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إدارة التسميد مع الرى بالنيتروجين والفوسفور والبوتاسيوم في الكوسة (Cucurbita pepo L.) تحت نظامين من الري بالتنقيط

NPK Fertigation Management in Squash (Cucurbita pepo L.) Under Two Drip Irrigation Systems

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الملخص

أجريت التجربة الحالية في مزرعة خاصة تقع في بحيرة ناصر، جنوب غرب محافظة أسوان، مصر خلال موسمي ٢٠٢٢ و ٢٠٢٣ لدراسة تأثير التسميد مع الرى بجرعات مختلفة من الـ **NPK** على الصفات الخضرية والمحصول وكفاءة استخدام المياه في صنف الكوسة اسكندرانى. تم استخدام تصميم القطاعات الكاملة العشوائية **(RCBD)** باستخدام ترتيب القطع المنقسمة بثلاثة مكررات في هذه التجربة. تم ترتيب نظامي الري أي التنقيط السطحي وتجت السطحى في القطعة الرئيسية، بينما كانت معاملات الري بالتنقيط الأربعة (٣ و ٦ و ٩ و ١٢ جرعة) في القطع الفرعية. أظهرت النتائج المتحصل عليها أن تطبيق الري بالتنقيط تحت السطحي أظهر أقصى معايير النمو مثل طول الساق، الوزن الطازج للنبات، الوزن الجاف للنبات، وزن الثمار، عدد الثمار/قطعة تجريبية، وزن الثمار/ قطعة تجريبية، محصول الثمار/ فدان وفعالية استخدام المياه في الموسمين. ومن بين جرعات التسميد الأربعة المختلفة، أظهرت استخدام الجرعات الأعلى (١٢،٩) تفوقًا في خصائص النمو والمحصول ومكوناته وكذلك فعالية استخدام المياه في الموسمين. كما أشارت النتائج إلى أن أقصى قيم لصفات النمو والمحصول وفعالية استخدام المياه لوحظ عند تطبيق نظام الري تحت السطحي مع جرعة التسميد بالـ **NPK** الأعلى (١٢) لنباتات الكوسة صنف إسكندراني في الموسمين المدروسين. ولذا توصى الدراسة بتطبيق نظام الري بالتنقيط تحت السطحي مع جرعات التسميد الأعلى من الـ **NPK** لانها بتعطى اعلى نمو خضرى واعلى محصول واكثر فعالية في استخدام المياه في صنف الكوسة إسكندراني في الموسمين المدروسين.

الكلمات المفتاحية: معاملات التسميد مع الرى، جرعات التسميد مع الرى، صنف الكوسة اسكندرانى، الرى بالتنقيط السطحى، الرى بالتنقيط تحت السطحى.

Abstract

The present experiment was conducted at a private farm located in Lake Nasser, southwest of Aswan Governorate, Egypt during the 2022 and 2023 seasons to study the effect of NPK fertigation management under two drip irrigation systems on vegetative characteristics, yield and water use efficiency of Eskandarany squash cultivar. A randomized complete block design (RCBD) using a split-plot arrangement with three replicates was used in this experiment. The two drip irrigation systems (surface drip and subsurface) were arranged in the main plot, while the four doses of fertigation treatments (3, 6, 9 and 12 doses) were in the subplots. The obtained results showed that the application of a subsurface drip irrigation system showed the highest growth parameters such as plant stem length, plant fresh weight, plant dry weight, fruit weight, No. of fruits per experimental plot, fruit weight per experimental plot, fruit yield per fed. and water use efficiency in the two seasons. Among the four different fertigation treatments, the use of the highest doses (9 and 12) showed superiority in growth characteristics, yield and yield components as well as water use efficiency in both seasons. The results also indicated that the maximum values of growth characteristics, yield and water use efficiency were observed when applying the subsurface irrigation system with the highest NPK fertigation dose (12) for the Eskanarany squash cultivar in the two studied seasons. Therefore, the study recommends applying the subsurface drip irrigation system with the highest NPK fertilization doses (9 and 12 doses) because it gives the highest vegetative growth, the highest yield, and the most water use efficiency in Eskanarany squash cultivar in the two studied seasons **.**

Keywords: Fertigation Treatments, Fertigation Doses, Eskandarany Squash Cultivar, Surface Drip Irrigation, Subsurface Drip Irrigation.

Introduction

Among the problems currently emerging on the scene is the problem of water shortage in Egypt. This problem is increasing with the increase in population and expansion of new land reclamation, which requires searching for ways to save irrigation quantities, increase irrigation water use efficiency, and also increase crop productivity. Irrigation plays a vital role to improve the crop yield or crop productivity **(Nut *et al*., 2017).** The proper irrigation frequency is necessary for improving the water use efficiency and the crop productivity by applying the required amount of water when needed. Then, there is a need to formulate an irrigation schedule that balances water, nutrient provision and yield improvement. Drip irrigation has been promoted to ensure optimal use of water and nutrients to improve irrigation efficiency **(Awe *et al*., 2016).**

Subsurface irrigation is a technique for water-saving irrigation that delivers water directly to the root zone of a crop in the soil through a network of percolation pipes or pipe pores buried below the ground, using soil capillary actions to provide water for crop growth **(Jin *et al*., 2022).** In a comparison study between surface and subsurface irrigation, **Guo *et al*. (2023)** showed that the greatest yield improved when fertilizer was used in a one-time application, and the water productivity and irrigation water productivity increased significantly when the number of fertilizer applications was <3. The results of **Kanda *et al*. (2019)** revealed that subsurface irrigation can effectively decrease soil evaporation and the surrounding weed growth, reduce deep seepage **(Yao *et al*., 2021)**, increase root activity **(Guo *et al*., 2016)**, improve deep root penetration **(Guo *et al*., 2018)**, and thus induce water productivity. **Borivoj *et al*. (2018)** studied the effects of surface and subsurface drip irrigation on the growth, yield and water productivity of onions proving that the value of the irrigation water use efficiency ranged from 3.55 to 4.97 kg/m^3. The highest yield of onions was produced with using a drip lateral placement depth of 0.1 m.

The results obtained by **Madane (1999)** indicated that the application of NPK on cucumber as fertigation produced optimum growth, yield and utilization of fertilizers as well as maximum plant length, fruit weight, diameter, number of branches/plant and yield. Likewise, fertigation resulted in a saving of 30% N while P and K of 20% and saving 51% of water use **(Tumbare and Bhoite, 2002)** and is more effective than the traditional method (soil application) for improving the crop yields **(Al-Wabel *et al*., 2006).** Using fertilizers through drip irrigation is observed to be more effective than the traditional method. Better uptake of fertilizers was observed with frequent application in appropriate doses at proper growth stages **(Janpriya *et al*., 2010; Patil and Gadge, 2016).**

Squash (*Cucurbita pepo* L.) is considered one of the most important cucurbit crops and is a vegetable crop cultivated either for local consumption or for foreign exporting markets. Squash has a very rich nutritional profile that consists of various minerals, nutrients, vitamins, and organic compounds, which are responsible for providing health benefits **(Mohsen *et al*., 2013).**

Thus, the current investigation was conducted to study the yield and water use efficiency responses of Eskandarany squash cultivar grown under Aswan conditions by using surface and subsurface drip irrigation with different NPK fertigation doses.

Materials and Methods

The location of Experiments:

This field experiment was conducted at a private farm located in Nasser Lake, southwest Aswan Governorate, Egypt (latitude of 23.1672°N a longitude of 32.7883°E and 185 m above the sea level) during the two seasons of 2022 and 2023 to study the effect of NPK fertigation management under two drip irrigation systems on vegetative characteristics, yield and water use efficiency of Eskandarany.

Experimental design and treatments:

A randomized complete block design (RCBD) using a split-plot arrangement with three replications was used in this experiment. The two irrigation systems i.e. surface and subsurface drip were arranged in the main plot, while the four fertigation treatments namely 3, 6, 9 and 12 doses were in sub-plots. Soil samples were air-dried, ground and sieved through a 2 mm sieve and characterized for the physical and chemical soil properties according to procedure **Klute (1986)** as shown in Table 1. The seedlings of the squash cv. Eskandarany were thinned to secure one seedling/hill. The drip irrigation system is set up of a 16 mm in diameter GR polyethylene pipe with auto emitters every 30 cm apart and 70 cm among the drip lines with a flow rate of 4-liter/hour/dripper at a pressure of 1.5 bars. The experimental plot area was 7 m^2 (10 × 0.7 m), and there was a separation of 1.20 m between each treatment and plot to reduce water movement among different treatments.

The amounts of NPK fertilizers:

Nitrogen, phosphorus and potassium fertilizers were applied according to the recommended doses. Nitrogen fertilization was added at a rate of 122 kg N fed^{-1} as 365kg ammonium nitrate (33.5% N), phosphate rate of 31 kg P_2O_5 fed^{-1} as phosphoric acid and potassium at a rate of 24 kg K_2O fed^{-1} as potassium sulfate 50 Kg (48% K_2O) were applied through fertigation.

The amounts of fertilizers were divided into 3, 6, 9 and 12 equal doses. The fertigation treatments were started after 14 days from sowing seeds. These doses were given at 28, 14, 9 and 7-day intervals for the 3, 6, 9 and 12 doses, respectively.

The amounts of NPK fertilizers applied per dose are shown in Table 2. All cultural practices were followed as recommended for the growing of squash plants. None of the injected fertilizer exceeded 1000 mg l^{-1} of irrigation water and the acid did not exceed 300 mg l^{-1}.

Table 1. The physical and chemical properties of the soil under study.

Particle size distribution (%)			Soil texture	Bulk density (g/cm^3)	SP (%)	PH	EC	CEC	Total $CaCO_3$ (%)
Sand	Silt	Clay							
93.44	3.16	3.40	Sandy	1.73	18.65	8.02	0.85	13.05	1.60

Table 2. NPK fertilizers amounts used per dose in the study.

Fertigation Doses	Days Intervals	Potassium Sulphate (kg fed^{-1})		Phosphoric Acid (kg fed^{-1})		Ammonium Nitrate (kg fed^{-1})	
		Total	Dose	Total	Dose	Total	Dose
3D	28	50	16.7	43	14.03	365	121.6
6D	14	50	8.3	43	7.2	365	60.8
9D	9	50	5.5	43	4.7	365	40.5
12D	7	50	4.2	43	3.6	365	30.4

The irrigation treatments started directly after sowing. This study has eight treatments (with three replicates) as follows:

- SD+3D: surface drip with three doses of fertigation.
- SD+6D: surface drip with six doses of fertigation.
- SD+9D: surface drip with nine doses of fertilization.
- SD+12D: surface drip with twelve doses of fertilization.
- SSD+3D: subsurface drip with three doses of fertigation.
- SSD+6D: subsurface drip with six doses of fertigation.
- SSD+9D: subsurface drip with nine doses of fertilization.
- SSD+12D: subsurface drip at with twelve doses of fertigation.

Sowing and agronomic practices:

Two squash seeds were sown on 1 March of the two seasons of 2022 and 2023, then were thinned 15 days after sowing to secure one seedling in each hole on one side of the dripper. The drip irrigation system is set up of GR polyethylene pipe of 16 mm in diameter with auto emitters every 30 cm apart and 70 cm among the drip lines with a flow rate of 4-liter/ hour/ dripper at a pressure of 1.5 bars. The experimental plot area was 7 m^2 (10 × 0.7 m). There was a space of 1.20 m between each treatment and plot, to reduce water movement between different treatments.

The irrigation treatments started directly after sowing. After 50 days from sowing seeds, the plant growth characteristics, *i.e.*, plant stem length (cm), plant fresh weight (g) and plant dry weight (g) were recorded. Squash fruits were collected at a marketable stage twice to three times a week. Fruit weight (g), No. of fruits per plot, fruits weight per plot (kg) were measured. The total fruits yield per fed. (ton) was calculated from the total yield of every experimental plot with in average of 12 picking of fruits.

Water use efficiency (kg m^{-3}) was calculated from the following equation as reported by **Allen *et al*. (1998).**

$$\textbf{Water use efficiency (WUE, kg } m^{-3}\textbf{)} = \frac{\textbf{Fruit Yield (kg } fed^{-1}\textbf{)}}{\textbf{Total Water Applied (} m^3 fed^{-1}\textbf{)}}$$

The crop evapotranspiration (ETc) is the daily use of water by different studied crops and calculated using the following equation **(Allen *et al*., 1998)**

$ETc = ETo \times K_c$

Where:

ETo Reference evapotranspiration, mm day^{-1}

K_c is the crop coefficient

Calculation of water consumptive use (CU): Actual evapotranspiration (Tables 3 and 4) was estimated by the sampling method and calculated according to the following formula:

C.U. = (D×Bd×(Q2-Q1)/100)
Where C.U. actual evapotranspiration (m).
D = soil depth (m).
Bd = bulk density of soil (Mg/m^3).
Q2 = the percentage of soil moisture one day after irrigation (field capacity).
Q1 = the percentage of soil moisture before the next irrigation.
Water content in soil was measured before and after each irrigation 14 days after sowing at 0-30 and 30-60 cm soil depth intervals Soil sample was taken at positions immediately under drippers using soil auger. The sample was weighted, and then oven dried. Percentages of soil moisture contents at the two depths were calculated on at a 105 ^{o}C oven dry basis. In each irrigation treatment, the amounts of water consumed were recorded from the difference between the soil moisture contents before the following irrigation and one day after irrigation (field capacity).

Statistical analysis:

The obtained data were statistically analyzed according to **Gomez and Gomez (1984)** using the computer MSTAT.C statistical analysis package as reported by **Freed *et al.* (1989).** The least significant differences (L.S.D) at a 5% probability level were calculated to compare the differences among means.

Table 3. Meteorological data of Aswan Governorate during the two years of 2022 and 2023.

Month	**2022**					**2023**				
	Avg. Temp °C	**Min. Temp °C**	**Max. Temp °C**	**RH (%)**	**ETo**	**Avg. Temp °C**	**Min. Temp °C**	**Max. Temp °C**	**RH (%)**	**ETo**
January	15.9	8.8	22.6	37.2	116.8	15.8	8.6	22.9	38.2	121.3
February	18.6	10.9	25.6	27.4	138.1	18.3	10.7	25.8	26.1	140.9
March	22.6	14.3	29.9	20.0	211.6	22.1	14.5	29.7	21.5	204.2
April	27.4	18.7	34.7	15.6	259.9	26.6	18.3	34.9	16.0	247.1
May	31.7	23.2	38.7	14.4	313.9	31.2	23.6	38.8	15.6	278.4
June	33.7	25.4	40.5	14.3	321.8	33.0	25.1	40.8	14.8	300.9
July	34.2	26.1	40.6	16.1	315.3	33.6	26.4	40.7	15.9	316.1
August	34.3	26.5	40.8	17.4	315.8	33.5	26.3	40.6	17.4	324.8
September	32.1	24.4	39.0	20.2	274.8	32.0	24.7	39.2	21.7	272.9
October	28.5	21.1	35.3	24.2	223.2	28.5	21.6	35.4	24.4	239.4
November	22.3	15.2	28.9	32.3	147.3	22.3	15.8	28.7	31.3	157.7
December	17.4	10.5	24.0	38.1	127.1	17.3	10.2	24.3	37.5	124.6

The meteorological data of Aswan Governorate were used to measure ETo for the two seasons of 2022 and 2023 (Table 3) and Kc for the different growth stages were used and irrigation efficiency of 90% was used for drip irrigation. The applied water is presented in Table 4.

Table 4. Calculation of water consumption (ETc) for squash during the two growing seasons of 2022 and 2023 by CROWAT using growth stage and ETo and Kc.

Growth stage	**Days**	**Age (days)**	**Month**	**2022**			**2023**		
				ETo (mm day^{-1})	**Kc**	**ETc (mm 5 day^{-1})**	**ETo (mm day^{-1})**	**Kc**	**ETc (mm 5 day^{-1})**
Sowing		0							
Initial (germination)	25	5	March	6.83	0.60	20.49	6.59	0.60	19.77
		10		6.83	0.60	20.49	6.59	0.60	19.77
		15		6.83	0.60	20.49	6.59	0.60	19.77
		20		6.83	0.60	20.49	6.59	0.60	19.77
		25		6.83	0.60	20.49	6.59	0.60	19.77

Development (vegetative)	35	30		6.83	0.95	32.44	6.59	0.95	31.30
		35	April	8.66	0.95	41.14	8.24	0.95	39.14
		40		8.66	0.95	41.14	8.24	0.95	39.14
		45		8.66	0.95	41.14	8.24	0.95	39.14
		50		8.66	0.95	41.14	8.24	0.95	39.14
		55		8.66	0.95	41.14	8.24	0.95	39.14
		60		8.66	0.95	41.14	8.24	0.95	39.14
Middle (fruiting)	25	65	May	10.13	0.95	48.12	8.98	0.95	42.66
		70		10.13	0.95	48.12	8.98	0.95	42.66
		75		10.13	0.95	48.12	8.98	0.95	42.66
		80		10.13	0.95	48.12	8.98	0.95	42.66
		85		10.13	0.95	48.12	8.98	0.95	42.66
Late (maturity)	15	90		10.13	0.95	48.12	8.98	0.95	42.66
		95	June	10.73	0.75	40.24	10.03	0.75	37.61
		100		10.73	0.75	40.24	10.03	0.75	37.61
Total mm season^{-1}	100	100				750.883			696.148
m^3 fed^{-1}						3154.97			2924.99
m^3 ha^{-1}						7508.83			6961.48
Applied water m^3 fed^{-1}						**3505.52**			**3249.99**

Results and Discussion

Effect of NPK fertigation treatments on plant stem length (cm), plant fresh weight (g) and plant dry weight (g) of Eskandarany squash cultivar grown under two drip irrigation systems:

Effect of drip irrigation systems:

Statistically, it was shown that the surface and subsurface drip irrigation systems have a significant effect on the plant stem length, plant fresh weight and plant dry weight of squash during the two seasons (Table 5 and Figures 1-3). Applying subsurface drip irrigation showed maximum growth parameters as plant stem length (55.11 and 55.40 cm), plant fresh weight (203.92 and 209.08 g) and plant dry weight (42.00 and 42.92 g) compared to surface drip irrigation in the 1st and 2nd seasons, respectively. Similar results were previously obtained by **Abou Al-Rejal *et al* (2014); Fathia El-Mokh *et al* (2014); Khalid *et al* (2016); Ahmed *et al*. (2017); Pejić *et al*. (2018).**

Effect of fertigation doses:

Applying fertigation doses led to a significant difference in the studied vegetative growth of squash during the two seasons of study as shown in Table 5. Among the various fertigation doses, using the higher doses (12 D) showed superiority in the plant stem length (55.58 and 56.20 cm), plant fresh weight (205.17 and 209.50 g), plant dry weight (42.33 and 45.00 g), plant fresh weight fed^{-1} (45.00 and 46.00 ton) and plant dry weight fed^{-1} (7.60 and 7.60 ton) in the 1st and 2nd seasons, respectively as compared to the other fertigation doses. The lowest values of the growth characteristics were recorded with three fertigation doses in the two studied seasons. The growth characteristics of squash significantly increased when treated with the higher fertigation doses and these effects may be due to the beneficial role of nutrition in improving vegetative growth of the plants. Also, **Shareef *et al*. (2022)** revealed that inorganic fertilizers had a higher increase in the growth characteristics of summer squash. These results were in harmony with that of **Shaheen *et al*. (2010); Obalum *et al.* (2012). Dunsin *et al*. (2019)** reported that the growth and fruit yield characteristics of *C. pepo* were increased with increasing NPK levels. Similar results were obtained by **Manuca (1989); Oloyede *et al*. (2013); Hari and Girija (2016)**

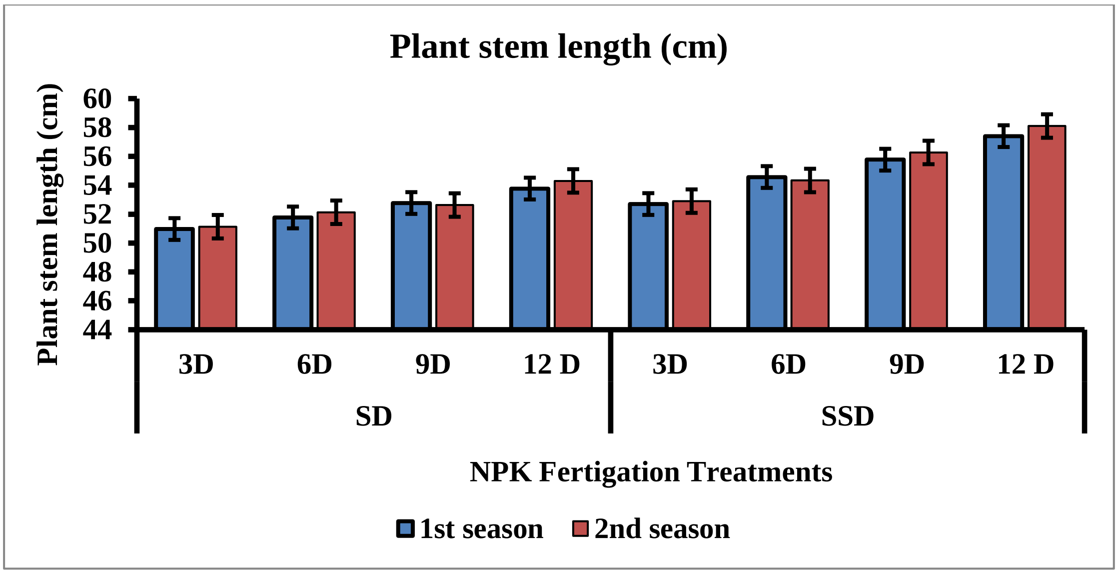
Effect of interactions:

The plant stem length, plant fresh weight and plant dry weight of squash plant significantly varied due to the interaction between irrigation systems and fertigation doses in both seasons (Table 5). Results pointed out that maximum values of the plant stem length (57.40 and 58.10 cm), plant fresh weight (225.33 and 231.67 g) and plant dry weight (46.00 and 48.00 g) were observed with applying subsurface irrigation plus 12 D for squash plants in the 1st and 2nd seasons, respectively. Meanwhile, the lowest values of the growth traits were noticed with plants irrigated by surface drip irrigation plus the three doses of fertigation. Subsurface irrigation system combined with NPK as fertigation can enhance productivity and WUE for squash plant compared to surface drip irrigation with the same level of NPK. These results were previously confirmed by **Sadik and Abd El-Aziz (2018).**

Table 5. Effect of NPK fertigation treatments on plant stem length (cm), plant fresh weight (g) and plant dry weight (g) of Eskandarany squash cultivar grown under two drip irrigation systems.

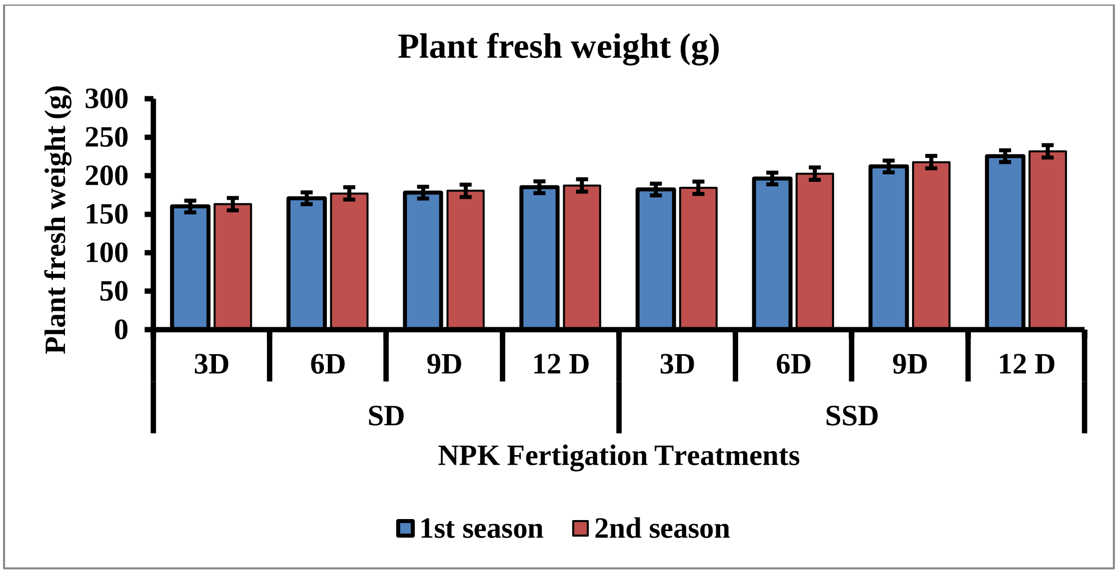
Factor	SD and SSD Irrigation Systems (A)	Fertigation Doses (B)	Plant stem length (cm)		Plant fresh weight (g)		Plant dry weight (g)	
			1st season	2nd season	1st season	2nd season	1st season	2nd season
A	SD		52.32	52.55	173.42	176.92	36.08	38.17
	SSD		**55.11**	**55.40**	**203.92**	**209.08**	**42.00**	**42.92**
LSD (0.05)			0.53	0.59	5.31	6.28	0.95	3.88
B		3D	51.83	52.02	171.00	173.67	34.67	36.50
		6D	53.17	53.23	183.50	189.83	38.83	39.33
		9D	54.27	54.45	195.00	199.00	40.33	41.33
		12 D	**55.58**	**56.20**	**205.17**	**209.50**	**42.33**	**45.00**
LSD (0.05)			0.40	0.55	5.25	4.79	1.60	1.43
AB	SD	3D	50.97	51.13	160.00	163.00	33.33	35.67
	SD	6D	51.77	52.13	170.67	177.00	35.67	37.33
	SD	9D	52.77	52.63	178.00	180.33	36.67	37.67
	SD	12 D	53.77	54.30	185.00	187.33	38.67	42.00
	SSD	3D	52.70	52.90	182.00	184.33	36.00	37.33
	SSD	6D	54.57	54.33	196.33	202.67	42.00	41.33
	SSD	9D	55.77	56.27	212.00	217.67	44.00	45.00
	SSD	12 D	**57.40**	**58.10**	**225.33**	**231.67**	**46.00**	**48.00**
LSD (0.05)			0.68	0.86	7.98	8.15	2.13	4.06

SD= Surface Drip, SSD= Subsurface Drip, D= Doses



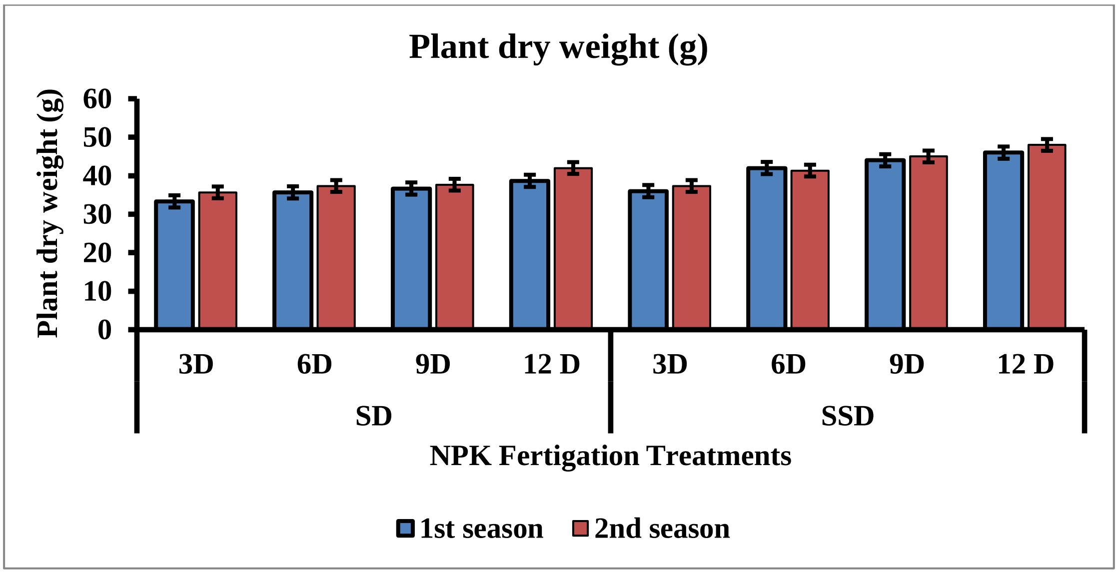
SD: Surface Drip, SSD: Subsurface Drip, D= Dose

Figure 1: Effect of NPK fertigation treatments on plant stem length (cm) of Eskandarany squash cultivar grown under two drip irrigation systems.



SD: Surface Drip, SSD: Subsurface Drip, D= Dose

Figure 2: Effect of NPK fertigation treatments on plant fresh weight (g) of Eskandarany squash cultivar grown under two drip irrigation systems



SD: Surface Drip, SSD: Subsurface Drip, D= Dose

Figure 3: Effect of NPK fertigation treatments on plant dry weight (g) of Eskandarany squash cultivar grown under two drip irrigation systems

Effect of NPK Fertigation Treatments on fruit weight (g), No. of Fruits per Plot, Fruits Weight per Plot (kg), Fruits Yield per Fed. (ton) and Water Use Efficiency (WUE, kg m-3) of Eskandarany Squash Cultivar Grown Under Two Drip Irrigation Systems.

Effect of drip irrigation systems:

Results in Table 6 and Figures 4-8 proved that surface and subsurface drip irrigation systems have a significant effect on the fruit weight, No. of fruits per plot, fruit weigh per plot, fruit yield per fed. and WUE (kg m^{-3}) of squash plant during the two seasons. Squash plants irrigated by subsurface drip irrigation showed maximum fruit weight (109.42 and 109.42 g), No. of fruits per plot (87.50 and 89.75), fruit weight per plot (9.65 and 9.88 kg), fruit yield per fed (5.79 and 5.93 ton) and WUE (3.07 and 3.30 kg m^{-3}) in the 1^{st} and 2^{nd} seasons, respectively. These results were in agreement with **Pejić *et al*. (2018),** who reported that the highest growth, yield and WUE of onions were recorded with a drip lateral placement depth of 0.1 m, which is suitable for high growth and yield of onion.

Effect of fertigation doses:

Concerning the effect of fertigation, increasing fertigation doses from 3 up to 12 doses was parallel with the increase in fruit measurements and Water Use Efficiency (WUE) during both seasons (Table 6). Adding 12 fertigation doses to squash plants showed the highest fruit weight (112.50 and 112.50 g), No. of fruits per plot (99.00 and 99.83), fruits weight per plot (11.17 and 11.26 kg), fruits yield per fed. (6.70 and 6.76 ton) and WUE (3.20 and 3.39 kg m^{-3}) in the 1^{st} and 2^{nd} seasons, respectively. Whereas, applying three fertigation doses to squash plants led to the lowest values of the fruit characteristics and WUE. **Shareef *et al*. (2022)** suggested that inorganic fertilizers had a higher increase in the plant yield and total yield of summer squash. Also, **Modak *et al.* (2021)** stated that the yield and yield contributing parameters of pumpkin were found to be significantly maximum in the higher level of NPK.

Effect of interactions:

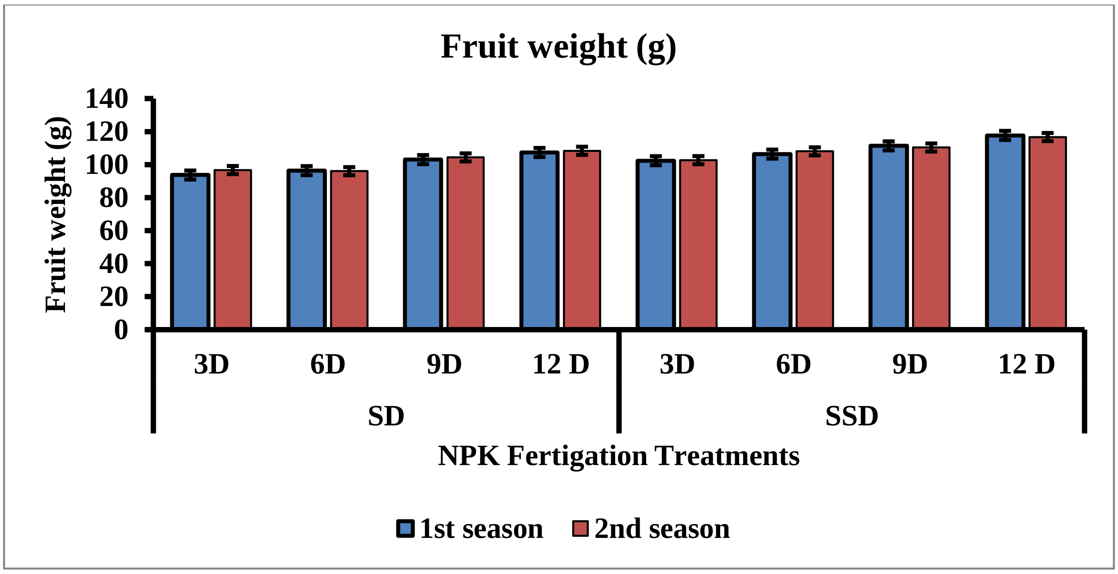
The effect of interaction between the two experimental factors was significant for the studied fruit parameters and Water Use Efficiency (WUE) of squash plants and WUE during the two seasons (Table 6). Among the different combinations, the use of subsurface irrigation system plus 12 fertigation doses led to the highest values of the fruit weight (117.67 and 116.67 g), No. of fruits per plot (104.67 and 106.33), fruits weight per plot (12.31 and 12.41 kg), fruits yield per fed. (7.39 and 7.45 ton) and WUE (3.65 and 3.79 kg m^{-3}) in the 1^{st} and 2^{nd} seasons, respectively. On the other side, the lowest values of fruit parameters and WUE were recorded by applying surface drip irrigation plus three fertigation doses. **Ibrahim, and Selim (2007)** pointed out that irrigation combined with the application of 75 kg N fed^{-1} resulted in chancing water and nitrogen use efficiency, and increased growth and fruit yield of squash.

Table 6. Effect of NPK Fertigation Treatments on fruit weight (g), No. of Fruits per Plot, Fruits Weight per Plot (kg), Fruits Yield per Fed. (ton) and Water Use Efficiency (WUE, kg m^{-3}) of Eskandarany Squash Cultivar Grown Under Two Drip Irrigation Systems.

Factor	SD and SSD Irrigation system (A)	Fertigation Doses (B)	Fruit weight (g)		No. of fruits per plot		Fruits weight per plot (kg)		Fruits yield per fed. (ton)		WUE (kg m^{-3})	
			1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season
A	**SD**		100.08	101.33	71.92	73.83	7.16	7.56	4.29	4.53	2.29	2.52
	SSD		**109.42**	**109.42**	**87.50**	**89.75**	**9.65**	**9.88**	**5.79**	**5.93**	**3.07**	**3.30**
LSD (0.05)			6.84	2.18	2.94	2.80	0.28	0.37	0.17	0.22	0.09	0.05
B		**3D**	98.00	99.67	61.33	63.50	5.81	6.35	3.49	3.81	2.14	2.38
		6D	101.33	102.00	73.33	75.33	7.48	7.74	4.49	4.65	2.54	2.77
		9D	107.17	107.33	85.17	88.50	9.16	9.52	5.50	5.71	2.84	3.11
		12 D	**112.50**	**112.50**	**99.00**	**99.83**	**11.17**	**11.26**	**6.70**	**6.76**	**3.20**	**3.39**
LSD (0.05)			2.47	3.12	4.68	3.35	0.63	0.40	0.38	0.2431	0.10	0.11
AB	**SD**	**3D**	93.67	96.67	52.67	54.33	4.45	5.25	2.67	3.15	1.78	2.00
	SD	**6D**	96.33	96.00	64.67	65.33	6.23	6.27	3.74	3.76	2.16	2.40
	SD	**9D**	103.00	104.33	77.00	82.33	7.93	8.59	4.76	5.15	2.48	2.70

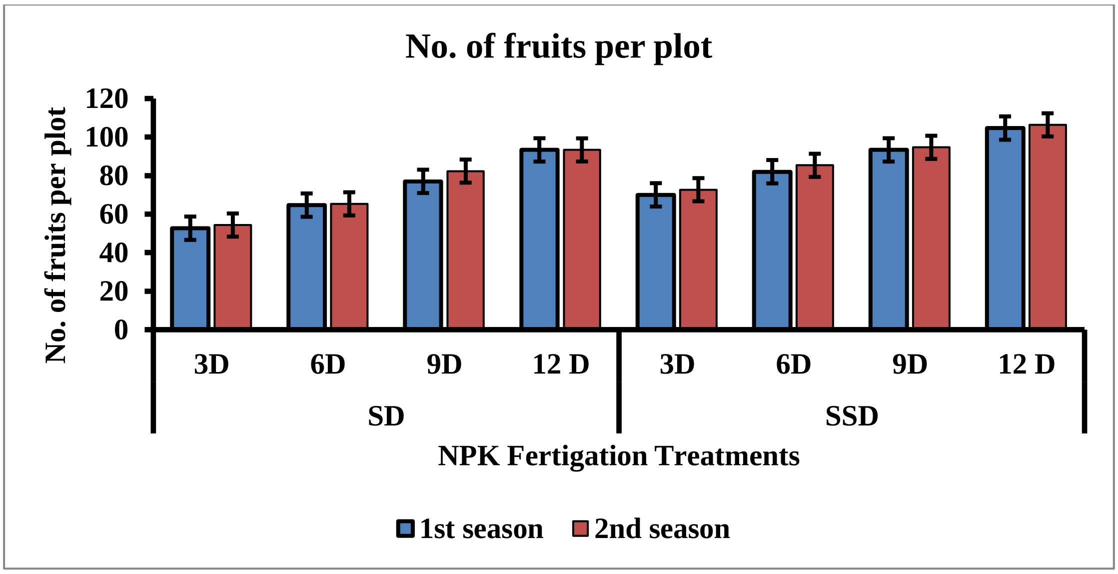
	SD	**12 D**	107.33	108.33	93.33	93.33	10.02	10.11	6.01	6.07	2.74	3.00
	SSD	**3D**	102.33	102.67	70.00	72.67	7.16	7.45	4.30	4.47	2.49	2.76
	SSD	**6D**	106.33	108.00	82.00	85.33	8.73	9.22	5.23	5.53	2.92	3.15
	SSD	**9D**	111.33	110.33	93.33	94.67	10.39	10.45	6.24	6.27	3.20	3.51
	SSD	**12 D**	**117.67**	**116.67**	**104.67**	**106.33**	**12.31**	**12.41**	**7.39**	**7.45**	**3.65**	**3.79**
LSD (0.05)			7.14	4.27	6.29	4.79	0.81	0.59	0.49	0.36	0.15	0.14

SD= Surface Drip, SSD= Subsurface Drip, D= Dose



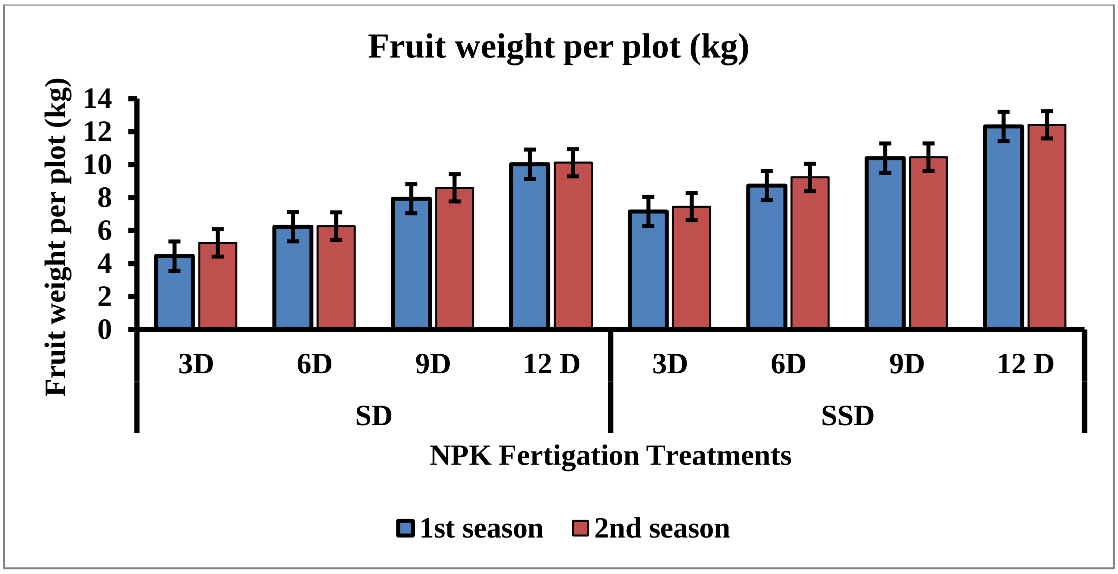
SD: Surface Drip, SSD: Subsurface Drip, D= Dose

Figure 4: Effect of NPK fertigation treatments on fruit weight (g) of Eskandarany squash cultivar grown under two drip irrigation systems



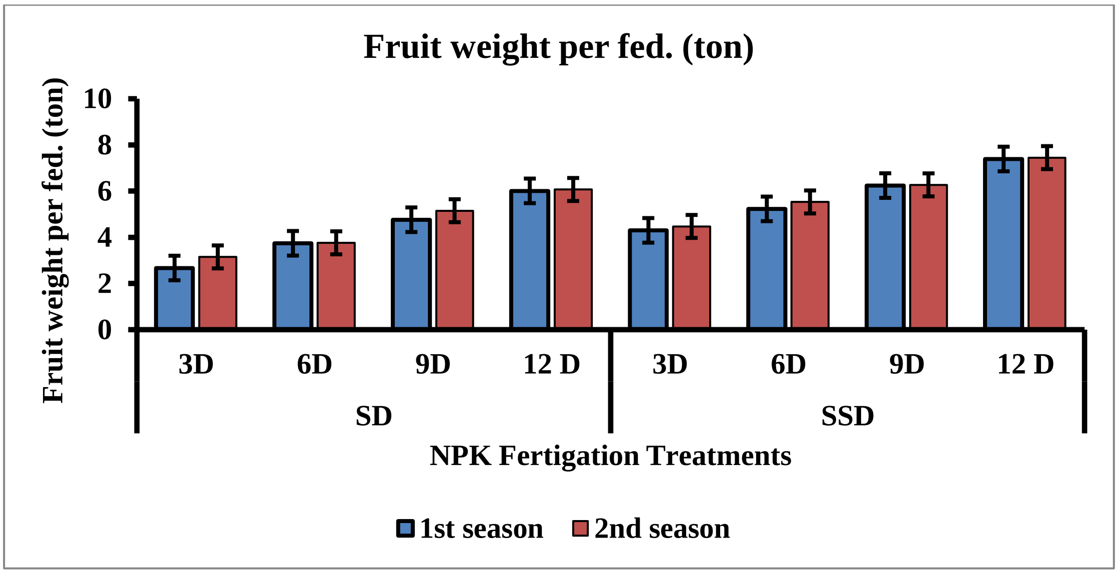
SD: Surface Drip, SSD: Subsurface Drip, D= Dose

Figure 5: Effect of NPK fertigation treatments on No. of fruit per plot of Eskandarany squash cultivar grown under two drip irrigation systems



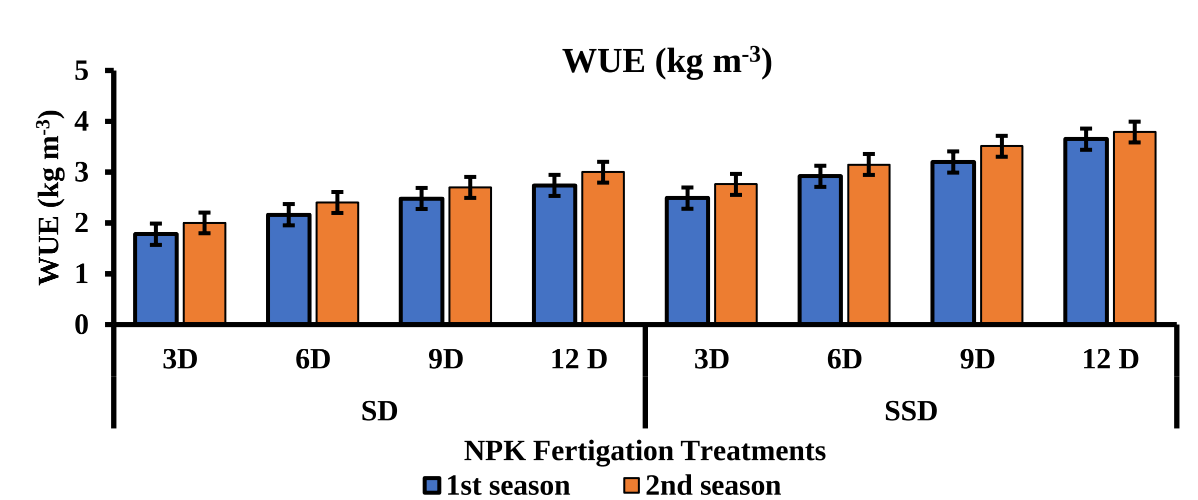
SD: Surface Drip, SSD: Subsurface Drip, D= Dose

Figure 6: Effect of NPK fertigation treatments on fruit weight per plot (kg) of Eskandarany squash cultivar grown under two drip irrigation systems



SD: Surface Drip, SSD: Subsurface Drip, D= Dose

Figure 7: Effect of NPK fertigation treatments on fruit weight per fed. (ton) of Eskandarany squash cultivar grown under two drip irrigation systems



SD: Surface Drip, SSD: Subsurface Drip, D= Dose

Figure 8: Effect Water Use Efficiency (WUE, kg m-3) of Eskandarany Squash Cultivar Grown Under Two Drip Irrigation Systems.

Conclusions

Based on this study and the results obtained, we can conclude that the subsurface drip irrigation system was quite suitable for increasing the vegetative growth, productivity, and water use efficiency of the Eskandarany squash cultivar. There were significant differences between the growth characteristics, productivity and water use efficiency as a result of applying different doses of NPK fertigation. The higher doses of NPK fertigation (9 and 12 doses) were significantly superior to the other doses in terms of higher values of growth and yield characteristics and water use efficiency in the two seasons studied. Therefore, it can be recommended that when growing squash in similar experimental conditions, the subsurface drip irrigation system should be applied with the addition of the highest doses (9 and 12 doses) of NPK fertigation because it achieves the best productivity and water use efficiency.

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