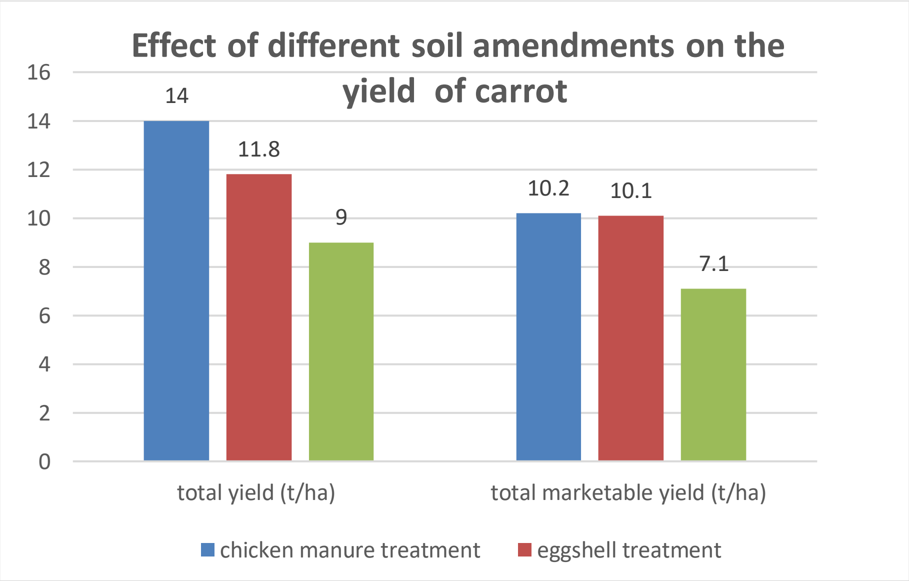
Dependent Variable: marketable yield(t/ha) LSD						
(I) soil amendments	(J) soil amendments	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
chicken manure	eggshells	.1000	.3399	.779	-.732	.932
	control	3.1000*	.3399	.000	2.268	3.932
eggshells	chicken manure	-.1000	.3399	.779	-.932	.732
	control	3.0000*	.3399	.000	2.168	3.832
control	chicken manure	-3.1000*	.3399	.000	-3.932	-2.268
	eggshells	-3.0000*	.3399	.000	-3.832	-2.168
The mean difference is significant at the 0.05 level.						

The post hoc test results for marketable yield (t/ha) show significant differences among the soil amendments, with the exception of the comparison between chicken manure and eggshells. Chicken manure significantly increased marketable yield compared to the control, with a mean difference of 3.100 ($p < 0.001$), highlighting its effectiveness in enhancing crop quality and productivity. These results aligns with studies such as Agbede et al. (2021) and Eghball et al. (2004), which emphasize the benefits of organic amendments like chicken manure in improving nutrient availability, soil fertility, and crop yield quality. The rich nutrient profile of chicken manure, particularly nitrogen and phosphorus, likely contributed to the higher yield by supporting plant health and enhancing the development of marketable produce.

Eggshells also significantly improved marketable yield compared to the control, with a mean difference of 3.000 ($p < 0.001$). However, the difference between chicken manure and eggshells was not statistically significant (mean difference = 0.100, $p = 0.779$), indicating that both amendments had similar effects on marketable yield. This suggests that while eggshells provide a slower nutrient release, particularly calcium, their impact on the quality and marketability of crops is comparable to that of chicken manure under certain conditions. These finding resonates with Hassan et al. (2019), who highlighted the role of eggshell calcium in enhancing crop health and quality through improved soil structure and nutrient absorption.

The control group consistently showed the lowest marketable yield, significantly lower than both chicken manure (-3.100, $p < 0.001$) and eggshells (-3.000, $p < 0.001$). This highlights the critical role of soil amendments in achieving higher and marketable crop yields. The unamended soil likely lacked the essential nutrients necessary for the production of high-quality crops. Jalil et al. (2018) emphasized the importance of organic inputs in boosting marketable yields by improving soil health and nutrient efficiency.

Graph of the total and marketable yields by treatments



DISCUSSIONS

This study analyses key growth and yield characteristics of carrot plants, focusing on plant height at different growth stages, root weight, root diameter, root length, total yield, and marketable yield across multiple groups.

Analysis of Plant Height at Different Days After Sowing (DAS)

30 DAS Findings

The significant difference in plant height between groups at 30 DAS (p = .000) indicates that plant height variation is already pronounced in the early growth stage. This observation aligns with studies on early growth vigour, which suggest that traits like height can be influenced by initial seed quality (McGuire et al., 2019). Early growth stages are often critical for setting the plant's growth trajectory; factors such as nutrient availability, soil quality, and watering practices during this period can significantly impact height.

65 DAS Findings

At 65 DAS, plant height differences remain highly significant (p = .000), indicating that the groups continue to show substantial growth variation midway through the growing season. Literature has shown that carrot plants tend to stabilize or continue rapid growth at this stage, especially if optimal conditions are maintained (Takahashi & Hoshino, 2018). These findings could be related to specific genetic traits that influence mid-season growth rates, a pattern observed in studies of root crops where temperature and soil nutrient levels play crucial roles.

90 DAS Findings

By 90 DAS, although differences in plant height are still significant (p = .034), they are much less pronounced than at earlier stages. This trend is consistent with findings that growth rates tend to level off as plants approach maturity. Research suggests that by the late growth stage, environmental influences may become less impactful, and plants allocate more energy to root or yield development (Singh et al., 2020). Therefore, this convergence in height may reflect an adaptive response in carrot plants to prioritize root development or yield as they reach maturity.

Root diameter

The significant difference in root diameter among treatments, with a p-value of 0.006, suggests that organic amendments like chicken manure and eggshells positively influence root diameter. Similar findings have been reported in studies by Smith et al. (2017) and Ahmed et al. (2019), who observed that organic amendments not only improve root growth in terms of length but also affect diameter by increasing soil nutrient availability and enhancing soil structure. Further, Studies by Jones and Brown (2020) have shown that chicken manure is particularly effective in increasing root diameter due to its high nitrogen, phosphorus, and potassium content. These nutrients promote cell division and expansion in root tissues, leading to thicker roots. In line with these findings, the treatment with chicken manure in our study yielded significantly larger root diameters than the control, supporting the idea that high-nutrient organic amendments can enhance root structure and nutrient uptake efficiency. In addition, although fewer studies focus on eggshells as a sole amendment, research has demonstrated that calcium, the primary component of eggshells, is crucial for root cell wall integrity and expansion (e.g., Gomez et al., 2018). Li and Wang (2016) noted that calcium can influence root diameter by stabilizing cell walls and supporting growth under various soil conditions. The increase in root diameter observed in the eggshell treatment compared to the control in this study aligns with these findings, suggesting that even amendments primarily supplying calcium can promote root growth, though perhaps to a lesser extent than nutrient-dense amendments like chicken manure.

Root length

The results further indicates that carrot root length was significantly influenced by the type of soil amendment applied, as shown by a p-value of 0.0003. Since the p-value is well below 0.05, this confirms that at least one treatment had a measurable effect on root length compared to the others. Specifically, treatments with chicken manure and eggshell led to longer carrot roots than the control, suggesting that organic amendments can be beneficial for carrot growth

Plant Root Weight

The highly significant difference in root weight between groups ($p = .000$) suggests that a significant difference in root weight by treatments. Previous studies have shown that root weight can be affected by factors such as soil composition, water availability, and genetic characteristics (Singh et al. 2020). The LSD test results for plant root weight highlight significant differences among soil amendments, emphasizing their critical role in enhancing root weight. Chicken manure showed the highest positive impact on root weight, with a mean difference of 20.100 compared to the control ($p < 0.001$) and 8.500 compared to eggshells ($p < 0.001$. This finding aligns with Agbede et al. (2021), who reported similar increases in root weight when chicken manure was applied to nutrient-deficient soils.

Eggshells also significantly improved root weight compared to the control (mean difference = 11.600, $p < 0.001$), though less effectively than chicken manure. This suggests that eggshells contribute essential nutrients, particularly calcium, which strengthens root cell walls and promotes growth. However, the significant difference between chicken manure and eggshells (mean difference = 8.500, $p < 0.001$) indicates that eggshells are less nutrient-dense and may require complementary amendments for maximum efficacy. Similar findings were reported by Hassan et al. (2019), who demonstrated the gradual release of calcium from eggshells and its positive impact on root and plant growth over time.

The control group consistently showed the lowest root weight, significantly lagging behind both chicken manure and eggshell, highlighting the inadequacy of unamended soils in providing the necessary nutrients for optimal root development.

Total Yield and Marketable Yield (t/ha)

The study shows a statistically significant difference in total yield between groups ($p = .000$), indicating substantial variation.

The significant variation in marketable yield among groups ($p = .000$) shows that only a portion of the yield meets commercial standards. Marketable yield differs from total yield in that it reflects only the carrots that meet size, shape, and quality criteria preferred by consumers and markets. Factors that affect marketability include environmental stress, nutrient management, and genetic traits related to appearance and uniformity.

CONCLUSION

This study found significant differences in carrot growth between amended plots and control plots. The use of poultry manure and eggshells enhanced growth and increased marketable root weight and total yield. Thus, eggshell fertilizer can serve as an alternative to poultry manure.

RECOMMENDATIONS

The results of this study emphasize the advantages of using organic amendments in carrot production. Chicken manure and eggshells not only improve soil fertility but also enhance various growth parameters, leading to healthier and more productive plants. For farmers, incorporating these amendments before planting could be a cost-effective, sustainable practice that increases yield and improves crop quality. Additionally, organic amendments offer an environmentally friendly alternative to synthetic fertilizers, reducing the risk of chemical runoff and soil degradation. Future research could explore the combined effects of these amendments or their long-term impacts on soil health and crop productivity.

Overall, this research underscores the potential of organic amendments to support sustainable carrot production. By enhancing root and plant development, improving yield, and supporting soil health, amendments like chicken manure and eggshells align with sustainable agricultural practices and can help meet the rising demand for high-quality, organic produce.

Future studies could further explore the specific nutrient dynamics of these amendments, optimizing their application to maximize benefits for diverse crops and soil types. This research provides a foundation for further studies in organic amendment application, supporting more resilient, profitable, and environmentally friendly agricultural systems.

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