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Effect of Shading By Date Palm Leaves on Growth and Yield of Potato under Different Irrigation Levels

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THIS STUDY was conducted during 2002 and 2003 seasons at the Experimental Farm of the College of Agriculture and Veterinary Medicine, King Saud University in Al-Qassim area to evaluate the effect of shading by date palm leaves on the performance of potato plants under different irrigation levels {80, 100 and 120% of potential evapotranspiration (ETo)}. The results revealed that shading by green plastic shades (40% light reduction) gave the highest potato yield under 80% irrigation levels. Moreover, shading by date palm leaves increased water use efficiency (WUE) under 100% irrigation level. The shading by green shades or date palm leaves increased leaf area of potato plants. However, the shading decreased both chlorophyll content and percentage of tuber dry matter. The highest leaf area, chlorophyll content and the percentage of tuber dry matter were observed with the plants grown under 80% irrigation level. Therefore, the shading could enhance water use efficiency and increase potato yield under semi-arid conditions such as central Saudi Arabia conditions where the study was conducted.

Potato *(Solanum tuberosum* L.) is considered as one of the most important vegetable crops all over the world. Qassim region produces about half of the potato produced in Saudi Arabia (Van der Zaag, 1991). Producing potatoes could be affected by several environmental factors, such as irrigation water level, temperature, day length, light intensity, nutrients availability and other factors. Reducing light intensity was found to affect plant growth and production. It changes the environmental conditions especially temperature, soil moisture content, chlorophyll, photosynthesis activity and evapotranspiration. It is assumed that changing the plant environment will affect the irrigation water consumption and the growth period span. This can affect the plant development and productivity.

High temperature represents a serious limitation to the extension of potato production to warmer areas (Van der Zaag & Horton, 1983). One way of cooling the microenvironment is utilizing the shade of associate crops or artificial shade (Kuruppuarachchi, 1990).Light intensity reduction, as a result of either self-shading or shading by other materials, may create physiological and

morphological changes in field crops (Al-Moshileh, 1992). O'Brien *et al.* (1998) reported that shading up to 75% did not affect the timing of onset or cessation of tuber initiation of potato cultivar "Estima", but shading by 50% or more delayed the tuber initiation potato cultivar "Maris Piper" compared with less severe shading.

In this particular study, we will try to compare the light intensity reduction by artificial shading and leaves of palm trees shading, especially when palm trees are grown in very wide range and have a lot of benefits through its food production or other plant parts usage. Date palms in the Kingdom of Saudi Arabia are increasing dramatically. In 1980, the estimated number was 11,300,000 palms while in the year 2000, the number jumped up to 19,760,00 (Al-khateeb & Deena, 2002). Qassim area is very famous for cultivating and producing palm trees and dates. The estimated area occupied by date palms in Qassim was about 23% of the date palms area in Saudi Arabia (Ministry of Agriculture and Water, 2001). It is common in Saudi Arabia to get red of about 10 leaves yearly from every palm. These leaves are considered as waste but could be of good benefits in agricultural practices such as in this study.

Shades of palms and other trees have been used to protect low growing crops, which are tender, grown for food and forage (Moysan, 1985). This natural shading reduces solar radiation and increases moisture around these plants (Rom, 1991). However, it has limits that makes it less suitable for commercial crops such as: a) Competition between palm tree and the grown crops in between for the water and nutrients, b) Excess shade during the winter period gives spindly growth, c) Difficulties of soil activities and d) Difficulties of control and caring of the crops (Moysan, 1985 and Rom, 1991).

Water is critical and vital factor for growth, yield and quality of crop. Potato is very sensitive to water quality and quantity (Nadler & Bruria, 1995). Successful management of irrigation water is necessary to achieve a high yield (Foti *et al.*, 1995). 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. Potato is usually grown in Saudi Arabia during fall and spring seasons. The successful irrigation of potatoes requires knowledge of both irrigation and scheduling methods.

Abdel-Razik (1996) indicated that as the applied water increased the percent of large tubers increased, while the percent of small tubers decreased. Tuber dry matter content and specific gravity were increased with decreasing water amount of irrigation. El-Banna *et al.* (2001) reported that using drip irrigation at the rate of 1650 m^3/fed. recorded a maximum total tuber yield and higher water use efficiency (WUE).

The main aims of this investigation were to minimize the irrigation water quantity up to the sufficient level and to determine the optimum rate of irrigation water by using different irrigation levels, *i.e.,* 80, 100 and 120%, of potential evapotranspiration (ETo) under the shading by date palm leaves compared with green plastic shades on the performance of potato plants.

Material and Methods

Plant materials and experimental design

This study was conducted at the Experimental Farm of the College of Agriculture and Veterinary Medicine, King Saud University, AL-Qassim branch during 2002 and 2003 seasons. The soil type of this farm is classified as sandy soil. Data in Table 1 show specific soil characteristics.

TABLE 1. The soil mechanical analysis of experimental site.

Mechanical analysis			Bulk density g /cm^3	Water Holding Capacity (%)	Field capacity (%)	Wilting point (%)
Sand 96.3 %	Silt 1.8 %	Clay 1.9 %	1.501	17.17	9.6	4.35

The irrigation water had 7.12 pH and 980 ppm total soluble salts. Drip irrigation was used and the amount of the irrigation water was applied as mentioned in Table 2.

TABLE 2. The amount of irrigation water (m^3 /fed.) added according to potential evapotranspiration (ETo) of 80, 100 and 120% for potato in two successive seasons.

Water Treatments	Season	
	2002	2003
80%	551.54	545.61
100%	689.43	622.01
120%	827.31	818.41

Meteorological data from Ministry of Defense & Aviation report (KINGDOM OF SAUDI ARABIA) average of 1998,1999 and 2000 to run "CROPWAT" model.

This investigation was carried out for evaluating the effect of three light intensity levels on potato growth and production. The reduction of total solar radiation was obtained by reducing solar radiation intercepted by using palm tree

leaves or one layer of Roklene shade netting iron tubes with size (1x2x1 m width, length and height, respectively). The experiment included an unshaded treatment. The photon flux density in every treatment was measured in the field using Spectroradiometer (Li.Cor 1800), and the average readings were1400, 3744 and 9360 Lux for the palm tree leaves, Roklene shade netting and control treatment, respectively.

Potential evapotranspiration (ETo)

Monthly and seasonal ETo values were estimated by Et method (Penman Monteith). ETo values were obtained from the average Eto values by Penman Monteith method. Potato crop coefficient (Kc) values were selected from the FAO paper No.24.The "CROPWAT" model (Smith, 1991) was used to calculate potential evapotraspiration.

Three levels of potential evapotranspiration (ETo) (80, 100, and 120%) were used to calculate three levels of irrigation (Table 2).

Each treatment was represented with three replicates and arranged in a randomized complete block design. The plot was 3 X 6 m and contained 4 rows each of 75cm width. The planting distance was 30cm within the row. Presprouted tubers of cv. Sponta were planted on September30, 2001 and October 1,2002, for two growing seasons, respectively. The required agricultural practices were done as necessary during the growing period in the two experimental seasons.

The plants were harvested on January 30 and 31 in 2002 and 2003, respectively. The following growth and yield parameters were measured and the data were statistically analysed by the analysis of variance using SAS package. Comparison of treatment means was done using Dancan's multiple range test at the p= 0.05 level of significance. Data were statistically analyzed according to Sendecor & Cocheran (1980).

Measurements

Vegetative growth parameters

Three plants were randomly chosen after 50 and 55 days after sowing in 2002 and 2003 seasons, respectively, for vegetative growth measurements, which included plant height and number of main stems per plants. Leaf area of the fifth upper leaf measured at fully expanded mature stage using leaf area meter, model LI-1300, was recorded after 84 and 83 days from sowing in 2002 and 2003 seasons, respectively.

Total chlorophyll

It was measured for the fifth leaf using Minolta chlorophyll Meter SPAD – 501 after 70, 84 and 75, 83 days from sowing in 2002 and 2003 seasons, respectively.

Potato tuber yield

The number and weight of marketable and unmarketable tubers, and total yield were recorded. Tubers sized between 15 and 55 mm in diameter were considered marketable tubers.

Quality of potato tuber

Specific gravity, tuber dry matter %, tuber fresh and dry weigh were measured after harvesting by choosing 10 marketable tuber randomly.

Air temperature

Air temperature was recorded by a thermometer under shade and non shade treatments.

Seasonal water use

The seasonal water use values were obtained from the sum of water consumptive use for all irrigation per treatment, from sowing until harvesting time.

Monthly evapotranspiration

Monthly values were obtained from daily water use multiplied by the number of days in one month. The potential ET (ETo) values were compared with those of the actual ET values (estimated from the 30 days of irrigation treatment).

Water use efficiency (WUE)

WUE value was calculated according to the following equation (Vites, 1965):

$$W.U.E = \frac{\text{Yield (Kg /fad.)}}{\text{Seasonal ET } (m^3/\text{fad.})}$$

Results and Discussion

Growth characters

Medium irrigation water level was found to be more favorable for plant height and number of branches in the two growing seasons. Leaf area was higher at the lower water level. These parameters were significantly higher in 2003 season (Table 3). The number of stems of potato plants followed the same trend of plant height but opposite trend of leaf area in response to water level. The medium water level seems to be more suitable for plant height and number of main stems more than the highest level. This could be due to the possibility of leaching of nutrients away of root zone especially at the sandy soil of this experiment. Low water level was the best for leaf area measurements.

In terms of shading treatments, it was found that shading by date palm leaves enhanced leaf height and leaf area. The green net shading plastic was favorable for potato number of branches.

The number of stems of potato plants followed an opposite trend to plant height in response to shading. The unshaded plants were shorter and produced less stems and less leaf area than the shaded plants either by date palm leaves or by artificial shade net during the two seasons. These results are in agreement with Kuruppuarachchi (1990) who found that potato plants were taller under shaded conditions and had higher leaf area. Al-Moshileh & Motawei (2001) found that increased shading significantly increased plant height, number of leaves per plant and leaf area of potato plants. Moreover, similar results were obtained for other crops (El-Aidy & El-Afry, 1983; El-Gezawi & Mohamed, 1999 and El-Kassas, 1985).

TABLE 3. Effect of irrigation and shade treatments on plant growth parameters in two successive seasons.

Treatments	Plant height (cm) 50 days	55 days	No. of main stems 50 days	55 days	Leaf area (cm^2) 84 days	83 days
	2002	2003	2002	2003	2002	2003
Irrigation (I)						
80% (I_1)	40.98	45.41	2.44	2.89	146.42	149.51
100% (I_2)	44.23	49.55	2.89	3.78	122.24	127.43
120% (I_3)	40.87	45.83	2.78	3.44	118.81	137.88
Mean	42.36	46.93	2.70	3.37	129.15	138.27
Shade (S)						
Date palm leaf (S_1)	62.31	70.22	2.67	3.34	142.90	161.98
Plastic net (S_2)	39.65	43.44	3.00	3.78	147.14	151.24
Non (S_3)	25.13	27.13	2.44	3.00	97.43	101.59
Mean	42.36	46.93	2.70	3.37	129.15	138.27
I_1S_1	60.83	66.33	2.33	2.67	177.29	182.27
I_1S_2	41.16	46.33	2.67	3.33	186.91	191.44
I_1S_3	20.96	23.57	2.33	2.67	74.87	74.75
I_2S_1	63.26	73.73	2.67	3.67	143.08	145.10
I_2S_2	37.66	41.10	3.33	4.33	119.37	122.57
I_2S_3	31.76	33.83	2.67	3.33	104.27	113.63
I_3S_1	62.83	70.60	3.00	3.67	152.04	158.59
I_3S_2	40.13	42.90	3.00	3.67	134.93	139.72
I_3S_3	22.66	24.00	2.33	3.00	113.15	114.00
LSD at 5% for: I.	1.86	1.99	N.S	0.50	N.S	8.61
S	1.86	1.99	0.45	0.50	30.75	8.61
I. X S	3.22	3.46	N.S	N.S	53.25	14.90

Chlorophyll contents

Expectingly, as water level decreased or light intensity increased, the chlorophyll in plant leaves was increased. Table 4 showed that the highest values

of chlorophyll were measured under water treatment of 80% in the two growing seasons as well as under control treatment where there were no shades. Although no significant differences were observed in the interaction treatments, it was clear that the highest values were obtained from treatments of unshaded plants under all water level treatment. That could be ascribed to the high concentration of solids in leaves with low water content and high light exposure. The high light intensity was known to increase carbohydrates and solids in leaves. The interaction between water level and shading treatments was insignificant indicating that these factors had independent effect on chlorophyll content.

TABLE 4. Effect of irrigation and shade treatments on chlorophyll (Spad) in two successive seasons.

Treatments	2002		2003	
	Chlorophyll (spad) 70 days	84 days	Chlorophyll (spad) 75 days	83 days
Irrigation (I)				
80% (I_1)	37.49	38.63	37.88	39.20
100% (I_2)	34.58	36.13	34.85	37.83
120% (I_3)	35.23	37.29	36.00	37.50
Mean	35.77	37.35	36.24	38.18
Shade (S)				
Date palm leaf (S_1)	33.34	35.10	33.81	36.00
Plastic net (S_2)	35.07	35.51	35.59	36.36
Non (S_3)	38.89	41.45	39.33	42.17
Mean	35.77	37.35	36.24	38.18
I_1S_1	35.59	35.85	35.76	36.13
I_1S_2	35.76	36.97	36.07	37.87
I_1S_3	41.13	43.08	41.80	43.60
I_2S_1	31.20	33.63	31.78	36.79
I_2S_2	34.28	34.00	35.20	35.63
I_2S_3	38.25	40.73	39.25	41.67
I_3S_1	33.23	35.81	33.89	35.10
I_3S_2	35.17	35.55	35.51	35.57
I_3S_3	37.27	40.54	38.61	41.83
LSD at 5% for : I.	1.35	1.18	1.40	N.S
S	1.35	1.18	1.40	2.18
I. X S	N.S	N.S	N.S	N.S

Potato yield

The results reported in Table 5 show that water treatments 2 and 3 gave insignificantly the highest yield. Low water level gave the lowest yield quality and quantity. This is contradicted with the vegetative development as the highest water level gave the lowest leaf area. It is well known that yield will reflect the foliage leaves development (Al-Moshileh & Motawei, 2001).

Shading had no significant effect on the yield and number of marketable tubers in both seasons. However, the highest values for yield were obtained from plants grown under shading by either leaves of date palms or artificial shade net.

The interaction between water regimes and shading showed that the significant yield was obtained by the medium water level for unshaded plants followed, in decreasing order, by the low water level for net shaded plants, with no significant differences between them in both seasons. Wurr *et al.* (1997) found that 70% shading in the field reduced number of stolons and tubers by reducing lateral and branch stolons, while in hydroponics, 45% at tuber initiation stage had no effect on tuber number.

TABLE 5. Effect of irrigation and shade treatments on marketable and unmarketable yield in two successive seasons.

Treatments	Marketable Yield (g/m²)		Unmarketable yield (g/m²)		Marketable Yield (Kg/fad.)	
	2002	2003	2002	2003	2002	2003
Irrigation (I)						
80%(I_1)	1852.11	1808.22	180.44	187.89	7778.86	7594.52
100%(I_2)	2011.89	1960.44	182.22	194.33	8449.94	8233.85
120%(I_3)	2008.56	2014.22	205.11	190.33	8435.95	5459.72
Mean	1957.52	1927.62	189.25	190.85	8221.58	8096.00
Shade (S)						
Date palm leaf(S_1)	1867.84	1897.11	203.44	213.77	7844.92	7967.86
Plastic net (S_2)	1983.00	1906.33	216.55	208.78	8328.60	8006.59
Non (S_3)	2021.67	1979.44	147.77	150.00	8491.01	8313.64
Mean	1957.52	1927.62	189.25	190.85	8221.58	8096.00
I_1S_1	1626.00	1653.00	213.66	215.67	6829.20	6942.60
I_1S_2	2582.33	2454.00	223.66	224.33	10845.79	10689.99
I_1S_3	1425.00	1317.00	104.00	123.66	5985.00	5531.40
I_2S_1	1603.66	1660.00	159.00	209.33	6735.37	6972.00
I_2S_2	1488.00	1493.33	252.33	233.00	6249.60	6271.99
I_2S_3	2944.00	2728.00	135.33	140.67	12346.80	11457.60
I_3S_1	1867.88	2378.33	237.66	216.33	7845.10	9988.98
I_3S_2	1982.99	1771.67	173.66	169.00	8328.56	7441.01
I_3S_3	2047.33	1895.67	204.00	204.00	8598.79	7961.81
LSD at 5% for: I.	N.S	N.S	N.S	N.S	N.S	N.S
S	N.S	N.S	N.S	43.63	N.S	N.S
I. X S	532.21	406.18	N.S	4.77	2235.28	1705.95

Specific gravity, total tuber weight and carbohydrates

The results reported in Table 6 indicate that low water level gave the highest tuber dry matter, tuber dry and fresh weight. This is reflecting the chlorophyll content in leaves (Table 4), which may emphasize the importance of chlorophyll

in carbohydrate formation. This can be reflected by leaves development which had the same trend as mentioned in Table 3.

TABLE 6. Effect of irrigation and shade treatments on quality parameters in two successive seasons.

Treatments	Specific gravity		Tuber dry matter %		Tuber Dry weight (g)		Av. of tuber fresh weight (g)	
	2002	2003	2002	2003	2002	2003	2002	2003
Irrigation (I)								
80% (I_1)	1.0612	1.0622	19.47	19.53	19.49	19.22	100.25	98.71
100%(I_2)	1.0588	1.0678	18.05	17.81	17.86	18.39	99.44	101.52
120%(I_3)	1.0705	1.0605	17.68	17.73	16.95	17.06	95.51	96.14
Mean	1.0732	1.0635	18.40	18.35	18.10	18.22	98.40	98.79
Shade (S)								
Date palm (S_1)	1.0619	1.0553	17.87	17.84	17.39	17.23	97.11	96.14
Plastic net (S_2)	1.0837	1.0653	18.04	18.06	17.02	17.17	93.77	94.02
Non (S_3)	1.0740	1.0697	19.29	19.17	19.89	20.26	104.29	106.22
Mean	1.0732	1.0635	18.40	18.35	18.10	18.22	98.40	98.79
I_1S_1	1.0588	1.0.39	18.5	18.49	18.75	18.51	102.89	100.22
I_1S_2	1.0666	1.0655	19.43	19.52	19.69	18.78	101.22	96.7
I_1S_3	1.0584	1.0625	20.47	20.57	19.83	20.33	96.66	99.22
I_2S_1	1.0726	1.0686	17.42	17.35	15.33	15.27	87.80	87.48
I_2S_2	1.0913	1.0592	17.09	17.05	15.49	16.56	90.33	93.77
I_2S_3	1.0994	1.077	18.95	19.04	22.76	23.37	120.11	123.32
I_3S_1	1.0544	1.0389	17.86	17.68	17.91	17.92	100.66	100.73
I_3S_2	1.0932	1.0734	17.72	17.61	15.86	16.21	89.77	91.59
I_3S_3	1.0641	1.0692	19.06	19.91	17.07	17.08	96.11	96.11
LSD at 5% for: I.	N.S	N.S	0.84	0.77	N.S	1.91	N.S	N.S
S	N.S	N.S	0.84	0.77	N.S	N.S	N.S	8.56
I. XS	N.S	N.S	N.S	N.S	N.S	3.30	N.S	14.82

Shading had a significant effect on the total carbohydrate content in the two seasons. Light intensity reduction either by palm tree leaves or by green shade net decreased total carbohydrate content and tuber weights. The reduction in total carbohydrate content resulting from high shading is in agreement with the result obtained by El-Gezawi & Mohamed (1993) on tomato and might be due to low carbohydrate manufactured in the leaves and translocated down to the tubers.

Water use efficiency (WUE)

The calculated water use efficiency (WUE) values as affected by the tested factor are presented in Table 7. Results indicated that the higher value of water use efficiency (WUE) was shown at 80 % water treatment in the two growing seasons.

Generally, the best value for water use efficiency (WUE) resulted from treatment of 100 % irrigation and shaded by date palm leaves followed by treatment of 120% and shaded by green net in two successive seasons. These two WUE high values indicated that suitability of using date palm leaves for potato shading. The less value for WUE was obtained from treatment of 100% with plastic green net shading. This result showed the difference between natural and artificial shading materials. The air temperature under date palm leaves was 2.3°C less than under the green plastic shade. This low temperature under date palm leaves could provide a moderate climate, which can reduce the evapotranspiration and improve the WUE.

TABLE 7. Average WUE (Kg/m^3 water consumed) values in two successive seasons.

Treatments	2002	2003
Irrigation (I)		
80% (I_1)	14.29	14.14
100% (I_2)	12.25	12.07
120% (I_3)	9.97	10.33
Average	12.17	12.18
Shade (S)		
Date palm (S_1)	10.54	11.72
Plastic net (S_2)	12.92	12.62
Non (S_3)	13.05	12.21
Average	12.17	12.18
I_1S_1	12.38	12.72
I_1S_2	9.77	10.25
I_1S_3	9.48	12.20
I_2S_1	19.66	19.59
I_2S_2	9.06	9.19
I_2S_3	10.06	9.09
I_3S_1	10.85	10.13
I_3S_2	17.93	16.76
I_3S_3	10.39	9.72

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تأثير التغطيـــة باســـتخدام أوراق النخيل علـــى نمـــو وإنتاجيـــة البطاطـــس تحت مســـتويات ري مختلفة .

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أجريت هذه الدراسة خلال الموسم الخريفي لكل من عامي ٢٠٠٢ ، ٢٠٠٣ وذلك بمزرعة كلية الزراعة والطب البيطري – جامعة الملك سعود فرع القصيم ، بهدف دراسة تأثير تغطية نباتات البطاطس بأوراق النخيل والتغطية بالبلاستيك الأخضر المثقب (تظليل ٤٠%) علي إنتاجية البطاطس تحت ثلاث مستويات من الري وهي ٨٠ ، ١٠٠ و ١٢٠% من قيمة البخر نتح الأساسي. أوضحت النتائج في هذه الدراسة أن التغطية بالبلاستيك الأخضر أعطت أعلى إنتاجية تحت مستوى ري ٨٠% بينما أدى استخدام التغطية بأوراق النخيل مع مستوى ري ١٠٠% الي حدوث أعلي كفاءة لاستخدام الماء ، ولقد أدت التغطية سواءاً بالبلاستيك الأخضر أو بأوراق النخيل إلى زيادة المساحة الورقية للنباتات ولكنها خفضت نسبة الكلوروفيل فيها وكذا النسبة المئوية للمادة الجافة في الدرنات . وكانت أعلى مساحة ورقية ونسبة كلوروفيل في الأوراق والنسبة المئوية للمادة الجافة في الدرنات للنباتات التي نمت تحت مستوى ري ٨٠%. وعموما يمكن القول بأن التظليل يمكن أن يحسن من كفاءة استخدام الماء وكذلك زيادة محصول البطاطس تحت ظروف المنطقة الوسطى للمملكة العربية السعودية.