Journal of Technology and Value Addition, Volume 6 (1), January, 2024: (01-17)

Research Article

Evaluating the Impact of Compound Fertilizers on Growth performances of Turmeric (*Curcuma longa* L.) in Nursery Condition

T.I. Croner[1], C.S. De Silva[2], P.R. Idamekorala[3], S. De Silva[1*]

**csdes@ou.ac.lk*

[1]Department of Agricultural and Plantation Engineering, Faculty of Engineering Technology, The Open University of Sri Lanka, Nawala, Nugegoda
[2]Faculty of Indigenous Medicine, University of Colombo
[3]Central Research Station, Department of Export Agriculture, Matale

Abstract

Turmeric, Curcuma longa (family Zingiberaceae) is a herbaceous perennial plant with an underground rhizome which is valuable as a spice, coloring agent and medicinal plant. The turmeric seed rhizome production in Sri Lanka was not sufficient for the increasing demand in food sector and Ayurveda and traditional medical systems and there was a scarcity of turmeric planting materials for the commercial production of turmeric. Due to the scarcity of planting materials for the turmeric production, smaller pieces, 10-12 g of seed rhizomes were recommended by the Department of Export Agriculture instead of recommended 30-35 g sized seed rhizomes. Therefore, this study was carried out to enhance the growth of such small pieces of turmeric by incorporation of inorganic nutrient sources. As treatments three different compound fertilizers such as Yara complex (N: P: K, 12:11:18), Yara grower (N:P:K, 21:7:14) and Hayleys balance (N:P:K, 15:15:15) were added to potting mixture (Top soil: sand: cow dung, 1:1:1) in three different levels of each fertilizer as 2 g per pot, 4 g per pot and 6 g per pot (Black polythene bag, size 6"×5"). The same potting mixture (Top soil: sand: cow dung, 1:1:1) was used as the control without adding any compound fertilizer. Each treatment contained three replicates and laid in Complete Randomized Block Design (RCBD). Growth parameters per pot such as percentage of sprouting (%), shoot height (cm), number of leaves, number of shoots, dry weights of uprooted plants and root volume were measured after seven weeks from the establishment. Soil pH and EC were taken as soil *parameters and leaf tissue analysis was also done for N%, P% and K% at the end of the experiment. 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. No significant differences were ($P \geq 0.05$) observed in sprouting % and number of shoots among treatments. Significantly the highest ($P \leq 0.05$) shoot height (63.8 cm) and number of leaves (5.4) were recorded in plants treated with 6 g of Yara complex fertilizer (N: P: K, 12:11:18). Plant tissues of all fertilizer treatments had significantly high ($P<0.05$) total N content than the control. Therefore, the results revealed that there is positive growth in 10 g sized turmeric rhizomes with 6 g of Yara complex fertilizer (N :P: K, 12:11:18) per pot and enhanced the growth in 6"×5" sized pot filled with recommended potting mixture of Department of Export Agriculture.*

***Keywords**: Compound fertilizer, Potting mixture, Rhizome, Turmeric.*

1. Introduction

Turmeric is one of the multi-use commodities, which has commercial, economic, cultural and medicinal significance across the globe (Abeynayaka *et al*., 2020). Turmeric, *Curcuma longa* is a herbaceous perennial, underground rhizomatic crop belonging to the family *Zingiberaceae*, grows to a height 60-90 cm with a short pseudo stem and long leaves (Reshma and Vishwanath, 2020). It is widely cultivated throughout the tropics. Turmeric has been used in India for more than 5000 years now (DEA, 2021). Currently India is the largest producer, exporter, and consumer of this commodity in the world. Other producers in Asia include Bangladesh, Pakistan, Sri Lanka, Taiwan, China, Burma (Myanmar), and Indonesia. India produces nearly the world's entire turmeric crop and consumes 80% of it. With its inherent qualities and high content of the important bioactive compound curcumin, Indian turmeric is considered to be the best in the world. Turmeric is also known as the "golden spice" as well as the "spice of life" (Reshma and Vishwanath, 2020).

Mainly, turmeric production in Sri Lanka is concentrated to the Wet and Intermediate Zones of the country and the highest share of production is drawn from Kandy, Kegalle and Kurunegala districts (Abeynayaka *et al*., 2020). Though there are a number of locally grown varieties they are not specially identified. There are imported varieties namely, Gunter, Puna and Madurasi Majal and they have been

mixed with local varieties (DEA, 2021). Many soil types are suitable for turmeric cultivation. However well-drained sandy clay loam soils rich with organic matter and sandy loam are the most suitable soil types (DEA, 2021). Turmeric is a horticultural crop demanding heavy fertilization for increasing yield and quality and chemical fertilizers affect growth, yield and quality of turmeric variously (Akamine *et al.,* 2007). It is grown under optimum temperature of 20°C-35°C and 5.5-6.5 pH. The major season for turmeric cultivation is March to April, while the minor season is September to October, which is mostly used in dry zones (DEA, 2021). Turmeric is propagated using rhizomes. There is a very high demand for planting materials because large quantity of rhizomes is required for new cultivation due to slow rate of propagation (Swarnathilaka and Nilantha, 2012).
Initially, turmeric was cultivated as a dye as its' vivid yellow color works brilliantly as a coloring agent. Then its highly developed uses came to know and people started using it for cosmetic and beautification purposes and eventually in traditional and ayurveda medicine. It also became popular as a spice and Turmeric is available in the market as a whole dried form or in a powdered form. It is also used as an ingredient in the preparation of curry mixtures. Oils and oleoresins are extracted from turmeric which is mainly used as a coloring and flavoring agent in the food industry. It is also used as a coloring agent in textiles and preparation of specific paints (DEA, 2021).

The biological compounds such as curcumene, curcuminoids, curcumenol, curcumin, eugenol and limonene are responsible for turmeric's anti-septic, anti-inflammatory, antioxidant, anti-cancer anti-diabetic anti-microbial, anti-venom, hepato-protective, nephron-protective and anti-depressant actions (Prasad and Aggarwal, 2011). The anti-inflammatory action of Turmeric is due to its ability to inhibit the neutrophil function and the biosynthesis of inflammatory prostaglandins during an inflammation (Labban, 2014). Research has revealed that turmeric and its main component, curcumin have antioxidant activity that is equivalent to Vitamins C and E (Jyotirmayee *et al.*, 2022). Curcumin has the ability to destroy free radicals derived from oxygen, especially hydroxyl radical, superoxide radical, singlet oxygen (Labban, 2014). Antioxidants prevent tissue damage caused by free radicals by inhibiting radical production, scavenging radicals or accelerating their breakdown (Jyotirmayee *et al.*, 2022). It was found that Curcumin is able to control carcinogenesis at 3 stages, the angiogenesis stage, tumor production stage and the tumor growth stage thus acting as an anti-cancer agent (Chanda, 2019). Turmeric's hepatoprotective and nephroprotective activities are due to its antioxidant activity and the ability to reduce the pro-inflammatory cytokines (Chanda, 2019). Turmeric acts in a beneficial manner on the Cardiovascular system by decreasing the susceptibility of low-density lipoproteins to lipid peroxidation and lowering the triglyceride and cholesterol levels (Labban, 2014).

According to Ayurveda, turmeric *(kaha*) has *katu* (pungent) and *tikta* (bitter) tastes, *laghu* (light) and *ruksha* (drying) qualities, *ushna virya* (hot potency) and *katu vipaka*. In Ayurveda, it is believed that the body consists of 3 main *dosha* (humors) which are *Vata*, *Pitta* and *Kapha*. The main effect *Kaha* has on these *dosha* is *kapha-vata shamaka*, which means that *Kaha* is beneficial in pacifying the aggravated *kapha* and *vata* dosha, therefore it can be used in diseases that are of *kapha* and *vata* origin. While *Kaha* has many pharmacological actions, some of the main actions mentioned are *Shwasa kasahara* (cure dyspnea and cough), *kaphahara* (pacify kapha), *medaghna* (mitigates fat), *shodhaka* (purificatory), *madhumeha hara* and *panduhara*. Due to its many properties, it is used mainly in diseases like *twakdosha* (skin disorders), *raktadosha* (disorders related to blood), *vruna* (wounds), *aruchi* (anorexia), *kasa* (cough), *shwasa* (dyspnea) and *peenas* (rhinitis). Medicines like *Haridra khanda* and *Dashanga lepa* include *Kaha* as an ingredient (Compendium of Medicinal Plants, 2001; Jayaweera, 1992).

Since year 2019, Sri Lankan government banned the importation of turmeric and several other spices, with a view to pushing local production and helping small-scale farmers (Abeynayake *et al.,* 2020). Therefore, Currently, the turmeric production in Sri Lanka is not self-sufficient and to keep pace with the increased demand in food and Ayurveda medicine. During COVID pandemic people were using Ayurveda medicine as those medicines have positive effects on human life and healthy lifestyle. In order to cope with the demand for production of turmeric plants and for its sustainability in the food sector and Ayurveda medicine, innovative propagation methods need to be identified to influence the growth. Due to the high demand and the high local market price for turmeric, Sri Lankan farmers had a great desire to cultivate turmeric.

Turmeric is a horticultural crop that demands heavy fertilization to increase both yield and quality. Chemical fertilizers have been found to affect the growth, yield, and quality of turmeric in various ways (Akamine *et al.,* 2007). According to research conducted by Akamine *et al.* (2007) on the effect of applying N, P, and K alone or in combination on the growth, yield, and curcumin content of turmeric, N applied alone or in combination with P and K resulted in significantly greater plant height, number of leaves, and tillers. The study also noted that plants grown without N exhibited poorer vegetative growth, while turmeric plants grown with P or K alone did not show improvements in any vegetative growth parameters. Similarly, Govind *et al.* (1990) reported that applying P or K alone could not increase the vegetative growth of turmeric, and P and K without N likely created nutrient imbalances, resulting in antagonistic effects on vegetative growth.

Compound fertilizer is the fertilizer which contains two or three nutrients of N, P, K. NPK fertilizers are three- component fertilizers providing Nitrogen, Phosphorus, and Potassium. It is available in powder or granular form (Anxin, 2021). When incorporating straight fertilizers such as Urea, MOP, TSP, etc., into turmeric nursery plants, direct contact with the plants may prove harmful. Additionally, achieving the correct NPK ratio by mixing two or three straight fertilizers can pose practical challenges. However, the application of compound fertilizers presents a solution to these issues. Each granule of compound fertilizer contains the precise nutrient ratio required, mitigating the risk of harm to the plants when applied directly to the nursery.

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

2. Materials and Methods

The study was conducted at the Central Research Station, Department of Export Agriculture, Matale (7º10´ N and 80º 7´ E. Elevation is about 375m in Mid Country Intermediate Zone – IM 3a) from 07th of April 2021 to 23rd of November 2021. A Randomized Complete Block Design (RCBD) was used as the experimental design. There were three types of compound fertilizers with three rates of application i.e., 2 g/pot, 4 g/pot, and 6 g/pot, each with three replicates. Accordingly, there were 10 treatment combinations including the control (Table 1). A treatment combination consisted of 10 plants. As the control, 10 g seed rhizome pieces were planted in the recommended potting mixture of Department of Export Agriculture of topsoil, sand and cow dung, 1:1:1 without adding any fertilizer.

Table 1: Treatment combinations

Treatments	Description
T1L1	2 g Yara Complex fertilizer (N:P:K, 12:11:18) per pot
T1L2	4 g Yara Complex fertilizer (N:P:K, 12:11:18) per pot
T1L3	6 g Yara Complex fertilizer (N:P:K, 12:11:18) per pot
T2L1	2 g Yara Grower fertilizer (N:P:K, 21:7:14) per pot
T2L2	4 g Yara Grower fertilizer (N:P:K, 21:7:14) per pot
T2L3	6 g Yara Grower fertilizer (N:P:K ,21:7:14) per pot
T3L1	2 g Hayleys Balance/SOP fertilizer (N:P:K, 15:15:15) per pot
T3L2	4 g Hayleys Balance/SOP fertilizer (N:P:K, 15:15:15) per pot
T3L3	6 g Hayleys Balance/SOP fertilizer (N:P:K, 15:15:15) per pot
T4	Control /normal potting mixture, top soil: sand: cow dung 1:1:1

2.1. Preparation of Planting Materials

Turmeric rhizomes that are plump, firm and free from blemishes were collected separately and they were cut into 10-12 g pieces. Then cut rhizome pieces were immersed in a 0.3% mancozeb solution (fungicide) for 30 minutes and after 30 minutes they were taken off from the solution and kept to drain for about 15 minutes. Disinfected seed rhizome pieces were kept on a wet coir fiber dust layer in a tray and then it was covered again with a layer of coir fiber dust and watered them. Seed rhizome pieces were kept on coir fiber dust for about 2-3 weeks until they started to germinate.

2.2. Bag Preparation and Planting

Before planting, topsoil, sand and cow dung in 1:1:1 ratio was taken as the potting mixture and separated into 10 parts. According to the mentioned treatments, compound fertilizers were added into each part of potting mixture and mixed well separately. After that, 250-gauge, 6"×5" black polythene bags were taken and filled with prepared mixtures separately. Then already prepared seed rhizomes (germinated) were planted in prepared bags. Control plants were planted by using

10 g seed rhizomes in the same potting mixture without adding any compound fertilizers. Afterwards, all bags were placed in a net house. Then they were mulched well using paddy straw and watered.

2.3. Sampling Procedure and Preparation

Sampling was carried out 60 days after planting. When sampling, plants were selected from each treatment in each replicate randomly. Soil samples were taken after removing the plants from bags. After removing turmeric plants from the bag, plant roots were washed thoroughly using running water to remove soil. The collected soil samples were air dried for about 48 hours and passed through a 2 mm sieve to analyze soil chemical properties (Soil pH and EC). The collected plant samples were oven dried about 48-72 hours and dried samples were grinded to prepare the samples for leaf tissue analysis (N, P, K).

2.4. Data Collection

Sprouting of rhizomes (%), shoot/tiller height, number of leaves and number of shoots per pot were recorded as growth parameters after seven weeks from establishment. After 60 days or at the end of the experiment soil pH and soil EC were recorded as soil chemical parameters. Plant shoot dry weight and root volume were recorded as plant destructive measurements and leaf tissue N%, P% and K% were recorded as leaf nutrient parameters at the end of the experiment.

2.5. Data Analysis

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

3. Results and Discussion

3.1. Growth parameters

Sprouting of Rhizomes (%)

The highest sprouting percentage (96.6%) was observed in T2-Yara Grower fertilizer – 4 g and the lowest sprouting percentage (76.6%) was observed in T2-Yara Grower fertilizer – 2 g. but there was no significant difference ($P \geq 0.05$) of mean percentage of sprouting (%) between control (T4) and treatments (T1-Yara Complex fertilizer, and T3- Hayleys Balance/SOP fertilizers) (Table 2). There cannot be a direct effect of fertilizer on sprouting as sprouting depend on stored nutrients and characteristics of rhizomes (number of eyes) (DEA, 2021). According to the observations of Indrajith and Avinash, (2015), there was no significant effect of bio fertilizer and chemical fertilizer on the number of turmeric seeds germinated (Visible Sprouting buds). The study of Indrajith and Avinash (2015), prove the findings that there was no significant difference ($P \geq 0.05$) in percentage of sprouting among fertilizer treatments. Therefore, no significant differences in sprouting means that the used rhizomes were similar and good in quality.

Shoot Height

There was a statistically significant difference ($P \leq 0.05$) in mean shoot height between control (T4) and turmeric seeds treated with 6 g Yara complex fertilizer (T1L3) and turmeric seeds treated with 4 g Yara grower fertilizer (T2L2) as shown in Table 2. According to the results obtained, turmeric seeds treated with 6 g of Yara complex fertilizer (T1L3) was recorded significantly highest ($P \leq 0.05$) mean shoot height (63.8 cm) and turmeric seeds treated with 2g Yara complex fertilizer (T1L1) was recorded the lowest shoot height (45.5 cm) compared to others. It revealed that the plant responses to the added Yara complex is higher compared to other compound fertilizers.

According to Akamine *et al.* (2007), nitrogen fertilizers ensured favorable condition for the growth of turmeric with optimum cell division and elongation of cell results was the tallest plant. Also, according to the results of Akamine *et al.* (2007), combine application of N, P and K resulted significantly higher plant height and turmeric plants grown with P or K alone was not shown improvement in any vegetative growth parameter. This is an attribute to all three compound fertilizers (Yara complex, Yara grower and Hayleys balance) gave good shoot height of turmeric nursery plants and performed well as shown in Table 2. There was no significant ($P \leq 0.05$) increase of shoot height in turmeric seeds treated with Hayleys balance/SOP fertilizer (T3) and low levels of complex and grower fertilizers compared to the control (T4) which contained normal potting mixture (topsoil: sand: cow dung, 1:1:1). But according to the results obtained, all three fertilizer treatments gave higher shoot height than control (T4) which contained normal potting mixture as an effect of compound fertilizers which contained blended mixture of N, P and K.

Turmeric is a horticultural crop demanding heavy fertilization for increasing yield and quality and chemical fertilizers affect growth, yield and quality (Curcumin Content, Texture, Aroma and Flavor) of turmeric variously (Akamine *et al.,* 2007). While considering fertilizer amount per pot, 6 g per pot were shown highest shoot height than 2 g and 4 g per pot in all three fertilizers (Yara complex, Yara grower and Hayleys balance/SOP). As shown in the Table 2, there was an increasing trend in shoot height with increasing the level of fertilizers especially.

Plants only uptake nitrogen in useful form, most plants take nitrogen in nitrate structure and proper growth and development of plants require optimum supply of nitrogen (Leghari *et al.,* 2016). Yara Mila Complex (N: P: K- 12:11:18) has a balanced nitrogen source, containing both nitrate-N and ammonium-N (Yara, 2022). Therefore, the highest tiller height was given from Yara complex fertilizer might be due to this balance nutrient composition of the fertilizer and due to the Nitrate-N that available for the plants.

Number of Leaves

A significant increase ($P \leq 0.05$) in the mean number of leaves was recorded from turmeric rhizomes treated with 6 g Yara complex fertilizer (T1L3) when compared to the control (T4) which contained normal potting mixture (topsoil: cow dung: sand 1:1:1) and there was no significant difference ($P \geq 0.05$) between control (T4) and other treatments as shown in the Table 2. According to the results obtained, turmeric seeds treated with 6 g Yara complex fertilizer (T1L3) recorded significantly highest ($P \leq 0.05$) (5.4) number of leaves and control (T4) recorded the lowest number of leaves (3.9). Turmeric seeds treated with 4 g and 6 g Yara grower fertilizer (T2L2 and T2L3) recorded as the second highest (4.5) mean number of leaves. The results are in agreement with the observations of Verma *et al.* (2019), who reported that the vegetative growth and yield significantly increased through the application of NPK fertilizers. This could be an attribute to the role of soil nutrients: NPK, increasing the early growth of turmeric plants.

Number of Shoots

There was no significant difference ($P \geq 0.05$) in mean number of shoots per pot between control (T4) and treatments (Table 2). No significant difference between control and treatments means that there was not much effect of fertilizers for the development of new shoots. According to the observations of May *et al.* (2005), the number of tillers/ shoots per plant varies with the number of eyes on the seed rhizome. When seed rhizomes are reduced in size (10-12 g), the number of eyes on the rhizomes decreases, and each rhizome may only have 1-2 eyes. As a result of the findings, the decrease in the number of shoots could be attributed to a decrease in the number of eyes on the seed rhizomes, as small rhizome pieces used for this experiment.

Shoot Dry Weight

According to the results, there was no statistically significant difference ($P \leq 0.05$) between control (T4) and treatments. According to the study of Akamine *et al.*, (2007) turmeric shoots dry weight increased with the application of NPK fertilizers due to the increased shoot biomass.

In compound fertilizers, a mixture of N, P and K nutrients is present in every particle of product, while in a blended NPK, separate particles of straight fertilizer like urea, nitrates, TSP, MOP, SOP etc. are mixed, or blended together (Yara, 2022). Therefore, compound fertilizers may increase the vegetative growth and yield of turmeric by providing balance NPK nutrients to the plant.

Shoot dry weight is affected the moisture content and dry up in the tissues. It represents the biomass contribution regarding whole yield directly. The optimum biomass dry weight of turmeric will show the optimum results at the end of the yield parameters taken down for the analysis procedures (Akamine *et al.,* 2007). According to the study of Hossain *et al.* (2005), imbalance of nutrients could not increase growth and yield of crops.

Table 2: Growth parameters of turmeric nursery plants after seven weeks from establishment

Treatments	Mean Percentage of Sprouting (%)	Mean Shoot Height (cm)	Mean Number of Leaves	Mean Number of Shoots
T1L1	76.6[a]	45.5[d]	3.7[b]	1.0[a]
T1L2	90.0[a]	52.2[bcd]	4.3[ab]	1.0[a]
T1L3	100.0[a]	63.8[a]	5.4[a]	1.1[a]
T2L1	76.7[a]	46.6[cd]	3.6[b]	1.0[a]
T2L2	96.6[a]	58.0[ab]	4.4[ab]	1.0[a]

T2L3	90.0[a]	54.7[bc]	4.4[ab]	1.0[a]
T3L1	86.6[a]	51.8[bcd]	4.2[b]	1.0[a]
T3L2	80.0[a]	51.0[bcd]	4.1[b]	1.0[a]
T3L3	93.3[a]	52.3[bcd]	4.2[b]	1.0[a]
T4 (Control)	86.6[a]	46.9[cd]	3.9[b]	1.0[a]

Note: *Means with same letters along the columns are not significantly different.*
(**T1**- Yara Complex, **T2**- Yara Grower, **T3**- Hayleys Balance/SOP, **T4**- Control, **L1** -2 g, **L2** – 4 g, **L3** – 6 g)

Root Volume

According to the results, there was no statistically significant difference (P≥0.05) in root volume of turmeric nursery plants between control (T4) and fertilizer treatments. The highest root volume (31.3 ml) was recorded from turmeric seeds treated with 6 g of Yara complex fertilizer (T1L3) and minimum root volume (12.5 ml) was shown in the control (T4). Also, there was an increasing trend in root volume with the increase in the amount of fertilizer. According to the results obtained, high fertilizer levels (6 g per pot) gave increased root volume than low fertilizer levels (2 g and 4 g per pot).
According to Cakmak and Kirkby (2008), Mg application has been reported to increase the translocation of assimilation from source to sink organs which increases root growth. Also, Chandra *et al.* (1997), has reported that an increase in rhizome yield of turmeric as a result of $MgSO_4$ when applied as a foliar spray. Each Yara Mila complex pill contains precisely balanced amounts of NPK. It contains 12% N, 11% Phosphorus, 18% K and 2.65% Mg, 19.9% S and trace metals 0.02% Zn and 0.015% B (Yara, 2022). These findings prove the results that turmeric seeds treated with Yara complex fertilizer which contain Mg (2.65% MgO) as secondary nutrient in its composition was recorded the highest root volume than other two fertilizers (Yara grower and Yara balance) which do not contain such secondary nutrients as Mg. The increase in root growth because of Mg fertilizer application may aid in the absorption of N and other nutrients in the soil, thereby enhancing growth and rhizome yield of turmeric (Chandra *et al.*, 1997).

3.2. Soil Parameters

Soil pH

There was no significant difference ($P \geq 0.05$) in soil pH between the control (T4) and compound fertilizer treatments (Table 3). The favorable soil pH range for turmeric cultivation is around 5.5-6.5 (DEA, 2021). According to results obtained, soil pH ranged between 6.2-7.4 which means slightly acidic to slightly alkaline in treatments. There were slight increases and decreases of soil pH in treatments compared to favorable pH range (5.5-6.5) as a result of fertilizer application due to the presence of inorganic ions. According to the study of Chandra et al. (1997), 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.
Nitrogen (N), Potassium (K), and Sulfur (S) are major plant nutrients that appear to be less affected directly by soil pH. Phosphorus (P), however, is directly affected. At alkaline pH values, greater than pH 7.5 for example, phosphate ions tend to react quickly with calcium (Ca) and magnesium (Mg) to form less soluble compounds. At acidic pH values, phosphate ions react with aluminum (Al) and iron (Fe) to again form less soluble compounds (Verma *et al.*, 2019). However, neither strong acidic nor alkaline pH (6.28-7.44) was recorded among the treatments in this study, indicating that soil pH may not have an effect on plant phosphorus and other nutrients uptake.

Soil EC

EC of the nutrient solution is related to the number of ions available to plants in the root zone. High EC has been associated with high levels of nitrate and other selected soil nutrients (P, K, Ca, Mg, Mn, Zn, and Cu) (Ding *et al.,* 2018). There was a statistically significant difference ($P<0.05$) in soil EC between control (T4) and treatments as shown in the Table 3. Turmeric seeds treated with compound fertilizers showed significantly highest ($P \leq 0.05$) soil EC than control (T4) which contained normal potting mixture of topsoil: sand: cow dung 1:1:1as a result of fertilizer application due to the presence of inorganic ions such as Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}, NH_4^{-} etc. As shown in the Table 3, maximum soil EC (195.0 µS) was recorded from turmeric seeds treated with 2 g of Hayleys balance fertilizer (T3L1) which contained

N: P: K 15:15:15 and control was shown significantly lowest (P≤0.05) (93.0 µS) soil EC because it didn't contain any inorganic/compound fertilizer.
According to the results obtained, cow dung alone (control/ T4) was recorded lower EC, while cow dung + compound fertilizers (NPK) showed significant increase in soil EC. These findings are in agreement with Arbad *et al.* (2008) who reported that bio fertilizers alone lower soil EC significantly and chemical fertilizers are responsible for the enhanced salinity of the soil.

Table 3: Soil parameters of turmeric nursery plants after 60 days from establishment

Treatments	Mean Soil pH	Mean Soil EC (µS)
T1L1	7.4^{a}	165.3^{abc}
T1L2	7.2^{a}	168.6^{abc}
T1L3	7.0^{a}	154.3^{bc}
T2L1	7.0^{a}	151.3^{c}
T2L2	6.6^{a}	184.0^{ab}
T2L3	6.2^{a}	168.0^{abc}
T3L1	6.5^{a}	195.0^{a}
T3L2	6.5^{a}	169.6^{abc}
T3L3	6.3^{a}	190.3^{a}
T4	7.0^{a}	93.0^{d}

Note: *Means with same letters along the columns are not significantly different.*
(**T1**- Yara Complex, **T2**- Yara Grower, **T3**- Hayleys Balance/SOP, **T4**- Control, **L1** -2 g, **L2** – 4 g, **L3** – 6 g)

3.3. Leaf Nutrient Parameters

Nitrogen Percentage (N%)

According to the Table 4, there was a significant difference (P≤0.05) between control (T4) and fertilizer treatments in leaf N%. According to the results obtained, turmeric seeds treated with cow dung + compound fertilizers (NPK) recorded significantly (P≤0.05) highest N% than those treated with cow dung alone (control/T4).

According to Akamine *et al.*, (2007), N is an essential nutrient of plants, which significantly increases vegetative growth parameters of turmeric than any other nutrients and also plants grown without N application resulted poorer vegetative growth. Results showed that turmeric seeds treated with 6 g Yara grower fertilizer (T2L3), which contains a nutrient ration of N: P: K at 21:7:14, recorded the maximum N% (2.6%) followed by 6 g Yara complex fertilizer (T1L3), which contains N: P: K at 12: 11: 18 recorded second highest N% (2.4%), while those treated with cow dung alone (control/T4) recorded significantly ($P \leq 0.05$) lowest N% (0.6%). These findings are in agreement with Kumar *et al.*, (2003), who reported that the optimum concentration of Nitrogen in leaves of turmeric is 1.22- 2.75%. According to the results obtained, Yara grower fertilizer (T2) showed highest N% because it contained highest N% (21%) in its composition and followed by Yara compound fertilizer (T1) and there was no significant difference between these two treatments. Also, there is an increasing trend in leaf N% with increasing the level of fertilizer (6 g>4 g>2 g) as shown in the Table 5. This is an attribute to that turmeric plants have uptake N from applied fertilizers. According to the study of Leghari *et al*. (2016), it revealed that plant height, number of tillers per plant, number of leaves per plant, leaf length and leaf width, number of mother rhizome, number of primary fingers, number of secondary finger and projected yield per hectare were influenced by N application (as foliar spray).

Phosphorus Percentage (P%)

While considering leaf tissue Phosphorus percentage (P%), there was significant difference between control (T4) and other treatments. Turmeric seeds treated with 4 g of Yara grower fertilizer (T1L2) showed the highest significant ($P \leq 0.05$) P percentage (6.2%) and followed by T1L3 treatment (6.2%). However, these two treatments were not significantly different from each other. Phosphorus is a major player when it comes to photosynthesis and has great significance in helping the plant grow. P aids the conversion of solar into chemical energy. Moreover, P supports and promotes root growth and blooming, respectively (Verma *et al*., 2019).

Potassium Percentage (K%)

According to Table 4, there was a significant difference ($P \leq 0.05$) in K% between control (T4) and other fertilizer treatments. Yara complex fertilizer of 6 g (T1L3) contained N: P: K 12:11:18 showed significantly ($P \geq 0.05$) highest potassium percentage (3.8%). According to Verma *et al*. (2019), Potassium is the third major plant nutrient following N and P. K helps greatly in photosynthesis, improving the quality of fruits, protein building, and disease reduction. On the whole, K is an important element for plant health, growth, and nutrition. These findings are in agreement with Kumar *et al.* (2003), who reported that the optimum concentration of Potassium in leaves of turmeric is 3.66- 6.6%.

Table 4: Leaf nutrient parameters of turmeric nursery plants after 60 days from establishment

Treatments	N%	P%	K%
T1L1	1.9[bcd]	5.3[ab]	2.0[f]
T1L2	2.1[abc]	6.2[a]	2.7[e]
T1L3	2.4[ab]	6.2[a]	3.8[a]
T2L1	2.1[abc]	4.8[ab]	2.7[de]
T2L2	2.5[a]	3.7[bc]	3.0[cde]
T2L3	2.6[a]	4.9[ab]	3.2[bcde]
T3L1	1.4[d]	4.7[ab]	3.8[ab]
T3L2	1.6[cd]	4.5[ab]	3.3[abcd]
T3L3	1.8[bcd]	5.2[ab]	3.4[abc]
T4	0.6[e]	2.5[c]	3.2[cde]

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

(**T1-** Yara Complex, **T2-** Yara Grower, **T3-** Hayleys Balance/SOP, **T4-** Control, **L1** -2 g, **L2** – 4 g, **L3** – 6 g)

4. Conclusions

This experiment indicated that growth performances of turmeric nursery plants propagated using 10 g rhizome pieces can be increased by the cooperation of compound fertilizers to potting mixture including Topsoil: Sand: Cow Dung (1:1:1). Yara complex, Yara grower and Hayleys balance/SOP compound fertilizers are effective for the early growth of turmeric plants. Yara complex fertilizer can be identified as the best compound fertilizer out of these three fertilizers. High fertilizer levels (6 g per pot) give excellent growth performance than low fertilizer levels (2 g per pot). Yara complex 6 g per pot (T1L3) is the best compound fertilizer and level to improve the vegetative growth of turmeric nursery plants.

5. References

Abeynayaka, A. A. S. L., Bandara, . A. M. K. R., Lankapura, A. I. Y. and Idamekorala, P. R. (2020). Economics of Turmeric Production in Sri Lanka: An

Empirical Analysis in Major Turmeric Growing. *Asian Journal of Agricultural and Horticultural Research,* 6(4): pp.10-17.

Akamine, H., Ishimine, Y., Yogi, K., Hokama, K., Iraha, Y. and Aniya, Y. (2007). Effects of Application of N,P and K along or in Combination on Growth, Yeild and Curcumin Content of Turmeric (*Curcuma longa L.*). *Plant Production Science,* 10(1): pp.151-154.

Anxin, 2021. Anxin plant fertilizer. [Online] What are compound fertilizers. Available at: https://plantingfertilizer.com/what-are-compound-fertilizers/ [Accessed 9 September 2021].

Chandra , R., Desai, A. and Govind, S. (1997). Effect of foliar spray of magnesium and planting materials on growth and yield of turmeric. *Journal of Hill Research* , 10(1): pp.1-4.

Chanda S., and Ramachandra T.V. (2019). Phytochemical and Pharmacological Importance of Turmeric (*Curcuma longa*): A Review. *A Journal of Pharmacology.* 9 (1): pp.16-23

Compendium of Medicinal Plants. (2001). *Department of Ayurveda, Sri Lanka.* ISBN 955-606-025-1. 1(1): 196-199.

DEA, (2021). *Department of Export Agriculture.* [Online] Turmeric Cultivation. Available at: http://www.dea.gov.lk/turmeric/ [Accessed 22 February 2021].

Govind, S., Gupta, P. N. and Chandra , R., (1990). Response of N and P levels on growth and yield components of turmeric in acid soils of Meghalaya.. *Indian Journal of Horticulture* ,47: pp.79-84.

Hossain, A., Ishimine, Y., Akamine, H. and Motomura, K. (2005). Effects of Seed Rhizome Size on Growth and Yield of Turmeric (*Curcuma longa* L.). *Plant Production Science,* 8(1): pp.86-94.

Indrajith, D. and Avinash, K. (2015). Turmeric Growth and development under Tropical Nursery Conditions at Basmath Tahsil of Hingoli district in Maharashtra. *Researcher,* 7(2): pp.20-27.

Jayaweera, D.M.A. (1982). Medicinal plant (Indigenous and Exotic) used in Ceylon, part 5, p.201, *National Science Council, Sri Lanka.*

Jyotirmayee, B.and Gyanranjan M. (2022) A review on selected pharmacological activities of *Curcuma longa* L., *International Journal of Food properties,* 25:(1): pp.1377-1398, DOI: 10.1080/10942912.2022.2082464

Kumar, D., Singh, R., Gadekar, H. and Patnaik, U. (2003). Effect of different mulches on moisture conservation and productivity of rainfed turmeric. *Indian Journal Soil Conservation,* 31(1): pp.41-44.

Labban L. (2014). Medicinal and pharmacological properties of Turmeric (*Curcuma longa*): A review. *International Journal of Pharmacology and Biomedical Sciences*. 5(1): pp.17-23

Leghari, S., Wahocho, N., Laghari, G., Laghari, A., Bhabhan, G., Talpur, K., Bhutto, T., Wahocho, S. and Lashari, A. (2016). Role of Nitrogen for Plant Growth and Development: A Review. *AENSI journals ,* 10(9): pp. 209-218.

May, A., Cecilio, F., Cavarianni , R. and Barbosa, J. (2005). Turmeric (*Curcuma longa* L.) development and productivity in function at nitrogen and potassium doses. *Revista Brasileira de plantas Medicinais,* 7(3): pp.73-78.

Prasad, S. and Aggarwal, B. (2011). Herbal Medicine: Biomolecular and Clinical Aspects. 2nd ed. Florida: Taylar and Francis., p. 500. Available at: www.routledge.com/Herbal-Medicine-Biomolecular-and-Clinical-Aspects-Secon.

Reshma, H. and Vishwanath, Y. (2020). Advances in production technology of turmeric. *Journal of Pharmacognosy and Phytochemistry,* 9(4): pp.1198-1203.

Swarnathilaka, D. and Nilantha, K. (2012). Effect of Plant Growth Regulators and Liquid-Solid Nature of the Media on In-vitro Propagation of *Curcuma longa* (Turmeric). *Journal of Food and Agriculture ,* 5(1-2): pp.22-29.

Verma, P., Padalia, R., Singh, V. and Kumar, A. (2019). Effect of Nitrogen, Phophorus and Potassium levels on growth and yield of turmeric (*Curcuma longa L.*) under the Katyur valley of western Himalayan region of Uttarakhand. *Journal of Medicinal Plants Studies,* 7(2): pp.117-122.

Yara, (2022). *Yara.* [Online] yara Mila Compex. Available at: https://www.yara.in/crop-nutrition/fertiliserchoices/yaramila/yaramilacomplex/?msclkid=b5b8085ccfa311ec94ffd9f953f2a73b [Accessed 18 June 2021].