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RESEARCH ARTICLE

Selection of best compound fertilizer amended potting mixture for successful growth of black pepper (*Piper nigrum l.*) hybrid ("Dingirala") nursery plants

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ABSTRACT

Black Pepper, Piper nigrum L.) is a perennial, evergreen, climbing vine and it is widely used as a spice and flavoring agent in the food industry and ayurvada medicine throughout the world. Therefore, continuous supply of pepper is important for the sustainability of these sectors. Pepper is usually propagated vegetatively using stem cuttings. Cuttings are planted in polythene bags filled with a mixture of equal parts of topsoil, cow dung, sand, and coir dust. Scarcity of cow dung and expensiveness resulted with huge demand are the limiting factors in commercial production of pepper. Incorporation of nitrogen and phosphorus containing fertilizers to potting mixture in the absence of cow dung may at least supply plant nutrients which highly essential for early growth of plants. Therefore, this study was carried out to investigate the effect of different compound fertilizer for nursery plants of P. nigrum L, hybrid "Dingirala" in the absence of cow dung in the potting mixture. Four different levels (1, 2, 3, 4 g per pot) of four different compound fertilizers were taken as treatments such as T1- Yara Complex (N:P:K 12:11:18), T2- Yara Grower (N:P:K 21:7:14), T3- NPK Balance (N:P:K 15:15:15) K as SOP, T4- NPK Balance (N:P:K 15:15:15) K as MOP and T5 a phosphate fertilizer Di-ammonium phosphate (DAP) (N:P:K 18:46 :0). All were mixed into a modified potting mixture of topsoil: sand: coir dust 2:1:1 without cow dung. Control was the potting mixture already recommended by Department of Export Agriculture (top soil: sand: coir dust: cow dung, 2:1:1:1) without inorganic fertilizer. Each treatment contained three replicates per treatment. Complete Randomized Block Design (RCBD) was the experimental design and each block consisted with 50 plants. Two nodal cuttings of Black pepper hybrid Dingirala were planted and maintained in a propagator under a net house at central research station Matale (IM3a). After 105 days from establishment, survival percentage, growth parameters such as shoot length (cm), number of leaves and shoot dry weight (g) were measured. Soil parameters such as soil pH and EC and total N%, P% and K% of tissues were analyzed. Significantly highest ($P<0.05$) survival rate (91%) was recorded from recommended potting mixture used as control in this experiment and cuttings treated with 1g of Di-ammonium phosphate. Significantly highest ($P<0.05$) shoot length (39.1cm) was recorded from cuttings treated with 1g of Yara complex fertilizer (N:P:K 12:11:18) and Significantly highest ($P<0.05$) number of leaves (9.0) was recorded from cuttings treated with 1g of DAP fertilizer. Therefore, cuttings planted with top soil: sand: coir dust: cow dung, 2:1:1:1 is the best potting mixture and in absence of cow dung with normal potting mixture with 1g of Di-ammonium phosphate excelled all compound fertilizers in terms of overall growth, soil and leaf nutrient parameters of Hybrid "Dingirala" pepper nursery plants over the first 105 days after establishment

Keywords: *Compound fertilizer, cow dung, growth, pepper, soil, leaf nutrients*

INTRODUCTION

Black pepper (*Piper nigrum* L.) belongs to the family Piperaceae which is a perennial, evergreen, climbing vine that is the most widely used spice and flavoring agent in the Ayurveda medicine and food industry throughout the world and known as "King of the Spices" (DEA, 2021). Pepper crop is native to South Asia and historical records reveal that pepper is originated in South India. Peppercorns were a much-prized trade good often referred to also as "black gold" and used by as a form of commodity money. All of the black pepper found in Europe, the Middle East, and North Africa traveled there from India's Malabar region during middle age. It was some part of the preciousness of these spices that led to the European efforts to find a sea route to India and consequently to the European Colonial occupation of the country (DEA, 2021).

Black pepper, commonly called Gammiris is mainly cultivated in Low and Mid Country Wet and Intermediate agro-climatic zones in Sri Lanka (DEA, 2021). The total extent of pepper in Sri Lanka is about 42,989 ha and Matale, Kandy, Kegalle, Badulla, Ratnapura, Monaragala, and Kurunegala are the major districts. Currently about 60% of pepper production of Sri Lanka is exported while the remainder is consumed domestically. Sri Lanka is the fifth largest exporter of pepper in the world where India buys 62% of pepper exports from Sri Lanka. In 2018 Sri Lanka exported a total pepper crop which had brought in earnings to of Rs.11.5 billion (Weerasinghe & Jayasundara, 2020). The dried fruit or the peppercorn is used as condiment and the same is used to produce white, red and green pepper (IPS, 2017). Pepper is largely produced as black pepper which is the dried whole fruit. White pepper is produced by removing outer pericarp and pepper is also available in crushed and ground forms (DEA, 2021).

In recent years, traditional and ayurveda medicine has gained popularity, with many people choosing it over western medicine. Firstly, traditional and ayurveda medicine are often more affordable than western medicine. Most of the remedies used in ayurveda medicine are derived from natural sources such as plants, animals, and minerals, which are often abundant and easily accessible. This makes traditional medicine more accessible to people from low-income backgrounds who may not be able to afford expensive western medicine. Traditional medicine often has fewer side effects than western medicine. Most traditional remedies are derived from natural sources and have been used for centuries, so they are less likely to cause adverse reactions. In contrast, western medicine often relies on synthetic drugs that can have serious side effects.

Nowadays majority of people are not aware about herbs and their value but with the impact of COVID-19 again people tend to use traditional and Ayurvedic medicines. Now there is a trend of using traditional medicine and Ayurvedic treatment (Nanayakkara *et al.*, 2021). This increases the demand for herbs and there are farmers who tend to grow herbs on a large scale. Medicinal plants have a good market value both locally and internationally.

Black pepper is a frequently used medicinal plant in the Sri Lankan Ayurveda and traditional medical systems. Black pepper includes 5-9% of Piperine, a pungent alkaloid, as its main bio active chemical compound. (Jiang, 2019). Piperine comprises of 4 isomers, namely Piperine, Chavicine, Isopiperine and Isochavicine. (Ahmad *et al*, 2012) Additionally, flavonoids, alkaloids, phenols, amides, terpenes and lignans are also present as bio active chemical compounds (Shityakov *et al*, 2019). As an anti-microbial agent, Piperine was found to be more effective against gram-positive strains like *Staphylococcus aureas* and *Streptococcus faecalis* compared to gram-negative strains like *Escherichia coli* and *Salmonella typhi*. (Shityakov *et al.*, 2019). As an anti-oxidant it acts against the actions of free radicals, thereby preventing the oxidative damage caused by these free radicals and reactive oxygen species. Free radicals in the body are involved in the oxidation of lipids in the cellular membranes, loss of receptor and enzyme activities and also leads to the mutation of DNA thus inducing cancer (Ahmad *et al*, 2012). Studies have found that Piperine due to its anti-allergic effect has the ability to inhibit both eosinophil infiltration and histamine release and also subdue allergic airway inflammation and airway hyper-responsiveness (Jiang, 2019). Piperine was found to be capable of stimulating the pancreatic and intestinal digestive enzymes as well as increase the secretion of biliary bile thereby being an effective digestive aid (Ahmad. *et al*, 2012). Piperine was also found to have a passive diffuse mechanism, short clearance time and a high apparent permeability coefficient which facilitates its ability to increase the bioavailability of certain drugs and nutrients (Jiang, 2019). Furthermore, according to research, Black pepper also exhibits thermogenic, anti-thyroid, chemo preventive, growth stimulatory and insecticidal activities (Ahmad *et al*, 2012). According to Ayurveda *gammiris* consists of *katu* (pungent) and *tikta* (bitter) tastes, *laghu* (light), *ruksha* (drying) and *tikshna* (sharp) properties, *ushna virya* (hot potency) and *katu vipaka*. There are three main *dosha* (humors) in the body, according to Ayurveda and they are *vata, pitta* and *kapha*. The main effect of *gammiris* on these dosha are *kapha- vata shamaka*, meaning that *gammiris* is beneficial to the pacification of the aggravated *kapha* and *vata doshas*. In Ayurveda many pharmacological actions have been listed under this plant and some of them are *kapha nissaraka* (expectorant), *lekhana* (scraping action), *balya* (strength promoting), *deepana* (appetizer), *pachana* (stimulates digestion), *yakrut uttejaka* (liver-stimulating) and *jwaraghna* (cures fever conditions). The parts of the plant that are used more commonly are the seeds, roots and leaves. *Gammiris* as a single drug or compound drug is mainly used in disorders like *kasa* (cough), *shwasa* (dyspnea), *peenas* (rhinitis), *shoola* (pain in relation to the abdomen), *yakrut vikara* (disorders related to the liver), *kushta* (skin disorders) and *jwara* (fever conditions). *Trikatu choorna*, *nirgundi thaila* and *suranvidura vati* are some of the medicines containing *Gammiris* (Compendium of Medicinal Plants, 2001; Godagama, 1997).

The research conducted by Ramya *et al* (2017) on evaluation of potting mixtures and humidity conditions for rooting and establishment of plagiotropic branches of black pepper (*Piper nigrum)* variety Panniyur 1 with nine treatments and three replications each revealed that after 50 days of planting the largest number of laterals established where on coir pith compost in 8 x 5 cm black nursery bags and kept under humid chamber (63.3 %) followed by coir pith compost in 19" x 8" transparent LDPE bags, planted the cuttings and tied the mouth for retaining humidity (60.8%). In both the cases the planting medium used was coir pith compost. Hence it is inferred that coir pith compost could be used as medium for rooting and establishment of laterals for large scale production of bush pepper.

Another experiment conducted at Peruvannamuzhi (Kerala) to study the feasibility of using soil-less medium containing coir pith compost and granite powder for raising black pepper (*Piper nigrum*) cuttings in the nursery. Plant height, leaf production, leaf area and total dry matter production were significantly higher in the medium consisting of coir pith compost and granite powder in 1:1 proportion along with Azospirillum sp. and phosphobacteria as nutrient sources whereas, the cost of production of rooted cuttings was cheaper in the medium consisting of coir pith compost, granite powder, and farmyard manure in 2:1:1 proportion compared to conventional potting mixture (soil: sand: farmyard manure in 2:1:1 proportion).

Therefore the main aim of this research was to select the most suitable compound fertilizer for potting mixture of black pepper nursery plants to enhance their growth and successful establishment in the field.

MATERIALS AND METHODS

The study was conducted at the Central Research Station, Department of Export Agriculture, Matale (7°10′ N and 80° 7′ E. Elevation is about 375 m in Mid Country Intermediate Zone – IM 3a). Randomized Complete Block Design (RCBD) was used as the experimental design as environmental factors such as light, temperature and ventilation are not controlled. There were total of six treatments, T1- Yara Complex fertilizer (N:P:K 12:11:18); T2- Yara Grower fertilizer (N:P:K 21:7:14); T3- Hayleys Balance/SOP fertilizer (N:P:K, 15:15:15); T4- Hayleys Balance/MOP fertilizer (N:P:K, 15:15:15); T5- DAP/ Di-ammonium Phosphate fertilizer including the control T6- Control with normal potting mixture, top soil: sand: coir dust: cow dung 2:1:1:1. Potting mixture for all the treatments was top soil: sand: coir dust: cow dung 2:1:1:1. Each treatment except the control had four levels of compound fertilizers *i.e.*, 1, 2, 3, and 4 g per pot, each with two replicates. There were 21 treatment combinations. Each treatment combination consisted of 50 plants (Table 1).

Table 1: Treatments.

Treatments	Details
T1	Yara Complex fertilizer (N:P:K 12:11:18)
T1L1	1g Yara Complex fertilizer (N:P:K 12:11:18) per pot
T1L2	2g Yara Complex fertilizer (N:P:K 12:11:18) per pot
T1L3	3g Yara Complex fertilizer (N:P:K 12:11:18) per pot
T1L4	4g Yara Complex fertilizer (N:P:K 12:11:18) per pot
T2	Yara Grower fertilizer (N:P:K 21:7:14)
T2L1	1g Yara Grower fertilizer (N:P:K 21:7:14) per pot
T2L2	2g Yara Grower fertilizer (N:P:K 21:7:14) per pot
T2L3	3g Yara Grower fertilizer (N:P:K 21:7:14) per pot
T2L4	4g Yara Grower fertilizer (N:P:K 21:7:14) per pot
T3	Hayleys Balance/SOP fertilizer (N:P:K, 15:15:15)
T3L1	1g Hayleys Balance/SOP fertilizer (N:P:K, 15:15:15) per pot
T3L2	2g Hayleys Balance/SOP fertilizer (N:P:K, 15:15:15) per pot
T3L3	3g Hayleys Balance/SOP fertilizer (N:P:K, 15:15:15) per pot
T3L4	4g Hayleys Balance/SOP fertilizer (N:P:K, 15:15:15) per pot
T4	Hayleys Balance/MOP fertilizer (N:P:K, 15:15:15)
T4L1	1g Hayleys Balance/MOP fertilizer (N:P:K, 15:15:15) per pot
T4L2	2g Hayleys Balance/MOP fertilizer (N:P:K, 15:15:15) per pot
T4L3	3g Hayleys Balance/MOP fertilizer (N:P:K, 15:15:15) per pot
T4L4	4g Hayleys Balance/MOP fertilizer (N:P:K, 15:15:15) per pot
T5	DAP/ Di-ammonium Phosphate fertilizer
T5L1	1g DAP/ Di-ammonium Phosphate fertilizer per pot
T5L2	2g DAP/ Di-ammonium Phosphate fertilizer per pot
T5L3	3g DAP/ Di-ammonium Phosphate fertilizer per pot
T5L4	4g DAP/ Di-ammonium Phosphate fertilizer per pot
T6	Control/ normal potting mixture, top soil: sand: coir dust: cow dung 2:1:1:1

Nursery Establishment

Potting mixer was prepared by mixing topsoil: sand: coir dust at 2:1:1 ratio. The potting mixer required for 100 bags for each treatment combination was separated and mixed with four different levels of compound fertilizers. 250 gauge, 8”x 5” black polythene bags were filled with the prepared potting mixture and kept for two days. Prior to two days, the middle one-third portion of runner shoots of black pepper “Dingirala” Hybrid were picked avoiding tender and too woody shoots. The selected runner shoots were cut into 2-3 nodded cuttings. Leaves, were clipped off leaving a small portion of the petiole on the stem. Mancozeb (Fungicide) was applied to the cut ends of the cuttings by dipping them in a slurry of Mancozeb (Fungicide) (40 g in 10 litter of water) for around 20 min. Cuttings were treated and planted in polythene bags at a rate of one cutting per bag. The first node was planted in the media, while the others remained outside. Control plants contained the regular standard mixture of topsoil, sand, cow dung and coir dust in 1:1:1:1 ratio. For around 4 weeks, planted poly bags were kept in a propagator (28 d). Then it was completely opened for watering and weeding, and kept in a shade house with 60 to 70% shade.

Sampling Procedure and Preparation

Soil and plant samples were collected 105 d after planting. Plants were selected randomly from each treatment combination in each replicate while sampling. After removing the plant from the bags, soil samples were taken. Pepper plant roots were washed well to remove soil. To analyze soil chemical characteristics (Soil pH and EC), collected soil samples were air dried for about 48 h and passed through a 2 mm sieve. Plant samples were oven dried for 48-72 h before being ground to prepare them for leaf tissue analysis (N, P, K).

Data Collection

All data were analyzed according to Analysis of Variance (ANOVA) using the analytical software Minitab version 19. Tukey Pairwise Comparisons was performed to compare the differences among treatment means and probability of 5% or less was considered as statistically significant.

Data Analysis

All data were analyzed according to Analysis of Variance (ANOVA) using the analytical software Minitab version 19.Tukey Pairwise Comparisons was performed to compare the differences among treatment means and probability of 5% or less was considered as statistically significant.

RESULTS AND DISCUSSION

Growth Parameters

Survival of Plants

Significantly highest (P<0.05) survival rates (91.1%) were recorded from both control (T6), recommended potting mixture containing cow dung and black pepper cuttings treated with 1 g of DAP fertilizer (Table 2), while minimum survival rate (22.2%) was recorded from pepper cuttings treated with 4 g of Yara complex fertilizer. According to the Table 2, there was no significant difference between control (T6) and black pepper cuttings treated with 1 g of Yara complex, 1 g of DAP, 2 g of DAP and 3 g of DAP fertilizers. Apart from 1 g of Yara Grower (T2L1), all other treatments, including 2 g of Yara Grower (T2L2), 3 g of Yara Grower (T2L3), and 4 g of Yara Grower (T2L4), showed the highest number of dead plants after 48 d from planting. This means 1 g of DAP fertilizer (T5L1) positively effects on survival of black pepper nursery plants as an alternative to cow dung than other fertilizers including Yara complex (T1), Yara grower (T2), balance/SOP (T3) and balance/MOP (T4).

According to the observations of Sher *et al.,* (2020), the growth of eggplants including shoot height, average number of leaves, total biomass and root length was stunted and highest number of plants were dead with increase in concentration of KCL more than 0.2M. Also, according to Yara (2021), in Yara grower fertilizer (N: P: K 21:7:14) K supply is in the form of KCL and it contains highest amount of Cl in the form of KCL which might be toxic to the plants. Therefore, this high concentration of KCL might be the reason for obtaining highest number of dead plants in treatment 2 (T2) which applied with Yara grower fertilizer. Therefore, Yara grower fertilizer is not suitable for giving nutrients to Dingirala nursery plants during their early stages of growth since high levels can harm the plants.

According to the results obtained, high fertilizer levels (3 g and 4 g per pot) showed minimum plant survival rates compared to low levels of fertilizer (1 g and 2 g per pot). Therefore, as shown in the Table 2, plant survival rates decreased with increasing amount of fertilizer used per pot, regardless of the type of fertilizer used. According to DEA (2021), Hybrid Dingirala, is the most sensitive variety to higher fertilizer concentrations than other local varieties of black pepper. This could be an attribute to the negative effect (decreased plant survival rates) of high levels of NPK fertilizers on pepper hybrid variety of Dingirala.

In contrast to organic fertilizer, inorganic fertilizer must be applied with care or the plants would die, according to an article statement by Mulin, (2020). Mulin (2020) also stated that excessive quantities than 0.5M of chemical salts in inorganic fertilizer can "burn" a plant's root system, the result is really dehydration, which occurs when the salts pull out all the moisture from the roots and it will desiccate them. Therefore, this may be the cause of the poor survival rates of those treated with 3 g and 4 g of compound fertilizers.

Shoot Length

According to the Table 2, significantly highest ($P<0.05$) shoot length (39.1 cm) was shown in black pepper cuttings treated with 1 g of Yara complex fertilizer (T1L1) which was statistically similar to 2 g and 3 g of Yara complex fertilizer treatments (34.3 and 34.6 cm, respectively. Minimum shoot length (17.1 cm) was recorded from black pepper cuttings treated with 1 g of Yara grower fertilizer (T2L1) than other treatments.

According to Yara (2022), apart from NPK Yara Complex Compound fertilizer contains some other micro nutrients such as Mg (2.65%) and S (19.9%), as well as Zn (0.02%) and B (0.015%). Therefore, Yara complex contains added micronutrients compared to other four fertilizers. A study by Kumar *et al.,* (2008), proved that various elements in complex compound fertilizer, such as Zn, B, S, and Mg, aids in boosting plant height and foliage coverage throughout the early phases of growth and as well as in later stages too. According to Kumar *et al.,* (2008) this might be the reason for higher shoot length of pepper plants performed in Yara complex fertilizer treatments (T1) than other fertilizers. Therefore, Yara complex fertilizer (T1) has an effect on early shoot growth of black pepper plants.

It is clear that shoot growth is negatively affected by increasing fertilizer levels (3 g and 4 g per pot). According to the study of Changthom *et al.,* (2017), application of fertilizers, especially N enhance black pepper plant growth but excessive supply (more than 3.40%) may lead to a negative effect. Therefore, this might be the reason for negative effect of high fertilizer levels for early growth of black pepper according to the results obtained.

Average Number of Leaves per Vine

According to the Table 2, pepper cuttings treated with 1 g DAP fertilizer recorded the significantly highest (P<0.05) number of leaves (9.0) and the minimum average number of leaves (3.0) were recorded by pepper cuttings treated with 3 g of balance/SOP fertilizer, 4 g of balance/SOP fertilizer and 2 g of balance/MOP fertilizer. There was no significant difference (P>0.05) between the control (T6) and Yara complex 1 g (T1L1), Yara complex 2 g (T1L2) and DAP 1 g (Table 2).

According to the study of Suprapto and Dwiwarni (1991), higher dosages of phosphate fertilizer (0.21-0.56%) resulted in an increase in internode development and the number of leaves compared to smaller doses (0.00 to 0.14%) on black pepper. As per a study on ground nuts by Adam *et al.,* (2011), phosphorus application significantly increased plant height, leaf number in the major season and total dry weight in both seasons. Similar results have been reported by Sharma and Yadav (1997). Therefore, the studies of Suprapto and Dwiwarni (1991) and Adam *et al.,* (2011) supports the results of the current study, where pepper cuttings treated with 1 g and 2 g DAP fertilizer which contains a greater phosphorus percentage (N:P-18:48) recorded the comparatively higher *number of leaves.*

Shoot Dry Weight

According to the Table 2 significantly highest (P<0.05) dry weight was recorded by pepper cuttings treated with 1 g of balance/SOP fertilizer (T2L1) (5.5 g) and there was a significant difference (P<0.05) between control (T6) and black pepper cuttings treated with 3g balance/SOP fertilizer (T3L2) which recorded the minimum shoot dry weight (1.5 g).

According to a study by Kandiannan *et al.,* (2000), commercially available traditional black pepper propagation methods have significant drawbacks, including low success rates, poor roots, stunted growth and low survival rates due to excessive fertilizer concentrations. Aswathy (2018) also stated that high NPK fertilizer concentrations slow the growth of black pepper cuttings and its vegetative parts. These findings by Kandiannan *et al.,* (2000) and Aswathy, (2018) clearly reveals that there is a stunted growth associated with increased fertilizer levels.

Table 2: Growth parameters of black pepper nursery plants after 105 d from establishment

Treatment Combination	Mean Survival %	Mean Shoot Length (cm)	Mean Number of Leaves per Vine	Shoot Dry Weight (g)
T1L1	80.00^{abc}	39.13^{a}	6.00^{bcd}	4.90^{ab}
T1L2	37.78^{efg}	34.33^{ab}	6.00^{bcd}	3.30^{abc}
T1L3	62.22^{bcde}	34.67^{ab}	5.00^{cde}	2.90^{abc}
T1L4	22.22^{g}	27.23^{cde}	5.00^{cde}	2.60^{abc}
T2L1	55.55^{cdef}	17.13^{h}	5.00^{cde}	5.50^{a}
T3L1	60.00^{bcdef}	29.57^{bcd}	5.00^{cde}	2.90^{abc}
T3L2	48.89^{defg}	26.97^{cde}	4.67^{cde}	1.50^{c}
T3L3	53.33^{cdef}	18.40^{gh}	3.00^{e}	2.95^{abc}
T3L4	42.22^{efg}	25.53^{cde}	3.00^{e}	4.80^{ab}
T4L1	57.78^{cdef}	30.70^{bc}	4.33^{de}	3.20^{abc}
T4L2	37.78^{efg}	24.50^{def}	3.00^{e}	2.25^{bc}
T4L3	24.44^{g}	23.23^{efg}	3.33^{e}	4.90^{ab}
T5L1	91.11^{a}	28.33^{cde}	9.00^{a}	4.75^{ab}
T5L2	86.67^{ab}	25.67^{cde}	6.67^{bc}	3.05^{abc}
T5L3	75.56^{abcd}	18.27^{gh}	4.00^{de}	2.50^{bc}
T5L4	33.33^{fg}	19.63^{fgh}	3.33^{e}	4.90^{ab}
T6	91.11^{a}	30.60^{bc}	7.67^{ab}	4.90^{ab}
p Value	0.05	0.05	0.05	0.05

Note: *Means with same letters along the columns are not significantly different (p = 0.05).*

(**T1**- Yara Complex (N:P:K 12:11:18), **T2**- Yara Grower (N:P:K 21:7:14), **T3**- NPK Balance (N:P:K 15:15:15 K as SOP, **T4**- NPK Balance (N:P:K 15:15:15 K as MOP, **T5**- DAP (N:P 18:46) (**L1** - 1g, **L2** - 2g, **L3** - 3g, **L4** -4g)

Soil Parameters

Soil pH

Control (T6) recorded the significantly highest (P<0.05) soil pH (7.9) and DAP 4 g (T5L4) recorded the minimum soil pH (6.2) than others. Treatments TILI, TIL2, T3L1 and T4L1 are not significantly different from control treatment T6. All the other treatments are significantly different from the control treatment (T6). According to DEA (2021), the optimum pH range for pepper is about 5.5-

6.5. According to the study of Yadav and Thakare (2015), cow dung helps in increasing the soil pH and helps in supplying nutrients to polluted soils. This might be due to the fact that when organic residues (plant or animal) are added to the soil, they release organic anions which neutralize the hydrogen ion of the acid soil (Zaman, *et al.,* 2017). Therefore, the results of this study support by the study of Yadav and Thakare (2015), that potting mixture of top soil: sand: coir dust: cow dung 2:1:1:1 (control) increases soil pH.

According to the Table 3, soil pH ranged between 6.2-7.9 in treatments after 105 d. Slight reduction of pH can be seen with increasing the level of DAP fertilizer. The study by IPN (2022) also showed that the ammonium in DAP is a good source of nitrogen, and it will be gradually transformed to nitrate by soil bacteria, leading to a pH decline, while nitrate concentration increases with the increasing N%. As a result, the increase in soil pH around DAP granules is only a transitory effect. The micro-site interactions of phosphate and soil organic matter can be influenced by this first rise in soil pH near DAP. A minor pH decrease recorded in the current study with increased DAP fertilizer level supports by the statement of IPN (2022).

As per the study of Baligar *et al.,* (2001), the availability of some plant nutrients is greatly affected by soil pH. The ideal soil pH is close to neutral, and neutral soils are considered to fall within a range from a slightly acidic pH of 6.5 to slightly alkaline pH of 7.5. It has been determined that most plant nutrients are optimally available to plants within this 6.5 to 7.5 pH range. As soil pH ranged between 6.2-7.9 in this study, it proves that no any strong acidic or alkaline pH was found in any of the treatments according to the results obtained.

Soil EC

According to the Table 3, there was no significant difference (P>0.05) between control (T6) and black pepper cuttings treated with 1g Yara complex (T1L1), 2 g balance/SOP (T3L2), 3 g balance/SOP (T3L3), 4 g balance/SOP (T3L4), 2 g balance/MOP (T4L2), 1 g DAP (T5L1), 2 g DAP (T5L2) and 4 g DAP (T5L4) but, there was a significant difference (P<0.05) between control (T6) and other treatments.

Control (T6) recorded the highest soil EC (50 µS cm^{-1}) and 1 g NPK balance/SOP (T3L1) recorded the lowest (13 µS cm^{-1}) soil EC than others. Further the treatments T1L2, TIL3, T2L1, T3L1, T4L1, T4L3 and T5L3 are not significantly different from control treatment (T6). Zaman *et al.,* (2015) reported that cow dung application to plants have been found to be increasing the total N, available P, exchangeable K, Ca, Mg, available S, Zn and B contents in soils. On the other hand, according to the study of Ding *et al.,* (2018), stated that high EC has been associated with high levels of nitrate and other selected soil nutrients including P, K, Ca, Mg, Mn, Zn, and Cu. Therefore, when soil nutrient levels rise as a result of cow dung application, this could explain that why control (T6) containing cow dung in the potting mixture had the highest EC.

Table 3: Soil parameters of pepper nursery plants after 105 d from establishment

Treatment combinations	Mean Soil pH	Mean Soil EC (µS cm^{-1})
T1L1	7.64^{ab}	19.00^{ab}
T1L2	7.36^{abc}	17.00^{b}
T1L3	7.33^{bcd}	13.50^{b}
T2L1	7.33^{bcd}	13.50^{b}
T3L1	7.37^{abc}	13.00^{b}
T3L2	7.20^{bcd}	20.50^{ab}
T3L3	7.06^{bcd}	24.50^{ab}
T3L4	7.11^{bcd}	22.00^{ab}
T4L1	7.40^{abc}	14.00^{b}
T4L2	7.06^{bcd}	41.00^{ab}
T4L3	7.14^{bcd}	14.50^{b}
T5L1	6.99^{cd}	32.00^{ab}
T5L2	6.81^{bcd}	19.50^{ab}
T5L3	6.71^{de}	18.50^{b}
T5L4	6.20^{e}	31.50^{ab}
T6	7.99^{a}	50.00^{a}
p value	0.05	0.05

Note: *Means with same letters along the columns are not significantly different.*

(**T1**- Yara Complex (N:P:K 12:11:18), **T2**- Yara Grower (N:P:K 21:7:14), **T3**- NPK Balance (N:P:K 15:15:15 K as SOP, **T4**- NPK Balance (N:P:K 15:15:15 K as MOP, **T5**- DAP (N:P 18:46) (**L1** - 1g, **L2** - 2g, **L3** - 3g, **L4** -4g)

Leaf Nutrient Content

Nitrogen Percentage (N%)

According to the Table 4, there was no significant difference ($P>0.05$) between control (T6) and 2 g of Yara complex fertilizer (T1L2) and there was a statistically significant difference ($P<0.05$) between control (T6) and other treatments. The black pepper cultivar 'Guajarina' grown in a medium textured yellow Latosol (Alic haplustox) removed nutrients in the order of N> Ca> K> Mg> P in a study conducted in Baligat *et al* (2001), with the amounts of macronutrients removed by the fruits being N - 11.22; K - 6.15; Ca - 3.84; Mg - 1.18 and P - 1.07 kgha^{-1} (Veloso, 1999). Veloso (1999) stated that as fertilizer concentrations rise, the proportion of nitrogen in the leaf tissues equally increases. The maximum N% (3.59%) was recorded from DAP 4 g (T5L4) and minimum N% (1.23%) was recorded from Yara complex 1 g (T1L1). N% ranged in this study from 1.23% to

3.59%, low to excess amount according to the DRIS norm submitted by Dinesh *et al.,* (2012).

Phosphorus Percentage (P %)

When considering P% according to the Table 4, there was no significant difference (*P*>0.05) between control (T6) and pepper cuttings treated with 1 g of DAP fertilizer (T5L1), 2 g of DAP (T5L2) and 3 g of DAP (T5L3) though there was a significant difference between (*P*<0.05) control (T6) and other treatments. Significantly highest (*P*<0.05) P% (6.8%) was shown by black pepper cuttings treated with 4 g of DAP fertilizer (T5L4) and the lowest P% (0.8%) was shown by Yara grower 1 g (T2L1).

According to the results obtained, DAP fertilizer has shown highest P% than other fertilizers. The P concentration in black pepper leaf tissue increases with increasing fertilizer amounts dramatically, according to the mean values measured. As Srinivasan *et al.,* (2007), stated the element concentrations in the leaves are correlated, and poor pepper performance is linked to high Ca and P leaf concentrations and low N, K, and Mg leaf concentrations.

This might be the reason for the reduction of growth among increasing fertilizer levels of each treatment. This is also in agreement with the previous findings of Ann (2012), an adequate amount of P can stimulate and improve the production of black pepper.

Potassium Percentage (K %)

Pepper requires a lot of potassium for growth and fruiting, and its need is linked to the amount of other nutrients in the plant, especially nitrogen (Srinivasan *et al.,* 2007). When considering K%, there was no significant difference (*P*>0.05) between control (T6) and black pepper cuttings treated with 4 g of NPK balance/SOP fertilizer (T3L4) as shown in the Table 5. Black pepper cuttings treated with 4 g of NPK balance/SOP (T3L4) was shown the highest K% compared to other treatments and other fertilizers were given similar results of K% according to the Table 5. Between treatments, there was an increase in K percent as fertilizer levels increased.

According to Waard, (1969), a critical level of 2% K in the Black Pepper plant serves as a limit for K deficiency. When comparing the mean values in the Table 4, no values below 2% were found, indicating that the plants had accumulated sufficient amounts of K, as revealed by the observation of Hamza *at el*, (2007), who indicated that leaf K ranges from 0.9% to 4.7% in Black Pepper. When comparing my results to Dinesh *et al.,* (2012) DRIS Norms, the K% values status appears to be excessive, as they were also outside of the optimum range.

Table 5: Leaf nutrient content of black pepper nursery plants after 105 d from establishment

Treatment combination	N%	P%	K%
T1L1	1.23^{l}	1.35^{i}	3.45^{def}
T1L2	1.57^{k}	2.36^{gh}	3.55^{cde}
T1L3	1.86^{ij}	2.61^{f}	3.81^{b}
T2L1	2.80^{d}	0.80^{j}	2.80^{h}
T3L1	1.85^{ij}	2.53^{fg}	3.06^{g}
T3L2	1.97^{gh}	3.38^{e}	3.59^{bcde}
T3L3	2.18^{f}	3.90^{d}	3.74^{bc}
T3L4	2.69^{de}	4.09^{d}	4.15^{a}
T4L1	1.82^{j}	2.17^{h}	3.06^{g}
T4L2	1.95^{hi}	2.32^{gh}	3.41^{ef}
T4L3	2.08^{fg}	3.51^{e}	3.66^{bcd}
T5L1	2.62^{e}	5.87^{c}	2.44^{i}
T5L2	2.97^{c}	6.12^{b}	2.56^{i}
T5L3	3.27^{b}	6.22^{b}	3.04^{g}
T5L4	3.59^{a}	6.87^{a}	3.26^{fg}
T6	1.60^{k}	6.04^{bc}	4.13^{a}
P Value	0.05	0.05	0.05

Note: *Means with same letters along the column are not significantly different.*

(**T1**- Yara Complex (N:P:K 12:11:18), **T2**- Yara Grower (N:P:K 21:7:14), **T3**- NPK Balance (N:P:K 15:15:15 K as SOP, **T4**- NPK Balance (N:P:K 15:15:15 K as MOP, **T5**- DAP (N:P 18:46) (**L1** - 1g, **L2** - 2g, **L3** - 3g, **L4** -4g)

CONCLUSIONS

The overall growth, soil and leaf nutrients parameters of Hybrid "Dingirala" pepper nursery plants over the first 105 days after establishment showed that the control treatment of normal potting mixture of topsoil: sand: coir dust: cow dung 2:1:1:1 has been identified as the best potting mixture. In the absence of cow dung, 1 g of Di ammonium phosphate can be recommended as an alternative. Considering additional cost of using inorganic fertilizer in potting mixture and to ensure the medicinal value of Black pepper it's recommended to use normal potting mixture consists of topsoil: sand: coir dust: cow dung 2:1:1:1. However further studies has to be conducted with other varieties, including hybrids and local cultivars.

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