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# Influence of cobalt application and irrigation intervals on Improvement of rice production: I- Growth characters

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## ABSTRACT

Rice has been grown under traditional irrigation practices along Egypt, and requires between 700 and 1,500 mm of water for a cropping season depending on soil texture. The actual amount of water used by the farmers for land preparation and during the crop growth period is much higher than the actual field requirement. The main problem which faces Egyptian agriculture is the limitation of irrigation water because of scarcity of water resources and limitation of Egyptian water budget which is 55.5 billion cubic meter. So, this experiment was carried out to maximize rice production from water unite after treated grown in clay soil by cobalt (7.5, 10, 12.5, 15, 17.5; 20 ppm ) under different irrigation intervals (2, 4, 6, 8; 10 days)to study the effect of cobalt application rates on the rice growth characters under different irrigation intervals. The obtained results indicated that the highest values of these characters were recorded at 12.5 ppm Co and 2 days irrigation intervals at all measured rice growth characters. There were dramatically decrease in those characters with increasing irrigation intervals periods under different Co application rates. There is no significant differences between 2 and 4 days irrigation intervals. Data also revealed that the rate of increase was low if cobalt application rates ranged between 0 and 7.5 ppm than the percentage of increase relative to cobalt application unite (2.5ppm) that was highly. Slightly decrease in the rice growth characters values if cobalt increased than 12.5 ppm.

***Key words:*** Cobalt irrigation intervals, clay soil, rice, growth characters, yield components, WUE.

## Introduction

Cobalt is an essential element for synthesis of vitamin $B_{12}$ (Smith, 1991). In addition to that, cobalt does not accumulate in human body as other heavy metals. Cobalt as one of the beneficial elements, seems to have a positive effect on higher plants to withstand water stress conditions. Kaura *et al.* (2015) reported that soil application of cobalt at rate 3g/kg dry soil increased leaf water content and decreased water deficit during day time in tomato and potato leaves. This application also, increased water absorption capacity and the content of strongly bond $H_2O$ in the leaves.

Blaylock *et al.* (1995) pointed out that cobalt increased cytoplasmic pressure and leaf resistance to hydration and decreased the wilting coefficient of the plants, increasing thereby their drought resistance. Soaking soybean seeds in cobalt solution partially alleviated the effect of moisture stress on seedlings growth. Nadia Gad, (2006) found that cobalt at 7.5 ppm had a promotive effect on tomato plants growth under two water regimes (100 and 30 % available water). She added also that application cobalt reduced both of transpiration rate and leaf water potential and hence reduced water loss as well as water consumption. Due to increasing scarcity of freshwater resources available for irrigated agriculture and escalating demand of food around the world, produce more food with less water is a great challenge. However, increased irrigated land is devoted to rice than to other crops. More than 75 % of the world's rice is produced in irrigated rice lands, which are predominantly found in rivers delta, such as Egypt. The abundant water environment in which rice grows best differentiates it from all other important crops. But, water is becoming increasingly scarce (IRRI, 2003).

Rice grown under traditional practices in Egypt depending on soil texture and water quality (El-Bably *et al.,* 2007). The actual amount of water used by the farmers for land preparation and during the crop growth period is much higher than the actual field requirement (Won *et al.,* 2005 and Jahan

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*et al.,* 2013). One method to save water in irrigated rice cultivation is the intermittent drying of the rice fields instead of keeping them continuously flooded (Bouman and Tuong, 2001). This method is referred to as irrigation intervals, which is a promising method in irrigated rice cultivation with dual benefits of water saving and human disease control, while maintaining rice yields at least at the same level. However, many factors play a role in determining the success or failure of the period between two irrigation. Some of these factors can be influenced, such as irrigation infrastructure and irrigation management capacity, while others cannot be, such as rainfall and soil conditions (Rajendran *et al.,* 1995 , Sharma, 1989 and Sharma *et al.,* 2003).

Rice sowing season plays a significant role in crop yield potential, since it affects the response of other management practices. According to Freitas *et al.* (2008), the intersection of rice flowering and grain filling time with the period of highest solar radiation availability is what determines when rice sowing season will occur, once optimal conditions of temperature and solar radiation are key to raising grain yield potential.

According to Slaton *et al.* (2003) and Freitas *et al.* (2008), the highest grain yields of irrigated rice are found when sowing is carried out early in the recommended season and they tend to decrease when sowing is performed at the end of the season. Moursi, (2002) found the increase of submergence depth from 2.5 cm up to 7.5 cm achieved the highest values of rice plant height, leaf area, panicle length, 1000- grain weight, grain yield and straw yield, while the lowest values of these parameters were recorded with 2.5 cm water depth.

El-Saiad, (2008) found that the highest crop water use efficiency and the lowest field water use efficiency was achieved under submergence head of 6 cm. Consequently, continuous submerged water head up to 3 cm could be recommended for rice crop watering to produce an economical production with less water consumption.

The main objectives of this investigation was to study the effect of irrigation intervals and cobalt application rate on growth characters of cultivated rice in North Delta.

## Material and Methods

Field experiment were conducted in summer growing seasons 2012 and 2013.The area was located in the Kafr El-Sheikh governorate, El-Hamoul district, where climate is characterized, according to the Köppen classification, as hot dry semiarid (Cfa),The experiments were performed on soil classified as vertisol. The experimental design was split plot design with four replications where irrigation intervals in the main plot and co application rates treatments as sub main plots.

The nitrogen was applied (as urea 46% N ) in two equal doses where the first dose was applied before transplanting and the second one was added after 25 days from transplanting .

To study the effect of cobalt application rates on the improve growth characters under different irrigation intervals (2, 4, 6, 8 ; 10 days).

The experimental field was tilled leveled and rice (Sakha 104) was transplanted at 2012 and 2013 growing seasons, respectively. Seedlings were transplanted in hills (four to five plants per each hill ) with spacing of 20 x 20 cm ( hills x rows ). The ordinary super phosphorus fertilizer (15.5 % $P_2O_5$ /fed ) was added during the preparation of land for cultivation. The end of experiments was took place at 24 and 27 September in the two growing seasons, respectively, then the plants were harvested and prepared for plant analysis.

Grain yield was estimated by manual harvesting of 4.16 $m^2$ on crop area, when they reached mean moisture of 25%. After sorting, cleaning and weighing of grain with shell, data were corrected to 13% moisture and converted to kg $fed^{-1}$.

The number of panicles $m^{-2}$wasdetermined by counting the panicles in a row meter, and in that same area we collected15 panicles at harvest to estimate the number of grains per panicle, 1000 grain weight (seed index) and spikelet sterility.

The values of global solar radiation and air temperature were obtained from the meteorological station of the Sakha which used in calculation of the rice crop water requirements in both seasons to compare with those actual applied.

Soil samples were collected from the experimental plots before planting and after the harvesting of rice at depths of 0-15, 15-30, 30-45 and 45-60 cm. to determine some soil physical and chemical properties. Particle size distribution was carried out according to Page, (1982).Co in soil was determined as follows: Soluble (0.23), available (5.3) and total (18.7) ppm

Soluble cations and anions were determined according to Page, (1982).Soil reaction ( pH ): was measured in (1:2.5 ) soil water and electrical conductivity (ECe) was measured by Hanna Instruments (HI 2550 pH/ORP/EC/TDS/NaCl Benchtop Meter) after Cottenie *et al.,* (1982). Some physical and chemical analyses of soil are shown in Table (1)

**Table 1:** Some soil physical and chemical properties.

| Sand% | Silt% | Clay% | Texture | ECdS/m | pH | $CaCO_3$% | OM % |
|---|---|---|---|---|---|---|---|
| 19.25 | 15.64 | 65.11 | Clay | 22.92 | 8.21 | 3.4 | 1.9 |
| SP | FC | WP | AW | DP | SAR | | |
| 68.9 | 46.2 | 15.9 | 30.3 | 22.7 | 2.41 | | |
| Soluble cations and anions (me/l) | | | | | | | |
| Ca | Mg | Na | K | $CO_3$ | $HCO_3$ | Cl | $SO_4$ |
| 1.5 | 1 | 2.7 | 0.2 | 0 | 0.2 | 3.8 | 1.4 |
| mg/100g | | | Av ppm | | | | |
| TN | Av P | Av K | Fe | Mn | Zn | Cu | |
| 0.44 | 0.32 | 1.4 | 6.4 | 0.61 | 0.96 | 0.46 | |

*EC: electrical conductivity, OM: organic matter, SP: saturation percentage, FC: field capacity, WP: wilting point, AW: available water, DP: drainable pores, SAR: sodium adsorption ratio*

Irrigation water applied under the different treatments was measured by using a cut-throat flume of (20 x 90 cm) according to Walker and Skogerboe, (1987).

*Cobalt and direct transplanting into the field:*

Rice transplants were sown in submerged field. After 10 days of cobalt application, rice seedlings were transplanted directly into the field and frequently irrigated. The transplanting was done by pulling seedlings out from the trays and inserting their roots into soil directly in the field as usually done with tomato seedlings. The percentage of successful transplanting.

Results were submitted to analysis of variance, comparing irrigation intervals and cobalt application rates which installed in split plot design with four replicates analysis according to Snedecor and Cochran, (1990). Means were compared by LSD test at 5% probability

**Results and Discussion**

Table (2) showed the effect of the Co application rates and irrigation intervals on the rice growth characters (plant height, leaf area and root length). Data noticed that the highest values of these characters were recorded at 12.5 ppm Co and 2 days irrigation intervals at all measured rice growth characters. Also, there were dramatically decrease in those characters with increasing irrigation intervals periods under different Co application rates

Regardless irrigation intervals effect, increasing Co application rates from 0 to 20 ppm was associated with increase in estimated growth cheaters till 12.5 ppm Co then values fall down at 15 ppm and more. The rate of increase was highly in the first Co application rate with values 1.9, 6.6, 10.8, 4.7, 6.3; 4.1 % for plant height, 22.6, 39.5,65.0,52.4,36.1; 21.9 %for leaf area and 5.6,22.5,56.3,46.9,37.8; 17.7 %for root length at 7.5, 10, 12.5 ppm of Co, respectively. The reduction percentage in measured rice growth characters when increased Co by examined rate (2.5 ppm) from 12.5 to 15.0 ppm were 6.5, 7.7; 6.0 % for plant height, leaf area and root length, respectively.

Regarding to the irrigation intervals impact on the rice growth characters, data noticed that increasing periods of intervals by days associated with reduction in estimated growth values, except 6 days for plant height. Also, it is clear to mention that the rate of change was highly with increasing the periods between successive irrigation relative to the 2 days. These values were (-0.24, 2.53, -10.53; -17.0 %) for irrigation intervals 4, 6, 8; 10 days relative to the 2 days.

Data in table (2) illustrated the effect of the rice growth characters (fresh and dry weight of shoot and root), data on hand revealed that increasing Co application rate had a positive effect and increasing Co rates combined with increasing measured rice growth parameters till 12.5 ppm Co and then decreased solely till 20 ppm under all investigated growth characters. Also, data pointed out increasing the periods between two successive irrigation associated with decreasing of the estimated growth characters. Also, it was clear the range between 0 and 20 ppm Co were 23.8, 51.6, 4.09, 10.2, -3.7 folds for shoot fresh weight under 2, 4, 6, 8 and 10 days intervals, respectively. Same trend was obtained for FW of root and DW for shoot and root.

**Table 2:** Effect of the Irrigation intervals and cobalt application rates on the some rice growth characters (mean of two seasons)

| | Irrigation intervals (days) | Cobalt application rates (ppm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 7.5 | 10 | 12.5 | 15 | 17.5 | 20 | LSD 5% |
| Plant height | 2 | 92.60 | 94.00 | 95.81 | 98.30 | 79.22 | 95.02 | 93.72 | 1.31 |
| | 4 | 88.20 | 90.51 | 92.70 | 96.20 | 95.01 | 93.13 | 91.41 | 0.98 |
| | 6 | 84.50 | 86.02 | 97.52 | 102.50 | 101.01 | 98.21 | 95.30 | 1.12 |
| | 8 | 79.70 | 81.00 | 83.60 | 86.51 | 85.11 | 83.09 | 81.34 | 1.05 |
| | 10 | 74.00 | 75.60 | 77.11 | 80.60 | 78.42 | 76.13 | 74.22 | 0.61 |
| Leaf area | 2 | 9.65 | 11.88 | 13.98 | 16.87 | 15.95 | 13.44 | 11.40 | 1.07 |
| | 4 | 8.56 | 11.03 | 13.12 | 15.31 | 13.24 | 12.02 | 10.56 | 1.21 |
| | 6 | 8.22 | 10.87 | 12.61 | 14.42 | 13.08 | 11.91 | 10.34 | 1.33 |
| | 8 | 8.04 | 8.93 | 9.44 | 11.31 | 11.02 | 10.19 | 9.90 | 1.02 |
| | 10 | 7.15 | 8.33 | 8.89 | 10.78 | 10.14 | 9.08 | 8.54 | 1.09 |
| Root length | 2 | 4.26 | 4.73 | 5.81 | 7.56 | 7.11 | 6.87 | 5.74 | 0.45 |
| | 4 | 4.19 | 4.54 | 5.66 | 7.13 | 6.96 | 6.59 | 5.33 | 0.34 |
| | 6 | 4.08 | 4.26 | 4.97 | 6.27 | 6.13 | 5.79 | 5.18 | 0.83 |
| | 8 | 3.93 | 3.98 | 4.23 | 5.66 | 4.85 | 4.42 | 3.86 | 0.21 |
| | 10 | 3.84 | 3.92 | 4.19 | 5.11 | 4.77 | 4.30 | 3.79 | 0.17 |
| Shoot FW | 2 | 3.56 | 3.98 | 4.88 | 6.12 | 6.01 | 5.79 | 4.92 | 0.46 |
| | 4 | 3.08 | 3.73 | 4.80 | 5.71 | 5.34 | 5.18 | 4.76 | 0.61 |
| | 6 | 2.88 | 3.12 | 3.94 | 4.62 | 3.89 | 3.42 | 3.02 | 0.77 |
| | 8 | 2.65 | 2.98 | 3.36 | 3.66 | 3.66 | 3.23 | 2.92 | 0.58 |
| | 10 | 2.19 | 2.48 | 2.92 | 3.24 | 2.79 | 2.40 | 2.11 | 0.34 |
| Root FW | 2 | 1.07 | 1.14 | 2.32 | 4.56 | 4.19 | 3.78 | 3.35 | 0.84 |
| | 4 | 1.01 | 1.12 | 2.20 | 4.32 | 4.19 | 3.78 | 3.35 | 0.31 |
| | 6 | 0.85 | 0.96 | 1.17 | 1.79 | 0.96 | 0.92 | 0.87 | 0.54 |
| | 8 | 0.79 | 0.85 | 0.88 | 0.91 | 0.88 | 0.82 | 0.78 | 0.44 |
| | 10 | 0.68 | 0.73 | 0.79 | 0.85 | 0.80 | 0.79 | 0.72 | 0.38 |
| Shoot DW | 2 | 0.79 | 0.81 | 0.89 | 1.24 | 0.89 | 1.24 | 0.89 | 0.14 |
| | 4 | 0.69 | 0.81 | 1.02 | 1.37 | 1.39 | 1.08 | 0.91 | 0.11 |
| | 6 | 0.58 | 0.67 | 0.85 | 0.93 | 0.92 | 0.89 | 0.87 | 0.13 |
| | 8 | 0.55 | 0.65 | 0.69 | 0.73 | 0.70 | 0.69 | 0.62 | 0.14 |
| | 10 | 0.49 | 0.57 | 0.68 | 0.79 | 0.72 | 0.69 | 0.62 | 0.11 |
| Root DW | 2 | 0.34 | 0.38 | 0.39 | 0.49 | 0.39 | 0.44 | 0.30 | 0.04 |
| | 4 | 0.31 | 0.36 | 0.43 | 0.46 | 0.47 | 0.46 | 0.41 | 0.05 |
| | 6 | 0.28 | 0.32 | 0.38 | 0.44 | 0.42 | 0.40 | 0.39 | 0.07 |
| | 8 | 0.21 | 0.25 | 0.33 | 0.39 | 0.36 | 0.31 | 0.29 | 0.06 |
| | 10 | 0.19 | 0.21 | 0.29 | 0.32 | 0.31 | 0.19 | 0.18 | 0.05 |

With respect to the mean values of the Co application rates on the investigated growth characters, data indicated that increasing Co rates from 0 to 20 ppm associated with increasing mean values of those characters till 12.5 ppm Co then decreased dramatically till 20 ppm Co. whereas, the rate of increase at 12.5 and 20 ppm Co relative to the control were 4.67/2.87, 3.55/-, 2.47/0.86, 1.77/0.86, 1.01/0.62, 0.78/0.62, 0.42/0.26, 0.31/0.26, for fresh weight and dry weight of shoot and root, respectively.

These observations are in consistent with previous obtained data by Nadia Gad, (2011) who stated that cobalt enhanced barley growth and yield up to 10 ppm , while increasing cobalt level, the promotive effect reduced . Atta Ali *et al.,* 1991. Reported that responses associated with low level of cobalt concentrations may be attributed to some enzymes activity such as catalase and peroxidase which are found to decrease with low levels of cobalt, and increased with the higher ones. Those enzymes are known to induce plant respiration and hence increasing catabolism rather than anabolism.

Regarding to the effect of irrigation intervals on the previous rice growth characters, resulted data indicated that the percentage of the reduction were -7.5, -29.4, -36.3, -48.6; 0.0, -63.7, -71.2, -73.6; 8.3, -14.6, -31.3, -32.3; 5.1, -2.6, -20.5, -38.5 % for fresh and dry weight for shoot and root, respectively at 4, 6, 8 and 10 days intervals compared with 2 days.

Regarding to the irrigation intervals on the examined rice plant growth characters (Plant height Leaf area, Root length, Shoot FW, Root FW, Shoot DW and Root DW), data in Table (2) and Fig. (1-4) showed that the highest values were attained at 6, 2, 2, 2-4, 4,4; 4 days, respectively. Whereas the lowest ones were recorded at 10 days irrigation intervals. So, one can notice that increased irrigation intervals lead to decrease the values of the investigated rice growth characters.

Regardless irrigation intervals, cobalt application rates had a promotive effect on the studied rice growth characters, where the highest values of those characters were recorded at 12.5 pp cobalt. Also, it is clear to mention that the lowest values were attained at control treatment (0 cobalt). Data on hand revealed that the rate of increase was low if cobalt application rates from 0 to 7.5 than the percentage of increase relative to cobalt application unite (2.5ppm) was highly. Slightly decrease in the rice growth characters values if cobalt increased than 12.5 ppm.

These data are in harmony with those obtained by Tong *et al.,* (2003), Pirdashti *et al.,* (2004) and Khairi *et al.* (2015) who reported that water stress was associated with the bend neck phenomenon and mediated by ethylene whose production seemed to be correlated with status Absicic acid. Cobalt reduced water loss and water consumption by tomato plants (Nadia Gad, 2006 and 2010)

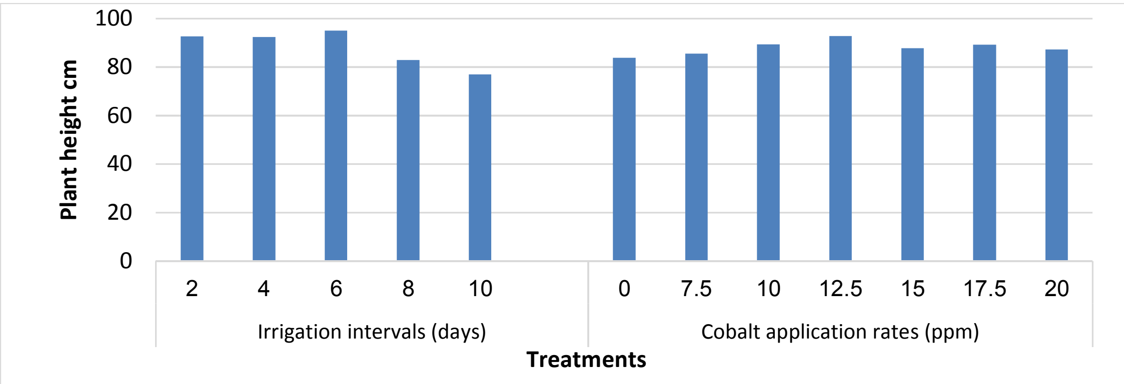


**Fig. 1:** Effect of the Irrigation intervals or cobalt application rates on the plant height of rice plant (mean of two seasons)

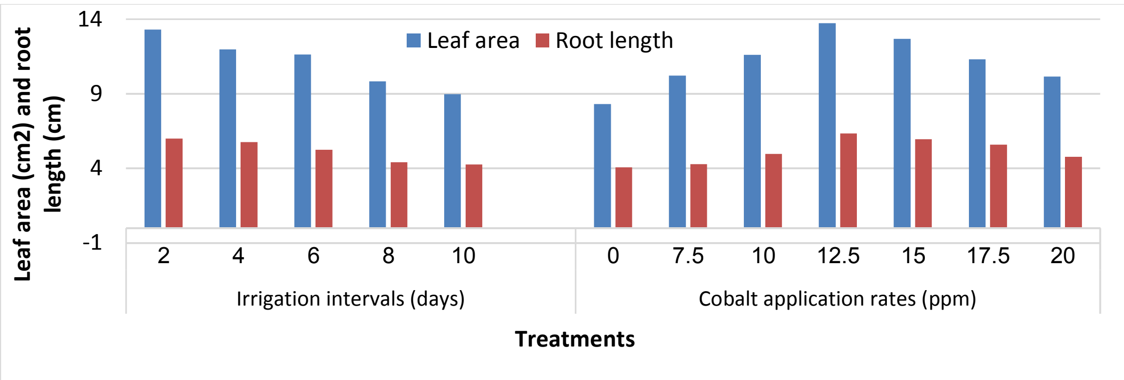


**Fig. 2:** Effect of the Irrigation intervals or cobalt application rates on the leaf area and root length of rice plant (mean of two seasons)

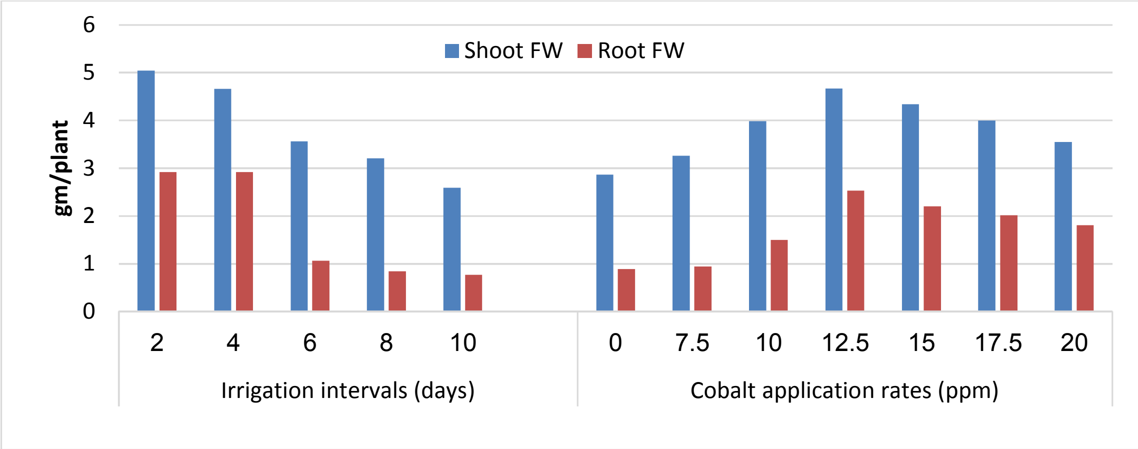


**Fig 3:** Effect of the Irrigation intervals or cobalt application rates on the fresh weight of shoot and root of rice plant (mean of two seasons)

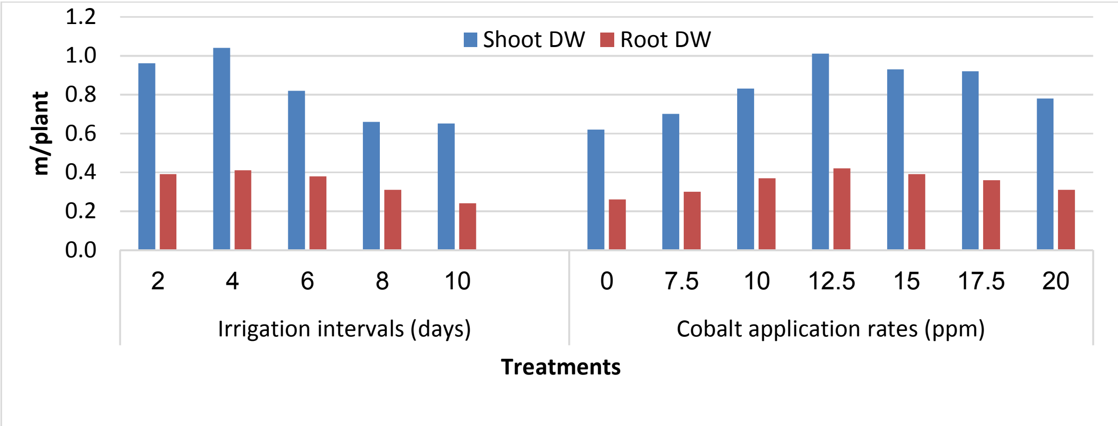


**Fig. 4:** Effect of the Irrigation intervals or cobalt application rates on dry weight of shoot and root of rice plant (mean of two seasons)

Our data was in line with those obtained by Yang *et al.* (2007). Also., El-Bably *et al.,* (2007) found that increasing the submergence depth from 4 to 7 or 10 cm, through the effect of the irrigation intervals, both significantly increased plant height, number of tillers/$m^2$, panicle weight, 1000-grain weight, and grain yield in North Delta. Also, they found that the submergence depth of 4 cm increased field water use efficiency by 16.6% and 49.7% more than 7 and 10 cm depth, respectively. It was evident that irrigation every six days intervals with submerged depth of 10cm received the highest amount of irrigation water followed by submerged depths of 7 and 4 cm, 196.38, 152.05 and 118.21 cm.

**Table 3:** Effect of the irrigation intervals on the some rice growth characters (mean of two seasons)

| Growth characters | Irrigation intervals (days) | | | | | LSD 5% |
|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | |
| Plant height | 92.67 | 92.45 | 95.01 | 82.91 | 76.92 | 2.31 |
| Leaf area | 13.31 | 11.98 | 11.64 | 9.83 | 8.99 | 1.23 |
| Root length | 6.01 | 5.77 | 5.24 | 4.42 | 4.27 | 0.64 |
| Shoot FW | 5.04 | 4.66 | 3.56 | 3.21 | 2.59 | 0.36 |
| Root FW | 2.92 | 2.92 | 1.06 | 0.84 | 0.77 | 0.45 |
| Shoot DW | 0.96 | 1.04 | 0.82 | 0.66 | 0.65 | 0.43 |
| Root DW | 0.39 | 0.41 | 0.38 | 0.31 | 0.24 | 0.11 |

**Table 4:** Effect of the cobalt application rates on the some rice growth characters (mean of two seasons)

| Growth characters | Cobalt application rates (ppm) | | | | | | | LSD 5% |
|---|---|---|---|---|---|---|---|---|
| | 0 | 7.5 | 10 | 12.5 | 15 | 17.5 | 20 | |
| Plant H | 83.80 | 85.43 | 89.35 | 92.82 | 87.75 | 89.12 | 87.20 | 1.15 |
| Leaf area | 8.32 | 10.21 | 11.61 | 13.74 | 12.69 | 11.33 | 10.15 | 1.02 |
| Root L | 4.06 | 4.29 | 4.97 | 6.35 | 5.96 | 5.59 | 4.78 | 0.45 |
| Shoot FW | 2.87 | 3.26 | 3.98 | 4.67 | 4.34 | 4.00 | 3.55 | 0.62 |
| Root FW | 0.89 | 0.94 | 1.50 | 2.53 | 2.20 | 2.02 | 1.81 | 0.41 |
| Shoot DW | 0.62 | 0.70 | 0.83 | 1.01 | 0.93 | 0.92 | 0.78 | 0.51 |
| Root DW | 0.26 | 0.30 | 0.37 | 0.42 | 0.39 | 0.36 | 0.31 | 0.13 |

## Conclusion

Rice has been grown under traditional irrigation practices along Egypt, where the actual amount of water used for land preparation and during the crop growth period is much higher than the actual field requirement. Regarding to the limitation of irrigation water because of scarcity of water resources, so this experiment was carried out to maximize rice production from water unite after treated grown in clay soil by cobalt under different irrigation intervals.

Application 12.5 ppm Co at 2 days irrigation intervals at all measured rice growth characters was superior to fulfill the maximum values. Dramatically decrease in those characters attained with increasing irrigation intervals periods under different Co application rates.

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