FOLIAR APPLIED THIOUREA AT DIFFERENT GROWTH STAGES MODULATED LATE SOWN WHEAT

M. Zain, I. Khan, M. U. Chattha, R. W. K. Qadri*, S. A. Anjum, M. U. Hassan, A. Mahmood and M. Ilyas

Department of Agronomy, University of Agriculture, Faisalabad-38040, Pakistan
*Institutes of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan
Correspondence: I. Khan, Department of Agronomy, University of Agriculture Faisalabad-38040, Pakistan.
Corresponding author's e-mail: drimran@uaf.edu.pk

ABSTRACT: Late sowing is a common problem of wheat in rice-wheat and cotton wheat cropping systems of Pakistan. The exogenous application of thiourea, due to its distinct properties, may potentially reduce the harmful effects on late sown wheat. A field study was conducted to estimate the potential of thiourea for enhancing the performance of late sown wheat. Wheat cultivar, Glaxy 2013 was sown in mid-December, 2014-15 and two foliar treatments i.e. 300 and 600 mg/L of thiourea solutions applied at different developmental stages i.e. tillering, jointing and booting, while, water spray and no spray were considered as double control. Growth characteristics of wheat were significantly enhanced with the foliar application of thiourea at tillering stage @ 300 mg/L. Likely, yield contributing traits as number of productive tillers, number of grains per spike, 1000-grain weight and grain yield were considerably improved by the application of 300 mg/L of thiourea at tillering stage. It was concluded that at tillering stage the application of thiourea (at 300 mg/L) was highly effective in improving the growth and yield of late sown wheat.

Keywords: Late sowing, wheat, thiourea, growth stages, growth, yield.

(Received 01-09-2016 Accepted 02-03-2017)

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop in the world as per its production and area under cultivation. It provides about 20% food energy to world population which makes it the primary staple food of maximum countries of the world. In Pakistan, the yield potential of our local varieties range from 6 to 8 t ha^{-1} but average yield is 2.9 t ha^{-1} in irrigated and 1.3 t ha^{-1} in rain fed areas. This huge gap between the genetic potential and average yield is due to many reasons such as selection of variety, late sowing, salinity, unavailability or shortage of quality water, poor management regarding nutrients and insect pest control. Among all these, late sowing is the most devastating (Ali *et. al*; 2008).

There are different reasons which account for late sowing of wheat like cropping system and weather conditions, etc. (Yajam and Madani, 2013). Iqbal *et. al*; (2001) observed that if wheat crop is planted after 15th December, then 50% of yield is reduced. Moreover, Sohail *et. al*; (2014) reported that late sowing of wheat reduces the grain yield up to 29%. Similarly, Nazir *et. al*; (2004) reported reduction in individual plant height and tiller production due to delay in sowing of wheat. On other hand, late sowing of wheat, not only results in decreased plant height but also the period of maturity and grain filling is suppressed, that finally results in substantial reduction in yield. According to Sial *et. al*; (2007), late wheat sowing disturbs the source sink relationship, due to which plant organs are not developed at appropriate time that ultimately results in decreased grain yield.

Different approaches and techniques such as selection of early maturing varieties (both for rice and cotton), use of growth promoters, relay cropping and zero tillage are used by the farmers to resolve the issue of late sowing. Uses of less expensive growth promoting substances which are easily available to farmers which can serve the purpose. Tang *et. al*; (2009) described that plant height and growth can be increased through exogenous application of different synthetic compounds like chlormequat, benzyladenine and ethephon. Photosynthetic pigments can be enhanced in wheat by exogenous application of plant growth regulators (Sabo *et. al*; 2002).

A number of growth regulators like thiourea, betaine, putrescine, etc are used to surge the yield and growth of crops. Thiourea enhances the tolerance against stress because of its high water solubility and quick absorption in living tissues. Kader *et. al;* (2012) reported that thiourea increases the vegetative growth, protein contents and yield in wheat under drought stress. Garg *et. al*; (2006) reported a substantial increase in net photosynthesis and chlorophyll contents by the application of thiourea in cluster bean, under drought stress. Hassane *et. al*; (2015) found a significant improvement in growth and photosynthetic efficiency of

wheat crop by the application of thiourea. By observing positive effects of thiourea on plants, this study was carried out to evaluate the response of late sown wheat to foliar applied thiourea at tillering, jointing and booting stages and optimized the suitable concentration of thiourea for better growth of late sown wheat.

MATERIALS AND METHODS

A field study was conducted during 2014-15 at Student Research Farm, Department of Agronomy, University of Agriculture, to determine the effect of foliar applied thiourea on the performance of late sown wheat. Prevailing weather conditions in field during growing season are given in Table-1. After performing soil analysis of area under study, it was reported that soil was sandy loam having organic matter 1.23%, pH 7.8, Electric Conductivity (EC) 1.92 dS m^{-1} and Nitrogen, Phosphorus and Potash contents were 0.014%, 4.1 and 120 mg kg^{-1}, respectively.

The experiment was conducted using RCBD (Randomized Complete Block Design) with factorial arrangement having three replications with net plot size of 1.8 m × 5 m. Seed of wheat cultivar (Galaxy, 2013) was collected from Wheat Research Institute, AARI, Faisalabad. Crop was sown on 16 December, 2014 with a hand drill using seed rate of 125 kg ha^{-1}.There were eight rows in each plot at a distance of 22.5 cm. The fertilizers NPK were applied at 100, 65 and 65 kg ha^{-1}, respectively. Phosphorus, potassium and one third of nitrogen were applied at the time of seed bed preparation. The remaining nitrogen was applied in two splits consecutively at first and second irrigation. Foliar application of water spray and thiourea solution of 300 and 600 mg/L was applied at tillering, jointing and booting stage. Knapsack sprayer with flat fan nozzle was used for foliar application. To determine the accurate volume of required water for foliar application of thiourea, calibration was made before spraying. The plots which were not subjected to foliar spray of water or thiourea solution were considered as control.

Wheat plants were harvested from an area of 50 cm × 50 cm fortnightly in each experimental unit, to analyze leaf area and dry matter accumulation. Further, leaf area index and crop growth rate were calculated by standard procedures of Watson (1952) and Hunt (1978), respectively.

At the time of maturity, the crop was harvested from one square meter area of each plot to measure the yield and yield related parameters on 22 April, 2015. Individual spikes from ten random tillers were threshed separately. The grains were counted and average number of grains per spike was also counted. For recording 1000-grain weight, electronic balance was used. Three samples of grains from each treatment within each replication were taken and average was calculated. The grain yield was measured in Kg per plot after adjusting grain weight to 14% moisture contents. The data collected was analyzed statistically using Fisher's analysis of variance technique and least significant difference test was applied at 0.05 probability level to compare treatment means (Steel *et.al*; 1997).

RESULTS AND DISCUSSION

Growth related parameters: The results revealed that foliar application of thiourea showed significantly higher values of all growth parameters as compared to water spray and control. The maximum leaf area index values were recorded for plants treated with foliar spray of thiourea at rate of 300 mg/L followed by I_4 treatment plants subjected to thiourea spray @ 600 mg/L (Figure-1). The same trend was recorded when thiourea concentrations were applied at tillering, jointing and booting stages. Figure-2 (d), (e) and (f) showed similar trend related to crop growth rate as was observed for leaf area index. Maximum crop growth rate was recordedduringI_3treatment (Thiourea @ 300 mg/L) at each stage of application. However, marginally lowest leaf area index and crop growth rate were observed in untreated plants (control).Increase in growth parameters like Leaf area index (LAI) and Crop growth rate (CGR) by thiourea application might be due to better translocation of photosynthates and increase in the ability of plants to with stand with the abiotic stress particularly heat stress that was common at the maturity stage of wheat crop. These results are corroborated with previous findings of Amin *et. al*; (2014) who also reported that foliar feeding of thiourea significantly increased the growth related parameters of faba bean.

The plant height was significantly affected due to different concentrations and timings of thiourea application (Table-2).Highest plant height (97.84 cm) was attained by plants treated with 300 mg/L thiourea which was statistically similar to plants sprayed with thiourea at rate of 600 mg/L. For stage of thiourea application, plants sprayed at tillering, gave statistically maximum plant height (95.47 cm) as compared to plants sprayed at jointing and booting stages. However, slightly reduced plant height (83.68 cm) was recorded in control plants. The application of thiourea increased the plant height by ameliorating the heat stress and by improving the photosynthetic activities that resulted in vigorous growth and enhancement in plant height similarly as reported by (Asthir *et. al*; 2013).

Yield related parameters: Application of thiourea significantly affected the yield and yield related attributes of late sown wheat. The maximum productive tillers (316.22) were recorded in plants sprayed with thiourea of 300 mg/L which was statistically at par with I_4treatment (Thiourea @ 600 mg/L).For time of application, foliar

application at tillering produced statistically more tillers as compared to spray at jointing and booting. Moreover, control plants exhibited minimum productive tillers (267.33 m^{-2}). The highest unproductive tillers (17.11) were produced by control plants. However, plants subjected to foliar thiourea @ 300 mg/L produced lowest unproductive tillers (12.11) Table-2. Increase in productive and decrease in unproductive tillers might be due to lowered oxidative stress, quenching of the reactive oxygen species (ROS) and protection of cell to lipid peroxidation by foliar feeding of thiourea (Asthir *et. al*; 2013). Maximum spike length (12.30 cm) was computed for I_3 treatment (Thiourea @ 300 mg/L) which was at par with I_4 treatment (Thiourea @ 600 mg/L). Moreover, minimum spike length (10.85 cm) was observed in control plants (Table-2).

Data presented in Table-2 revealed that maximum spikelets per spike (16.78) and grains per spike (36.11) were counted in I_3 treatment (Thiourea @ 300 mg/L) which was statistically similar to I_4 treatment (Thiourea @ 600 mg/L) while the control plants gave least grains per spike (28.33) and spikelets per spike (14.11). Garg *et. al*; (2006) also reported that thiourea application substantially improved the number of spikelet's and grains per spike by increasing the enzymatic (rubisco) and photosynthetic activities and plants resistance against the abiotic stresses, particularly for heat stress tolerance.

The results presented in Table-3expressed that 1000-grain weight was statistically different among treatments as I_3 treatment (Thiourea @ 300 mg/L) gave maximum grain weight (45.13 g) which was at par with I_4 treatment (Thiourea @ 600 mg/L). On the other hand, control plants showed minimum 1000-grain weight (38.90 g).These results are supported with previous findings of Nilesh *et. al*; (2012) who reported a significant increase in grain weight with thiourea application which might be due to better photosynthesis and translocation of starch towards the developing kernel.

The results revealed a considerable variation among the thiourea treatments for the grain and biological yield. Maximum grain yield (5.26 t ha^{-1}) and biological yield (11.29 t ha^{-1}) were recorded from the plants fed with the thiourea spray @ 300 mg/L and thiourea spray @ 600 mg/L, respectively (Table-3). Moreover, minimum grain and biological yield were recorded from control plants (Table-3). Similarly, in case of time of application, thiourea sprayed at tillering stage gave higher grain and biological yield as compared to other stages. Similarly, the maximum harvest index (46.87%) was observed with the use of thiourea @ 300 mg/L, while, the lowest harvest index was recorded without the use of thiourea. Increase in grain and biological yield by thiourea application could be due to higher rate of photosynthesis, more proficient nitrogen metabolism, better translocation and accumulation of metabolites in different plant organs that resulted in profound increase in grain and biological yield. Improvement in biological and grain yield with foliar applied thiourea in this study was consistent with the earlier reports of (Garg *et. al*; 2006). Similarly, a remarkable increase in harvest index was also seen with the application of thiourea. This increase in harvest index might be due to the combined increase in grain and biological yield of wheat. These results are supported with previous findings of (Asthir *et. al*; 2013), who reported substantial increase in harvest index with the application of thiourea.

Table-1: Prevailing climatic conditions of the experimental site during crop growing seasons for the year 2014-15.

Months	Monthly Mean Max. Temp. (°C)	Monthly Mean Min. Temp. (°C)	Monthly Avg. Temp. (°C)	Relative Humidity (%)	Rainfall (mm)
Dec-21014	18.5	5.9	12.2	75.0	0.0
Jan-2015	16.6	6.9	11.7	75.3	12.2
Feb-2015	22.0	11.1	16.5	66.0	20.5
Mar-2015	24.5	13.6	19.1	64.0	67.9
Apr-2015	33.2	20.7	27.0	43.9	32.8

Table-2: Effect of different concentrations and time of exogenous application of thiourea on plant height (cm), productive tillers, unproductive tillers, spike length (cm) and spikelets per spike of late sown wheat.

Treatments	Plant height (cm)	Productive tillers	Unproductive tillers	Spike length (cm)	Spikelets per spike
I_1 (Control)	83.68 C	267.33 B	17.11 A	10.85 B	14.11 B
I_2 (Water spray)	90.90 B	277.33 B	14.78 AB	10.91 B	14.78 B
I_3 (Thiourea @ 300 mg/L)	97.84 A	316.22 A	12.11 C	12.30 A	16.78 A
I_4 (Thiourea @ 600 mg/L)	96.78 AB	300.56 A	12.33 BC	12.06 A	16.00 A
LSD ($p \leq 0.05$)	**6.120**	**18.948**	**2.614**	**0.685**	**0.988**
Spray at tillering stage	95.47 A	301.83 A	12.33 B	11.82 A	16.00 A

Spray at jointing stage	88.79 B	287.83 AB	14.67 A	11.08 B	15.33 AB
Spray at booting stage	92.65 AB	281.42 B	15.25 A	11.69 A	14.92 B
LSD (p≤0.05)	5.300	16.410	2.264	0.593	0.856
Interaction=Thiourea×Spray	**NS**	**NS**	**NS**	**NS**	**NS**

Values sharing a common letter in a column do not differ significantly at P≤0.05.

Table-3: Effect of different concentration and time of exogenous application of thiourea on grains per spike, 1000-grain weight (g), biological yield (t ha^{-1}), grain yield (t ha^{-1}) and harvest index of late sown wheat.

Treatments	Grains per spike	1000-grain weight (g)	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})	Harvest index
I_1 (Control)	28.33 C	38.90 B	10.23 B	4.24 D	41.50 B
I_2 (Water spray)	32.67 B	40.72 B	10.68 AB	4.55 C	42.82 B
I_3 (Thiourea @ 300 mg/L)	36.11 A	45.13 A	11.25 A	5.26 A	46.87 A
I_4 (Thiourea @ 600 mg/L)	34.33 AB	44.78 A	11.29 A	4.96 B	44.33 AB
LSD (p≦ 0.05)	**3.010**	**2.147**	**0.814**	**0.176**	**3.844**
Spray at tillering stage	34.92 A	43.49 A	11.09	4.88 A	44.08
Spray at jointing stage	30.67 B	42.83 A	10.68	4.69 B	43.98
Spray at booting stage	33.00 AB	40.83 B	10.82	4.70 B	43.58
LSD (p≦0.05)	**2.607**	**1.859**	**NS**	**0.153**	**NS**
Interaction=Thiourea×Spray	**NS**	**NS**	**NS**	**NS**	**NS**

Values sharing a common letter in a column do not differ significantly at P≤0.05.

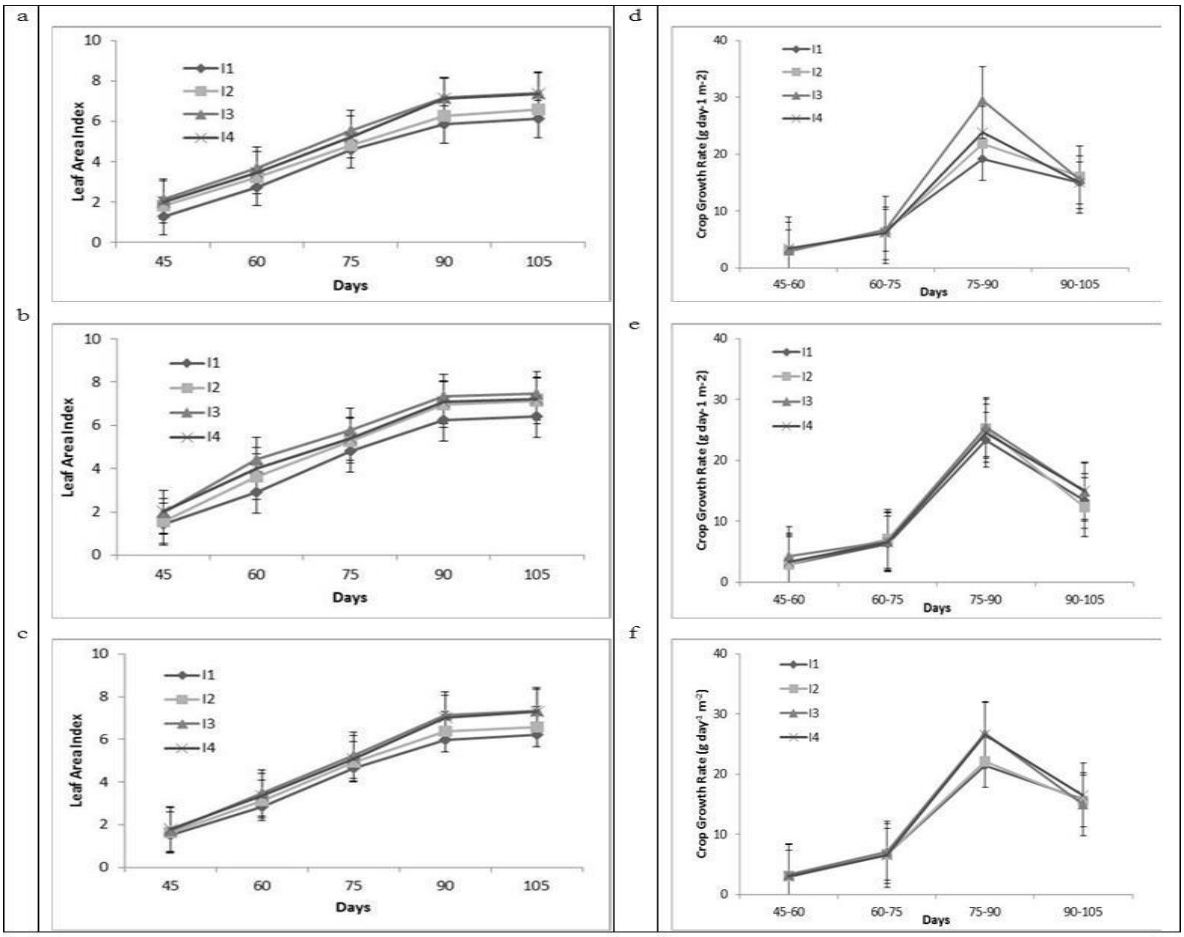

Figure-1: Effect of exogenous application of different thiourea levels on leaf area index (LAI) (a), (b), (c) and crop growth rate (g day^{-1} m^{-2}) (d), (e), (f) at tillering, jointing and booting stages, respectively of wheat crop.

I_1 = Control, I_2 = Water spray, I_3 = Foliar application of thiourea @ 300 mg/L, I_4 = Foliar application of thiourea @ 600 mg/L

Conclusion: Application of thiourea at rate of 300 mg/L resulted in significant increase in growth, yield and yield related attributes of late sown wheat crop. Foliar spray of thiourea at tillering stage found to be more beneficial as compared to jointing and booting stages of wheat crop.

REFERENCES

Abdelkader, A.F., R.A. Hassanein, and H. Ali (2012). Studies on effects of salicylic acid and thiourea on biochemical activities and yield production in wheat (*Triticum aestivum* var. Gimaza 9) plants grown under drought stress. African J. Biotech. 11(64): 12728-12739.

Ali, S., A.R. Khan, G. Mairaj, M. Arif, M. Fida, and S. Bibi (2008). Assessment of different crop nutrient management practices for yield improvement. Crop Sci. 2:150-157.

Amin, A.A., H.F. Abouziena, M.T. Abdelhamid, El-Sh. M. Rashad, and A.E. Fatma Gharib (2014). Improving growth and productivity of faba bean plants by foliar application of thiourea and aspartic acid. Int. J. Plant Soil Sci. 3: 724-736.

Asthir, B., R. Thapar, M. Farooq and N. S. Bains (2013). Exogenous application of thiourea improves the performance of late sown wheat by inducing terminal heat resistance. Int. J. Agric Biol. 15: 1337-1342.

Garg, B.K., U. Burman, and S. Kathju (2006). Influence of thiourea on photosynthesis, nitrogen metabolism and yield of cluster bean (*Cyamopsis tetragonoloba* L.) under rainfed conditions of Indian arid zone. Plant growth Reg. 48:237-245.

Hassanein, R.A., A. A. E.S. Amin, E.S.M. Rashad, and H. Ali (2015). Effect of thiourea and salicylic acid on antioxidant defense of wheat plants under drought stress. Int. J. Chem. Tech. Res. 7(01): 346-354.

Hunt, R. (1978). Plant growth analysis. Edward Arnold U.K: 26-38.

Iqbal, M.S., A. Yar, A. Ali, M.R. Anser, J. Iqbal, and H.M. Akram (2001). Effect of sowing date and seed rate on grain yield of wheat (cv. 93-BT-022). J. Agric. Res. 39: 217-220.

Nilesh, G. P. Chakrborti, A.K. Rai, and P.C. Gupta (2012). Effect of plant growth regulator on growth response and yield component in wheat (*Triticum aestivum* L.) crop. Res. J. Agric. Sci. 3: 204-208.

Sabo, M., T. Teklic, and I. Vidovic (2002). Photosynthetic productivity of two winter wheat varieties. Rostlinna Vyroba. 48: 80-86.

Sial, M.A., M.A. Arain, S.K. Mazhar, H. Naqvi, M. Umar, and A.N. Nizamani (2007). Yield and quality parameters of wheat genotypes as affected by sowing dates and high temperature stress. Pak. J. Bot. 3:575-584.

Sohail, M., I. Hussain, Riaz-ud-Din, S.K. Tanveer, M. Qamar, and S.H. Abbas (2014). Evaluation of advance wheat lines for agronomic traits in rain fed environment. Pak. J. Agric. Res. 27: 79-88.

Steel, R.G.D. and J.H. Torrie (1997). Principles and Procedures of Statistics: A Biomaterical Approach, pp: 187-188. McGraw Hill Company, New York.

Tang, D., Y. Wang, J. Cai, and R. Zhao (2009). Effects of exogenous application of plant growth regulators on the development of ovule and subsequent embryo rescue of stenospermic grape (*Vitis vinifera* L.). Sci. Hort. 120: 51-57.

Watson, D.J. (1952). The physiological basis of variation in yield. Adv. Agron. 4: 101-145.

Yajam, S. and H. Madani (2013). Delay sowing date and its effect on Iranian winter wheat cultivars yield and yield components. Ann. Bio. Res. 4: 270-275.