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Pomegranate Trees Productivity in Response to Three Levels of Irrigation and Slow or Fast Nitrogen Release Fertilizer as Well as their Combinations.

Abdel-Sattar, M. [1] and Y. I. Mohamed[2]
[1] Pomology Department, Faculty of Agriculture (El-Shatby), Alexandria Univ., Egypt.
[2] Faculty of Desert and Environmental Agriculture, Matrouh Branch, Alexandria Univ., Egypt.

ABSTRACT

This investigation was carried out during two successive seasons of 2014 and 2015 on mature pomegranate trees cv. Manfalouty grown in calcareous soil at Borg-El-Arab region, Alexandria governorate, Egypt. It was conducted to determine if a combination of fast or slow release (i e phosphorus coated urea PCU 37%) nitrogen fertilizer with different levels of soil moisture can enhance growth of Manfalouty pomegranate trees with high productivity as compared to the current production practices as well as to reduce both rate and number of soil applications during the growing season. The results showed that all vegetative growth, leaf mineral contents and fruit characteristics parameters were significantly affected by interaction between levels of soil moisture of field capacity (FC) and slow-release nitrogen fertilizer. The chemical fruit characteristics, i e TSS, TSS/ acidity, vitamin C and anthocyanin were the maximum values at 50% FC + 400 g actual slow release nitrogen fertilizer, while the acidity value was the highest in the treatment of 100% FC + 200 g/tree as a slow release nitrogen fertilizer in both seasons. The fruit set was the maximum at 75% FC +200 or 300 g actual slow release nitrogen fertilizer in the first and second seasons, respectively. Also, yield showed the highest significant values of 44.1 and 47.1 Kg/tree with the treatment of 100% FC+ 400 g/tree in the first and second seasons, respectively. Moreover, the results showed that the combination between the 100% FC irrigation treatment and the highest amount of slow release fertilizer of 400 g actual slow release nitrogen fertilizer /tree produced the highest values of most vegetative growth traits i.e., tree height, shoot length, dry weight of 30 leaves, and chlorophyll content (SPAD) in both seasons. Also leaf nitrogen, potassium, phosphorus and magnesium content was increased under such conditions.

Keywords: Pomegranate, *Punica granatum*, Slow release fertilizer, Fast release fertilizer, Field capacity,Irrigation.
Corresponding author:M. Abdel-Sattar Fax: +2035922780, Email: mahmoud.hassan @alexu.edu.eg.

INTRODUCTION

Pomegranate (*Punica granatum* L.) is considered one of the important deciduous and favorable fruit crops in Egypt. The cultivation of the pomegranate is mainly confined to semi-arid mild-temperate in the main growing areas including most of Mediterranean countries (Stover and Mercure, 2007). The trees are particularly adapted to saline and poor soils (Martinez *et al*., 2006), as well as grown in many tropical and subtropical countries. Pomegranate production is increasing due to higher demand for pomegranate fruit and products, especially juice for their health benefits. They are considered a good source of carbohydrate, minerals and antioxidants as well as using them for controlling diarrhea, hyperacidity, tuberculosis, leprosy, abdominal pain and fever (Michel *et al*., 2005). In addition, they can be used as a remedy of cancer and chronic inflammation (Ephraim and Robert, 2007). The total fruiting area of pomegranate trees is about 6040 hectare that produces about 132030 tons at the year of 2014(Arab Agricultural Statistics Yearbook,2015). Hence, intensive efforts have been made to increase the productivity of pomegranate trees by improving the cultural practices in pomegranate orchards such as fertilization and irrigation.

The fertilization with nitrogen is considered one of the important management tools and the major nutrient required for proper tree growth and increasing crop. It plays an important role as a constituent of all proteins, nucleic acids and enzymes. Nitrogen fertilization effects depend on the nutrient status of the cultivated soil, as well as applied amount, sources and methods of N application (Yagodin, 1990). The loss of nitrogen by leaching, volatilization, denitrification is considered the most important problem in the Egyptian soils. Thus, the management of N applied sources is required to control this problem.

The loss of nitrogen via leaching through drainage water may be reduced to some extent by using the slow release-N fertilizers that could regulate the release of their own N as the plant needs. During the last decades, several controlled-release fertilizers were developed mainly to improve the efficiency of nitrogen used by the fruit trees (Miller *et al*., 1990). Application of controlled-release fertilizers seem to be very effective for improving the growth and productivity of most fruit trees. These is attributed to the continuous amendment of N during all growth and fruit development stages as well as release their own N at a longer period and at the critical date of fruit development (Koo, 1988; Wang and Alva, 1996 and El-Salhy *et al*., 2013).

Applying water to fruit tree crops is a widely used practice but efficient water use has become important only in recent years due to the rapid depletion of available water resources in many areas of the world (Kang *et al.,* 2002). For example, pomegranates are very drought tolerant but ensuring adequate soil moisture will result in a substantial improvement in plant vigor and fruit yield. Also, in Egypt, the availability of water in some regions is very limited and then irrigation is concentrated in a few irrigation events.

The present investigation is an attempt to determine if a combination of fast or slow release (i e phosphorus coated urea PCU 37%) nitrogen fertilizer with different levels of soil moisture can enhance growing of Manfalouty pomegranate trees with high productivity as compared to the current production practices and to reduce both rate and number of soil applications during the growing season.

MATERIALS AND METHODS

The present study was conducted during two successive seasons 2014 and 2015 on Manfalouty pomegranate grown in calcareous soil at Borg- El-Arab region area, Alexandria governorate, Egypt. Fifteen-year-old healthy Manfalouty pomegranate trees, nearly similar in growth and vigor were planted at 5 × 5 meters and irrigated with drip irrigation system with two lines per tree with 4 drippers (8 L h^{-1}) per tree were chosen. In the two successive seasons, potassium sulphate (48 % K_2O) was added at a rate of 400 g per tree during May and July into two equal doses.

The experimental design, used in the two season, was split – plot in randomized complete block design (RCBD) according to Snedecor and Cochran (1990) and the total number of experimental trees were (3 soil moistures x 4fertilizers x 4 replications) 48 trees for each season. The main plots included three levels of soil moisture,

1- 100 % of field capacity (FC).
2- 75 % of field capacity (FC).
3- 50% of field capacity (FC).

The sub-plot included four soil application treatments of fertilizers,

1- Fast release nitrogen fertilizer with a rate of 700 g actual nitrogen / tree/ year as control
2- Slow release nitrogen fertilizer with a rate of 200 g actual nitrogen / tree/ year
3- Slow release nitrogen fertilizer with a rate of 300 g actual nitrogen / tree/ year
4- Slow release nitrogen fertilizer with a rate of 400 g actual nitrogen / tree/ year.

The irrigation treatments were carried out by applying the water when the soil moisture within the first top foot area was depressed to reach 50, 75 and 100 of field capacity (FC) during the growing season according to the electronic digital tensiometers.

Slow release nitrogen (N) fertilizer in the form of phosphorus coated urea (PCU 37%) was applied at twice dose in February and May in circular digs around each tree 50 cm apart from trunk and covered with soil. The fast release fertilizer in the form ammonium nitrate (33.5% N) and ammoniumsulphate (15.5% N) at a rate of 300 and 400 g actual nitrogen per tree respectively, was added with equal doses with drip irrigation system in both seasons as control.

At the beginning of the experiment, soil analysis of the experimental orchard was carried out as listed in Table 1:

Table 1 Physical and chemical properties of the experimental soil orchard.

Depth (cm)	Physical properties				Chemical properties											
							Cations meq L^{-1}				Anions meq L^{-1}					
	Sand (%)	Clay (%)	Silt (%)	S.P	pH	EC (dS/m)	Ca	Mg	Na	K	HCO^{-3}	Cl-	SO^{-4}	CEC (meq/100g)	OM (%)	$CaCO_3$(%)
0-20	45.20	11.33	43.47	0.6	7.8	4.0	0.32	0.30	0.65	0.05	0.20	1.0	0.20	7.00	0.52	28.96
20-50	23.90	22.77	53.33	25.9	7.6	2.12	0.27	0.09	0.19	0.03	0.18	0.23	0.08	5.42	0.46	19.82
50-90	16.30	26.39	57.31	26.8	7.5	1.65	0.39	0.51	1.25	0.04	0.09	2.12	0.12	6.21	0.22	14.24

The following determinations were recorded during this study:

A. Vegetative growth, **chlorophyll and leaf mineral contentsas** as well as fruit set

In order to determine tree growth, under different treatments, the average length of spring and summer shoots were recorded by measuring the length of 4 labeled branches one inch diameter at different directions per tree and then the average shoot length (cm) was calculated. At the end of October, tree height (m) of each tree was measured from the soil surface to the main branch apex. Samples of 30 leaves from the middle part of non-fruiting shoots on each tree were collected in the first week of August. Then the leaves were washed carefully with tap water and distilled water, then dried at 65 -70^{o} C to constant weight and leaf dry weight was calculated. Dried leaves were used to determine the leaf mineral constituents (Reisenauer, 1978). Total leaf chlorophyll content was determined in fresh leaf samples according to the method described by Yadava (1986) using Minolta Chlorophyll METER SPAD – 502 (Minolta camera, LTD JAPAN).For mineral elements determination, one gram from the dried ground materials of the leaves of each replicate was digested with sulphuric acid and hydrogen peroxide according to Evenhuis and Dewaard (1980). In the digested solution, nitrogen (%) was determined by the micro-kjeldahl method according to the methods described by Chapman and Pratt (1975). Total nitrogen and phosphorus were colorimetrically determined according toto the methods described by Evenhuis (1976) and Murphy and Riley (1962), respectively. Potassium was determined by flame photometer as described by Jackson (1967). Magnesium was determined by atomic absorption spectrophotometry as described by Jones (1977). The number of set fruitlets on the previously tagged branches was recorded in late May and fruit set percentage was calculated according the following equation:

Fruit set percentage = No. of fruit set x100 / total number of perfect flowers %.

B. Tree yield and fruit characteristics

In order to determine fruit quality characteristics, a random sample of five fruits reached the ripening stage and became fully colored were taken from each replicate in the second week of October. Also, fruits were weighed in Kg to record yield (kg) /tree. Fruit characteristics; i e fruit volume and shape index (fruit length / fruit diameter ratio), juice volume and fruit weight were recorded. Fruit grains were squeezed and the obtained juice was used to determine the percentage of TSS by hand refractometer and expressed as (%). The titratable acidity was expressed as grams citric acid /100 milliliter juice. Vitamin C was determined in juice by titration with 2, 6-dichlorophenolindophenol blue dye, according to the AOAC (1995) and expressed as milligrams ascorbic acid/100 milliliter juice. Anthocyanin content was determined by a pH differential method with two buffer systems, sodium acetate buffer, pH 4.5 (0.4 M) and potassium chloride buffer pH 1.0 (0.025 M) according to the methods described by Giusti *et al.* (1999).

Statistical analysis

Treatment means were separated and compared using least significant difference (LSD) at 0.05 level of probability according to Snedecor and Cochran (1990). The statistical analysis was performed using SAS (Statistical Analysis System) version 9.13, (2008).

RESULTS AND DISCUSSION

1- Effect of the irrigation treatments on

A. Vegetative growth, leaf chlorophyll and mineral contents as well as fruit set.

Concerning the effect of levels of soil moisture of field capacity (FC), data presented in Table 2 showed that most of the studied characteristics were significantly affected by the irrigation treatments in both seasons. It was observed that, tree height, shoot length, chlorophyll content (SPAD) and dry weight of 30leaves tended to increase by increasing the soil moisture of field capacity. Moreover, fruit set percentage was significantly higher with 75 % FC treatments as compared with the other treatments in both seasons. As for leaf nutrient contents of N, P, K, and Mg, the data showed that it proportionally and significantly increased by increasing field capacity of soil from 50 to 100 %.

These results are in harmony with those obtained by Khattab *et al.* (2011), who concluded that all the components of chlorophyll, N, P, K content were significantly increased by increasing the amount of irrigation water in pomegranate trees. This result might be due to increasing availability of these nutrients under the highest soil moisture of field capacity, which would enhance uptake rate by tree, responsible for increasing photosynthetic rate and consequently on increase in leaf area (El-Kassas, 1983) .

Table 2. Main effect of three levels of soil moisture of field capacity (F C) on the vegetative growth, leaf chlorophyll and mineral contents as well as fruit set of Manfalouty pomegranate trees in 2014 and 2015 seasons.

Characters	Tree height (m)		Shoot length (cm)		Chlorophyll content (SPAD)		Dry weight of 30 leaves (g)		N (%)		P (%)		K (%)		Mg (%)		Fruit set (%)	
Seasons / Treatments	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
50% FC	3.04	3.52	25.8	24.6	32.7	33.6	58.48	57.17	1.17	1.16	0.49	0.49	0.91	0.92	0.14	0.18	65.8	48.1
75% FC	3.31	3.61	30.9	28.8	44.6	45.0	60.22	62.07	1.30	1.30	0.54	0.54	1.23	1.23	0.31	0.33	75.9	60.1
100% FC	3.90	4.03	34.2	34.1	49.3	49.9	66.33	66.74	1.54	1.51	0.63	0.63	1.35	1.36	0.64	0.63	55.1	50.2
$LSD_{0.05}$	0.16	0.17	1.35	1.04	1.24	1.40	0.94	1.09	0.03	0.02	0.02	0.02	0.03	0.04	0.03	0.03	0.3	0.10

B. Tree yield and fruit characteristics.

Fruit characteristics of the pomegranate i e fruit weight and volume, juice volume per fruit as well as acidity % significantly increased with increasing FC of soil moisture, while fruit shape index was not affected by irrigation treatments in both seasons of study (Table 3).Yield ranged from 31.2-37.8 Kg/ tree and 32-38.9 Kg/tree in the first and second seasons, respectively, and the highest values were found at the irrigation treatment of 100% FC. On contrary, vitamin C, anthocyanin, TSS and TSS/acidity in juice were higher at the treatment of 50 % FC as compared to the 100 FC irrigation treatment.

Deficit irrigation is usually the main reason for reducing fruit weight (Intrigliolo *et al*., 2013) and it is well known that pomegranate fruit yield is highly dependable on the fruit characteristics, i e volume and weight (Selahvarzi *et.al.*, 2017). In the present study, the fruit yield dropped by almost 17.5% in both seasons in 50 % FC irrigation treatment as compared to the treatment of 100 % FC irrigation treatment. Similar results for the reduction impact of deficit irrigation were obtained by Mena *et al*. (2013), who found that decreasing irrigation amount as low as 43 and 12% from the ET0 caused a dramatic decrease in bioactive phenolic compounds, especially anthocyanin which consequently affected the color of the juice to be more yellowish. Also, Schwartz *et al*. (2009) reported that pomegranate fruits grown in desert areas exhibited lower levels of total anthocyanin in both the peel and arils as compared to fruits grown under Mediterranean conditions. On the other hand, acidity as well as juice percentage were not affected by different irrigation treatments (Mellisho *et al.*, 2012 and Mena *et al.,* 2013).The deficit moisture led to improving of fruit qualitative index such as TSS, vitamin C, TSS /acidity ratio and anthocyanin content, while acidity reduced with deficit moisture. The results of the present study agreed with those of Khattab *et al*. (2011) who concluded that increasing levels irrigation rate decreased TSS, vitamin C and TSS/acidity ratio in pomegranate juice.

In arid and semi-arid areas, by increasing the irrigation, water efficiency is considered as very important task in order to prevent drought stress and maintain plants productivity (Laribi *et al.,* 2013). Furthermore, irregular pomegranate irrigation results in a tangible change in plant water status, which have been reported to result in serious physiological disorders with severe economic impact such as the cracking of ripe fruits (Prasad *et al.,* 2003 and Holland *et al.,* 2009).

2- Effect of the fast and slow release fertilizers on

A. Vegetative growth, leaf chlorophyll and mineral contents as well as fruit set.

Data in Table 4 showed that the application of nitrogen slow fertilizers in the form of phosphorus coated urea significantly increased the growth of pomegranate trees in both seasons. The vegetative growth traits, i e tree height, shoot length, dry weight of30 leaves, and leaf chlorophyll content (SPAD) were significantly increased by slow-release nitrogen fertilizers in both seasons. In addition, the data concerning leaf nutrient contents revealed that, increasing slow release nitrogen rate from 200 to 400 g actual slow release nitrogen fertilizer / tree/ season significantly and proportionally increased percentage of nitrogen, phosphorus, potassium and magnesium content in leaves of Manfalouty pomegranate trees in both seasons except for magnesium in the second season. Fruit set percentage was significantly higher in fast release nitrogen in the first season only, while in the second one, adding 300 g nitrogen / tree / season significantly increased fruit set as compared with the fast and slow release nitrogen treatments.

Results highlight the role of nitrogen as one of the essential nutrients for plant growth and as an important constituent of chlorophyll, protein, nuclic acid, which results in an increase in cell growth and number (Said, 1998; and El- Naggar *et al.,* 2002).

Table 3. Main effect of three levels of soil moisture of field capacity (F C) on yield and fruit characteristics of Manfalouty pomegranate tree in 2014 and 2015 seasons.

Characters	Yield (kg /tree)		Fruit weight (g)		Fruit volume (ml)		Juice volume (ml)		Fruit shape index		TSS (%)		Acidity (%)		TSS/ acidity ratio		Vitamin C (mg/100ml)		Anthocyanin (mg/100ml)	
Seasons Treatments	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
50% FC	31.2	32.0	308.7	306.1	298.1	299.1	122.43	122.6	0.89	0.88	17.2	17.4	1.22	1.29	14.1	13.7	14.1	14.2	13.9	13.8
75% FC	33.1	33.9	329.8	330.3	310.7	314.8	142.01	143.6	0.89	0.89	16.8	16.5	1.30	1.34	13.0	12.3	13.0	13.4	12.9	13.0
100% FC	37.8	38.9	359.2	362.2	349.7	354.8	190.59	191.0	0.89	0.90	14.9	15.3	1.36	1.36	10.9	11.3	13.8	13.8	13.4	13.4
LSD $_{0.05}$	0.69	1.01	4.1	8.3	6.04	3.78	4.12	3.05	NS	NS	0.54	0.85	0.02	0.12	0.48	0.84	0.11	0.37	0.15	0.42

Table 4. Main effect of fast and slow-release nitrogen fertilizers on the vegetative growth, leaf chlorophyll and mineral contents as well as fruit set of Manfalouty pomegranate trees in 2014 and 2015 seasons.

Characters	Tree height (m)		Shoot length (cm)		Chlorophyll content (SPAD)		Dry weight of 30 leaves (g)		N (%)		P (%)		K (%)		Mg (%)		Fruit set (%)	
Seasons Treatments	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
700 g actual fast N as control	3.13	3.3	26.0	24.5	37.0	37.3	56.5	56.5	1.12	1.1	0.42	0.4	0.85	0.9	0.27	0.2	79.6	47.0
200 g actual slow N	3.38	3.6	29.9	31.0	42.5	43.5	61.3	61.4	1.19	1.2	0.55	0.5	1.21	1.2	0.38	0.4	58.4	53.5
300 g actual slow N	3.55	3.9	30.9	29.6	44.3	44.8	63.7	64.7	1.42	1.4	0.60	0.6	1.27	1.3	0.40	0.4	69.1	60.1
400 g actual slow N	3.61	4.1	33.8	31.8	45.1	45.8	65.1	65.4	1.61	1.6	0.65	0.6	1.33	1.3	0.41	0.4	53.9	52.0
LSD $_{0.05}$	0.18	0.10	1.56	0.40	1.43	1.60	1.09	1.10	0.03	0.01	0.02	0.01	0.04	0.01	0.03	0.01	0.34	0.10

B. Tree yield and fruit characteristics.

It is clear from the data in Table 5 that, the application of nitrogen slow fertilizer in the form of phosphorus coated urea improved the fruit characteristics of pomegranate trees in both seasons. The fruit characteristics, i e fruit weight and volume, juice volume, TSS, TSS/ acidity, vitamin C and anthocyanin were significantly affected by slow-release nitrogen fertilizers in both seasons. On the contrary, the fruit shape index, in general, showed insignificant response to both treatments over the two years of study. Yield was significantly increased by increasing the dose of the slow release fertilizers from 200 to 400 g actual slow release nitrogen fertilizer /tree by almost 23% in both seasons (Table 5).The highest dose of slow release nitrogen, i e 400 g /tree produced the highest values of all fruit characteristics of the pomegranates.

Table 5. Main effect of fast and slow-release nitrogen fertilizers on tree yield and fruit characteristics of Manfalouty pomegranate tree in 2014 and 2015 seasons.

Characters	Yield (kg /tree)		Fruit weight (g)		Fruit volume(ml)		Juice volume (ml)		Fruitshape index		TSS (%)		Acidity (%)		TSS/acidity ratio		Vitamin C (mg/100ml)		Anthocyanin (mg/100ml)	
Seasons Treatments	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
700 g actual fast N as control	30.6	29.3	306.5	303.5	294.4	303.8	129.3	133.7	0.89	0.9	14.7	14.4	1.22	1.2	12.1	11.2	13.4	13.0	13.1	12.6
200 g actual slow N	31.1	32.9	318.7	320.7	309.6	311.8	148.3	148.3	0.89	0.9	16.7	16.9	1.42	1.4	11.8	11.9	13.2	13.6	13.1	13.5
300 g actual slow N	35.4	37.1	346.3	347.8	333.2	333.7	163.3	163.3	0.89	0.9	16.5	17.2	1.31	1.3	12.7	13.1	13.7	14.1	13.4	13.5
400 g actual slow N	38.3	40.5	358.8	359.4	341.1	342.5	165.5	164.5	0.90	0.9	17.3	17.2	1.23	1.3	14.1	13.2	14.1	14.5	14.0	14.0
LSD $_{0.05}$	0.80	1.00	4.7	7.0	7.00	2.90	4.75	2.8	0.01	NS	0.62	0.50	0.03	0.11	0.55	1.00	0.13	0.53	0.17	0.56

An exception was the acidity, which has its highest values of 1.42 and 1.40 with the 200 g/tree in the first and the second seasons respectively. Previous studies showed that supplying pomegranate and other deciduous fruit crops with their needs from N, P and K at balanced rate was very necessary for improving yield and fruit quality (Mansour *et al*., 2007; El- Sayed, 2013 and Kumar & Ahmed; 2014).

Slow release fertilizers effect might be attributed to their effect on regulating the release of nitrogen according to the tree's needs. In addition they gave the highest values of residual nitrogen in soil due to the low activity index as compared with that of fast release fertilizer which produces the lowest values of residual N in the soil (Mikkelsen *et al.,* 1994). Similar results for the positive effect of slow release fertilizers were obtained by Kandil *et al.* (2010).

3- Interaction between irrigation and fertilization treatments in relation to

A. Vegetative growth, leaf chlorophyll and mineral contents as well as fruit set.

Concerning the interaction between levels of soil moisture of field capacity (FC) and fast and slow-release nitrogen fertilizers, it is clear from Table 6 that the combination between the 100% FC irrigation treatment and the highest amount of slow release fertilizer of 400 g actual slow release nitrogen fertilizer /tree, in general, produced the highest values of most of the vegetative growth traits, i e tree height, shoot length, dry weight of 30 leaves, and chlorophyll content (SPAD) in both seasons. The leaf mineral contents, i e leaf nitrogen, phosphorus and potassium content showed a similar response to the vegetative growth of the pomegranate trees (Table 6). In most cases, this treatment has no significant difference with the treatment of 100% FC+300 g fertilization /tree / season as in the case of nitrogen, phosphorus, potassium and magnesium content in leaves. Again, the fruit set responded differently as compared to the other parameters, i e the fruit set was the maximum at 75% FC +200 g actual slow release nitrogen fertilizer and at 75 % FC + 300 g actual slow release nitrogen fertilizer in the first and second seasons, respectively. These results are in harmony with those reported by many investigator in different fruit crops (El-Kassas, 1983 on pomegranate, Kandil *et al.,* 2010 and Soliman *et al*., 2016 on peach).

Table 6. Interaction effect of three levels of soil moisture of field capacity (F C) and fast or slow-release nitrogen fertilizers on the vegetative growth, leaf chlorophyll and mineral contents as well as fruit set of Manfalouty pomegranate trees in 2014 and 2015 seasons.

Characters	Tree height (m)		Shoot length (cm)		Chlorophyll content (SPAD)		Dry weight of 30 leaves (g)		N (%)		P (%)		K (%)		Mg (%)		Fruit set (%)	
Seasons / Treatments	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
50% FC+700 g actual fast N	2.6	3.1	22.5	20.0	29.1	30.8	53.1	46.9	1.1	1.1	0.4	0.4	0.2	0.2	0.1	0.1	34.0	29.7
50% FC +200 g actual slow N	3.1	3.5	25.9	25.5	32.0	32.9	57.5	57.6	1.1	1.1	0.5	0.5	1.1	1.1	0.1	0.2	40.7	50.8
50% FC +300 g actual slow N	3.2	3.6	26.7	26.3	34.2	34.3	61.0	61.9	1.2	1.2	0.5	0.5	1.1	1.1	0.1	0.2	61.5	64.0
50% FC +400 g actual slow N	3.3	3.9	28.1	27.1	35.6	36.5	62.3	62.4	1.3	1.3	0.6	0.6	1.1	1.2	0.2	0.2	55.9	50.5
75% FC +700 g actual fast N	3.1	3.3	26.7	23.9	37.2	34.5	53.8	60.1	1.1	1.1	0.4	0.4	1.2	1.1	0.3	0.2	57.7	56.8
75% FC +200 g actual slow N	3.4	3.4	29.4	29.6	45.3	46.2	60.6	61.2	1.2	1.2	0.5	0.5	1.2	1.2	0.4	0.4	79.0	54.5
75% FC +300 g actual slow N	3.5	3.7	30.5	29.2	49.0	49.0	62.9	63.4	1.4	1.4	0.6	0.6	1.2	1.2	0.3	0.4	71.0	72.0
75% FC +400 g actual slow N	3.4	4.0	33.8	32.5	47.3	50.6	63.7	63.5	1.5	1.5	0.6	0.6	1.3	1.4	0.3	0.3	64.3	58.7
100% FC +700 g actual fast N	3.7	3.4	30.3	29.5	44.8	46.7	62.6	62.6	1.1	1.1	0.4	0.5	1.2	1.2	0.4	0.4	62.0	54.5
100% FC +200 g actual slow N	3.7	3.9	32.3	38.1	50.2	50.4	65.9	65.4	1.3	1.3	0.6	0.6	1.3	1.3	0.6	0.6	56.5	55.2
100% FC +300 g actual slow N	4.1	4.3	34.9	33.2	49.9	51.3	67.3	68.7	1.7	1.7	0.7	0.7	1.5	1.4	0.7	0.8	47.8	44.5
100% FC +400 g actual slow N	4.2	4.5	39.8	35.8	52.4	51.5	69.6	70.3	2.0	1.9	0.7	0.7	1.5	1.5	0.7	0.7	41.8	47.0
$LSD_{0.05}$	0.30	0.22	2.7	2.15	2.50	2.83	1.90	1.96	0.10	0.07	0.02	0.03	0.10	0.06	0.10	0.04	0.6	0.14

B. Tree yield and fruit characteristics.

It is clear from the data in Table 7 that all fruit characteristics parameters were significantly affected by interaction between levels of soil moistures of field capacity FC and slow-release nitrogen fertilizers. The physical fruit characteristics, i e juice volume, fruit volume and fruit weight produced the highest values especially in both treatments with 100% FC + slow release nitrogen fertilizer at 300 or 400 g / tree/ season as compared with the other interactions in the experiment. Yield showed a similar response to the other parameters and produced its highest values of 44.1

and 47.1 Kg/tree with the treatment of 100 FC+400 g/tree in the first and second seasons, respectively. The fruit shape index showed no significant response to all treatments over the two years of study.

The chemical fruit characteristics i e TSS, TSS/ acidity, vitamin C and anthocyanin were the maximum at 50% FC +400 g actual slow release nitrogen fertilizer, while the acidity values showed a different response, where it was the highest with the treatment of 100% FC and 200 g/tree as a slow release fertilizer producing a value of 1.5 in the second seasons. Most of the studied characteristics have the highest values with using a combination of 100% FC as irrigation treatment with 400 g/tree of the slow release fertilizer.

Table7. Interaction effect of three levels of soil moisture of field capacity (FC) and fast or slow-release nitrogen fertilizers on tree yield and fruit characteristics of Manfalouty pomegranate trees in 2014 and 2015 seasons.

Characters	Yield (kg /tree)		Fruit weight (g)		Fruit volume (ml)		Juicevolume (ml)		Fruit shape index		TSS (%)		Acidity (%)		TSS/ acidity ratio		Vitamin C (mg/100ml)		Anthocyanin (mg/100ml)	
Seasons / Treatments	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
50%FC +700 g actual fast N	32.7	30.3	302.8	288.8	285.0	290.8	109.2	111.2	0.9	0.9	16.3	17.1	1.2	1.3	13.1	13.6	12.8	12.9	12.8	12.4
50%FC +200 g actual slow N	29.2	31.3	307.0	308.8	298.8	298.8	119.2	117.4	0.9	0.9	16.9	16.6	1.3	1.3	12.9	12.3	14.0	14.1	14.0	14.1
50%FC +300 g actual slow N	30.9	32.6	311.8	314.0	302.5	301.5	129.8	129.6	0.9	0.9	17.8	17.9	1.2	1.2	14.9	14.8	14.6	14.8	14.2	14.4
50%FC +400 g actual slow N	32.2	34.1	313.3	313.0	306.5	305.5	131.5	132.4	0.9	0.9	18.1	18.1	1.1	1.4	15.8	14.0	15.2	15.2	14.9	14.4
75%FC +700 g actual fast N	29.2	28.0	303.5	308.0	288.0	294.8	125.5	130.8	0.9	0.9	15.7	14.3	1.3	1.3	12.5	10.7	12.4	12.1	11.9	11.9
75% FC +200 g actual slow N	31.0	32.4	319.3	319.0	306.3	310.3	142.7	140.2	0.9	0.9	17.1	17.3	1.4	1.4	12.2	12.2	12.9	13.4	13.0	13.0
75%FC +300 g actual slow N	33.8	35.1	330.8	332.3	317.0	319.0	151.5	150.9	0.9	0.9	17.0	17.7	1.3	1.3	12.8	13.2	13.2	13.8	13.3	13.4
75% FC +400 g actual slow N	38.6	40.3	365.8	361.8	331.8	335.3	148.4	152.4	0.9	0.9	17.7	16.7	1.2	1.3	14.6	13.1	13.6	14.4	13.7	13.7
100% FC +700 g actual fast N	30.0	29.7	313.3	313.8	310.3	325.8	153.3	159.2	0.9	0.9	12.4	11.9	1.1	1.1	10.8	10.5	15.2	14.1	14.6	13.6
100% FC + 200 g actual slow N	33.4	35.1	329.8	334.3	323.8	326.3	183.2	187.5	0.9	0.9	16.3	16.9	1.5	1.5	10.5	11.3	12.9	13.4	12.7	13.3
100% FC + 300 g actual slow N	41.6	43.8	396.3	397.3	380.0	380.5	208.9	208.6	0.9	0.9	14.8	15.9	1.4	1.4	10.4	11.1	13.5	13.8	12.9	13.2
100% FC + 400 g actual slow N	44.1	47.1	397.5	403.5	385.0	386.8	217.0	208.6	0.9	0.9	16.4	16.9	1.3	1.3	12.2	12.6	13.7	14.1	13.6	13.9
$LSD_{0.05}$	1.40	1.79	8.2	12.08	12.1	5.04	8.20	4.8	NS	NS	1.10	0.94	NS	0.19	1.00	1.73	0.20	0.92	0.30	0.96

The main factors believed to be responsible for decline in productivity were improper use of irrigation water and fertilization (El-Kassas, 1983). The results are in agreement with those of El-Salhy *et al.* (2013) and Soliman *et al.* (2016) on peach.

CONCLUSION

From the obtained results, it could be concluded that a combination of fast and slow release (i e phosphorus coated urea PCU 37%) nitrogen fertilizer with different levels of soil moisture can enhance growing of Manfalouty pomegranate trees with high productivity as compared to the current production practices and can reduce both rate and number of soil applications during the growing season.

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استجابة إنتاجية أشجار الرمان لمستويات رى مختلفة مع السماد النتروجينى البطئ أو السريع والتوافيق بينهم.

محمود عبدالستار[١] و يحيى إبراهيم محمد[٢]
[١]قسم الفاكهة – كلية الزراعة - جامعة الإسكندرية
[٢]كلية الزراعة الصحراوية والبيئية بفوكة – فرع مطروح - جامعة الإسكندرية

أجريت هذه الدراسة خلال عامى ٢٠١٤ و٢٠١٥ على أشجار الرمان صنف منفلوطى مزروعة فى أرض جيرية بمنطقة برج العرب بمحافظة الإسكندرية بهدف تحديد أى توليفة من السماد النتروحينى بطئ التحلل (يوريا مغلفة بالفوسفور) مع مستويات مختلفة من رطوبة التربة وذلك لتحسين نمو أشجار الرمان مع زيادة إنتاجيتها مقارنة بالممارسات الإنتاجية الموجودة ، مع تقليل معدل وعدد مرات إضافة الأسمدة خلال موسم النمو. وقد أوضحت النتائج أن النمو الخضرى للأشجار ومحتوى الأوراق من العناصر المعدنية والكلوروفيل وصفات الثمار الطبيعية والكيماوية والمحصول زادت معنويا متأثرة بالتوليفة بين مستويات الرطوبة بالتربة بالنسبة للسعة الحقلية من جانب والتسميد النتروجينى البطئ من الجانب الأخر. وقد أظهرت النتائج أن الصفات الكيماوية للثمار مثل المواد الصلبة الذائبة الكلية و فيتامين ج وصبغة الانثوسانين ونسبة المواد الصلبة الذائبة الكلية/ الحموضة كانت أعلى فى التوليفة بين ٥٠ % سعة حقلية + ٤٠٠ جم نتروحين صافى بطئ التحلل،فى حين أن قيمة الحموضة كانت أعلى فى المعاملة ١٠٠ % سعة حقلية + ٢٠٠ حم نتروحين صافى بطئ التحلل و٧٥ % سعة حقلية + ٣٠٠ جم نتروحين صافى بطئ التحلل فى الموسم الأول والثانى على التوالى. أما نسبة عقد الثمار فكانت اعلى فى المعاملة ٧٥ % سعة حقلية + ٢٠٠ أو ٣٠٠جم نتروحين صافى بطئ التحلل فى الموسم الاول والثانى على التوالى. وقد إرتفع المحصول معنويا فى المعاملة ١٠٠ % رطوبة أرضية من السعة الحقلية + ٤٠٠ جم نتروجين بطئ التحلل للشجرة حيث زاد إلى ٤٤,١ و ٤٧,١ كجم/ شجرة فى الموسم الأول والثانى على التوالى. وقد وجد أن معظم صفات النمو الخضرى مثل إرتفاع الأشجار وطول النموات والوزن الجاف لـ ٣٠ ورقة ومحتوى الأوراق من الكلوروفيل وأيضا محتوى الأوراق من النتروجين والفوسفور والبوتاسوم والماغنسيوم زاد فى كلا الموسمين.