Evaluating the Effectiveness of Organic and Inorganic Liquid Fertilizers on Growth and Development of Pepper (*Piper nigrum* L.) Nursery Plants

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Abstract

This study aimed to identify the effectiveness of different liquid fertilizers and suitable application intervals for black pepper nursery growth as an alternative to cow dung. The study used three different fertilizers with two different factors variety of fertilizer and fertilizer application rate combined to create nine treatments (F1A1, F2A1, F3A1, F1A2, F2A2, F3A2, F1A3, F2A3, and F3A3) and two control groups. The results showed that the majority of growth parameters were highest in the Bio Green Beper which is an inorganic fertilizer enriched with seaweed extraction and fish emulsion. Specifically, treatments F3A1 and F3A3, which used a potting mix of top soil, sand, and coir dust in a ratio of 2:1:1 and were applied with Bio Green Beper once or three times, showed the highest survival rates among all the treatments. The cost-benefit analysis showed that Bio-Green Beper was the most cost-effective, followed by Albert Solution. Because the usage amount of fertilizer was lower than others. In conclusion, the study demonstrated the effectiveness of using liquid fertilizers as an alternative to cow dung.

Keywords: Black Pepper, Organic Liquid Fertilizer, Nursery

I. INTRODUCTION

Piper nigrum L. (Pepper) is a highly valuable spice crop and it is often referred as the "King of Spices" or "Black Gold". The spikes are derived from a perennial climbing vine in the Piperaceae family. (DEA, 2015). Black pepper was believed to have originated in the tropical evergreen forests of the Western Ghats in South India, but also considered native to Sri Lanka due to its genetic diversity and wild pepper relatives. Nowadays, black pepper is widely cultivated in the humid tropical regions of 26 countries around the world. The cultivation of pepper in Sri Lanka is concentrated in low- and mid-country, wet, and intermediate agro-climate zones, with the major districts being Matale, Kandy, Kegalle, Badulla, Rathnapura, Monaragala, and Kurunegala. The export volume of black pepper in Sri Lanka has increased in recent years, and the local pepper varieties are mostly cultivated due to their high yields and resistance to diseases (DEA, 2015).

Black pepper requires friable soil with good drainage and sufficient nutrients, particularly N, P, K, S, Ca, Mg, and micronutrients. Cow dung is a valuable source of these nutrients and commonly used in black pepper nursery and field. Foliar liquid fertilizer application can also supplement the plant's nutrient needs and slow senescence processes (Srinivasan, 2007). Nursery management practices are crucial for field establishment and yield, with stem cuttings which is commonly used for planting. The nursery stage is crucial for black pepper cultivation, with cow dung being an important fertilizer used in the potting mixture. However, cow dung is becoming increasingly difficult to find due to high demand and transportation issues, leading to a need for alternative fertilizers. This study focused on identifying suitable liquid fertilizers that can replace cow dung in the nursery stage. Therefore, the current study was conducted to evaluate the effectiveness of organic fertilizers, including only seaweed extraction, seaweed and fish emulsion liquid fertilizer, and inorganic fertilizers, on the growth and development of Pepper (*Piper nigrum* L.) nursery plants.

II. MATERIALS AND METHODS

The research was carried out at the Central Research Station, Department of Export Agriculture, Matale which belongs to Mid-Country Intermediate Zone (WM $_{3b}$ Agro-ecological Region). It is located in 7^0 27' N, 80^0 38 E, at an altitude of 375 m above sea level.

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Average annual rainfall is 1400–3300 mm from two main monsoonal rains, and the maximum average temperature is 25–30 °C. The daytime relative humidity range is 55%–80%. The soil type is Reddish Brown Latesolic Soil (Typic Rhodusalfs) belonging to the Matale series.

A local black pepper hybrid, Digirala, was selected for the study. Ground runners with two nodes were selected for pepper cutting, and they were obtained from the multiplication technique. The selected ground runners were cut into two nodal cuttings. Leaves were clipped off, leaving a small portion of the petiole on the stem. Media were prepared according to treatments (Table 01). Pepper cuttings were treated with a Capatan fungicide slurry by dipping their ends for 20 minutes. Cuttings were then planted one node below ground level and watered in a closed chamber propagator with 40–50% sunlight and 85–95% humidity.After 21 days, the nursery plants were acclimatised to the environment by removing the polythene cover of the propagator.

This research was carried out in a randomized complete block design (RCBD) with two factors. The first factor was application of different fertilizer including inorganic fertilizer (Albert Solution®) and organic fertilizers (Maxi Crop®, Bio Green Beper®). The second factor was fertilizer application intervals Maxi Crop® was with only seaweed extraction, and Bio Green Beper® has seaweed extraction with fish emulsion. Data were analyzed by following ANOVA and post hoc (Turkey's pairwise) comparison using SPSS version 25. The significant level was set at $p \leq 0.05$.

III. RESULTS AND DISCUSSION

A. Leaf Growth Characteristics

Control 1 (C1) produced the highest average leaf area and number of leaves and was significantly different from the treatments (Table 02). The use of foliar fertilizers can improve the growth conditions of plants by supplying minerals to the leaves. It is particularly effective in the early stages of growth when the root system is not fully developed, as the leaves can absorb nutrients. Netty (2021), research found that the same foliar spray of liquid fertilizer increased the number of leaves. Macro- and micro-nutrients are needed to increase photosynthetic assimilatory surface area. Statistically, the treatments and controls gave insignificant results on the fresh and dry weight of leaves. The treatment F1A3 showed the highest value.

Table 02: Potting Mixtures and Treatments Schedule

Treatment number	Composition of treatments	
C1	without any liquid fertilizer - DEA recommended potting media (Top soil: coir dust: sand: cow dung 1:1:1:1) (Agriculture, 2015)	
C2	Without any fertilizer	Top soil: sand: coir dust (2:1:1)
F1A1	Albert solution® – one time apply	
F2A1	Maxi Crop® – one time apply	
F3A1	Bio Green Beper®– one time apply	
F1A2	Albert Solution® – two time apply	
F2A2	Maxi Crop® – two time apply	
F3A2	Bio Green Beper® – two time apply	
F1A3	Albert solution – three time apply	
F2A3	Maxi Crop® – three time apply	
F3A3	Bio Green Beper ® – three time apply	

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Table 02: Interaction between Control and Treatments on leaf growth Characteristics of Nursery Pepper Plants

Treatment	Number of leaves	Fresh weight of leaves (g)	Dry weight leaves (g)	Leaf area (cm^2)
C1	4.53±O.58^{a}	2.93±0.41	0.45±0.02^{ab}	106.67±3.28^{a}
C2	1.73±0.27^{b}	1.60±0.25	0.34±0.08^{ab}	34.51±16.71^{b}
F1A1	2.80±0.53^{ab}	1.87±0.38	0.42±0.04^{ab}	28.09±7.28^{b}
F2A1	2.07±0.57 ^{ab}	2.15±0.52	0.41±0.09^{ab}	56.61±20.09^{ab}
F3A1	2.67±0.07^{ab}	2.21±0.10	0.51±0.04^{ab}	54.16±12.76^{ab}
F1A2	2.60±0.58^{ab}	1.73±0.20	0.37±0.05^{ab}	35.73±14.26^{b}
F2A2	2.40±0.20^{ab}	1.66±0.39	0.30±0.05^{b}	47.09±11.08^{ab}
F3A2	2.07±0.41^{ab}	1.83±0.35	0.37±0.07^{ab}	37.21±3.46^{b}
F1A3	2.60±0.50^{ab}	3.13±0.61	0.62±0.10^{a}	79.55±9.10^{ab}
F2A3	2.33±0.77^{b}	1.88±0.14	0.38±0.07^{ab}	57.00±3.84^{ab}
F3A3	2.80±0.31^{ab}	2.49±0.28	0.47±0.02^{ab}	59.66±20.99^{ab}
P value	0.0400	0.0820	0.0840	0.0110
Grand mean	2.6	2.13	0.42	54.21
CV%	27.73	33.76	29.22	52.86

Table 03: Interaction between Control and Treatments on Root Growth Characteristics

Treatment	Fresh weight of root (g)	Dry weight of root (g)
C1	0.88±0.44	0.15±0.02
C2	1.26±0.46	0.20±0.07
F1A1	1.01±0.21	0.16±0.04
F2A1	1.57±0.30	0.22±0.05
F3A1	1.51±0.16	0.35±0.06
F1A2	1.39±0.22	0.23±0.03
F2A2	1.12±0.24	0.19±0.02
F3A2	0.95±0.21	0.16±0.06
F1A3	1.84±0.44	0.29±0.08
F2A3	1.06±0.17	0.18±0.02
F3A3	1.42±0.21	0.25±0.04
P value	0.4730	0.1850
Grand mean	1.27	0.22
CV%	40.79	42.27

B. Root Characteristics

The results of the analysis of variance showed that there was no significant differences between the control and treatments on the fresh and dry weight of roots. However, the highest fresh weight was observed in F1A3, and the highest dry weight was observed in F3A1. Similar findings were recorded and found that chemical fertilizers led to better growth and root development in common crops compared to using organic manure from livestock.

C. *Shoot Characteristics*

The analysis of variance showed that controls and treatments had a significant effect on the number of newly formed nodes, but other shoot characteristics had no significant effects (Table 03). C1 produced the highest average number of nodes. Table 04 shows that the treatment F2A1 resulted the highest values for fresh and dry weights of vines, while the lowest value was from C1. The growth of vines could be affected by different organic substitutions of nitrogen. High plant dry matter in pepper vines is due to the

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optimal uptake of nutrients through soil and foliar-based fertilizers.

The F3A3 treatment had the highest number of shoots. According to Netty (2021), the level of fertilizer application was highly significant in determining the emergence of shoots, the leaf numbers, and the shoot length of pepper seedlings. The highest internode distance was recorded in the F1A1 treatment, and the lowest value was recorded in control 2. The organic fertilizer treatment resulted in an average increase in plant height, number of leaves, number of internodes, and leaf green levels that were not significantly different.

Table 03: Interaction between Control and Treatments on Root Growth Characteristics

Treatment	Fresh weight of root (g)	Dry weight of root (g)
C1	0.88±0.44	0.15±0.02
C2	1.26±0.46	0.20±0.07
F1A1	1.01±0.21	0.16±0.04
F2A1	1.57±0.30	0.22±0.05
F3A1	1.51±0.16	0.35±0.06
F1A2	1.39±0.22	0.23±0.03
F2A2	1.12±0.24	0.19±0.02
F3A2	0.95±0.21	0.16±0.06
F1A3	1.84±0.44	0.29±0.08
F2A3	1.06±0.17	0.18±0.02
F3A3	1.42±0.21	0.25±0.04
P value	0.4730	0.1850
Grand mean	1.27	0.22
CV%	40.79	42.27

Table 04:

Interaction Between Control and Treatment on Shoot Characteristics of Nursery Pepper Plant

Treatment	Number of shoots	Fresh weight of vine (g)	Dry weight of vine (g)	Inter node distance (cm)	Number of newly form node
C1	9.33±0.88	3.65±0.09	0.76±0.02	2.91±0.38	3.47±0.44^{a}
C2	7.00±1.00	4.89±0.71	1.14±0.27	2.73±0.30	1.80±0.20^{b}
F1A1	6.67±0.88	5.68±0.23	1.07±0.05	3.30±0.18	1.93±0.07^{b}
F2A1	7.67±1.33	6.32±0.64	1.43±0.15	3.21±0.03	2.00±0.12^{b}
F3A1	8.00±1.15	5.88±0.82	1.37±0.16	2.79±0.12	1.80±0.20^{b}
F1A2	9.00±1.73	5.15±0.79	1.12±0.23	2.97±0.30	1.73±0.24^{b}
F2A2	8.67±1.20	4.02±0.30	0.85±0.05	3.22±0.34	1.67±0.13^{b}
F3A2	6.00±1.52	4.23±0.82	0.92±0.21	2.94±0.19	2.20±0.23^{b}
F1A3	8.00±0.58	6.18±0.23	1.32±0.02	3.05±0.25	2.27±0.18^{b}
F2A3	8.00±1.54	4.79±0.43	1.02±0.11	3.13±0.40	1.67±0.07^{b}
F3A3	10.33±2.85	5.64±1.02	1.20±0.27	3.05±0.21	2.07±0.07^{b}
P value	0.6570	0.0770	0.1630	0.9050	0.0000
Grand mean	8.06	5.13	1.11	3.03	2.05

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D. Survival Rate

Liquid fertilizer-applied treatments significantly increased the survival rate compared to the control treatments. Results appearing in Figure 01 showed that the survivability percentage was high for F3A1 and F3A3. The lowest value was recorded from control 2, which was without any fertilizer supplement.

E. Fertilizer Cost for Different Treatments

Table 05 showed that cow dung was the most expensive organic fertilizer. Bio Green Beper® (F3A1, F3A2, and F3A3), which par at Albert Solution® (F1A1, F1A2, F1A3) and Maxi Crop® (F2A1, F2A2, F2A3), were found to have the most economical cost-benefit analysis. Because the usage amount of fertilizer was lower than others. Cow manure is required in higher quantities per plant and also has a high transportation cost. Liquid fertilizers, on the other hand, could be added directly to the plants at a lower concentration.

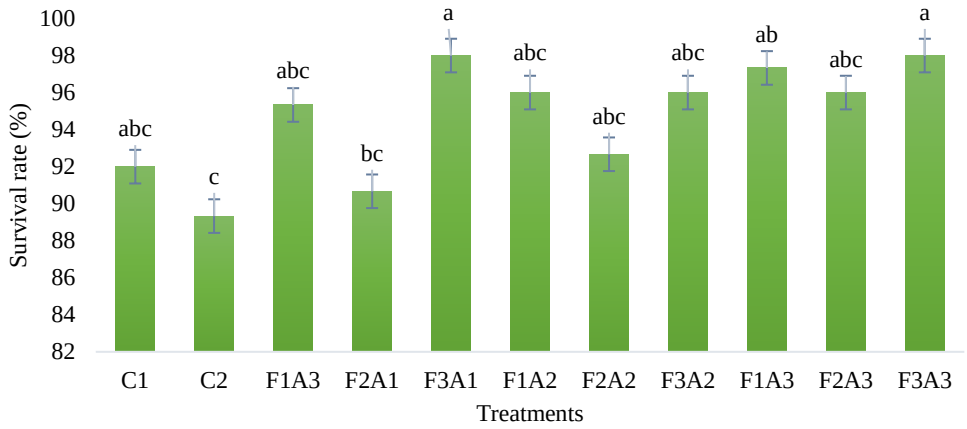

Figure 01: Survival Rate of Nursery Plants among the Treatments

Table 03: Fertilizer Requirement for 10000 plants

Treatment	**Fertilizer for 10000 plants**
C1	1.5 m^3
C2	-
F1A1	73 mL
F1A2	147 mL
F1A3	219 mL
F2A1	67 mL
F2A2	134 mL
F2A3	201 mL
F3A1	333 mL
F3A2	666 mL
F3A3	999 mL

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