<u>Original Research Article</u>

Effect Of Indole-3-Acetic Acid and Nano-Urea on Agronomic Attributes of Radish Crops

Abstract:

This study aimed to evaluate the impact of nano-urea, indole-3-acetic acid, phosphorus, and potassium on seed germination and various growth parameters of *Raphanus sativus* L. Seeds were subjected to different treatments, and seed germination percentage was measured on the 14th day after sowing. The results demonstrated that all treatments improved seed germination compared to the control. Nano-urea alone increased the germination percentage from 40.83% to 54.16%, while the combination of nano-urea and indole-3-acetic acid further enhanced it to 67.5%. The highest germination percentage of 75.83% was achieved with the simultaneous application of nano-urea, phosphorus, potassium, and indole-3-acetic acid. Additionally, the treatments influenced the number of leaves at different stages of growth. The treatment with indole-3-acetic acid, nano-urea, phosphorus, and potassium resulted in the highest leaf count of 61.26. Moreover, the length of leaves, roots, and shoots were significantly affected by the treatments. The combination of indole-3-acetic acid, nano-urea, phosphorus, and potassium resulted in the longest leaf, root, and shoot lengths. These findings highlight the positive effects of the tested treatments on seed germination and various growth parameters of Raphanus sativus L. The results contribute to our understanding of the potential applications of nano-urea, indole-3-acetic acid, phosphorus, and potassium in improving crop productivity and growth. This information can aid in the development of sustainable agricultural practices for enhanced crop performance and yield.

Keywords: Radish, Indole-3-acetic acid, Nano-urea, Foliar spray, Plant Growth Regulators

Introduction

The radish (*Raphanus sativus* L.) belong of the Brassicaceae family, probably originated in Europe or Asia. It is grown for its young, fleshy tuberous roots, which are primarily consumed as a salted vegetable or grated salad. Having a long history, radish roots and leaves are excellent sources of calcium, phosphorus, ascorbic acid, folic acid, and potassium. This fast-growing plant is easy to cultivate. While the root is commonly eaten, the entire plant is edible, including the leafy tops (Shirani *et al*., 2009). Sun-dried radish roots are cooked and consumed during the off-season and for long-term storage. Sun-dried radish has higher levels of sucrose, proline, and branched-chain amino acids (Kumakura *et al.,* 2017). Radish is a cool-season crop classified into two groups: European or temperate and Asiatic or tropical. Asiatic varieties thrive in tropical climates, producing roots and seeds, while European varieties grow roots in sub-tropical and tropical regions. However, European varieties require chilling temperatures in hilly areas for seed development. Asiatic varieties generally have higher yields but may lack quality attributes. European varieties are smaller in size, mildly pungent, mature early, and have high-quality parameters (Tripathi *et al.,* 2017). In India, radish production totals 3347MT, with Punjab contributing 385.15T (NHB, 2022).

Integrated nutrient management aims to combine traditional and modern methods of nutrient management into environmentally sustainable and economically viable farming systems. The objective is to efficiently and judiciously utilize both organic and inorganic sources of nutrients. Given its short duration and rapid growth, radish requires rapid and uninterrupted root growth, making the application of organic, inorganic, and biofertilizers crucial (Poonkodi *et al.,* 2019). Foliar fertilization, particularly with trace elements, has consistently shown positive effects on plant metabolism and yield under various practical cultivation conditions. This highlights the significance of foliar application of macro elements as well (Poonkodi *et al.,* 2019). Urea is absorbed and translocated by plants, serving as an effective nitrogen source. It contains 46% N, reduces handling costs, and has minimal environmental impact. Spraying urea solution is widely used for nitrogen application. Foliar application swiftly counteracts mineral imbalances, enhancing nutrient absorption efficiency (Shirani *et al.,* 2009).

Plant hormones and growth regulators influence plant growth. Auxins, gibberellins, cytokinins, abscisic acid, and ethylene play crucial roles. They have rapid impacts on vegetative growth and crop yield, making them time-efficient and environmentally friendly (Kaur *et al.*, 2018). Compared to traditional urea, foliar application of nano urea liquid during crucial crop growth phases of a plant effectively satisfies its nitrogen need and increases crop yield and quality (Sahu *et al*., 2022).

Methods and material

The field experiment covered an area of 200 square meters (20 m length and 10 m breadth) in the experimental field at latitude 31°25, 23N and longitude 75°48, 32, E, determined. The experiment followed a randomized block design with three replications and eight treatments. In this study, nano-urea (Nano urea is a nitrogen source essential for crop growth and development, applied at a rate of 16 ml in 4 L) was used. Nano urea (IFFCO) was the nitrogen fertilizer source, with a total volume of 500 ml, of which 4 ml was mixed with 100 ml of water for foliar spray on the leaves. It was applied at intervals of 15 days, 45 days, 75 days, and 110 days to supplement nitrogen (N). Single super phosphate (@ 225.12 gm) was used as the source of phosphorous (P), and muriate of potash (MOP) (@ 450 gm) was used as the source of potassium in the soil. The following treatments (T0 - T7) were replicated in triplicates:

Table. 1. Details of treatments

Treatment Symbols	Treatments details
T_0	Control: only irrigation water
T_1	Nano-urea as a foliar spray about (4%).
T_2	Phosphorous (P) + Potassium (K) alone as fertilizer in soil as per recommended.
T_3	Nano-urea as a foliar spray, P+K as a fertilizer in soil.
T_4	Indole-3 acetic acid (IAA) as a foliar spray.
T_5	Indole-3 acetic acid and nano-urea as a foliar spray
T_6	Indole-3-acetic acid as a foliar spray and P+K as a solid fertilizer.
T_7	Indole-3-acetic acid as a foliar spray, nano-urea as a foliar spray and P+K as a solid form.

2.1. Seed and Sowing

Selecting fresh and healthy seeds, they were thoroughly washed before sowing. The seeds were continuously sown in ridges, maintaining a seed-to-seed distance of 10 cm within each row. The row-to-row distance was 45 cm. Field sowing was completed on October 18, 2022.

2.2. Thinning and weeding

Thinning is crucial in radish cultivation. Once the seedlings reached a height of two inches or around one week old, thinning was conducted to ensure a three-inch spacing between radishes. Crowded radishes hinder proper growth, leading to small and shriveled plants. One or two weeding were sufficient for this crop. The first weeding was done during earthing up, and if necessary, a second weeding was conducted a week later.

2.3. Soil Sampling and Plant Material Observations

Soil sampling was conducted in three different parts of the field. The soil observations are as follows: pH 7.60, N 75.26, P 29, K 160, organic content 0.98, and electrical conductivity 0.06. Observations on the plant material collected from various plants randomly selected in the field are as follows:

2.4. Number of leaves per plant and length

The total number of leaves on three randomly selected plants from each plot was counted at the time of harvesting, and the mean was calculated. The length of leaves was measured using a meter scale on three randomly selected plants from each plot.

2.5. Root length and shoot length (cm)

The root length of three randomly selected plants from each plot in each replication was measured using a meter scale, and the mean was calculated. The shoot length of three randomly selected plants from each plot in each replication was measured using a meter scale, and the mean was calculated.

2.6. Fresh biomass and dry weight

The fresh biomass of the roots was measured by weighing the fresh roots of three randomly selected plants from each plot. The dry weight of the roots was measured by weighing the dried roots.

2.7. Bud initiation

The number of days taken from the date of sowing (October 18, 2022) to the date when buds were initiated in each plot was recorded. Bud initiation occurred on February 2, 2023.

2.8. Flower, fruit and seed set

The number of days taken from the date of sowing (October 18, 2022) to the date when flowers were set in each plot was recorded. Flower set occurred on February 15, 2023. The number of days taken from the date of sowing (October 18, 2022) to the date when fruits were set in each plot was recorded. Fruit set occurred on February 15, 2023. The number of days taken from the date of sowing (October 18, 2022) to the date when seeds were set in each plot was recorded. Seed set occurred on February 15, 2023.The data was statistically analyzed as per the procedure given by Panse and Sukhatme (1985).

Results and Discussion

3.1. Number of leaves at 30, 60, 90 and 135 days after sowing of radish plants

The number of leaves was monitored at 30, 60, 90, and 135 days after sowing. Upon seedling emergence, it was observed that untreated conditions (control) yielded an average of 56.113±0.388 leaves (Table 2 and Figure 1). The application of nano-urea alone (58.33±0.616) and the co-application of nano-urea and indole-3-acetic acid (60.484±0.131) resulted in the lowest leaf count. Conversely, the highest leaf count (61.26±0.295) was observed with the co-application of indole-3-acetic acid, nano-urea, phosphorus, and potassium. The treatment applied significantly influenced various plant parameters, including the number of leaves per plant at different stages of growth. Jawad *et al.*, (2015) reported the maximum number of leaves with the application of nitrogen, while Monirumzzaman*et al.*, (2013) found that nitrogen application had a significant effect on the number of leaves per plant.

Table.2. Effect of nano-urea, indole-3-acetic acid, potassium and phosphorus on number of leaves at 30, 60, 90 and 135 (DAS) of radish plants

Tr. No.	**Number of leaves**			
	30 (DAS)	**60 (DAS)**	**90 (DAS)**	**135 (DAS)**
T_0	15.79±0.386	25.963±0.223	50.52±0.096	56.113±0.388
T_1	16.507±0.302	30.337±0.167	51.633±0.133	58.33±0.616
T_2	15.807±0.285	18.793±0.283	54.59±0.62	59.66±0.127
T_3	10.527±0.388	15.02±0.451	55.78±0.064	60.553±0.061
T_4	14.287±0.521	16.107±0.087	58.553±0.166	60.7±0.484
T_5	16.083±0.012	22.087±0.053	58.00±1.56	60.484±0.131
T_6	20.743±0.472	26.007±0.255	57.513±1.157	60.437±0.224
T_7	11.807±0.334	11.947±0.315	61.333±0.292	61.26±0.295
F-ratio	56.78	69.123	75.34	90.123
CD	0.814	0.832	0.446	1.117
CV	3.03	2.847	0.856	1.058

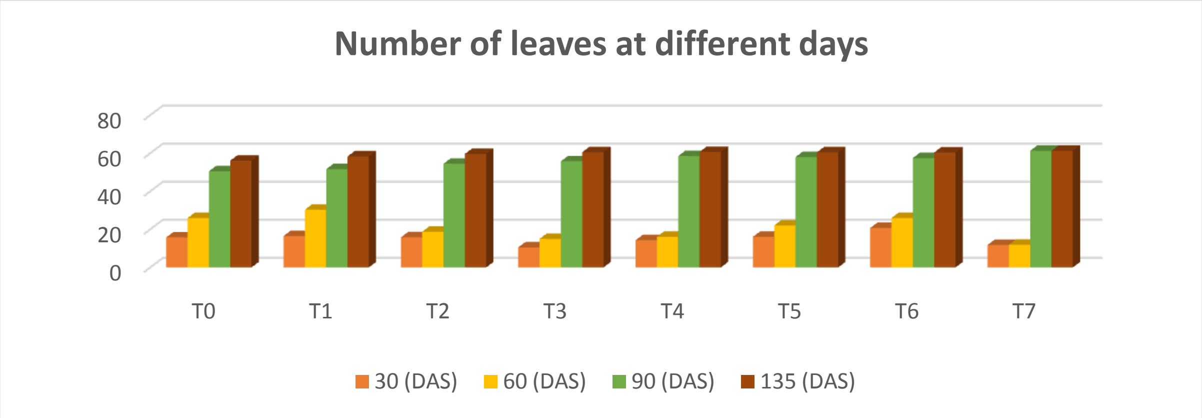

Figure 1. Effect of nano-urea, indole-3-acetic acid, potassium and phosphorus on number of leaves at 30, 60, 90and 135 (DAS) of radish plants

3.2.Effect of root length on radish plants at different (30, 60, 90 and 135 DAS)

The length of roots was measured at 30, 60, 90, and 135 days after sowing. Upon the emergence of seedlings, it was observed that untreated conditions (control) resulted in an average root length of 40.91±0.795 (Table 3 and Figure 2). The application of nano-urea alone (42.517±0.303) and the co-application of nano-urea and indole-3-acetic acid (46.76±0.162) resulted in the minimum root length. Conversely, the longest root length (48.3±0.097) was observed with the co-application of indole-3-acetic acid, nano-urea, phosphorus, and potassium.The present increase in growth is similar to previous studies on various plants, showing that plant growth regulators like GA3 and IAA contribute to plant height and the number of certain plant characteristics. Frankenberger *et al.* (1990) discusses the effect of indole-3-acetic acid (IAA) on plant growth. The study found that the application of L-tryptophan, a precursor of IAA, promoted radish yield comparable to plants treated with IAA and other auxin precursors. The application of L-tryptophan increased the shoot dry weight and root dry weight of radish crops.

Table. 3. Effect of nano-urea, indole-3-acetic acid, phosphorus and potassium on root length at 30, 60, 90 and 135 (DAS)

Tr. No.	Root length (cm)			
	30 (DAS)	60 (DAS)	90 (DAS)	135 (DAS)
T0	15.48±0.096	16.413± 0.113	33.227± 0.112	40.91±0.795
T1	16.907±0.325	17.92±0.357	34.557± 0.063	42.517±0.303
T2	17.63±0.035	18.213±0.072	35.543± 0.188	44.17±0.023

T3	16.363±0.764	19.393±0.163	36.483± 0.131	45.697± 0.037
T4	16.96±0.295	18.307±0.113	38.48±0.128	46.103±0.28
T5	17.633±0.982	19.69±0.329	39.697±0.127	46.76±0.162
T6	18.15±0.302	19.39±0.163	40.547±0.127	47.297±0.13
T7	17.557±0.609	21.333±0.126	42.737±0.148	48.3±0.097
F-ratio	2.701	6.878	14.675	36.123
CD	N/A	1.443	0.046	0.981
CV	5.264	2.617	0.609	1.227

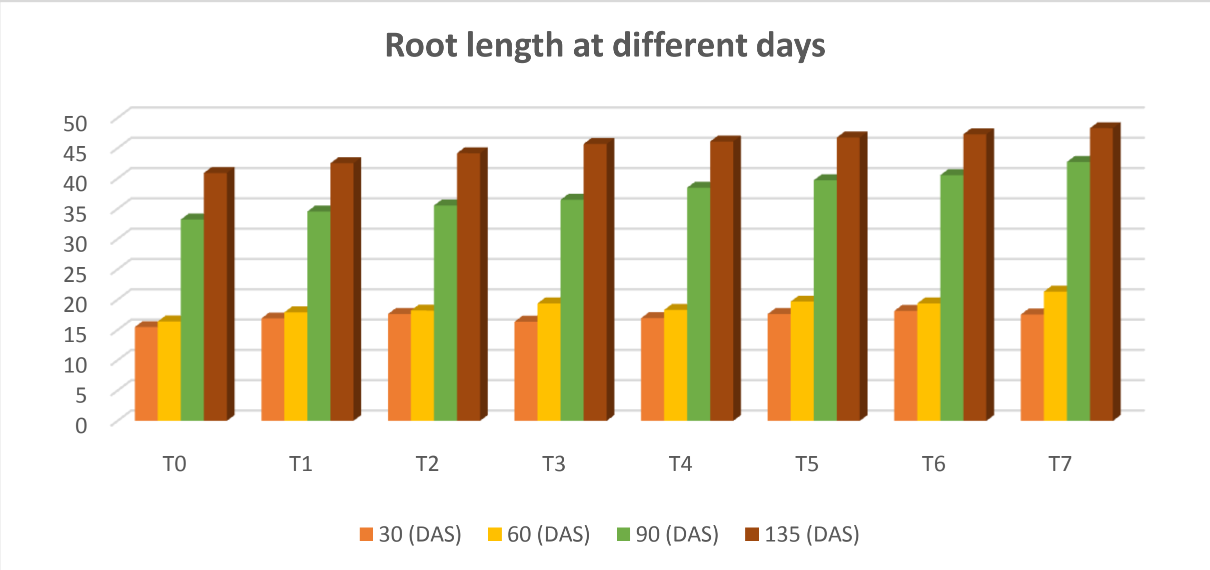

Figure 2. Effect of nano-urea, indole-3-acetic acid, potassium and phosphorus on root length at (30, 60, 90and 135 DAS) of radish plants

3.3. Effect of nano-urea, indole-3-acetic acid, potassium and phosphorus on shoot length at 30, 60, 90and 135 days after sowing of radish plants

The length of the shoot was measured at 30, 60, 90, and 135 days after sowing. Upon the emergence of seedlings, it was observed that under untreated conditions (control), the average shoot length was 54.413±0.098 (Table 4 and Figure 3). The application of nano-urea alone (60.557±0.064) and the co-application of nano-urea and indole-3-acetic acid (69.546±0.012) resulted in the shortest shoot length. Conversely, the longest shoot length (75.453±0.401) was observed with the co-application of indole-3-acetic acid, nano-urea, phosphorus, and potassium.Similar studies were found by (Parveen *et. al.*, 2023) that the combined treatment of indole acetic acid (IAA) and gibberellic acid (GA3) at a concentration of 60 mg L-1 (IAA2 + GA2) had the most significant impact on the growth and yield of mung beans, including increased biological yield by (Choudhury *et al*., 2023; and Hossain *et* *al*., 2018). IAA has been recognized to increase growth and photosynthetic pigments' concentration in the leaves of plants, as shown in the current study Naeem*et al.* (2004)

Table. 4. Effect of nano-urea, indole-3-acetic acid, potassium and phosphorus on shoot length at 30, 60, 90and 135 (DAS) of radish plants

Tr. No.	Shoot length (cm)			
	30 (DAS)	**60 (DAS)**	**90 (DAS)**	**135 (DAS)**
T0	6.407±0.094	15.177±0.044	16.923±0.289	54.413±0.098
T1	6.66±0.548	14.017±0.132	22.837±0.094	60.557±0.064
T2	7.7±0.096	12.21±0.072	29.583±0.072	65.456±0.151
T3	8.253±0.364	10.413±0.202	30.547±0.064	66.483±0.155
T4	7.56±0.061	11.247±0.111	31.737±0.098	68.667±0.321
T5	8.363±0.26	13.433±0.127	32.657±0.17	69.546±0.012
T6	8.477±0.245	12.243±0.184	34.77±0.064	70.234±0.302
T7	8.627±0.131	16.067±0.09	36.587±0.099	75.453±0.401
F ratio	15.135	18.156	198.33	523.409
CD	0.802	0.503	0.446	0.377
CV	5.759	3.456	0.856	0.224

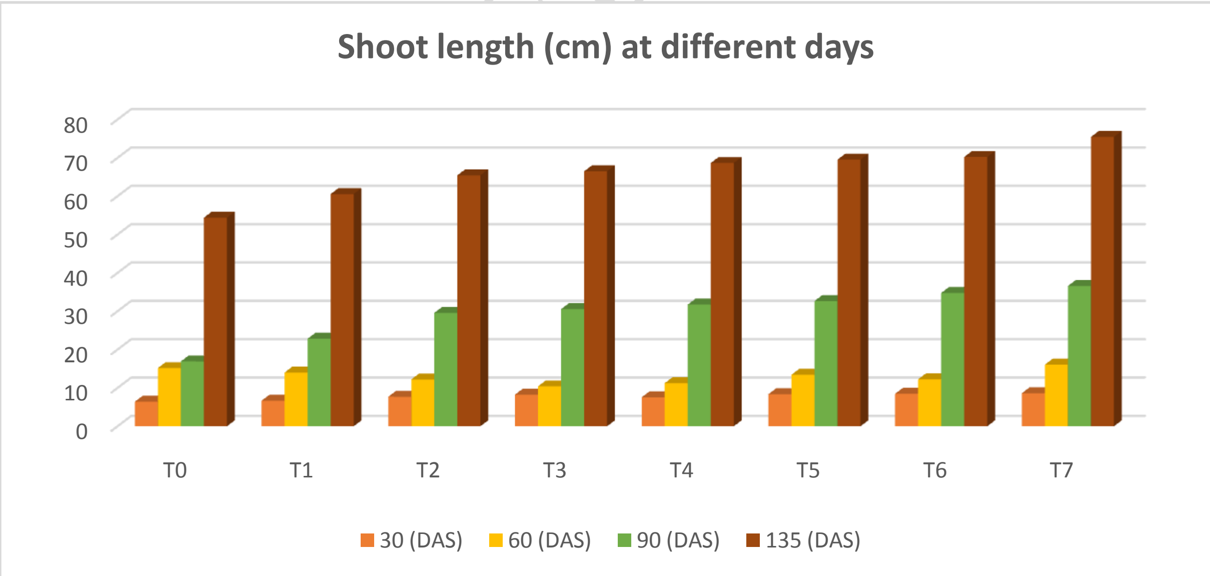

Figure 3. Effect of nano-urea, indole-3-acetic acid, potassium and phosphorus on shoot length at 30, 60, 90and 135 days after sowing of radish plants

3.4. Effect of nano-urea, indole-3-acetic acid, phosphorus and potassium on length of leaves at different days after sowing

The length of leaves was measured at 30, 60, 90, and 135 days after sowing. Upon the emergence of length of leaves, it was observed that untreated conditions (control) resulted in an average leaf length of 26.74±0.887 (Table 5 and Figure 4). The application of nano-urea alone (27.883±0.905) and the application of nano-urea and indole-3-acetic acid (35.433±0.388) resulted in the shortest leaf length. Conversely, the longest leaf length (37.623±0.132) was observed with the co-application of indole-3-acetic acid, nano-urea, phosphorus, and potassium.Various plant parameters, including leaf length, were recorded at different stages of growth and at the time of harvesting, influenced by different treatments. The effect of different levels of nitrogen on the growth and yield of radish has been studied. Mehwish *et al.* (2016) revealed that higher nitrogen content led to improved growth and yield, while the application of NPK significantly enhanced all growth attributes and yield, Parveet*et al.* (2023).

Table 5.Effect of nano-urea, indole-3-acetic acid, phosphorus and potassium on length of leaves at 30,60,90 and 135 DAS

Tr. No.	**Length of leaves (cm)**			
	30 (DAS)	**60 (DAS)**	**90 (DAS)**	**135 (DAS)**
T0	10.833±0.367	22.18±0.075	25.48±0.157	26.74±0.887
T1	12.793±0.326	26.25±0.41	26.413±0.147	27.883±0.905
T2	9.837±0.349	22.827±0.264	27.697±0.093	29.447±0.226
T3	8.840±0.255	18.23±0.087	28.52±0.075	30.253±0.034
T4	8.457±0.327	17.32±0.173	28.073±0.69	34.81±0.37
T5	7.980±0.765	16.86±0.391	29.7±0.095	35.433±0.388
T6	11.293±0.551	14.583±0.425	28.703±0.157	36.407±0.039
T7	11.537±0.280	14.06±0.395	30.447±0.166	37.623±0.132
F ratio	23.45	38.66	45.66	67.88
CD	0.654	1.016	1.121	1.234
CV	2.24	3.018	3.556	4.554

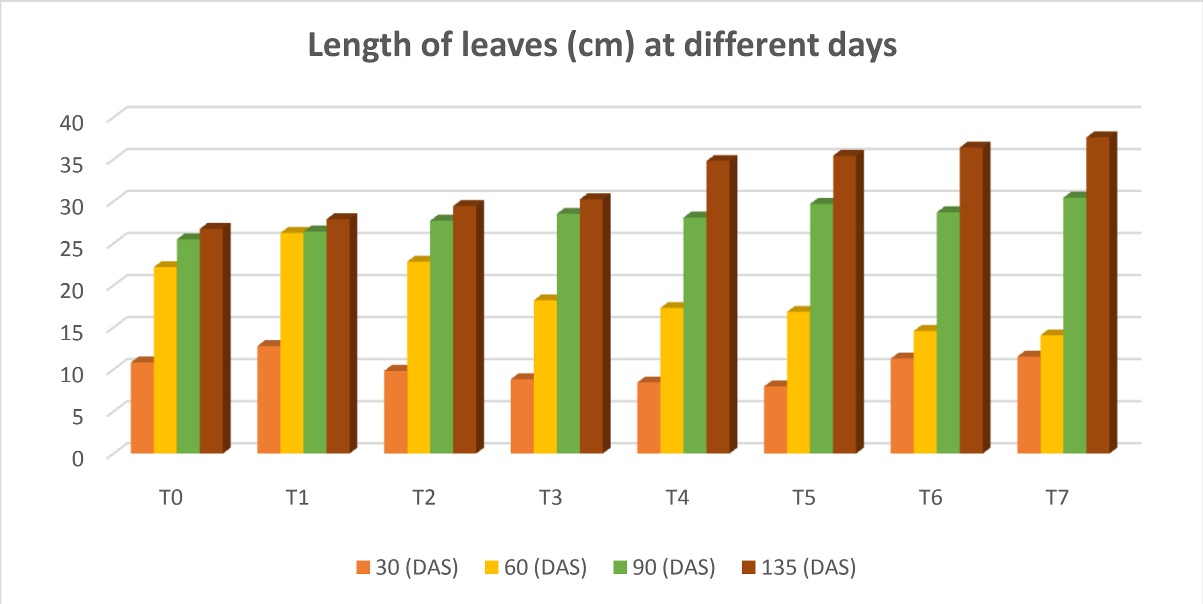

Figure 4.Effect of nano-urea, indole-3-acetic acid, phosphorus and potassium on length of leaves at 30, 60, 90 and 135 DAS

Conclusion

The application of nano-urea, indole-3-acetic acid, phosphorus, and potassium demonstrated significant positive effects on seed germination and various growth parameters of *Raphanussativus* L. The treatments improved seed germination percentages compared to the control, with the highest germination observed when all four substances were combined. This indicates the potential of these treatments in promoting early seedling establishment and overall crop performance.Furthermore, the treatments influenced the number of leaves at different stages of growth, with the combination treatment resulting in the highest leaf count. This suggests that the application of these substances can enhance leaf development and contribute to increased photosynthetic activity, which is crucial for plant growth and productivity.Moreover, the treatments affected the length of leaves, roots, and shoots. The combination treatment consistently resulted in the longest lengths, indicating the positive impact of these substances on overall plant growth and development.These findings highlight the potential of nano-urea, indole-3-acetic acid, phosphorus, and potassium as effective tools for improving seed germination, leaf development, and overall plant growth in *Raphanus sativus* L. Incorporating these treatments into agricultural practices may contribute to enhanced crop productivity, yield, and ultimately, sustainable food production.Further research and field trials are warranted to explore the optimal application rates and combinations of these substances, as well as their long-term effects on crop performance and soil health. Overall, these findings provide valuable insights for agricultural practitioners and researchers working towards sustainable and efficient crop production systems.

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