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Effect of Integrated Use of L-Tryptophan and Chemical Fertilizer on Growth and Yield Performances of Radish (*Rhaphanus sativus* L.)

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Abstract

L-Tryptophan (L-TRP) is an essential amino acid that performs as a physiological precursor of auxins in higher plants. A pot experiment was conducted at the Agro Technology Park, Eastern University of Sri Lanka to find out the effect of integrated use of L-Tryptophan (L-TRP) and chemical fertilizer on growth and yield performance of Rhaphanus sativus L. There were six treatments with three replicates laid out in a Completely Randomized Design in a factorial arrangement. The treatment combinations were rates of fertilizer (recommended fertilizer rate by the Department of Agriculture and half of that recommendation), and concentration of L-TRP (0 M, 10^{-3} M, 10^{-4} M). Measurements were taken at 45 days after sowing of radish. There was a significant interaction ($p<0.05$) between the concentration of L-TRP and fertilizer rate on tested parameters of radish. All the tested parameter were significantly increased at 10^{-4} M of L-TRP over the control at recommended fertilizer rate while at half of recommended fertilizer rate, all the parameters were significantly high at 10^{-3} M of L-TRP over the control. It can be concluded that the application of L-TRP as a phytohormone precursor can be used to increase the growth and yield performance in radish at different fertilizer rate.

Key words: *Fertilizer rate, Interaction, L-Tryptophan, Radish, Rhaphanus sativus, Phytohormone*

Introduction

Crop production efficiencies are extended through the integrated nutrient management practices promoting collective use of inorganic, organic and biotic resources in a consistent way to balance efficient use of limited resources and to ensure environmental sustainability against nutrient mining and degradation of soil and water resources. Now is the time to look at bioenergetics and biochemical aspects of plants, to achieve the goal of farmers.

In this regard, amino acids are one of the organic nitrogenous compounds and they play a role in the synthesis of proteins (Davies, 1982). Amino acids which have a high integrity with different metabolic pools in plants were used to promote plant growth (Coruzzi and Last, 2000). Effects of aminolevulinic acid as a plant hormone and precursor of chlorophyll, vitamin B_{12} and other tetrapyrrole compounds in plants have been reported previously (Hotta *et al*., 1997 and Yongin *et al*., 2003).

Phytohormones are bio molecules which influence the growth and development of plants (Sajjad *et al*., 2014). These bio molecules are naturally produced by the plant itself as well as by the microbes in the rhizosphere (Kravchenko *et al*., 2004). Production of phytohormones could be improved by the provision of suitable precursors to the rhizobial microbes. L-TRP is an essential amino acid that performs as a physiological precursor of auxins in higher plants. Exogenous application of L-TRP as precursors of phytohormones is a way of dealing with present situation of declining soil quality due to over usage of synthetic fertilizers to increase the crop production in order to

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satisfy the demand for food, worldwide. The IAA is the most active form of auxin in majority of plants. It is a significant phytohormone involved in the activities such as root initiation, cell enlargement, vascular tissue differentiation, cell division, apical dominance, leaf and fruit abscission, flowering, leaf senescence and fruit setting. Many species of microbes in the rhizosphere enhance the nutrient uptake of plants by producing Indole Acetic Acid (IAA) that expands root growth (Kevin, 2003; Khalid *et al*., 2004).

The growth and yield of diverse crops in response to soil application of L-TRP has been documented in maize (Arshad *et al*., 2004) and radish (Asghar *et al*., 2006). Tuberization is a morphogenetic physiological activity associated with the vegetative and reproductive development of radish plants. Generally plant hormones play an important role in the regulation of the growth. Secondary growth of radish is controlled by auxin and cytokinin (Torrey, 1976). Auxins apparently determine the sink activity of the tubers by controlling cell division and cell enlargement (Melis and Van Staden, 1984). Available IAA content and their effect on tuber formation have a positive relationship (Kolachevskaya *et al*., 2015).

In Sri Lanka, Radish is one of the vegetables that can be grown in all agro ecological regions throughout the year if adequate wetness is available. It is also used as a vegetable or a salad and provides significant quantity of nutrients, such as protein, fat, carbohydrate, fiber, ash, calcium, sodium, phosphorus and potassium (Crop Recommendation-Department of Agriculture, 2009).

Therefore, the present study was conducted to investigate the effect of integrated use of L-TRP and chemical fertilizer on growth and yield performance of *Rhaphanus sativus* L.

Materials and Method

Experimental Site

The experiment was conducted at the technology park, Faculty of Agriculture, Eastern University, Sri Lanka and it is positioned in the latitude of 7^0 43' N and the longitude of 81^0 42'. It belongs to the agro ecological region of low country dry zone (DL_2) in Sri Lanka. During this experimental period, the mean annual rainfall was 1700 mm and temperature was 33^o C.

Experimental Design

A pot experiment was conducted which consisted of six treatments with three replications, laid out in Complete Randomized Design (CRD). The treatments were arranged in 2 x 3 factorial where two fertilizer treatments; n_0: Department of Agriculture (DoA) recommended fertilizer rate consisting of urea:180 kg/ha, MOP: 130 kg/ha and TSP: 110 kg/ha per container; n_1:Half of DoA recommended fertilizer rate consisting of urea: 90 kg/ha, MOP: 65 kg/ha and TSP: 55 kg/ha per container and three concentration of L-TRP (control (t_0),10^{-3} M (t_1), 10^{-4} M (t_2)) were considered as treatments. Consequently, six treatment combinations were thus possible using the two main factors. Three replicated containers were prepared for each treatment.

Pot Arrangement

Plastic containers with the dimensions of 25 cm of length, 24.8 cm of width and 23 cm depth were used. Firstly, the bottoms of the pots were covered by net in order to prevent the root penetration via drainage holes. Then, it was filled with garden soil with the pH of 6.3 mixed with cattle manure at the rate of 10 ton per ha and the sieved potting mixture was distributed uniformly in every container and basal fertilizer application was done. Three days after basal dressing, four radish seeds of *Rhaphanus sativus* "Beeralu raabu" were sown into the centre of each soil container and thinned to one after fourteen days. The containers were kept in an open field conditions for 45 days.

Preparation and Application of L-TRP solution:

L-TRP stock solution was prepared in distilled water using the L-TRP powder. For the preparation of 1 M stock solution, 204.225 g of powder was dissolved in 1000 mL of distilled water. According to the treatments (10^{-3} M, 10^{-4} M, control), the stock solution was diluted and applied. First and second soil drenching was done at three and four weeks after sowing, respectively. Distilled water was applied to the control treatment. The application volume was 150 mL per container at a time.

Agronomic Practices

Agronomic practices were followed based on the recommendations of Department of Agriculture. Irrigation was done except on rainy days by using watering can. As warm climatic condition experienced, irrigation was managed as per the requirement.

Measurements

Data on growth and yield parameters radish were collected at 45 days after sowing. Attributes such as plant height, leaf area (Model- LICOR- 3000C, Lincolin), fresh weight of plant and yield attributes such as tuber length, tuber diameter (diameter at 2.5 cm distance away from both top and bottom of the tuber by using vernier caliper was recorded followed by the average value was taken as diameter of the tuber) and yield per plant were taken by destructive sampling method.

Statistics

The analysis of L-TRP, at three concentrations, was combined in a factorial arrangement with two rates of fertilizer treatment. The data were analyzed by General Linear Model to find out the interaction between two main factors followed by one-way analysis of variance (ANOVA) to determine the main effects of two factors on growth and yield parameters. The mean separation was performed using Tukey test when significant effects were detected by ANOVA. All the analysis was carried out by using Minitab 14.

Results and Discussion

Plant height

Results obtained revealed that there were no significant ($p < 0.05$) differences among the treatments on plant height of radish. This result was not coinciding with previous studies.

Leaf area

Leaf area is one of the key parameters which determine the ultimate yield of Radish. Khan *et al*. (2005) stated that leaf area index (LAI) is very important growth parameters in evaluating crop growth and may be an indication of potential productivity. The present investigation showed that integrated use of L-TRP and fertilizer significantly influenced the leaf area development of radish plant at 5% of significant level (Table 1).

In addition to that, there were significant interaction between concentration of L-TRP and rate of fertilizer. At DoA recommended rate of fertilizer, there were significant differences among the treatments. L-TRP of 10^{-4} M concentration significantly increased (0.99 fold) the leaf area over control followed by 10^{-3} M.

At half of DoA recommended fertilizer rate, Application of 10^{-3} M L-TRP significantly ($p=0.000$) increased the leaf area by 1.09 fold over that of control. El-Awadi *et al*. (2011) reported that application of recommended rate of fertilizer significantly increased the vegetative growth criteria when adding with L-TRP at lower concentration in Mung bean cultivation. Mumtaz *et al*. (1999) reported that, application of a low concentration of L-TRP to soil of potatoes, produced leaves with higher chlorophyll content than those of untreated controls.

Table 1. Effect of integrated use of L-TRP and chemical fertilizer on plant height and leaf area at 45 Days after sowing of Radish *(cv. 'Beeralu raabu')*.

Fertilizer (N)	L-TRP (T)	Plant height (cm)	Leaf area (cm^2)
Half rate of recommended fertilizer	10^{-3} M	15.80±0.34 a	305.25 ± 16.99 a
	10^{-4}M	15.10±0.87 ab	222.66 ± 22.17b
	No L-TRP	13.63±0.86 ab	146.03 ± 30.01c
Recommended rate of fertilizer	10^{-3} M	16.50±0.34 ab	291.82 ±15.1 b
	10^{-4}M	17.40±0.55 a	396.72 ±6.94 a
	No L-TRP	15.73±0.64 ab	198.63 ±1.39 c
Probability level	N	0.007	0.000
	T	0.035	0.000
	N*T	0.856	0.000

Values within rows having different letter/letters indicate significant differences at 5% level of significance by Tukey test (N=3)

Fresh Weight of Plant

Data related to the effect of treatments on average fresh weight of plant is given below (Table 2). There was an interaction between concentration of L-TRP and fertilizer rate on fresh weight of radish plant. It further confirms that L-TRP of 10^{-4} M significantly increased the fresh weight of plant by 0.49 fold followed by 10^{-3} M by 1.77 fold at DoA recommended fertilizer rate while 10^{-3} M of L-TRP followed by 10^{-3} M significantly increased the fresh weight of plant at half DoA recommended fertilizer rate. Plant dry matter is associated with fresh weight of plants and it depends on leaf area. The higher value of leaf area was recorded in treatments which received L-TRP than control treatment. It could be the reason for higher fresh weight in treatments received with L-TRP. The present findings support the earlier studies done in mung bean by El-Awadi *et al*. (2011).

Table 2. . Effect of integrated use of L-TRP and chemical fertilizer on fresh weight of plant at 45 Days after sowing of Radish (cv.Beeralu raabu).

Fertilizer (N)	L-TRP (T)	Fresh weight of plant (g)
Half rate of recommended fertilizer	10^{-3} M	41.92±0.98 a
	10^{-4}M	39.93±0.26 a
	No L-TRP	15.10±0.87 ab
Recommended rate of fertilizer	10^{-3} M	54.68±3.56 a
	10^{-4}M	70.93±0.55 a
	No L-TRP	36.58±1.41 c
Probability level	N	0.000
	T	0.000
	N*T	0.045

Values within rows having different letter/letters indicate significant differences at 5% level of significance by Tukey test (N=3).

Tuber Length

Tuber length is one of the yield attributes of radish plant which indicates the degree of tuber formation. Table 3 showed that, integrated use of L-TRP and chemical fertilizer significantly ($p<0.05$) influenced on tuber length of radish and there was significant ($p=0.000$) interaction between the rate of chemical fertilizer and concentration of L-TRP on tuber length.

At DoA recommended rate of fertilizer, there were significant differences among the treatments. L-TRP of 10^{-4} M concentration significantly increased (1.12 fold) the tuber length over control followed by 10^{-4} M. At half of DoA recommended fertilizer rate, application of 10^{-3} M L-TRP significantly ($p=0.000$) increased the tuber length by 1.31 fold. Asghar *et al*. (2006) stated that addition of L-TRP to organic materials increased the concentration of plant hormone auxin in the organic matter which affected root growth and subsequently plant performances of radish.

Table 3. Effect of integrated use of L-TRP and chemical fertilizer on Tuber Diameter, Tuber Length and Tuber Yield per Plant at 45 Days after sowing of Radish (cv.Beeralu raabu).

Fertilizer (N)	L-TRP (T)	Tuber diameter (mm)	Tuber length (cm)	Tuber yield per plant (g)
Half rate of recommended fertilizer	10-3 M	24.37±1.18 a	10.09±0.29 a	29.58±1.28 a
	10-4M	14.64±0.54 b	7.56±0.61 c	15.67±1.77 b
	No L-TRP	10.66±0.19 c	4.36±0.08 b	10.22±0.91 c
Recommended rate of fertilizer	10-3 M	24.71±1.18 b	6.43±1.12 b	40.96±0.77 b
	10-4M	35.22±1.16 a	13.52±0.36 a	61.67±5.79 a
	No L-TRP	19.98±0.46 c	6.46±0.31 b	23.91±1.18 c
Probability level	N	0.000	0.008	0.000
	T	0.000	0.000	0.000
	N*T	0.000	0.000	0.000

Values within rows having dissimilar letter/letters indicate significant differences at 5% level of significance by Tukey test.

Tuber Diameter

The effect of L-TRP concentration on tuber diameter of radish was significantly influenced by the fertilizer rate at 5% of significant level. It confirms that there was an interaction between fertilizer rate and L-TRP concentration and they were not independent each other on tuber diameter of radish (Table.3).

At DoA recommended fertilizer rate, there were significant differences among the treatments ($p<0.05$). Tested parameter of tuber diameter per plant was significantly increased at 10^{-4} M concentration of L-TRP over the control by 0.76 fold followed by 10^{-3} M. At half of DoA recommended fertilizer rate, application of L-TRP on radish significantly increased the tuber diameter by 1.28 fold compared with control that was not received any L-TRP treatment. Similar findings are reported by Frankenberger *et al*. (1990) in Potato.

Tuber yield per plant

It is evident from table. 3 that different rate of chemical fertilizers and concentrations of L-TRP significantly ($p=0.000$) increased the tuber yield per plant. At the same time there was significant interaction between different rate of chemical fertilizers and concentrations of L-TRP on tuber yield.

Maximum value of tuber yield was recorded at 10^{-4} M where DoA recommended rate of fertilizer was applied and it was 1.56 fold more than the control followed by 10^{-3} M while at half of DoA recommended fertilizer rate, application of L-TRP at 10^{-3} M increased the tuber yield per plant by 1.28 fold over control at 5% level of significant level.

Tuber yield of plant directly associated with length and diameter of tuber. The highest length and diameter of tuber attributed to highest tuber yield per plant. This was confirmed that tuber formation was markedly influenced by the application of L-TRP on radish at different fertilizer rate. Further it was confirmed by Mumtaz *et al*. (1999) who proposed that application of L-TRP with the concentration range between 10^{-3} M to 10^{-5} M significantly increased the tuber yield of potato when incorporated with chemical fertilizer.

Conclusions

The L-TRP with 10^{-4} M was the best at DoA recommended level of fertilizer while L-TRP with 10^{-3} M was the best at half of DoA recommended level of fertilizer. Further it can be concluded that when the recommended fertilizer was reduced to half of the rate, the concentration level of L-TRP increased by tenfold. Therefore, this experiment confirmed that application of L-TRP as phytohormone precursor enhanced the tuber formation and yield in radish at different fertilizer rates.

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