International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:9, No:3, 2015

Effect of Three Sand Types on Potato Vegetative Growth and Yield

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***Abstract*—**Potato (*Solanum tuberosum* L.) is one of the major vegetable crops that are grown world –wide because of its economic importance. This experiment investigated the effect of local sands (River Base, Al-Ekader and Karbala) on number and total weight of minitubers. Statistical analysis revealed that there were no significant differences among sand cultures in number of stem/plant, chlorophyll index and tubers dry weight. River Base sand had the highest plant height (74.9 cm), leaf number/plant number (39.3), leaf area (84.4 dcm^2/plant), dry weight/plant (26.31), tubers number/plant (8.5), tubers weight/plant (635.53 gm) and potato tuber yields/trove (28.60 kg), whereas the Karbala sand had lower performance. All the characters had positive and significant correlation with yields except the traits number of stem and tuber dry weight.

***Keywords*—**Correlation, Potato, Sand Culture, Yield.

I. Introduction

POTATO is a popular and major vegetable crop of Iraq; it is the most widely cultivated food crop after wheat, rice and maize. Each year potato plants are infected by a number of viruses, fungal and bacterial diseases [1]-[3]. Infections can have a dramatic effect on yield and marketable quality of a crop. The total potato yield loss caused by diseases is estimated between 6 to 25%, with up to 60% during cultivation and in storage [4]. The fungal and bacterial diseases could be controlled or minimize by applying chemicals while viruses diseases are uncontrollable. Once a plant is infected by virus, it carried over generations through tubers and caused degeneration and yield loss [5].

To overcome this problem, the basic seed materials must be free of many pathogens. Therefore tissue culture technique is used to produce micro-tubers. Micropropagation of potatoes in laboratories has shown to eliminate virus diseases thus ensuring a virus-free material resulting in increased yields. Although microtubers area source of genetically preserved for easy transfer and circulation and the possibility of production laboratory in large quantities throughout the year [6], it is expensive and needs the availability of experienced workers in this area. Recently used as an efficient method to produce and propagate minitubers, which are healthy seeds without any contamination to pathogens, the propagation of potato is hydroponically. Hydroponic systems differ in whether plants are cultivated on nutrient solution alone with the root systems emerged in the solution like nutrient film technique or NFT [7] and aeroponics [8] or on nutrient solution in combination with a solid material using perlite, coir [9], rockwool, vermiculite, gravel or sand as inert substrates. In hydroponic systems with solid materials, the nutrient solution is commonly supplied by ebb and flow irrigation systems, by drip irrigation, or simply on top by hand and watering can [10].

Simple correlation coefficient is a useful method to study the interrelationships between tuber yield and other characters. Khayatnezhad et al. [11] found positive correlations between tuber yield and main stems/plant (r= 0.925), plant tuber weight (r=0.992), plant height (r=0.843). Felenji et al. [12] stated that tuber weight has positive and significant correlation with tuber yield. Lamboro et al. [13] determined that a positive and significant correlation between tuber yield and biological yield, plant height and tuber yield, stems per plant and tuber per plant. Darabad [14] concluded that the tuber yield had a significant positive correlation with leaf area index, plant height, main stem diameter, weight of tubers/ plant, number of tubers/ plan. Maralian et al. [15] reported that yield had the positive and significant correlation with chlorophyll

Expanded crop potatoes in Iraq in order to increase demand was accompanied by the increase import large quantities of seed potatoes in hard currency, so the need arises to search for ways to reduction of the import process like using simply hydroponic system and evaluate its efficiency through the use of different types of local sand and to determine their effects on growth and tuber yield of potato plants.

II. Materials and Methods

This study was conducted during January to April 2012 at greenhouse of Agricultural Research Directorate/ Ministry of Science and Technology, Baghdad-Iraq. Greenhouse included 6 basins (trove) [the size of each basin 12.5 x 1.25x 0.6 m] with a perforated plastic tube from each side (diameter 15 cm) in the corner of the basin to help in the conduct of excess water after irrigation drainage. These basins build of concrete and thermestone and covered with polyethylene sheet from inside. Each Basin filled with one type of local sand, river base sand (black sand), Al-Ekader sand (red sand) and Karbala sand (white sand). Elite potato tubers Rivera variety planted ina distance of 25 x 25 cmspacing (Fig. 1). Hanging yellow traps used at two or three points in the greenhouse to help to control insects.

Plot were manually irrigated, N and K and P fertilizers were applied at the rate of 400, 300 and 200 kg/h respectively as top dressing [16].

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Fig. 1 Elite potato Rivera variety plants in a distance of 25 x 25 cm spacing. A trove contained Al-Ekader sand

Foliar nutrients application began by which time plants had 5 leaves for effective foliar application. Foliar application at the rate of 100-250 ml/plant of liberal BMX fertilizer (complete trace elements) was sprayed twice a month.

The level of chlorophyll in the youngest expanded leaves was recorded by taking SPAD (chlorophyll content) readings with a SPAD-502 Chlorophyll Meter (Minolta Camera Co. Ltd., Japan).

After measuring the total leaf area (5 plants/replication) by using a leaf area meter (LI 3100, Li-COR, USA), the plant height, number of stem/plant and the number of leaves/plant were recorded. Shoot and tubers (5 plants/ replication) were oven-dried (48 h at 72 °C) for dry weight determination. At the end of the experiments number of tubers/plant and tuber yield/trove were recorded.

The experiment was setup using Randomized Complete Block Design with 2 replicates. Analysis of variance (ANOVA) and correlation were performed using the SPSS program. If ANOVA determined that the effects of the treatments were significant ($p < 0.05$ for F-test), then the treatment means were separated by Duncan's multiple range test.

III. Results and Discussion

The average yield of potato in Iraq is low (15.7 t/ ha), compared to average yield in New Zealand and USA which are 41.8 and 44.9 t/ha respectively (FAOSTAT: http://faostat.fao.org). Iraqi farmers generally use own grown potato tuber as seed in the next season year, this method of propagation allows viruses to be transmitted to the new crop each year, resulting in diseases which in turn reduce yields. Efforts were made to increase the productivity of disease-free planting material in net houses and polytunnels through improved culture methods such as changing growth media, introduced suitable culture systems for minituber production or hydroponics in order to supply farm with good quality seed for further multiplication. The present study was undertaken to establish a protocol for mass tuber production free of virus and pathogen of elite cultivar (Rivera variety), for this purpose different type of local sands was used. Aphids are important insect as vector of potato viruses, in our experiment we tried to control of aphids on greenhouse using mesh crop covers that allows 90% of light to penetrate (Fig. 1) and proper choice and application of pesticides when they are needed.

No necrosis (dead spots on leaves) has been discovered during growing season. Yield tubers at the end of season tested for *Potato virus Y* (PVY) and *Potato virus X* (PVX) using immunological methods (ELISA, Enzyme Linked Immunosobent). The result revealed (data not shown) that the tubers are healthy without any contamination to pathogens.

Vegetative growth of potato in sand treatments is represented in Table I. The result showed that there were no significant differences among sand cultures in number of stem per plant and chlorophyll index (determined as SPAD readings). It was notable that the plant height, leaf number/plant of Al-Ekader sand treatments were not statistically different compared with River Base and Karbala sand treatments. From other hand, River Base sand had the highest leaf area (85.4 dcm^2/plant), whereas the Karbala sand had lower performance (44.51 dcm^2/plant). River Base sand significantly surpassed compared with Al-Ekader and Karbala sands in plant height, number of leaves/plant, plant dry weight. Plant height reached 74.9, 61.5 and 53.15 cm, number of leaves/plant reached 39.3, 25.6 and 22.4 and plant dry weight reached 26.31, 17.39 and 16.96 gm in River Base, Al-Ekader and Karbala sands respectively.

TABLE I
EFFECT OF SANDS TYPE ON PLANT GROWTH OF POTATO CV. ARNOVA

Sand Type	Plant Height (cm)	No. Leaf /Plant	No. Branch /Plant	Leaf Area dcm^2/ Plant	Chlorophyll	Plant Dry Weight (gm)
River Base	74.90a	39.30a	2.40a	85.40a	38.98a	26.31a
Al-Ekader	61.50b	25.60b	2.10a	71.23a	36.81a	17.39b
Karbala	53.15b	22.40b	1.70a	44.51b	34.94a	16.96b

Different letters show significant differences at P≤0.05 (Duncan)

Reproductive growth of potato is represented in Table II. No significant differences in tubers dry weight were found among sand treatments, while River Base sand had the highest number of tubers/plant (8.5), tubers weight/plant (635.53 gm) and potato tuber yields/trove (28.6 kg) compared with Al-Ekader and Karbala sands.

TABLE II
EFFECT OF SAND TREATMENTS ON YIELD OF POTATO CV. ARNOVA

Sand Type	No. Tubers /Plant	Tubers Weight/ Plant (gm)	Tubers Dry Weight (gm)	Yield/ Trove (kg)
River Base	8.50a	635.53a	17.14a	28.60a
Al-Ekader	6.50b	497.74b	16.66a	22.40b
Karbala	4.70b	458.74b	15.01a	20.64b

Different letters show significant differences at P≤0.05 (Duncan)

This result is in agreement with those obtained by [17] and [18] who found that the highest yield of potato varieties was in River Base sand. This is maybe due to the small size of granules middle to high clay and silt which compared with the rest of the circles, which helps to increase the space quality of soil particles, a property key associated with phenomena

important and useful ion exchanges and grab and release various ions, and helps soil particles to hold more water and water keeping [17] and then increase the cations exchange capacity CEC per unit mass. A high CEC is regarded as favorable as it contributes to the capacity of soils to retain plant nutrient cations. Soils with high CEC not only hold more nutrients, but they are better able to buffer, or avoid rapid changes in soil solution levels of these nutrients by replacing them as the solution becomes depleted and increase nutrients adsorbed on their surfaces. Once these cations are bound to these sites, they are protected from leaching away in water, yet they are still available for uptake by plant roots.

Increase of dry matter and tuber is determined by a production of photosynthesis especially by leaves. Higher leaf area may increase yield directly by enabling the plants to intercept more solar radiation. Although stem density is one of the most important yield components in potato, it was not significantly influenced by sand types; this result is agreement with [19]. Generally correlation coefficient analysis clarifies the relationships between characteristics. Correlation coefficients calculation among the traits (Table III) revealed positive correlations between plant height and number of leaf per plant (0.862), tuber weight per plant (0.792), tuber number per plant (0.832), plant dry weight (0.951), leaf area (0.846) and yield/trove (0.792). Number of stem was not significantly correlated with other traits except with chlorophyll (0.834), from other hand chlorophyll content had positive and significant correlation with all traits except with plant dry weight (0.538) and tubers dry weight (0.544). Number of leaf per plant significantly correlated with tubers weight per plant (0.910), tuber number per plant (0.733), plant dry weight (0.896), leaf area (0.872) and yield/trove (0.910). Also leaf area tuber number and weight per plant exhibited significant and positive correlation with all traits except with number of stem per plant and tuber dry weight. Leaves are the principal sources of photosynthesis carbon, the partitioning and allocation of carbon is correlated with plant growth since the export of carbohydrate from leaves provides the substrate for the growth and maintenance of non-photosynthetic tissues [20], [21].

Tuber yield is a complex character associated with many traits, our result showed that all the traits had positive and significant correlation with yields (except the traits number of stem and tuber dry weight) that mean any positive increase in such characters will increase in tuber yield. These findings were in similar with the results of other researches [11]-[15].

TABLE III
CORRELATION AMONG VEGETATIVE AND YIELD COMPONENTS CHARACTERS OF POTATO CV. ARNOVA

Traits	No. Stem /Plant	Chlorophyll	No. Leaf /Plant	Tubers Weight/Plant	No. Tubers /Plant	Dry Weight/Plant	Tubers Dry Weight	Leaf Area	Yield/ Trove
Plant Height (cm)	0.070	0.529	0.862*	0.792*	0.832*	0.951**	0.320	0.846*	0.792*
No. Stem/Plant		0.834*	0.350	0.435	0.355	0.132	0.267	0.334	0.435
Chlorophyll			0.778*	0.819*	0.733*	0.538	0.544	0.763*	0.819*
No. Leaf /Plant				0.910**	0.790*	0.896**	0.561	0.872*	0.910**
Tubers Weight/ Plant					0.935**	0.796*	0.332	0.789*	1.000**
No. Tubers /Plant						0.745*	0.224	0.805*	0.935**
Dry Weight/Plant							0.248	0.736*	0.796*
Tubers Dry Weight								0.716	0.332
Leaf Area									0.789*

* Correlation is significant at the 0.05, ** Correlation is significant at the 0.01 level.

IV. CONCLUSION

Sand cultures are an efficient method to produce and propagate clean tubers (free virus). Type of the sand culture effect on vegetative growth and yield of potato, River Base sand is the best compared with other sand types

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