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EFFECT OF IRRIGATION INTERVAL, ORGANIC MANURING AND NITROGEN FERTILIZATION LEVEL ON YIELD AND YIELD ATTRIBUTES OF MAIZE

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ABSTRACT

This investigation was carried out in an demonstrated field at Al-Ibrahimia District, Sharkia Governorate, during 2011 and 2012 seasons to find out the effect of irrigation interval (14 and 18 days), starting from 3rd irrigation (48 and 52 days after planting) organic manuring (check, 20 m^3/fad., farmyard manure "FYM" and 5 tons compost/ fad.) and three N levels (20, 60 and 120 kg N/fad.) on yield and its attributes of maize (single cross 129). The irrigation interval had no significant effects on maize grain yield and its yield attributes. However, the combined analysis detected significant differences in shelling percentage and harvest index where, irrigation interval every 14 days recorded higher averages compared with irrigation every 18 days. Addition of 20 m^3/fad., of FYM, significantly increased grain, ear, stover and total yields/ fad., ear length, number of grains/ ear, 100-grain weight and grain weight/ ear according to the combined analysis. Increasing N level up to 120 kg / fad., gave significant increments in grain yield and yield attributes except shelling percentage which was decreased. Stover yield was responded only to 60 kg N/ fad. Increasing N levels had no significant effect on of number rows/ ear and grain protein content. The first order interactions between factors had significant effects on some yield attributes. The most interesting of these was detected with ear and grain yields/ fad., traits in the second season. Organic manuring was effective to avoid a significant decrease in ear and grain yields/ fad., which was observed in the un-manured plots when the irrigation interval was prolonged to 18 instead of 14 days. Such finding confirmed the benefits of organic manure in improving soil-water holding capacity which functionally reduces water requirements for plants.

Key words: Maize, irrigation interval, organic manure, FYM, nitrogen fertilizer.

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop which ranks the third after wheat and rice. In Egypt, the total cultivated area of maize reached 2.204 millions fad., in 2012 season, produced 7.200 millions ton, with an average production of 23.02 ardabs/fad. This production, however, does not meet consumption where about 5 million tons are imported. Moreover, the strategy bused in mixing maize grain partly with wheat to reduce wheat importing and increase self sufficiency from bread wheat is partly based on making use of maize. This in turn necessitates more extension in the maize cultivated area and as well optimizing the needs of irrigation water. Optimal water management strategies thus become an important factor due to limitations in the supply of irrigation water caused by un controlled increase in rice cultivated area which receives a great part of irrigation water in the summer season.

Several studies had been carried out to find out the effect of irrigation interval on maize yield and its attributes. These studies showed significant decrease in maize grain yield due to prolonging the irrigation interval or irrigation deficit. Such decrease was attributed to a reduction in number of ears/ plant (Assouline, 2002 and Oktem *et al.*, 2003), ear length and

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diameter (Hussein and El-Melegy, 2006; Ibrahim and Kandil, 2007), number of rows/ ear and number of grains/ row (Oraby *et al.,* 2005; Ibrahim *et al.,* 2005 and Samuel *et al.,* 2006), 100- kernal weight and grain weight/ ear (El-Hendawy *et al.,* 2008 and Mansouri-Far *et al.,* 2010). Grain protein content was reported to decrease due to extreme drought (Mohsen *et al.,* 2012)

Many studies have shown that application of organic manures played an efficient role in sustaining maize production throw improving soil physical, chemical and biological properties. The most important of these properties is the water holding capacity (Flavio, 2004). Application of organic manure has been shown to improve the soil organic matter content (Adani *et al.,* 2007). Maize grain yield was increased due to increasing organic manuring rates up to 5, 20, 10 and 40 m^3/ fad., as reported by Negassa *et al.* (2001); Nofal and Hinar (2003); Nofal *et al.* (2005) and El-Naggar *et al.* (2012), respectively. Some authors reported significant increase in maize yield attributes *i.e.* No. ears/ plant, ear length and diameter (Pattanashetti *et al.,* 2002; Mohamed, 2006; El-Hamdi *et al.,* 2008), number of rows/ ear and number of grains/ row (Tejada *et al.,* 2008 and Hassanein and Abul-Soud, 2010), 100-kernal weight and grain weight/ear (Achieng *et al.,* 2010 and Abd El-Wahed and Ali, 2013) due to the addition of organic manuring.

Mineral fertilization with nitrogen was also reported to increase grain yield of maize. Abdel-Maksoud *et al.* (2002); Shams (2000) and El-Murshedy (2002) reported that increasing N levels up to 105,120 and 140 kg N/fad., increased grain yield, number of rows/ear, number of grains/ row, 100 kernal weight and grain weight. These increases were attributed to the increase of yield attributes *i.e.* ears/ plant, ear length and diameter (El-Metwally *et al.,* 2001; Darwish, 2003; Bader *et al.,* 2003; Ghazy, 2004; Ash-Shormillesy, 2005; Abd-Alla, 2005; Atia and Mahmoud 2006; Abd El-Maksoud and Sarhan, 2008; Soliman and Gharib, 2011; El-Azab, 2012 and Darwich, 2013).

Therefore, the present investigation aimed to find the effect of irrigation interval, on yield and yield attributes of maize under organic manuring with FYM and compost as well as the different levels of mineral nitrogen.

MATERIALS AND METHODS

The present study was conducted in a demonstrated field at Al-Ibrahimia District, Sharkia Governorate, Faculty of Agriculture, Zagazig University, during 2011 and 2012 seasons. The study aimed to find out the effect of two irrigation intervals (14 and 18 days), organic manuring with FYM (20 m^3/fad.) and compost (5 tons/ fad.) compared with a check (without manuring) and three N fertilization levels (20, 60 and 120 kg N/fad.) on maize grain yield and its attributes using the maize cultivar single cross 129.

A split-split plot design of four replications was used, where the irrigation interval treatments were allocated in the main plots. Main plots were surrounded by wide borders (1.5 m) to avoid seepage of water among irrigated and non irrigated plots. Organic manuring and N fertilization levels were allocated in the sub and sub-sub plots (15 m^2), respectively. Each second order sub plot included 5 ridges of 5 m length, 60 cm apart. The irrigation interval treatments started from the 3rd irrigation (48 and 52 days after planting in the 1st and 2nd seasons, respectively) in order to complete the addition of N fertilizer. In order to trace the effects of the irrigation intervals on growth and yield of maize, soil moisture was determined before the 3rd to 7th irrigation at two soil depths (0-30 and 30-60 cm) in the main and sub plots occupied by irrigation interval and organic manuring, respectively. The first dose of N fertilizing (20 kg N/fad.) was added before planting as ammonium sulphate (20.5%). Second and third N doses were added at (20 and 34 DAP) before the first and second irrigations as ammonium nitrate (33.5% N). Organic manures were soil incorporated before planting.

At harvest, (120 days from planting), the two central ridges, were harvested for grain yield determination and the following yield attributes were recorded on ten plants and ears: Ear number per plant, ear diameter (cm), ear length (cm), row number per ear, grain number per row, grain number per ear, hundred grain weight (g), Shelling (%) and grain weight per ear (g).

The following final yield traits were recorded from the two central ridges:

Grain yield, ear yield, total yield, Stover yield (ton/fad.) and harvest index (%).

Grain samples at harvest were dried at 70°C where their contents from total N and grain protein content (%) were determined, using the colorimeterical method according to Jackson (1967).

Single cross 129 white maize cultivar was planted on 15th and 20th May in 1st and 2nd seasons, respectively. Maize grains were hand sown in hills 25 cm apart using dry sowing method on one side of the ridge. Planting was made after wheat as a preceding crop in both seasons using seeding rates of 10 kg/fad. Plants were thinned to one plant per hill before the first irrigation (20 DAP). Phosphorus at a level of 15.5 kg P_2O_5/fad., as ordinary superphosphate (15.5% P_2O_5) was band placed at the time of planting. Soil samples were collected from the experimental sites at the depth of 0 -30 cm before planting to determine soil physical and chemical properties.

Data were statistically analyzed according to Gomez and Gomez (1984) by using MSTAT-C (1989) where statistical program Version 2.1 was used for analysis of variance (ANOVA). A combined analysis was undertaken for the data of the two seasons after testing the homogeneity of the experimental errors. Duncan Multiple range test was used to compare statistical significant difference (Duncan, 1955). In interaction Tables, capital and small letters were used to denote significant differences among rows and columns means, respectively.

Data in Table 1 show some soil physical and chemical properties of the experimental field, farmyard manure and compost nutrient contents in the two seasons.

RESULTS AND DISCUSSION

Number of Ears/ Plant and Ear Dimensions

Irrigation interval effect

In both seasons and their combined, the irrigation interval was without any significant effect on the number of ears/ plant or ear length and diameter (Table 2). These results are not in accordance with those reported by Assouline (2002); Oktem *et al.* (2003); Hussein and El-Melegy (2006) and Ibrahim and Kandil (2007).

Organic manuring effect

Organic manuring was without significant effect on the number of ears/ plant and ear length and diameter in both seasons. However, the combined analysis detected significant increase in ear length due to organic manuring with FYM as compared to the check *i.e.* without organic manuring (Table 2). Similar significant effects were reported by Pattanashetti *et al.* (2002); Mohamed (2006) and El-Hamdi *et al.* (2008).

Nitrogen level effect

Each increase in N level was followed by a significant increase in each of the number of ears/ plant and ear length and diameter in both seasons and their combined (Table 2). This response was consistent up to the addition of 120 kg N/ fad. Similar significant effects were reported by Darwish, (2003); Ghazy (2004); Ash-Shormillesy, (2005) and Soliman and Gharib (2011).

Interaction effect

Ear length was significantly affected by the irrigation interval x organic manuring interaction in the second season. This interaction was ascertained by the combined analysis and is presented in Table 2-a for ear length. Results regarding ear length indicate that addition of FYM was effective to increase ear length when the irrigation interval was prolonged to 18 days instead of 14 days. This effect was not observed in the check or compost organic manuring treatments indicating a possible beneficial effect to soil fertility from physical, chemical or biological points of view, due to the addition of FYM.

Data in Table 1 regarding the chemical properties of the used organic manures, showed that FYM had the narrowest C:N ratio (25:1) in the second season compared with the first one (29:1) as compared with C:N ratio of compost in two seasons which was wider (29:1 and 36:1) in the two seasons, respectively.

Table 1. Soil mechanical and chemical analyses of the experimental site at 30 cm soil depth and the nutrient contents of organic manures in the two seasons(*)

Properties	2011	2012
Soil analyses		
Texture	clay loam	clay
pH (1: 5, soil:water)	7.84	7.90
EC (dS m^{-1})	0.94	0.25
Total N (%)	0.14	0.18
Available P (mg kg^{-1})	5.84	11.00
Available K (mg kg^{-1})	156	285
Organic matter (%)	2.80	3.15
C/N ratio	12 : 1	10 : 1
Cations (mq/100g soil)		
K^+	0.04	0.07
Na^+	0.21	1.27
Ca^{++}	0.15	0.90
Mg^{++}	0.10	0.30
Anions (mq/100g soil)		
HCO_3^{--}	0.20	0.50
SO_4^{--}	0.04	0.28
CL^-	0.24	1.76
(Farmyard manure):		
Total N (%)	0.40	0.50
Total P (mg kg^{-1})	900	1200
Total K (mg kg^{-1})	3875	5344
Organic matter (%)	19.90	21.82
C/N ratio	29 : 1	25 : 1
Compost		
Total N (%)	0.39	0.47
Total P (mg kg^{-1})	1250	1100
Total K (mg kg^{-1})	4275	11625
Organic matter (%)	20.10	29.54
C/N ratio	29 : 1	36 : 1

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Table 2. Ear number per plant, ear length and ear diameter of maize as affected by irrigation interval, organic manuring and nitrogen fertilization level and their interactions in the two seasons

Main effects and interactions	Ear number per plant			Ear length (cm)			Ear diameter (cm)		
	2011	2012	Combined	2011	2012	Combined	2011	2012	Combined
Irrigation interval (I)									
14 days	1.09	1.03	1.06	20.23	18.78	19.51	4.70	4.59	4.65
18 days	1.12	1.00	1.06	20.22	19.00	19.61	4.71	4.56	4.64
F.test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Organic manure (M)									
Check	1.09	1.02	1.06	19.98	18.60	19.29 b	4.68	4.56	4.62
20 m^3 FYM/fad.	1.13	1.03	1.08	20.50	19.21	19.86 a	4.73	4.58	4.66
5 tons compost/fad.	1.10	1.00	1.05	20.19	18.87	19.53 ab	4.71	4.58	4.65
F.test	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.
Nitrogen level (N)									
20 kg N/ fad.	1.00 c	0.98 b	0.99 c	18.52 c	15.87 c	17.20 c	4.58 c	4.45 b	4.52 c
60 kg N/ fad.	1.11 b	1.02 a	1.07 b	20.57 b	19.60 b	20.09 b	4.71 b	4.61 a	4.66 b
120 kg N/ fad.	1.20 a	1.05 a	1.13 a	21.59 a	21.21 a	21.40 a	4.83 a	4.66 a	4.75 a
F.test	**	**	**	**	**	**	**	**	**
Interactions									
I x M	N.S.	N.S.	N.S.	N.S.	**	**(2-a)	N.S.	**	*
I x N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
M x N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*,** and N.S. indicate significancy at 0.05 and 0.01 levels and insignificancy of differences, in respective order.

Table 2-a. Ear length (cm) of maize as affected by irrigation interval and the organic manuring interaction (combined data)

Irrigation interval	Organic manuring		
	Check	20 m^3/fad., FYM	5 tons compost
14 days	A 19.52 a	A 19.39 b	A 19.61 a
18 days	B 19.06 a	A 20.33 a	B 19.45 a

Accordingly the possibility of earlier release of available nitrogen from FYM could account for the increase of ear length observed herein in the second season which was ascertained by the combined analysis. This beneficial effect was not observed except when the irrigation interval was prolonged to 18 days referring to a possible improvement to soil fertility from the physical point of view where soil moisture could have been more available to maize plants during the early reproductive stage after silking where ear length is known to be defined (Fageria *et al.*, 1997). The present interaction is the first signal of a possible beneficial effect from organic manuring as far as grain yield attributes are concerned.

Number of Rows and Grains Per Ear

Irrigation interval effect

In both seasons and their combined, irrigation interval was without any significant effect regarding the row or grain numbers/ ear (Table 3). This insignificant effect was previously observed in ear length and diameter (Table 2) and could account for the results obtained herein. These results are not in accordance with those reported by Oraby *et al.* (2005); Ibrahim *et al.* (2005) and Samuel *et al.* (2006).

Organic manuring effect

Though organic manuring did not reflect any significant effect on the number of rows/ ear or the number of grains/ row in both seasons, however, the combined analysis detected significant increase in the number of grains/ ear in favor of the two organic manuring treatments. Where FYM and compost recorded at par higher averages of grain number per ear than the check (Table 3). Similar findings were reported by Tejada *et al.* (2008) and Hassanein and Abul-Soud (2010).

Nitrogen level effect

Each increase in N level was followed by a significant increase in the number of grains/ row and hence the number of grains/ ear irrespective of failure of N increments in varying the number of rows/ear (Table 3). These results clearly indicate that the increase of ear diameter due to the increase of N level was without significant effect on rows number/ ear. However, these N increments increased ear length (Table 2) which resulted in a significant increase in the number of grains/ row and finally the number of grains/ ear. Moreover, these results refer to more photosynthates which might have had been available for grain set. Similar significant results were reported by El-Metwally *et al.* (2001); Bader *et al.* (2003); Abd-Alla (2005); Abd El-Maksoud and Sarhan (2008) and El-Azab (2012).

Interaction effect

According to the combined analysis, the number of grains/ row (Table 3-a) and per ear (Table 3-b) were significantly affected by the irrigation interval x organic manuring. Also, the number of rows/ ear (Table 3-c) and the number of grains/ ear (Table 3-d) were significantly affected by the irrigation interval x N level. It is evident from Table 3-a and Table 3-b that FYM addition was effective to increase both number of grains/ row and per ear when the irrigation interval was prolonged to 18 days. This effect was not observed due to addition of compost or in the check plots without manuring.

The present trend of results was previously seen in ear length (Table 2-a) and could account for the increase in the number of grains/ row and also the increase in the number of grains/ ear. This effect was fully discussed while presenting the effect of this interaction on ear length.

It is evident from Table 3-c that the number of rows/ ear was significantly increased due to narrowing the irrigation interval to 14 days for the low N fertilized plants (20 kg N/ fad.). This effect was not observed for the moderate (60 kg N/fad.) or high (120 kg N/fad.) N fertilized plants. This refers to more availability of N for the narrow irrigated plants which might have had played a role in increasing the number of rows/ear when plants received the low N fertilization level.

It is evident from Table 3-d that each increase of N level was accompanied by a significant increase in the number of grains/ ear at the two irrigation intervals but with different magnitudes. The percentage increase in these numbers amounted to 16.7 % and 28.0 % for the short (14 days) and long (18 days) intervals, respectively. This clearly indicates that the increase of N level was more needed by maize

Table 3. Row number per ear and grain number per row and per ear of maize as affected by irrigation interval, organic manuring and nitrogen fertilization level and their interactions in the two seasons

Main effects and interactions	Row number per ear			Grain number per row			Grain number per ear		
	2011	2012	Combined	2011	2012	Combined	2011	2012	Combined
Irrigation interval (I)									
14 days	14.60	14.53	14.57	42.53	38.81	40.67	620.7	564.0	592.4
18 days	14.80	14.38	14.59	43.08	39.21	41.15	634.5	564.3	599.4
F.test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Organic manure (M)									
Check	14.48	14.33	14.41	42.50	38.25	40.38	615.8	548.5	582.2 b
20 m^3 FYM/fad.	14.86	14.37	14.62	43.10	39.78	41.44	634.9	571.6	603.3 a
5 tons compost/fad.	14.76	14.67	14.72	42.81	39.00	40.91	632.1	572.5	602.3 a
F.test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
Nitrogen level (N)									
20 kg N/ fad.	14.58	14.45	14.52	39.65 c	33.12 c	36.39 c	578.1 c	479.7 c	528.9 c
60 kg N/ fad.	14.68	14.55	14.62	43.61 b	40.54 b	42.08 b	634.8 b	589.8 b	612.3 b
120 kg N/ fad.	14.83	14.37	14.60	45.15 a	43.37 a	44.26 a	669.9 a	623.1 a	646.5 a
F.test	N.S.	N.S.	N.S.	**	**	**	**	**	**
Interactions									
I x M	N.S.	N.S.	N.S.	N.S.	**	** (3-a)	N.S.	**	** (3-b)
I x N	*	N.S.	** (3-c)	N.S.	*	N.S.	N.S.	**	** (3-d)
M x N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*,** and N.S. indicate significancy at 0.05 and 0.01 levels and insignificancy of differences, in respective order.

Table 3-a. Grain number per row of maize as affected by irrigation interval and organic manuring interaction (combined data)

Irrigation interval	Organic manuring		
	Check	20 m^3/fad., FYM	5 tons compost
14 days	A 40.82 a	A 40.19 b	A 41.00 a
18 days	B 39.94 a	A 42.69 a	B 40.81 a

Table 3-b. Grain number per ear of maize as affected by irrigation interval and organic manuring interaction (combined data)

Irrigation interval	Organic manuring		
	Check	**20 m^3/fad., FYM**	**5 tons compost**
14 days	A 589.1 a	A 584.2 b	A 603.9 a
18 days	B 575.2 a	A 622.3 a	AB 600.7 a

Table 3-c. Row number per ear of maize as affected by irrigation interval and nitrogen fertilization level interaction (combined data)

Irrigation interval	N level (kg N/ fad.)		
	20	**60**	**120**
14 days	A 14.77 a	A 14.40 a	A 14.53 a
18 days	B 14.26 b	A 14.83 a	AB 14.67 a

Table 3-d. Grain number per ear of maize as affected by irrigation interval and nitrogen fertilization level interaction (combined data)

Irrigation interval	N level (kg N/ fad.)		
	20	**60**	**120**
14 days	C 543.5 a	B 599.1 b	A 634.5 b
18 days	C 514.3 b	B 625.5 a	A 658.4 a

plants to maximize the number of grains/ ear when the irrigation interval was prolonged to 18 instead of 14 days. In other words, narrowing the irrigation interval might have had made added N more available and hence the percentage increase in the number of grains/ ear due to the increase of N level was lower than that recorded when the irrigation interval was widened to 18 days.

Grain Weights and Shelling (%)

Irrigation interval effect

Irrigation interval did not significantly affect 100-grain weight and grain weight/ ear in both seasons and their combined (Table 4). However, shelling percentage was significantly increased due to narrowing the irrigation interval in the second season and the combined analysis. These results ascertain the view that the 4 days difference between the two irrigation intervals was not enough to create any significant difference as observed herein in single grain weight and grain weight/ ear with the exception of shelling percentage. These results are not in accordance with those reported by El-Hendawy *et al.* (2008) and Mansouri-Far *et al.* (2010).

Organic manuring effect

Due to its slow acting effect, organic manuring had a significant effect on the 100-grain weight where the addition of FYM resulted in a significant increase in grain weight/ ear as detected from the combined analysis only. This increase was also observed in the 100-grain weight and could partly account for the increase observed herein in grain weight/ ear as the number of grains/ ear was previously mentioned to increase due to FYM addition (Table 4). Similar results were reported by Achieng *et al.* (2010) and Abd El-Wahed and Ali (2013).

Nitrogen level effect

In both seasons and their combined a significant increase could be detected in 100-grain weight and grain weight/ ear irrespective of the significant decrease of shelling percentage due to each increase in N level (Table 4). The increase of grain weight/ ear due to the increase of N level up to 120 kg N/ fad., could be attributed to the significant increase observed in ear length and diameter (Table 2) as well as in the number of grains/ row and per ear (Table 3) in addition to the increase observed herein in 100-grain weight. Similar results were reported by Atia and Mahmoud (2006) and Darwich (2013).

Interaction effect

The 100- grain weight was significantly affected by organic manuring x N level interaction in the second season and was ascertained by the combined analysis (Table 4-a). It is evident from Table (4-a) that in the check or FYM organic manuring treatments, the increase of 100- grain weight was not significant beyond the addition of 60 kg N/ fad. Whereas in the compost treatment the 100- grain weight was not increased unless 120 kg N/ fad., was added. This interaction effect was not reflected in grain weight/ ear (Table 4).

Stover, Ear and Total yields/fad.

Irrigation interval effect

In both seasons and their combined, the irrigation interval was without significant effect on stover, ear and total maize yields/fad. (Table 5). Similar insignificant effects were observed in all yield attributes (Tables 2, 3 and 4). These results are not in accordance with those reported by Ibrahim and Kandil (2007); Farre and Faci (2009) and Iqbal *et al.* (2010) as they reported that the total yield was decreased due to prolonging irrigation interval or due to irrigation deficit.

Organic manuring effect

In the first season, organic manuring with FYM recorded significantly higher stover and hence higher total yield/ fad., than the check or compost organic manuring treatments. The combined analysis ascertained these results and in addition in the ear yield/ fad. These results could be attributed to the increase of some yield attributes such as grain number/ ear and grain weight/ ear due to FYM addition (Tables 3 and 4). Similar findings were reported by Gentile *et al.* (2008); Zhao *et al.* (2009) and Kato and Yamagish (2011).

Nitrogen level effect

In both seasons and their combined, addition of 60 kg N/ fad., produced a significant increase in stover yield/ fad., but the further increase of N

Table 4. Hundred grain weight, shelling percentage and grain weight per ear of maize as affected by irrigation interval, organic manuring and nitrogen fertilization level and their interactions in the two seasons

Main effects and interactions	Hundred grain weight (g)			Shelling (%)			Grain weight per ear (g)		
	2011	2012	Combined	2011	2012	Combined	2011	2012	Combined
Irrigation interval (I)									
14 days	31.45	27.01	29.23	85.86	85.75	85.80	190.6	146.2	168.4
18 days	30.76	26.59	28.68	85.70	85.14	85.42	190.6	145.0	167.8
F.test	N.S.	N.S.	N.S.	N.S.	**	*	N.S.	N.S.	N.S.
Organic manure (M)									
Check	31.04	26.59 ab	28.82 ab	85.86	85.77	85.82	187.0	141.7	164.4b
20 m^3 FYM/fad.	31.45	27.48 a	29.47 a	85.70	85.15	85.42	194.7	152.0	173.4a
5 tons compost/fad.	30.83	26.33 b	28.58 b	85.83	85.38	85.61	190.2	143.1	166.7b
F.test	N.S.	*	*	N.S.	N.S.	N.S.	N.S.	N.S.	**
Nitrogen level (N)									
20 kg N/ fad.	29.74 c	25.01 c	27.38 c	86.53	86.31 a	86.42 a	166.4 c	113.5c	140.0c
60 kg N/ fad.	31.00 b	26.96 b	28.98 b	85.63	85.40 b	85.51 b	194.2 b	152.7b	173.5b
120 kg N/ fad.	32.57 a	28.42 a	30.50 a	85.38	84.93 c	85.15 b	211.4 a	170.7a	191.1a
F.test	**	**	**	N.S.	**	**	**	**	**
Interactions									
I x M	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
I x N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
M x N	N.S.	**	**(4-a)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*,** and N.S. indicate significancy at 0.05 and 0.01 levels and insignificancy of differences, in respective order.

Table 4-a. Hundred grain weight (g) of maize as affected by organic manuring and nitrogen fertilization level interaction (combined data)

Organic manuring	N level (kg N/ fad.)		
	20	**60**	**120**
Check	B	A	A
	27.45 a	29.02 a	29.97 a
20 m^3/ fad. (FYM)	B	A	A
	27.71 a	29.88 a	30.80 a
5 tons Compost	B	B	A
	26.97 a	28.04 a	30.73 a

level to 120 kg N/ fad., failed to add a further significant increase in this respect. However, ear yield/ fad., responded to each increase in N level in both seasons and their combined and hence the total yield/ fad., according to the combined analysis (Table 5). These data are rather expected as all yield attributes of maize responded to the increase of N level up to 120 kg N/ fad. The failure of stover yield/ fad., to respond to the second N increment along with the response of ear yield/ fad., to this increment refers to a more dry matter partitioning towards ears filling which is mainly in maize grains. Similar results were reported by Mohamed (2006); Abd El-Maksoud and Sarhan (2008); Achieng *et al.* (2010) and El-Azab (2012).

Interaction effect

With very few exceptions which was not ascertained by the combined analysis, none of the yield criteria listed in Table 5 was affected by any first order interaction between the three factors under study (Table 5). These results ascertained the view that the main effects of organic manuring and N level dominated any interaction effect between them or between any of them and the irrigation interval. However, the ear yield/ fad., was significantly effected by the irrigation interval x organic manuring in the second season (Table 5-a).

It is evident from Table (5-a) that widening the irrigation interval to 18 days was followed by a significant decrease in ear yield/ fad., in only the check plots without organic manuring. This was not observed in the two organic manuring treatments. This interaction refers to a possible beneficial effect of organic manuring in holding soil moisture and may be plant nutrients, particularly nitrogen, more available where widening the irrigation interval did not decrease ear yield/ fad., as observed in the check plots without organic manuring.

Grain yield/fad., Harvest Index (%) and Grain Protein Content

Irrigation interval effect

As was expected and repeatedly seen in all yield attributes of maize, grain yield/ fad., or grain protein content were not significantly affected by the irrigation interval in both seasons and their combined with the exception of harvest index which was increased according the combined analysis due to narrowing the irrigation interval. These results are not in accordance with these reported by Ibrahim and Kandil (2007) as they reported a significant decrease in maize grain yield due to prolonging the irrigation interval to 18 days. However, Mohsen *et al.* (2012) found that, grain protein content was undesirably decreased under extreme drought stress. The controversy among authors regarding the effect of irrigation treatments on maize yield could be attributed to several factors among them the variation of soil physical properties *i.e.* field capacity, wilting point, amount of available moisture in addition to variations in the maize genotypes under study.

In the present study prolonging the irrigation interval to 18 instead of 14 days in an attempt to save one irrigation *i.e.* giving six instead of seven irrigations, did not significantly affect any of the yield attributes (Tables 2 to 5). This in turn was observed in all grain yield components as plants of the two irrigation intervals carried similar number of ears/ plant (Table 2). These ears had similar numbers of rows and grains/ row and finally similar number of grains/ ear (Table 3). This trend was observed in the 100-grain weight and grain weight/ ear (Table 4). These results were finally observed in the grain yield/ fad., and grain protein content as observed herein in (Table 6).

Organic manuring effect

The combined analysis detected significant increase in the grain yield/ fad., due to the addition of FYM compared with that recorded by the check or compost organic manuring treatments. This effect was neither observed in harvest index or grain protein content (Table 6). Similar significant increase was observed in ears yield/ fad., due to addition of FYM Table (5) and could account for the increase observed herein in grain yield/ fad. These results are in accordance with those reported by Negassa (2001); Nofal and Hinar (2003); Nofal, *et al.* (2005); and El-Naggar, *et al.* (2012) as they found significant increase in grain yield of maize due to increase of organic manuring up to 5, 20, 10 and 40 m^3/fad., respectively.

Nitrogen level effect

Each increase of N level was followed by a significant increase in the grain yield/ fad., up to

Table 5. Stover, ear and total yields of maize as affected by irrigation interval, organic manuring and nitrogen fertilization level and their interactions in the two seasons

Main effects and interactions	Stover yield (ton/fad.)			Ears yield (ton/fad.)			Total yield (ton/fad.)		
	2011	2012	Combined	2011	2012	Combined	2011	2012	Combined
Irrigation interval (I)									
14 days	6.01	5.75	5.88	3.48	2.65	3.07	9.49	8.40	8.95
18 days	5.85	6.07	5.96	3.35	2.51	2.93	9.20	8.58	8.89
F.test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Organic manure (M)									
Check	5.63 b	5.82	5.73 b	3.31	2.51	2.91 b	8.94 b	8.33	8.63 b
20 m^3 FYM/fad.	6.42 a	6.15	6.29 a	3.62	2.68	3.15 a	10.0 a	8.83	9.43 a
5 tons compost/fad.	5.75 b	5.76	5.76 b	3.30	2.55	2.93 b	9.10 ab	8.31	8.68 b
F.test	**	N.S.	**	N.S.	N.S.	*	*	N.S.	**
Nitrogen level (N)									
20 kg N/ fad.	4.98 b	4.73 b	4.86 b	2.84 c	1.94 c	2.39 c	7.82 c	6.66 b	7.24 c
60 kg N/ fad.	6.24 a	6.42 a	6.33 a	3.47 b	2.66 b	3.07 b	9.71 b	9.07 a	9.39 b
120 kg N/ fad.	6.57 a	6.59 a	6.58 a	3.93 a	3.14 a	3.54 a	10.5 a	9.73 a	10.11 a
F.test	**	**	**	**	**	**	**	**	**
Interactions									
I x M	N.S.	N.S.	N.S.	N.S.	*(5-a)	N.S.	N.S.	N.S.	N.S.
I x N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
M x N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*,** and N.S. indicate significancy at 0.05 and 0.01 levels and insignificancy of differences, in respective order.

Table 5-a. Ear yield (ton/fad.) of maize as affected by irrigation interval and organic manuring interaction (second season data)

Irrigation interval	Organic manuring		
	Check	20 m^3/fad., FYM	5 tons compost
14 days	**A**	**A**	**A**
	2.70 a	**2.63 a**	**2.62 a**
18 days	**B**	**A**	**B**
	2.33 b	**2.72 a**	**2.48 a**

Table 6. Grain yield, harvest index and grain protein content of maize as affected by irrigation interval, organic manuring and nitrogen fertilization level and their interactions in the two seasons

Main effects and interactions	Grain yield (ton/fad.)			Harvest index (%)			Grain protein content (%)		
	2011	2012	Combined	2011	2012	Combined	2011	2012	Combined
Irrigation interval (I)									
14 days	2.99	2.27	2.63	31.50	27.06	29.28	8.21	8.30	8.26
18 days	2.85	2.13	2.49	30.98	24.86	27.92	8.23	8.28	8.26
F.test	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.
Organic manure (M)									
Check	2.83	2.15	2.49 b	31.68	25.83	28.76	8.27	8.27	8.27
20 m^3 FYM/fad.	3.11	2.28	2.69 a	31.07	25.82	28.45	8.30	8.46	8.38
5 tons compost/fad.	2.82	2.18	2.50 b	31.00	26.20	28.60	8.10	8.15	8.12
F.test	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Nitrogen level (N)									
20 kg N/ fad.	2.45 c	1.67 c	2.06 c	31.28	25.11	28.20 ab	8.29	8.30	8.29
60 kg N/ fad.	2.97 b	2.27 b	2.62 b	30.63	25.03	27.83 b	7.96	8.35	8.15
120 kg N/ fad.	3.34 a	2.67 a	3.00 a	31.81	27.41	29.61 a	8.41	8.23	8.32
F.test	**	**	**	N.S.	N.S.	**	N.S.	N.S.	N.S.
Interactions									
I x M	N.S.	*(6-a)	N.S.	N.S.	**	**	N.S.	N.S.	N.S.
I x N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
M x N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*,** and N.S. indicate significancy at 0.05 and 0.01 levels and insignificancy of differences, in respective order.

the addition of 120 kg N/ fad., in both seasons and their combined. Also, the harvest index was significantly increased due to this addition as compared with next lower N level (60 kg N/ fad.). However, the grain protein content was not significantly affected by the increase of N level (Table 6). The consistent increase of grain yield/ fad., with each increase in N level could be attributed to the increase of grain yield components (Tables 2 to 5). This increase did not cause a dilution effect to the content of maize grain from protein. These results are in harmony with those reported by Xiaobin *et al.* (2011) and Darwich (2013) as they reported significant increase in grain yield of maize due to N addition of 75 and 120 kg N/fad., respectively. Moreover, Soliman and Gharib (2011) and El-Naggar, *et al.* (2012) got significant increase in grain yield of maize up to more additions of 140 and 135 kg N/ fad., respectively.

Interaction effect

In the second season, the grain yield/ fad., was significantly affected by the irrigation interval x organic manuring interaction. This interaction was not ascertained by the combined analysis. However, due to differences in soil fertility conditions it is presented in Table (6-a) seeking an answer about the role of organic manuring in affecting the irrigation interval and hence the grain yield/ fad. It is evident from Table (6-a) that organic manuring was without significant effect on maize grain yield/ fad., when the irrigation interval was narrowed to 14 instead of 18 days *i.e.* when plants received 7 instead of 6 irrigations. However, when the irrigation interval was prolonged to 18 days, addition of FYM was effective to significantly increase the grain yield compared with the check or compost treatments. Also, prolonging the irrigation interval significantly decreased the grain

Table 6-a. Grain yield (ton/fad.) of maize as affected by irrigation interval and the organic manuring interaction (second season data)

Irrigation interval	Organic manuring		
	Check	20 m^3/fad. FYM	5 tons compost
14 days	A 2.32 a	A 2.25 a	A 2.24 a
18 days	B 1.98 b	A 2.31 a	B 2.11 a

yield/ fad., in the check un-manured plots but not in the organic manured ones with either FYM or compost. These results were earlier observed in ear yield/ fad., (Table 5-a) and interestingly indicate that added manures might, probably, improve soil-water holding capacity and made plant nutrients more available and hence grain yield was not decreased due to prolonging the irrigation interval.

Soil moisture determination

In order to trace the effect of irrigation interval on maize yield and its attributes, the soil moisture content was determined before the 3rd to the 6th or 7th irrigation at two soil depths *i.e.* 0-30 and 30-60 cm in the two seasons. Figs. 1 and 2 illustrate the soil moisture content in the check without manuring and in the FYM and compost treated plots for the two irrigation intervals at the two soil depths in the two seasons, respectively. The present study introduces a new terminology regarding the extent of soil moisture availability *i.e.* the Critical Soil Moisture Content (CSMC) below which the growth of plants might suffer from difficult availability of soil moisture. This critical level was defined by several authors as 50% of the available soil moisture content *i.e.* the soil moisture between the field capacity and wilting point (Hansen *et al*., 1979).

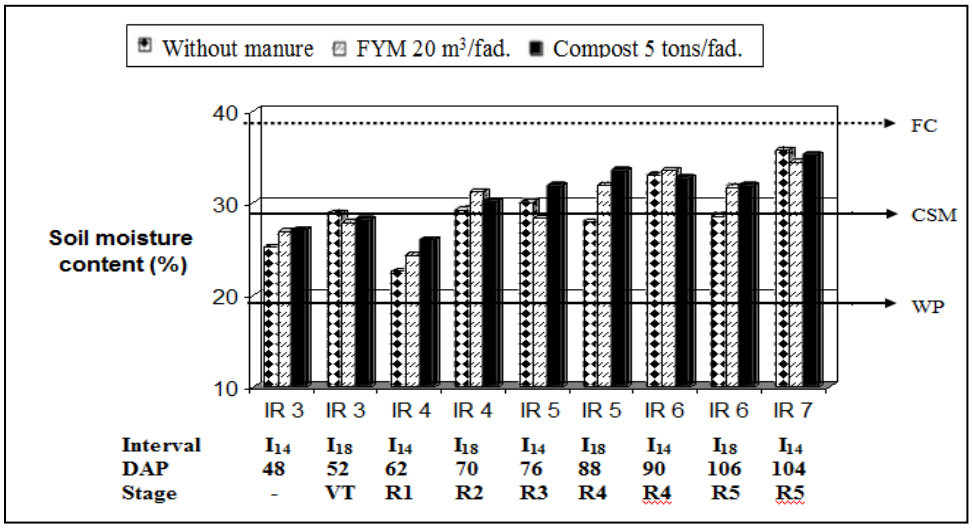
Irrigation interval effect

In the first season, the soil moisture content was below the CSMC before the 3rd and 4th irrigation for the 14 days interval, but however at or even above this level for the 18 days interval. The 3rd irrigation was given at 48 and 52 days whereas the 4th irrigation was given at 62 and 70 days for the 14 and 18 days intervals in respective order. With the advance of the season, the soil moisture content was, always, above the CSMC level before the 5th to 7th irrigation and in most cases surpassed the field capacity particularly at the lower soil depth *i.e.* 30-60 cm.

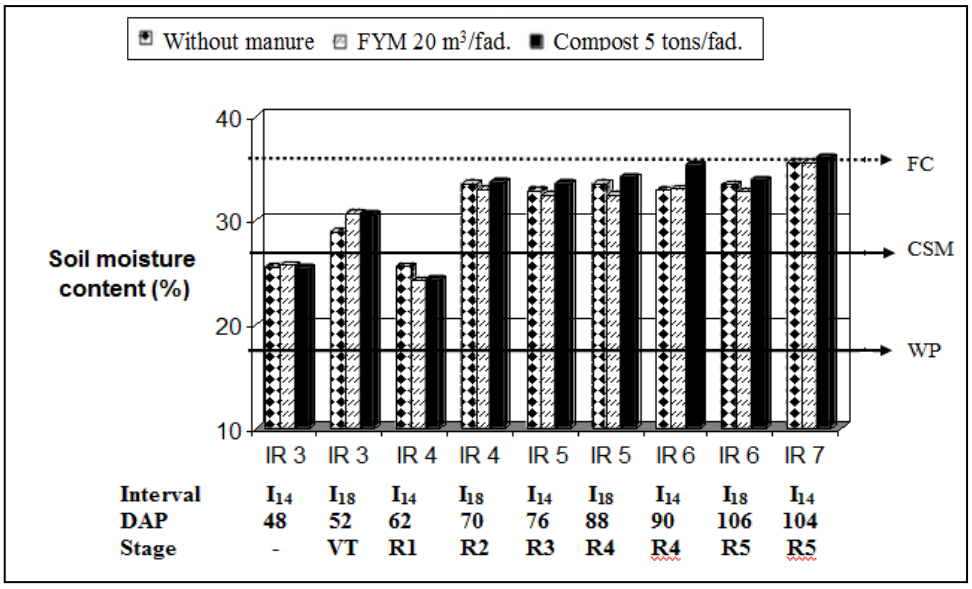
In the second season, the soil moisture content was, always, above the CSMC from the 3rd to the 7th irrigation with few exceptions. Moreover, these contents were always increased from the 3rd to the 7th irrigation with more clear trend in the lower than in the higher soil depth. These contents were at or above the field capacity particularly before the 6th and 7th irrigation. These results clarify the insignificant effect of irrigation interval on maize yield and almost all yield attributes (Tables 2 to 6). Surprisingly, the longer irrigation interval (18 days) had higher soil moisture content than the shorter one (14 days) particularly in the second season and at the lower (30-60 cm) than at the upper soil depth (0-30 cm). These data refer to a possible contribution by the under ground water to the soil moisture content of the two soil depths by capillarity through a wetting effect. This effect was more clear in the second than in the first season due to differences in soil texture which was clay (52.5% clay) and clay loam (26% clay) in the second and first seasons, in respective order. Unfortunately, the depth of water table was not measured and as well no information was available about this depth.

Organic manuring effect

No particular trend could be observed in Figs. 1 and 2 regarding the soil moisture content before the 3rd to 7th irrigation due to organic manuring. This probably could be attributed to the high organic matter content of the experimental sites which surpassed 3% in the second season and hence might have had masked any possible significant effect on availability of soil moisture which surpassed the CSMC in organic and un organic manured plots.

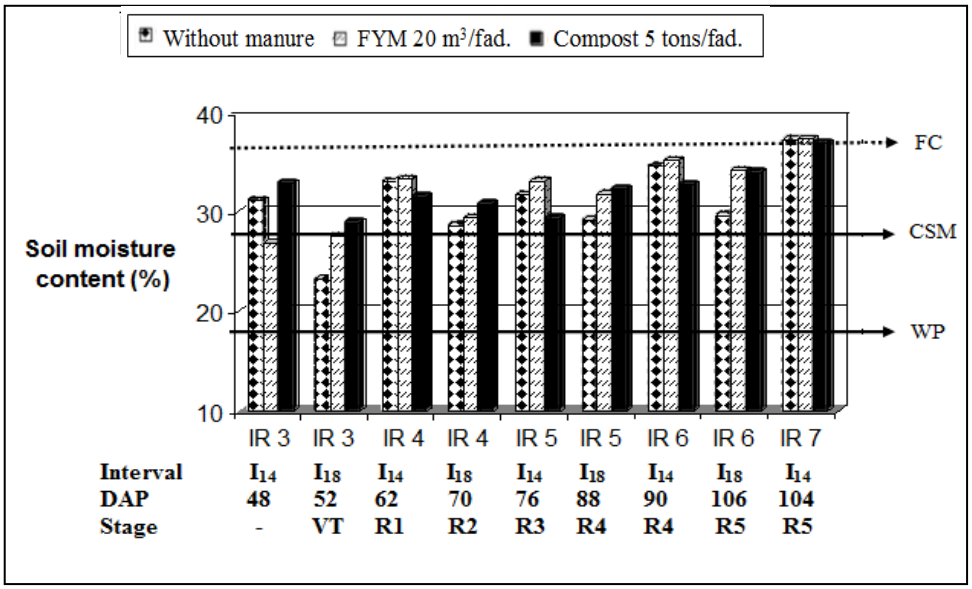


0-30 cm soil depth

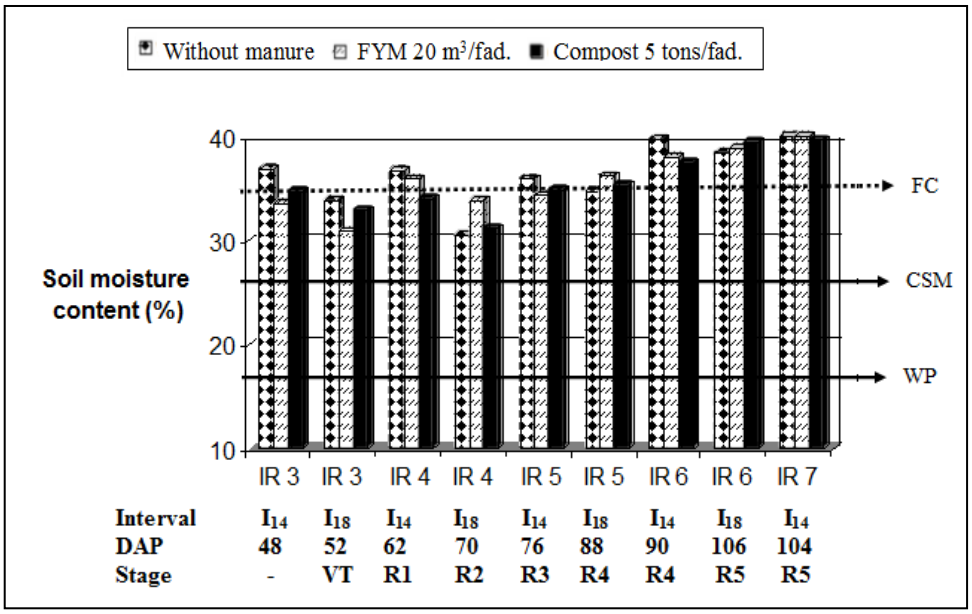


30-60 cm soil depth

Fig. 1. Soil moisture content (%) before the 3rd to 7th irrigation at two soil depths as affected by irrigation interval and organic manuring in the first season



0-30 cm soil depth



30-60 cm soil depth

Fig. 2. Soil moisture content (%) before the 3rd to 7th irrigation at two soil depths as affected by irrigation interval and organic manuring in the second season

These results indicate that, the beneficial effect of organic manuring, particularly with FYM, which was reflected in a significant increase in grain yield/ fad., (Table 6) was probably due to enriching soil fertility from chemical and biological points of view rather than a physical point of view. The results of soil moisture recorded at the two soil depths for the manured and un manured plots did not clear any particular increase in the availability of soil moisture due to organic manuring as illustrated in Figs. 1 and 2. Therefore, the increase of maize grain yield due to organic manuring with FYM could be attributed to a possible increase in the nutrients availability due to direct and indirect effects. Directly, FYM carried a number of plant nutrients which add to the soil fertility particularly from nitrogen (Table 1). Indirectly, FYM through its decomposition evolves CO_2 and heat which are know to increase the availability of plant nutrients (Tisdal and Nelson, 1975) and hence could account for the increase of grain yield/ fad., due to addition of FYM.

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تأثير فترة الري والتسميد العضوي ومستوي التسميد النيتروجيني علي محصول الذرة الشامية ومؤشرات المحصول

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أجريت هذه الدراسة لموسمين (2011 - 2012) بحقل تجريبي بمركز الإبراهيمية محافظة الشرقية، حيث تم دراسة تأثير كل من فترة الري (14 و 18 يوم) والتسميد العضوي (بدون ، 20م3 سماد بلدي/ فدان و 5 طن كمبوست/ فدان) ومستوي التسميد النيتروجيني (20 ، 60 و 120 كجم ن/ فدان) وذلك علي محصول الذرة الشامية ومؤشرات المحصول وتجدر الإشارة إلي أن معاملة فترة الري تمت من الرية الثالثة (48 يوم من الزراعة) حتي الحصاد وذلك لضمان استكمال إضافة السماد النيتروجيني مع الرية الأولي والثانية لجميع المعاملات تحت الدراسة وبذلك نالت فترة الري 14 يوم سبع ريات ومعاملة فترة الري 18 يوما ست ريات، ويمكن تلخيص النتائج المتحصل عليها علي النحو التالي: لم يكن لفترة الري تأثير معنوي علي محصول الذرة الشامية ومؤشرات المحصول ، رغم الزيادة المعنوية في نسبة التفريط ودليل الحصاد خلال التحليل التجميعي للموسمين، حيث حققت فترة الري كل 14 يوم أعلي متوسط مقارنة بفترة الري كل 18 يوم، أدي التسميد العضوي إلي تأثير معنوي علي محصول الذرة الشامية وبعض مؤشرات المحصول. حيث أدي التسميد البلدي بمعدل 20م3 / فدان إلي زيادة كل من محصول الحبوب، الكيزان، القش، والمحصول الكلي/ فدان، طول الكوز، عدد حبوب الكوز، وزن 100 حبة ووزن حبوب الكوز وذلك خلال التحليل التجميعي للموسمين ، أدي زيادة مستوي النيتروجين حتي 120 كجم ن/ فدان إلي زيادة معنوية في محصول الذرة الشامية ومؤشرات المحصول باستثناء نسبة التفريط والتي انخفضت ، بينما استجاب محصول الحطب حتي 60 كجم ن/ فدان ولكن لم تؤدي الزيادة في مستوي النيتروجين إلي تأثير معنوي علي عدد سطور الكوز ومحتوي الحبوب من البروتين ، كان هناك تأثير معنوي لتداخل الفعل بين عوامل الدراسة علي بعض مؤشرات المحصول تحت الدراسة ، ومن ثم كان لذلك تأثير معنوي علي محصول الحبوب والكيزان/ فدان خلال الموسم الثاني والذي أتضح منه أن إطالة فترة الري أدى إلى انخفاض معنوي لمتوسطات هاتان الصفتان عند عدم إضافة أي سماد عضوي وهو ما لم يلاحظ عند إضافة السماد البلدي بما يشير لبعض التأثيرات الايجابية لإضافته على العناصر الغذائية وخصوصا النيتروجين وليس تيسر رطوبة التربة عند توقيت الري علي 18 يوم بدلا من 14 يوم.

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