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Maximize Crop Water Productivity of Garlic by Modified Fertilizer Management under Drip Irrigation

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Abstract: Semiarid regions forced to maximize utilization from available of water unit, which is a significant factor that affecting not only the agricultural productivity but also extended reclamation projects. Field experiment was conducted in two successive seasons in the Production and Research Station of National Research Centre, Nubaria, Behera Governorate, Egypt, to study the effect of surface and subsurface drip irrigation methods on garlic yield under different organic manure source.

Results showed that the highest and lowest values of the soil bulk density and soil hydraulic conductivity were recorded at sub-surface drip irrigation and NPK and ChM and FYM ChM and FYM under surface drip irrigation system relative to NPK treatments and FYM enriched by 50 % NPK. Organic manure used enriched by 50 % NPK or in specific ratio between both lead to increase all the garlic growth characters. FYM enriched by 50% NPK has the best performance to improve garlic yield with exceed consume of NPK fertilizer from side and from the other one reduced soil pollution by mineral fertilizers and the impact of FYM enriched by 50 % under surface drip irrigation by 19 % comparing with NPK treated plot. Surface drip irrigation has a pronounced effect on garlic yield than sub-surfac drip. Garlic yield increased by 18.7 % above sub-surface one. Garlic yield was positively correlated (5% level) with bulb diameter and clove length. Surface drip irrigation has superior effect on the garlic water crop productivity and the increase was highly after of FYM application enriched by 50 % NPK fertilizer than others.

Obtained results data mentioned that the vital role of continuous application of the organic manure in maximizing not only the garlic yield and the other studied growth characters that help in maximizing yield but also improve studied soil hydrophysical properties under investigated irrigation methods.

Keywords: Drip irrigation, organic manure, hydrophysical properties, water crop productivity; garlic.

Introduction

Egypt is located in dry and semi–dry climate. The most important limiting factor in agriculture sector and economic developments, where water crisis raise recently. However, water is an important factor in reducing yield. Modern irrigation system is a must to increase water use efficiency. The drip irrigation decreases the use of water and has more efficiency rather than surface irrigation and even sprinkler methods[1].

Garlic (*Allium sativum* L.), with 12 million ton production per each year in world is the one of the important onion, that is used as vegetable, Spices and drug. Garlic is sensitive to water limitation and drought stress, and maximization yield of garlic bulb depends mainly on well-managed irrigation[2]. Use of drip irrigation method is more suitable under cultivation under arid region for prevent of drought stress in garlic yield. Weed

is a major problem in garlic production. Weed competes with crops for light, soil, nutrient and moisture. [3]reported that garlic is sensitive to weed that caused decreasing in bulb yield and use of drip irrigation practice can reduce this requirement. [4]stated that the golbal use of N and P fertilizers increased 7 and 3-5 fold, respectively between 1960 and 1995. They added that both N and P are expected to increase another 3 times by 2050 unless there sis a substanial increase in fertilizer use effeicency. the facts mentioned before necessitate researchs in field of both water and fertilizer use eficiency (FUE). [5]contended that yield improvement was generally accompained with increase in both total water applied and FUE. But when yield increase was greater than the increase in ET, water use efficiency (WUE) improvement would be acheieved . [6]found that using slow release fertilizers in reclaimed sandy soil under modern irrigation methodss increased WUE via increasing crop yield/unit of applied water. [7]conducted a field experiment to study the effect of both irrigation methods and irrigation schedule on yield and WUE of maize crop (single cross 310).

The main objective of this research was study the effect of surface and subsurface drip irrigation methods under different organic manure source on garlic.

Materials and Methods

This Study was carried out during winter of 2013-2014seasons in the Production and Research Station of National Research Centre, Nubaria, Behera Governorate, Egypt. Main factors consisted of sub-surface and surface drip irrigation. Sub-factor was recommended NPK (100%), chicken manure + 50% NPK, farm yard manure +50% NPK and 50 % of both chicken manure + farm yard manure. Drip irrigation was installed in experimental area with lateral length 40 m, 0.3 m distance between drippers (4 liter/h), 0.9 m among laterals, each treatments has 6 lines and two meter among treatments. Subsurface laterals were buried till 20 cm.

Cloves of garlic(120 kg/fed) with same size and weight were cultivated in density were planted in both lateral 8 cm among in two direction, 4 rows each side at mid of September in both seasons (2013 and 2014).irrigation process was carried out twice a week according to the obtained evapotranspiration (ET) of the farm meteo station by 85 % from ET and total water consumed during growing season was 3175 m^3/season

Super phosphate (15 % P_2O_5) and ammonium nitrate (33.3 % N) and elemental sulfur were applied during soil preparation at rates 200, 50 and 150 kg per feddan following the experimental treatments. Well decomposed farm yard manure (FYM) and chicken manure (ChM) were added to the treatments before planting and well mixed as mentioned above at 15 and 5 ton/fed, respectively.

Control of weed was done by manual method, for 3 times. In the end of cultivation season, 2middle-line was chosen from each plot and garlics bulbs were taking as examined samples. The bulb yield of garlic was recorded in each plot and then converted to kg/fed. Also twenty bulbs were taken accidently from treatment and average of number, weight, length and diameter for cloves in bulbs were calculated.

Some soil characteristics were determined as follows: soil particle size distribution by pipette method [8], $CaCO_3$ content by Scheibler-calcimeter[9]. Chemical characteristics were determined[10]. The experimental soil were sandy loam with pH (8.15), electrical conductivity (3.42 dS^{-1}) in soil paste extract, $CaCO_3$ (1.24 %) and organic matter (0.85 %).

HC was measured in the laboratory under a constant head technique [11]using the following formula:

$$HC = (QL)/(At.\Delta H)$$

Where: HC = water quantity flowing through saturated soil sample/area / unit time, Q = volume of water flowing through saturated soil sample per unite time (L^3/T), A = cross sectional flow area (L^2) L = length of the soil sample (L) and ΔH = differences in hydraulic head across the sample (L) and t = time (hr).

Soil water retention at 0.1 (FC) and 15.0 (WP) bars were estimated [12]. According soil available water was calculated by subtracting FC –WP and the values were 16.5, 5.7 and 10.8 % on weight base, respectively.

Data recorded were analyzed using statistical software[13].The purpose of analysis of variance was to determine the significant effect for treatments. Duncan test was applied when analysis of variance showed significant different for treatment[14].

Results and Discussion

Growth characters:

Analysis of the variance of the investigated factors, irrigation methods; NPK and organic manure fertilizers, Table (1) showed significant difference at 5% level between both examined factors. Data on hand revealed that organic manure used (ChM and FYM) enriched by 50 % NPK or alone in case of the specific ratio between them lead to increase the growth characters such as bulb diameter (mm) , cloves length (mm), no. of cloves per bulb and plant height (cm). The increase percentage were 7, 32, 29; 15, 38, 46; 3, 24, 49; 5, 11, 9 %, respectively after ChM and FYM and mixture of them as compared with recommended NPK under sub-surface drip irrigation. In case of surface drip irrigation the values were 6, 29, 27; 9, 28, 29; 19, 35, 26; 8, 12, 9 % in same sequences. In same view the rate of increase regardless the irrigation methods were 6, 30, 28; 12, 33, 38 and 7, 12, 9 %f or fertilizers treatments ChM and FYM and their mixture as compared with NPK treatment.

Table (1) Effect of drip irrigation methods and organic manure types enriched by 50% of recommended NPK on some growth and yield of garlic plant. (Mean of the two years)

		Diameter (mm)	**Clove length (mm)**	**Number of cloves per bulb**	**Yield ton /f**	**Plant Height (cm)**	**Fresh weight (g/plant)**	**Dry weight (g/plant)**	**Fresh/Dry**
Sub-surface	NPK (100%)	44).1	30.2	12.0	4.568	41.5	78.2	30.1	2.60
	ChM+50 %NPK	47.0	34.7	12.3	5.145	43.5	85.4	32.9	2.59
	FYM+50%NPK	58.0	41.7	14.8	5.724	46.2	86.4	56.4	1.53
	ChM +FYM	56.8	44.2	17.8	4.985	45.1	88.6	60.7	1.46
	Mean	**51.5**	**37.7**	**14.3**	**5.106**	**44.1**	**84.7**	**45.0**	**2.05**
Surface	NPK (100%)	45.3	31.1	12.0	4.782	41.8	82.4	30.9	2.67
	ChM+50 %NPK	48.2	34.0	14.3	6.365	45.3	87.8	33.3	2.63
	FYM+50%NPK	58.3	39.8	16.2	7.236	46.8	93.5	47.9	1.95
	ChM +FYM	57.6	40.1	15.1	5.864	45.7	94.1	45.6	2.06
	Mean	**52.3**	**36.3**	**14.4**	**6.062**	**44.9**	**89.5**	**39.4**	**2.33**
LSD 5%	Irrigation method	0.3	0.3	0.1	0.04	0.3	0.7	1.5	
	Fertilizers	0.6	0.4	0.2	0.08	0.5	1.2	2.1	
	Interaction	0.4	0.2	0.1	0.05	0.4	0.9	1.7	

Regarding to the effect of main factor, irrigation methods, and data showed that surface drip irrigation has a recognized impact than slightly increase in the studied garlic growth characters and the rate of change were 2, -4, 1 and 2 % for the previous characters in same sequences.

In other word, using surface drip irrigation decreased use of water facilitates in irrigation and maximizes all estimated garlic growth characters. In surface drip irrigation treatments, garlic use most stored water in root zone than happened in case of sub-surface drip irrigation. So, it increased the availability of macro essential nutrients such as N, P and K near garlic root zone and it might have increased the translocation of photosynthesis to storage organ resulting increased weight and no. of cloves in bulb. This finding agreed with those obtained by[15,16] who reported that highly significant garlic bulb yield under drip irrigation methods.

Regarding to the fresh and dry weight of garlic bulb and the ratio of fresh/ dry weight as affected by irrigation methods and fertilizer treatments, table (1) and figure (1) showed that the highest and lowest values were recorded at FYM enriched by 50% NPK and recommended NPK treatment under both studied irrigation methods, while the fresh /dry weight ratio was highly under recommended NPK followed by ChM enriched by % NPK. But the ratio under surface drip irrigation, ChM and FYM was much closed to the recommended NPK plot.

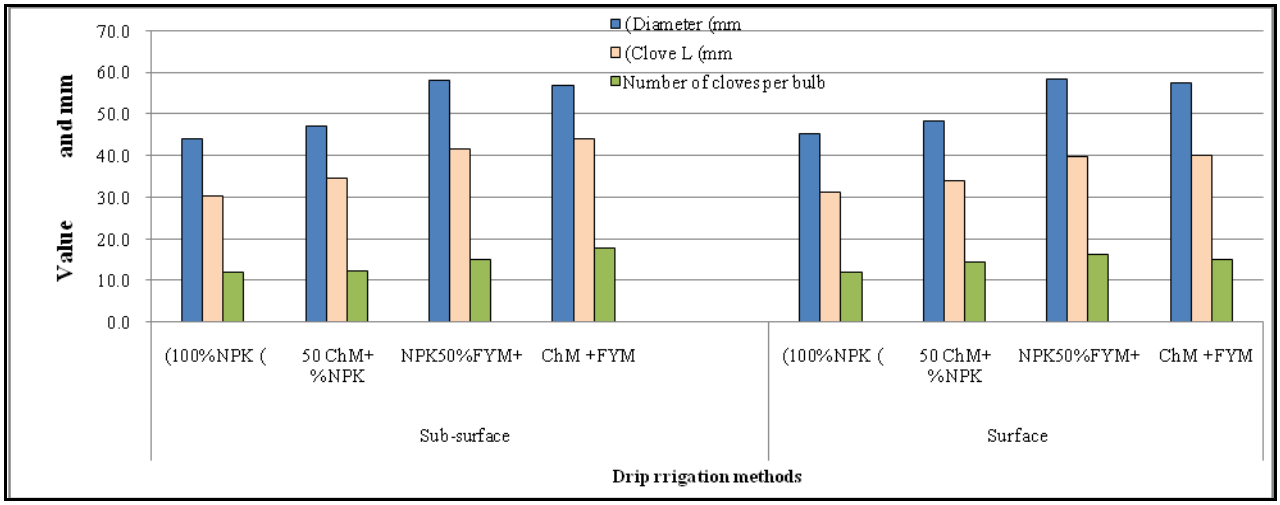

Fig. (1) Effect of drip irrigation system, NPK and organic manure on some garlic growth characters.

Yield :

The dry weight of the bulb yield of garlic increased with increasing applied organic manure (ChM and FYM) relative to the control treatment (recommended NPK) and the values ranged between 4.658 and 5.724 ton fed -1 for recommended NPK and FYM + 50 % NPK and sub-surface drip irrigation, while it ranged from 4.782 to 7.236 ton fed-1 in same sequence under surface drip irrigation. Also, data showed that application of the organic manure enriched by 50% NPK led to increase garlic yield by about 13, 25; 9 and 33, 51, 28 % under sub and surface drip irrigation method for ChM, FYM and mixture organic manure as compared with recommended NPK, respectively. So, FYM enriched by 50 % NPK has the best performance to improve garlic yield with exceed consume of NPK fertilizer from side and from the other one reduced soil pollution by mineral fertilizers and the impact of FYM enriched by 50 % under surface drip irrigation by about 19% as compared with NPK treated plot.

Regarding to the effect of irrigation methods on the garlic yield, data pointed out surface drip irrigation has a pronounced effect on garlic yield than sub-surface drip irrigation, where the yield values were 5.106 and 6.062 ton fed^{-1}, respectively. And surface drip irrigation increased yield of garlic by about 18.7 % above sub-surface drip irrigation. Regardless irrigation methods effect, increasing organic manure enriched or not by NPK improved garlic yield and the rate of increase was 23, 39 and 16 % for ChM and FYM enriched by 50 % NPK and their mixture in specific ratio as compared with recommended NPK. Simple correlation was carried out between garlic yield and other studied growth characters, it can be concluded that garlic yield was positively correlated with bulb diameter and clove length with r values 0.569* and 0.477*, respectively. These results supported by[17,18]. They conclude that the use of surface drip irrigation method has an important role in dry region especially when organic manure added continuously and it can improved yield and water use efficiency in drought condition. Also, [16,19] in experiment compared between different irrigation methods and their effect on different garlic stressed on surface drip irrigation caused increase in number and weight of cloves in bulb rather than sprinkler irrigation and surface water irrigation.

Water crop productivity:

Same trend was achieved for water crop productivity (WCP). Fig. (2) illustrated the influence of both investigated factors and their interactions on the WCP for garlic. Values of the WCP were highly at the surface drip than subsurface drip irrigation, which ranged from 1.606 to 2.012 kg/m^3 irrigation water and 1.681 to 2.543 kg/m^3, respectively. Surface drip irrigation has a promotive effect on the garlic WCP with increasing percentage by 19 %. Also, one can notice that the rate of increase was highly in case of FYM application enriched by 50 % NPK fertilizer. Under both used irrigation methods with values 25.3 and 51.3 % for sub- and surface drip irrigation methods. While the rate of increase were 12.6, 33.1 % and 9.1 , 28.0 % for mixture of the used manure.

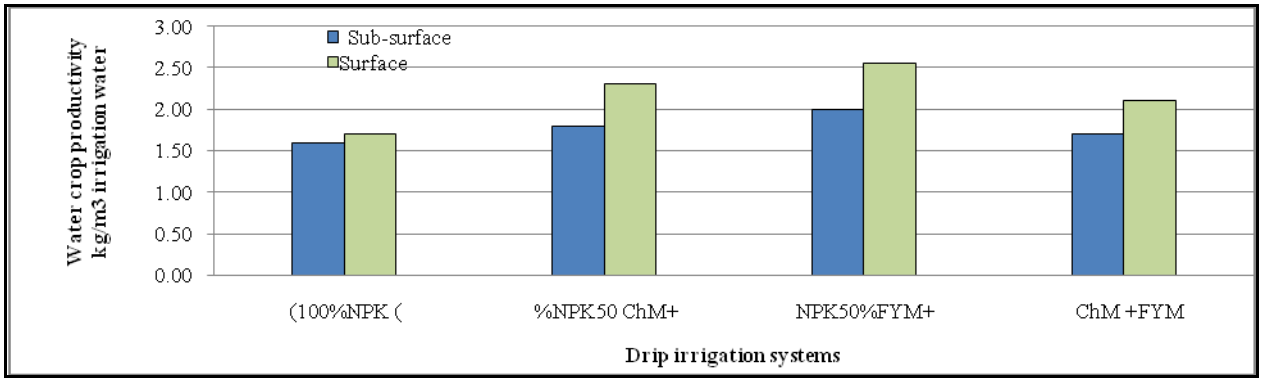

Fig. (2) Effect of sub-surface drip and surface drip irrigation on the water crop productivity of garlic yield.

Regression analysis was carried out to study the impact of irrigation methods sub or surface drip on the water crop productivity of garlic; the obtained equations were polynomial type and they significant at 1 % level. However, the equation 2 is more significant the first one that represent the importance of the surface drip irrigation on maximize yield especially after FYM enriched by 50 % NPK recommended.

$Y_{Sub\text{-}surface} = -0.12\ x^2 + 0.64\ x + 1.06$ $R^2 = 0.8733^{**}$ ……. (1)

$Y_{Surface\ drip} = -0.26\ x^2 + 1.96\ x - 1.23$ $R^2 = 0.9628^{**}$ ……. (2)

Bulk density and hydraulic conductivity:

With respect to the some soil physical properties, data on hand revealed that the maximum and minimum values of the soil bulk density (BD) and soil hydraulic conductivity (HC) recorded at sub-surface drip irrigation and NPK (1.573 g cm^{-3} and 14.4 cm h^{-1}) and ChM and FYM ChM and FYM (1.556 cm^{-3} and 11.2 cm h^{-1}) under surface drip irrigation system relative to NPK treatments and FYM enriched by 50 % NPK with values 1.573cm^{-3} and 14.4 cm h^{-1} and 1.561 cm^{-3} and 12.2 cm h^{-1}, respectively (Fig. 3 and 4).

Fig. (3) Effect of sub-surface drip and surface drip irrigation on bulk density after garlic crop.

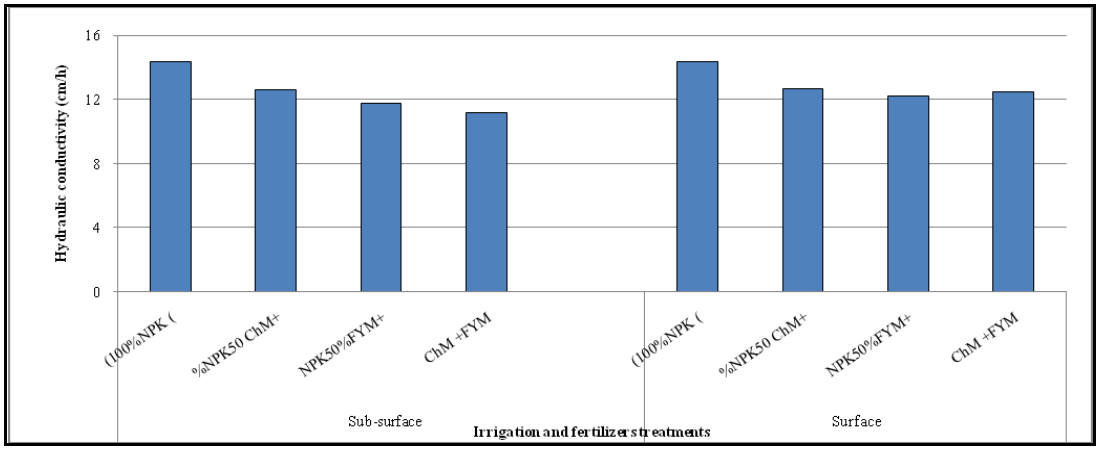

Fig. (4) Effect of sub-surface drip and surface drip irrigation on hydraulic conductivity after garlic crop.

Regardless the impact of irrigation methods on the soil BD and HC, the highest values of these soil properties were attained in recommended NPK treatment under both irrigation methods used (1.573, 14.4; 1.561 and 11.9, respectively. Also, data notice that HC was significantly correlated with plant height (-0.584**), bulb fresh (-0.651*) and dry weight (-0.764**), while the values with BD were -0.783**, -0.867**, -0.921**, -0.618*, -0.514*; -0.702** for bulb diameter, cloves length, no. cloves per bulb, plant height and bulb fresh weight and dry weight, respectively.

These finding agreed with those obtained by[20]. They reported that both fine particles such as clay and/or silt and organic matter content play an important role in improving soil water movement through soil profile and other hydrophysical characteristics.

From the above mentioned results data mentioned that the vital role of continuous application of the organic manure in maximizing not only the garlic yield but also soil hydrophysical properties such as BD, HC, soil water characteristics (water holding capacity) under investigated irrigation methods. [21]stated that drip irrigation is more suitable for coarse textured soil due to application low amount of water in specific time and also for shallow roots crop. [22]mentioned that in surface drip irrigation water flows from surface towards down of the soil profile, there for evaporation is happened for water or absorbed by plants and in fact a low amount of water lost, lower yield in sub-surface drip irrigation method could be attributed to in efficient use of irrigation water, weak of capillary rise of water whenever, garlic roots were very close to soil surface regarding to its characteristics and uneven distribution of irrigation water but the opposite was true in surface drip one where the increased yield was due to available soil moisture, uniform distribution of water during growth period. [23]reported that after estimatation of simple correlation coefficients between WUE and fertilizer use effciency of N, P and K, they found that ioncreasing WUE was associated with increasing fertilizer use effciency.

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