Australian Journal of Basic and Applied Sciences, 6(13): 566-574, 2012
ISSN 1991-8178

# Physiological Response To Potassium Application In Fodder Beet Plant Grown Under Water Stress

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**Abstract:** Two field experiments were conducted in the farm of the National Research Centre, El-Nobaria, Al-Behaira Governorate, Egypt during the 2010/2011 and 2011/2012 growing seasons to investigate the response of fooder beet to potassium foliar application( 0.5kg/fed.,0.75kg/fed.,1kg/fed). Under different levels of sprinkler irrigation water, i.e. 100, 75 and 50% of reference crop evapotranspiration (ETo). The results indicated that in both seasons, increasing irrigation level led to significant increases in all growth and yield characters. While water use efficiency of fooder beet plants increased significantly by decreasing the irrigation level (water stress). Foliar K spray of 1kg/fed. gave the highest values of growth and yield parameters as well as WUE in both seasons. The interaction between irrigation regime and k fertilizer was significant in most growth and yield parameters except for plant height and No. of green leaves/plant in the first season and root length/plant in the second season, as well as WUE. Potassium application at 1 kg/fed. To fodder beet plants responded higher increments in CAT & POX enzymes activities at different water irrigation levels. These increments lowered MDA content, increased tolerance to oxidative damage and improved cell membrane of fodder beet plants grown under water regime.

**Key words:** irrigation regime, water use efficiency, fodder beet, potassium foliar application, growth, yield components, antioxidant enzymes activities.

## INTRODUCTION

The increasing demand for animal proteins of the growing population in Egypt is handicapped through the shortage of the carbohydrate components in animal feeds. On the other hand, the horizontal expansion of new reclaimed areas requires the cultivation of crops offering a source for satisfying income to the farmers. Fodder beet can easily fulfill both aims through its high content of carbohydrate which reached about 72% DM and production in some new regions ranged between 25-30 tons/fed.

In Egypt, most of the new reclaimed soils suffer from water deficit. This may affect growth, leaf mineral content and many other physiological characteristics. It is characterized by decrease in water content, osmotic potential and total water potential accompanied by loss of turgor, close of stomata and decrease in growth as well as decrease in the photosynthesis process. (Abd El- Dayem *et al*., 2007). Drought stress is one of the several environmental factors greatly limiting crop production and plant distribution worldwide. A common consequence of drought stress is an increased production of reactive oxygen species (ROS) such as superoxide radical ($O^{-}_2$), hydrogen peroxide ($H_2O_2$) and hydroxyl radical ($OH^{\cdot}$). These ROS are all toxic (Beyer and Fridovich, 1987) and very reactive and cause severe damage to DNA, proteins and lipids (Bird *et al*., 1983) .To eliminate or reduce toxicity of ROS, plants have evolved various protective mechanisms (includes enzymatic and non enzymatic antioxidant defense systems), which are effective at different levels of stress induced deterioration (Tohidi-Moghaddam *et al*., 2009). Thus, study of the agronomic and physiological characteristics associated to high yield potential under sub-optimal environmental conditions could be used as stress tolerance indexes in future elite germ plasm. Drought stress increased CAT and SOD activities of the sunflower (Gunes et al., 2008 and Manivannan *et al*., 2008). Also, increase of SOD, CAT and GPX activities under drought stress in canola was reported by Tohidi-Moghaddam *et al*. (2009). Potassium plays a vital role in: photosynthesis, translocation of photosynthates, protein synthesis, control of ionic balance, regulation of plant stomata and water use, activation of plant enzymes and, many other processes (Marschner, 1995; Reddya *et al*., 2004). Potassium is not only an essential macronutrient for plant growth and development, but also is a primary osmoticum in maintaining low water potential of plant tissues. Therefore, for plants growing in drought conditions, accumulating abundant K+ in their tissues may play an important role in water uptake along a soil–plant gradient. In general, K+ is accumulated in response to soil water deficits, while Na+ is accumulated under saline conditions (Glenn *et al*., 1996). The accumulation and release of potassium by stomatal guard cells lead to changes in their turgor, resulting in stomatal opening and closing (Fischer and Hsiao, 1968). In water stressed plants, increased abscisic acid (ABA) levels are known to stimulate the release of potassium from guard cells, giving rise to stomatal closure (Assmann and Shimazaki, 1999). Numerous studies have shown that the application of K fertilizer mitigates the adverse effects of drought on plant growth (Andersen *et al*., 1992;

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Sangakkara et al., 2001 and Hasanzadeh *et al*, 2012). The aim of this study was to detect the response of growth and yield of fodder beet to potassium foliar application 0.5kg/fed.,0.75kg/fed.,1kg/fed. Under different levels of water supply.

## MATERIALS AND METHODS

Two field experiments were conducted in El-Nobaria farm of National Research Centre, Al- Behaira Governorate, Egypt during the 2010/2011 and 2011/2012 seasons. The study was aimed to investigate the physiological response of fooder beet potassium foliar application (potassium citrate45%) p 0.5kg/fed.,0.75kg/fed.,1kg/fed. Under different levels of water supply. The adopted irrigation regime were 100, 75 and 50% of reference crop evapotranspiration (ETo). These reflecting conditions achieved as optimum level of water supply moderate and severe water stress respectively. In the two growing seasons, the amount of water needed for each irrigation was calculated according to the crop coefficient (Kc) and the daily reference potential (ETo). The latter was determined according to the Penman-Monteith equation depending on the predicted climatic factors at each irrigation time and the growth stage of fodder beet plant. At the end of the last irrigation. The quantity of water applied for each of the three irrigation regime was calculated according to the total amount of water added from sowing until harvesting for the two seasons. The average amounts of water during the two growing seasons were 2106, 1619and 1132 m3/fed for the three irrigation treatments, respectively. The experimental design used was a split plot one with three replications. Irrigation regime were arranged in the main plots, whereas the potassium foliar application were randomly distributed in the sub-plot. Soil characteristics of the experimental location are shown in Table (1). particle size distribution and moisture of the soil sample was determined as described by Blackmore, (1972). Soil organic matter, CaCo3, EC and pH were determined according to Black *et al*., (1982).

Seeds of fooder beet which were obtained from Agricultural Research Centre, Giza, Egypt, were sown on 21 November in both seasons. The normal cultural treatments of growing fooder beet of the location were followed. Phosphorus fertilizer was applied to the soil before sowing at a dose of 200kg/fed in the form of calcium super phosphate (15.5% p2O5) potassium was applied in the form of 50 kg/fed. potassium sulphate (48%K2o) and ammonium nitrate (33.5%N)at the rate of 20 kg/fed.at before the first irrigation. at 110 days from sowing, plant height (cm), root length per plant (cm), number of green leaves/ Plant, root diameter/plant(cm),root fresh wt/plant(g), foliage wt/plant(g), total fresh wt/plant(g),root dry wt/plant(g),foliage dry wt/plant(g) and total dry wt/plant(g)were estimated. At harvest (180days from sowing) the following data were recorded: plant height (cm), root length/plant(cm), root diameter/ Plant(cm), root wt/plant(g),foliage yield/plant(g),total yield/plant(g), root yield/fed.(ton), foliage yield/fed.(ton) biological yield/fed.(ton)and water use efficiency (kg/m3). Water use efficiency (WUE) value was calculated according to the following equation (Jensen, 1983).

$$\text{UWE (kg/m}^3\text{)} = \frac{\text{Seed yield (kg/fed)}}{\text{Seasonal ET (m}^3\text{/fed)}}$$

**Table 1:** Soil characteristics of the experimental sites

| | |
|---|---|
| Particle size distribution | |
| Sand % | 70.80 |
| Silt % | 25.60 |
| Clay % | 3.60 |
| Texture | Sand Loam |
| Field capacity | 20.10 |
| Chemical character | |
| Soil reaction pH (1:2.5) | 7.90 |
| Electric conductivity (dsm-1) | 0.12 |
| Organic matter (%) | 0.23 |
| Calcium carbonate (%) | 3.57 |
| Available macronutrients (mg/100g) | |
| N | 15.10 |
| P | 13.00 |
| K | 21.00 |
| Available micronutrients (ppm) | |
| Fe | 4.47 |
| Mn | 2.61 |
| Zn | 1.44 |
| Cu | 4.00 |

***Methods Of Extraction:***

Five grams of frozen newly leaf tissues were homogenized in pre-chilled motar in presence of 10 ml of 50 mM potassium phosphate buffer (Ph7) with1%(w/v) insoluble polyphenylpyrrolidine (pvp) and 0.1mM EDTA.

The extraction procedures were repeated twice and the supernatants were pooled, raised to certain volume, referred as curde enzyme extract, all the operations were carried out at-4ºC and the enzyme extract was kept at -20ºC for further analsis.

Assay of catalase activity (CAT,EC1.11.1.6):):

The activity of CAT was measured at 25ºC according to the method described by Aebi(1984).

Assay of Guaiacol peroxidase(POX,EC 1.11-1.7)was assayed according to Hemmeda&Klein(1990).

Lipid per-oxidation:

Lipid per-oxidation was determined by measuring malondialdehyde (MAD) using the thiobarbituric acid (TBA) method described by Hodges et al (1999).

The obtained data were statistically analyzed according to analysis of variance method described by Snedecor and Cochran (1980).

## RESULTS AND DISCUSSION

### *1. Vegetative Growth Characters:*

### *Effect Of Irrigation Regimes:*

Data found in Table (2) contain the effect of irrigation regimes, i.e. 100 %, 75 % and 50 % of reference crop evapotraspiration (ETo), corresponding to 2106, 1619and 1132 m3/fed./ season on vegetative growth of fodder beet in the two experimental seasons of 2010/ 2011 and 2011/ 2012. Data showed that growth parameters; i.e. plant height (cm), root length per plant (cm)and number of green leaves/plant as well as root diameter/ plant(cm),root fresh wt/plant(g), foliage wt/plant(g), total fresh wt/plant(g),root dry wt/plant(g),foliage dry wt/plant(g) and total dry wt/plant(g). were significantly affected by irrigation treatments. It is clear from Table (2) that an obvious trend was obtained in both experimental seasons regarding the effect of irrigation on the studied growth parameters indicating that in both seasons, plant height (cm), root length per plant (cm)and number of green leaves/plant as well as root diameter/ plant(cm),root fresh wt/plant(g), foliage wt/plant(g), total fresh wt/plant(g),root dry wt/plant(g),foliage dry wt/plant(g) and total dry wt/plant(g)in the two growing seasons were increased significantly by increasing irrigation amount from 1132 and up to2106 m3/ fed./ season. These results coincided with those reported by (Abdallah and Yassen, 2008 and Hussein *et al*., 2011) showed that extension of irrigation to 21 and 28 days reduced the foliage fresh weight/plant, although foliage dry weight and root diameter were not significantly affected by irrigation augmentation, but the root length/plant was seriously affected and showed a clear reduction. Water stress condition have been found to disrupt several physiological processes leading to reduction in growth (Bloch and Hoffmann, 2005), restrict growth and alter the chemical composition of beet under drought

### *Effect of Potassium:*

Table (2) contains the data concerning the effect of sprayed potassium fertilizer rates; i.e.05, 0.75and 1kg/fed. on growth parameters; which almostly were significantly affected by potassium fertilizer rates. It is clear from Table (2) that an obvious trend was obtained in both experimental seasons regarding the effect of potassium treatment on the studied growth parameters indicating that in both seasons, plant height (cm), root length per plant (cm)and number of green leaves/ plant as well as root diameter/ plant(cm), root fresh wt/plant(g), foliage wt/plant(g), total fresh wt/plant(g),root dry wt/plant(g), foliage dry wt/plant(g) and total dry wt/plant(g)in the two growing seasons were increased significantly by increasing sprayed potassium fertilizer rates from 0.5 and up to1 kg/ fed./ season. These results coincided with those reported by (Abdel El-Wahab *et al*., 1996; El-Ramady, 1997; El-Hawary, 1999; Omar *et al*., 2002; Attia, 2004; El-Kholy et al., 2006; Abdel-motagally and Attia. 2009 ). And they also reported that, application of K fertilizer at the rate of 114kgK $ha^{-1}$, significantly increased all growth attributes and sugar yield of sugar beet plants, which could be attributed to the stimulatory effect of K on rate of photosynthesis, as well as, transport of the photosynthetic product from the leaves to the storage root.

### *Effect Of Interaction:*

Effect of interaction between irrigation regimes and sprayed potassium fertilizer rates on vegetative growth characters is exhibited in Table (2). Significant differences due to interaction were attained in all growth parameters in both experimental seasons except plant height (cm) and number of green leaves/ Plant in the first season as well as both dry matter of leaves and root length per plant (cm)in the second season. Data demonstrated that 1kg/fed. sprayed potassium fertilizer rates showed highest values of, root diameter/ plant(cm),root fresh wt/plant (g), foliage wt/plant (g), total fresh wt/plant(g),root dry wt/plant (g),foliage dry wt/plant (g) and total dry wt/plant (g) when plants were irrigated by 2016m3/ fed. / season in both years of investigation, except for the plant height (cm)and number of green leaves/ Plant in the first season and root length per plant (cm) in the second season.

**Table 2:** Vegetative growth characters of fodder beet plants as affected by irrigation regime, potassium foliar treatments and their interaction at 140 days from sowing in 2010/ 2011 and 2011/2012seasons

| Irrigation treatments, $m^3$/fed. | Potassium foliar treatments , kg/fed. | Plant height (cm) | Root length/ plant (cm) | No. of green leaves/ plant | root diameter/ plant (cm) | Root fresh wt./ plant (g) | Foliage fresh wt./ plant (g) | Total fresh wt. plant (g) | Root dry wt. plant (g) | Foliage dry wt. plant (g) | Total dry wt. plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010/2011 | | | | | | | | | | | |
| 2106 | 0.5 | 69.33 | 21.33 | 26.00 | 6.20 | 204.99 | 85.57 | 290.57 | 65.60 | 49.39 | 114.99 |
| | 0.75 | 69.33 | 24.00 | 27.00 | 7.37 | 231.47 | 102.51 | 333.98 | 70.85 | 57.78 | 128.63 |
| | 1 | 72.00 | 27.00 | 31.00 | 9.23 | 276.51 | 136.55 | 413.06 | 97.53 | 64.41 | 161.94 |
| Mean | | 70.22 | 24.11 | 28.00 | 7.60 | 237.66 | 108.21 | 345.87 | 77.99 | 57.19 | 135.18 |
| 1619 | 0.5 | 58.00 | 17.33 | 20.33 | 5.63 | 146.50 | 69.75 | 2166.25 | 44.83 | 33.15 | 77.98 |
| | 0.75 | 60.00 | 18.67 | 22.00 | 6.80 | 170.65 | 85.82 | 256.47 | 56.82 | 44.70 | 101.52 |
| | 1 | 63.00 | 19.67 | 28.00 | 8.23 | 205.54 | 106.84 | 312.38 | 73.89 | 51.74 | 128.64 |
| Mean | | 60.33 | 18.56 | 23.44 | 6.89 | 174.22 | 87.47 | 261.70 | 58.51 | 43.20 | 102.71 |
| 1132 | 0.5 | 52.00 | 14.33 | 16.33 | 5.20 | 105.19 | 54.90 | 160.09 | 33.27 | 25.22 | 58.15 |
| | 0.75 | 53.00 | 15.00 | 18.67 | 6.23 | 121.51 | 68.30 | 189.81 | 35.86 | 32.18 | 68.04 |
| | 1 | 54.67 | 16.33 | 23.00 | 7.27 | 153.35 | 82.76 | 236.11 | 57.86 | 41.64 | 99.50 |
| Mean | | 53.22 | 15.22 | 19.33 | 6.23 | 126.68 | 68.65 | 195.34 | 42.33 | 33.01 | 75.23 |
| Mean values k, kg/fed.. | 0.5 | 59.78 | 17.67 | 20.89 | 5.68 | 152.23 | 70.07 | 222.30 | 47.90 | 35.92 | 83.71 |
| | 0.75 | 60.78 | 19.22 | 22.56 | 6.80 | 174.54 | 85.54 | 260.08 | 54.51 | 44.80 | 99.40 |
| | 1 | 63.22 | 21.00 | 27.33 | 8.24 | 211.80 | 108.72 | 320.52 | 76.43 | 52.60 | 130.02 |
| L.S.D. at 5% | I | 1.00 | 1.10 | 1.44 | 0.30 | 2.73 | 1.13 | 2.64 | 2.53 | 0.16 | 0.57 |
| | K | 1.24 | 0.59 | 0.83 | 0.16 | 4.34 | 1.76 | 4.95 | 1.87 | 0.22 | 0.30 |
| | I x K | N.S | 1.03 | N.S | 0.27 | 7.51 | 3.05 | 8.56 | 3.23 | 0.38 | 0.53 |
| 2011/2012 | | | | | | | | | | | |
| 2106 | 0.5 | 68.33 | 221.67 | 20.67 | 6.03 | 207.99 | 88.47 | 296.46 | 79.89 | 55.39 | 135.28 |
| | 0.75 | 71.33 | 23.67 | 23.33 | 7.23 | 232.17 | 105.44 | 337.58 | 89.83 | 60.11 | 149.94 |
| | 1 | 73.00 | 27.33 | 28.00 | 8.87 | 282.54 | 136.76 | 419.30 | 99.14 | 67.18 | 166.32 |
| Mean | | 70.89 | 24.22 | 24.00 | 7.38 | 240.90 | 110.22 | 351.11 | 89.62 | 60.89 | 150.51 |
| 1619 | 0.5 | 57.00 | 15.33 | 16.67 | 4.87 | 146.51 | 72.16 | 218.67 | 63.20 | 43.10 | 106.30 |
| | 0.75 | 60.33 | 18.00 | 18.67 | 6.20 | 177.91 | 86.37 | 264.47 | 70.08 | 49.72 | 119.80 |
| | 1 | 65.00 | 21.00 | 20.00 | 8.00 | 212.43 | 108.58 | 321.00 | 81.93 | 58.17 | 140.10 |
| Mean | | 60.78 | 18.11 | 18.44 | 6.36 | 178.95 | 89.04 | 267.98 | 71.73 | 50.33 | 122.07 |
| 1132 | 0.5 | 48.00 | 14.67 | 15.33 | 3.60 | 108.25 | 57.80 | 166.04 | 40.80 | 31.10 | 71.90 |
| | 0.75 | 50.33 | 16.00 | 16.67 | 4.83 | 130.30 | 67.74 | 198.04 | 49.81 | 38.10 | 87.91 |
| | 1 | 55.33 | 18.00 | 18.33 | 5.67 | 165.29 | 82.50 | 253.79 | 67.36 | 45.18 | 112.54 |
| Mean | | 51.22 | 16.22 | 16.78 | 4.70 | 134.61 | 69.35 | 205.96 | 52.65 | 38.12 | 90.78 |
| Mean values k, kg/fed. | 0.5 | 57.78 | 17.22 | 17.56 | 4.83 | 154.25 | 72.81 | 227.06 | 61.29 | 43.20 | 104.49 |
| | 0.75 | 60.67 | 19.22 | 19.56 | 6.09 | 180.13 | 86.51 | 266.63 | 69.90 | 49.31 | 119.21 |
| | 1 | 64.44 | 22.11 | 22.11 | 7.51 | 220.09 | 109.28 | 331.37 | 82.81 | 56.84 | 139.65 |
| L.S.D. at 5% | I | 0.90 | 0.91 | 0.73 | 0.32 | 5.19 | 1.29 | 9.46 | 0.32 | 0.29 | 0.77 |
| | K | 0.87 | 0.80 | 0.61 | 0.26 | 2.88 | 1.05 | 4.05 | 0.20 | 0.15 | 0.24 |
| | I x K | 1.51 | N.S | 1.05 | 0.44 | 4.99 | 1.82 | 7.02 | 0.35 | 0.25 | 0.41 |

I = Irrigation          k = Potassium foliar treatments          I x k = Interaction

***2. Yield and its related characters and Water use efficiency (WUE, kg/m3):***
***Effect of Irrigation Regimes:***

Data shown in Table (3) contain the effect of irrigation regimes; i.e. 2016, 1619 and 1132 m3/ fed. / season on yield and its related characters and water use efficiency (WUE, kg/$m^3$). of fodder beet in the two experimental seasons of 2010/ 2011 and 2011/ 2012. Yield parameters i.e. plant height (cm), root length/plant (cm), root diameter/ plant (cm), root wt/plant(g), foliage yield/plant (g),total yield/plant (g), root yield/fed.(ton),foliage yield/fed.(ton) bilogical yield/fed.(ton) and water use efficiency (kg/m3) in the two growing seasons were significantly affected by irrigation treatments. Decreasing irrigation amounts (water stress) led to substantial decreases in the forementioned yield parameters. Irrigation treatments could be arranged as follows: 2016, 1619 and 1132 m3/ fed. / season in a descending order. The present results showed that water use efficiency of seed yield of fodder beet plants increased significantly by decreasing the irrigation level (water stress) in the first season .The results reported here in this investigation coincided with those previously obtained by Drawycott and Messem (1977) who reported that the main factors controlling the yield response to irrigation were period and size of deficit. Sepaskhah and Kamger-Haghighi (1997) found that the furrow irrigation at 10 days and 6 days intervals produced a similar root yield. On the other hand, Tognetti *et al*. (2003) found that plots irrigated with surface drip irrigation produced the highest sugar beet yield, but furrow irrigation produced the lowest one. However, higher root yield with irrigation every 3 weeks compared to every 5 or 7 weeks in this experiment is in agreement with the results reported by Hassanli *et al*. (2010). On the other hand, Isoda *et al.* (2007) found that the irrigation led to an increase in the net sugar yield due to an increase in the root yield. However, there was a slight reduction in the sugar content in roots. Ancuta *et al*. (2007) noticed that in cultivated sugar beet under rainfall conditions, which excluded the use of irrigation, all factor graduals of irrigation regime had practically equal yields.

***Effect of Potassium:***

Table (3) contains the data concerning the effect of sprayed potassium fertilizer rates i.e0.5, 0.75, and 1 kg/fed. on yield and its related criteria as well as WUE of fodder beet plants in 2010/ 2011 and 2011/ 2012. The related parameters i.e plant height (cm), root length/plant (cm), root diameter/ plant (cm), root wt/plant(g)foliage yield/plant(g),total yield/plant(g), root yield/fed.(ton),foliage yield/fed.(ton) bilogical yield/fed. (ton) and water use efficiency (kg/m3) in the two growing seasons were significantly affected by sprayed potassium fertilizer rates. Table (3) indicates that an obvious trend was obtained in both experimental seasons regarding the effect of sprayed potassium fertilizer rates on the studied yield and its related criteria as well as WUE of fodder beet plants indicating that in both seasons i.e. plant height (cm), root length per plant (cm)and number of green leaves/ Plant as well as root diameter/ Plant(cm),root fresh wt/plant(g), foliage wt/plant(g), total fresh wt/plant(g),root dry wt/plant(g),foliage dry wt/plant(g) and total dry wt/plant(g)in the two growing seasons were increased significantly by increasing sprayed potassium fertilizer rates from 0.5 and up to1kg / fed./ season. These results coincided with those reported by Cooke and Scott, 1993 and Abo-Shady *et al*., (2010) .they also pointed out that, the increases in root length may be due to increasing in photosynthesis and translocation as assimilates to storage root for K on plant. On the other hand, Sarhan (1998) reported that potassium fertilizer had insignificant effect on root length.

***Effect of Interaction:***

Effect of interaction between irrigation regimes and sprayed potassium fertilizer rates on yield and its related criteria as well as WUE is exhibited in Table (3). Significant differences due to interaction were detected in almostly all previous parameters in both experimental seasons.

The response of fodder beet plants regarding the effect of interaction was the same water use efficiency indicating that the highest significant interaction values were achieved at 1kg/fed.when plants were subjected to water stress (1132m3/ fed. / season. Whereas, the lowest significant values in the same connection were shown by 0.5kg/fed. sprayed potassium fertilizer rates when obtained the highest amount of irrigation (2016m3/ fed. / season) in both growth seasons. According to above mentioned results Mona et al (2000) and Abdallah and Yassen (2008). Explained the vital roles of water supply at adequate amount for different physiological processes such as photosynthesis respiration, transpiration translocation, enzyme reaction and cells turgidity. Reduction of plant size and growth under water stress my be attributed to a decrease in the activity of meristemic tissues responsible for elongation.

**Table 3:** Yield and its components and water use efficiency of fodder beet plants as affected by irrigation regime, potassium foliar treatments and their interaction in 2010/2011 and 2011/2012 seasons

| Irrigation treatment, $m^3$/fed. | Potassium foliar treatments, kg/fed. | Plant height (cm) | Root length/ plant (cm) | Root diameter / plant (cm) | Root wt. / plant (g) | Foliage yield / plant (g) | Total yield / plant (g) | Root yield / fed.(ton) | Foliage yield / fed. (ton) | Biological yield / fed. (ton) | WUE, kg/$m^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010/2011 | | | | | | | | | | | |
| 2106 | 0.5 | 70.67 | 23.00 | 7.17 | 411.19 | 219.83 | 631.02 | 11.74 | 6.28 | 18.05 | 5.58 |
| | 0.75 | 73.67 | 26.00 | 8.64 | 462.49 | 287.60 | 750.09 | 13.21 | 8.21 | 21.42 | 6.27 |
| | 1 | 77.33 | 30.00 | 11.12 | 576.66 | 363.58 | 940.57 | 16.48 | 10.38 | 26.86 | 7.83 |
| Mean | | 73.89 | 26.33 | 8.98 | 483.45 | 290.34 | 773.90 | 13.81 | 8.29 | 22.11 | 6.56 |
| 1619 | 0.5 | 61.00 | 21.67 | 5.66 | 303.95 | 192.41 | 496.36 | 8.68 | 5.49 | 14.20 | 5.36 |
| | 0.75 | 66.00 | 26.33 | 7.14 | 379.52 | 211.30 | 590.82 | 10.84 | 6.03 | 16.87 | 6.70 |
| | 1 | 71.00 | 17.00 | 9.19 | 458.99 | 276.38 | 735.36 | 13.11 | 7.89 | 21.00 | 8.10 |
| Mean | | 66.00 | 23.89 | 7.33 | 380.82 | 226.70 | 607.52 | 10.88 | 6.47 | 17.36 | 6.71 |
| 1132 | 0.5 | 51.00 | 17.00 | 4.62 | 221.14 | 148.55 | 369.69 | 6.32 | 4.26 | 10.58 | 5.58 |
| | 0.75 | 56.00 | 19.33 | 6.12 | 268.38 | 170.62 | 439.00 | 7.66 | 4.87 | 12.53 | 6.77 |
| | 1 | 62.33 | 22.00 | 7.57 | 356.95 | 195.80 | 522.75 | 10.20 | 5.58 | 15.78 | 9.01 |
| Mean | | 56.44 | 19.44 | 6.10 | 282.16 | 171.65 | 443.81 | 8.06 | 4.91 | 12.96 | 7.12 |
| Mean values, k kg/fed. | 0.5 | 60.89 | 20.56 | 5.82 | 312.09 | 186.93 | 499.02 | 8.91 | 5.34 | 14.28 | 5.51 |
| | 0.75 | 65.22 | 23.00 | 7.30 | 370.13 | 223.17 | 593.31 | 10.57 | 6.37 | 16.94 | 6.58 |
| | 1 | 70.22 | 26.11 | 9.29 | 464.20 | 278.58 | 732.89 | 13.26 | 7.95 | 21.22 | 8.31 |
| L.S.D. at 5% | I | 1.15 | 0.87 | 0.25 | 12.57 | 11.32 | 30.46 | 0.28 | 0.33 | 0.27 | 0.23 |
| | K | 0.78 | 0.98 | 0.19 | 9.48 | 4.62 | 23.78 | 0.27 | 0.13 | 0.32 | 0.20 |
| | I x K | 1.35 | N.S | 0.34 | 16.43 | 8.00 | 41.18 | 0.47 | 0.23 | 0.55 | 0.35 |
| 2011/2012 | | | | | | | | | | | |
| 2106 | 0.5 | 71.33 | 23.67 | 8.23 | 404.06 | 209.06 | 613.11 | 11.54 | 5.97 | 17.51 | 5.48 |
| | 0.75 | 75.00 | 27.67 | 9.75 | 473.30 | 293.83 | 767.14 | 13.52 | 8.39 | 21.91 | 6.42 |
| | 1 | 78.67 | 31.67 | 12.00 | 580.58 | 369.73 | 950.31 | 16.58 | 10.56 | 27.14 | 7.87 |
| Mean | | 75.00 | 27.67 | 9.99 | 485.98 | 290.87 | 776.85 | 13.88 | 8.31 | 22.19 | 6.59 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1619 | 0.5 | 63.00 | 20.67 | 5.96 | 310.00 | 190.55 | 500.55 | 8.85 | 5.44 | 14.29 | 5.47 |
| | 0.75 | 68.00 | 23.67 | 7.96 | 384.61 | 208.21 | 592.82 | 10.98 | 5.95 | 16.93 | 6.78 |
| | 1 | 72.67 | 27.67 | 9.54 | 456.18 | 290.59 | 746.77 | 13.03 | 8.30 | 21.33 | 8.05 |
| Mean | | 67.89 | 24.00 | 7.82 | 383.60 | 229.78 | 613.38 | 10.96 | 6.56 | 17.52 | 6.77 |
| 1132 | 0.5 | 54.00 | 16.33 | 5.91 | 215.36 | 150.14 | 364.17 | 6.15 | 4.29 | 10.44 | 5.43 |
| | 0.75 | 60.00 | 19.00 | 7.29 | 267.86 | 174.64 | 392.50 | 7.65 | 4.99 | 12.63 | 6.76 |
| | 1 | 63.67 | 22.67 | 8.32 | 353.64 | 196.28 | 519.92 | 10.10 | 5.60 | 15.70 | 8.92 |
| Mean | | 59.22 | 19.33 | 7.18 | 278.96 | 173.69 | 425.53 | 7.97 | 4.96 | 12.92 | 7.04 |
| Mean values k, kg/fed. | 0.5 | 62.78 | 20.22 | 6.70 | 309.81 | 183.25 | 492.61 | 8.85 | 5.23 | 14.08 | 5.46 |
| | 0.75 | 67.67 | 23.44 | 8.33 | 375.26 | 225.56 | 584.15 | 10.72 | 6.44 | 17.16 | 6.65 |
| | 1 | 71.67 | 27.33 | 9.96 | 463.47 | 285.53 | 739.00 | 13.24 | 8.15 | 21.39 | 8.28 |
| L.S.D. at 5% | I | 0.77 | 1.02 | 0.31 | 14.40 | 8.13 | 21.47 | 0.41 | 0.23 | 0.54 | N.S |
| | K | 0.97 | 0.73 | 0.23 | 6.53 | 6.43 | 39.81 | 0.18 | 0.18 | 0.21 | 0.11 |
| | I x K | N.S | N.S | 0.39 | 11.31 | 11.14 | 68.96 | 0.32 | 0.32 | 0.37 | 0.20 |

I = Irrigation k = Potassium foliar treatments I x k = Interaction

***Effect Of Irrigation Regime And Foliar Potassium Fertilizer On CAT, POX Enzymes Activities And Lipid Per-Oxidation Of Fodder Beet Plants And Their Interaction:***

Guaiacol peroxidase (POX) and catalase CAT activities showed gradual increase with the increase of water regime levels (Fig.1). Spraying of potassium at 1kg/fed with the moderate level of water regime (1619 $m^3$/fed) resulted in the best significant result in the CAT enzyme activities.

The lowest significant value of MDA was detected with the highest level of water irrigation (2106 $m^3$ /fed) in contrast to 1132 $m^3$ /fed irrigation which recorded the highest significant values of lipid per- oxidation

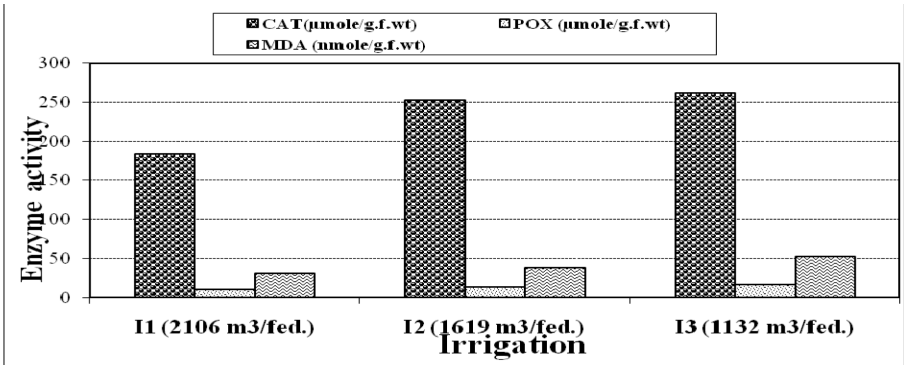
These increments in lipid per-oxidation of fodder beet plant grown under water stress came in parallel to results of Irigoyen et al (2006) on alfalfa leaves Liu et al (2008) on Tobacco plants and Ahmed et al (2010) on sorghum.

Application of potassium treatments responded slight increments in the enzymes activities and slight decrements in MDA contents . Highest significant response almostly attained at 1 kg/fed potassium compared to the moderate treatment (0.75 kg/fed) or the lowest treatment (0.5 kg/ fed).

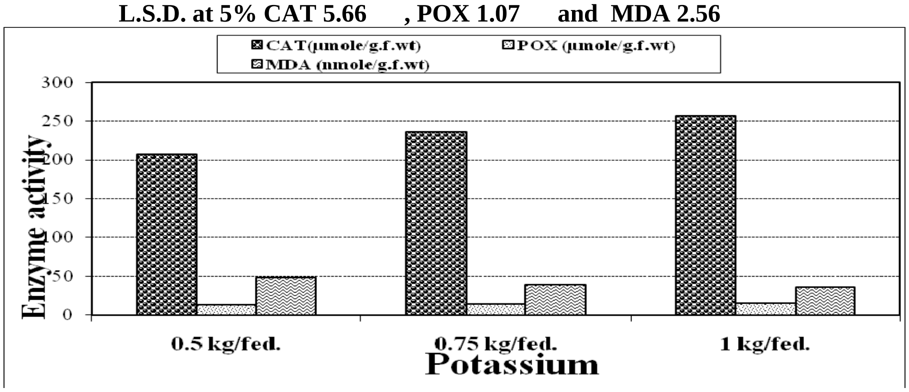
The increase in the activities of the antioxidative enzymes under water stress could be considered as an indicative of the increased production of reactive oxygen species (ROS) formed by water deficit (salekjalali et al , 2011) and a build up of a protective mechanism to reduce oxidative damage which in turn led to eleveate the plant tolerance under water stress (Dolatabadien and saleh Jouneghani , 2009 and Ahmed et al , 2010).

Application of potassium highly decreased lipid per-oxidation especially under water stress conditions, this result confermed by Zheng et al (2008) and Gholizadeh et al (2012) i.e potassium act as antioxidant by increasing CAT and POX enzymes activites followed by decrements in lipid per-oxidation attained in fodder beet plants grown under water regime, that helped the plants to destroy $H_2O_2$ and build up of a protective mechanism to reduce oxidative damage.

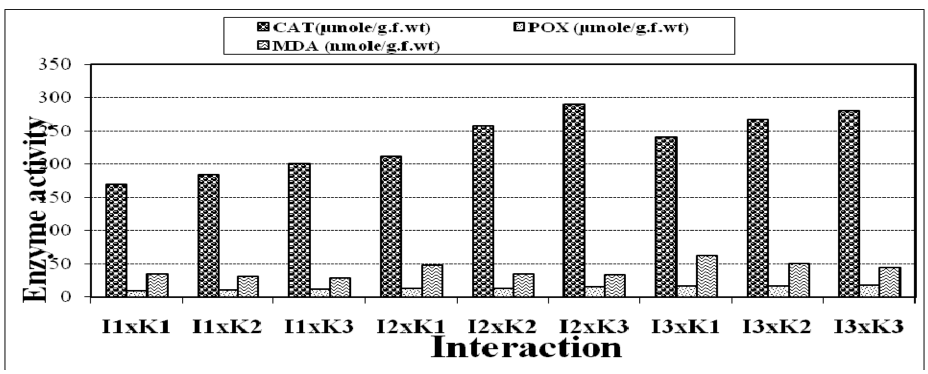
Numerous studies have shown that the application of potassium fertilizer mitigate the adverse effects of drought on plant growth (Andersen et al (1992) on barley, abdilwahab and Abdalla (1995) on faba beans Sudama et al (1998) on sugar cane and Tiwari et al (1998) on rice. That confirmed results of this study indicating the inhibitory role of potassium against ROS production during photosynthesis and NADPH oxidase and through its functions in stomatal regulation, osmoregulation, energy status, charge balance, protein synthesis and homeostasis beside increasing plant tolerance (Fanaei et al, 2009) mainly through synthesis and accumulation of osmolytes which play a major role in osmotic adjustment and also protect the cells by scavenging ROS (Pinhero et al, 2001).




**L.S.D. at 5% CAT 5.66 , POX 1.07 and MDA 2.56**




**L.S.D. at 5% CAT 11.22 , POX 1.24 and MDA 2.59**




**L.S.D. at 5% CAT 19.43 , POX N.S and MDA 4.48**

**Fig. 1:** Mean values of activity of CAT(µmole/g.f.wt), POX (µmole/g.f.wt) and MDA (nmole/g.f.wt) of fodder beet plants treated with potassium, grown under water stress and their interaction.

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