Journal of Stress Physiology & Biochemistry, Vol. 9 No. 1 2013, pp. 87-95 ISSN 1997-0838

ORIGINAL ARTICLE

Effect of Thiourea on Yield and Quality of Potato (*Solanum tuberosum* L.)

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Received October 9, 2012

A field experiment was carried out to study the effect of five concentrations (0, 250, 500, 750 and 1000 mM) of thiourea application on mother tubers on yield and quality attributes of harvested potato, variety Spunta in the region of Chott-Mariem in Tunisia. Treated tubers (Ø = 50 mm) were planted in field after breaking dormancy at a spacing of 80 cm x 30 cm according to completely randomized design (CRD) in three replications. Quality attributes of potato tubers especially fresh matter and dry matter of plant, total reducing sugars in leaves, tuber yield, number and diameter of tubers per plant and number of sprouts per tuber was measured. Soluble proteins and starch content in potato tubers were also quantified.

In general we noted that application of thiourea showed significant influence on yield and on quality of tubers comparing to control. Maximum tuber yield per plant, maximum number of tubers per plant and maximum starch content was recorded with 250 mM of thiourea. Moreover, highest dry matter of potato plant was found also at this concentration. While increasing dose of thiourea thereafter it showed slight significant improvement and do not affect significantly the diameter of tubers comparing to control.

Key words: Potato, Thiourea, Yield, Quality parameters, Total reducing sugars, Soluble proteins.

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Potato (*Solanum tuberosum* L.) is considered as an important and strategic product in Tunisia (Rejeb and Elfehem, 2007). Among the chemicals applied for breaking down the potato nodes dormancy, thiourea, a catalase inhibitor which triggers potato tubers germination and healing tubers injuries especially when it is applied in an appropriate concentration. Also, many studies reported that thiourea treatment is not only more efficient to break dormancy but it increases also sprouts number, comparing to other chemicals (IAA and GA3) (Germchi *et al.,* 2010). In addition, earlier workers reported that thiourea has great influence on yield and quality of potato tubers (Panah *et al.,* 2007). However, the impact of this substance on plant growth, and on quality of potato tubers is not well established. In fact, quality attributes of potato tubers particularly size of tubers, dry matter, starch

and soluble proteins contents are of prime concern of potato agricultures, in order to fetch good prices of their produce from processors demanding potato. Hence, this experiment was conducted to determine the effect of thiourea on yield and quality of potato plants and tubers, variety Spunta under Chott-Mariem conditions in Tunisia.

MATERIALS AND METHODS

This field experiment was carried out at Chott-Mariem Farm in The Institute of Agricultural Sciences during 2011- 2012. Healthy potato tubers of uniform size (Ø = 50 mm) and of Spunta cultivar were washed with distilled water immediately after harvesting to remove surface soils and then each 21 tubers were immersed in various treatment of thiourea (0, 250, 500, 750 and 1000 mM) for two hours in 24°C of laboratory condition. After dipping, treated and control tubers were dried and kept in a store with 90% relative humidity and total darkness until dormancy release (Rykaczewska, 1996). After 3 weeks, tubers sprouted and we consider that germination of a 3 mm sprout out of tuber is a good criterion for end of dormancy period and this time was considered as dormancy breaking time (Van Ittersum and Struik, 1992).

After breaking dormancy, tubers were planted in field at a spacing of 80 cm x 30 cm according to completely randomized design (CRD) in three replications. The soil is composed of clay (11.5%), silt (22.5%), sand (61%) and organic matter (1%). Its pH is of 7.6. The irrigation water has a conductivity of 1.4 mS. cm^{-1} and a pH of 6.2. The chemical composition of water, expressed in $meq.l^{-1}$, is as follows: Ca^{2+} (7.4), K^{+} (0.1), Na^{+} (4.9) and Cl^{-} (5.9). The amounts of mineral fertilizers and organic, recommended in the area of Chott-Mariem for culture of potato (Hannachi *et al.,* 2004; Chehaibi *et al.,* 2008) and used in our tests, are farmyard manure (30 $t.ha^{-1}$), triple super phosphate (P_2O_5 45% :150 $kg.ha^{-1}$), and potassium sulphate (K_2O 54% : 400 $kg.ha^{-1}$), they were used as P and K sources respectively. Theses fertilizers are incorporated in soil before planting. One month after planting, potassium sulphate (K_2O 54%: 400 $kg.ha^{-1}$) and ammonium nitrate (NH_4 NO_3); (N 33% :100 $kg.ha^{-1}$) are also incorporated. During the culture period, from October 10 to January 26, monthly weather records set each day give minimum of 9°C and maximum of 21°C maxima of temperature regime.

During growth period, total reducing sugars (Sucrose, fructose and glucose) in leafs were measured. After 4 months and at the end of growth period, the tubers were collected and features such as fresh matter and dry matter of plant, tuber yield, number, diameter of tubers per plant and number of sprouts per tuber are measured. Soluble proteins and starch content in potato tubers were also quantified. Data variance analysis was performed by SAS statistical software. The means were compared by Duncan multi-dimension test at 5% signification level.

RESULTS

Effect of thiourea on fresh and dry matter of potato plants

Significant difference was observed using different concentrations of thiourea comparing to control plants in term of fresh matter and dry matter in potato plants. In fact, increasing thiourea concentrations to 1000 mM increased significantly fresh matter of potato plants to 225 g/plant (Table 1). In addition, dry matter was increased in plants up to 17g/plant with higher concentrations of thiourea (1000 mM). So, it seems that thiourea, by increasing fresh matter, lead to an increase of dry matter.

Effect of thiourea on yield of potato

Various concentrations effect of thiourea on yield of potato tubers is indicated in figure 1. As it can be seen, application of thiourea improved yield whatever the concentration applied. Moreover, applying at least 250 mM solution of thiourea increased yield up to 810 g/plant, which equivalent to 28t/ha. This value is significantly superior over control (630 g/plant). Otherwise, there are negative link between thiourea concentrations and yield, since by increasing concentrations of thiourea, yield decreased a little bit. So, more availability of thiourea might have decrease the yield up to a limit.

Effect of thiourea on quality attributes of tubers

In the present investigation, number of tubers/plant was found to be maximum (5.6 tubers/plant) with 250 mM of thiourea, followed by 500 mM of thiourea (5.2 tubers/plant) (Table 2). These values were significantly superior over the other concentrations and over control plants (4.2 tubers/plant). However, difference between number of tubers/plant for 750 and 1000 mM were no significant.

On the other hand, size of potato tubers recorded for different concentrations of thiourea showed no significant difference (Table 2). Indeed, the recorded diameter of tubers is ranged from 6 to 6.4 cm. Also, comparing means of thiourea effects (Table 2) on harvested tubers showed that consuming thiourea decreases number of sprouts in tubers from 17.1 to 15.3 comparison with control (18.1).

Otherwise, the effect of thiourea application on quality of potato was evaluated in potato leaves by evaluating total reducing sugars content and in tubers after harvesting by evaluating starch content and soluble proteins content. We noted that application of thiourea on tuber mother increased slightly the contents of glucose and fructose and significantly total reducing sugars and sucrose in leaves of potato plants. As we can see in figure 2, plants treated with 1000 mM of thiourea recorded highest total reducing sugar content (9.361 mg/ g FM) followed 500 and 750 mM (2.68 and 1.42 mg/ g FM respectively). However, lowest total reducing sugar content was noted in control plants (0.76 mg/g FM) and in those treated with 250 mM of thiourea (0.93 mg/g FM). Similar results were established by Rehman *et al.* (2002, 2003).

Although, both fresh and dry matter were increased in potato plants through using thiourea, soluble proteins was significantly decreased and reached from 16.65 mg/ g FM in control tubers to a bit less than 12 mg/ g FM in plants treated with 1000 mM of thiourea, while maximal soluble proteins (21 mg/g FM) was recorded when 250 mM of thiourea was applied (Figure 3).

The analyzes showed that starch content was maximum (19.4 mg/g FM) in tubers treated with 250 mM of thiourea, followed by those treated with 750 mM of thiourea (18.9 mg g FM). However, lowest starch content was found with 500 mM of thiourea, followed by 1000 mM (15.7 and 14.7 mg/ g FM respectively) (Figure 4). These results suggest that thiourea application increased starch content only when it is applied at 250 mM. Thereafter, further increase in thiourea did not showed any remarkable influence.

Table 1: Effect of thiourea on fresh and dry matter of potato plants

Thiourea levels (mM)	0	250	500	750	1000
Fresh Matter (g)	142.2 ± 12.2[b]	131.1±14.33[d]	186.2±10.77[c]	225.9±12.87[a]	207.8 ± 9.11[b]
Dry Matter (g)	11.8 ± 0.96[c]	15.7 ± 0.96[b]	11.8 ± 0.08[c]	14.2 ± 0.88[c]	16.9 ± 1.04[c]

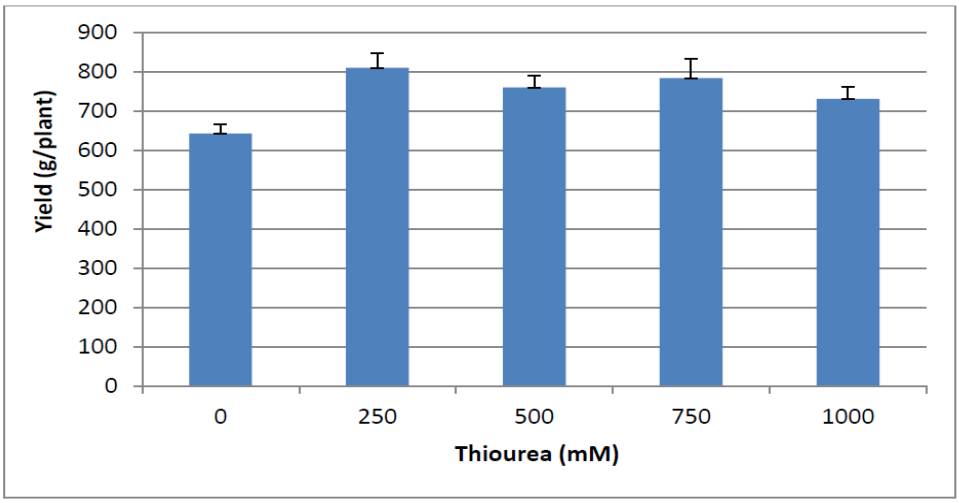

Figure 1: Effect of thiourea on tuber yield of potato (g/plant)

Table 2: Effect of thiourea on quality attributes of tubers

Thiourea levels (mM)	0	250	500	750	1000
Number of tubers/plant	4.2 ± 0.26 [b]	5.6 ± 0.28 [a]	5.2 ± 0.27[a]	4.38 ± 0.21[b]	4.3 ± 0.19 [b]
Diameter of tubers (cm)	6.2 ± 0.20 [a]	6.0 ± 0.18 [a]	6.1 ± 0.18 [a]	6.4 ± 0.19 [a]	6.2 ± 0.19 [a]
Number of sprouts/tuber	18.1 ± 2.25 [a]	17.6 ±1.8 [a]	16.6 ± 1.7 [a]	15.3 ± 2.1 [b]	18.1 ± 2.7 [a]

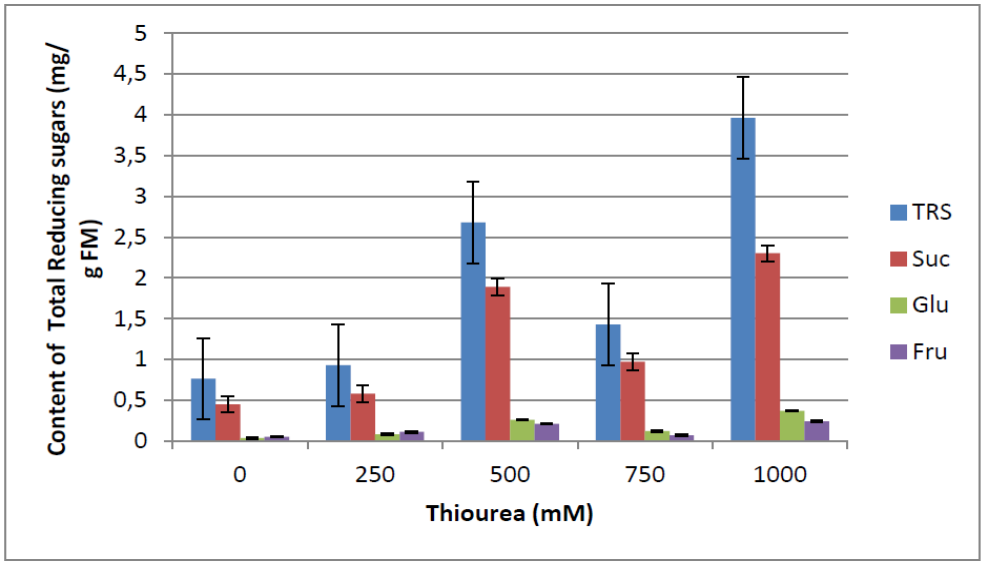

Figure 2: Effect of thiourea on total reducing sugars (Sucrose, Glucose and Fructose) content of potato plants

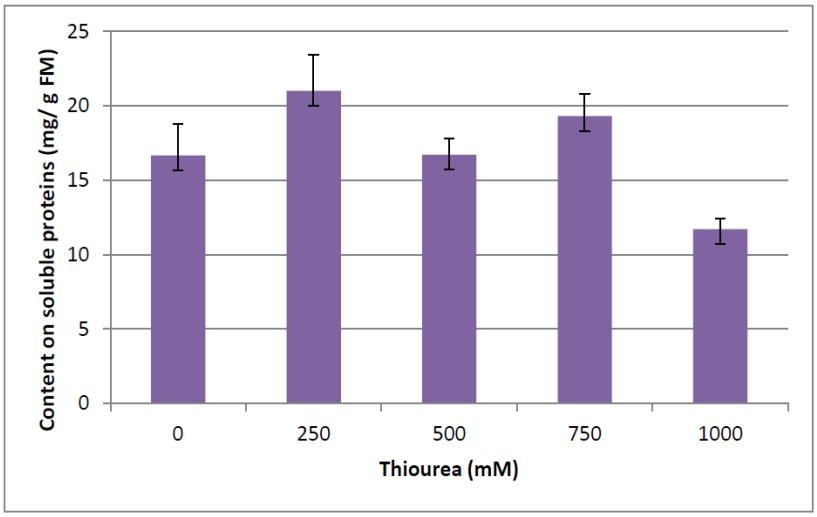

Figure 3: Effect of thiourea on soluble proteins content of tubers

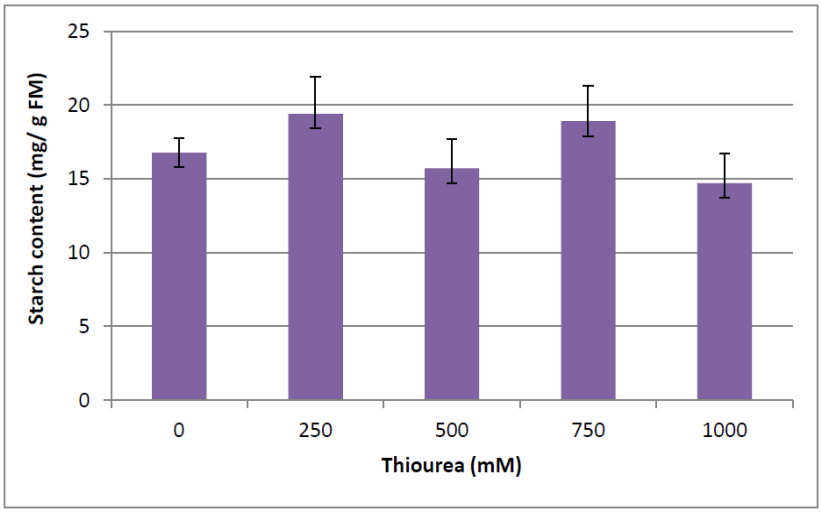

Figure 4: Effect of thiourea on starch content of tubers

DISCUSSION

Thiourea levels showed positive influence on tuber yield comparing to control. Similarly, Bajji *et al.* (2007) have also reported significant effect on tuber yield and increase in bulking rate with thiourea application. But, there was a slight decrease in tuber yield with increase in thiourea concentrations. However, total reducing sugar content in potato leaves recorded reverse trend and showed increase in sugar content with increasing concentrations of thiourea up to 1000 mM. These results suggest that high concentrations of thiourea stress plant. This stress is generally accompanied by an accumulation of carbohydrates in leaves and a low transfer of photosynthates in sink organs according to Ayari (2000). This leads to the accumulation of sugars and decrease performance. Otherwise, the low levels of sucrose observed in plants treated with thiourea (250 and 750 mM) and in control plants could be an early indicator of the implementation of metabolic changes necessary for the induction of an early tuberization according to Kumar *et al.* (2004) and Chicinska *et al.* (2008).

Besides, using thiourea increased significantly number of tubers per plant and dry matter of

potato plants, so it seems that strong plants produce more tubers. In addition, using 250 mM of thiourea increased average tuber number per plant from 4.2 to 5.6, while using 1000 mM of thiourea increased that to 4.3. So, there was a significant difference between various concentrations of thiourea in terms of this feature. Higher tuberization and bulking capacity might have resulted in more number of tubers per plant. However, it was noted that plants treated with 250 mM thiourea provide more tubers with a diameter slightly less than the rest of the plants. This can be attributed according Delaplace *et al.* (2008) and Badr (2011) to a momentary blocking of starch synthesis due to an accumulation of sucrose and status osmotic disruption of the potato. In contrast, statistical analyzes showed that the effect of thiourea concentrations had no significant influence on diameter of tubers. These results suggest that the diameter of the tuber is an intrinsic character of the variety. This is consistent with the works of Horvart (2008) and Guler (2009).

Though, thiourea affected starch content in tuber significantly. Certainly, starch content was found maximum with application of 250 and 500 mM of thiourea which was significantly superior over other thiourea levels. Whereas, lowest starch content was recorded under control. So, high levels of thiourea reduced the starch content of potatoes.

In one hand we noted that each incremental dose of thiourea enhances the soluble proteins content in potato tuber comparing to control, Germchi *et al.* (2010) found similar results. While further increase in thiourea concentration (up to 1000 mM) recorded slight reduction in soluble proteins content. On the other hand, we noted that the sucrose content in leaves is low in plants with high starch content and a high content of soluble proteins. This phenomenon was explained by (Blenkinsop *et al.* (2003); Ortiz-Medina *et al.* (2003) and Matsuura-Endo *et al.* (2004) who proposed that the accumulation of starch and soluble proteins accumulate in parallel and in proportion to the tuber sucrose translocated from the leaves to the tubers. therefore reducing sugar content in the leaves is high less the synthesis of starch and soluble proteins is stimulated in tubers.

CONCLUSION

Hence, it may be concluded based on the present field experiment that thiourea has significant influence on yield and quality attributes of potato plants and potato tubers. In the present study, application of 250 mM of thiourea excelled over other doses for growth plant parameters, tuber yield and quality attributes. It gives an increase in yield of 26% with tubers rich in starch and in soluble proteins due to an increase in total sugars and sucrose measured in growing leaves of treated plants.

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