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EFFECT OF COVER THE PLANT AND DEPTH OF DRIP IRRIGATION ON GROWTH AND YIELD OF POTATO (*SOLANUM TUBEROSUM* L.), LAPEARLA VARIETY IN GYPSUM SOIL

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Abstract

This study was conducted in the research station of Horticulture and Landscape Department - College of Agriculture – Tikrit University, in the spring of 2019, to study the effect of two factors; the first factor is to cover the *Solanum tuberosum Plant* (without cover, plastic cover for 45 days from planting,plastic cover for 45 days from plant in, then cover with saran only 45 days before harvesting and cover with saran only for 45 days before harvesting). The second factor is the depth of drip irrigation systemwhich includes: (surface irrigation, subsurface irrigation with a depth of 5 cm). Field experiment was performed by using *Split-Plot Design* in randomized complete block design (RCBD), with three replicates, each one made up of (8) treatments, these treatments randomly distributed according to the design followed. The number of experimental units was (24) units at a length of (3 m.) and (60 cm) width. After the data entry, the averages were compared by using Duncan's multiple range test at a significant level 0.05. The results indicated that the treatment of plastic cover with saran exceeded the height of Plant, the rate of the largest tuber, the hardness of the tubers, the percentage of dry matter of the tubers and the speed of germination. The treatment of plastic cover only was superior at the number of air stems, field germination speed and total soluble solids T.S.S. concerning with the saran cover treatment, the total chlorophyll was superior at the number of marketable tubers, and the total number of plant tubers, the marketable yield, the length of the tuber and the total yield. While the second factor: "depth of irrigation", the surface irrigation treatment exceeded the hardness of the tubers and the length of the tubers; Subsurface irrigation has outnumbered marketable tubers only. In the interaction treatment between the cover of the Plant and the irrigation system, we observed that the treatment of saran cover with subsurface irrigation exceeds the number of marketable tubers and the marketable yield. In plastic and saran cover treatment with surface irrigation exceeded according to the number of air stems, tuber rate, tuber firmness, length of tubers, dry weigh and specific gravity tubers; while the same treatment of cover for the subsurface irrigation system showed outdone in Plant height and growing speed as it achieved the fastest growing was about 19.81days.

Key words : Plant, drip irrigation, potato, lapearla, gypsum soil.

Introduction

Solanum tuberosum L. is one of the most important Plant of Solanaceae, which is considered one of the strategic crops (Coleman *et al.*, 1992), and one of the most important food crops in the world, and tops the list of tuber crops. In terms of importance, it ranks fourth after wheat, rice and maize (Al-Dhabibi, 2003). Scientists agree that its native country is the Andes Mountains range in Peru and Bolivia (Kloosterman *et al.,* 2013).

Production of potato (*Solanum tuberosum* L.) in Iraq is unconvincing when compared with other countries, because of many problems experienced by potato farmers, including as the most important problem: high temperatures and variations in temperature per day, as well as the possibility of frost due to low temperatures in February and March. This has led many farmers and researchers to try to find different means and methods such as "cover", especially in the early times of Plant life to protect it from decreasing in temperature or reduce the effect of rain that leads to many fungal diseases; or cover with Saran to reduce the effect of high temperature caused by high solar radiation at the end of the growing season of potato and fluctuation during all the days and to prolong the growth and development of tubers.

Drip irrigation system is one of the advanced irrigation systems compared with other irrigational systems, so drip

irrigation works to deliver water to the soil and accurately to the roots. One of the most important indicators that assess the efficiency of irrigation is the uniformity of the distribution of water on a regular basis; the higher of uniformity in distribution of water, the higher of discharge of water will be equal, The higher distribution of drip irrigation, the greater of uniform distribution of water will be equal and organized (Ahmed *et al.,* 1999). In order to achieve this distribution, two ways of drip irrigation "surface and subsurface irrigation" were used and the results were compared. So, this study aims at determining the optimal irrigation system for *Solanum tuberosum crop* in gypsum soils, and identifying the significant problems and constraints of these soils in irrigation through the use of subsurface drip irrigation; As well as providing good environmental conditions to help the germination speed and improve the production of quantity and quality by using different cover treatments.

Materials and Methods

The experiment was conducted in the Department of Horticulture and Landscape - College of Agriculture - University of Tikrit, in the spring of 2019, the experiment was made by using Split-Plot Design in randomized complete block design (RCBD), to study two factors: irrigation depth and cover treatments. The depth of irrigation was put in the main plot that was at two depths, the first one was surface irrigation and symbolized by the symbol "S", the second was subsurface irrigation at a depth of 10 cm and symbolized by the symbol "U". The second factor was the cover, and the secondary took "sup plot" as the most important, which included four treatments of cover are:

1. Treatment of non-cover and symbolized by the symbol "W".
2. Treatment of transparent plastic cover and then lifted after 45 days of planting and symbolized by the symbol "P".
3. Saran cover treatment only 45 days before harvesting and symbolized by the symbol "C".
4. The plastic treatment of cover for 45 days from the date of planting, and then cover by Saran 45 days before the harvesting and symbolized by the symbol "PC".

Where the thickness of the plastic used was 100 microns placed on iron arches above the Plant to make tunnels, and the number of Plant in each experimental unit was 10 plants, a length of 3 meters and a width of 60 cm; each replicator consists of 8 experimental units, and 3 replicators, bringing the total of 24 experimental units. *Potato tuber* of "La Perla" grade A + was imported from the Netherlands on 14-2-2019. It is characterized by an average in the proportion of dry matter, and fast-growing, and tolerate drought somewhat, and the large number of stems and length that spread sideways and large tubers and skin is soft and the outer color is light brown, and the color of the pulp yellowish white. Crop service after planting was carried out in accordance with the recommendations for the cultivation of *Solanum tuberosum* from irrigation, weeding and exportation of soil, control of diseases and insects equally for all treatments. The plants were fertilized according to the recommended recommendations in the *Solanum tuberosum* production fields. The harvesting operations took place on 16 June 2019; Then samples from the soil of the field were taken before planting at a depth of 0-30 cm for analyzing to determine some of the physical and chemical properties as in Table 1.

The following characteristics were measured: Plant height (cm), number of air stems (Stem. plant^{-1}), field germination speed (day), total chlorophyll (SPAD), number of marketable tubers (tuber plant^{-1}), total tubers (tuber. Plant^{-1}), marketable product (ton. ha^{-1}), largest tuber weight (g), tuber diameter (cm), tuber length (cm), total yield (ton. ha^{-1}), total soluble solids T.S.S, hardness of tubers (kg. cm^{-2}), percentage of dry matter of tubers (%), percentage of starch (%), specific density.

Results and Discussion

Through the results obtained in table 2, which show the effect of Plant cover on the characteristics of vegetative growth and the quantitative and qualitative yield, we noted that there were significant differences in most of characteristics measured at different cover except the characteristic number of air stems, total chlorophyll and Total Soluble Solids (TSS), in which there were no significant differences.

In terms of Plant height, germination speed, starch and specific weight, the treatment of "P" and "PC" exceeded 56.57, 57.88 cm - 22.44, 20.38 days - 13.36, 13.54%, 1.064 and 1.065 respectively compared with other treatments. The increase in Plant height when treated with "P" and "PC" cover may be attributed to the fact that the cover process resulted in the provision of suitable temperatures (Almekinders and Brien, 1986), so this resulted in an increase in Plant height. As for the increase in the field germination speed when cover the tubers, the reason may be due to the effect of cover in stimulating buds because they provide relatively high temperatures than other treatments, and thus lead to stimulate their growth and then early field germination

Table 1: Physical and Chemical Characteristics of Field Soil.

Organic matter (mg. kg^{-1})	Gypsum (g. kg^{-1})	EC (Ds. M^{-1})	pH	N (mg. kg^{-1})	P (mg. kg^{-1})	K (mg. kg^{-1})	Sand (g. kg^{-1})	Silt (g. kg^{-1})	Clay (g. kg^{-1})	Textural class
32	0.15	46	7.5	25	0.20	4.0	604	233	163	Loamy sand

(Mikael, 2013).

The reason for increasing the percentage of starch and the specific weight of tubers at the treatment of "P" & "PC" may be due to the role of cover, which served to provide appropriate temperatures compared with other treatments (Almekinders and Brien, 1986 and Mikael, 2013). This led to an increase in vegetative growth and an increase in Plant height, then consequently to increased nutrient absorption, increased photosynthesis, which led to the rapid construction and transmission of carbohydrates to tubers and increased materials manufactured in the leaves subsequently stored in tubers in the form of dry matter; This increases the percentage of starch and specific weight of tubers (Rastorksi and Vanes, 1981). Or it may be due to the physiological maturity speed and aging of tubers, due to the rapid drying of total vegetative of the cover treatment, and the transfer of carbohydrates to tubers; unlike the rest of the other treatments, which remained the total vegetative, until the end of the experiment.

Through the same table, there is a significant increase in the number of marketable tubers, the total number of tubers, the marketable yield, the length of the tubers and the total yield when cover with saran; the values were 8.98 tuber, 13.15 tuber, 1.06, 11.12 cm and 1.293 tons respectively. The reason may be due to the role of saran, which worked to suit the climatic conditions of the Plant, which caused an increase in the percentage of total chlorophyll and thus improved the characteristics of vegetative growth (Sweed, 2019) and reflected positively on the characteristics mentioned. Moderate heat plays an important role in increasing the number of tubers, the

Table 2: The impact of cover on vegetative traits, quantitative and qualitative yield of potato.

Total yield (ton. ha^{-1})	Tuber weight (g)	Marketable yield (ton. ha^{-1})	Total of tuber (tuber. Plant^{-1})	Number of marketable tuber (tuber. Plant^{-1})	Number of arial stem (stem. Plant^{-1})	Plant height (cm)	Germination speed(Day)	Treatments
0.942b	216.00b	0.62b	12.63a	6.02b	3.60a	34.78b	29.05a	W
0.815b	226.83b	0.62b	10.67b	6.12b	4.27a	56.57a	22.94b	P
1.293a	313.83a	1.06a	13.15a	8.98a	3.74a	38.14b	28.61a	C
0.901b	329.83a	0.71a	11.13b	6.37b	4.18a	57.88a	20.38b	PC
Specific weight	**Starch (%)**	**Chlorophyll (SPAD)**	**Percentage of dry matter in tuber(%)**	**Tuber hardness (%)**	**T.S.S.**	**Tuber length (cm)**	**Tuber diameter (cm)**	**Treatments**
1.o57b	10.72c	44.34a	14.96ab	9.54a	13.65a	9.95b	7.05bc	W
1.064a	13.36a	44.43a	14.22b	9.07a	13.92a	9.97b	6.40c	P
1.056b	11.76b	45.20a	15.60ab	7.85b	13.58a	11.12a	7.35b	C
1.065a	13.54a	45.00a	17.31a	9.79a	13.87a	10.18a	8.30a	PC

*The numbers with the same letter means no significance on Duncan Multiple Test at 5% probability.

Table 3: The impact of irrigation depth on vegetative traits, quantitative and qualitative yield of the potato.

Total yield (ton. ha^{-1})	Tuber weight (g)	Marketable yield (ton. ha^{-1})	Total of tuber (tuber. Plant^{-1})	Number of marketable tuber (tuber. Plant^{-1})	Number of arial stem (stem. Plant^{-1})	Plant height (cm)	Germination speed(Day)	Treatments
0.908a	296.83a	0.67a	10.90a	5.87b	4.07a	48.08a	25.63a	S
1.067a	246.42b	0.83a	12.89a	7.88a	3.86a	45.60a	24.86a	U
Specific weight	**Starch (%)**	**Chlorophyll (SPAD)**	**Percentage of dry matter in tuber(%)**	**Tuber hardness (%)**	**T.S.S.**	**Tuber length (cm)**	**Tuber diameter (cm)**	**Treatments**
1.062a	12.45a	45.52a	15.15a	9.63a	13.77a	10.62a	7.48a	S
1.059a	12.24a	43.97a	15.89a	8.50b	13.74a	9.99b	7.08a	U

*The numbers with the same letter means no significance on Duncan Multiple Test at 5% probability.

Table 4: The impact of cover and irrigation depth on vegetative traits, quantitative and qualitative yield of the potato.

Total yield (ton. ha^{-1})	Tuber weight (g)	Marketable yield (ton. ha^{-1})	Total of tuber (tuber. Plant^{-1})	Number of marketable tuber (tuber. Plant^{-1})	Number of arial stem (stem. Plant^{-1})	Plant height (cm)	Germination speed(Day)	Treatments
0.874b	213.67d	0.51b	10.97a	4.23d	3.71cd	37.89b	29.57a	W S
1.010b	218.33d	0.73b	14.30a	7.80b	3.48d	31.67c	28.52a	W U
0.799b	223.00d	0.58b	9.50a	4.60d	4.39ab	57.33a	23.14b	P S
0.830b	230.67d	0.65b	11.83a	7.63b	4.14abc	55.81a	22.73b	P U
1.127ab	338.33b	0.92ab	12.50a	8.17b	3.43d	40.50b	28.86a	C S
1.458a	289.33bc	1.20a	13.79a	9.80a	4.05bcd	31.77bc	28.37a	C U
0.830b	412.33a	0.67b	10.65a	6.47c	4.76a	56.58a	20.95b	PC S
0.971b	247.33cd	0.75b	11.63a	6.27c	3.60cd	59.17a	19.81b	PC U
Specific weight	**Starch (%)**	**Chlorophyll (SPAD)**	**Percentage of dry matter in tuber(%)**	**Tuber hardness (%)**	**T.S.S.**	**Tuber length (cm)**	**Tuber diameter (cm)**	**Treatments**
1.059e	9.80e	45.33a	14.87a	10.63a	13.60a	10.37b	6.93bc	W S
1.056ab	11.65cd	43.34a	15.05a	8.45ab	13.70a	9.53c	7.17bc	W U
1.064ab	13.26ab	44.16a	11.58b	9.28a	14.07a	9.53c	6.37c	P S
1.064ab	13.46ab	44.71a	16.85a	8.85a	13.77a	10.40b	6.43c	P U
1.059ab	12.37bcd	47.54a	15.88a	9.12a	13.60a	11.27a	7.73b	C S
1.052b	11.14d	42.86a	15.33a	6.59b	13.57a	10.97ab	6.97bc	C U
1.066a	14.37a	45.05a	18.30a	9.47a	13.80a	11.30a	8.87a	PC S
1.063ab	12.72bc	44.95a	16.32a	10.10a	13.93a	9.07c	7.73b	PC U

*The numbers with the same letter means no significance on Duncan Multiple Test at 5% probability.

total yield and qualitative characteristics of the tuber, such as the length and diameter of the tuber. The best temperature for the emergence of tubers is 12 C° after 3-5 weeks of Planting, and this process decreases when the temperature rises above 21 °C, and may stop at 29.4 °C. Knobbiness or secondary growths often occur in tubers when temperatures rise to 32 °C for two weeks. The growth of tubers increases at a temperature of 15.5 - 18 °C, which in turn reduces respiration and increases the accumulation of carbohydrates resulting from photosynthesis (USDA, 2003) and thus improves the yield.

Table 1 also shows an increase in the largest tuber rate with "PC" & "C" treatments, reaching 329.83 and 313.83 grams respectively; also, there was a significant increase in the characteristic of the diameter of the tuber, reaching 8.30 cm for the treatment "PC" compared with the lowest diameter in the treatment "P", which was 6.40 cm. The same table also shows an increase in the hardness of tubers at the treatment of "PC" and reached 9.79 kg.cm^{-1} and did not differ from the rest of the treatments except treatment "C", which was less hardness at 7.85 kg. cm^{-1}. As for the percentage of dry matter for tubers, it was higher in the treatment "PC" 17.31% compared with the lowest percentage of dry matter for tubers at treatment "P" 14.22%. This increase in the aforementioned traits, especially in the treatment "PC" may be due to the role of cover, which caused an increase in Plant height and the number of air stems, which was positively reflected in the increase in the percentage of dry matter of tubers (Caliskan *et al.,* 2009).

Table 3 shows the results of irrigation depth, which show that there were no significant differences between the treatments except: The number of marketable tubers, the largest tuber rate, the length of the tuber, and the hardness of the tuber. Subsurface irrigation treatment outperformed the number of marketable tubers when treating subsurface irrigation and gave 7.88 tuber per Plant, compared to the surface irrigation method that gave 5.87 tuber per Plant. This increase may be attributed to the fact that subsurface irrigation has resulted in water staying longer in the soil and near the roots, and not affected by air transpiration. This may increase the density of the roots and thus increase the absorption of nutrients which ultimately increases the number of marketable tubers (Al- Issawi, 2017).

Whereas from the same table, the surface irrigation method exceeds the maximum tuber rate, tuber length and tuber hardness at 296.83 gm, 10.62 cm and 9.63 kg. cm^{-1}, respectively; compared with the subsurface irrigation method which was 246.42 gm, 9.99 cm and 8.50 kg. cm^{-1} for the aforementioned traits respectively.

This may be due to the nature of the *Solanum tuberosum* Plant, which has roots centered at a depth of 30 cm. As the nature of the study soil was gypsum and contains a high proportion of gypsum, it may have led to the formation of a solid layer that significantly impedes the movement of the roots downward; This is consistent with the view of (Al- Abbasi, 2015) and thus the Plant will benefit from surface irrigation water more than subsurface drip irrigation. This in turn is reflected in the qualitative and quantitative traits such as the yield per Plant and the length and diameter of the tubers and tubers hardness (Shock *et al.*, 2007 and Cabrera *et al.*, 2016).

As for table 4, which shows the interaction treatments between the cover and the depth of irrigation, we notice significant differences between treatments except total chlorophyll, total number of tubers and total soluble solids T.S.S. For field germination speed and Plant height, the interaction treatment exceeded at "PC" cover and at subsurface irrigation at 19.81 days and 59.17 cm, respectively, compared to the fastest germination and the lowest height at 28.52 days and 31.67 cm under interaction treatment of without cover with subsurface irrigation.

Interaction between treatment "PC" cover at surface irrigation exceeded the number of air stems, tuber rate, tuber diameter, tuber length, percentage of tubers dry matter, percentage of starch and specific weight: 4.76 stems per Plant, 412 33 grams, 8.87 cm, 11.30 cm, 18.30%, 14.37% and 1.066, respectively.

In the interaction treatment between cover "C" using subsurface irrigation methods, it exceeded the number of marketable tubers and the marketable yield was 9.80 tubers per Plant and 1.20 tons respectively. Compared with the smallest number of marketable tubers was 4.23 tubers per Plant and the lowest yield was 0.51 tons; This is when the interference is treated when there is no cover treatment "W" and surface irrigation. In the interaction treatment between the treatment of non-cover "W" and surface irrigation "S" has excelled in the hardness of tubers, reaching 10.63 kg. cm^{-1} compared with the lowest hardness was 6.59 kg. cm^{-1}. This is the case when bilateral interference between Saran "C" cover treatment is treated when the subsurface irrigation method "U" is used.

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