Effect of Organic and Nano Fertilization As Substitutes of Mineral Fertilization on The Growth and Chemical Composition of Marigold (*Tagetes erecta* L.) Plants

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ABSTRACT: This investigation was carried out in the Horticulture Research Institute, Agricultural Research Center at El- Montazah, Alex. Egypt, during two successive seasons of 2014 and 2015 to determine the effect of various combinations of fertilizer treatments (NPK, humic and nano NPK) on the growth and chemical composition of *Tagetes erecta* L., to find out the best combination of these fertilizers that achieve the goal of this study. The experimental design was split- split plot with three replications. Three different NPK fertilizers at three rates each (0 , 50 and 100 mg/l NPK) were allocated in the main plot, humic acid levels assigned in the sub plots (0, 500 and 1000 mg/l) and nano levels were positioned in sub-sub plots (0, 25 and 50 mg/l). The obtained results showed significant differences among the three types of fertilization on the given traits, but in general the gained results revealed that the applied fertilizers, at their higher rates, significantly increased plant growth characters (plant height (cm), number of leaves/ plant, inflorescence diameter, stem diameter, plant leaf area (cm), number of inflorescence/ plant, number of branches/plant, days spanned to first flower emergence, blooming periods, flower durability, chlorophyll content (SPAD), carbohydrates % and carotene contents and N, P and K percentages) in response to the various treatments used in the current study in comparison to that gained from untreated plants (control). Nevertheless, it could be recommended that fertilization of *Tagetes erecta* with Nano NPK at 50 mg/l and interaction between mineral NPK at 100 mg/l + humic acid at 1000 mg/l + Nano-NPK at 50 mg/l during both growing seasons were the best treatment in producing the highest quality of growth.

Keywords: *Tagetes erecta,* NPK, humic, Nano NPK, vegetative growth, yield, chemical composition.

INTRODUCTION

Marigold (*Tagetes erecta* L.) belongs to compositae family and herbaceous plant with aromatic, pinnately divided leaves and is usually used as a bedding plant, cut flower or as a coloring agent in poultry feed to obtain yellow egg yolks (Dole and Wilkins, 2005).

Marigold is a potential commercial flower that is gaining popularity on account of its easy culture, wide adaptability, and increasing demand in the sub-continent (Asif, 2008). Also, marigold is grown as an ornamental crop for its flowers, which are sold in the market as loose flowers in bulk, as specialty cut flowers, or for making garlands. It is also one of the most important natural sources of xanthophylls for use as natural food additive to brighten egg yolks and poultry skin (Bosma *et al.*, 2003). Moreover, it is also being used effectively to dye fabrics commercially, where its ethanol-based flower extracts produce different colors on fabrics (Vankar *et al.*, 2009).

Nutrient status of the plants can be a pointer to the response of plant to the fertilization, and internal content of the nutrients determine the fertilizer requirements. Nitrogen applied as fertilizer is the main sources used to meet the N requirements of plant growth (Konnerup and Brix, 2010). When N is used properly, at the right application rates and at the right time, N contributes to optimal growth. Excessive N fertilization has an adverse effect making leaves a darker green and delaying flowering (Singh *et al.*, 2002 and Gadagi *et al.*, 2004). In adition, Phosphorus is also important elements for plant growth and yields. Lack of P nutrition resulted in a low basal root fresh weight and a shorter stem length (Filippelli, 2008; Niedziela *et al.*, 2008 and Joshi *et al.*, 2012). Information about nutrient requirements for marigold production and cultural practices are necessary aims to set up a protocol or strategy to fulfill or satisfy the best growth and flowering of this plant.

It is vital to support the use of nitrogen, phosphate and potassium fertilizers for the achievement and maintenance of soil health and to sustain the crop productivity. The application of appropriate dose of these fertilizers and the coefficient of fertilizer use has considerably gone up; thus favourably affecting the yields of such economical crops (Alam and Khan, 1999).

Despite of chemical fertilizers advantages, but sittl have various negative environmental effects on soil, water and air pollutions (Moradi *et al.,* 2011). Over using of chemical fertilizers has altered the biological ecosystem, affected non-target organisms and adversely influenced microorganisms in the soil (Tanu *et al.,* 2004). To avoid the risk of these negative effects of chemical fertilizers, it is necessary to use organic or biological fertilizers which provide plant with nutrients and increase long term sustainability of agroecosystems (Mehnaz and Lazarovits, 2006). However, there is a strong relation between soil organic matter content and soil fertility, widely and universally accepted (Moradi *et al.,* 2011).

Organic farming is one of the practices which make the production system more sustainable without adverse effects on the natural resources and the environment (Kochakinezhad *et al.,* 2014 and Ram *et al.*, 2014). It not only maintains soil fertility, but also conserves soil moisture (Yadav *et al.,* 2014). Organic fertilizers and their extracts enhance soil fertility *via* improving nutrient retention and cycling and play an essential role in growth and yield of plants (Khalid and Shafei, 2005 and Ram *et al.,* 2014).

The use of humic acid and chemical fertilizers improves plant nutrient absorption (Ayas and Gulser, 2005). Humic acid is a commercial product contains many elements which improve the soil fertility and increasing the availability of nutrient elements and consequently affected plant growth and yield (Hartwigson and Evans, 2000). Humic substance supports growing plants and makes soil more fertile and productive, increases soils water holding capacity; therefore, it helps plants to resist droughts and stimulates seed germination (Hartwigson and Evans, 2000).

Nowadays nanotechnology plays a vital role in our life, because it can not only engineer shape and size of metal but its basic properties (chemical, physical, mechanical, optical and catalytic, etc.) may also be changed in the useful manner (Alqudami and Annapoorni, 2007). Nanotechnology has achieved the importance in different fields such as health care, food and feed, cosmetics, energy science, electronics, mechanics, space industries, environmental health, biomedical science, chemical industries, drug and gene delivery(Korbekandi and Iravani, 2012). The aim of this study is to find out the effect of organic and nano fertilization on plant growth and chemical composition of marigold (*Tagetes erecta* L).

MATERIALS AND METHODS

This investigation was carried out in the Horticulture Research Institute, Agricultural Research Center - El-Montazah, Alex., Egypt, during two successive seasons of 2014 and 2015 to determine the effect of various combinations of fertilizers treatments (NPK, humic and Nano NPK) on the growth and chemical composition of *Tagetes erecta*, grown in sandy clay soil to find out the best fertilization treatment and the appropriate growing medium for *Tagetes erecta* L. plants to achieve the best growth.

Soil type

The type of soil that used during experimentation was analyzed and determined its physical and chemical properties trend considered as sandy clay soil as illustrated in Table (1).

Table (1). Some physical and chemical properties of the experimental soil in 2015.

Soil properties	
A) Mechanical analysis :	**Season 2015**
Clay %	11
Sand %	87
Silt %	2
Soil texture	Sandy Clay
B) Chemical properties	
pH (1 : 1)	8.63
EC (dS/m)	2.87
$CaCO_3$ %	15.7
O.M. %	1.5
1) Soluble cations	
K^+ (mg/l)	950
Ca^{++} (mg/l)	245.28
Mg^{++} (mg/l)	322.22
Na^{++} (mg/l)	650
2) Soluble anions	
HCO_3^- (mg/l)	1581.13
Cl^- (mg/l)	298.2
SO_4^{--} (mg/l)	209.8
Available nitrogen (mg/kg)	76.39
Available phosphorus (mg/kg)	36.5
Available potassium (mg/kg)	950

Plant material

Seeds of marigold were obtained from local variety (orange flowers), were sown in clay pots of 30 cm diameter at the first week of May, after 40 days the seedling was transplanted in pots of polyethelen of 30 cm diameter.

Experimental design

The followed experimental design was split-split plot with three replication. Three different NPK fertilizers through irrigation at the rates (0, 50 and 100 mg/l NPK) were used and allocated in the main plot, humic acid levels through irrigation assigned in the sub plots (0, 500 and 1000 mg/l) and Nano-NPK through irrigation levels were positioned in sub-sub plots (0, 25 and 50 mg/l), as follows:

A. NPK levels 19-19-19 powder (Main plots)

- Control (without fertilizers)
- 50 mg/l
- 100 mg/l

B. Humic acid levels (potassium humate (humate 85% powder)) (Sub plots)

- Control (without fertilizers)
- 500 mg/l
- 1000 mg/l

C. Nano-NPK levels 19-19-19 liquid (Sub-sub plots)

- Control (without fertilizers)
- 25mg/l
- 50mg/l

So the experiment contained 27 treatments (3 NPK x 3 humic acid x 3 nano-NPK and each treatment included 3 plants per treatments)The fertilization treatments were divided into three doses. The first dose was added after a month of transplanting and the other doses after every two weeks intervals.

Data recorded

- **Vegetative growth**

Plant height (cm.), number of leaves/ plant, number of branches/ plant, number of inflorescence/ plant, inflorescence diameter, stem diameter, days spanned until first flower emergence (day), blooming periods(day), flower durability(day) and plant leaf area (cm) were determined at the end of experiment time course at the end of October.

- **Chemical analysis**

chlorophyll content was determind in both seasons as SPAD units using "Minolte (chlorophyll meter) SPAD – 502", Japan (Yadava, 1986), Also N% by method of Pregl (1945), P% by methods of Trough and Meyer(1939), K% according to Brown and Lilland (1964), Carotene pigments (mg/g) by methods of Ramely (1993) and total carbohydrate % by Herbert *et al.* (1971).

Statistical analysis

All the data collected were subjected to statistical analysis of variance as described by Gomez and Gomez (1984). The treatment means were compared using L.S.D. test at 0.05 level of probability.

RESULTS AND DISCUSSIONS

A) Vegetative growth

Results presented in Table (2) revealed that the main effects of the studied treatments had significant effect on plant height (cm), number of leaves/ plant, inflorescence diameter, stem diameter, plant leaf area (cm^2) in 2014 and 2015 seasons. The macro-elements sush as N,P and K play a major role in growth and development of plants. Nitrogen (N) is a main constituent of all proteins and nucleic acids, as well as, of both structural and non structural components of plant cells. Besides, involving phosphorus (P) in energy transfer process and building of phospholibids and nucleic acids (Yeonhee *et al*., 2000). In addition, potassium (K) is the factor affecting many functions of plants, stomata movement, regulating photosynthesis, respiratory rate and activating many enzymes involved in plant growth. It also increases protein synthesis and different metabolic processes, as well as reducing respiration, hence energy losses (Csirzinsky, 1999). However, there were direct proportional relationships between the used fertilizers rates and every given trait. In other words, as the fertilizer rate increased, the given trait increased. Moreover, data in Table (2) indicated that NPK or humic acid and nano-NPK at the lowest application rate achieved the lowest mean values and *Vice versa* during both successive seasons. The fertilizers are protected by the nanoparticles for better survival in inoculated soils, allowing for their controlled release into the soil (Saigusa, 2000). Applying nanomaterials to improve soil fertility and water retention links soil science and agriculture to surface chemistry (Navrotsky, 2000). Meanwhile, the first order interaction between NPK (mg/l) x humic acid (mg/l) had no significant on plant height, flower diameter and stem diameter, but the other traits were not so during both examined seasons. On the other hand , the first order interaction between the other both interactions and the second order interaction among the 3 variables affected the studied traits significantly ($P \leq 0.01$). These results are in agreement, more or less, with Ramesh (2006) on zinnia, Youssef *et al.* (2008) on marigold and also agreement with Ahmad *et al.* (2011) on marigold.

Data outlined in Table (3) revealed that the treated characteristics were affected, significantly, by the three examined types applied at various tested rates and their interactions within the both growing seasons. With regard to the main effects of the fertilizers types, they in general exhibited direct proportional relationships between the various tested rates and numbers of flowers and branches per plant, blooming periods. On the other hand, there were inverse relationships were recorded regarding's days spanned to first flower emergence and flower durability. The obtained results mean that as any fertilizer type rate increased, nanotechnology offers an important role in improving existing plant growth and crop management techniques (Nair *et al*., 2010). The former -

above mentioned- traits increased and *Vice versa* in terms of days elapsed to first flowers to amperage. This was true during both successive seasons of the study. This result agree with Ahmad *et al.* (2011) on marigold, Amirnia *et al*. (2014) on *Crocus sativus* L., Razavi *et al.* (2015) on *Echinaceae Purpuerea*, Singha *et al*. (2015) and Sultana *et al.* (2015) on zinnia ; (L.).

The interaction either between each of combination (the first order interaction) each or among triples of combination (the second order interaction) affected significantly ($P \leq 0.01$) the various studied traits, except for number of branches/ plant, in case of the interaction between NPK x humic acid (mg/l), during the both seasons of the study. Improvement of the plant growth may by explained by the role of humic acid in increasing the availability of nutrients in the soil through influencing on soil microbial activity , help in fixing atmospheric N and secrete more vitamins and growth promoting substances necessary for good and healthy growth El-Sayed and El- Shal, (2008).

Table (2). Effect of NPK, humic acid and nano-NPK rates and their interactions on plant height (cm), number of leaves / plant, inflorescence diameter, stem diameter and plant leaf area (cm) of *Tagates eracta* plants during 2014 and 2015 seasons.

Treatments	Plant height (cm)		Number of leaves/ plant		inflorescence diameter (cm)		Stem diameter (cm)		Plant leaf area (cm2)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A) NPK(mg/l)										
0	60.46c	65.71c	105.95c	118.99c	2.71c	2.99c	0.66c	0.69c	20.09b	22.34b
50	64.44b	70.04b	123.22b	138.38b	2.97b	3.29b	0.69b	0.72b	22.67a	25.18a
100	70.50a	76.62a	130.19a	146.24a	3.96a	4.38a	0.77a	0.80a	23.25a	25.82a
L.S.D.(0.05)	2.02	2.19	2.63	0.29	0.19	0.19	0.02	0.01	0.72	0.78
B) Humic acid(mg/l)										
0	62.44c	67.87c	109.24c	122.69c	2.77c	3.07c	0.68c	0.71c	20.69c	22.98c
500	65.71b	71.43b	121.78b	136.78b	3.17b	3.51b	0.70b	0.73b	21.93b	24.34b
1000	67.24a	73.08a	128.33a	144.15a	3.69a	4.09	0.74a	0.77a	23.39a	26.01a
L.S.D.(0.05)	1.01	1.09	0.81	0.92	0.09	0.09	0.01	0.02	0.09	0.11
C) Nano-NPK (mg/l)										
0	59.10c	64.24c	80.95c	90.90c	2.45c	2.71c	0.63c	0.66c	19.28c	21.43c
25	65.33b	71.01b	132.14b	148.41b	3.21b	3.56b	0.71b	0.74b	22.82b	25.36b
50	70.96a	77.13a	146.26a	164.31a	3.97a	4.39a	0.79a	0.82a	23.91a	26.55a
L.S.D.(0.05)	0.49	0.53	0.88	1.018	0.05	0.05	0.01	0.01	0.15	0.15
Interactions										
AxB	ns	ns	**	**	ns	ns	ns	ns	**	*
AxC	**	**	**	**	**	**	**	**	**	**
BxC	**	**	**	**	**	**	**	**	**	**
AxBxC	**	**	**	**	**	**	**	**	**	**

Means of each factor designated by the same letter not significantly different at 5% using least significant difference (L.S.D.).
*: Significant at 0.05 level of probability.

Table (3). Effect of NPK, humic acid and nano-NPK rates and their interactions on number of inflorescence / plant , number of branches/plant, days spanned to first flower emergence (days), blooming periods and flower durability of *Tagates eracta* plants during 2014 and 2015 seasons.

Treatments	Number of inflorescence / plant		Number of branches/plant		Days spanned to first flower emergence(days)		blooming periods (days)		Flower durability (days)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A) NPK(mg/l)										
0	32.89c	36.53c	21.51c	23.90c	102.51a	99.96a	68.59c	72.19c	33.27a	31.91a
50	34.58b	38.67b	22.92b	25.43b	101.66b	99.15b	70.15b	73.94b	31.84b	30.54b
100	40.49a	44.91a	26.72a	29.64a	99.32c	96.94c	74.45a	78.42a	30.21c	28.66c
L.S.D.(0.05)	1.13	1.22	0.83	0.97	0.69	0.72	0.43	0.25	1.09	0.59
B) Humic acid(mg/l)										
0	32.67c	36.23c	22.01c	24.41c	102.54a	99.97a	68.12c	71.72c	33.34a	31.99a
500	36.75b	40.79b	23.91b	26.54b	101.23b	98.76b	70.85b	74.71b	31.99b	30.35b
1000	38.79a	43.10a	25.24a	28.02a	99.72c	97.31c	74.22a	78.11a	29.99c	28.77c
L.S.D.(0.05)	0.36	0.39	0.51	0.52	0.56	0.69	0.33	0.20	0.86	0.26
C) Nano-NPK (mg/l)										
0	29.79c	33.00c	19.55c	21.69c	104.66a	102.04a	63.33c	66.62c	35.87a	34.47a
25	37.26b	41.39b	24.39b	27.08b	100.34b	97.91b	72.99b	76.91b	30.65b	29.38b
50	41.17a	45.73a	27.22a	30.19a	98.48c	96.11c	76.87a	81.02a	28.81c	27.26c
L.S.D.(0.05)	0.19	0.20	0.23	0.24	0.49	0.73	0.35	0.26	0.79	0.18
Interactions										
Ax B	**	*	ns	ns	**	**	**	**	ns	**
AxC	**	**	**	**	**	**	**	**	ns	**
BxC	**	**	**	**	**	**	**	**	ns	**
AxBx C	**	**	*	*	**	**	**	**	*	**

Means of each factor designated by the same letter not significantly different at 5% using least significant difference (L.S.D.).
*: Significant at 0.05 level of probability.

B) Chemical composition

Results of Table (4) showed that types of applied fertilizer at various rates and their combination, in general exhibited, highly significant effects on the studied traits as Leaf green color degree, carbohydrates and carotene pigment contents. Nano fertilizers or nano-encapsulated nutrients have properties effectively to release nutrients and chemical fertilizers on demand that regulate plant growth and enhance target activity (Rosa *et al*., 2010 and Nair *et al*., 2010).The main effect of the various tested types fertilizers declared a direct proportional relationship between the rates of such fertilizer and the given traits, i.e., as the given rate increased, the mean values of these traits increased.Whereas, the lowest fertilizer's rate, the lowest mean value and *Vice versa*. On the other hand, the first and second order interaction exerted highly significant effects on the various tested characters, except carbohydrates content during both seasons, when humic acid was in interaction with Nano-NPK. Increasing the content of active constituents in tissues of the treated plants may indicate the role of humic acid in enhancing the metabolic activity of microorganisms and activity as a source of N, P and K (Higa and Wididana, 1991). These results are in agreement, more or less, with those of Ahmad *et al.* (2011) on marigold; Sarwar *et al*. (2013) on (*Matthiola incana* R. Br.); Ali *et al.* (2014) on (*Tulipa gesneriana*) and Ali *et al.* (2015) on (*Tulipa gesneriana*).

Table (4). Effect of NPK, humic acid and nano-NPK rates and their interactions on leaf green color degree, carbohydrates and Carotene pigments of *Tagates eracta* plants during 2014 and 2015 seasons.

Treatments	chlorophyll (SPAD)		Carbohydrates %		Carotene pigments (mg/g)	
	2014	2015	2014	2015	2014	2015
A) NPK(mg/l)						
0	37.64c	41.82c	2.26c	2.45c	1.53b	1.61b
50	39.67b	44.04b	2.41b	2.61b	1.52b	1.60b
100	44.30a	49.20a	2.78a	3.01a	1.85a	1.94a
L.S.D.(0.05)	0.91	1.01	0.08	0.09	0.03	0.04
B) Humic acid(mg/l)						
0	38.17c	42.39c	2.30c	2.49c	1.55c	1.64c
500	40.16b	44.58b	2.50b	2.71b	1.64b	1.73b
1000	43.28a	48.08a	2.65a	2.87a	1.71a	1.79a
L.S.D.(0.05)	0.23	0.24	0.03	0.02	1.01	0.01
C) Nano-NPK (mg/l)						
0	35.59c	39.50c	2.02c	2.18c	1.43c	1.50c
25	41.29b	45.88b	2.57b	2.78b	1.63b	1.71b
50	44.73a	49.68a	2.88a	3.11a	1.85a	1.95a
L.S.D.(0.05)	0.27	0.29	0.02	0.02	0.01	0.01
Interactions						
Ax B	**	**	**	**	**	**
AxC	**	**	**	**	**	**
BxC	**	**	ns	ns	**	**
AxBx C	**	**	**	**	**	**

Means of each factor designated by the same letter not significantly different at 5% using least significant difference (L.S.D.). *: Significant at 0.05 level of probability.

Data tabulated in Table (5) declared that different levels of applied fertilizer and their combinations exerted significant effect on the given traits.The main effect of the various tested types fertilizers showed that the fortifying with nano-NPK resulted in the highest percentage of N,P and K (2.38,0.49 and 2.12%) in the first season and (2.57, 0.53 and 2.29%) in the second season. On the other side, the lowest percentage of N,P and K were obtained by control treatment (1.89, 0.38 and 1.65%) in the first season and (2.04, 0.41 and 1.79%) a direct relationship between the rates of such fertilizer and the given traits, i.e., as the given rate increased, the mean values of these traits increased. Nano fertilizers or nano-encapsulated nutrients have properties effectively to release nutrients and chemical fertilizers on demand that regulate plant growth and enhance target activity (Rosa *et al*., 2010 and Nair *et al*., 2010). On the other hand, the combination between various fertilizers had significant effect on the studied traits, except the combination between npk and humic on n percentage in the first season, and the interaction between nano npk and humic on p percentage in the first season and k in the first and second season. These results are in agreement, more or less, with Ahmad *et al.* (2011) on marigold, Sarwar *et al*. (2013) on (*Matthiola incana* R. Br.), Ali *et al.* (2014) on (*Tulipa gesneriana*) and Ali *et al.* (2015) on (*Tulipa gesneriana*) Nevertheless, it could be recommended that fertilization of *Tagetes erecta* with Nano NPK at 50 mg/l and interaction between mineral NPK at 100 mg/l + humic acid at 1000 mg/l + Nano-NPK at 50 mg/l during both growing seasons were the best treatment in producing the highest quality of growth.

Table (5). Effect of NPK, humic acid and nano-NPK rates and their interactions on N, P and K% of *Tagates eracta* plants during 2014 and 2015 seasons.

Treatments	N%		P%		K%	
	2014	2015	2014	2015	2014	2015
A) NPK(mg/l)						
0	1.94c	2.09c	0.39c	0.43c	1.70c	1.85c
50	2.14b	2.32b	0.43b	0.46b	1.83b	1.98b
100	2.34a	2.54a	0.49a	0.53a	2.16a	2.34a
L.S.D.(0.05)	0.07	0.08	0.03	0.02	0.06	0.06
B) Humic acid(mg/l)						
0	1.96c	2.12c	0.37c	0.39c	1.76c	1.91c
500	2.15b	2.33b	0.45b	0.48b	1.88b	2.04b
1000	2.32a	2.50a	0.49a	0.54a	2.04a	2.22a
L.S.D.(0.05)	0.02	0.03	0.01	0.04	0.02	0.02
C) Nano-NPK (mg/l)						
0	1.89c	2.04c	0.38c	0.41c	1.65c	1.79c
25	2.16b	2.34b	0.44b	0.47b	1.92b	2.08b
50	2.38a	2.57a	0.49a	0.53a	2.12a	2.29a
L.S.D.(0.05)	0.02	0.02	0.01	0.01	0.02	0.02
Interactions						
Ax B	ns	*	*	**	*	*
AxC	**	**	**	**	**	**
BxC	**	**	ns	*	ns	ns
AxBx C	**	**	*	**	**	**

Means of each factor designated by the same letter not significantly different at 5% using least significant difference (L.S.D.). *: Significant at 0.05 level of probability.

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الملخص العربي

تأثير التسميد العضوي والنانو كبدائل للتسميد المعدني على النمو والتركيب الكيماوى لنباتات القطيفة

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أجريت هذه الدراسة في المنتزه، معهد بحوث البساتين، مركز البحوث الزراعية بالمنتزه – الإسكندرية – مصر خلال موسمين متتاليين هما ٢٠١٤ و٢٠١٥ وذلك لدراسة مقارنة استخدام التسميد العضوي والنانو كبدائل للتسميد المعدني على النمو والتركيب الكيميائي لنباتات القطيفة. ولتحقيق أفضل نمو أجريت التجربة في تصميم تجريبي قطع منشقة مرتين مع التسميد (بالاسمدة النانو – الهيوميك – NPK) وكان العامل الأول NPK بمعاملات (صفر، ٥٠ و ١٠٠ ملليجرام/ لتر)، العامل الثاني التسميد بحمض الهيوميك بمعاملات (صفر ، ٥٠٠ و ١٠٠٠ ملليجرام / لتر) العامل الثالث : التسميد أسمدة النانو بمعاملات (صفر ، ٢٥، ٥٠ ملليجرام / لتر).

وأشارت النتائج إلى وجود تأثيرات معنوية لمختلف أنواع الأسمدة المستخدمة ولقد أتضح أن الجرعات الأعلى من الأسمدة أدت إلى زيادة معنوية في نتائج كل من ارتفاع النبات (سم)، عدد الأوراق / نبات، قطر النورة ، قطر الساق ، مساحة الورقة النبات (سم)، وعدد النورات/ نبات، عدد الأفرع / نبات، عدد الأيام من الزراعة حتى ظهور أول زهرة ، فترة الأزهار ، ، إلى جانب زيادة في محتوى الكلورفيل و الكربوهيدرات والمحتوى من الكاروتين والنيتروجين والفسفور والبوتاسيوم مقارنة بالكنترول.

ومع ذلك فقد كانت الأسمدة النانو بتركيز 50 ملليجرام / لتر وأيضا التفاعل الثلاثي ما بين الأسمدة المعدنية بتركيز ١٠٠ ملليجرام / لتر + حمض الهيوميك بتركيز ١٠٠٠ ملليجرام / لتر+ الأسمدة النانو بتركيز ٥٠ ملليجرام / لتر خلال موسمين الدراسة ٢٠١٤ و٢٠١٥ على نبات القطيفة قد أعطت أفضل النتائج على مستوى النمو والتركيب الكيمائي.