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Interlaced Influence of Various Water Quantities and Mite Densities on Broccoli (Brassica Oleracea.) Production

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Abstract
This study was carried out at Faculty of Agricultural- Suez Canal University which located in north eastern Egypt, within the Governorate of Ismailia. The experiment was conducted to assess the influence of different amounts of water and mite densities (phytophagous & predaceous) on Broccoli production. Thus; the factor of water amounts comprise into three treatments (Q_1, Q_2 and control) with average (977.63, 1955.28 and 2371.5 m^3/fed.) respectively during period December 2014 to April 2015. The results revealed that The water quantities have a significant influence on Phytophagous and Predacieous mites where the highest mean value for mites density was observed with (Q2) by (10.5N/in^2) and (8.16 N/in^2) for Phytophagous and Predacieous mites respectively. On the other hand; the density of Phytophagous mite by (1 n/in^2) need approximately 167.12, 134.18 and 154.82 heat units under treatment Q1, Q2 and C respectively. However; Predacieous mite density (1n/in^2) needs for 269.38 heat units under Q1 and 172.23 heat units under both Q2 and C treatments. Furthermore; the value of yield under treatment Q2 was the highest value (9.017 ton / fed) comparing with others treatment's values (7.91 & 5.04 ton/fed) for (Q1 and Control respectively). However; with treatment Q1 recorded a highest Irrigation water use efficiency (IWUE) by (7.96 Kg/m^3) after obtaining Heat use efficiency (HUE) 5.5 heat unit. Thus; from previous data analysis that best treatment is Q1 (low amount of water) which gain a good value both (IWUE) and (HUE).
Keywords: water quantities; mite densities; Irrigation water use efficiency and broccoli production.

INTRODUCTION

Numerous of countries have suffering from climate change and global warming which affect on water, crops and pests in different countries. Consequently, the main challenge confronting water management in agriculture is to improve water use efficiency and its sustainability. This can be achieved through (i) an increase in crop water productivity (an increased in marketable crop yield per unit of water transpired) through irrigation, (ii) a decrease in water losses through soil evaporation that could otherwise be used by plants for their growth, and (iii) an increase in soil water storage within the plant rooting zone through better soil and water management practices at farm. Furthermore; increased temperature due to climate change could impact crop pest populations in several complex ways. Although decreased temperature may tend to depress insect populations, most researchers seem to agree that warmer temperatures in temperate climates will result in increased number of species and higher populations of insects. Basis of the foregoing; climate change affects insect, mites, nematodes, other invertebrates, vertebrates and also microbial pests and the damage they cause is directly influenced by their reproduction, development, survival, spread, or altering host defenses and susceptibility. Thus, the relation between factors of agricultural system specially (water and pests and environments elements) should be controlled to get a positive upshot.

One of the important factors at Agricultural system that influence on plants development is water management (irrigation system – amount of water). Amount of water is very critical to make the most efficient use of irrigation system especially for drip irrigation system, as excessive irrigation reduces yield, while inadequate irrigation causes water stress and reduces production. The optimum use of irrigation can be characterized as the rooting area, and at the same time, avoiding the leaching of nutrients into deeper soil layers (Kruger et al., 1999).moreover; (Oloumi et al., 1988) found that water stress can reduce the density of mites and especially the density of females and eggs. (Ferree and Hall ,1980) showed that low soil moisture did not affect the intensity of mite reproduction. However; there have been different hypotheses about the effects of water stress on mite development and reproduction. According to some authors, such stress leads to an increase in plant damage and mite numbers, as well as their nutritional activity (Youngman & Barnes, 1986; DeAngelis et al., 1983).

Otherwise; higher mite densities on leaves is cause stomata to remain open for longer periods which allows a greater loss of water. Spider mite densities of 10 and 50 mites per leaf cause a reduction in flower stem length of 17 and 26%, respectively (Landeros et al.,2004). For instance; Phytophagous mites, especially spider mites, are a major agricultural pest of orchards, greenhouses and many vegetable and fruit crops, including peppers, tomatoes, potatoes, squash, eggplant, cucumber, broccoli and strawberries. Mites damage leaf and/or fruit surfaces using their sharp mouthparts. Besides direct damage to plant parts (referred to as stippling), mite feeding also causes increased susceptibility to plant and crop diseases (Bayer , 2014).

On the other hand; the important winter vegetable crops is Broccoli which is one of mostly produced at outdoor (Uni.oF California 2015) Broccoli is planted from early September through early of December for harvest from early December through mid-march. Moreover; its seed will germinate and grow from (4° to 35° C) but optimum growth is obtained when monthly air temperatures average from (16° to 18° C). Thus; water deficit at flowering period will cause decreases in yield. Furthermore; (AYAS et al., 2011) Broccoli exhibits a tolerance against water deficit at early or late vegetative period. Deficit irrigation can be applied during these growing periods and production can be carried out over larger areas with the same amount o water and without causing significant losses in yield and quality.

Clearly, there is some tantalizing potential for using low amount of water for upcoming a highest value for product and water unit because the interlaced influence between water and some mites on some crops. Thus; The aim of this study is to monitoring the influence of two water quantities with average (100, and 50%) from total water applied for broccoli using drip irrigation system comparing with the traditional irrigation technique which is use at the region (furrow irrigation) Ismailia governorate on broccoli production and on mites densities (Phytophagous mites and Predacieous mites) during the stages of growth.

MATERIAL AND METHOD

The experimental was carried out at farm faculty of agricultural – Suez Canal university – Ismailia governorate The study site, established in late May of (2014-2015), (30° 37' 10.91"N - 32° 16'1.33"E).

The site of experiment falls into an arid area with a Mediterranean climate. The site is about 30 m above sea level with an annual rainfall of 29 mm/year, temperatures of 21.6 °C, relative humidity of 53.9%, and wind speed of 2.5 m/s. The total annual evapotranspiration (ETo) is 1821 mm/year(table 1).

Table 1: Climatic characteristics at Ismailia governorate.

Month	Prc.	Wet days	Tem. max	Tem min.	Hum.	Sun shine	Wind (2m)	ETo
	mm/m		°C	°C	%	%	m/s	mm/d
Jan	5	4.5	19.1	13.7	58.9	68.1	2.2	2.4
Feb	5	3.5	20.7	14.9	56.1	70.1	2.6	3.2
Mar	5	2.5	23	11	52.1	71.7	2.8	4.2
Apr	2	1.1	28.1	14.6	46	74.1	2.8	5.7
may	2	0.6	31.5	17	45.1	78.8	2.8	6.8
Jun	0	0	34.4	20.1	48.4	87.3	2.8	7.5
Jul	0	0	35.2	21.8	51.9	85.3	2.5	7.3
Aug	0	0	34.9	22	54.6	86.5	2.4	6.8
Sep	0	0	32.8	20.4	56.4	81.9	2.4	5.7
Oct	1	1	29.7	17.5	57.2	82.9	2.4	4.6
Nov	5	2	25.1	13.5	59.5	76.7	2	3.1
Dec	4	3.4	20.6	9.7	61	65.5	2	2.3

(*Prc.* = Precipitation; *Wet days* = Number of days per month with >0.1mm of precipitation; *Tmp. min*/*max* = minimum/maximum temperature; *hum.* = relative humidity; *Sun shine* = Sun shine as percentage of day length; *Wind*(*2m*) = wind speed at 2m; *ETo* = Reference evapotranspiration) (FAO AQUASTAT 2015).

Analyses of soil and some physical and chemical characteristics were carried out according to (Klute, 1986). These analyses are presented in tables [(2)and (3)]. The soil of the experimental site is sandy texture, none saline, and none calcareous. Silt and clay content are quite low there for field capacity is 6.75%

Used a trickle irrigation system [trickle (*using GR 4L/50cm/h – 1.2bar*). two amounts of water (Q1and Q2) (50% and 100%) respectively from total water applied for broccoli plus the traditional methods as a control which irrigated by furrow irrigation technique. Moreover; the seed planted on 2nd December 2014 with distance (1m x 0.5 m.

Table 2. Some chemical characteristic for the experimental site.

Depth (cm)	PH	Ec dS/m	Soluble cations meq/l				soluble anions meq/l			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
0-20	5.63	0.21	1.1	0.15	0.67	0.18	0	0.6	0.61	0.89
20-40	5.76	0.18	1.03	0.11	0.46	0.195	0	0.533	0.352	0.913

Table 3. Particle size distribution for the experimental site.

Depth, cm	Particle size distribution % (mm)				Textural class
	C.Sand	F.Sand	Silt	Clay	
0-20	8.21	87.24	3.35	1.2	S*
20-40	10.68	85.12	3.2	1.00	S*

S* = sand

Water samples were analyzed by standard analytical methods for pH, electrical conductivity and ion composition **(APHA 1992).** Average values of the analyzed parameters in irrigation water are given in [table (4)]

Table 4. Some chemical characteristic for the different irrigation water type.

Ph	EC (dS/m)	Soluble Cations (meq/L)				Soluble Anions(meq/L)				SAR
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO^{-2}_{3}	HCO^{-3}	CL^{-1}	SO^{-2}_{4}	
7.34	1.18	2.8	0.6	8.2	0.2	0	2.92	6.83	2.05	6.36

The total water applied calculated related to the FAO “Irrigation and Drainage Paper #56: Crop Evapo-transpiration: Guidelines for Computing Crop Water Requirements.” Further; Crop water requirement and total water applied. Using an average Reference Evapotranspiration (ETo) and the Crop coefficients (Kc) [table (5).] by the following equations.

$$ETc = ETo * KC \quad (1)$$

Where;
Etc Crop Evapotranspiration, (mm/day).
ETo Reference Evapotranspiration, (mm/day).
Kc Crop coefficients.

$$IRn = ETc – Peff \quad (2)$$

where;
IRn Net irrigation requirement, (mm/day).
Etc Crop evapotranspiration,(mm/day).
Peff Effective rainfall, (mm/day).

$$IRt= IRn/Ea \quad (3)$$

where;
IRt total water applied (mm/day).
IRn Net irrigation requirement, (mm/day).
Ea Overall irrigation efficiency for modern irrigation system (drip. Approximately (95%). And for surface irrigation is ((65 – 75%) (Phocaides, 2000).

Table 5. The average crop coefficients (Kc) for Broccoli

Item	Init.	Dev.	Mid.	Late.	Total.
Days	35	45	40	8	127
KC	0.7	1.05	1.05	0.95	

The total water applied is (232.77, 465.54 and 564.64mm) for (Q1, Q2 and control) respectively.

Measurements and calculations

Sample technique

The study of population of phytophagous & predaceous mites was conducted on Broccoli growing at Faculty of Agriculture Farm, Suez Canal University in Ismailia Governorate in 2015. Monthly leaf samples (contain thirty leaves) was taken from each treatment. The leave samples were directly examined by stereo–microscope; the debris samples extracted by using modified Tullgren funnal. All mite individuals were mounted in Hoyer’s medium. The identification of mites was based on illustrated scientific keys. Mites preliminarily identified as *Tetranychus urticae* Koch, ***T.*** *cucurbitacearum* (Sayed) both Tetranychidae & phytoseiidae, were counted, and approximately 50 specimens of each of these were taken at randomand mounted in Hoyer’s medium for later confirmation of the identification, as well as all phytoseiid mites, were mounted in Hoyer’s medium for identification and counting(fig.1). The predaceous mites in this study *Phytoseiulus persimilis* Athias-Henriot**,** *Euseius scutalis* (Athias-Henriot)**,** *Neoseiulus enab* El–Badry**,** *Typhlodromus athiasae* Porath

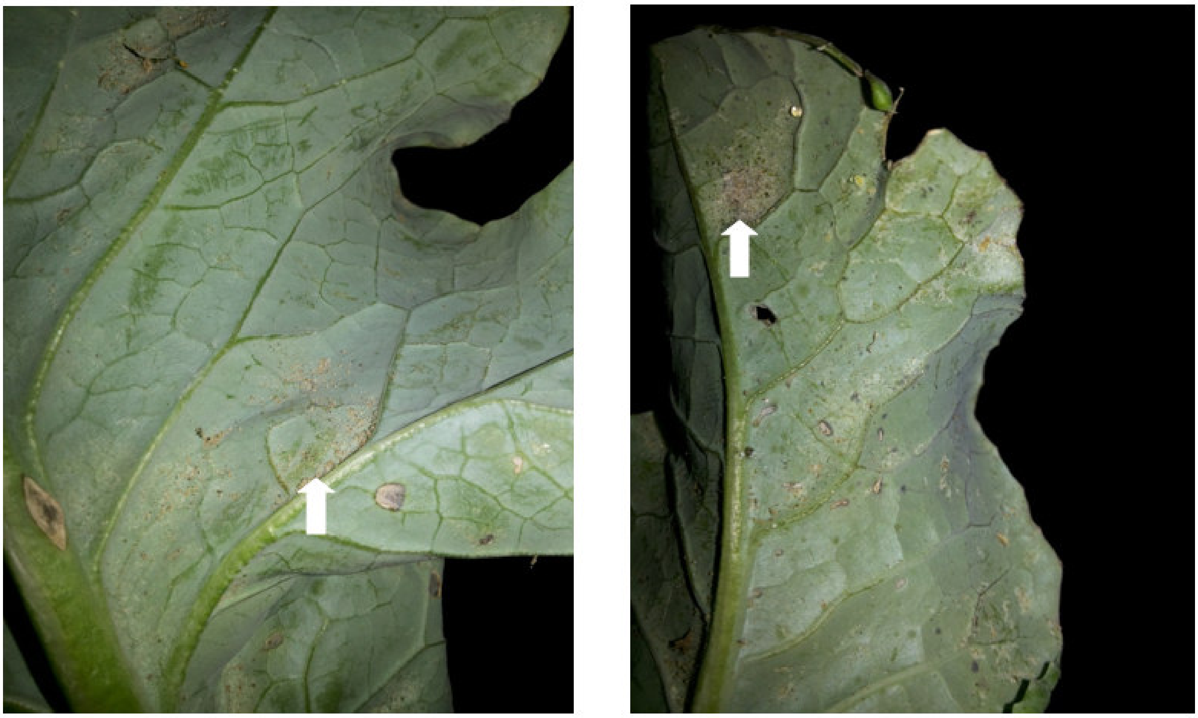

Fig.(1) Population of Phytophagous & Predaceous mites was conducted on Broccoli.

Irrigation water use efficiency (IWUE)

Irrigation water use efficiency using the **Bos, M.G. (1979)** equation (4).

$$IWUE = [Y_{gi} - Y_{gd}] / IRR_i \quad (4)$$

Where:

- IWUE = Irrigation water use efficiency (kg / m^3).
- Y_{gi} = The economic yield (kg/fed).
- Y_{gd} = The dry yield (kg/fed). (Actually, the crop yield without Irrigation).
- IRR_i = The irrigation water applied (m^3 / fed)

* Often, in most semiarid to arid locations, Y_{gd} may be zero

Growing degree-days (heat units) (GDD)

Growing degree days (GDD) or heat units was calculated using the single sine curve method (Baskerville & Emin, 1969) during growing season of wheat crop. This simple linear method requires only daily minimum and maximum air temperatures, which recorded by the local meteorological weather station in site of experiment, equation (5) give explanation for calculating growing degree days:

$$GDD = [(T_{max} + T_{min}) / 2] - T_{base} \quad (5)$$

Where:

- T_{max} = Daily maximum temperature (C°)
- T_{min} = Daily minimum temperature (C°), and
- T_{base} = Base temperature (C°).

Heat use efficiency (HUE) is the ration of yield to accumulated growing degree days according to Kingra & Prabhjyot-Kaur, 2012 equation (6).

$$HUE = Yield(Ygi) / (AGDD). \quad (6)$$

Where:

- HUE = Heat use efficiency (kg fed^{-1} $C°^{-1}$ day^{-1})
- Y_{gi} = The economic yield (kg/fed).
- GDD = Accumulated growing degree days (C° day).

Heat units are often used to predict the rate of phonological development of plant species. Developmental rates increase approximately linearly as a function of air temperature (Snyder et al., 1999), therefore the higher or lower temperature will be affected on crop by reducing the plant growth and total yield. So; the lower temperature (Tbase), was set as 4.4C° (Robert, 1997).

Statistical analysis:
The data were analyzed using the one way ANOVA as randomized complete blocks with Duncan's HSD test at $p<0.05$ using the COSTAT 3.03 System software.

The simple models with predictor variables $X_1; \ldots ; X_p$ can be describe by equation (7).

$$y = B_0 + B_1 X_1 + \ldots\ldots\ldots\ldots + B_p X_p + k \qquad (7)$$

Where:
Variable y, called a response or dependent variable, depends on another variables $X_{(1..p)}$ which is called the independent or predictor variable (also called the regressor variable), B_0 is intercept, $B_{1\text{-}P}$ is the slope parameters and the variability of the error (k) is constant for all values of the repressor

RESULT AND DISCUSSION

Amounts of water and mites:-

It was observed that the amounts of water have a significant influence on mite density especially for both Phytophagous and Predacieous mites as shown in fig.(2). Furthermore; data indicated that there is not any significant influence for water amounts on both mites density on Feb after 63 days from planted crop. however; on March the amounts of water has a significant influence on Predacieous mite density comparing with Phytophagous mite; where the high amount of water (Q2 and C) recorded (7.21 N/in^2) for Predacieous mite which is a highest mean density comparing with low amount of water Q1 which acquired (2.66 N/in^2).On the other hand; at April the water quantities have a significant influence on both mites where the highest mean value for mites density was observed with (Q2) by (10.5N/in^2) and (8.16 N/in^2) for Phytophagous and Predacieous mites respectively. Nevertheless; the low amount of water (Q1) obtained (8.41 N/in^2) for Phytophagous mite and (5.21 N/in^2) for Predacieous mite; this appropriate with (Oloumi et al., 1988) which indicated that water stress lead to reduce the density of mites and especially to affect the density of females and eggs.

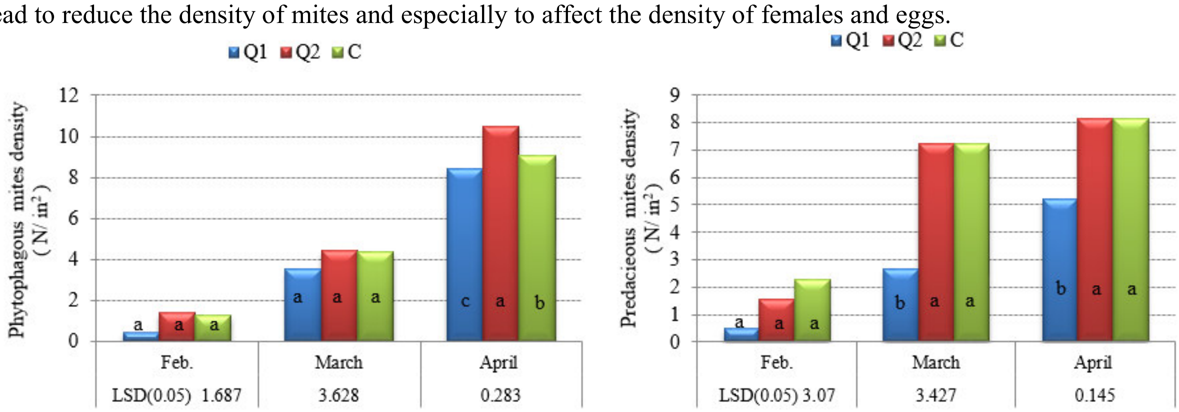

Fig.(2) Effect of water quantities on Population of Phytophagous & Predaceous mites during growth.

Accumulated growing degree days (AGDD) and mites

Table (6) illustrate the mean 10 day monthly, real and adjusted temperature, growing degree days (GDD) and accumulated growing degree days (AGDD) during Broccoli growing season; Generally, the total amount of heat units required for Broccoli to develop from one point to another in its life cycle was 1408.9 C °/ season.

Table 6. Mean 10day monthly, temperature, growing degree days (GDD) and accumulated growing degree days (AGDD) during broccoli growing season.

Month	Day	T_{max}	T_{min}	GDD	AGDD
(2014-2015)	D	C°	C°	(C°)	(C° day)
Dec.	2-11	20	14.3	127.5	127.5
	12-21	18.8	13.8	119	246.5
	22-31	18	12.6	109	355.5
Jan	1-10	18	12	106	461.5
	11-20	17	12	101	562.5
	21-31	17	11	96	658.5
Feb.	1-10	17	11	96	754.5
	11-20	17	11	96	850.5
	20-28	18	12	84.8	935.3
Mar	1-10	18	13	111	1046.3
	11-20	19	14.2	122	1168.3
	21-31	20.3	15.2	133.5	1301.8
Apr.	1-7	22.4	17	107.1	1408.9

Moreover; Fig.3 illustrates the relationship between Phytophagous and Predacieous mites density and accumulation of growing degree-days (AGDD). consequently ; data indicated that the density of Phytophagous mite by (1 n/in^2) need approximately 167.12, 134.18 and 154.82 heat units under treatment Q1, Q2 and C respectively. However, Predacieous mite density (1n/in^2) needs for 269.38 heat units under Q1 and 172.23 heat units under both Q2 and C treatments. Thus; Phytophagous mite needs for low heat units to increase comparing with Predacieous mite which needs for a high heat units to increase specially under low water quantity (Q1).
Further; there is a linear response between both (Phytophagous and Predacieous mites density) and accumulative growing degree-days in three water quantities treatment with R^2 more than 0.91.(Equation 8&9)

$$Phyto = 0.0124(AGDD) - 8.9857 \quad (8)$$
$$Pred = 0.0105(AGDD) - 6.5889 \quad (9)$$

Where:

Phyto	=	Phytophagous mite density N in^{-2})
Pred	=	Predacieous mite density N in^{-2})
GDD	=	Accumulated growing degree days (C° day).

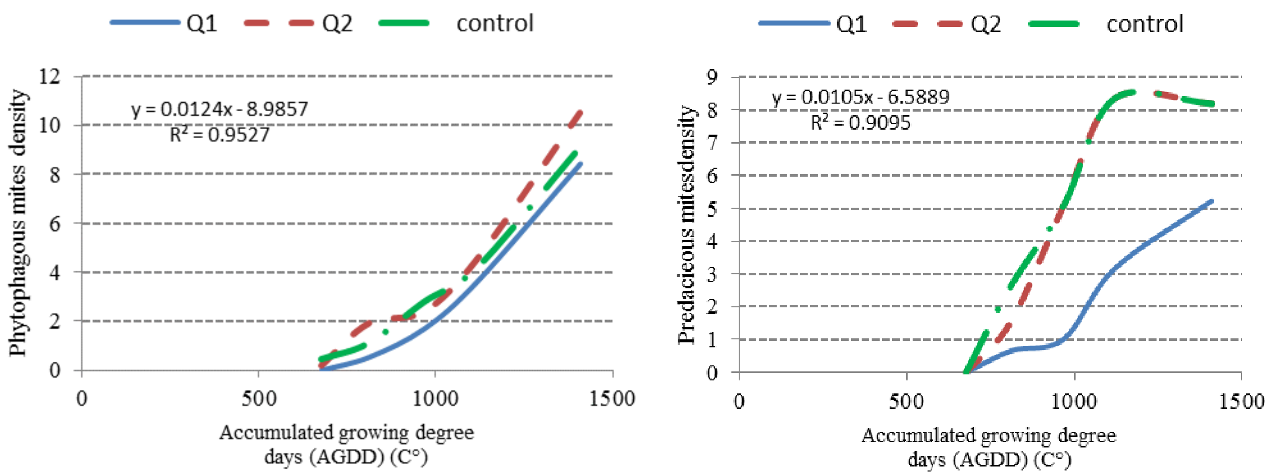

Fig.(3) Relationship between (Phytophagous and Predacieous mites density) and accumulation of growing degree-days (AGDD).

Consequently; these relations can be used to determine Phytophagous and Predacieous mites density depending on one climatic factor (air temperature) for broccoli crop under such water conditions.

Amounts of water with growth parameters and yield:-

As shown at table (7); the data indicated that there is an influence for water quantities on some growth parameter especially during the growing season. For instance; after 65 days from planted on Feb mean data for root length (RL) reflected that there is a significant influence for Q2 comparing with both Q1 and control; Where Q2 recorded (17 cm) which is a highest mean value for (RL) at Feb. However; other growth parameters (SL & N.Leaf) did not have any significant difference between mean values at the same month. This agrees with that; water stress is considered to be one of the most important environmental factors that limit plant production. (Tahar et al ,2010).

On the other hand; obtained data on March reflected that Q2 has a significant impact on (SL & RL) values which acquired 16 cm and 28.6 cm for both SL and RL respectively; which reckon as a highest values comparing with other treatments. Further; N.leaf at the same time did not restrict any significant different on all three water quantities.

Obviously; at the end of season on April; N.leaf acquired a significant mean value by (38.3) which observed with Q2 while with Q3 and C data recoded 24.6 and 29.6 respectively. may this is related to that Plants require sufficient water for a healthy growth rate, but over watering plants will result in slower growth(BBc, 2014).

Table 7. Influence of water quantities on some mean growth parameters for Broccoli.

ITEMS	Steam length(SL) (cm)			Root length(RL) (cm)			N.leaf (N)		
	Q1	Q2	control	Q1	Q2	control	Q1	Q2	control
Feb	10 a	12.33 a	13.1 a	12 b	17 a	12.16 b	16 a	15.6 a	14.3 a
$LSD_{0.05}$		5.157			3.379			4.105	
March	13.3 b	16 ab	16.8 a	18.6 b	28.6 a	14.6 b	18.3 a	19.3 a	24 a
$LSD_{0.05}$		3.39			8.31			7.7	
April	18 a	18.3 a	17.6 a	47.6 a	46.6 a	39 a	24.6 b	38.3 a	29.6 b
$LSD_{0.05}$		5.4			16.54			6.9	

In addition; the statistical analyses data for broccoli production (ton Fed^{-1}) indicate that there are a significant influence for amounts of water on yield. Furthermore; the value of yield under treatment Q2 was the highest value (9.017 ton / fed) comparing with others treatment's values (7.91 & 5.04 ton/fed) for (Q1 and Control respectively). (fig.4). May this related to; that the over watering plants will result in slower growth. Thus; that higher amount of irrigation does not necessarily result in higher yield.(Dong et al. 2007). This means; if too much water is applied, yield might even decline as a result of water logging or leaching of nutrients from the root zone. (Wang, Wang, Li, and Chang, 2006).

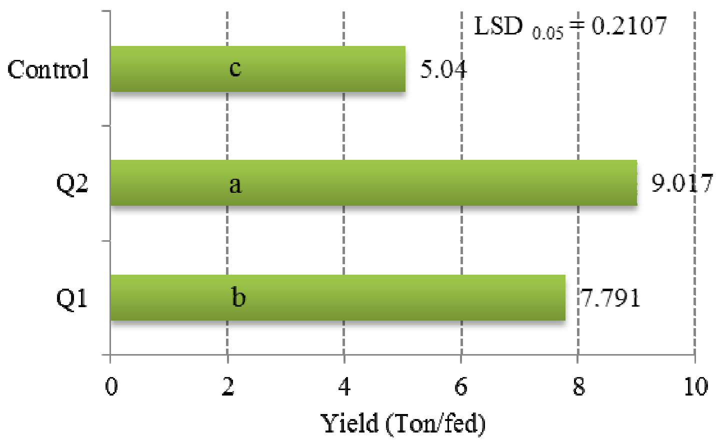

Fig. (4) Impact of water treatments on (Broccoli) mean yield production.

Irrigation water use efficiency (IWUE) and heat use efficiency (HUE).

IWUE is one of the most important indices for determining optimal water management practices. The obtained results for IWUE and HUE are given in Table 9, the lower IWUE values was observed for treatment(control) while higher values was in treatment Q1. That's means too much irrigation led to a decrease of IWUE and effective deficient irrigation may result in a higher production and IWUE (Jin, Zhang, & Gao, 1999). In addition; the result of IWUE under water treatments were 7.96, 4.61and 2.21(Kg/m^3) So; broccoli is not need to irrigate by higher amount of water to obtained a highest value for unit of water and irrigate by low amount of water can acquired an effective and economical irrigation water unit.

Table 8. IWUE and HUE for broccoli under amounts water treatments.

Treatments	IWUE (Kg/m^{-3})	HUE (Kg fed $^{-1}$ C^{-1}day^{-1})
Q1	7.96	5.5
Q2	4.61	6.4
control	2.21	3.57

Moreover, the observation for HUE reflect that highest of crop yield under treatment Q2 increased HUE with the same value 1408.9 C° of accumulated growing degree days (AGDD) for water treatments (Q1, Q2 and control). Heat use efficiency (HUE), i.e., efficiency of utilization of heat in terms of dry matter accumulation, depends on crop type, genetic factors and sowing time and has great practical application (Rao, Singh, 1999). However; with treatment Q1 which recorded a highest IWUE by (7.96 Kg/m^3) obtained HUE 5.5 heat unit. Thus; from previous data analysis that best treatment is Q1 (low amount of water) which gain a good value both (IWUE) and (HUE).

Ultimately; Interaction between the influence of mites and water treatments (fig. 5) can be explain using the flowing model (Eq. 10) which illustrate the behavior of both factors on yield production.

$$Y = 0.972 \text{ (Phyto.)} + 1.766 \text{ (Predu.)} - 0.0061(Q) - 3.627 \quad (R^2=0.98) \qquad (10)$$

Where:

Y	=	Yield for Broccoli (Ton fed^{-1})
Phyto	=	Phytophagous mite density(N in^{-2})
Pred	=	Predacieous mite density (N in^{-2})
Q	=	Total water applied (m^3 fed^{-1}).

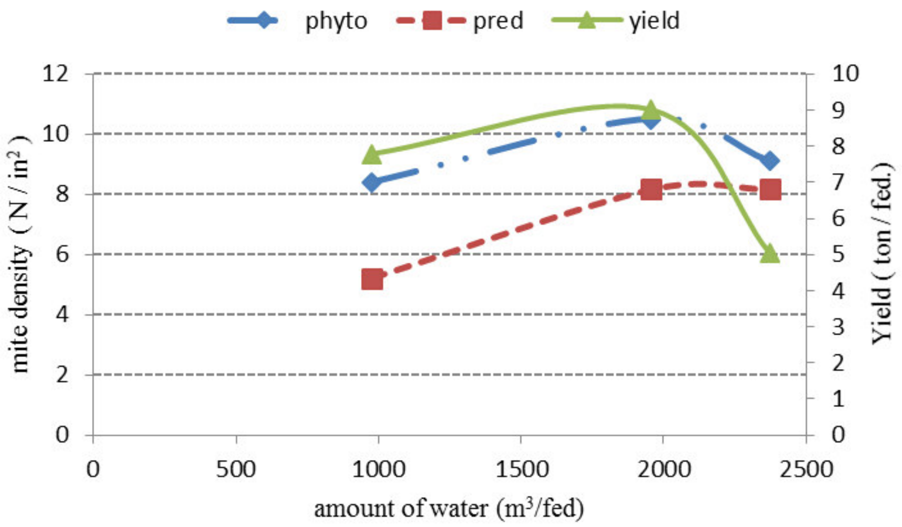

Fig. (5) Influence of mite density of water treatments on (Broccoli) mean yield production.

CONCLUSION

To conclude; this study ultimately a several points. For instance; The water quantities have a significant influence on Phytophagous and Predacieous mites where the highest mean value for mites density was observed with (Q2) by (10.5N/in^2) and (8.16 N/in^2) for Phytophagous and Predacieous mites respectively. On the other hand; the density of Phytophagous mite by (1 n/in^2) need approximately 167.12, 134.18 and 154.82 heat units under treatment Q1, Q2 and C respectively. However; Predacieous mite density (1n/in^2) needs for 269.38 heat units under Q1 and 172.23 heat units under both Q2 and C treatments. Furthermore; the value of yield under treatment Q2 was the highest value (9.017 ton / fed) comparing with others treatment's values (7.91 & 5.04 ton/fed) for (Q1 and Control respectively). However; with treatment Q1 which recorded a highest IWUE by (7.96 Kg/m^3) obtained HUE 5.5 heat unit. Thus; from previous data analysis that best treatment is Q1 (low amount of water) which gain a good value both (IWUE) and (HUE).

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