J. Plant Production, Mansoura Univ., Vol. 3 (12): 2993 - 3009, 2012

EFFECT OF FOLICOTE ANTITRANSPIRANT ON SWEET POTATO CROP AND WATER-USE EFFICIENCY UNDER DRIP IRRIGATION TREATMENTS

Moussa, S. A. M.
Sabaheya Hort. Res., Horticultural Res. Inst., Agric. Res. Center, Egypt.
E-mail address for correspondence: samehmoussa@yahoo.com

ABSTRACT

Two field experiments concerning sweet potato crop were carried out during the two successive summer seasons of 2009 and 2010 at a newly reclaimed area, at El-Nubariya city south of Alexandria governorate, Egypt. The experiments were designed to study the efficiency of the film-forming antitranspirant (Folicote) concentrations; i.e., 0, 5, 10, 15% (v/v) on optimization irrigation water in the low-water areas. Four irrigation quantities were applied; 1800 m^3/fed., 2080 m^3/fed., 2360 m^3/fed. and 2640 m^3/fed. (common rate) to investigate the effects of water deficiency on some important economic traits on sweet potato crop. The studied vegetative characters were positively affected with increasing Folicote concentration from zero up to 15 %. The total tuber root yield per fed. trait was gradually increased with increasing Folicote concentrations from zero up to 15 %. The decreasing of irrigation quantity from 2640 m^3/fed. down to 1800 m^3/fed. led to negatively effects on sweet potato yield and the economical studied characters. It could be concluded from this study that 280 m^3 water per feddan could be saved when sweet potato plants foliar sprayed with Folicote at the rate of 15 % and at the same time obtaining high yield compared with the common irrigation water quantity (2640 m^3/fed.). Folicote applications resulted in significant increases in the water-use efficiency over the control treatment. The increases in water-use efficiency were about 36.05% and 18.40% over the control treatment (zero Folicote) when 15 % Folicote was sprayed on the sweet potato foliage during the two seasons of the study, respectively.

Keywords: Sweet potato, *Ipomoea batatas, L.*, Folicote, antitranspirants and water-use efficiency.

INTRODUCTION

Sweet potato (*Ipomoea batatas, L.)* is a member of the family Convolvulaceae. It ranks as the world's seventh most important crop, with an estimated annual production of approximately 122 million metric tons. It is grown in more than 100 countries in tropical, subtropical and temperate climates (FAO, 2006). Sweet potato is a popular vegetable crop especially for developing countries such as Egypt, since it is an important and not expensive source of carbohydrates, vitamins A and C, fiber, potassium and protein (Woolfe, 1992). In developing countries, sweet potato is especially valued because it is highly adapted and tolerates high temperatures, low soil fertility and drought (Yamakwa and Yoshimoto, 2002). Sweet potato was grown in Egypt in about 27290 fed. (season 2009), this produced 370905 metric tons with an average of 13.59 ton / fed.(FAO, 2010). It is cultivated for both human food consumption (tuber roots) and starch production. Moreover, the foliage is used for animal feeding.

Emerged in the recent years the problem of water shortages and the emergence of conflicts between states over water sources, this problem has affected a lot of countries specially Egypt, where this problem arose disputes between the Nile Basin countries to re-divide the water among them. In this respect, The Egyptian Ministry of Agriculture directs a lot of their policies in order to reduce the consumption of irrigation water in various ways so as to meet the shortage of irrigation water potential during the next few years. The understanding of the water needs of different crops, compared with its addition of irrigation water is considered a basic and useful in order to reduce the quantities of water consumed a great deal.

The addition of antitranspirants, compounds applied to the leaves of plants to reduce transpiration, is considered one of the important subjects, which also benefit the plants resistant to drought. Abdel–Nasser and El-Gamal (1996) illustrated that such antitranspirants may be categorized into two types; 1) Physical agents which either reduce energy available for conversion to latent heat by reflecting and decrease the load of heat on leaf surface (reflecting materials) or related vapor loss by the formation of thin film s which coat leaf surface that are more permeable to CO_2 and O_2 and impervious to water vapor (film-forming antitranspirants). Examples include silicone oil and waxes. 2) Active biochemical materials (metabolic inhibitors) which physiologically induce stomatal closure of inhibiting stomatal opening hence reduce water vapor loss (stomatal antitranspirants). Examples include phenylmercuric acetate, abscicic acid (ABA) and aspirin.

The antitranspirants which cause the closing of stomata affect the plant metabolism frequently causing toxic effect and reduce proportionally the intensity of transpiration and photosynthesis (Parkinson, 1970; Davenport et. al. 1971; Mishra and Pradhan, 1972 and Kreith et. al., 1975). On the other side, film-forming and reflecting antitranspirants which form a protective layer on the leaf surface have found to be not toxic and have a longer duration of effectiveness than metabolic materials (Davenport et. al., 1974; Kreith et. al., 1975 and Patil and De, 1976).

The objectives of this investigation were: (1) Evaluate the effect of application of Folicote antitranspirant on sweet potato production and tuber root quality. (2) Study the possibility of reducing the quantity of irrigation water applied. (3) Improving the water-use efficiency of sweet potato crop.

MATERIALS AND METHODS

Experimental site:

Two field experiments were carried out at El-Nubariya city, 90 Km south of Alexandria governorate, Egypt during the summer seasons of 2009 and 2010. Some of physical and chemical properties of employed soil were determined before carrying out the experiments according to Jackson (1973). The determinations are presented in Table (1). The permanent wilting point (P.W.P.) and field capacity (F.C.) of the trial soil were determined according to Israelsen and Hansen (1962) and are shown in Table (2).

Table (1): Physical properties and chemical analyses of the experimental soil:

Mechanical analysis			Texture	pH	EC. m mohs/cm	$CaCo_3$ %	O.M. %
Sand%	Silt%	Clay%					
74.50	5	20.5	sandy clay loam	8.00	0.4	33.5	0.65

Chemical analysis								
Cations (meq/100 gm soil)						Anions (meq/100 gm soil)		
N^+	P^-	Ca^{++}	Mg^{++}	Na^+	K^+	$HCO_3^- + CO_3^{--}$	CL^-	SO_4^{--}
0.33	0.40	0.60	0.37	0.38	0.08	2.00	0.25	0.60
Available P_{AV}, ppm		Available K_{AV}, ppm			Saturation %			
8.90		3.70			26			

Table (2): Field capacity, wilting point and soil bulk density of the experimental location (average of the two years).

Soil depth (cm)	Field capacity (%)	Wilting point (%)	Soil bulk density
0-30	18.20	10.03	1.33
30 - 60	17.90	9.40	1.40

Planting Material:

Stem cuttings of the sweet potato cv. Beauregard obtained from Agro Food Farm Co. at El-Nubariya region, Behera governorate was used for planting in this study. Planting was done on the first of May for 2009 and 2010 growing seasons, respectively. Harvesting was done at 110 days later planting for both years. Stem cuttings of about 30 cm length were planted in rows, 0.70 m wide, and at spacing of 0.25 m within rows. The row is 20 m long. The planting was under a drip irrigation system.

Agricultural operations:

Phosphorus fertilizer was applied at the rate of 300 Kg/fed. in the form of mono calcium phosphate (15.5 % P_2O_5) at soil preparation, plus 5 tons/fed of compost were added. Nitrogen fertilizer was applied at the rate of 150 Kg N/fed. to the soil throughout the drip irrigation system in the form of ammonium nitrate (33.5% N). Potassium fertilizer was added at the rate of 100 Kg / fed. in the form of potassium sulphate (48% K_2O) throughout the drip irrigation system. All other agricultural practices for sweet potato production were followed as recommended in the area.

Treatments:

Each experiment contained four irrigation treatments (1800, 2080, 2360 and 2640 "common used" m^3 / fed.) and four Folicote (a film-type antitranspirant) spraying concentrations; i.e. 0.0%, 5%, 10% and 15% (v/v). Tap water was sprayed for the untreated plants (without Folicote spraying). Folicote was sprayed on the vegetative growth until plants were dripping wet with a hand pressure sprayer. The foliar spraying with Folicote was three times during the growing season. The first spraying application was done 40 days of planting, the second was 60 days and the third was 80 days of planting. The irrigation water quantities were randomly distributed in the main plots; whereas, the Folicote concentrations were randomly assigned in the sub-plots. Each sub-plot consisted of four rows, 20 m long and 0.70 m wide, with a sub-plot area of 56 m^2. The Folicote used in this study is a hydrocarbon paraffin wax emulsion (an emulsion wax polymers). The total amount of drip irrigation at different treatment was calculated and expressed in terms of time based on the rate of water flow through the drippers (2L / h.) and the dripper's number / fed. were 20000 ones to give such amount of water for each treatment. The irrigation numbers, the time and the water quantity (m^3) for each irrigation treatments are shown in Table (3). All treatments received equal amounts of irrigation water from transplanting the stems until 40 days of growing season where Folicote was sprayed and water treatments were started irrigation.

Table (3): The time (minute) and amounts of applied irrigation water (m^3/fed) in every irrigation during the growth period of sweet potato via dripper lines with discharge of 2 liter /h. for each dripper at 0.5 bar.

Total water quantity (m^3/fed*)	Total Irrigation numbers	Irrigation numbers from transplanting until 40 days	Water quantity (m^3/fed) from transplanting until 40 days	Irrigation time in every irrigation (min.) from transplanting until 40 days	Irrigation time in every irrigation (min.) from age 40 days until harvesting	Water quantity (m^3/fed) in every irrigation from age 40 days until harvesting
1800	45	24	960	60	60	40
2080	45	24	960	60	80	53.33
2360	45	24	960	60	100	66.67
2640	45	24	960	60	120	80

***feddan = 3800 m^2**

Data recorded:

Vegetative characters: Ten randomly plants were used to determine the plant length (cm) and the vegetative fresh weight (m), and then the data were averaged and recorded. The percentage of foliage dry weight was calculated as the result of dividing the foliage dry weight which oven dried at (70 °C to reach constant weight) on the foliage fresh weight then multiplied by 100. The chlorophyll content was determined in plant leaves; average of 10 leaves, using the handheld chlorophyll content meter (CCm-200), produced by Opti-Sicences, Inc. 8 Winn Avenue Hudson, NH 03051, U.S.A.

Yield and yield attributes: Tuber root yield was calculated for a sub-plot (56 m^2) and then attributed to yield per feddan (3800 m^2). Tuber yield was also determined for ten plants then the average weight and numbers of tubers per plant were calculated. Marketable yield / plant (Kg) and marketable tuber root number / plant were recoded as an average of randomly ten plants in a sub-plot, where; marketable tuber roots represent tubers of healthy, regular shapes, 30 mm > tuber root diameter < 100 mm and more than 100 gm in weight.

Tuber roots characteristics and quality: A sample of ten randomly tuber roots per treatment were used to determine tubers' dry matter percentage. The samples were sliced and dried at 70 °C for 48 hrs and then calculated according to the formula:

$$\text{Dry matter \%} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Reducing and non-reducing sugars content (%) were determined in fresh tubers using sulphuric acid and phenol (5%) for extraction ,then they were colourimetrically determined, according to the method of Dubios *et. al*. (1956). Starch content (%) was determined in tuber roots using the method described in A.O.A.C. (1970). Carotene content was determined as β carotene, using the method described by Umiel and Gabelman (1971) using a Milton Roy, spectrophotometer-601 at 440 nm.

Water – use efficiency (WUE):

Water – use efficiency (WUE) was calculated as Kg of sweet potato tuber root yield produced per cubic meter of water consumed (Doorenbos and Kassem, 1979 and Ahmed, 1987).

$$\text{WUE} = \frac{\text{Tuber root yield produced (Kg / fed.)}}{\text{Water used (m}^3\text{ / fed.)}}$$

Experimental design and statistical analysis:

A split plot technique in a randomized complete blocks design (R.C.B.D.), with three replicates was followed during both years of this study. Irrigation quantities were randomly distributed in the main plots. While Folicote concentrations were randomly distributed in the sub-plots.

The collected data of the experiments through the two years of the study were statistically analyzed, using the analysis of variance method as illustrated by Al-Rawi and Khalf-Allah (1980). Comparisons among the means of different treatments were done, using Duncan's multiple range test procedure at p = 0.05 level of significance, as illustrated by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1- Effect of irrigation quantities, Folicote concentrations and their interaction on sweet potato vegetative characters:

Data presented in Table (4) showed that the studied vegetative characters were positively affected by irrigation quantities, exception for chlorophyll content during the two years of the experiment. Generally, vegetative characters increased significantly with increasing irrigation quantities from 1800 m^3 / fed. up to 2640 m^3 / fed. These results are agreed with that obtained by Ezzat *et al*. (2009). The authors suggested that increasing water quantity applied to potato plants led to keep higher moisture content in the soil and this in turn might favored the plant metabolism that leads to increase the plant growth characters and to produce higher dry matter. The data presented also detected that all the tested vegetative characters were significantly increased due to increasing the Folicote concentrations from zero up to 15 % (Table, 4). There were no significant differences between either of the 15 % treatment or 10 % treatment for the characters of plant length, foliage fresh and dry weight especially during the first season (2009). Meanwhile, both were significantly differed from zero and 5 % rates for most studied vegetative traits. This effect might be taken place due to the availability of more water in the plant tissues because of Folicote applications that enable more plant growth, as explained by Abd-Allah (1996). The total chlorophyll content appeared to be significantly increased by increasing the Folicote concentrations (Table, 4) during the two seasons of the study. This result is on contrary with that obtained by Abd-Allah (1996) who stated that chlorophyll content was decreased with increasing Folicote concentrations. Foliage fresh weight and foliage dry weight percentage seemed to be significantly affected by Folicote concentrations. In this respect, the concentration of 15 % Folicote gave the highest values for both the two tested characters, in spite of that there were no significant differences between the two concentrations 10 % and 15 % during the first year of the study. The positive effects of Folicote observed in increasing the studied vegetative characters may be due to promoting the rate of assimilation which, in turn, reflected on the observable rate of growth. This result is in agreement with those of Abd-Allah (1996) and Abdel- Nasser and El-Gamal (1996).

The above findings show that Folicote used in this study proved to have favorable effects on the growth of sweet potato plants when used after 40, 60 and 80 days of planting. In this regard, Gale and Hagan (1966) reported that the antitranspirant may form a coating film on the leaf surface, leading to increase in the diffusive resistance of water vapor from stomata. Thus, more water might be hold in plant tissues due to reducing the transpiration rate. Abde-Nasser and El-Gamal (1996) concluded that Folicote could be minimizes the moisture losses from leaf surface, because of it is a wax emulsion then when sprayed on the foliage, it dries out to form an invisible discontinuous thin film that prevents the escape of water vapor from stomata. In general, the interaction between Folicote concentrations and irrigation quantities had not significant effect to alter any of the studied vegetative characters.

Table (4): Effect of irrigation quantities, Folicote concentrations and their interaction on the studied vegetative characters during the two years of the study.

Treatments	Year of 2009				Year of 2010			
	plant length (m)	Foliage fresh weight (Kg)/ plant	Foliage dry weight (%)	Total chlorophyll content (mg/100gm)	plant length (m)	Foliage fresh weight (Kg)/ plant	Foliage dry weight (%)	Total chlorophyll content (mg/100gm)
Irrigation quantities								
2640 m^3/fed.	3. 21 a	0. 61 a	22. 59 a	31. 90 a	3. 42 a	0. 71 a	25. 69 a	33. 60 a
2360 m^3/fed.	2.70 b	0. 60 b	22. 11 b	32. 19 a	2. 90 b	0. 68 a	22. 52 b	33. 48 a
2080 m^3/fed.	2. 58 c	0. 52 c	20. 72 c	31. 96 a	2. 71 c	0. 57 b	20. 68 c	33. 31 a
1800 m^3/fed.	2. 34 d	0. 41d	20. 37 d	32. 13 a	2. 42 d	0. 41 c	19. 89 d	33. 82 a
Folicote concentrations								
15 % Folicote	2. 85 a	0. 62 a	21. 72 a	33. 70 a	3. 05 a	0. 64 a	23. 53 a	36. 14 a
10 % Folicote	2. 79 a	0. 59 a	21. 67 ab	32. 52 b	2. 91 b	0. 61 b	22. 75 b	34. 63 b
5 % Folicote	2. 67 b	0. 50 b	21 .43 b	31. 59 c	2. 80 c	0. 58 b	21. 59 c	32. 44 c
0 % Folicote	2. 53 c	0. 45 c	20. .97 c	30. 37 d	2. 69 d	0. 53 c	20. 92 d	31. 00 d
Irrigation quantities X Folicote concentrations Interaction								
2640 m^3/fed.								
15 % Folicote	3. 36 a	0. 72 a	22. 97 a	33. 19 a	3. 69a	0. 75 a	27. 17 a	36. 52 a
10 % Folicote	3. 33 a	0. 69 a	22 .73 a	32. 23 a	3. 52 a	0. 72 a	26. 67 a	34. 98 a
5 % Folicote	3. 13 a	0. 54 a	22 .40 a	31. 74 a	3. 32 a	0. 71 a	24. 67 a	31. 62 a
0 % Folicote	3. 00 a	0. 52 a	22. 27 a	30. 43 a	3. 15 a	0. 65 a	24. 33 a	31. 28 a
2360 m^3/fed.								
15 % Folicote	2. 85 a	0. 69 a	22. 43 a	34 .75a	3. 08 a	0. 73 a	23. 37 a	36. 05 a
10 % Folicote	2. 77 a	0. 67 a	22. 33 a	33 .07a	2. 91 a	0. 70 a	22. 70 a	39. 35 a
5 % Folicote	2. 69 a	0. 53 a	22. 17 a	31. 09 a	2. 80 a	0. 67a	22. 33 a	32. 65 a
0 % Folicote	2. 50 a	0. 52 a	21. 50 a	29 .86a	2. 79 a	0. 60 a	21. 67 a	30. 88 a
2080 m^3/fed.								
15 % Folicote	2. 70 a	0. 60 a	20. 97 a	33. 24 a	2. 85 a	0. 61 a	22. 40 a	35. 65 a
10 % Folicote	2. 68 a	0. 55 a	20. 90 a	32. 24 a	2. 70 a	0. 57 a	21. 00 a	34. 15 a
5 % Folicote	2. 55 a	0. 52 a	20. 67 a	31. 24 a	2. 68 a	0. 57 a	20. 00 a	32. 38 a
0 % Folicote	2. 40 a	0. 43 a	20. 33 a	31. 11 a	2. 60 a	0. 52 a	19. 33 a	31. 05 a
1800 m^3/fed.								
15 % Folicote	2. 48 a	0. 48 a	20. 50 a	33. 64 a	2. 57a	0. 47 a	21. 17 a	36. 35 a
10 % Folicote	2. 37 a	0. 44 a	20. 70 a	32. 54 a	2. 51 a	0. 43 a	20. 70 a	35 .05a
5 % Folicote	2. 29 a	0. 41 a	20. 50 a	32. 27 a	2. 40 a	0. 38 a	19. 37 a	33. 12 a
0 % Folicote	2. 20 a	0. 33 a	19. 77 a	30. 08 a	2. 23 a	0. 37 a	18. 33 a	30. 78 a

Means having an alphabetical letter in common, within a comparable group of means, do not significantly differ from each other, using Duncan's multiple range test procedure at p= 0.05 level of significance.

2- Effect of irrigation quantities, Folicote concentrations and their interaction on sweet potato yield and yield component traits:

As Shown from the data presented in Table (5), the total root yield character (ton /fed.) was significantly affected with the irrigation quantities. Common irrigation quantity (2640 m^3/fed) produced the highest yield followed with the treatment of 2360m^3/fed. The lowest total yield was pronounced with the treatment of 1800 m^3/fed. In this regard, Fig. (1) clearly illustrated the positive influence of the total yield with increasing the irrigation quantity from 1800 m^3/fed. up to the common quantity.

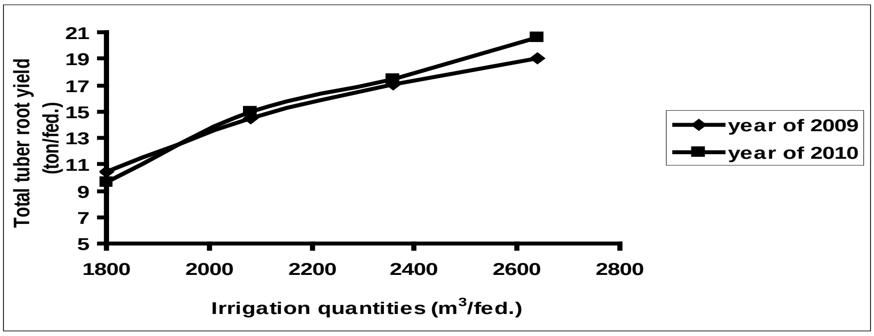

Fig.(1): The relationship between Total tuber root yield (ton/fed.) and irrigation quantity (m^3/fed.) during the two years of the study.

Spraying sweet potato grown plants with Folicote had positive effects on the total root yield/fed. In this respect, foliar spraying with 15% Folicote gave significant positive effect on root yield trait compared with the other three tested concentrations during the two years of the study. The treatment zero Folicote (non-spraying) ranked last significant differences compared with the other three tested treatments. In this respect, Fig. (2) obviously illustrated the high values of the total yield obtained with increasing the concentrations of the Folicote from zero up to 15 %.

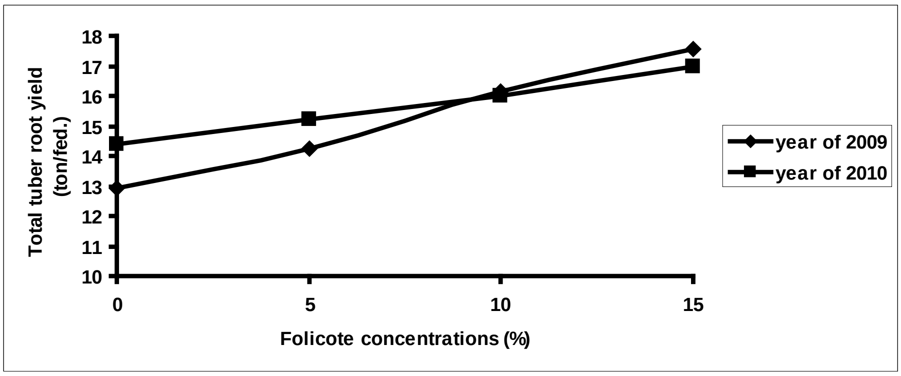

Fig.(2): The relationship between Total tuber root yield (ton/fed.) and Folicote concentrations (%) during the two years of the study.

The obtained results may be explained as a result of the positively effects of tuber root number and average root weight characters on total root yield trait (Table, 5). Tuber root number appeared to be did not affect with varying in irrigation quantities especially in the first year (2009). Average tuber weight character was negatively affected with the low water quantities especially the treatments 2080 m^3/fed. and 1800 m^3/fed. The previous results might be indicated that the increasing in tuber root yield per feddan might be referred to the good healthy of plants regarding vegetative characters resulted with the high levels of Folicote spraying (Table, 4) and or the positive effect of the average tuber root character especially with the high water quantities applied (Table, 5). Gawish (1992) illustrated in his study on snap beans that; the antitranspirants used led to Improving plant growth and productivities of the growing crops. It could be conducted from the obtained data that the average tuber root weight character is the main factor specified the total yield for the sweet potato crop under the conditions of this study and not the number of tuber root per plant.

Both tuber root number and average tuber weight characters did not significantly affect with increasing the Folicote concentrations from zero up to 15% during the two years of this study, as shown in Table (5).Marketable tuber root number per plant and marketable tuber root yield per feddan positively affected with increasing irrigation water quantity from 1800 m^3/fed. up to 2640 m^3/fed. The two mentioned characters also increased gradually with increasing Folicote concentrations applied from zero up to 15% in spite of there were not any significant differences between the treatments 10 and 15% Folicote, as appears from Table (5). Ezzat, *et al*. (2009) in their studied on potasto suggested that increasing the quantity of water applied to the soil increases the soil moisture content, that makes the nutritional elements more available to the plant and this in turn might favored the plant growth characters and most of the physiological processes, that directly affect the yield and yield components. In addition, higher water quantity applied to plants led to keep higher water content in the plant tissues, and this turn produced tubers heavier than those under water stress.

The interaction between irrigation water quantities and Folicote concentrations was insignificant for yield and its studied component characters. This result might explain that the obtained results might be gone in harmony and in the same direction with the differences in the irrigation quantities and Folicote foliar concentrations. In this respect, the highest yield was given with the treatment 2640 m^3/fed. sprayed with 15%Folicote followed with the treatment 2640 m^3/fed. sprayed with 10% Folicote (Table, 5). The data of Table (5); clearly, illustrated that the treatment 2360 m^3/fed. + 15 % Folicote gave a greater total yield than the control treatment (2640 m^3/fed. + zero Folicote) during the tow years of the study. The treatment 2360 m^3/fed. + 10 % Folicote gave a tight total yield; as an average over the two years, with that obtained with the control treatment. So, it could be conducted from the previous obtained results over the two tested years that spraying sweet potato plants with 15 % Folicote could be save 280 m^3 irrigation water per feddan. without leading that to affect the total yield negatively.

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Abde-Nasser and El-Gamal (1996) explained that the increasing happened for sweet potato growth and the subsequent root yield and characteristics as a result of Folicote applications primarily to the effect of this material on improving the plant water potential at the time when the growth of plant was more dependent on water status than on photosynthesis. The authors added that root formation stage is also more related to plant water status, which is related with available moisture in the root zone.

3- Effect of irrigation quantities, Folicote concentrations and their interaction on sweet potato tuber root quality characteristics:

Data presented for the effect of irrigation quantities on tuber roots quality (Table, 6) appeared that tuber root dry matter percentage was increased gradually with increasing the irrigation water quantity from 1800 m^3/fed. up to 2640 m^3/fed. during the two seasons of the study. The non-reducing sugars seemed to be unaffected with the irrigation regimes. Also, the reducing sugars percentage did not affect with the varying in irrigation quantities applied only in the first season. The highest starch content was obtained with the treatment 2080 m^3/fed. in the first year without significant differences with the treatments 2360 m^3/fed. and 1800 m^3/fed. On the contrary, the common treatment (2640 m^3/fed.) gave the highest starch percentage during the second year of the study with significant differences among the other tested water quantities. Carotene content was differently responded with the varying in water quantities from year to year.

Data presented in Table (6) obviously detected that neither carotene content nor reducing sugars content affected with the varying in Folicote concentrations from zero up to 15 % during the two years of the experiment. The other studied quality traits, i.e.; carotene content, reducing sugars and starch percentages differently responded from year to another with respect to Folicote concentrations, as appears from Table (6). It is clearly obvious from Table (6) that the interaction between irrigation quantities tested and Folicote spraying concentrations applied expressed insignificant effects on all studied quality characteristics.

4- Water-use efficiency (WUE):

Data presented in Table (7) illustrated that water-use efficiency was positively increased as water quantity increased from 1800 m^3/fed. up to the common treatment (2640 m^3/fed.). This result is not accordance with that obtained by Ezzat *et al*. (2009). The authors found that the value of WUE gradually decreased with increasing water quantity up to the highest level and showed opposite trend to that of total yield. Same trend of results are also obtained by Anwar (2005) and Youssef (2007) on potato crop. They found that, the efficiency of water use was increased by applying deficit water irrigation. Folicote applications resulted in significant increases in the water-use efficiency over the control treatment with significant differences among the other tested concentrations used (5%, 10% and 15%) in the present study, as appears from Table (7) and Fig. (3).

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The increases in water-use efficiency were about 11.11% and 5.32% for 5% Folicote; 25.43% and 10.42% for 10% Folicote and 36.05% and 18.40% for 15% Folicote over the control treatment (zero Folicote) during the two seasons of the study, respectively. These results mean that the untreated plants with Folicote produced 4.05 and 4.51 Kg of sweet potato tuber roots as a result of consuming 1m^3 of irrigation water during the first and second years of this study, respectively, meanwhile sweet potato plants treated with 15% Folicote led to produce 5.51 and 5.34 Kg of sweet potato tuber roots using the same amount of irrigation water during the two years of the study, respectively.

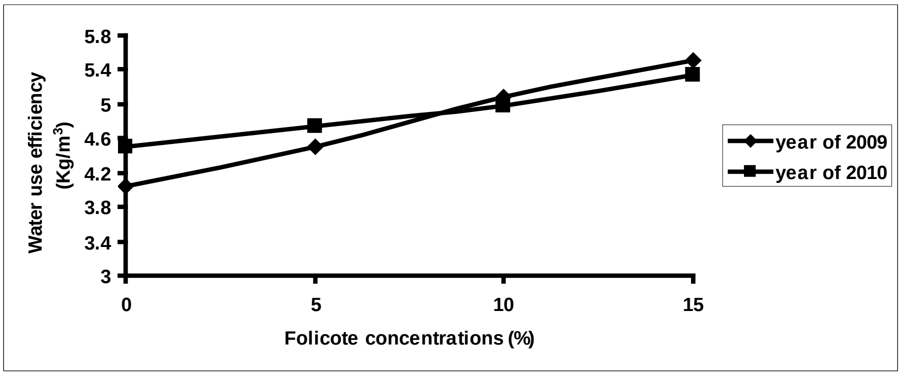

Fig.(3): The relationship between water use efficiency (Kg/m^3) and Folicote concentrations (%) during the two years of the study.

Abd-Allah (1996) demonstrated that the increasing of water-use efficiency due to application of Folicote might be related to the less water-use during the growing season and the increasing happened in the total yield. The increasing in water-use efficiency is in accordance with those obtained by Abdel-Nasser and El-Gamal (1996).The interaction effect between water quantities and Folicote concentrations on WUE seemed to be insignificant as appears from the data of Table (7). The result of Ezzat *et al*. (2009) regarding the interaction between water quantity and reducing irrigation water substances showed significant effect among the different combinations.

Table (7): Effect of irrigation quantities, Folicote concentrations and their interaction on the water use efficiency during the two years of the study

Treatments	Year of 2009 water use efficiency (Kg sweet potato yield per fed./ irrigation water (m3/fed.) of consumed water	Year of 2010 water use efficiency (Kg sweet potato yield per fed./ irrigation water (m3/fed.) of consumed water
Irrigation quantities		
2640 m3/fed.	5.27 a	5.72 a
2360 m3/fed.	5.15 a	5.29 b
2080 m3/fed.	4.85 b	5.02 c
1800 m3/fed.	3.87 c	3.55 d
Folicote concentrations		
15 % Folicote	5.51 a	5.34 a
10 % Folicote	5.08 b	4.98 b
5 % Folicote	4.50 c	4.75 c
0 % Folicote	4.05 d	4.51 d
Irrigation quantities X Folicote concentrations Interaction		
2640 m^3/fed.		
15 % Folicote	6.17 a	6.04 a
10 % Folicote	5.55 a	5.91 a
5 % Folicote	4.76 a	5.64 a
0 % Folicote	4.61 a	5.30 a
2360 m^3/fed.		
15 % Folicote	6.02 a	6.01 a
10 % Folicote	5.41 a	5.27 a
5 % Folicote	4.81 a	5.13 a
0 % Folicote	4.38 a	4.73 a
2080 m^3/fed.		
15 % Folicote	5.53 a	5.49 a
10 % Folicote	5.29 a	5.09 a
5 % Folicote	4.55 a	4.84 a
0 % Folicote	4.02 a	4.66 a
1800 m^3/fed.		
15 % Folicote	4.32 a	3.83 a
10 % Folicote	4.07 a	3.64 a
5 % Folicote	3.89 a	3.40 a
0 % Folicote	3.20 a	3.34 a

Means having an alphabetical letter in common, within a comparable group of means, do not significantly differ from each other, using Duncan's multiple range test procedure at p= 0.05 level of significance.

CONCLUSIONS

It could be generally concluded that Folicote can be used as a foliar spray on growing sweet potato plants in the arid and semi-arid lands, as well as the newly reclaimed areas where irrigation water is a limiting factor. In addition, spraying Folicote at 15 % rate lead to reduce the irrigation water quantity used during the irrigation by 10.61 % per feddan, compared with the common water quantity used in this area leading to increase the water use efficiency and finally increasing the total tuber root yield.

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تأثير مضاد النتح الفوليكوت على محصول البطاطا وكفاءة استخدام الماء تحت معاملات الرى بالتنقيط

سامح عبد المنعم محمد موسى

محطة بحوث البساتين بالصبحية - معهد بحوث البساتين - مركز البحوث الزراعية – ج0م0ع0

أجريت تجربتين حقليتين على محصول البطاطا بإحدى المزارع الخاصة بمنطقة النوبارية 90 كم جنوب مدينة الإسكندرية – جمهورية مصر العربية وذلك بغرض التعرف على تأثير الرش بمضاد النتح الفوليكوت على الإنتاج الكلى للبطاطا وكفاءة إستخدام مياه الرى تحت نظام الرى بالتنقيط .

زرعت شتلات الصنف الأمريكى المنشأ بيوريجارد بدءا من شهر مايو لعامى 2009 ، 2010 على التوالى ، هذا وقد تم جمع محصول الجذور عند عمر 110 يوما خلال موسمى الزراعة .

نفذت أربعة مستويات لمياه الرى وهى :- 2640 م^3 / فدان (الكمية الشائعة الإستخدام فى تلك المنطقة من قبل المزارعين) ، 2360 م^3 / فدان ، 2080 م^3 / فدان ، 1800 م^3 / فدان . كذلك رشت نباتات البطاطا بالفوليكوت حيث تم تطبيق أربعة تركيزات وهى : صفر ، 5 % ، 10 % ، 15 %. علما بأن الرش لكل تركيز تم ثلاثة مرات عند أعمار 40 ، 60 ، 80 يوم من زراعة الشتلات .

أستخدم فى تطبيق التجربتين نظام القطع المنشقة فى تصميم القطاعات الكاملة العشوائية ،وذلك بثلاث مكررات ، حيث وزعت عشوائيا معاملات الرى على القطع الرئيسية ،بينما معاملات تركيزات الفوليكوت فوزعت على القطع تحت الرئيسية .

أهم النتائج المتحصل عليها:

- كان لإزدياد معدلات الرى تأثير إيجابى بشكل عام على كل من الصفات الخضرية المدروسة والمحصول ومكوناته .
- أدت زيادة تركيز الرش بالفوليكوت من صفر الى15 % الى إزدياد قوة النمو الخضرى لنباتات البطاطا واتضح ذلك من خلال صفات طول النبات ،وعدد الفروع ،ووزن العرش الأخضر .
- لم يكن لتركيزات الفوليكوت تأثير معنوى على صفتى عدد الجذور / نبات ،و متوسط وزن الجذر / نبات .
- إرتفعت كمية محصول الجذور (طن/ فدان) وزاد كل من عدد الجذور الصالحة للتسويق / نبات ،وكمية المحصول الصالح للتسويق (طن / فدان) مع إزدياد تركيز الفوليكوت من صفر الى 15 % .
- لم يكن هناك أى تأثير معنوى نتيجة للتداخل بين معاملات الرى وتركيزات الفوليكوت على كل الصفات المدروسة مما يبرهن على أن تأثير هذا التداخل قد سار فى إتجاه واحد مع الإختلافات فى معدلات الرى وتركيزات الفوليكوت .
- دلت النتائج على زيادة كفاءة إستخدام مياه الرى بزيادة تركيز الفوليكوت من صفر الى15 % مما يبرز دور الفوليكوت فى تقنين إستخدام مياه الرى .
- إتضح من النتائج أنه يمكن بإستخدام الفوليكوت رشا على نباتات البطاطا بتركيز 15 % تقليل كمية مياه الرى المستعملة بنسبة 10,61 % من الكمية الكنترول (التى إعتاد المزارعون إستهلاكها فى هذه المنطقة) وفى نفس الوقت للحصول على كمية أعلى من محصول البطاطا ،ومن ثم يوصى البحث بإستخدام مادة الفوليكوت كإحدى مضادات النتح رشا على المجموع الخضرى لنباتات البطاطا ثلاث مرات عند أعمار 40 ، 60 ، 80 يوم من زراعة الشتلات للحصول على إنتاج عالى مع ترشيد إستخدام مياه الرى لأقل كمية ممكنة .

قام بتحكيم البحث

أ.د / سمير طه العفيفى — **كلية الزراعة – جامعة المنصورة**

أ.د / السعيد لطفى السيد — **مركز البحوث الزراعية**

Table (5): Effect of irrigation quantities, Folicote concentrations and their interaction on total tuber root yield and its component characters during the two years of the study.

Treatments	Year of 2009					Year of 2010				
	Total yield (ton/fed.)	tuber root No./ plant	Aver. Tuber root weight /plant (Kg)	No. of mark. roots/pl.	Mark. yield (ton/fed.)	Total yield (ton/fed.)	tuber root No./ plant	Aver. Tuber root weight /plant (Kg)	No. of mark. roots/pl.	Mark. yield (ton/fed.)
Irrigation quantities										
2640 m^3/fed.	19.00 a	6.23 a	0.152 ab	4.92 a	18.80 a	20.6 a	6.28 a	0.164 a	4.50 a	17.20 a
2360 m^3/fed.	17.02 b	5.27 a	0.161 a	4.00 b	13.60 b	17.40 b	5.82 ab	0.149 a	3.83 b	16.60 a
2080 m^3/fed.	14.52 c	5.95 a	0.122 b	3.39 b	13.00 b	15.00 c	5.14 b	0.146 a	3.17 c	13.00 b
1800 m^3/fed.	10.42 d	5.95 a	0.087 c	2.50 c	8.00 c	9.60 d	6.34 a	0.076 b	2.78 c	6.80 c
Folicote concentrations										
15 % Folicote	17.56 a	6.39 a	0.137 a	4.55 a	15.00 a	17.00 a	6.23 a	0.136 a	3.97 a	15.00 a
10 % Folicote	16.16 b	6.06 a	0.133 a	4.36 a	13.80 a	16.00 b	5.59 a	0.143 a	3.75 ab	14.40 a
5 % Folicote	14.26 c	5.16 a	0.138 a	3.39 b	12.00 b	15.20 c	6.19 a	0.123 a	3.47 bc	13.00 b
0 % Folicote	12.94 d	5.75 a	0.113a	2.50 c	10.80 b	14.40 d	5.30 a	0.135 a	3.08 c	11.40 c
Irrigation quantities X Folicote concentrations Interaction										
2640 m^3/fed.										
15 % Folicote	22.20 a	7.18 a	0.154 a	5.78 a	20.60 a	21.80 a	7.07 a	0.154 a	5.22 a	19.00 a
10 % Folicote	20.00 a	6.53 a	0.153 a	5.33 a	19.40 a	21.20 a	6.5 a	0.163 a	5.00 a	18.60 a
5 % Folicote	17.14 a	5.83 a	0.147 a	4.33 a	15.20 a	20.40 a	6.10 a	0.167 a	4.22 a	18.00 a
0 % Folicote	16.60 a	5.61 a	0.148 a	4.00 a	13.20 a	19.00 a	5.62 a	0.169 a	3.56 a	14.00 a
2360 m^3/fed.										
15 % Folicote	19.87 a	6.07 a	0.164 a	5.33 a	14.80 a	20.00 a	5.39 a	0.185 a	4.00 a	18.40 a
10 % Folicote	17.87 a	5.95 a	0.150 a	5.11 a	13.80 a	17.40 a	5.47 a	0.159 a	3.89 a	17.00 a
5 % Folicote	15.87 a	4.72 a	0.133 a	3.33 a	13.20 a	17.20 a	6.36 a	0.135 a	3.89 a	16.40 a
0 % Folicote	14.47 a	4.28 a	0.169 a	2.22 a	12.60 a	15.60 a	5.61 a	0.139 a	3.55 a	14.60 a
2080 m^3/fed.										
15 % Folicote	16.58 a	5.78 a	0.143 a	3.89 a	14.80 a	16.00 a	5.26 a	0.152 a	3.67 a	14.60 a
10 % Folicote	15.80 a	5.94 a	0.133 a	3.78 a	13.40 a	15.20 a	5.13 a	0.148 a	3.11 a	13.80 a
5 % Folicote	13.66 a	4.44 a	0.154 a	3.44 a	12.40 a	14.60 a	5.08 a	0.144 a	3.00 a	12.80 a
0 % Folicote	12.07 a	7.72 a	0.078 a	2.44 a	11.60 a	14.00 a	4.17 a	0.168 a	2.89 a	11.00 a
1800 m^3/fed.										
15 % Folicote	11.67 a	6.66 a	0.088 a	3.22 a	9.60 a	10.40 a	7.18 a	0.072 a	3.00 a	8.00 a
10 % Folicote	11.00 a	6.14 a	0.089 a	3.00 a	9.00 a	9.80 a	5.49 a	0.089 a	3.00 a	7.80 a
5 % Folicote	10.52 a	5.62 a	0.093 a	2.44 a	7.60 a	9.20 a	7.29 a	0.063 a	2.78 a	5.60 a
0 % Folicote	8.64 a	5.37 a	0.080 a	1.33 a	6.00 a	9.00 a	5.67 a	0.079 a	2.33 a	6.00 a

Means having an alphabetical letter in common, within a comparable group of means, do not significantly differ from each other, using Duncan's multiple range test procedure at p= 0.05 level of significance.

Table (6): Effect of irrigation quantities, Folicote concentrations and their interaction on tuber root quality characters during the two years of the study.

Treatments	Year of 2009					Year of 2010				
	tuber dry matter (%)	carotene mg/100g	reducing sugars (%)	non reducing sugars (%)	starch (%)	tuber dry matter (%)	carotene mg/100g	reducing sugars (%)	non reducing sugars (%)	starch (%)
Irrigation quantities										
2640 m^3/fed.	29.18 a	5.10 bc	3.95 a	2.09 a	16.62 b	27.10 a	5.16 ab	4.20 b	1.64 a	14.22 a
2360 m^3/fed.	28.40 b	5.45 a	3.95 a	2.20 a	17.27ab	26.03 b	4.85 b	4.35 b	1.62 a	12.70 c
2080 m^3/fed.	27.57 c	5.41 ab	3.94 a	2.06 a	18.18 a	24.47 c	4.85 b	4.67 a	1.66 a	12.68 c
1800 m^3/fed.	26.47 d	4.89 c	3.99 a	2.08 a	18.15a	23.77 d	5.47 a	4.72 a	1.58 a	13.50 b
Folicote concentrations										
15 % Folicote	28.21a	5.16 a	3.99 a	1.91 a	18.67 a	25.85 a	5.20 a	4.49 a	1.75 a	12.45 d
10 % Folicote	28.08a	5.19 a	3.99 a	2.23 a	18.02 a	25.54ab	5.03 a	4.61 a	1.69 ab	12.87 c
5 % Folicote	27.82ab	5.23 a	3.86 a	2.28 a	17.02 b	25.07bc	5.24 a	4.29 a	1.60 b	13.50 b
0 % Folicote	27.52b	5.26 a	4.01 a	2.01 a	16.50 b	24.91 c	4.88 a	4.55 a	1.47 a	14.29 a
Irrigation quantities X Folicote concentrations Interaction										
2640 m^3/fed.										
15 % Folicote	29.60 a	5.31 a	4.35 a	1.75 a	17.86 a	27.67 a	5.45 a	4.22 a	1.37 a	12.83 a
10 % Folicote	29.43 a	4.75 a	3.95 a	2.12 a	17.23 a	27.37 a	5.12 a	4.12 a	1.47 a	13.80 a
5 % Folicote	28.97 a	5.26 a	3.62 a	2.62 a	15.83 a	26.07 a	5.28 a	4.09 a	1.87 a	14.87 a
0 % Folicote	28.73 a	5.09 a	3.89 a	1.88 a	15.53 a	26.67 a	4.81 a	4.22 a	1.87 a	15.4 a
2360 m^3/fed.										
15 % Folicote	28.67 a	5.17 a	3.95 a	2.05 a	18.07 a	26.56 a	4.87 a	4.15 a	1.50 a	12.37 a
10 % Folicote	28.53 a	5.49 a	4.02 a	2.22 a	17.53 a	26.43 a	4.65 a	4.39 a	1.70 a	12.50 a
5 % Folicote	28.10 a	5.30 a	3.75 a	2.55 a	17.16 a	25.73 a	5.09 a	4.25 a	1.60 a	12.87 a
0 % Folicote	28.30 a	5.82 a	4.15 a	1.98 a	16.43 a	25.10 a	4.82 a	4.62 a	1.70 a	13.07 a
2080 m^3/fed.										
15 % Folicote	27.90 a	5.15 a	3.82 a	1.52 a	20.13 a	24.87 a	5.16 a	4.85 a	1.50 a	12.00 a
10 % Folicote	27.77 a	5.68 a	3.79 a	2.95 a	19.03 a	24.50 a	4.54 a	4.95 a	1.60 a	12.33 a
5 % Folicote	27.66 a	5.44 a	4.19 a	1.72 a	16.97 a	24.20 a	4.98 a	4.32 a	1.70 a	12.9 a
0 % Folicote	26.97 a	5.37 a	3.99 a	2.05 a	16.6 a	24.04 a	4.74 a	4.55 a	1.83 a	13.50 a
1800 m^3/fed.										
15 % Folicote	26.60 a	5.16 a	3.85 a	2.32 a	18.60 a	23.97 a	5.34 a	4.59 a	1.50 a	12.60 a
10 % Folicote	26.60 a	4.72 a	4.19 a	1.65 a	18.43 a	23.83 a	5.74 a	4.99 a	1.63 a	12.83 a
5 % Folicote	26.57 a	4.93 a	3.89 a	2.25 a	18.13 a	23.60 a	5.65 a	4.49 a	1.60 a	13.37 a
0 % Folicote	26.07 a	4.77 a	4.02 a	2.12 a	17.43 a	22.60 a	5.15 a	4.82 a	1.60 a	15.20 a

Means having an alphabetical letter in common, within a comparable group of means, do not significantly differ from each other, using Duncan's multiple range test procedure at p= 0.05 level of significance.