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Evaluation of Potato Production as Affected by Irrigation Levels and Different Material Using in Mulching

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Abstract: The effect of water regime and light reduction on potato development and yield were studied during 2012 and 2013 seasons. The present experiment was conducted at the Experimental Farm of the College of Agriculture and Veterinary Medicine, Qassim University. The purpose of this research is to study the impact of different material using in mulching: shading by date palm leaves, 60% full sunlight and 100% sunlight on the performance of potato plants under different irrigation levels (80, 100 and 120% of class A pan). The results revealed that shading by green shades gave the highest potato yield under 80% irrigation level. The shading by green shades or date palm leaves increased leaf area of potato plants. But, the shading decreased chlorophyll and the percentage of tuber dry matter. The highest leaf area, chlorophyll and the percentage of tuber dry matter were observed for plants grown under 80% irrigation level with shading treatments. Therefore, the shading could enhance water use efficiency and increase potato yield under central Saudi Arabia conditions.

Key words: Light reduction · Light quantity · Potato production · Water regimes · Evapotranspiration · Shade level

INTRODUCTION

Potato (*Solanum tuberosum* L.) is an important source ofcarbohydrates. It ranks fourth among the world's crop production after wheat, rice and corn. The total world production is estimated at 381, 682, 000 tons in 2014. Potato production in Saudi Arabia is around 445, 028 tons in 2014 [1]. 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 found to affect plant growth and production. It changed 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 or enlarging the growth period span or both of them together. This can affect the plant development and productivity.

High temperature represents a serious limitation to the extension of potato production to warmer areas [2]. One way of cooling the microenvironment is utilizing the shade of associate crops or artificial shade [3]. High temperature at the late stage of potato crop is also detrimental to the tuber yield, particularly when soil was exposed to incoming radiation [4]. Reduction in soil temperature during the late part of tuber bulking stage in warm conditions, through the use of soil reflections, resulted in yield increase up to 50% [4]. Light intensity reduction as a result of either self-shading or shading by other materials, may create physiological and morphological changes in field crops [5].

Shade of palms and other trees have always been used to protect low growing crop, which are lender, grown for food and forage [6]. This natural shading reducing solar radiation and increasing moisture around these plants [7]. However, it has limits that make it less suitability for commercial crops:

- Competition between palms and the grown crops in between for the water and nutrients.
- Excess shade during the winter period giving spindly growth.
- Difficulties of soil activities.
- Difficulties of control and caring of the crops [6, 7].

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Table 1: Mechanical analyses of the experimental soil site

Mechanical analysis			Bulk density gm/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

Water is critical and vital factor for growth, yield and quality of crop. Potato is very sensitive to water [8]. Successful management of irrigation water is necessary to achieve a high yield, [9]. 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 [10]. 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 a knowledge of both irrigation and scheduling methods. Continuous water supply is generally recommended from tuber initiation to maturity, Miller and Marriam [11]. Insufficient irrigation water causes depression of plant size and growth, Hang and Gruz [12].

Abdel-Razik [13] and Abubaker [14] indicated that, as the applied water increased, the percent of large tubers size increased; while the percent of small tubers size decreased .Tuber dry content and specific gravity were increased with decreasing water amount of irrigation. El-Banna *et al*. [15] reported that using drip irrigation at rate of 1650 m^3/fed. recorded a maximum total tubers yield and higher water use efficiency (WUE).

The main aims of this investigation were to adjust the irrigation water quantity and to determine the optimum rate of irrigation water by using different irrigation levels 80, 100 and 120% of class A pan under the shading by date palm leaves and by green shades on the performance of potato plants.

MATERIALS AND METHODS

Plant Materials and Experimental Design: This study was conducted at the Experimental Farm of the College of Agriculture and Veterinary Medicine, Qassim University, during 2012 and 2013 seasons. Soil texture was sandy soil. Mechanical analyses of the experiment soil site were presented in Table 1.

This investigation was carried out for evaluation the effect of three shading treatments on potato growth and production under different irrigation levels (80, 100 and 120% of class A pan). The reduction of total solar radiation was obtained by reducing solar radiation intercepted by plants in the experimental plots using; palm tree leaves and artificial green shade consisting of one layer of “Roklene shade netting”. The experiment included an unshaded treatment. The photon flux density in every treatment was measured in the field using Specroradiometer (Li.Cor 1800) and the average readings were; 10800, 6100 and 3100 Lux for the palm tree leaves, Roklene shade netting and control treatment respectively.

Treatments were assigned randomly in three replication according to randomized complete block design. The plot was 4.5 X 4.5m and contained 6 rows 75cm apart. The planting distance was 30cm within the row. Presprouted tubers of cultivar Spunta were used.

Planting date of experiment 1 and 2 was 17 of January, 2002 and 19 January 2003 respectively. The required agricultural practices were done as necessary during the growing period in the two experimental seasons.

The plants in experiment 1 and 2 were harvested on 8 May 2012 and on 10 May 2013, respectively. The following growth and yield parameters were measured and the data were statistically tested by the analysis of variance using SAS package. Comparison of treatment means was done using least significant differences (LSD) test at the p= 0.05 level of significance.

Measurements
Vegetative Growth Parameters:

- Plant height, leaf area and number of branches were recorded.

Potato Tuber Yield: The number and weight of marketable and unmarketable tubers and total yield were recorded. Tubers sized between 15-55 mm in diameter were considered marketable tubers.

- Chlorophyll Content Was Determined:

RESULT AND DISCUSSION

Growth Characters: Medium irrigation water level was found to be more favorable for plant height and number of branches at the two growing seasons. Leaf area was higher at the lower water level. These parameters were significantly higher in 2013 season (Table 2). The number of stems of potato plants followed the same trend to plant height but opposite trend of leaf area in response to water level. The high water level (120%) gave the lowest parameters of the vegetative growth. The medium water level seems to be more suitable for plant height and number of branches more than the highest level. This could be due to the possibility leaching of nutrients away of root zone especially at the sandy soil such as this experiment soil. Low water level was the best for leaf area measurements.

In terms of shading treatments, it is found that shading plants by date palm leaves was enhancing plant height and leaf area. The green net shading was favorable for potato number of branches. Regarding the interaction between irrigation water level and shading treatments, the lowest water level with date palm shading was the best treatment for plant growth development.

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 plantseither by date palm leaves or by artificial shade net during the two seasons. These results are in agreement with Kuruppuarachchi [3] who found that potato plants were longer under shaded conditions and had higher leaf area. And also with agreement with Al-Moshileh and Motawei [16] who found that increased shading was significantly increased plant height, number of leaves per plant and leaf area. Moreover, similar results were obtained for other crops such as tomato [17, 18, 19].

The results also demonstrated that plants grown under palm tree leaves shading had more leaves as compared to plants subjected to other treatments, while the unshaded plants produced the lowest values in vegetative growth under any water level treatment. Similar results were obtained for onion plants [5]. He concluded that leaf number showed a progressive decline under non shaded treatment. On the other hand, the unshaded plants had the lowest leaf area in both seasons. Similar increment in leaf area in response to shading on tomato plants was obtained by El-Gezawi and Mohamed [18].

Chlorophyll Contents: Expectantly, as water level decreased and light intensity increased, the chlorophyll in plant leaves increased. Table 3 showed that highest values of chlorophyll was measured under water treatment of 80% in the two growing seasons as well as under control treatment where there were no shades. In spite of no significant differences were observed in the interaction treatments, it is clear that highest values were obtained from treatments of unshaded plants under any 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 knows to increase carbohydrates and solids in leaves.

Potato Yield: The results reported in Table 4 show that water treatments 100% and 120% gave the highest yields. The highest water level (80%) gave the lowest yield quality and quantity. This is in contradicting with the vegetative development when the lowest water level gave the lowest leaf parameters. It is well known that yield will reflect the foliage leaves development [17].

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

The interaction between water regimes and shading show the significant yield increment at the low water level with using the green shade net. Second water level gave also high yield with the green shade net and unshaded plants. The lowest water level (80%) also gave high yield using the green shade net for light reduction.

The low number of tubers produced by shaded plants could be ascribed to the low light intensity which may reduced the number of lateral stolons and the frequency of their tuberization [20]. Moreover, Wurr *et al*. [21] 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.The results of the potato yield in both seasons are presented in Table (4) and show that increasing water level and shading led to an increase in potato yield per unit area.

Specific Gravity and Total Tuber Weight: The results reported in Table 5 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 3), which may emphasis the importance of chlorophyll in carbohydrate formation. High water level gave the lowest tuber dry weight; this can be reflected of leaves development which had the same trend as mentioned in Table 2.

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 tuber weights. The reduction in tuber weights

Table 2: Effect of irrigation and shad treatments on plant growth parameters

Season	2012	2013	2012	2013	2012	2013
Characters	Plant height (cm)		No. of branches		Leaf area (cm^2)	
Treatments	50 days	55 days	50 days	55 days	84 days	83 days
80%	40.98	45.41	2.44	2.89	146.42	149.51
Irr.(I) 100%	44.23	49.55	2.89	3.78	122.24	127.43
120%	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
Date palm leaf	62.31	70.22	2.67	3.34	142.90	161.98
Net (S)	39.65	43.44	3.00	3.78	147.14	151.24
Non	25.13	27.13	2.44	3.00	97.430	101.59
Mean	42.36	46.93	2.70	3.37	129.15	138.27
I_1S0	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	74.870	74.750
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
L.S.D. 5% Irr.	1.857	1.99	N.S	0.495	N.S	8.606
Shad	1.857	1.99	0.451	0.495	30.75	8.606
Irr. x Shad	3.216	3.46	N.S	N.S	53.25	14.90

Table 3: Effect of irrigation and shad treatments on chlorophyll

Season	2012		2013	
Characters	Chlorophyll (spad)		Chlorophyll (spad)	
Treatments	70 days	84 days	75 days	83 days
80%	37.49	38.63	37.88	39.20
Irr.(I) 100%	34.58	36.13	34.85	37.83
120%	35.23	37.29	36.00	37.50
Mean	35.77	37.35	36.24	38.18
Date palm leaf	33.34	35.10	33.81	36.00
Net	35.07	35.51	35.59	36.36
(S) Non	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_3 S_1	33.23	35.81	33.89	35.10
I_3S_2	35.17	35.55	35.51	35.57
I_3 S_3	37.27	40.54	38.61	41.83
L.S.D. 5% Irr.	1.349	1.184	1.395	N.S
Shad	1.349	1.184	1.395	2.183
Irr.x shad	N.S	N.S	N.S	N.S

Table 4: Effect of irrigation and shad treatments on yield components in two successive seasons

Season	2012	2013	2012	2013	2012	2013	2012	2013
Characters								
Treatments	Yield (g/m^2)		Unmarketable yield (g/m^2)		No. of tuber (m^2) (marketable)		No. of tuber (m^2) (unmarketable)	
80%	1852.11	1808.22	180.44	187.89	18.89	14.44	11.11	12.55
Irr.(I) 100%	2011.89	1960.44	182.22	194.33	20.89	17.33	9.110	15.44
120%	2008.56	2014.22	205.11	190.33	23.44	21.22	11.55	13.22
Mean	1957.52	1927.62	189.25	190.85	21.07	17.66	10.59	13.73
Dat palm leaf	1867.84	1897.11	203.44	213.77	20.67	18.78	11.22	15.22
Net	1983.00	1906.33	216.55	208.78	21.78	15.78	10.33	13.77
Non (S)	2021.67	1979.44	147.77	150.00	20.78	18.44	10.22	12.22
Mean	1957.52	1927.62	189.25	190.85	21.07	17.66	10.59	13.73
I_1S_1	1626.00	1653.00	213.66	215.67	15.33	14.67	12.66	13.67
I_1S_2	2582.33	2454.00	223.66	224.33	26.00	15.33	1300	12.67
I_1S_3	1425.00	1317.00	104.00	123.66	15.33	12.33	7.660	11.33
I_2S_1	1603.66	1660.00	159.00	209.33	18.67	14.33	9.330	16.00
I_2S_2	1488.00	1493.33	252.33	233.00	17.00	14.33	9.330	18.00
I_2S_3	2944.00	2728.00	135.33	140.67	27.00	23.33	8.660	12.33
I_3S_1	1867.88	2378.33	237.66	216.33	28.00	27.33	11.66	16.00
I_3S_2	1982.99	1771.67	173.66	169.00	22.33	16.67	8.660	10.67
I_3S_3	2047.33	1895.67	204.00	204.00	20.00	21.22	14.33	13.00
L.S.D.5% Irr.	N.S	N.S	N.S	N.S	3.097	2.757	N.S	2.007
Shad	N.S	N.S	N.S	43.625	N.S	N.S	N.S	2.007
Irr.xShad	532.21	406.18	N.S	4.77	5.36	4.77	N.S	3.478

Table 5: Effect of irrigation and shad treatments on quality parameters in two successive seasons

Season	2012	2013	2012	2013	2012	2013	2012	2013
Characters								
Treatment	Specific gravity		Tuber dry matter (g)		Tuber Dry weight (g)		Ava. of tuber fresh weight (g)	
80%	1.0612	1.0622	19.47	19.53	19.49	19.22	100.25	98.71
Irr.(I) 100%	1.05877	1.0678	18.05	17.81	17.86	18.39	99.44	101.52
120%	1.0705	1.0605	17.68	17.73	16.95	17.06	95.51	96.14
Mean	1.0732	1.0635	18.4	18.35	18.10	18.22	98.40	98.79
Dat palm leaf	1.0619	1.0553	17.87	17.84	17.39	17.23	97.11	96.14
Net	1.0837	1.0653	18.04	18.06	17.02	17.17	93.77	94.02
Non (S)	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	1.05838	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
L.S.D. (5%) Irr.	N.S	N.S	0.836	0.77	N.S	1.91	N.S	N.S
Shad	N.S	N.S	0.836	0.77	N.S	N.S	N.S	N.S
.Irr.xShad	N.S	N.S	N.S	N.S	N.S	3.30	N.S	14.82

resulting from high shading is in agreement with the result obtained by Li Cai Bin; Guo Hua Chun [22] on potatoes and also by El-Gezawi and Mohamed [18] and Ozer [23] on tomato. This could be ascribed to low carbohydrate manufactured in the leaves and translocated down to the tubers.

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