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EFFECT OF NPK FERTILIZATION ON GROWTH AND CHMEICAL COMPOSTION OF *Paulownia kawakamii* T**. ITO SEEDLINGS UNDER SANDY SOIL CONDTIONS**

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By

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ABSTRACT

This work was carried out in a field experiment at the Research and Production Station of the National Research Center (NRC) at Nubaria during two successive seasons 2006/2007 and 2007/2008. The aim was to investigate the effect of different rates of NPK fertilization on growth and the main constituents of *Paulownia kawakamii* T. Ito seedlings grown in sandy soil. The treatments of NPK fertilizer were: NPK at (1:1:1), (1:2:1), (1:1:2), (2:1:1) ,(2:2:1) ,(2:1:2) ,(3:1:1) , (3:2:2) as well as the control (without fertilization).The results indicate that the application of NPK fertilizer at the different rates gave a better effect on all vegetative characteristic{plant height (cm), stem diameter (cm), fresh weight of leaves, stems and roots (gm/plant), dry weight of leaves, stems and roots (gm/plant), leaf area, number of roots and root diameter } and chemical constituents (chlorophyll a,b and carotenoids, mineral contents of N, P and K in the leaves and total sugar contents in the leaves) compared with the control. Also, the results indicated that the application of NPK fertilizer at (3:1:1) was the most effective treatment gave significant increases in all vegetative characteristics and chemical constituents in both seasons.

Key words: *fertilization, growth, nitrogen, NPK, Paulownia, phosphorus, potassium.*

1. INTRODUCTION

Paulownia is one of fast growing trees which occurs naturally in many countries specially China. *Paulownia* is a deciduous tree, belongs to Family Scrophulariaceae,it is a marvelous tree species. It is considered one of the best trees for agro- forestry. This tree species is highly adaptable and widely distributed (Zhu, 1981). *Paulownia* has also a unique biological character *i.e.,* its root system grows in deep earth, which makes it suitable to be intercropped with other crops.

Chemical fertilization, especially NPK is well known to promote the vegetative growth of tree seedlings. Some investigators studied the effect of NPK treatments on vegetative growth of some ornamental trees as compared with unfertilized seedlings. In this respect Badran *et al*. (1994) on *Leucaena leucocephala,* Ishtiaq *et al.* (1998) on *Ficus macrophylla,* Ahmed and Aly (1998) on *Acacia saligna,* Abd Elaziz (2000) on *Azadirachta indica,* Rabie (2002) on *Taxodium distichum,* Gad (2003) on *Ficus benjamina,* Knapik and angelo (2007) on *Prunus sellowii,* Chen *et al.* (2008) on *Paeonia lactiflora,* Petterson *et al.* (2008) on *Rhapis excelsa,* and Cicek *et al.* (2010) on *Fraxinus angustifolia*., concluded that the seedling height, stem and root diameter, number of leaves and roots, fresh and dry weight of leaves, stems and roots as well as leaf area were increased as a result of the NPK application. Moreover, a number of investigators pointed out the positive relationship between sugar content and NPK treatments such as Darwish (1994) on *Casuarina glauca,* El-Sallami and Mahros(1997) on *Thuja orientalis,* Ewais (2000) on *Brunfelsia calycina* and Kandeel *et al*. (2002) on *Taxodium distichum.* Abd-Elaziz (2000) on *Azadirachta indica,* and Gad (2003) on *Ficus benjamina*., reported that the pigment contents increased due to NPK fertilization treatments.

Regarding the effect of NPK fertilization on mineral contents Shehata (1995) on *Poinciana regia,* Li *et al*. (1998) on *Phyllostachys pubescens,*and Gad (2003) on *Ficus benjamina*., concluded that mineral contents increased as a result of NPK fertilization applications.

The objective of this study was to evaluate the effect of NPK levels on growth parameters and chemical composition of *Paulownia kawakamii* T. Ito at Nubaria, Egypt.

2. MATERIALS AND METHODS

The experiment was carried out in a field of the Research and Production Station of the National Research Center (NRC) at Nubaria during two successive seasons 2006/2007 and 2007/2008. The aim of this study was to investigate the effect of NPK fertilizer rates on the growth and the main constituents of *Paulownia kawakamii* T. Ito in sandy soil. The uniform *Paulownia* seedlings were obtained from tissue culture laboratory, Faculty of Agriculture, Ain Shams University with an average length 15-20 cm.

On September, 10^{th} in both seasons, uniform seedlings of *Paulownia kawakamii* were transplanted in field holes (50cm diameter x 50cm depth) 3 m in between. The cultivation was on rows 3m apart.Drip irrigation system was used (4 L/hr per dripper) for 16 hr/week. Every treatment contained three replicates and each replicate was represented by two seedlings. The experiment included eight treatments of NPK fertilizer at levels of (1:1:1),(1:2:1), (1:1:2),(2:1:1),(2:2:1), (2:1:2),(3:1:1) and (3:2:2) as well as the control (without fertilization).Each hole received 100 gm NPK monthly as a dressing application. The sources of chemicals used were ammonium nitrate (33.5%N), calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48 % K_2O). The application was done monthly throughout the period of growth. The first dose was applied after a month from planting. The plants were pruned monthly for enhancing the development of seedling trunk. The plants were held under natural environmental conditions. The experiment continued for 14 successive months and ended on October 10^{th}. The following data were recorded: - Plant height (cm), stem diameter (cm), leaf area (cm^2), number of roots/plant and root diameter (cm), fresh and dry weight of leaves, stems and roots (gm/plant). The contents of chlorophyll a,b and carotenoids were determined according to Wettstein (1957). The following chemical analyses were determined in dry leaves, nitrogen content was determined by modified micro-Kjeldahl method as described by Pregl (1945), phosphorus content in leaves was estimated according to Snell and Snell (1949), potassium was determined using flame photometer according to Chapman and Pratt (1961) and total sugars were determined according to Dubois *et al.* (1956).

2.1. Statistical analysis

The layout of the experiment was a randomized complete block design. Data were analyzed statistically according to Snedecor and Cochran (1980).The least significant difference (L.S.D) at 5% for each character was calculated to compare means of the treatments.

3. RESULTS AND DISCUSSION

3.1. Vegetative growth

3.1.1. Plant height (cm)

The data presented in Table (1) indicate that plant height of *Paulownia* was significantly increased by each increase in the NPK rate up to $N_3P_2K_2$ compared to the control ($N_0P_0K_0$). In both seasons, the plants fertilized with $N_3P_1K_1$ were the tallest (456.0 and 432.7 cm, respectively), while the shortest plants (200.7 and 155.0 cm, respectively) were obtained by the controls.These results coincided with those obtained by El-Khateeb(1983) on *Eucalyptus torquata* and *E.angulosa* , El-Sallami and Mahros (1997)on *Thuja orientalis,* Jerlin and Vadivelu (2004) on *Pongamia pinnata* and Knapik and Angelo(2007) on *Prunus sellowii,* and Cicek *et al.* (2010) on *Fraxinus angustifolia*. who concluded that all NPK fertilization rates resulted in taller plants than untreated plants.

3.1.2. Stem diameter (cm)

Data on stem diameter in response to NPK treatments are presented in Table (1). NPK treatment at the rate of 3:1:1 increased significantly stem diameter as compared with the control and the other NPK rates in the two seasons. In both seasons, the thinnest stem (2.88 and 2.57 cm, respectively) resulted from control plants.The present results are in accordance with those mentioned by many authors.Farahat(1986) on *Eucalyptus camaldulensis*, Kandeel *et al.*(2002) on *Taxodium distichum*, Cicek *et al.* (2010) on *Fraxinus angustifolia,* who found that stem diameter was stimulated by the addition of NPK fertilizer.

3.1.3. Leaf area (cm^2)

The results presented in Table (1) show the effect of NPK treatments on leaf area of *Paulownia* seedlings. The use of all examined NPK rates caused the leaf area to become much larger and more expanded than the leaves of the control plants with the best results being obtained from $N_3P_1K_1$ and the differences were statistically significant, in the two seasons. These results agreed with those of Thomas and Teoh (1983) on *Ficus macrophylla,* Abd Elaziz(2000) on *Azadirachta indica* and Kandeel *et al.* (2002) on *Taxodium distichum* who

mentioned that leaf area was significantly increased with increasing NPK fertilization rate.

3.1.4. Root number /plant

Regarding the data shown in Table (2), it is pointed out that the rates of NPK at 3:1:1 and 2:1:2 increased significantly the number of roots/plant than the control and other treatments in both seasons. In both seasons, the greatest number of roots (23.67 and 17.67 roots/plant, respectively) resulted from treating the plants with NPK at 3:1:1. Increasing the levels of NPK from 1:1:1 or 2:1:1 to 3:1:1 which led to an increase in the number of roots/plant. Many authors reported the favorable effect of NPK on root growth; Gad (2003) on *Ficus benjamina*, and Petterson *et al.* (2008) on lady palm (*Rhapis excelsa*).

3.1.5. Root diameter (cm)

Data on the effect of NPK on root diameter as shown in Table (2), indicate that all the rates of NPK increased root diameter over the control in both years. In the two seasons, the thickest roots (10.87 and 10.00cm, respectively) were those of plants supplied with NPK at 3:1:1 while, the thinnest one(4.60 and 4.66 cm, respectively) were found on the plants treated with NPK at 1:2:1,but more than the control(3.60 and 3.67 cm, respectively).The promoting effect of NPK fertilizer on root diameter was mentioned by some investigators, *i.e.*, Mhando *et al.* (1993) on *Eucalyptus saligna*, Rabie. (2002) on *Taxodium distichum* and Chen *et al.* (2008) on *Paeonia lactiflora.*

3.1.6. Fresh and dry weights of leaves, stems and roots (gm)/plant

The effect of NPK fertilizer on fresh and dry weights of leaves, stems and roots/plant are shown in Tables (3) and (4).All NPK treatments resulted in significant increases in fresh and dry weights of leaves, stems and roots in the first and second seasons. The heaviest fresh and dry weights of leaves, stems and roots /plant were recorded on the plants treated with NPK at the rate of 3:1:1 in both seasons. While, the lowest values of fresh and dry weights for the different plant parts were recorded on the control plants. It can be concluded that raising N level in NPK mixture, in most cases, greatly increased the fresh and dry weights of leaves, stems and roots. The results of the present study are in harmony with those obtained by many workers, Farahat (1986) on *Eucalyptus camaldulensis*, Taha (1994) on *Cordia myxa*, Shehata(1995) on *Poniciana regia* and Ahmed and Aly (1998) on *Acacia saligna*. Roots of *Paulownia* were greatly affected by NPK treatments on increasing fresh and dry weights than leaves and stems.Also, roots fresh and dry weights were, generally, affected by their root numbers and root diameter as already mentioned. Increasing P rate in NPK treatment from 1:1:1 to 1:2:1 decreased the fresh weight of leaves, stems and roots in both seasons, but such decrease did not attain the level of significance. These results agreed with those of Darwish (1994) on *Populus nigra*, Rabie (2002) on *Taxodium distichum* and Kumar and Siddiqui (2004) on *Terminalia arjuna*.

3.2. Chemical constituents

3.2.1. **Pigments content**

From the data in Table (5), all NPK treatments increased chlorophyll a, b and carotenoid contents over that of the control in both seasons. The highest contents of chlorophyll a and b were found in the leaves of the plants treated with NPK at 3:1:1.However, the least amounts were detected in the leaves of the plants received NPK at 1:2:1, but more than the control.There were insignificant differences in chlorophyll (a) between NPK treatments containing the low level of nitrogen (N1) (1:1:1 or 1:2:1 or 1:1:2) and control in the first and second seasons. In both years, NPK at 1:1:1 resulted in the formation of the greatest amounts of carotenoids (0.81 and 0.77mg/gm, respectively. This result is in harmony with Rabie(2002) on *Taxodium distichum* who found that NPK at the formula (15:15:15) gave the highest chlorophyll (b) content. Whereas, fertilizing of NPK at 1:1:2 led to the least content of carotenoids (0.63 and 0.59 mg/gm, respectively).These results are in agreement with those found by Abd-Elaziz(2000) on *Azadirachta indica*, Kandeel *et al.* (2002) on *Taxodium distichum*, and Gad(2003) on *Ficus benjamina*, who found that chlorophyll a,b and carotenoids were increased by the use of NPK treatments.

3.2.2. Total sugars

Data on total sugar percentages (%DW) are presented in Table (6). All NPK treatments increased total sugar percentages in the leaves in both years. In both seasons, NPK treatment at the rate of 3:1:1 resulted in the highest content of total sugars in the leaves (29.11 and 27.09%DW, respectively), whereas, the lowest contents were obtained from NPK treatment at the rate of 1:2:1 in the leaves (16.98 and 13.91% DW, respectively), but they were more, than control. Total sugar contents of the leaves were

Table (1): Effect of NPK fertilizer rates on plant height, stem diameter and leaf area of *Paulownia kawakamii* **during 2006/2007 and 2007/2008 seasons after 14 months.**

Tested character / Treatment	Plant height (cm)		Stem diameter (cm)		Leaf area (cm^2)	
	First season	Second season	First season	Second season	First season	Second season
$N_0P_0K_0$	200.70	155.00	2.88	2.57	582.00	198.00
$N_1P_1K_1$	291.70	224.30	3.65	3.10	955.30	919.00
$N_1P_2K_1$	276.70	204.70	3.60	3.11	686.30	863.30
$N_1P_1K_2$	302.30	239.00	3.83	3.61	1065.00	983.30
$N_2P_1K_1$	386.30	316.30	5.28	4.70	1106.00	1228.00
$N_2P_2K_1$	326.70	257.00	4.10	4.00	1080.00	992.70
$N_2P_1K_2$	429.30	356.00	6.23	5.81	1206.00	1459.00
$N_3P_1K_1$	456.00	432.70	7.00	6.40	1580.00	1853.00
$N_3P_2K_2$	360.30	293.00	4.71	4.12	1097.00	1049.00
LSD at 0.05	**34.70**	**31.37**	**1.31**	**1.12**	**242.30**	**537.40**

Table (2): Effect of NPK fertilizer rates on root number and root diameter of *Paulownia kawakamii* **during 2006/2007 and 2007/2008 seasons after 14 months.**

Tested character / Treatment	Root number/plant		Root diameter (cm)	
	First season	Second season	First season	Second season
$N_0P_0K_0$	6.33	6.00	3.60	3.67
$N_1P_1K_1$	10.00	10.00	5.40	4.76
$N_1P_2K_1$	8.33	9.33	4.60	4.66
$N_1P_1K_2$	12.33	11.00	5.97	5.56
$N_2P_1K_1$	17.67	14.00	8.10	7.00
$N_2P_2K_1$	14.33	13.00	6.27	5.93
$N_2P_1K_2$	20.33	15.67	9.57	7.90
$N_3P_1K_1$	23.67	17.67	10.87	10.00
$N_3P_2K_2$	15.67	13.33	6.89	6.43
LSD at 0.05	**3.60**	**3.70**	**0.81**	**0.90**

Table (3): Effect of NPK fertilizer rates on fresh weight (gm) of leaves, stems and roots of *Paulownia kawakamii* **during 2006/2007 and 2007/2008 seasons after 14 months.**

TestedcCharacter / Treatment	Leaves F.W.		Stem F.W.		Root F.W.	
	First season	Second season	First season	Second season	First season	Second season
$N_0P_0K_0$	279.63	463.89	453.30	450.00	1533.00	983.30
$N_1P_1K_1$	698.30	957.31	823.30	1013.00	2150.00	1633.00
$N_1P_2K_1$	590.69	593.40	730.00	843.30	2033.00	1208.00
$N_1P_1K_2$	1178.70	1247.72	1144.00	1310.00	2433.00	1667.00
$N_2P_1K_1$	1190.83	1233.32	1888.00	2490.00	3433.00	3333.00
$N_2P_2K_1$	743.67	654.00	1225.00	1617.00	2600.00	2300.00
$N_2P_1K_2$	1048.52	943.21	2538.00	3733.00	4300.00	3883.00
$N_3P_1K_1$	1740.80	1746.18	3397.00	4467.00	5633.00	4350.00
$N_3P_2K_2$	1134.95	1004.09	1304.00	2107.00	3267.00	2617.00
LSD at 0.05	**176.6**	**171.80**	**391.50**	**406.50**	**467.50**	**425.50**

Table (4): Effect of NPK fertilizer rates on dry weight (gm) of leaves, stems and roots of *paulownia kawakamii* **during 2006/2007 and 2007/2008 seasons after 14 months.**

Tested character / Treatment	Leaves D.W.		Stem D.W.		Root D.W.	
	First season	Second season	First season	Second season	First season	Second season
$N_0P_0K_0$	89.09	154.94	313.000	222.000	636.000	455.000
$N_1P_1K_1$	203.61	315.19	745.000	769.700	924.300	978.000
$N_1P_2K_1$	262.53	166.63	525.300	462.700	782.300	725.700
$N_1P_1K_2$	391.60	525.24	821.700	906.000	1011.000	1052.000
$N_2P_1K_1$	440.46	550.17	1630.000	1472.000	1839.000	1651.000
$N_2P_2K_1$	285.61	219.37	996.300	1029.000	1105.000	1131.000
$N_2P_1K_2$	326.87	382.53	1886.000	1851.000	1638.000	1956.000
$N_3P_1K_1$	673.17	795.47	2600.000	2545.000	2883.000	2758.000
$N_3P_2K_2$	375.65	396.77	1152.000	1264.000	1680.000	1374.000
LSD at 0.05	**85.56**	**96.76**	**169.000**	**287.500**	**239.100**	**283.500**

Table (5): Effect of NPK fertilizer rates on leaves chlorophyll a,b and carotenoids mg/g F.W. of *Paulownia kawakamii* seedlings during 2006/2007 and 2007/2008 seasons after 14 months.

Tested character / Treatment	First season 2006/2007			Second season 2007/2008		
	Chl.a	Chl.b	Carot.	Chl.a	Chl.b	Carot.
$N_0P_0K_0$	0.86	0.38	0.45	0.85	0.31	0.41
$N_1P_1K_1$	0.98	0.51	0.81	0.95	0.43	0.77
$N_1P_2K_1$	0.92	0.46	0.76	0.88	0.40	0.73
$N_1P_1K_2$	1.01	0.55	0.63	0.91	0.51	0.59
$N_2P_1K_1$	1.54	0.68	0.71	1.48	0.61	0.68
$N_2P_2K_1$	1.11	0.61	0.65	0.98	0.55	0.60
$N_2P_1K_2$	1.87	0.73	0.72	1.80	0.68	0.68
$N_3P_1K_1$	1.96	0.81	0.76	1.89	0.77	0.62
$N_3P_2K_2$	1.32	0.65	0.69	1.11	0.60	0.63
LSD at 0.05	**0.18**	**0.09**	**0.09**	**0.14**	**0.11**	**0.08**

Table (6): Effect of NPK fertilizer rates on total sugars, nitrogen, phosphorus and potassium percentage of *Paulownia kawakamii* leaves during 2006/2007-2007/2008 seasons after 14 months.

Tested characters / Treatment	First season 2006/2007				Second season 2007/2008			
	Total sugars%	N% D.W.	P% D.W.	K% D.W.	Total sugars%	N% D.W.	P% D.W.	K% D.W.
$N_0P_0K_0$	12.44	1.85	0.32	0.76	9.21	1.51	0.38	0.57
$N_1P_1K_1$	18.12	2.54	0.39	1.90	16.10	1.83	0.42	1.24
$N_1P_2K_1$	16.98	2.83	0.43	1.63	13.91	1.84	0.43	1.12
$N_1P_1K_2$	18.66	2.62	0.45	0.90	16.45	1.78	0.51	0.78
$N_2P_1K_1$	26.14	2.39	0.37	1.15	24.23	2.46	0.45	0.90
$N_2P_2K_1$	21.26	2.67	0.41	1.18	20.11	2.22	0.49	0.96
$N_2P_1K_2$	27.63	2.51	0.37	0.68	24.68	2.12	0.42	0.68
$N_3P_1K_1$	29.11	2.86	0.48	1.67	27.09	3.70	0.55	1.23
$N_3P_2K_2$	24.63	2.79	0.39	1.22	21.28	2.24	0.51	0.95
LSD at 0.05	**1.98**	**0.21**	**0.11**	**0.12**	**1.26**	**0.29**	**0.20**	**0.07**

significantly reduced by increasing the rate of P and the mixture of NPK treatments at high level of N (N_3:P_2:K_2) compared with N_3:P_1:K_1, in the first and second seasons. In both seasons, leaves of the untreated plants contained the lowest value of total sugars compared with all NPK treatments. From the above mentioned results, it can be concluded that increasing N level in the NPK treatment at (3:1:1) greatly increased the content of total sugars in the leaves of *Paulownia kawakamii*. These findings are in agreement with those obtained by Darwish(1994) on *Casuarina glauca*, Osman(1996) on *Araucaria excelsa* and El-Sallami and Mahros (1997) on *Thuja orientals* . They reported that using different NPK treatments had a positive effect on increasing the content of total sugars.

3.2.3. Nitrogen content

Data on nitrogen percentage (N %) in the leaves in response to NPK treatments are presented in Table (6). It was noticed that all the rates of NPK resulted in a significant increase in N % of the leaves compared with the control during the two years. NPK fertilizer treatments had a remarkable effect on N concentration in the leaves which increased with increasing the nitrogen in the mixture of NPK fertilizer treatments from N_1 or N_2 to N_3.

3.2.4. Phosphorus content

The results in Table (6) show the effect of NPK treatments on phosphorus percentage in the leaves of *Paulownia kawakamii* plants. Increasing nitrogen level in NPK treatment caused an increase in P % in the leaves. In both seasons; all NPK treatments increased the content of phosphorus in the leaves. The greatest amounts of phosphorus were detected in the leaves of the plants treated with N3P1K1. The least phosphorus content was found in the leaves of the plants supplied with $N_2P_1K_2$ treatment (0.37 and 0.42, respectively but more than the control (0.32 and 0.38, respectively).

3.2.5. Potassium content

The data on potassium (K) concentration of the leaves (% dry weight) as affected by NPK fertilization treatments are presented in Table (6). In both seasons, the highest percentage of potassium (1.9 and 1.24 %, respectively) was detected in the leaves of the plants treated with $N_1P_1K_1$ treatment, while, $N_2P_1K_2$ treatment resulted in the accumulation of the least amount of potassium in the leaves (0.68 and 0.68, respectively), but more than the control in the second season (0.57). The present results on *Paulownia* are in agreement with those reported by El-Labban *et al*.(1988)on *Khaya senegalensis*,Darwish(1994) on *Casuarina glauca*,Shehata(1995) on *Poinciana regia*, Mohamed(1996) on *Casuarina* and *Eucalyptus* and El- Kayal(1996) on *Melia azedarach, Acacia stenophylla, Casuarina glauca, Eucalyptus camaldulensis* and *Taxodium distiechum*.

In conclusion, the application of NPK at the rate of 3:1:1 gave better effect on vegetative characteristics, and chemical constituents (pigments, macro elements and total sugar) of *Paulownia kawakamii* plants.

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تأثير التسميد الكيميائي على النمو والتركيب الكيميائي لشتلات البولونيا تحت ظروف الأرض الرملية

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ملخص

أجريت هذه الدراسة فى محطة البحوث والإنتاج بالنوبارية- المركز القومى للبحوث خلال موسمى 2006-2007 و2007-2008 وذلك بغرض دراسة تأثير التسميد الكيميائي بمستويات مختلفة من النيتروجين والبوتاسيوم و الفوسفور على نمو شتلات البولونيا فى الأراضى الرملية . كانت المعاملات (1:1:1) (1:2:1) (2:1:1) (1:1:2)(1:2:2) (2 : 1:2) (1:1:3) (2:2:3) بالإضافة الى الشتلات غير المعاملة وتم اخذ القراءات الخضرية {طول النبات (سم)- قطر الساق(سم)- الوزن الغض للاوراق و الساق والجذور والوزن الجاف للأوراق والساق والجذور- مساحة الأوراق(سم ^{2})- عدد الجذور وقطر الجذور) وكذلك التركيب الكيميائي (كلوروفيل أ وب والكاروتونيدات- محتوى الأوراق من النيتروجين والبوتاسيوم والفسفور والسكريات الكلية).

أظهرت النتائج ان جميع المعاملات أدت الى زيادة معنوية فى الصفات الخضرية والتركيب الكيميائي كما اظهرت النتائج أن المعاملة بالتسميد الكيميائي (1:1:3) أعطت افضل معاملة من بين المستويات السابقة فى كلا الموسمين.

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