Minufiya J. Agric. Res. Vol.38 No. 5: 1031 - 1039 (2013) **"http://www.mujar.net"**

EVALUATING PHYSICAL PROPERTIES OF POTATO BY DIFFERENT WATER IRRIGATION

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(Received : ၉၉Aug. 6 , 2013)

ABSTRACT: *Potato is a complete and cheap food and can be considered as a source of starch. One the most important things about potato from customer's point of view is it appearance. One of the most important factors that affect shape and other properties of potato is water irrigation prior to seeding. The physical properties of potatoes are necessary for the design of equipment to handle, transport, market, process, and store the crop. Thus through experiments at educational farm located in King Faisal University, KSA, in form of complete random tests, two treatments of water irrigation, traditional water, and treated water irrigation under drip irrigation, were divided and then tested. Through several experiments, the physical properties of potato measured such as shape dimensions, spherecity, surface area, firmness, and product performance (output) were measured and by a statistical analysis method were compared. In comparing products from traditional water irrigation and treated water irrigation being significant differences were observed in tubers dimensions and product performance, but for tubers quantity and tubers weight averages, the differences were significant, 102g±4.01 for traditional water and 93g±4.01 for treated water irrigation. Also, firmness for tubers was significant 5.9±0.08 Kg for treated water and 6.5±0.08 for traditional water irrigation. In comparing the traditional water irrigation and treated water irrigation for above mentioned factors, mostly the differences were significant.*

Key words: *Physical Properties, Potato, Water Irrigation, Treated water, Firmness, drip irrigation.*

INTRODUCTION

Among food products around the world, potato is the fourth well-known crop after wheat, rice and corn. It has been estimated that about 307 million tons of potato is produced all over the world (Fennir M.A. 2002). The population growth and limitation of farm lands has forced researchers to concentrate on mechanized production of potato (Rembeza J. 1993). Mechanization is consisted of land preparation, planting, cultivation, harvesting and also post-harvest practices which all have effect on the technical aspects of potato production (Spiess E. 1994).

In fact, every progress in mechanization has an impact on quantity and quality of potato production (Balbach, F, W. *et al.* 1992). One of the main objectives of tillage is to keep and maintain a high level of clod in soil, so that the roots could penetrate and develop better, maintain highest amount of water for plants consumption, surface soil particles would have more resistance to rainfall, preventing from soil hardening and allowing maximum moisture penetration, minimizing erosion caused by water-flow, and breakage of nutrients holding clods which are carried around by water. Also to increase the resistance of soil particle clods against compaction caused by wheels of trailers and other farm machineries and tillage practices (Richey C. B. *et al.* Carl W. Hall. 1961). There is no standard tillage system for preparing potato field, but low-tillage system which economizes time and energy consumption, and minimizes compaction is useful. The vast range of soils in which potato can grow and different proper plants remnants should be mixed with soil in order to help the planter work properly. The level of tillage needed depends on the type of soil and how the machinery can operate among plant remnants. Tillage practices should loosen the soil as much as possible so that the planter openers easily penetrate to the preferred depth and listers create a proper ridge using the loosened soil. The most common tillage practice is to put the plants remnants inside the soil by means of a moldboard plow during spring or summer and then breaking large clods by means of a disk harrow during spring. It is normal to use a spring-harrow to mix fertilizers with soil (Skorupinska A. *et al*. 1991).

Field preparation for planting is very important and therefore using a suitable tillage device can play an eminent role to do so. Three different tillage machines have been used in this experiment in order to find out which one is the best for preparing soil for planting potato.

The increase in demand for water resources in the world, especially in arid and semi-arid paying farmers to use less irrigation water quality, such as agricultural drainage water, groundwater and lower purity. The use of such lower quality water in the irrigation process during the crop growing season does not always give a highly productive crop. Is one of the appropriate applications to address water scarcity in such areas mentioned above, the mix of agricultural drainage water or lower quality groundwater with high-quality groundwater in certain proportions maintain salinity of irrigation water under the limit, which does not affect the growth and productivity of the crop (Oster, 1994; Abdel Gawad, and Ghaibeh, 2001).

Irrigation factor is one of the important factors in the production of potatoes and needs to be kyat codified enough during the growing season to avoid excessive loss of water.On the other hand found that the water needs of the potato under warm climatic conditions affected many deviation such as sprinkler irrigation or surface or drip. Abd El-Maksoud *et al* (1988) noticed that the efficiency of the use of drip irrigation water greater than those sprinkler irrigation. On the other hand, the method of drip irrigation is distinct from other methods because it reduces the running water on the soil as well as water evaporated, as well as drip irrigation reduces the risk of damage during service crop Baezzik or get rid of weeds, in addition to the possibility of using less chemical pesticides to combat with this method.

In a study by (Abdel Gawad, 2005) found that the tomato crop irrigation drip irrigation gave way more productive crop, compared with conventional surface irrigation method and better specifications. The method of drip irrigation has reduced the amount of water consumption compared with traditional surface irrigation method addition, it has contributed to provide fresh water for other crops are more sensitive to salt water. Meanwhile operations are creating soil for planting by using different machines of the most important processes affecting the agricultural soil characteristics and productive capacity as the quality and quantity of the crop planted. The process of tillage using different types of plows is the main process in the preparation of soil field of agriculture, taking into account the fact that the process of determining the type plow appropriate are often according to the soil type and its characteristics (Kepner, *et al*., 1978; Hunt, 1983 Alakukku, *et al* ., 2003).

The physical properties of sweet potato, like those of other agricultural materials such as fruits and vegetables are essential for the design of equipment for handling, harvesting, and storing the tubers or determining the behavior of the tubers for its handling. Various types of cleaning, grading and separation equipment are designed on the basis of the physical properties of the agricultural materials. Physical properties affect the converting characteristics of solid materials by air or water and cooling and heating load of food products (Sahay and Singh, 1994). It is therefore necessary to determine these properties. The properties of different types of grains, seeds, fruits and vegetables have been determined by other researchers such as (Baryeh, 2001; Bart-Plange & Baryeh, 2005; Sharma, Dubey and Teckchandani, 1985; Sreenarayanan,;; Dutta, Nema & Bhardwaj, 1988; Joshi, Das, & Mukherji, 1993; Deshpande *et al,* 1993; Suthar & Das, 1996; Gupta & Das, 1997, 1998; Jain & Bal, 1997; Aviara,; McClure & Morrow, 1987).

Since Saudi Arabia is one of the dry areas that suffer from lack of water needed for agriculture, so it was necessary to use alternative systems and modern irrigation and the use of sources other than traditional irrigation water and follow the appropriate ways to prepare the ground contribute to the provision of water for irrigation. And the aim of this study is evaluate the use of regular irrigation water and treated wastewater under drip irrigation system on physical and mechanical of potato tuber under conditions Al-hassa, Kingdom of Saudi Arabia.

MATERIALS AND METHODS

Study field has been done through two seasons agricultural 2011 and 2012 in one of the fields station training and agricultural research and veterinary King Faisal University using two types of irrigation water: the first is plain water (fresh) used to irrigate inside station training and other water drainage (processor) is supplied from outside the station's headquarters (according to the specifications approved by the Ministry of Agriculture). It was the use of drip irrigation system on two different depths. Transactions experiment included two irrigation water (normal and processor) drip irrigation system. Where the site was divided in which the experiments took place for the area of each basin (30 m × 30 m) and before starting work has been removed weeds and waste manually from the place prepared for experiments in this field.

Experiment was carried out in the field and will divide the land into two main pieces, where it is plowing then land settlement and then use the machine in a row after each transaction plowing and to bring it into line. Each piece was divided from those pieces into two equal to irrigate it by drip irrigation system as shown in Fig (1), one is told with plain water (fresh) and the other with water drainage (processor). Design and implementation of a drip irrigation network in place allocated in each piece of the experience. The deadline for planting potato tubers were planted in lines and the distances specified in each line so that close anagatat water as much as possible and then backfilling with soil by the method used in the cultivation of potatoes as shown in Fig (2). Irrigate the crop at specific intervals and quantities are codified by the recommendations of the water needs required for the potato crop. As well as fertilization and control needed for the study as recommended by the (Ministry of Agriculture and Water, 1425). 200 tubers were selected at random after harvest and the major (length), intermediate (width), and minor (thickness) diameters were measured in three mutually perpendicular directions using a venier caliper to a 0.01 mm accuracy. Several researchers (Edison & Boron, 1971; Mohsenin,1996; Tennes *et al*., 1969; McClure & Morrow,1987) have measured these dimensions for other fruits and vegetables in a similar manner to determine size and shape properties. The sphericity was calculated and geometric mean diameter using equation (1) the surface area using equation (2). Mass of tubers was measured with a sensitive electronic balance of 0.001g sensitivity.

Geometric mean diameter of tubers was calculated according to **(**Chakespari *et al*., 2010**)** as follows**:**

$$D_g = \sqrt[3]{LWT} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Dg Geometric mean diameter, mm;
L Length of tuber, mm;
D Width of tuber, mm.
T Thickness tuber, mm.

Surface area of tubers:

Surface area (S) was calculated by using the following equations:

$$S = \pi D^2{}_g \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Firmness:

Digital instrument for measuring penetration resistance were used to measure firmness, or degree of softness or crispness, which is used worldwide as a test of hardness of tubers

Fig.1. Drip irrigation system under study.

Fig.2. A growth of potatoes periods

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) and the treatment means were separated using Duncan's multiple range test at 5% probability level (Hinkelman and Kempthorne, 1994).

RESULTS AND DISCUSSION

1. Effect of water irrigation on physical properties of potato tubers:

The mean and standard error of the major, intermediate, and minor diameters and geometric mean diameter of tubers were presented in Table (1), under two treatments (plain water (fresh) and other water drainage) were calculated as: 83.2±1.44, 49.6±0.72, 41.1±0.58, 55.1±0.73 mm and 78.3±1.44, 46.5±0.72, 39.0±0.58, 52.0±0.73 mm, respectively. And results showed that mean square values for dimensions potato tubers and geometric mean diameter were presented in Table (3) for two treatments (plain water (fresh) and other water drainage) There were highly significant differences among tubers for width and thickness at ($P \leq 0.01$), but there were significant differences among tubers for length at ($P \leq 0.05$). The results showed mean square values for three dimensions of tubers and geometric mean diameter under two treatments of water (plain water (fresh) and other water drainage) were (1015.29, 396.21, 176.10, 418.01), respectively.

The mean and standard error of sphericity for tubers under two treatments (plain water (fresh) and other water drainage) were calculated as: 67.0 ± 0.71 and 67.5 ± 0.71, respectively. And results showed that mean square values for sphericity of potato tubers were presented in Table (4) for two treatments (plain water (fresh) and other water drainage). There were highly significant differences among tubers at ($P \leq 0.01$). The results showed mean square values for sphericity of tubers under two treatments of water (plain water (fresh) and other water drainage) was (13.31).

Surface area for potato tubers given by equation (2). The mean and standard error of surface area for potato tubers under two treatments (plain water (fresh) and other water drainage) were calculated as: 97.0±2.51, 88.0±2.51, respectively. And results showed that mean square values for surface area of potato tubers were presented in Table (4) for two treatments (plain water (fresh) and other water drainage). There were significant differences among tubers at ($P \leq 0.05$). The results showed mean square values for surface area of tubers under two treatments of water (plain water (fresh) and other water drainage) were (3474.38).

Table (1). Means ± Standard error for some physical properties for potato tubers.

Items	Mass, g	Length, mm	Width, mm	Thickness, mm	Dg, mm
Traditional	101.7±4.01	83.2±1.44^{a}	49.6±0.72^{A}	41.1±0.58^{A}	55.1±0.73^{A}
Treated	92.5±4.01	78.3±1.44^{b}	46.5±0.72^{B}	39.0±0.58^{B}	52.0±0.73^{B}
Surface	97.1±4.01	81.3±1.44	48.2±0.72	40.0±0.58	53.8±0.73
Subsurface	97.0±4.01	80.2±1.44	47.8±0.72	40.1±0.58	53.4±0.73

Means within the same column carry different small superscripts are significant at level $P \leq 0.05$,
Means within the same column carry different capital superscripts are significant at level $P \leq 0.01$.

Table (2). Means ± Standard error for some physical properties for potato tubers.

Items	Spherecity, %	Surface area, mm^2	Average Firmness, Kg
Water			
Traditional	67.0±0.71	97.0±2.51^{a}	6.5±0.08^{A}
Treated	67.5±0.71	88.0±2.51^{b}	5.8±0.08^{B}
Irrigation			
Surface	67.0±0.71	92.3±2.51	6.3±0.08^{A}
Subsurface	67.5±0.71	92.8±2.51	6.0±0.08^{B}

Means within the same column carry different small superscripts are significant at level $P \leq 0.05$,
Means within the same column carry different capital superscripts are significant at level $P \leq 0.01$.

Table (3). Mean square, F value, and Probability for some physical properties.

Items	*Mean Square*				
	Mass, g	Length, mm	Width, mm	Thickness, mm	Dg, mm
Water	3556.72	1015.29	396.21	176.10	418.01
Irrigation	1.34	53.72	6.88	0.60	6.48
*Water * Irrigation*	3501.72	1411.72	1.17	24.38	33.48
Error	1348.76	174.54	43.18	28.18	44.68
F value, and Probability					
Water	2.637 NS	5.817 *	9.177 **	6.248 **	9.355 **
Irrigation	0.001 NS	0.308 NS	0.159 NS	0.021 NS	0.145 NS
*Water * Irrigation*	2.596 NS	8.088 **	0.027 NS	0.865 NS	0.749 NS

(**), Significant at level $P \leq 0.01$, (*), Significant at level $P \leq 0.05$, (N.S.) No significant.

Table (4). Mean square, F value, and Probability for some physical properties.

Items	*Mean Square*		
	Spherecity, %	Surface area, mm^2	Average Firmness, Kg
Water	13.31	3474.38	18.17
Irrigation	12.58	10.50	5.41
Water * Irrigation	605.38	729.17	0.00
Error	42.25	530.51	0.56
F value, and Probability			
Water	0.315 NS	6.549 *	32.333 **
Irrigation	0.298 NS	0.020 NS	9.628 **
Water * Irrigation	14.327 **	1.374 NS	0.000 NS
(**), Significant at level P≤ 0.01, (*), Significant at level P≤ 0.05, (N.S.) No significant.			

The mean and standard error of mass potato tubers under two treatments (plain water (fresh) and other water drainage) were calculated as: 101.7±4.01, 92.5±4.01, respectively. And results showed that mean square values for mass of potato tubers were presented in Table (3) for two treatments (plain water (fresh) and other water drainage). There were no-significant differences among tubers at (*P≤ 0.01*). The results showed mean square values for surface area of tubers under two treatments of water (plain water (fresh) and other water drainage) were (3556.72).

The mean and standard error of firmness potato tubers under two treatments (plain water (fresh) and other water drainage) were calculated as: 6.5±0.08, 5.8±0.08, respectively. And results showed that mean square values for firmness of potato tubers were presented in Table (2) for two treatments (plain water (fresh) and other water drainage). There were highly significant differences among tubers at (*P≤ 0.01*). The results showed mean square values for firmness of tubers under two treatments of water (plain water (fresh) and other water drainage) were (18.17).

2. Effect of irrigation systems on physical properties of potato tubers:

The mean and standard error of the major, intermediate, and minor diameters and geometric mean diameter of tubers were presented in Table (1), under two irrigation systems (surface, subsurface) were calculated as: 81.3±1.44, 48.2±0.72, 40.0±0.58, 53.8±0.73 mm and 80.2±1.44, 47.8±0.72, 40.1±0.58, 53.4±0.73 mm, respectively. And results showed that mean square values for dimensions potato and geometric mean diameter were presented in Table (3) for irrigation systems (surface, subsurface). There were no significant differences among tubers for width and thickness at (*P≤ 0.01*). The results showed mean square values for three dimensions of tubers and geometric mean diameter under two irrigation systems (surface, subsurface) were (53.72, 6.88, 0.60, 6.48), respectively.

The mean and standard error of sphericity for tubers under two irrigation systems (surface, subsurface) were calculated as: 67.0 ± 0.71 and 67.5 ± 0.71, respectively. And results showed that mean square values for sphericity of potato tubers were presented in Table (4) for two irrigation systems (surface, subsurface). There were no significant differences among tubers at ($P \leq 0.01$). The results showed mean square values for sphericity of tubers under two irrigation systems (surface, subsurface) were (12.58).

The mean and standard error of surface area for potato tubers under two irrigation systems (surface, subsurface) were calculated as: 92.3±2.51, 92.8±2.51, respectively. And results showed that mean square values for surface area of potato tubers were presented in table (4) for two irrigation systems (surface, subsurface). There were no significant differences among tubers at ($P \leq 0.05$). The results showed mean square values for surface area of tubers under two irrigation systems (surface, subsurface) were (10.50).

The mean and standard error of mass potato tubers under two irrigation systems (surface, subsurface) were calculated as: 97.1±4.01, 97.0±4.01, respectively. And results showed that mean square values for mass of potato tubers were presented in Table (3) for two irrigation systems (surface, subsurface). There were no-significant differences among tubers at ($P \leq 0.01$). The results showed mean square values for surface area of tubers under two irrigation systems (surface, subsurface) were (1.34).

The mean and standard error of firmness potato tubers under two irrigation systems (surface, subsurface) were calculated as: 6.3±0.08, 6.0±0.08, respectively. And results showed that mean square values for firmness of potato tubers were presented in Table (4) for two irrigation systems (surface, subsurface). There were highly significant differences among tubers at ($P \leq 0.01$). The results showed mean square values for firmness of tubers under two irrigation systems (surface, subsurface) were (5.41).

CONCLUSIONS

1. All the linear dimensions of potato tubers, tuber surface area and mass were higher in plain water than water drainage
2. The porosity of potato tubers was slightly higher in plain water than water drainage.
3. Firmness at the two treatments of water was highest, the values of firmness tubers were higher in plain water than water drainage.
4. Use treated water showed harvest tubers at good quality and quantity.
5. Saudi Arabia one of the dry areas that suffer from lack of water needed for agriculture, so it was necessary to use alternative systems (treated water) and modern irrigation (subsurface).

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تقييم الخصائص الطبيعية للبطاطس بواسطة مياه ري مختلفة

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الملخص العربي

تعتبر البطاطس هي الغذاء الكامل والرخيص وتعتبر مصدر للنشا .ويعتبر مظهر درنة البطاطس أحد أهم الأشياء التى يهتم بها المستهلك . و من أهم العوامل التي تؤثر في شكل وخصائص البطاطس هى مياه الري قبل الزراعة .الخصائص الطبيعية للبطاطس ضرورية لتصميم معدات التدوال والنقل والتسوق، المعالجة، وتخزين المحاصيل . وبالتالي من خلال التجارب في المزرعة التعليمية التي تقع في جامعة الملك فيصل، المملكة العربية السعودية، في شكل اختبارات عشوائية كاملة، واثنين من المعاملات من مياه الري (المياه التقليدية، المياه المعاملة) تحت ظروف الري بالتنقيط، تم تقسيمها ومن ثم اختبارها .من خلال العديد من التجارب، الخصائص الطبيعية التى تم قياسها للبطاطس مثل أبعاد الشكل، spherecity ، مساحة السطح، والصلاية، وأداء المنتج (المخرجات) تم قياسها وبطريقة التحليل الإحصائي تمت مقارنتها .في المقارنة بين المنتجات من مياه الري التقليدية ومياه الري المعالجة وحظت فروق ذات دلالة إحصائية في أبعاد الدرنات وأداء المنتج، ولكن لكمية الدرنات ومتوسط وزن الدرنات ، كانت هناك فروق ذات دلالة إحصائية، 4.01 ± 102 جم لمياه الرى التقليدية و 93 جم± 4.01 لمياه الرى المعالجة .أيضا، كانت صلاية درنات البطاطس ذات دلالة إحصائية 0.08 ± 5.9 كجم للمياه المعالجة و 0.08 ± 6.5 كجم للمياه التقليدية .وبمقارنة مياه الري التقليدية ومياه الري المعالجة للعوامل المذكورة أعلاه، كانت في معظمها فروق ذات دلالة إحصائية.