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Research Article

Effect of *Trichoderma*-Based Biofertilizers on the Flower and Fruit Pattern of Horned Melon (*Cucumis metuliferus* E. Mey. ex Naudin)

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The lack of agronomic information is one of the various reasons given for the failure of indigenous vegetables to move from subsistence plants of restricted use to vegetables that are considerably researched, utilized, available, and commercially aggressive. A greenhouse study was conducted at Midlands State University's Department of Horticulture and Agronomy to consider the impact of *Trichoderma* biofertilizer at different stages on the overall performance of horned melon (*Cucumis metuliferus*). A complete randomized block design (CRBD) was used for this greenhouse experiment. Four *Trichoderma*-based biofertilizer treatments (0.1 g/pot, 0.2 g/pot, 0.3 g/pot, and 0.4 g/pot) and a control treatment (0.0 g/pot) in four replications were laid down. Inoculation by way of biofertilizer registered significant ($p < 0.05$) results as a greater number of male flowers were recorded. Higher rates of biofertilizers of 0.3 g/pot and 0.4 g/pot gave more flowers, 10.75 and 12.25, respectively, versus lower application rates of 0.1 g/pot and 0.2 g/pot with 6.25 and 6.50 flowers, respectively. The days to flowering increased from 0.0 g/pot (44.75 days) to 0.4 g/pot (49.00 days). Time taken to fruiting was affected significantly ($p < 0.05$) with the application of the biofertilizer. The number of fruits per plant followed the same trend of number of female flowers along the main stem. The number of small fruits increased numerically from 0.0 g/pot (0.5 fruits) to 0.4 g/pot (1.5 fruits) but did not differ ($p > 0.05$) statistically between all treatments. The results of this current study indicate that the *Trichoderma*-based biofertilizer significantly affects the flowering pattern and fruiting characteristics of horned melon at different application rates. Further investigations need to be conducted to reveal the potential derived from the *Trichoderma*-based biofertilizer in the production of horned melon.

1. Introduction

The world population is estimated that by 2050, it will be about 9 billion [1], while the projected annual population growth rate for sub-Saharan Africa (SSA) of 2.7% is the highest globally [2]. There is much concern about increasing famine in a world where population, urbanization, and climate variability are increasing dramatically, exacerbating food insecurity in areas currently vulnerable to famine and undernourishment [3, 4]. This is particularly true in the absence of appropriate food production technology and integrated programs that simultaneously meet the food needs of society, providing enhanced food security which is a fundamental right of people and is one of the major global challenges [5, 6]. Several studies [7–9], for example, advise that it is viable to feed ten billion people using current agricultural technologies and techniques and without using more land, water, or fertiliser. This would require humans to make major adjustments to their diet, often with the help of adopting a plant-based diet, which is unlikely to be common. Other options are likely to reduce the environmental impact of intensified agricultural production.

Africa is a rich source of a diverse variety of indigenous fruits and vegetables that have an unexploited potential for nutrition, food security, and medicine. For centuries, people in Africa have relied heavily on fruits and vegetables collected from the wild or cultivated in home gardens. A number of these species are indigenous, but many of them developed into the culinary habits of the indigenous people over time [10]. Be that as it may, there has been a nutritional transition as a consequence of changes in global food systems as populations have shifted away from traditional diets on the way to globalized consumption patterns. Indigenous foods were replaced by the monoculture of high-yielding non-native crops such as rice and maize. Thus, the consumption of indigenous fruits and vegetables is low, and knowledge of how to prepare indigenous plants is no longer widespread. These species deserve much more awareness and funding in agricultural research and improvement than they have at present. Indigenous vegetables are the dominant candidates for increased use of crop biodiversity in horticulture as they are already consumed and enjoyed locally and can be produced profitably in both rural and urban environments. However, many of these species have acquired little scientific interest so far. More effort in research and development is likely to produce rewarding results, as productivity increases in these neglected crops are much easier to realize than for intensively researched staple cereals.

There is an overdue need to not only understand the limiting factors but also to highlight opportunities in order to guide policy decisions. Among these limiting factors, lack of agronomic information is one of the many reasons given for the failure of indigenous vegetables to move from subsistence crops with limited use to more researched, available, commercially competitive crops. Several studies [1, 11–17] demonstrated the potential to improve yields by the use of nonsynthetic fertilizers in our cropping systems. It is therefore hypothesized in this research that *Trichoderma*-based biofertilizers can influence the growth of horned melon. The study should contribute by providing information towards the domestication and commercial production of horned melon in Zimbabwe under climate-smart farming systems.

2. Materials and Methods

2.1. Description of Research Site. This greenhouse experiment was conducted by the Department of Horticulture and Agronomy at Midlands State University, Zimbabwe. The university is located at a latitude of

19°45′ S and 29°84′ E in Natural Agro-Ecological Region III of Zimbabwe and is situated 10 km southeast of Gweru Central Business District. The soils in the area originated from the fersialitic group and are sandy loams with kaolinite clay minerals [18].

2.2. Experimental Procedure. The experiment was laid out in a complete randomized block design in the greenhouse with four biofertilizer treatments and a control treatment in four replications. The treatments for the application rate of the biofertilizer were as follows: 0 g/pot (control), 0.1 g/pot, 0.2 g/pot, 0.3 g/pot, and 0.4 g/pot.

Polyethylene pots were filled with 3 kg of soil that was thoroughly mixed with 200 g of FYM and water to field capacity. The treatments of biofertilizers were also incorporated at transplanting. No mineral fertilizers were added to the plants during this growing period. Healthy horned melon seedlings at 4 weeks were selected and transplanted into the media amendments and watered. The pots were maintained by watering and spraying against any pests and diseases using Karate, Copper Oxychloride, and Ridomil Gold. Data collection was started two weeks after transplanting.

The biofertilizer selected for this study is a commercial product which contains *Trichoderma harzianum*, with at least 1.0×10^6 colony forming units per gram (cfu/g) dry weight of the product. Seeds were extracted from fruits that were bought from the commercial fruit and vegetable market in Sakubva, Zimbabwe. The seedlings were then produced in the greenhouse under natural conditions in floating trays with 200 cells.

2.3. Data Collection. The following growth parameters were recorded at different times during the growth of plants, starting 2 weeks after transplanting.

Days to flower initiation were recorded as the number of days counted from the day of transplanting to the day of the first flower appearing.

Male and female flowers were recorded at full bloom by counting the flowers on the main stem of the plant.

Time to fruiting was determined when the ovary of female was developed to at least a centimetre, while the number of fruits was recorded a week after fruiting on the main stem.

2.4. Data Analysis. Analysis of variance (ANOVA) was carried out on the parameters recorded using GenStat 18th edition, and the least significant difference (LSD) test at 5% level of probability was used to compare interaction effects. Any treatment means that were found to be statistically different were separated using Fischer's protected $LSD_{0.05}$.

3. Results

3.1. Flowering Pattern

3.1.1. Days to 1st Flower Appearance. As shown in Figure 1, there were significant ($p < 0.05$) differences between treatment means for the days to first flower appearance. Excluding the comparison treatment, the lowest number of days to 1st flower appeared was from application of 0.1 g/pot

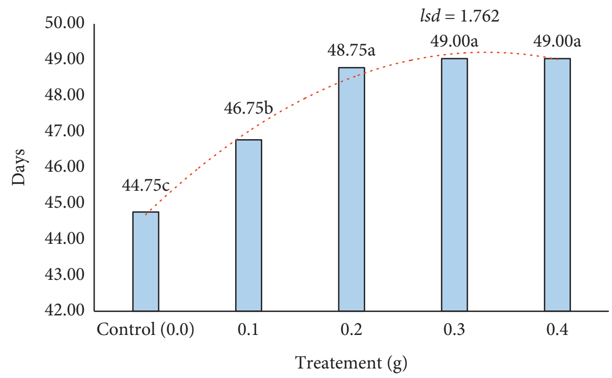

Figure 1: Influence of *Trichoderma*-based biofertilizer on days to first appearance. Figures not sharing a common letter in a column differ significantly at 0.05 probability.

(46.75 days). After using 0.2 g/pot of *Trichoderma*-based biofertilizer per pot, there was no statistically significant ($p > 0.05$) effect on the number of days until first recorded flowering. The mean number of days to 1st flower appearance recorded was 47.65 days.

3.1.2. Days to 50% Flower. The means of days taken to reach 50% of flowers affected by *Trichoderma*-based biofertilizer, as given in Table 1, do not reveal statistical ($p > 0.05$) differences between treatments. Numerically, the number of days to 50% flower was higher at a higher biofertilizer application than at a lower application rate and control treatment.

3.1.3. Days to Full Flower. No significant ($p > 0.05$) differences were recorded for days to full flowering (Table 1). Numerically, the number of days it takes to reach full flowering from the appearance of the first flower has been increasing with the increase in the rate of application of *Trichoderma*-based biofertilizer. Only the control (0 g/pot) recorded a mean (1.25 days) below the average (1.50 days) for all treatments under investigation.

3.2. Number of Flowers. The effect of *Trichoderma*-based biofertilizer application was significant ($p < 0.05$) with regard to the production of male flowers on the main stem of horned melon (Table 1). The number of male flowers increased with the increase in the use of biofertilizer. The means for 0.1 g/pot and 0.2 g/pot were registered among the lowest number of male flowers and were not significantly ($p > 0.05$) different from the control treatment. The highest number of male flowers was registered at 0.4 g/pot (12.25), followed by 0.3 g/pot (10.75). However, both treatment means did not differ significantly ($p > 0.05$) from each other.

Also, the biofertilizer did not significantly ($p > 0.05$) affect the number of female flowers on the main stem. Numerically, however, the number of female flowers was increasing with the increase in the rate of biofertilizer application.

Table 1: Influence of *Trichoderma*-based biofertilizer on days to 50% flower, days to full flower, and number of flowers.

Treatment	50% flower	Full Flower	Number of flowers Male	Number of flowers Female
Control (0 g/pot)	0.50	1.25	5.25	0.50
0.1 g/pot	0.50	1.50	6.25	0.50
0.2 g/pot	0.50	1.50	6.50	0.75
0.3 g/pot	0.75	1.50	10.75	1.25
0.4 g/pot	0.75	1.75	12.25	1.50
Mean	0.60	1.50	8.20	0.90
Significance	ns	ns	<0.001	ns
$LSD_{0.05}$	—	—	2.048	—

ns, nonsignificance at 0.05 probability.

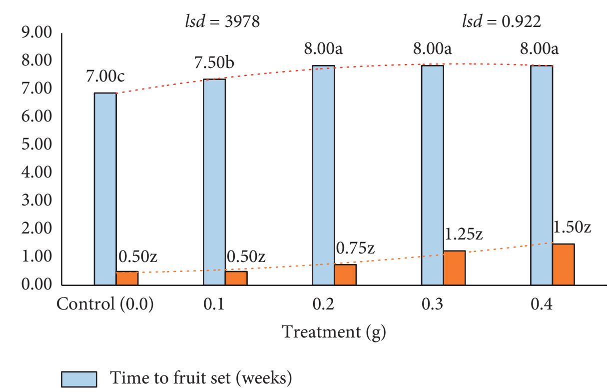

Figure 2: Influence of *Trichoderma*-based biofertilizer on days to fruiting and number of fruits. Figures not sharing a common letter in a column differ significantly at 0.05 probability.

3.3. Fruiting Pattern

3.3.1. Time to Fruiting. As shown in Figure 2, there was a significant ($p < 0.05$) effect on fruit time from the application of *Trichoderma*-based biofertilizer. Except for the control treatment, plants after application of 0.1 g/pot took the least (7.50 weeks) time to reach fruit set, while 0.2 g/pot, 0.3 g/pot, and 0.5 g/pot took the longest, 8.00 weeks, respectively. The average time to fruit set recorded was 7.70 weeks.

3.3.2. Number of Fruits. Regarding the number of fruits that were recorded as 63DAS, there were no statistically significant ($p > 0.05$) differences between the means for the treatments. However, the number of fruits was numerically increasing with the increasing rate of biofertilizer application (Figure 2). The records from application of 0.3 g/pot and 0.4 g/pot registered means that were above the average (0.90) for all the treatments under investigation.

4. Discussion

Days until first flower appearance were significant ($p < 0.05$) in this current study, suggesting that *Trichoderma*-based biofertilizer has an influence on flowering time in horned melon. The extended number of flowering days and, subsequently, prolonged vegetative growth by plants from inoculated treatments with biofertilizers may be attributed to the favorable conditions provided by the biofertilizer to provide plant growth promoting hormones, amplified roots, advanced plant growth, and finally an extended vegetative period. Kenndy [19] and Haque et al. [20] revealed that an upsurge in nitrogen may be the contributory factor to delaying phonological stages as well as crop maturity as nitrogen increased vegetative growth. Results from this current investigation are in agreement with Javahey and Rokhzadi [21], who reported extended phonological stages due to biofertilizers on sunflower. This result is also in line with Mardalipour et al. [22], who reported that nanobiofertilizers increased the growing period length in wheat.

Trichoderma-based biofertilizers are known to produce growing substances that stimulate phytohormones and provide nutrition from soil for plant growth due to the extended vegetative growth period and then extended for a greater number of flowering days. *Trichoderma* species enhance the absorption of nutrients from soil by secreting organic acids to activate nutrients and dissolve minerals in soil, which leads to the influx and utilization of nutrients in soil that are used for flower development. Also, *Trichoderma*-based biofertilizers have the ability to increase the transport and uptake of mineral nutrients from soil to host plant to induce tolerance towards abiotic stresses [23] and biotic [24], thus promoting flowering. Likewise, *T. harzianum* and *T. viride* treatments applied to verbena, marigold, and petunia induced an increase in the number of flowers [25], showing that it has an influence on flowering characters of plants. This current study follows a disparate trend of results and findings reported by Sharma et al. [26] and Das et al. [27] in pointed gourds. Also, disparate profiles of conclusions were informed in bottle gourd [28], muskmelon cucurbits [29], and ridge gourd [30].

The results for the time to fruiting in this current study could be attributed to the capabilities that the *Trichoderma*-based biofertilizer substantially upsurges the uptake of macronutrients and acquisition of water through the promotion of stronger root systems [31]. The presence of the biofertilizer in soil leads to the release of mineral elements. For instance, macronutrients (K, P, Ca) and micronutrients (Zn) in the soil rhizosphere are actively absorbed by the plants. Such form of nutrition helps in amplifying production of dry matter during vegetative stage and encourages flowering as well as promoting fruiting subsequently higher yields [32].

The number of fruits on the main stem depends on the number of female flowers that are born. A similar trend as shown for the number of female flowers is exhibited as well for the number of fruits that were recorded. The nonsignificant ($p > 0.05$) difference in the number of fruits contradicts the observations by Vinale et al. [33] who reported a dramatic upsurge in the number of fruits per plant with *Trichoderma* spp. inoculation save for the control in tomato, lettuce, and pepper grown in greenhouse. Findings by Barua et al. [28] clearly presented that the sole application of *Trichoderma*-based biofertilizer at a rate of 3 kg/pit provided a higher yield relative to the standard dose of NPK application. Applications of TH1 and *T. harzianum* strain T22 were likewise found to significantly increase the number of fruits per plant by 17 and 39%, respectively [34].

5. Conclusion

The study accepts the hypothesis that there is a statistical significance to the effect of *Trichoderma* biofertilizer on the flowering pattern with regards to days to flower start blooming and total number of male flowers of horned melon only. Beyond 0.4 g/pot, the biofertilizer could not positively influence the days to flower initiation and number of male flowers. There was a statistically significant effect of the variation of *Trichoderma* biofertilizer level on the number of days of fruiting for horned melon. Fruiting was delayed by inoculating with biofertilizer, but the number of fruits was not affected. Therefore, it can be concluded that *Trichoderma*-based biofertilizer application was effective in terms of flowering and fruiting pattern of horned melon and may be incorporated into commercial horned melon cultivation for sustainable crop productivity in view of flowering and fruit yield as well as environmental safety. However, more extensive and systematic studies are necessary to further understand the benefits of *Trichoderma*-based biofertilizers in improving the production of horned melon.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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