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# EFFECT OF VARIOUS ORGANIC NUTRIENT COMBINATIONS ON GROWTH AND YIELD OF PALAK (*BETA VULGARIS* L. VAR. BENGALENSIS) IN HYDROPONIC NFT SYSTEM

**Poojitha V.[1*], Anitha B.[1], Tanuja P.[1], and Babith Raj Goud G.[2]**
[1]Department of Horticulture, School of Agricultural Sciences, Malla Reddy University, Hyderabad, India
[2]Department Crop Physiology, School of Agricultural Sciences, Malla Reddy University, Hyderabad, India
*Corresponding author E-mail: poojithaveerapaga@gmail.com
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**ABSTRACT**

A study was conducted to assess the impact of various nutrient solutions on the growth and productivity of palak (spinach) under a Nutrient Film Technique (NFT) hydroponic system. This research aims to evaluate the effects of different organic nutrients on growth, yield and quality parameters. Research method used in this study was a randomized block design with seven treatments and three replications. The treatments consist of different organic nutrients with combination. $T_1$-Vermiwash, $T_2$-Jeevamruta, $T_3$-Seaweed extract, $T_4$-Vermiwash +Sol A & B, $T_5$-Jeevamruta + Sol A & B, $T_6$-Seaweed extract +Sol A & B, $T_7$-Control Sol A & B. Among the seven treatments, $T_2$ shows less results compared to other treatments and $T_7$ control Sol A and Sol B (4 liters per 200 liters of water) showed the best results. This treatment led to improved plant growth, higher yields and better quality compared to other formulations. It also proved to be more economical, suggesting that this nutrient combination is a suitable and efficient choice for hydroponic cultivation of palak.
***Keywords***: Hydroponics, Palak, Nutrient solution and Growth performance.

## Introduction

Everlasting spinach, spinach beet, Indian spinach, and beet leaf are other names for palak (*Beta vulgaris* L. var. bengalensis), a leafy green vegetable that is closely related to Swiss chard (*Beta vulgaris* subsp. vulgaris). It belongs to the Chenopodiaceae family as well. It is a popular and versatile vegetable that is renowned for its healthy leaves and mild flavour. Palak is produced widely because of its adaptability to different climates and its value as a nutrient-dense leafy green vegetable. Spinach beet is a common leafy vegetable in tropical and subtropical regions. The Indo-Chinese region is where Palak originated. Although it is not very popular in South India, it is grown in many Indian states, particularly in the northern plains during the winter. Palak is commonly grown in states where it is very popular, such as Uttar Pradesh, West Bengal, Maharashtra, Rajasthan, Haryana, Punjab, Delhi, Madhya Pradesh Bihar, and Gujarat. The plant is referred to as the "Mines of Minerals" since it is rich in essential amino acids, protein, and antioxidants like carotene, flavones, and isothiocyanates, as well as minerals like iron, calcium, vitamin A, vitamin K, vitamin E, vitamin D, vitamin C, folic acid, thiamine, riboflavin, nicotinic acid, and pyridoxine.

Using hydroponics with or without the application of an inert medium to give the plant mechanical support, such as rockwool, gravel, vermiculite, peat moss, sawdust, coir dust, or cocopeat. The meaning behind the term hydroponics, which literally means "water work." In the early 1930s, Professor William Gericke coined the term "hydroponics" to describe the technique of cultivating plants with their roots suspended in mineral-rich water (Qiansheng *et al.*, 2018). Hydroponics can be promoted as "Smart Agriculture" for urban areas and integrated with the Indian government's "Smart Cities" plan, in addition to utilizing 22 times less water than traditional farming methods (Sari *et al.,* 2020).

## Materials and Methods

The following study was conducted at Malla Reddy University's college farm (Fan and Pad system) under protected circumstances. There were fifteen plants in each treatment and replication. The seeds are planted in displays that employ vermiculite, perlite, and cocopeat as a medium in a ratio of 3:1:1. One seed per cell is planted on November 11th in a fan and pad system (polyhouse) under a covered structure. There are 98 plug trays utilized for the sowing process, and each tray is 53.5 cm long and 27.5 cm wide. Tools used in this study are EC-mater, pH-meter and water pumps.

**Details of the experiment** - Experiment was designed as a randomized block design (RBD) with 3 replications and 7 treatments in a poly house with dimensions of 144 $m^2$.

Palak grown in a hydroponic system, NFT (nutrient film technique), Structure Fan & pad system poly house Structure, Randomized Block design (RBD), Variety-All green Treatments-7, Replications-3 in college farm, SOAS, Malla Reddy University.

**Treatments:**

$T_1$ Vermiwash 40ml/lit of water

$T_2$ Jeevamruta 40ml/lit of water

$T_3$ Seaweed extract 2ml/lit of water

$T_4$ Vermiwash+ solution A and B 20ml+ 10ml/lit of water

$T_5$ Jeevamruta + Solution A and B 20ml+10ml/lit of water

$T_6$ Seaweed extract+ Solution A and B 1ml+10ml/lit of water

$T_7$ Control (Solution A and B)

**Hydroponics:** The vertical hydroponics NFT system, which is most frequently used for growing green vegetables, was the subject of the experiment. Because the solution that supplies the oxygen for plant growth and development is continuously regenerated in the NFT system. NFT farming is advantageous in that it uses less water for crop development and growth. Plants can be grown in a straightforward nutrient solution or in sterile, microbe-free substrates (Kumari *et al*., 2018).

**Nutrient Solutions:** In accordance with the therapy, nutrient solutions were prepared and left unreplaced throughout the crop growth period. Every treatment has a separate reservoir that can hold 200 liters. Depending on their concentration, dilute the nutrients in each tank. The nutrient solutions are Vermiwash, Jeevamruta, Seaweed extract and Solution A&B.

## Results and Discussion

**Growth parameters**: Plant height (cm) and number of leaves: Four weeks following transplanting, palak plants cultivated under the investigated conditions were collected. Until harvest, plant height and leaf count were measured every 7, 14 and 21 days.

**Leaf length and width:** leaf length and width were measured from four weeks following transplanting and palak plants cultivated under the investigated conditions were recorded. Until harvest, leaf length and width were measured every 7, 14 and 21 days.

**Root length (cm):** Four weeks following transplanting, palak plants cultivated under the investigated conditions were collected. At harvest, root length was measured.

**Crop Growth Rate (CGR):** It can be defined as the increase of dry matter in grams per unit area per unit time. The mean CGR over an interval of time T1 and T2.

**Nutrient uptake:** After the harvest, plant samples were collected and sun-dried before being placed in brown paper bags with labels. After being oven dried for 48 hours at 600 C, the samples weight remained constant. The plant samples that had been oven-dried were pulverized, and the finely powdered samples were stored in butter paper bags with labels.

**Total yield (kg):** This was measured by weighing the marketable and non-marketable palak using a digital analytical weighing scale during the harvest.

**Plant fresh weight (g):** This is the total fresh matter weight and was measured by weighing the fresh weight of palak during harvest.

**Plant height and number of leaves:** The growth of palak, particularly plant height and number of leaves, is strongly influenced by water, light and nitrogen availability. In the present study, treatment $T_7$ produced the greatest plant height (23.97 cm) and highest number of leaves (22.93), which can be attributed to sufficient water supply, proper light exposure and higher nitrogen levels that enhanced chlorophyll formation, nutrient absorption and photosynthetic activity. As a result, plants under $T_7$ showed more vigorous vegetative growth. Conversely, treatment $T_2$ recorded the lowest plant height (16.19 cm) and leaf number (6.12), likely due to reduced nutrient availability and less favourable water and light conditions, limiting photosynthesis and cell expansion. Overall, the results emphasize that maintaining optimal environmental and nutrient inputs is crucial for promoting maximum vegetative growth in palak. The application of Vermi tea and nutrient solution under

non circulating hydroponic system has significant effects on the Plant height after Transplanting (Lorjhon *et al*., 2023). Investigated the role of liquid organic manures in tomato (*Solanum lycopersicum* L.) cultivation and observed that Jeevamruta application markedly enhanced plant growth. The improvement was greater than that obtained with the recommended dose of fertilizers, highlighting the effectiveness of liquid organic manures in promoting better nutrient uptake and growth (Gore, N. S. and Sreenivasa, M. N. 2011). Green Bean (*Phaseolus vulgaris* L.) in non-circulating hydroponic system with 0.5% vegetable waste solution was high in number of leaves (Madushani and Karunarathna, 2023).

**Leaf length and width:** Different nutrient solutions showed a clear impact on palak growth under hydroponics. T7 recorded the highest leaf length (17.27 cm) and width (7.45 cm), indicating superior nutrient support for leaf development. T2 showed the lowest values (8.14 cm and 2.45 cm), reflecting insufficient nutrient supply. The water hyacinth solution also improved growth, giving the highest leaf length (5.57 cm), width (3.73 cm) and leaf number (5) among organic treatments. These results highlight the importance of nutrient composition in enhancing palak leaf growth. The application of moringa leaf extract along with rice-washing water fertilizer noticeably enhanced the vegetative growth of *Pak Choi*, resulting in larger leaves and an increased number of leaves when treated with a 40% AB mix and 60% fermented organic liquid fertilizer (Sari *et al*., 2020). Albert solution showed the longest stem (5.10 cm), Water hyacinth solution performed well, proving cost-effective (Chamodya and Vijitha, 2024).

**Root length:** Using multiple nutrient solutions in the NFT hydroponics system resulted in notable differences in root properties in palak. Based on outcomes 21 days following transplantation. $T_7$ Solution A&B shows the maximum root length (29.60 cm) which contains macronutrients like phosphorus, which helps in root development. $T_2$ shows the lesser results (19.47 cm) due to various reaction that occur in jeevamruta which leads less oxygen and nutrients to the root system shows results in (Table 1). Lettuce grown under aeroponic conditions showed the highest root development and biomass, although this did not result in greater shoot growth when compared with hydroponics. The results indicate that aeroponic cultivation is more suitable for crops where root yield is of primary importance rather than shoot productivity (Li *et al*., 2018). In comparison study hydroponically and soil-grown spinach, finding that hydroponic cultivation resulted in longer roots (Gaikwad *et al*., 2023).

**Leaf area index:** The evaluation of leaf area across all treatments revealed notable differences based on the nutrient solutions applied in the NFT hydroponic system for palak cultivation. Among them, the control treatment using a synthetic nutrient solution showed an increase in the leaf area index. However, the $T_7$ treatment, which involved the application of Solution A & B, recorded the highest leaf area index (0.82), indicating superior performance." The low leaf area index was recorded in $T_2$ (0.05). Spinach grown under a green shade net in a hydroponic system produced the highest leaf area (22.2 $dm^2/m^2$), while cocopeat under the same shade also performed well, indicating improved vegetative growth under filtered green light (Karne *et al*., 2028). The results of some studies concluded that AB mixed nutrients at a concentration of 1950 ppm resulted in a leaf area of (47.32 $cm^2$) (Harahap *et al*., 2020). The study found that spinach grown hydroponically exhibited superior leaf characteristics, including a larger leaf area (Gaikwad *et al*., 2023).

**NPK uptake:** The highest NPK content (0.83, 0.43, 1.08% respectively) in leaves was observed in treatment $T_7$ with Solution A & B shows in (Fig. 3) due to high inorganic nutrient concentration and continuous flow of nutrients. Nutrient uptake depends on optimal pH (5.5– 6.5) and TDS (800–1000). Minimum NPK was found (0.37, 0.09, 0.46% respectively) in $T_2$ (Jeevamruta) due to its slow nutrient release and reliance on microbial conversion. The study showed that the NPK content in lettuce leaves was highest in the hydroponic growing medium, with significantly higher values compared to the substrate culture (Qiansheng *et al*., 2028). An investigation on yield and quality traits of lettuce and spinach grown under different hydroponic systems revealed that hydroponic cultivation, especially through the NFT system, resulted in considerably higher nutrient accumulation. Plants grown in NFT recorded greater nitrate, phosphorus and sulphur content compared with other systems, indicating its efficiency in nutrient uptake (Acharya *et al*., 2021).

**Fresh weight:** Fresh weight of palak recorded at seven-day intervals (Fig. 4) showed noticeable differences among the treatments. Plants grown under T7 consistently registered the highest fresh weights (9.17, 14.60 and 23.77 g), which can be attributed to the efficient supply of nutrients that enhanced water uptake and maintained greater turgor pressure, thereby improving biomass accumulation. In contrast, T2 recorded lower fresh weights (7.37, 13.80 and 21.47 g), indicating that the nutrient availability under this

treatment was not sufficient to support maximum growth. These results suggest that balanced and adequate nutrient solutions play a key role in increasing the fresh weight of palak in hydroponic systems. The study showed that hydroponic yield depended on both lettuce cultivar and nutrient level, with the N3 solution (250 ppm N, 300 ppm K, 250 ppm Ca) giving the highest fresh weight for Buttercrunch and Black Seeded Simpson cultivars (Sapkota *et al*., 2029). The study showed that spinach grown in the NFT (Nutrient Film Technique) system exhibited significantly improved plant growth characteristics, including higher fresh weight (Indira and Sabitha, 2024).

**Yield:** Three consecutive yields were reported at 15-day intervals following 23 days of transplanting. Control gives higher yield (5.07, 7.03, 9.90kgs) because there is no nutrient competition between the plants, nutrients are readily available and better light interception gives more biomass, multiple harvests significantly increase the yield. Vermicompost tea improved lettuce and tomato yields in a non-circulating hydroponic system, even when nutrient solutions were reduced by 25–50%, showing its effectiveness as a supplement for maintaining productivity with lower nutrient input (Norman *et al.,* 2019). Application of vermicompost and foliar spray of vermiwash on the growth, yield, and nutritional status of lettuce plants. The results showed a significant increase in yield (Yassen *et al*., 2020).

**Table 1 :** Effects of different nutrient solutions on leaf length and leaf width (cm) at different growth intervals of hydroponically grown palak.

| Treatments | 7 DAT | | 14 DAT | | 21 DAT | |
|---|---|---|---|---|---|---|
| | Leaf length (cm) | Leaf width (cm) | Leaf length (cm) | Leaf width (cm) | Leaf length (cm) | Leaf width (cm) |
| $T_1$ -Vermiwash (40ml/lit of water) | 3.28 | 1.47 | 6.38 | 2.66 | 12.33 | 5.2 |
| $T_2$ -Jeevamruta (40ml/lit of water) | 2.49 | 1.22 | 5.24 | 1.37 | 8.14 | 2.45 |
| $T_3$ -Sea weed extract (2ml/lit of water) | 3.47 | 1.53 | 7.46 | 3.15 | 12.75 | 6.18 |
| $T_4$-Vermiwash + Solution A&B (20ml+10ml/lit of water) | 3.69 | 1.57 | 7.50 | 3.28 | 13.50 | 6.48 |
| $T_5$-Jeevamruta + Solution A&B (20ml+10ml/lit of water) | 3.38 | 1.50 | 7.33 | 2.94 | 12.49 | 6.06 |
| $T_6$-Sea weed extract + Solution A&B (1ml+10ml/lit of water) | 4.13 | 1.70 | 9.05 | 3.58 | 15.61 | 7.16 |
| $T_7$-Control Solution A&B (10ml+10ml/lit of water) | 4.24 | 1.72 | 9.14 | 3.99 | 17.27 | 7.45 |
| SEm (±) | 0.12 | 0.04 | 0.28 | 0.19 | 0.28 | 0.11 |
| CD(P=0.05) | 0.36 | 0.11 | 0.87 | 0.59 | 2.02 | 0.34 |

**Table 2 :** Effects of different nutrient solutions on root length (cm) of hydroponically grown palak.

| Treatments | Root length (cm) |
|---|---|
| $T_1$ -Vermiwash (40ml/lit of water) | 21.03 |
| $T_2$ -Jeevamruta (40ml/lit of water) | 19.47 |
| $T_3$ -Sea weed extract (2ml/lit of water) | 23.77 |
| $T_4$-Vermiwash + Solution A&B (20ml+10ml/lit of water) | 24.90 |
| $T_5$-Jeevamruta + Solution A&B (20ml+10ml/lit of water) | 22.43 |
| $T_6$-Sea weed extract + Solution A&B (1ml+10ml/lit of water) | 28.34 |
| $T_7$-Control Solution A&B (10ml+10ml/lit of water) | 29.60 |
| SEm (±) | 0.46 |
| CD(P=0.05) | 1.42 |

**Table 3 :** Effects of different nutrient solutions on yield (kg/m$^2$) of hydroponically grown palak.

| Treatments | 23 DAT | 33 DAT | 43 DAT |
|---|---|---|---|
| | Yield/Unit (kg/m$^2$) | Yield/Unit (kg/m$^2$) | Yield/Unit (kg/m$^2$) |
| $T_1$ -Vermiwash (40ml/lit of water) | 2.83 | 3.13 | 6.00 |
| $T_2$ -Jeevamruta (40ml/lit of water) | 0.87 | 1.20 | 4.07 |
| $T_3$ -Sea weed extract (2ml/lit of water) | 3.70 | 4.87 | 7.27 |
| $T_4$-Vermiwash + Solution A&B (20ml+10ml/lit of water) | 4.10 | 5.03 | 8.10 |
| $T_5$-Jeevamruta + Solution A&B (20ml+10ml/lit of water) | 3.33 | 4.10 | 6.53 |
| $T_6$-Sea weed extract + Solution A&B (1ml+10ml/lit of water) | 4.50 | 6.00 | 8.87 |
| $T_7$-Control Solution A&B (10ml+10ml/lit of water) | 5.07 | 7.03 | 9.90 |
| SEm (±) | 0.12 | 0.10 | 0.17 |
| CD(P=0.05) | 0.37 | 0.32 | 0.52 |

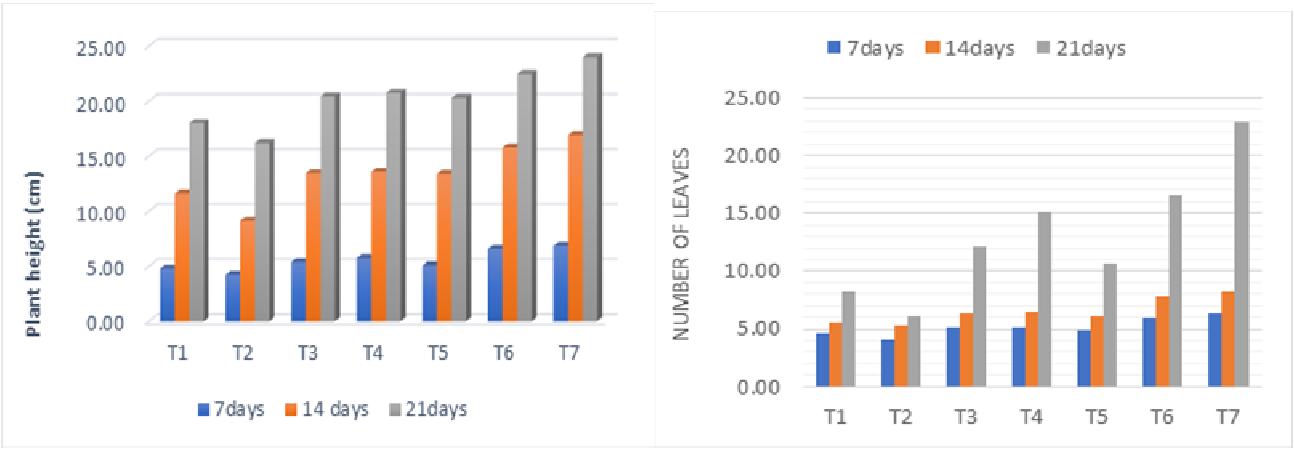


**Fig. 1 :** Graphical representation on plant height (cm) and number of leaves of hydroponically grown palak using different organic nutrient solutions at 7,14 and 21 DAT.

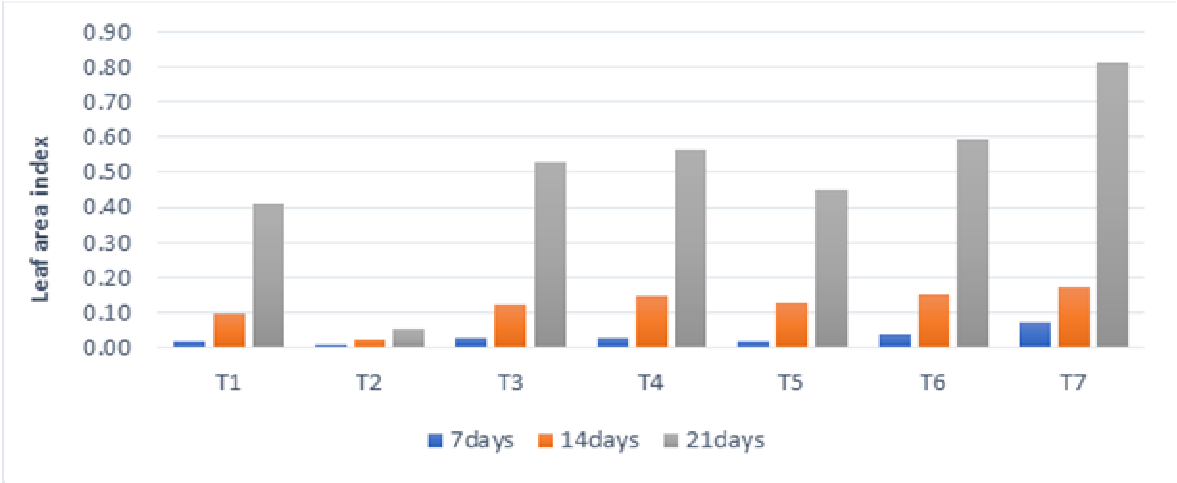


**Fig. 2 :** Graphical representations on leaf area index of hydroponically grown palak using different organic nutrient solutions at 21 DAT.

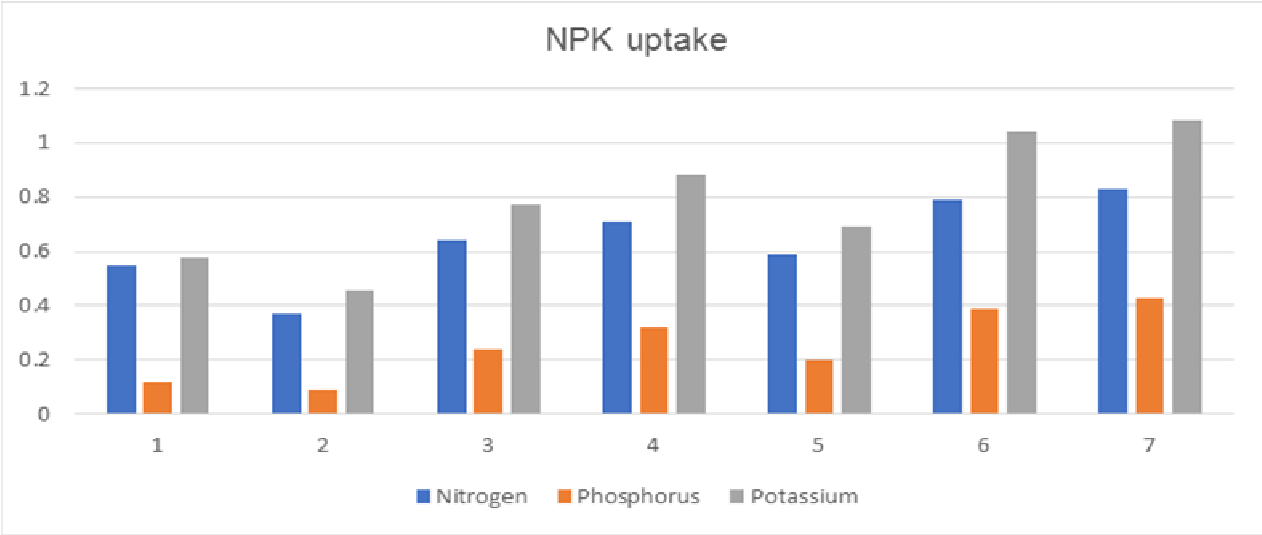


**Fig. 3 :** Graphical representations on NPK (%) uptake on hydroponically grown palak using different organic nutrient solutions at 21 DAT.

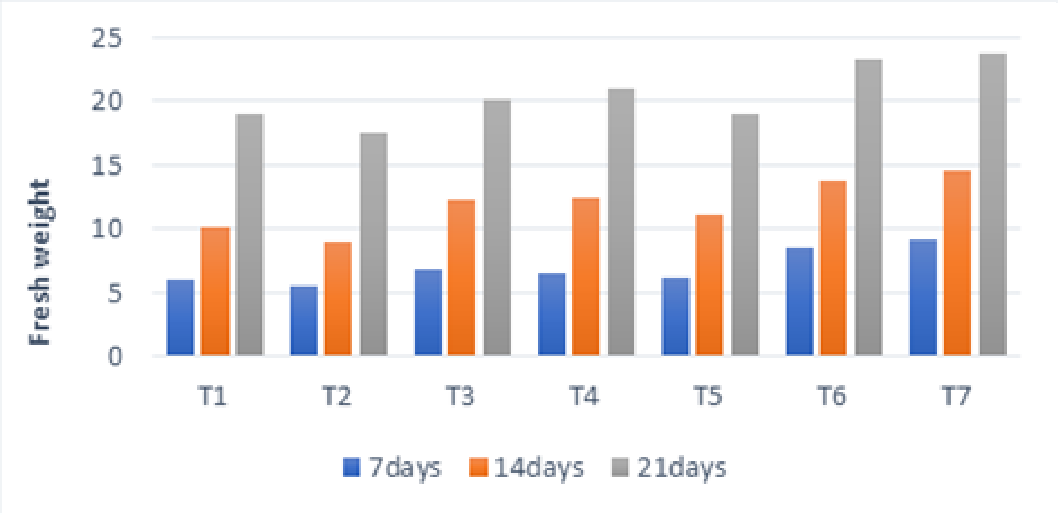


**Fig. 4 :** Graphical representations on fresh weight (g. plant$^{-1}$) of hydroponically grown palak using different organic nutrient solutions at 21 DAT.

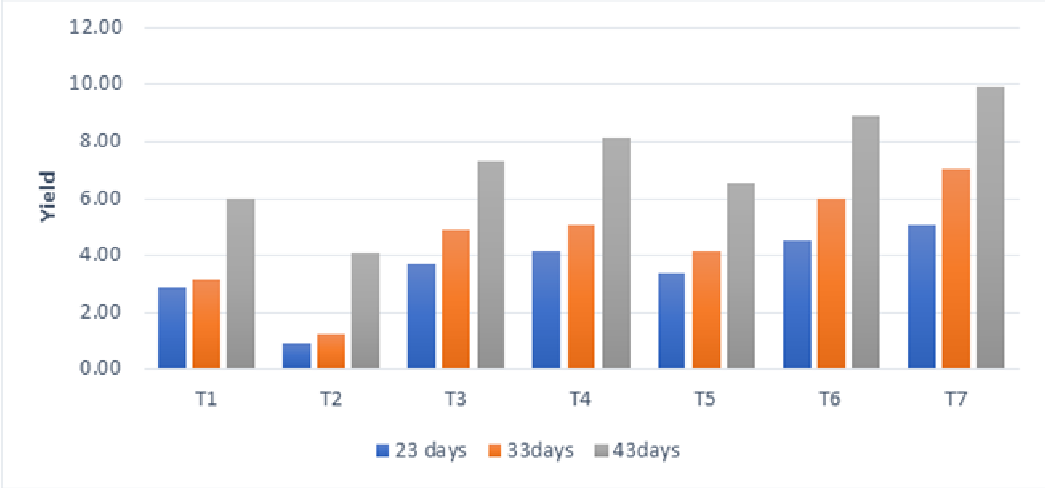


**Fig. 5 :** Graphical representations of the yield (kg/m$^2$) of hydroponically grown palak using different organic nutrient solutions at 21 DAT.

## Conclusion

Different organic nutrient solutions effect the growth and yield of the palak and treatment $T_7$, using Sol A and Sol B was the most effective for hydroponic palak cultivation under the NFT system. It resulted in better plant growth, higher yield, improved quality and greater economic efficiency compared to other treatments. Thus, $T_7$ is recommended for optimal performance in hydroponic palak production.

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