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RESPONSE OF GROWTH AND PRODUCTIVITY OF ANISE (*Pimpinella anisum* L.) TO CHEMICAL, ORGANIC AND BIOLOGICAL FERTILIZERS

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ABSTRACT: In order to study the response of anise growth and yield components to different fertilizers types (chemical, organic and bio fertilization) treatments, two field experiments were carried out at a private farm named Royale for herbs in El-Bawiti Village, El Wahat El Bharia District, Giza Governorate, Egypt during the two consecutive winter seasons of 2018/2019 and 2019/2020. The efficiency of organic fertilization (humic acid and/or compost) and biological fertilization (nitrobein or/and phosphorein) were compared with standard commercial rates of N, P and K as chemical fertilizers with regard to the growth and yield traits of anise plant. The obtained results referred that, in most cases, anise plants treated with chemical fertilization (N_{100} P_{75} K_{50} /feddan) produced the highest values in plant growth (plant height, number of branches per plant and herb fresh and dry weights per plant) compared to the others types of fertilizers under study. In most cases, fertilized plants with 20 m^3 compost + 3 kg humic acid /feddan gave the highest values regard root fresh and dry weights and root length compared to the other fertilizers type under study. The rate of chemical fertilizers (N, P_2O_5 and K_2O at 100, 75 and 50 kg/feddan, respectively) gave the highest values in yield components (umbels and umblets number per plant as well as fruit yield per plant and per feddan) compared to the other ones under study, in most cases. Also, biological fertilization (20 m^3 compost + 2 kg phosphorein /feddan) was the aforementioned treatment which increased the fruit yield per feddan.

Key words: *Pimpinella anisum*, NPK, organic, biological fertilization, growth and yield.

INTRODUCTION

Anise or aniseed (*Pimpinella anisum* L.) is one of the most serious annual aromatic and medicinal plants from *Apiaceae* (Umbellefera) family in the world. Its fruits contain from about 1.5 to 5.0% of volatile oil which gives sweet herbaceous odour and taste of this important plant (**Ullah and Honermeier, 2013**). It is a dainty, white-flowered plant, about 44 cm high, native of Iran, Egypt, Crete, Turkey, Greece and Asia Minor. Its active substances are utilized in various pharmaceutical and food industries (**Nabizadeh *et al.*, 2012**). Because of the strong aroma, it is often utilized in pharmaceutical industry for masking the bad taste of remedies, as well as for the preparation of many sweets (chocolate, candies and cookies) and alcoholic beverages.

Nitrogen (N) is the most substantial nutrient element in terms of plant growth, physiology and carbohydrate synthesis (**Almodares *et al.*, 2008**). It is a constituent of chlorophyll, amino acids, proteins, protoplasm and alkaloids. Phosphorus (P) is an substantial constituent of bio-molecules like phospholipids, nucleic acids, and energy components (ATP and ADP). Usually the soils are P deficient because of fixation problems, which makes it less available to the plants especially in clays soils (**Gentili *et al.*, 2006** and **Rotaru and Sinclair, 2009**). Potassium (K) is substantial for maintaining osmotic balance, phloem transport and photosynthesis (**Tripler *et al.*, 2006**). Also, these nutrients improving nutrient utilize efficiency of crop plants leads to a substantial improvement of the plant yields.

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Organic fertilizers (such as compost) are extremely saved for environment, human and animal. It enhances the soil properties and reduces the costs as well as raising fertility of soil and improves the product quality and safe of environment pollution. Organic agriculture is based on minimizing the application of external inputs and avoiding the utilization of synthetic fertilizers and pesticides **(Lazcano *et al*., 2009)**. **Mikkelsen (2005)** pointed out that humic acid has a high complications ability and high molecular weight. In addition, **Sangeetha *et al.* (2006)** found that humic material have both direct and indirect influences on physiological and biochemical processes in plant and on soil chemical, physical and biological attributes.

Regarding the importance of aromatic and medicinal plants and their role in human health, it is very serious to raise their biomass without application of harmful chemical fertilizers. Moreover, **Nyoki and Ndakidemi (2014)** found that *Bradyrhizobium* inoculation and supplementation of P independently or in combination had positive impacts on legumes growth and grain yield. Likewise, **Abdou *et al.* (2020**) indicated that fennel vegetative and yield parameters were significantly increased by all utilized bio-fertilization treatments compared with control (un-inoculated plants).

The most remarkable aim of this study was to investigate the response growth, and fruit yield components of Anise (*Pimpinella anisum* L.) plant to chemical, organic and biological fertilization type.

MATERIALS AND METHODS

In order to study the response of anise growth and yield components to different fertilizers types (chemical, organic and bio fertilizers) treatments two field experiments were carried out at a private farm named Royale for herbs in El-Bawiti Village, El Wahat El Bharia District, Giza Governorate, Egypt during the two consecutive winter seasons of 2018/ 2019 and 2019/2020.

Seeds of anise were obtained from Research Centre of Medicinal and Aromatic Plants, Dokky, Giza, Egypt. The seeds were sown on 20th November during both seasons. Seeds were sown on one side of each ridge in 70 cm width and 30 cm apart. Then it immediately irrigated. After complete germination at 15 days after sowing seeds were thinned to one plant per hill. Each plot consists of three ridges; each one is 20 m long. The area of the experimental unit was (42 m^2). The physical and chemical properties of the used soil (average of two seasons) were shown in Table 1, according to **Chapman and Pratt (1978**).

The present study was established to evaluate the influence of different fertilization types as follow:

Chemical Fertilization

1. N 80 + P 60 + K 40 kg/ feddan.
2. N 100+P 75+ K 50 kg/ feddan (recommended level).
3. N 120 + P100 + K 60 kg/ feddan.

The chemical fertilizers were applied throw irrigation as ammonium sulfate (20% N), urea phosphate (44% P_2O_5) and potassium sulfate (50% K_2O) every three days intervals during the 1st and 2nd seasons.

Organic Fertilization

1. Control (without application).
2. Compost at 20 m^3 + 2 kg humic acid /feddan.
3. Compost at 20 m^3 + 3 kg humic acid / feddan.
4. Compost at 20 m^3 + 4 kg humic acid / feddan.
5. Compost at 20 m^3 / feddan.

Organic fertilization compost at 20 m^3/ feddan rate as a soil application was added at the time of soil preparation. The moisture of compost was about 25-30%. Also, physical and chemical properties of the used compost are shown in Table 2. Vegetarian humic acid was obtained from Abo Zaabal Company to Fertilizers (AZCF) contains 89% humic acid. Humic acid rates were applied four times to the plant root area during the vegetative period starting 25 days intervals from sowing date and between additions through drip irrigation system after being dissolved in fixed amount of irrigation water, when each addition.

Table 1. Physical and chemical properties of experimental farm soil (average of two seasons)

Mechanical analysis			Soil texture
Clay (%)	Silt (%)	Sand (%)	Sandy
2.45	3.85	93.70	

Chemical analysis											
pH	E C m.mohs/ cm	Soluble cations (meq. / l)				Soluble anions (meq. / l)			Available (ppm)		
		Mg^{++}	Ca^{++}	K^{+}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
7.80	0.77	2.5	3.5	1.3	0.8	1.5	0.5	5.0	0.04	8.30	0.2

Table 2. Physical and chemical properties of the compost applied in the present study (average of two seasons)

pH	E C m.mohs/ cm	Organic matter (%)	Organic carbon (%)	C:N ratio	Mg^{++}	Ca^{++}	K^{+}	Na^{+}	P
					(ppm)				
8.10	0.62	39.80	22.60	1:14	46.60	1405.10	476.20	644.00	4.30

Bio-fertilization

1. 20 m^3 compost + 2 kg nitrobein / feddan.
2. 20 m^3 compost + 2 kg phosphorein /feddan.
3. 20 m^3 compost + 2 kg nitrobein + 2 kg phosphorein / feddan).

Anise seeds were inoculated with nitrobein (*Azospirillum lipofrum*) and phosphorein (*Bacillus megatherium*) just before sowing and repeated again before flowering as soil drench as stated in the company's recommendations. All agricultural practices were performed as usual, in the region for the production of anise plants.

The eleven treatments were arranged as a simple experiment in randomized complete block design with three replicates.

Recorded Data

Plant growth

After 98 days from the sowing date of anise, a sample of 3 plants were randomly taken from each experimental unit and the plant growth parameters were recorded as plant height (cm) and number of branches/plant as well as fresh and dry weights of herb and roots/plant (g) and root length were tabulated.

Yield and its components

At the harvesting stage (after 145 days from sowing date) the yield components expressed as number of umbels and umblets per plant, fruit yield/plant (g) and seed yield/faddan (kg) were recorded.

Statistical Analysis

Data of the present study were statically analyzed and the differences between the means of the different treatments were considered significant when they were equal or more than the least significant differences (L.S.D) at the 5% level by using Statistix Version 9 computer program (**Analytical Software, 2008**).

RESULTS AND DISCUSSION

Plant growth

Data recorded in Tables 3 and 4 shows that fertilized anise plants with NPK fertilizers (N, P_2O_5 and K_2O at 100, 75 and 50 kg/feddan, respectively) level followed by 20 m^3 compost + 3 kg humic acid per feddan without significant difference between them gave the highest values regard plant height, branches number per plant and fresh and dry weights per plant in both seasons, in most cases. Furthermore, the lowest

Table 3. Effect of different fertilizer sources on plant height (cm), number of branches/plant and herb fresh and dry weight per plant (g) of *Pimpinella anisum* during 2018/2019 and 2019 /2020 seasons

Fertilization type	Plant height (cm)		Number of branches / plant		Herb fresh weight / plant (g)		Herb dry weight / plant (g)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
N80 P60 K40	56.67a	56.67a	11.00ab	12.33ac	41.00ab	49.89ac	10.35ac	15.26b
N100 P75 K50	57.33a	60.33a	13.67 a	15.00 a	52.70 a	68.98 a	14.04a	25.28a
N120 P100 K60	48.33ab	44.33b	8.33 b	10.00 c	42.33ab	38.40bd	10.04ac	11.04c
Control (without application)	49.33ab	43.00b	9.00 b	10.00 c	17.33ab	20.97d	4.91ac	5.90b
20 m^3 Compost + 2kg Humic acid	54.67ab	50.00a	9.67 b	11.33 bc	17.67ab	46.95ac	5.91ac	14.35b
20 m^3 Compost + 3kg Humic acid	57.00a	57.67a	11.33ab	13.33 ab	30.33ab	51.62ac	12.88ab	16.21b
20 m^3 Compost + 4kg Humic acid	42.67b	51.67ab	9.00 b	11.67 bc	34.72ab	36.50bd	6.03ac	13.54bc
20 m^3 Compost	46.67ab	50.67ab	10.33ab	12.33ac	17.47ab	36.35bd	2.75c	12.12bc
20 m^3 Compost + 2kg Nitro	47.67ab	51.00ab	9.00 b	12.33ac	31.00ab	32.11cd	5.57ac	10.26bc
20 m^3 Compost + 2kg Phosph	51.33ab	56.67a	9.67 b	12.33ac	38.50ab	56.09ab	3.70bc	15.70b
20 m^3 Compost + 2kg Nitro+2kg phosph	43.67b	58.33a	9.00 b	10.33 bc	6.10 b	42.63bd	1.82c	13.46bc

* Nitro = Nitrobein and Phosph = Phosphorein
Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

Table 4. Effect of different fertilizer sources on root fresh and dry weights/plant (g) and root length (cm) of *Pimpinella anisum* during 2018/2019 and 2019 /2020 seasons

Fertilization type	Root fresh weight / plant (g)		Root dry weight / plant (g)		Root length (cm)	
	First season	Second season	First season	Second season	First season	Second season
N80 P60 K40	3.53ab	4.37ac	1.15ad	1.71ab	11.33 b	20.67bd
N100 P75 K50	4.70ab	6.15ab	1.66 ab	2.45a	15.33 ab	26.00ab
N120 P100 K60	4.43ab	4.87ac	1.89 a	1.56ab	12.00 b	20.00bd
Control (without application)	4.60ab	3.19c	0.67cd	1.00 b	9.67 b	16.33 d
20 m^3 Compost + 2kg Humic acid	2.13ab	4.89ac	0.61cd	1.68 ab	14.00 ab	21.33bd
20 m^3 Compost + 3kg Humic acid	5.02 a	6.61a	1.49ac	2.25 a	21.00 a	27.67 a
20 m^3 Compost + 4kg Humic acid	4.57ab	5.91ab	0.58cd	2.17 a	13.00 b	23.00ac
20 m^3 Compost	4.87ab	3.77bc	0.50 d	1.46ab	15.33 ab	23.67ac
20 m^3 Compost + 2kg Nitro	3.47ab	4.12ac	0.88bd	1.48ab	11.67 b	18.67cd
20 m^3 Compost + 2kg Phosph	3.30ab	3.60bc	0.33 d	1.49ab	12.67 b	22.67ac
20 m^3 Compost + 2kg Nitro+2kg phosph	0.98 b	4.80ac	0.33 d	1.60ab	12.33 b	25.00ab

* Nitro = Nitrobein and Phosph = Phosphorein
Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

values in this connection were recorded with control (without chemical, organic and biological fertilization) compared to the other ones under study, in most cases. Moreover, organic fertilization with 20 m^3 compost + 3 kg humic acid per feddan followed by chemical fertilization types significantly increased the fresh and dry weights of roots per plant and root length compared to the control in both seasons.

Moreover, **Ahmed *et al*. (2019)** reported that the highest rate of chemical fertilizers (125, 100, 62.5 and 30 kg/feddan of N, P_2O_5, K_2O and MgO, respectively) gave the highest values of plant height, branches number per plant, fresh and dry weights per chamomile plant. Likewise, **Ahmed and Abdelkader (2020)** demonstrated that plant height and branch number /plant as well as total fresh and dry weights/plant and root length of chilli plant significantly increased with NPK fertilization level at 100% recommended rate during both seasons.

In addition, **El-Sayed *et al.* (2018)** showed that the organic fertilizers had a significant influence on total herb fresh and dry weights per plant of *Cymbopogon citratus* than bio fertilizer treatments. Also, **Mohammed *et al*. (2019,a)** on chamomile plant, indicated that the maximum values of plant height, branch number/plant and herb dry weight/plant were detected when chamomile plants were applied with the highest rate of humic acid (3.0 kg/feddan).

Yield and its Components

Data listed in Table 5 suggest that the chemical fertilizers especially at N, P_2O_5 and K_2O at 100, 75 and 50 kg/feddan, progressively induced the highest number of umbels and umblets /plant as well as fruits yield /plant and /feddan of anise plant as compared with organic or biological fertilization in both seasons. However, increasing humic acid rates from 2 to 3 kg /feddan plus 20 m^3 compost gradually increased fruit yield per plant as well as fruit yield per feddan in both seasons. Generally, 20 m^3 compost + 2 kg phosphorein gave the highest values in anise yield components (umbels and umblets number per plant as well as fruit yield per plant and per feddan) during both seasons, in most cases.

Kamrozzaman *et al*. (2016) reported that coriander seed yield was higher when 100% of chemical fertilizer rate was utilized but yield decreased when 25% less fertilizer used. **Mohammed *et al*. (2019,b**) revealed that the maximum value for each of total dry herb yield/plant as well as dry yield of leaves and herb/feddan were detected when stevia plants were fertilized with 100% recommended rate of NPK fertilization compared to control. **Jabborova *et al*. (2021)** reported that using NPK fertilizers as macronutrients significantly increased ginger yield rhizome compared to control.

Almarie *et al*. (2019) noticed the superiority of organic manure via improving caraway yield and its components (umbels number per plant as well as seed yield per plant and seed yield per hectare compared to control (without fertilization). Also, **Abdelkader and Mostafa (2019)** revealed that the highest rate of humic acid (3 ml/l) recorded the maximum values of pods number/plant and seed yield /plant and /faddan of cluster bean plant compared to the lowest rates under study (1.0 or 2.0 ml/l) and control.

Arafa *et al*. (2017) pointed out that the farmyard manure + nitrobein treatment was the most effective for enhancing herb fresh and dry yield of *Mentha longifolia*, as well as the treatment of rabbit manure + nitrobein was the most effective for increasing the yield components. In the same time, **Khalil *et al*. (2019)** found that the highest values of umbels number per plant at full flowering stage and dry fruits yield per plant at harvest stage achieved with inoculating celery seeds with mixture of mycorrhizal and mycrobein compared to control.

Conclusion

It is preferable from the previous results that treating anise plants with chemical fertilizers treatment (N_{100} P_{75} K_{50}/feddan), for improving growth and yield components of anise plant. Therefore, the present study strongly admit the utilize of such treatment (organic + biological fertilization) especially 20 m^3 compost + 2 kg phosphorein to provide high and good exportation properties due to its safety role on human health with increasing fruits yield of *Pimpinella anisum*.

Table 5. Effect of different fertilizer sources on number of umbels and umblets/plant as well as fruit yield per plant (g) and per feddan (kg) of *Pimpinella anisum* during 2018/2019 and 2019 /2020 seasons

Fertilization type	Number of umbels / plant		Number of umblets / plant		Fruit yield / plant (g)		Fruit yield / feddan (kg)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
N80 P60 K40	61.33ab	67.67 b	654.3a	576.7bd	8.73ac	18.33 ac	174.67 ac	366.53ac
N100 P75 K50	69.33 a	120.33a	664.3a	871.3 a	15.23 a	22.47 a	304.67a	449.47 a
N120 P100 K60	52.67ab	34.33bc	589.6a	340.3cd	6.47 c	15.10 bc	129.33c	302.00bc
Control (without application)	35.67ab	25.33 c	338.0b	292.7 d	5.63 c	6.08 d	112.67c	121.60 d
20 m^3 Compost + 2kg Humic acid	28.33ab	51.00bc	315.3bc	537.3bd	7.70 bc	12.41c	154.00bc	248.20 c
20 m^3 Compost + 3kg Humic acid	29.67ab	55.00bc	276.0bc	618.0bc	8.90 ac	14.30bc	178.00ac	285.93bc
20 m^3 Compost + 4kg Humic acid	28.00ab	54.00bc	258.3bc	661.0bc	5.09 c	17.00ac	101.73c	340.07ac
20 m^3 Compost	35.33ab	38.33bc	311.0bc	484.7bd	6.21 c	17.13ac	124.27c	342.60ac
20 m^3 Compost + 2kg Nitro	42.00ab	40.67bc	337.3b	458.7bd	11.23ac	19.78ab	224.67ac	395.67ab
20 m^3 Compost + 2kg Phosph	64.33 a	55.33bc	647.3a	725.0 b	13.84ab	20.06ab	276.80ab	401.27ab
20 m^3 Compost + 2kg Nitro+2kg phosph	14.67 b	49.33bc	176.3c	500.7bd	11.39 ac	13.38 c	227. 73ac	267.53 c

* Nitro = Nitrobein and Phosph = Phosphorein

Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

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استجابة نمو وإنتاجية نبات الينسون إلى التسميد الكيميائي والعضوي والحيوي

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أجريت تجربتان حقليتان في مزرعة خاصة تسمى رويال للأعشاب بقرية الباويطي بمنطقة الواحات البحرية، محافظة الجيزة، مصر لدراسة استجابة نمو ومكونات المحصول لنبات الينسون لأنواع الأسمدة المختلفة (كيماوية وعضوية وحيوية) خلال موسمي الشتاء المتتاليين لأعوام 2019/2018 و 2020/2019. تمت مقارنة كفاءة التسميد العضوي (حمض الهيوميك و/أو الكمبوست) والتسميد الحيوي (النيتروبين و/أو الفوسفورين) بالمعدلات القياسية والتجارية للنيتروجين والفسفور والبوتاسيوم كأسمدة كيميائية فيما يتعلق بنمو وإنتاجية نبات الينسون. أشارت النتائج المتحصل عليها إلى أن نباتات الينسون المعاملة بالتسميد الكيميائي (ن100 و فو75 وبو50) في معظم الحالات أنتجت أعلى القيم في نمو النبات (ارتفاع النبات، عدد الأفرع لكل نبات، والأوزان الطازجة والجافة للعشب لكل نبات) مقارنة بأنواع الأسمدة الأخرى قيد الدراسة. في معظم الحالات، أعطت النباتات المسمدة بالكمبوست بمعدل 20 م^3 + 3 كجم من حمض الهيوميك للفدان أعلى القيم فيما يتعلق بالوزن الطازج والجاف للجذر وطول الجذر مقارنة بأنواع الأسمدة الأخرى قيد الدراسة. أعطي معدل التسميد الكيماوي (ن، فو$_2$أ$_5$ و بو$_2$أ بمعدل 100، 75، 50 كجم/فدان، على التوالي) أعلى القيم في مكونات المحصول (عدد النورات والنويرات للنبات وكذلك محصول الثمار/نبات و/الفدان) مقارنة بالمعاملات الأخري قيد الدراسة، في معظم الأحيان. كما تبعت تلك المعاملة من التسميد الكيميائي بالتسميد الحيوي (20 م^3 كمبوست + 2 كجم فوسفورين) لإحداث زيادة في محصول الثمار للفدان.

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