EFFECT OF IRRIGATION SCHEDULING ON YIELD, QUALITY AND FUNCTIONAL PROPERTIES OF POTATO TUBERS

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ABSTRACT

*Potato growth, yield, and quality are important parameters under scheduling of surface irrigation using gated pipes to evaluate water management in Nile valley soils. A field experiment was conducted during 18 Jun.-20 May 2015 spring growing season using potato (Solanum tuberosum) grown in northern Egypt at Qusina, Minoufia, Egypt to study potato response, quality and functional properties to different irrigation scheduling levels. A Randomized Split-Plot Design with irrigation scheduling treatments as irrigation levels 75, 60 and 45% from available water and water cutoff times when water flow was reached the field end (after 5 min, exactly reached and before 5 m) were randomly distributed. Non-uniformity of irrigation applications were evaluated along irrigation furrow as dependent variables measured at the (0–20), (20–40) and (40–60) m along 60 m irrigation line. Potato tuber yield and quality were significantly affected by irrigation levels (IL), water cutoff time (WCT) and distance from upstream end (D). Tuber yield, water use efficiency, dry matter percentage, percentage of tuber size grade and yield of chips were significantly affected by IL, WCT and D, and their interaction IL*WCT; WCT*D; IL*D and IL*WCT*D except percentage of tuber size which was non-significantly affected at medium size by (WCT) and large size by interaction IL*WCT*D. The highest tuber yield was under treatment irrigation level of 75% from AW and when water flow was exactly reached the field end. Improving quality and saving water were under both irrigation level of 45% AW and water cutoff before reaching 5 m from downstream end.*

Keyword: *surface irrigation; gated pipes; quality and functional properties; tuber yield, water use efficiency, dry matter percentage, percentage of tuber size grade and yield of chips.*

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1. INTRODUCTION

The cultivated area of old land is about 2.7 million hectares irrigated by surface irrigation from total cultivated area of 3.9 million hectares according to data issued by Ministry of Agriculture, Egypt in 2013. Despite this progressive water shortage farmers continue to use surface irrigation. Poor management, uniformity and distribution of water have been cited as the most frequent problems of surface irrigation, resulting in waterlogging, salinization and less water use efficiency AbouKheira (2009). Potato is considered one of the main important vegetable ranks as manufacture and export crop among the different vegetable crops in Egypt. About 178 thousand hectares are only cultivated in spring, fall and winter seasons. Total production of potato in Egypt is about four million tons per year.

Bosnjak and Pejic (1997) working on Potato which were given irrigation to 75-80 or 60-65% field water capacity (FWC) or without irrigation (control). They found that the yields were highest in the 75-80% FWC treatment compared to control treatment. Podstawka and Malicki (1997) recorded that average tubers yield was 40.1 t/ha without irrigation and 47.4 t/ha with irrigation. Aksic et al. (2012) grew potato plants under different irrigation rates, i.e., irrigated by three treatments with irrigation (soil matrix potential of 20, 30 and 40 kPa) as well as control. Irrigation schedule was determined by tensiometers. They found that total yield increased with increasing irrigation rate.

El-Banna et al (2001) revealed that, specific gravity and percentage of tuber dry matter were significantly increased with decreasing irrigation water rates. On the contrary, Samey (2006) indicated that, specific gravity and percentage of tuber dry matter in two season were significantly increased with decreasing irrigation rates, i.e., irrigation by 50% of the evapotranspiration, compared with irrigation by 75, 100 and 125% of the evapotranspiration, while, the lowest value of water supply, i.e., irrigation by 125% of the evapotranspiration also, it ranged from 21.0 % to 23.5 %.

Karafyllidis et al (1996) found that, high soil moisture availability levels tended to give higher proportions of large tubers (> 60 mm), whereas, small tubers (< 35 mm) were more frequent in the water deficit treatments. The percentage of tubers 45 – 60 mm was inconsistent, but all treatments had similar proportions of tubers, but all treatments had similar proportions of tubers 35 – 45 mm.

Samey (2006) showed that the high level of water regimes (irrigation by 125% of evapotranspiration) led to an insignificant reduction weight after frying. Meanwhile, irrigation by 50% of evapotranspiration gave the highest value of weight after frying may be due to increasing dry matter content of potato tubers under this condition.

The purpose of the work is to find out the best management of the irrigation scheduling for surface irrigation with gated pipes to give the highest productivity, the best quality and functional properties of potato tubers.

2. MATERIAL AND METHODS

Field experiment was conducted in 2015 spring growing season using potato (Solanum tuberosum) grown in northern Egypt at Qusina area, 17.9 m above sea level, 30^{o} $56^{/}$ N, 31^{o} $15^{/}$ E, Minoufia, Egypt to study potato response, quality and functional properties to different irrigation scheduling levels. All treatments were irrigated each growing season with the same sufficient water amount using surface irrigation to ensure uniform soil moisture prior to planting. The crop was seeded when soil moisture content was almost 0.39 m^3 m^{-3} using potato planter on 18 January and terminated on 20 May in the 2015 spring season. A Randomized Split-Plot Design with irrigation scheduling treatments as irrigation levels (75, 60 and 45% from available water) and water cutoff times when water flow was reached the field end as (after 5 min, exactly reached and before 5 m) were randomly distributed. Non-uniformity of irrigation applications were evaluated along irrigation furrow as dependent variables measured at the (0–20), (20–40) and (40–60) m along 60 m irrigation line. The outside diameter of pipe is 6" and 6 m length as shown in Fig. 1. Pipe is made of UPVC with gates spacing 0.75 m. The flow rate out of each gate system is controlled by head inside the pipe to be 11.4 m^3/h with 22.86 cm head. Surface irrigation system using gated pipes was divided into three sectors to evaluate the best parameters. Sub-plot area was 60 m length × 2.25 m width. Each plot was included three furrows with 0.75 m furrow width. A distance of 1.5 m was between each irrigation treatments. In the gated pipes technique, the pipes were located at the head of the irrigated field across the furrows.

Three irrigation levels 75, 60 and 45% from available water were used with three different water cutoff times in which water flow reached downstream end as 5 min after, exactly reached and before 5 m.

The soil was clay in texture. The properties of the soil were shown in Table 1.

The seed tubers of coefficient of variation, Herms were imported from abroad (Scotland UK) was showed at Table 2.

Table 1.The physical properties of the experimental soil.

Soil depth	Sand	Silt	Clay	Texture class	Bulk density $g \cdot cm^{-3}$	Field capacity %	Permanent wilting point %	Available soil water %
0–20	20.27	41.17	38.56	Clay loam	1.29	42.45	21.90	20.55
20-40	20.80	40.51	38.69	Clay loam	1.31	40.95	20.45	20.50
40-60	17.32	36.75	45.93	Clay	1.33	38.89	19.14	19.75

Table 2. Label of using potatoes

Variety	Crop No	Grade	Class	Date	Size
Hermes	87813	EC2	SE2 FG 4	27/11/2014	35/60mm

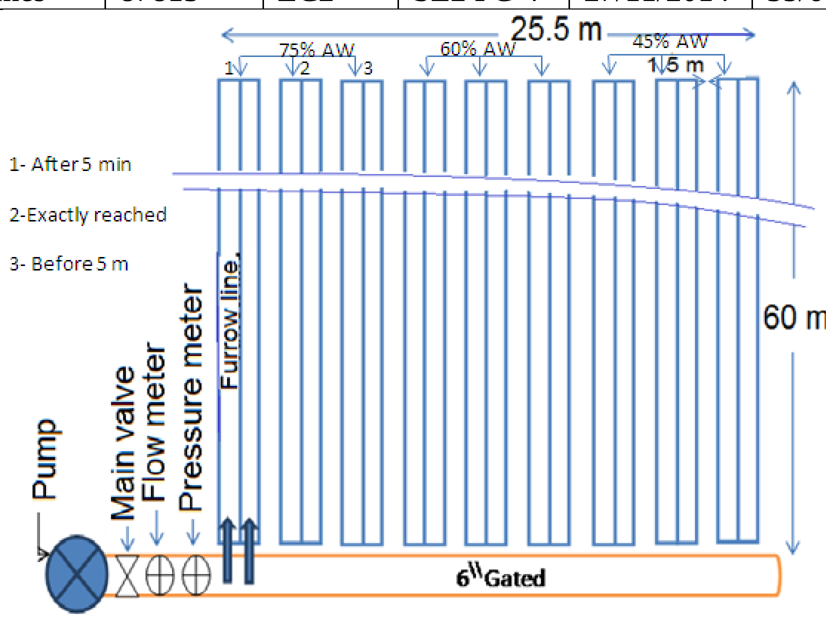

Fig.1. Layout of experimental replicate

The average weight of the tubers ranged from 40-50 g/tuber. The potato tuber seeds were cured and planted 0.25 m apart in furrow 60 m in long and 0.75 m in width. All cultural practices as well as diseases and pests control applied as recommended by the Egyptian Ministry of Agriculture. All experimental units received identical amounts of composted animal manure (75 m^3/ha) and phosphorus (200 kg/ha) using single a calcium super phosphate (15.5 % P_2O_5) banded on furrow before planting with agricultural sulfur (300 kg/ha SO_4). Nitrogen fertilizer was added at the rate of 400 kg N/ha at four times, planting, first irrigation, and 45 and 60 days from planting, respectively.

Water advance and recession times were functioned of their length at the second irrigation for the mentioned treatments by using field marks and surveying tape, the furrows were divided into number of six stations having equal distances between them (10 m). Irrigation water advance times into the furrow were recorded at the end of each station. At the upstream end when water started to disappear, recession times were observed and recorded at each station. This mark is the initiation of the water drying or recession front.

The water infiltration opportunity time along furrow length is the difference between the last time when water disappeared and the first time when water started to advance at the same point along furrow. It can be determined according to Amer (2009) as formulated in equation.

$$t_o = T + t_r - t_\ell \qquad (1)$$

where t_o is opportunity infiltrated time into the root zone in minute, T is total time of advance, storage, and depletion phases that started from water turn on and ended when the water at the upstream end disappeared in minutes, t_ℓ is advance time in min and t_r is recession time in min.

The rate of infiltration was considered as a time dependent process and represented by Kostiakov's equation. Field infiltration rate in soil (I) that was measured in the upper 30 cm of soil surface using double ring infiltrometer in the beginning of the experiment. Water infiltration rate was determined according to Kostiakov equations (2 and 3) were found in the experimental field. It was functioned to opportunity time to in minute for the clay soil as:

$$I = 5.75\, t_o^{-0.401} \qquad (2)$$

Cumulative infiltrated depth Z in mm was integrated from infiltration rate function and reported as

$$Z = 9.599\, t_o^{0.599} \qquad (3)$$

where Z in mm and t_o in min.

To evaluate the furrow irrigation treatments, the distribution uniformity was taken as a function of coefficient of variation (CV) can be determined according to Amer (2010) as follows:

$$DU = 1 - 1.27\, CV \qquad (4)$$

Application efficiency (E_a) was determined as the ratio of water stored in the rootzone to the total water applied when no runoff occurred in blocked furrow. In non uniformity condition, E_a can be determined according to Amer (2010) as follows:

$$E_a = 1 - \frac{(1.725 - \alpha)^2}{6.9}\, CV \qquad (5)$$

In complete surplus irrigation, E_a can be determined be as follows:

$$E_a = 1 + \alpha\, CV \qquad (6)$$

The schedule parameter was (α) determined from the following equation (Amer, 2007):

$$\alpha = \frac{1}{CV}\left(\frac{d}{\bar{Z}} - 1\right) \qquad (7)$$

where

d was the schedule depth which was taken equal to the minimum infiltrated depth (Z_{min}) in mm and $\bar{Z}$ was the average infiltrated depth along the strip or the furrow in mm.

Potato yield produced each experimental per unit volume of the used water (kg yield / m^3 water) was evaluated as water use efficiency. Tuber dry matter percentage (%) was determined by drying the tuber slices at 70 C^o according to method of Dogras et al. (1991). Percentage of tuber size grade was taken 10 kg using by sizing rings

Percentage of tuber size was divided into four parts which were called seeds <40 mm, small 40-60 mm, medium 60-80 mm, large >80 mm. Large and seeds tubers are not manufactured for chips. Yield of chips was determined using the method of Wilbur(1999) as the following equation was adopted:

$$\text{Yield of chips} = \frac{\text{Weight after frying (chips)}}{\text{Weight before frying (tubers)}} \times \text{yield of fresh tubers}\,\frac{\text{Mg}}{\text{ha}} \quad (7)$$

3. RESULTS AND DISCUSSIONS

3.1. Infiltrated irrigation depth and uniformity along furrow

Results shown in Table 3 represent scheduling and evaluation parameters for all nine studied treatments. Depletion phase time was decreased as both water cutoff decreased and initial available soil water increased because the storage water on furrow ditch and soil infiltration rate were, respectively, smaller than those occurred in cutoff time after 5 min from water advanced the downstream end and 75% AW treatments. A minimum infiltrated depth Z_{min} was occurred by applying 75% soil water regimes with water cutoff 5 m before water advanced the field end.

Table 3. Furrow irrigation scheduling by three Water cutoff times with three irrigation levels.

Evaluating parameters	Water cut off								
	After 5 min from the end			Exactly reached the end			Before 5 m from the end		
Soil AW*	75%	60%	45%	75%	60%	45%	75%	60%	45%
T_{off} (min)	13.35	17.033	20.1	10.16	13.25	16.51	9.41	12.81	16.15
T_d (min)	2.0	2.05	3.283	1.035	1.715	1.867	1.0	1.515	1.18
α	-0.013	-0.01	-0.006	-0.017	-0.017	-0.006	-0.021	-0.01	-0.018
Z_{min} (mm)	47.27	52.73	58.39	39.55	45.53	51.52	36.49	38.66	39.9
Z_{max} (mm)	83.36	83.83	85.29	43.63	57.38	59.31	40.69	59.29	51.01
$\overline{Z}$ (mm)	60.75	62.35	63.55	41.59	47.77	52.95	39.26	43.82	47.2
CV %	17.0	15.0	12.18	2.88	2.67	4.2	3.3	7.0	8.4
Du %	78.5	80.95	84.53	96.3	96.6	95.66	95.8	91.1	89.3
Ea %	77.8	84.6	91.89	94.8	95.1	97.11	92.94	88.2	84.5
I (d)	19	24	28	19	24	28	19	24	28

*AW is available water, T_{off} is water cutoff, T_d is depletion phase time, α is schedule parameter, Z_{min}, Z_{max}. $\overline{Z}$ are minimum, maximum and average infiltrated depths, respectively, CV is coefficient of variation, DU is distribution efficiency, E_a is application efficiency, and I is irrigation interval.

On the other hand, Z_{max} was insignificantly changed by 75% AW regime under water cutoff 5 min after water advanced field end treatment in which caused more water beyond rootzone. Z_{max} was decreased by 75% AW regime under both water cutoff exactly and 5 m before water advanced downstream end in which both treatments decreased water seepage beyond rootzone. For a given water cutoff time, average depth $\bar{Z}$ was optimized under both 60 and 45% AW regimes. Z_{min} was nearly equal to Z_{max} by water cutoff of exactly and before 5 m from water flow was reached the field end. Infiltrated depth was increased along furrow because total recession time was larger than total advance time and storage stage. For a given water cutoff time, coefficient of variation CV, DU and E_a were improved by 60 and 45% AW treatments. Irrigation interval (I) was decreased applying 70% AW and water cutoff after 5 min from reaching downstream end. Results showed that the best water distribution and application were acquired for water cutoff Levels as water flow exactly and before 5 m reached the field end. These results agreed with those obtained by Al-Kathiri (2009) and Amer (2009).

3.2 Potato fresh and chips yields, dry matter and water use efficiency

Data presented in Tables 4 and 5 showed significant differences among water cutoff times, irrigation levels and distances along furrow on tuber and chip yields, dry matter and water use efficiency. Results in Table 4 showed that the highest value of tuber and chips yields, dry matter and water use efficiency were occurred under both water cutoff before 5 m water advancing to downstream end and 75% AW, except dry matter which occurred under 45% AW treatment.

Regarding the interactions effect of both irrigation levels and water cutoff levels, data presented in table (4) showed significant differences yield the interactions effect between (irrigation levels and sample distances), (water cutoff levels and sample distances) and (irrigation levels, water cutoff levels and sample distances) that results showed that the interactions were significant.

Similar results were obtained by Amer (2011) on squash, reported that total yield increased under high level of soil moisture. El-Banna et al (2001), Alva et al (2002), Kashyap and panda (2003), Samey (2006) and Amer et al (2016) all of them on potato, they found that total tubers yield was significantly increased with increasing water supply and they reported that percentage of tubers dry mater was significantly increased with decreasing soil moisture and irrigation water rates ,also similar results were obtained by Gunnel and Karadogan (1998) and Samey (2006) on potato reported that, yield of chips was significantly increased as water rates decreased that may be due to increasing dry matter, specific gravity and starch contents of potato tubers.

Table 4. Means and standard errors for tuber yield

Items	Mean ± SE			
	Yield (Mg/ha)	WUE (kg/m^3)	Dry matter %	Chip yield (Mg/ha)
Water cutoff time (T)				
5 min after downstream end	49.61±0.125^A	13.61±0.093^A	21.09±0.034^A	16.51 ± 0.11^A
Exactly reached downstream	51.02±0.125^B	15.99±0.093 ^{B}	21.66±0.034^B	17.45 ± 0.11^B
before 5 m from downstream	53.09±0.125^C	17.02±0.093 ^{C}	21.84±0.034^C	18.3 ± 0.11^C
Irrigation Level (I)				
75% AW	58.01±0.125^C	15.89±0.093^B	21.22±0.034^A	19.5 ± 0.11^C
60% AW	51.37±0.125^B	15.45±0.093^A	21.52±0.034^B	17.5 ± 0.11^B
45%AW	44.34±0.125^A	15.3±0.093^A	21.86±0.034^C	15.3 ± 0.11^A
Distance along furrow (D)				
0-20m of furrow length	48.26±0.125^A	14.6±0.093^A	21.52±0.034^A	16.45 ± 0.11^A
20-40 m of furrow length	57.79±0.125^B	17.5±0.093^B	21.61±0.034^B	19.66 ± 0.11 ^{B}
40-60 m of furrow length	47.66±0.125^A	14.51±0.093^A	21.46±0.034^A	16.16 ± 0.11^A

*Significant at the p ≤0.05 level& NS = non- significant

Table 5. Mean square, F value and probability for fresh tubers yield

Items	df	**Mean square**				**F value and probability**			
		Yield Mg/ha	WUE Kg/m^3	Dry matter %	Chip yield Mg/ha	Yield Mg/ha	WUE Kg/m^3	Dry matter %	Chip yield Mg/ha
Cutoff (T)	2	82.82	82.43	4.13	21.5	69.01*	701.1*	265.5*	131.3*
Irrigation (I)	2	1261.1	2.732	2.74	120.8	1050.8*	23.23*	176.3*	735.3*
Distance (D)	2	873.7	76.49	0.157	102	728.04*	650.5*	10.10*	621.1*
I * T	4	269.9	24.90	0.057	30.1	224.9*	211.8*	3.65*	183.6*
I * D	4	137.0	9.736	0.239	14.1	114.2*	82.8*	15.36*	86.1*
T * D	4	98.51	8.969	1.007	11.1	82.09*	76.3*	64.75*	68.11*
I * T* D	8	94.75	9.376	0.088	11.1	78.96*	79.8*	5.63*	67.60*
Exp. Error	54	1.2	0.118	0.016	0.164				

3.6. Percentage of tuber size.

Percentage of tuber size was significantly affected by 2015 spring season as presented in Tables 6 and 7. Data presented in Table 6 showed significant differences percentage of tuber size between three water cutoff times on percentage of tuber size. Data presented in table 7 showed significant between all water cutoff times with four parts of tuber size.

High yield percentage of seed tubers (culls) was at water cutoff 5 min from water advanced to downstream end and it was at 45% from AW and it was at the third part from the furrow. The low and best values were at water cutoff before water flow was reached the field end for 5 m and it was at 75% from AW and it was at the second part from the furrow.

Secondly, about small tuber, it showed that the highest value was at water cutoff after water flow was reached the field end for 5 min and was at 45% from AW. The lowest value was at water cutoff before water flow was reached the field end for 5 m and was at 75% from AW.

Thirdly, about medium tuber, it showed non-significant between all Water cutoff Levels, they were nearly equal. It showed that the highest and best value at 75% from AW, and the lowest value was at 45% from AW.

Fourthly, about large tuber, the highest value was recorded as 9.98%at water cutoff when water flow was reached the field end, and the lowest value was recorded as 7.16% at water cutoff before water flow was reached the field end for 5m. Results percentage of tuber size was better under conditions of low water supply.

Regarding the interactions, data presented in table (6) showed significant differences percentage of tuber size the interactions effect between (irrigation levels and Water cutoff levels), (irrigation levels and sample distances) and (irrigation levels, Water cutoff levels and sample distances), and it showed non-significant between Water cutoff levels and sample distances.

Similar results were obtained by Amer (2011) on squash reported that, the percentage of large size increased with increasing soil moisture. El-Banna et al (2001), Samey (2006) and Amer et al (2016) all of them on potato, they reported that percentage of large tubers size was significantly increased as water rates increased and percentage of tuber seeds were significantly increased as soil moisture and water rates decreased .

Table (6): Mean square, F value and probability for fresh tubers size

Items	Df	seeds%		small%		medium%		large%	
		Mean	F	Mean	F	Mean	F	Mean	F
Cutoff time (T)	2	316.8	63.5*	352.5	46.8*	7.5	1 ns	53.6	9.8*
Irrigation Level (I)	2	927.3	186*	695.1	92.4*	1470.7	199.5*	330.9	60.8*
Distance(D)	2	199.7	40*	190.2	25.2*	184.6	25*	19.2	3.5*
I*T	4	187.4	37.6*	57.1	7.5*	44.7	6*	18.5	3.4*
I*D	4	38.4	7.7*	113.3	15*	98.6	13.4*	23.4	4.3*
T*D	4	26.9	5.4*	35.1	4.6*	59.6	8.1*	3.2	0.6 ns
I*T*D	8	13	2.6*	24.1	3.2*	37.4	5.1*	31.3	5.7*
Exp. Error	54	4.9		7.5		7.3		5.4	

Table (7): Means and standard errors for tubers size

Items	Mean ± SE			
	Seeds%	Small%	Medium%	large%
Water cutoff Level				
After 5min	16.08 ± 0.6 C	23.77 ± 0.74 A	51.45 ± 0.74 A+	8.68 ± 0.63 B
Exactly reached	11.46 ± 0.6 B	26.45 ± 0.74 B	51.99 ± 0.74 A+	9.98 ± 0.63 C
Before 5 m	9.4 ± 0.6 A	30.92 ± 0.74 C	52.51 ± 0.74 A+	7.16 ± 0.63 A
Irrigation Level				
75% AW	7.08± 0.6 A	22.5± 0.74A	58.13± 0.74C	11.6± 0.63 C
60% AW	10.2± 0.6 B	26.19± 0.74B	54± 0.74B	9.4± 0.63 B
45%AW	18.9± 0.6 C	32.5± 0.74C	43.8± 0.74A	4.75± 0.63 A
Sample distance				
0-20 m from furrow	12.18 ± 0.6 B	30.09 ± 0.74 B	49.9 ± 0.74 A+	7.8 ± 0.63 A
20-40 m from furrow	9.6 ± 0.6 A	25.8 ± 0.74 A+	54.93 ± 0.74 B	9.5 ± 0.63 B
40-60 m from furrow	15.09 ± 0.6 C	25.23 ± 0.74 A+	51.1 ± 0.74 A+	8.5 ± 0.63 AB

*Significant at the $p \leq 0.05$ level &ns = non- significant.

4. CONCLUSION

Yield of fresh potato was significantly increased with increasing soil moisture content. At water cutoff level, the highest value was recorded as 53.088 Mg/ha at water cutoff before water flow was reached the field end for 5 m. About irrigation level, the highest value was recorded as 58.0 Mg/ha at 75% from available water

The highest value of water use efficiency was recorded as 17.018 kg/m^3 at water cutoff 5 m before water advanced the field end. For a given irrigation cutoff, the highest value was recorded as 15.89 kg/m^3 at 75% from available water.

The highest value of dry matter and specific gravity for potato tubers were obtained under 45% soil available water. Furthermore, the highest value of dry matter for potato tubers was obtained under water cutoff before 5 m water advanced to downstream end.

The best values for manufacturing potato chips were at low level of water supply which is water cutoff 5 m before water advanced downstream end because it had low values from Large and seeds tubers.

Chips yield was significantly decreased by increasing water cutoff level and the highest value was recorded as 18.3 Mg/ha at water cutoff at before 5 m water advanced the field end. For a given irrigation regimes, chips yield was significantly increased with increasing soil moisture content and the highest value was recorded as 19.5 Mg/ha at 75%from available water. The best values of potato tuber yield and quality were in furrow location in between 20 to 40 compared to the obtained results from 0 to 20 m and 40 t0 40 m furrow locations.

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الملخص العربي

جدولة الري و تأثيرها علي خواص المحصول والجودة والتصنيع لدرنات البطاطس

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أجريت هذه الدراسة خلال موسم ٢٠١٥ الربيعي للبطاطس وذلك بمنطقة قويسنا بشمال مصر بتربة طينية لدراسة تأثير جدولة الري باستخدام نظام الري السطحي بالخطوط مزودة بالأنابيب المبوبة وذلك على خواص محصول البطاطس وجودة الدرنات وجودة تصنيعها على هيئة شرائح شيبسي ، أجريت هذه الدراسة على صنف بطاطس هيرمس باستخدام تقاوي مستوردة من إسكتلندا حيث تمت الزراعة باستخدام درنات التقاوي وكان متوسط وزن الدرنة من ٤٠-٥٠ جرام تقريبا وكانت الزراعة في خطوط وكان طول الخط ٦٠ مترا والمسافة بين الخطوط ٧٥ سم والمسافة بين النباتات ٢٥ سم وتمت الزراعة في التاسع عشر من شهر يناير لموسم ٢٠١٥. تم إضافة الأسمدة العضوية والكيماوية طبقا لتوصيات وزارة الزراعة أثناء موسم النمو.

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اشتملت التجربة على دراسة:

١- تأثير ثلاث مستويات للري عند وصول رطوبة التربة إلى ٧٥ ، ٦٠ ، ٤٥% من الماء المتاح بالتربة.

٢- تأثير مستويات قطع المياه عن الخط وهم قطع المياه عند وصول موجة المياه إلى (قبل نهاية الخط ب ٥ م وعند وصولها إلى نهاية الخط مباشرة وبعد وصولها لنهاية الخط ب ٥ دقائق).

٣- تأثير مكان أخذ العينة على طول الخط على صفات النمو وخواص الجودة وتصنيع الدرنات.

٤- تأثير التفاعل بين الفترة بين الريات وزمن إضافة المياه داخل الخط وأماكن أخذ العينة.

تم قياس الاختلافات بين معاملات الري كالآتي:

- إنتاجية الدرنات:

الإنتاجية زادت معنويا بزيادة المحتوى الرطوبي للتربة. تأثير مستويات قطع المياه أعطت أعلى أنتاجية سجلت ٥٣.٠٨٨ ميجا جرام/هكتار عند قطع المياه قبل وصول موجة المياه لنهاية الحقل. أما بالنسبة لمستويات الري فقد أعطت أعلى قيمة سجلت ٥٨.٠٠٧ ميجا جرام/هكتار عند ٧٥% من الماءالمتاح. وأيضا عند التفاعل بين زمن الري والفترة بين الريات كانت أفضل قيمة ٥٨.٧٥ ميجا جرام/هكتار عند مستوى ري ٧٥% من الماء المتاح و مستوى قطع الماه عند وصول موجة المياه لنهاية الحقل. وأقل قيمة سجلت ٣٩.٣ ميجاجرام/هكتار عند مستوى ري ٤٥% من الماء المتاح و مستوى قطع للماء بعد وصول موجة المياه لنهاية الحقل ب ٥ دقائق.

- كفاءة استخدام المياه:

أعلى قيمة سجلت كانت ١٧.٠١٨ كجم/م٣ عند مستوى قطع للماه قبل وصول موجة المياه لنهاية الحقل ب ٥ متر. وأيضا أعلى قيمة سجلت ١٥.٨٩ كحم/م٣ عند مستوى ري ٧٥% من الماء المتاح بالتربة. أفضل وأعلى قيمة لكفاءة استخدام المياه كانت ١٩.١٢ كحم/م٣ عند مستوى ري ٤٥% من الماء المتاح و مستوى قطع للماه قبل وصول موجة المياه لنهاية الحقل ب ٥ متر. وأقل قيمة لكفاءة الاستخدام كانت ١٢.٧٥ كجم/م٣ عند مستوى ري ٤٥% من الماء المتاح و مستوى قطع للماه بعد وصول موجة المياه لنهاية الحقل ب ٥ دقائق.

- جودة الدرنات:

أفضل قيمة لنسبة المادة الجافة والوزن النوعي لدرنات البطاطس كانت عند مستوى ري ٤٥% من الماء المتاح و مستوى قطع للماه قبل وصول موجة المياه لنهاية الحقل ب ٥ متر. نسبة حجم الدرنات وتم تقسيمها إلى ٤ أجزاء وسميت بذور (40 mm>) و صغيرة (60mm - 40) و متوسطة من (60-80 mm) وكبيرة من (80 mm <) وبصفة عامة درنات البذور (بلية) والكبيرة لا تدخل في تصنيع الشيبسي. ونجد أن الدرنات المتوسطة والكبيرة تزيد معنويا بزيادة المحتوى الرطوبي للتربة. والدرنات الصغيرة تقل معنويا أيضا بزيادة المحتوى الرطوبي. أما

تأثير زمن الري على نسبة حجم الدرنات المتوسطة كان غير معنويا على جميع مستويات زمن الري. وأفضل قيم لبطاطس التصنيع كانت عند أفضل مستوى لإضافة المياه عند قطع المياه قبل وصول موجة المياه لنهاية الخط ب ٥ متر وذلك لأن نسبة الدرنات الكبيرة والبذور أقل قيمة.

- الخواص التصنيعية للدرنات وإنتاجية الشيبسي

إنتاجية الشيبسي تقل معنويا بزيادة مستوى قطع المياه وأعلى قيمة سجلت ١٨.٣ ميجا جرام/هكتار عند قطع المياه قبل وصول موجة المياه لنهاية الحقل ب ٥ متر. وأيضا تزيد الإنتاجية بزيادة المحتوى الرطوبي للتربة أي بزيادة مستوى الري وأعلى قيمة سجلت ١٩.٥ ميجا جرام/هكتار عند ٧٥% من الماء المتاح للتربة. أفضل قيم من نمو المحصول وإنتاجية الدرنات وجودتها كانت عند الجزء الثاني من طول الخط أي على مسافة من ٢٠-٤٠ متر من خط الري مقارنة ببداية الخط ونهايته أي جزئين من٠ -٢٠ متر ومن ٤٠-٦٠ متر.