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Determination of the Best of Irrigation System for Water Conservation

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Abstract

The current study was carried out at Agricultural and Veterinary Research Station, Faculty of Agricultural and Veterinary Medicine, Qassim University during 2001 and 2002 spring growing season. The purpose of this study is to determine of the best irrigation system and investigate the effect of sprinkler irrigation, surface and subsurface drip irrigation systems with different water regimes on potato yield and wtaer use efficiency. Potato plants were irrigated with five diffeent levels of soil moisture contenct (85% , 70%, 55%, 40% and 25% of field capacity). The amount of the applied water was determined by the difference between the values of soil moisture content using tensiometers. The results showed that the amount of the applied water decreased by decreasing the soil moisture content before irrigation. The minimum amount of the applied water was obtained at subsurface drip irrigation with water regime 0.25 Fc. At water regime (0.85 Fc) subsurface drip irrigation syatem decreased the sesonal applied water by 30% and 12% copared with sprinkler irrigation and drip irrigation systems, respectively. The potato comsumptive water use increased by increasing the value of soil moistue content before irrigation. At the same water regime, subsurface drip irrigation system decreased the potato comsumptive use compared with that of sprinkler irrigation system or surface drip irrigation sysytem. the water application efficiency decreased by increasing the value of soil moistue content before irrigation. The minimum value of the water application efficiency was that of sprinkler irrigation soil moisture content before irrigation (0.85fc). Maximam value of the potato consumptive use was that of subsurface drip irrigation at soil moisture content before irrigation (0.25 fc). Maximam value of the potato water use efficiency was that of subsurface drip irrigation when the soil moisture content before irrigation was (0.70 fc).

Introduction

Economic use of water is a vital problem which confronts farmers and agricultural scientists in irrigated areas of arid and semi-arid regions. Knowledge of the right amounts of irrigation water is essential to obtain economically maximum yields of different crops, Brown (1999). Irrigation water

consumption in Saudi Arabia represents about 90% of the national water use, and the limited groundwater resources are the major water supply for irrigation. Improper irrigation water operation accounts for significant water losses in some large irrigation schemes. Consequently, the use of modern irrigation systems in irrigation operation and scheduling is essential for the reduction of irrigation water demands. Potato (*Solanum tuberosum* L.) is considered as one of the most important vegetable crops all over the world, (Rowe, 1993). Al- Qassim region produces about half of the potato produced in Saudi Arabia, Van der zaag (1991). Potato is usually grown in Saudi Arabia during fall and spring seasons. The succesful irrigation of potato, requires a knowledge of both irrigation and schudling methods. Improved irrigation methods can save water without compromsing Potato yield or quility, Shae *et. al.* (1999). Contnuous water supply is generally recommended from tuber initiation to maturity, Miller and Marriam (1983). Insufficient irrigation water causses depression of plant size and growth , Hang and Gruz (1989). Potato tuber yields and quality can be reduced by water stress occurring at any time during the growing seasons, Adams and sternson (1990). Sprinkler irrigation is the most common irrigation system used for potato production at Al- Qassim area. However, alternative irrigation methods such as drip irrigation and subsurface drip irrigation , save water and decrease nutrante leaching was usd, Phene and Sander (1976). Angus and Herwaarden (2001) reported that transpiration efficiency (TE), the ratio of yield to transpiration, is relatively stable for well managed crops, but the amount of water used is strongly affected by crop management. A possible mean of increasing yield potential of dryland crops is to manage transpiration so that relatively more water is used during the vegetative phase when vapor pressure deficit is low, and hence TE is high. Fontana *et. al.* (1990) study four crop coefficients (0.5, 0.7, 1.0 and 1.2) the maximum yield was obtained at kc = 0.7. El- Zaid *et. al.* (1986) found the water requirements of spring potato 710mm, while Darzagh (1991) found it 610mm. kassem (2000) mentioned that subsurface drip irrigation provides a great potential for increasing crop production since it minimizes the conmuped of amount of irrigation water which gives a way for expanding the cultevated areas. Bader (1992) indicated that the water use efficiency of surface drip irrigation is higher than that of sprinkler irrigation system. El-Mowelhi *et. al.,* (1999) concluded that decreasing the amount of irrigation water increased water use efficiency.

Since fresh irrigation supplies are inadequate to the total crop water requirements in the Kingdom of Saudi Arabia, careful use of the available water resources is a promising preposition and a necessity. Therefore, It is important to study the effect of subsurface drip irrigation, surface drip irrigation and sprinkler irrigation systems on the growth and development, and the water use efficiency of potatoes. The other purpose of this study is to determine the suitable water regime for each irrigation system.

Materials and Methods

A field experiment was carried out at Agricultural and Veterinary Research Station, Faculty of Agriculturel and Veterinary Medicine, King Saud

University, Al-Qassim branch during 2001 and 2002 spring seasons. The purpose of this resarche is study the effect of subsurface drip irrigation, surface drip irrigation and sprinkler irrigation systems on the growth and development, and the water use efficiency of potato. The other perpouse is study the effect of different water regimes (soil moisture content before irrigation) on the potato production water application efficiency and water use efficiency under different irrigation systems and chossing the suitable one of water regime for each irrigation system. A split plot design with five replicates was used in this study. The size of each plot was (90 m^2) . Main plots consisted of three irrigation systems subsurface drip irrigation, surface drip irrigation and sprinkler irrigation. Sub-plots consists of five water regimes, irrigating when the soil moisture content before irrigation were 85%, 70% , 55%, 40% and 25 % of field capacity.

Surface, subsurface drip irrigation and sprinkler irrigation systems with computerized control were designed and built for this experimental field. For surface and subsurface drip irrigation, spacing between laterals was 0.8 m and spacing between inline emitter was 0.3 m. The inlines laterals were (GR) type with 2.3 l/h discharge rate per emitter. In subsurface drip irrigation the lateral lines were bird at 20 cm from soil surface.

Potato tuber seeds cv. "Spunta" were hand planted at 5-7 cm depth in rows 30 m long and 0.8 m apart and the intra row spacing was .25 m, on march 15^{th}, and 23 th in the two successive growing seasons, respectively. All the experiments treatment received the same local agricultural practices in the area. The potato plants were irrigated by different levels of soil moisture contents.

Before beginning the experimental work, soil samples were taken from the experimental field. These soil samples were taken for the determination of soil texture (soil mechanical analysis), the field capacity, the wilting point and the bulk density according to Anter *et. al* (1987). The results showed that the soil type of this farm is classified as a sandy soil, 96.3 % sand, 1.8% silt and 1.9 % clay. The field capacity by weight was 13 %, the wilting point was 4% by weight, and the bulk density was 1.51gm/cm^3 .

To determine the soil moisture content, water application efficiency (AE) water consumptive use, soil moisture sensors were fixed in the soil at six depths: 5 cm, 15 cm, 25 cm, 35cm, 45 cm and 55cm to represent the soil moisture content at the soil layers (0-10cm), (10-20 cm), (20-30cm), (30-40cm), (40-50) and (50-60), respectively. The values of soil moisture content in the soil were collected just before irrigation and two hours after irrigation.

The irrigation water was obtained from local well. The irrigation water has a pH of 7.11 and total soluble salts of 945 PPM. Sodium adsorption ratio (SAR) value was 2.66.A fixed computerized sprinkler irrigation system and drip irrigation were designed and built. The sprinklers were spaced at fixed distance 3.0 meter apart in a square pattern with precipitation rate of 40.0 mm/h. To determine the distribution uniformity of the sprinkler irrigation system, 12.0 cm diameter catch cans were distributed and spaced at 1.0 meter distance apart in a square pattern. The operating time was determined for each treatment from the amount of applied water and the precipitation rate.

After 90 days of seed sowing, vegetative growth traits of the resultted plants were recorded in terms of plant hight, number of main stems per plant and leaf area per plant. At harvest time, 120 days after seed sowing, tuber of each plot were digged, weighed and graded into three various sizes; < 35, 35-55 and > 55 mm in diameter. Then, the folowing data were caculated: total tuber yield hectare $^{-1}$, average tubber yield plant^{-1}, fresh and dry weight tuber^{-1} and percentage of tuber size grades.

Actual water consumptive use of potato (Cu) was determined from equation (2) according to Hansen and Israelson (1962).

$$Cu = Bd * Di*(s2- s1)/100 \qquad \text{Eq.2}$$

where:

Cu = Water consumptive use (cm)
Bd = Soil bulk density (g/cm^3)
Di = Soil layer depth (cm)
s2 = Soil moisture content by weight before irrigation.
s1 = Soil moisture content by weight after irrigation.

The water application efficiency (AE) is defined as the percentage of stored water in the root zone (sw) to the total amount of applied water (Aw) .Ea was determined by the following equation.

$$AE= (Sw/Aw)*100$$

The water use efficiency (WUE) has been used to evaluate various irrigation regimes which produce maximum yield per unit of water consumed by the crop or applied in the field. The crop water use efficiency (CWUE) and the field water use efficiency (FWUE) were determined according to Begg and Turner (1976).

CWUE = (the potato tuber yield (kg/m^2)) / (water consumed use m^3/m^2)) kg/m^3

FWUE = (the potato tuber yield (kg/m^2)) /(applied water (m^3/m^2)) kg/m^3

Results and Discussion

1- Effect of irrigation systems and water regimes on the sesonal amount of the applied.

The amount of the applied water to potato under each treatement are shown in figure (1). The data reealed that the sesonal amount of the applied water for subsurface drip irrigation is lower than that of surface drip irrigation and sprinkler irrigation. The maximum monthly values were obtained at April for each treatment, where the plant was at its maximum growth, besides the climate becomes hot. The monthly and sesonal values of applied water were affected by irrigation system and water regime. The maximum value of the

sesonal applied water was that of sprinkler irrigation with water regime (0.85fc), while the minimam value of the sesonal applied water was that of subsurface drip irrigation at soil moisture content before irrigation (0.25 fc). At water regime (0.85 Fc) subsurface drip irrigation syatem decreased the sesonal applied water by 30% and 12% copared wirh sprinkler irrigation and drip irrigation systems, respectively.

2- Determination of water consumptive use under different irrigation systems.

The values of potato consumptive use for each treatements are shown in figure (2). The data revealed that the Potatos comsumptive use increased by increasing the value of soil moistue content before irrigation. The mixiumum value of comsumptive use was obtained at "0.85 fc " soil moisture content before irrigation, while the minimum value of comsumptive use was obtained at "0.25 Fc" soil moisture content before irrigation. At the same water regime, subsurface drip irrigation system decreased the potatos comsumptive use compared with that of sprinkler irrigation system or surface drip irrigation sysytem. Also, surface drip irrigation system decreased the potatos comsumptive use compared with that of sprinkler irrigation system. The maximum value of the potatos consumptive use was that of sprinkler irrigation soil moisture content before irrigation (0.85fc), while the minimam value of the potato plants consumptive use was that of subsurface drip irrigation at soil moisture content before irrigation (0.25 fc). Potatoes consumptive use decreased by using Subsurface drip irrigation because, the evaporation losses decreased than that of sprinkler or surface drip irrigation systems.

3- Effect of irrigation systems and water regimes on the water application efficiency.

The values of the water application efficiency for each treatements are shown in figure (3). The data revealed that the water application efficiency decreased by increasing the value of soil moistue content before irrigation. The minimum value of water application efficiency was obtained at "0.85 fc " soil moisture content before irrigation, while the maximum value of water application efficiency was obtained at "0.25 Fc" soil moisture content before irrigation. At the same water regime, subsurface drip irrigation system increased the water application efficiency compared with that of sprinkler irrigation system or surface drip irrigation sysytem. Also, surface drip irrigation system iccreased the water application efficiency compared with that of sprinkler irrigation system. The minimum value of the water application efficiency was that of sprinkler irrigation soil moisture content before irrigation (0.85fc), while the maximam value of the water application efficiency was that of subsurface drip irrigation at soil moisture content before irrigation (0.25 fc).

4- Effect of irrigation systems and water regimes on the water use efficiency.

The values of the water use efficiency for each treatements are shown in figure (3). The data revealed that the water use efficiency decreased by increasing the value of soil moistue content before irrigation from 0.25 fc to 0.7

fc but it declined when the soil moisture increased to 0.85fc. The minimum value of water use efficiency was obtained at "0.85 fc " and 0.25 fc soil moisture content before irrigation, while the maximum value of water use efficiency was obtained at "0.70 Fc" soil moisture content before irrigation. At the same water regime, subsurface drip irrigation system increased the water use efficiency compared with that of sprinkler irrigation system or surface drip irrigation sysytem. Also , surface drip irrigation system iccreased the water use efficiency compared with that of sprinkler irrigation system. The minimum value of the water use efficiency was that of sprinkler irrigation soil moisture content before irrigation (0.85fc), while the maximam value of the potato water use efficiency was that of subsurface drip irrigation at soil moisture content before irrigation (0.7 fc).

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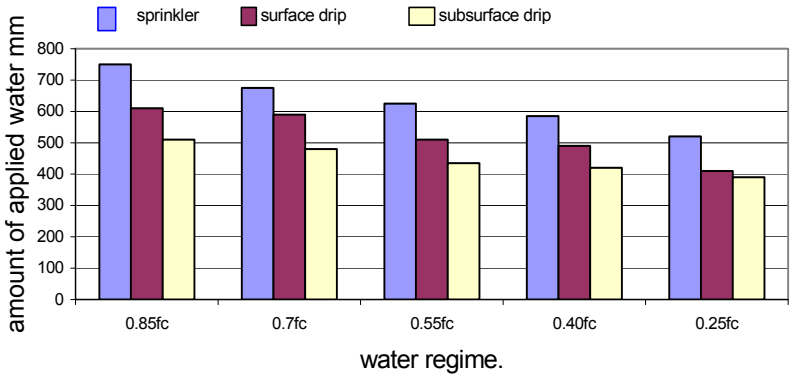
Fig(1): Effect of irrigation systems and water regimes on the amount of applied water.



Fig(2): Effect of irrigation system and water regime on water consumptive use.

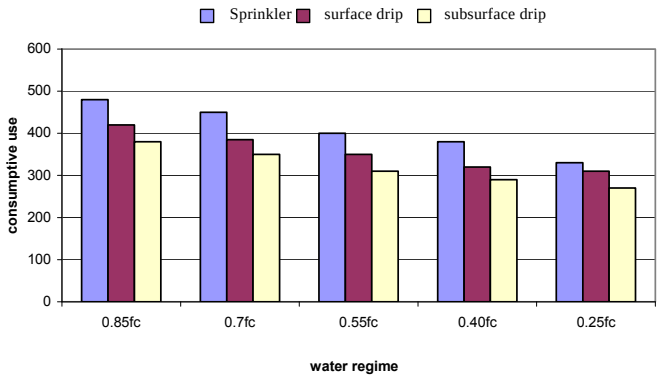


Fig.(3): Effect of irrigation system and water regime on water application efficiency.

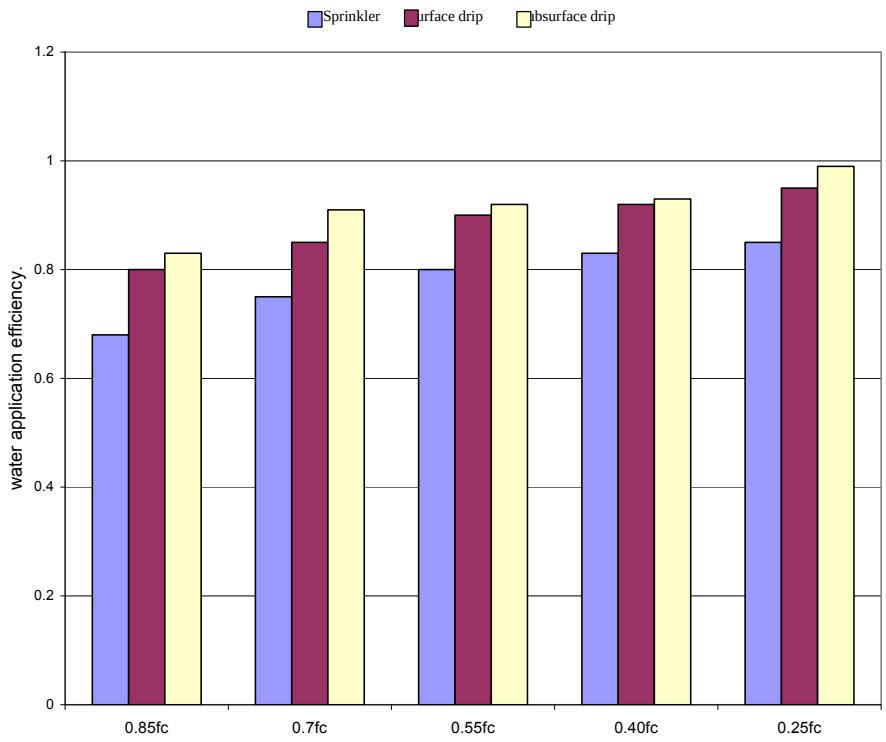
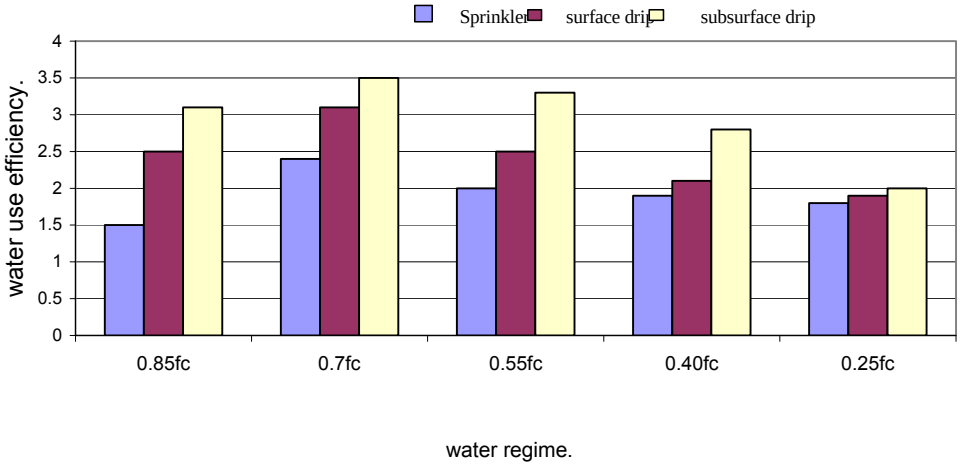
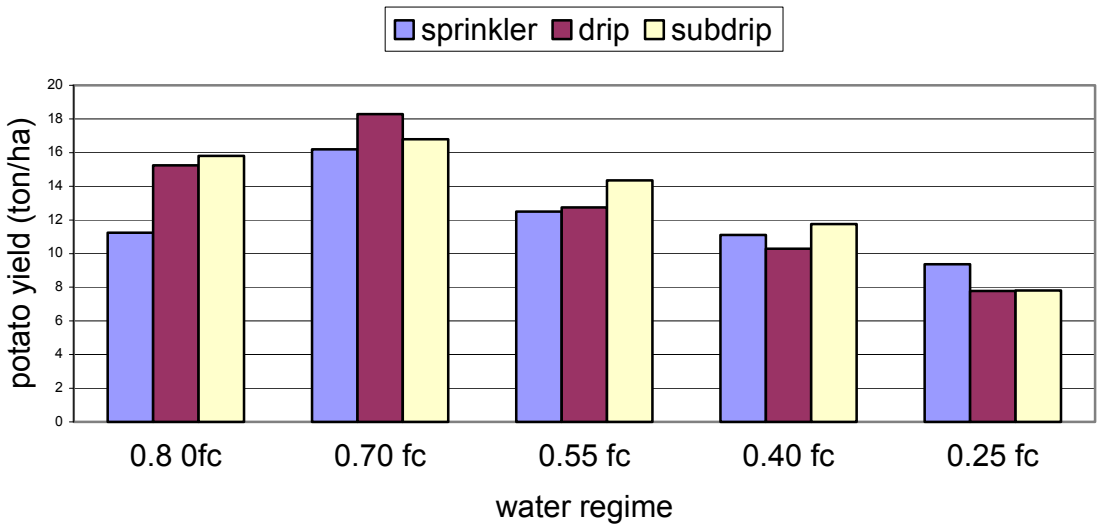


Fig.(4): Effect of irrigation system and water regime on water use efficiency.



Fig(5): Effect of irrigation systems and water regime on potato yield



تحديد أفضل نظام للري للمحافظة على المياه

محمد عبد الوهاب قاسم وعبد الرحمن محمد المشيلح
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أجريت هذه الدراسة الحقلية بمحطة التجارب الزراعية والبيطرية بكلية الزراعة والطب البيطري - جامعة القصيم. خلال الموسم الربيعي لعامي 2002/2001 م وذلك لتحديد أفضل نظام للري من نظم الري المعروفة وهي الري بالتنقيط تحت السطحي والري بالتنقيط السطحي والري بالرش وتأثيرها على إنتاجية محصول البطاطس وكفاءة الاستخدام المائي. لقد كانت النظم المائية المستخدمة هي خمس مستويات مختلفة من الرطوبة الأرضية قبل الري وهي (0.85 ، 0.70، 0.55، 0.40 و 0.25 من السعة الحقلية).

وقد أظهرت أهم النتائج ما يلي:

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1. إجمالي كمية المياه المضافة لطريقة الري بالتنقيط تحت السطحي اقل من إجمالي كمية المياه المضافة لآي من طريقتي الري بالتنقيط السطحي أو الري بالرش. وكان إجمالي كمية المياه المضافة تقل عند قلة المحتوى الرطوبي بالتربة قبل الري من 0.85 إلى 0.25 من السعة الحقلية. وقد وجد أن اقل قيمة لإجمالي كمية المضافة تحققت عند استخدام الري بالتنقيط تحت السطحي ورطوبة أرضية قبل الري 0.25 من السعة الحقلية. وقد وجد أن نظام الري بالتنقيط تحت السطحي يقلل من كمية المياه المضافة بنسبة 30% ,12% مقارنة بنظام الري بالرش والري بالتنقيط السطحي وذلك عند رطوبة أرضية قبل الري 0.85 من رطوبة السعة الحقلية.
2. قيمة الاستهلاك المائي تزيد عند زيادة الرطوبة الأرضية قبل الري وقد وجد أن الري بالتنقيط تحت السطحي يقلل من قيمة الاستهلاك المائي مقارنة بنظم الري بالرش والري بالتنقيط السطحي.
3. كفاءة إضافة المياه تقل عند زيادة الرطوبة الأرضية قبل الري وقد وجد أن الري بالتنقيط تحت السطحي يزيد من كفاءة إضافة المياه مقارنة بنظم الري بالرش والري بالتنقيط السطحي. وقد تحققت اعلي كفاءة لإضافة المياه عند استخدام الري بالتنقيط تحت السطحي عند رطوبة قبل الري 0.25 من السعة الحقلية.
4. كفاءة الاستخدام المائي تزيد عند زيادة الرطوبة الأرضية قبل الري من 0.25 إلى 0.70 من السعة الحقلية , ثم تقل قيمة الاستخدام المائي عندما تكون الرطوبة الأرضية قبل الري 0.85 من السعة الحقلية. وقد تحققت اعلي كفاءة للاستخدام المائي عند استخدام الري بالتنقيط تحت السطحي عند رطوبة قبل الري 0.70 من السعة الحقلية.