Effect of Paclobutrazol under Different Levels of Nitrogen on Some Physiological Traits of Two Wheat Cultivars (Triticum aestivum L.)

H. Nouriyani, E. Majidi, S.M. Seyyednejad, S.A. Siadat and A. Naderi

Abstract: The use of growth regulators in manipulation of growth physiology and development of grain yield to increase quantity and quality of grain is extensively expanding in many countries. To investigate the effects of paclobutrazol and nitrogen application rates on chlorophyll a, chlorophyll b, total chlorophyll (a+b), carotenoids and soluble proteins contents in flag leaf (anthesis stage) of two wheat cultivars. Field experiments were conducted in Dezful region of Iran during period of 2009 to 2011. The experiment was carried out as a split plot design using randomized complete block design in triplicates. The main plots consisted of four nitrogen rates (40, 80, 120 and 160 kg/ha) from urea with 46% N content. The sub-plots consisted of two cultivars of wheat (Star and Vee/Nac). The sub-plots consisted of four paclobutrazol concentrations (0, 50, 100 and 150 mg/l) which were foliar sprayed at stem elongation stage. The results indicated that increase in paclobutrazol concentrations significantly affected chlorophyll a, chlorophyll b and total chlorophyll (a+b); whereas no significant difference between paclobutrazol concentrations was detected for carotenoids content. Increasing of nitrogen rate application caused significantly increase in chlorophyll a, chlorophyll b, total chlorophyll and carotenoids content. Paclobutrazol and nitrogen application with increasing, total chlorophyll and carotenoids content increased. The maximum rate of these photosynthetic pigments were obtained from 150 mg/l paclobutrazol and 160 kg/ha nitrogen. Soluble proteins content increased with higher rates of the paclobutrazol and nitrogen application. Comparison of two wheat cultivars showed that star cultivar had more chlorophylls, carotenoids and soluble proteins content under paclobutrazol and nitrogen application than other cultivar. There was the highest positive correlation between chlorophyll a and soluble proteins content (r = 0.86). Besides, there was the lowest positive correlation between total chlorophyll (a+b) and carotenoids content (r = 0.69). It seems that the application of paclobutrazol led to absorption and transportation of nitrogen in plant has increased. Therefore, wheat produced significant amount of photosynthetic pigments and soluble proteins content in star cultivar.

Key words: Wheat • Paclobutrazol • Nitrogen • Photosynthetic pigments • Soluble proteins

INTRODUCTION

Wheat production can be optimized by the use of agronomical inputs such as chemical and organic fertilizers, adequate irrigation, controlling limiting factors such as weeds, insects, diseases and appropriate management practices [1]. Nowadays, phytohormones have been found to play an important role in plants growth and development. Plant growth regulators have plentiful applications in agriculture such as delaying or accelerating maturity, stimulation flowering, abscission controlling weeds and etc [2]. Triazole compounds are the chemicals belongs to a class of compounds known as ergosterol biosynthesis inhibitors and are used as fungicides as well as plant growth regulators (PGR) [3]. Triazoles have been called plant multiprotectants, because
of their ability to induce tolerance in plants to environmental and chemical stresses [4]. The inhibition of gibberellins biosynthesis is the main reason behind the PGR properties of triazoles. Protection of plants from apparently unrelated stress by triazole is also mediated by a reduction in free radical damage and increase in the antioxidant potential. Triazole has an efficient free radical scavenging system that enables them to detoxify active oxygen [4-6]. The most important effect of triazole on plants is a reduction in height. Paclobutrazol [(2RS, 3RS)-1-(4-chlorophenyl)-4,4- dimethyl-2-(1,2,4- triazol)-pentan-3-ol] is a triazole plant growth regulator that consists of two enantiomers, namely 2R, 3R and 2S, 3S forms [7]. Triazoles interfere with three steps of the ent-kaurene oxidation pathway and inhibit the formation of Ent-kaurenol, ent-kaurenal and ent-kaurenoic acids [8]. These microsomal oxidation reactions are catalyzed by kaurene oxidase and interfere with different isoforms of this enzyme which lead to inhibition of gibberellic acid (GA) biosynthesis and abscisic acid (ABA) catabolism [9]. Thus, paclobutrazol blocks the biosynthesis of active gibberellic acid (GA). Therefore, paclobutrazol decreases plant growth and development [10]. Some researchers indicated that paclobutrazol has a biochemical effect on plant, such as increase in levels of proline [11], antioxidants [12] and chlorophyll content [13]. It was hypothesized that paclobutrazol treated plants had a better quality of growth under salt stress than non-treated plants due to slower growth rate of the former [14].

Nitrogen (N) is also the most limiting nutrient for crop yield in many regions of the world [15]. The N fertilizer is one of the main inputs for cereals production systems. Over the past four decades, worldwide increase of agricultural food production has been associated with increase in the use of the N fertilizers. Therefore, the challenge for the next decades will be to accommodate the needs of the expanding world population by developing a highly productive agriculture, whilst at the same time preserving the quality of the environment [16]. The application of nitrogen fertilizer increase cereal growth and yield [17]. Losses of the N fertilizer have been attributed to the combined effects of denitrification, volatilization and leaching [18]. Reduction of applied N fertilizer rate to an optimized level can reduce soil nitrate leaching. Nitrogen fertilizers have been largely used to increase grain yield and grain protein content in bread wheat [19]. However, several plant growth regulators have been examined for their reduced shoot elongation and potential to control abiotic stresses [9, 20]. But there is limited information available on influence of these compounds on physiological and biochemical processes in wheat.

The objectives of present study was to investigate the effects of paclobutrazol and nitrogen on photosynthetic pigments and soluble proteins content of two wheat cultivars (Triticum aestivum L.).

MATERIALS AND METHODS

Field experiments were conducted in Dezful region of Iran (Lat. 32°16 N., Long. 45°25 E., Alt. 143 m) during years 2009-10 and 2010-11. The climate of region was semi arid and warm with annual mean precipitation of 386 mm, mean temperature 23.8°C. Soil analysis (0-60 cm) indicated that soil texture was clay-loam, pH 7.6 and EC 1.30 ds/m. Other soil testing parameters includes N, P and exchangeable K were 5.1, 6.4 and 182 ppm, respectively. The experiment was carried out as a split plot design using randomized complete block design in triplicates. The main plots consisted of four nitrogen rates (40, 80, 120 and 160 kg/ha) from urea with 46% N content were applied twice (Split application), one half broadcasted prior to planting in each plot and another guess as top dressing in stem elongation stage. The sub-plots including two cultivars of wheat (Star and Vee/Nac). The sub-plots consisted of four paclobutrazol concentrations (0, 50, 100 and 150 mg/l) which were foliar sprayed at stem elongation stage. Fertilizers were applied to the field according to the soil analysis. Based on results of soil analysis and recommendations of soil and water research center, 70 kg P/ha (P2O5) from triple super phosphate and 150 kg K/ha (K2O) from potassium sulfate were added to the soil. Each plot consisted of six 7 m rows length, with 20 cm distance and seed density was 400 seed per m². The weeds were controlled by hand, because there could be interactions between paclobutrazol and herbicides. Soluble proteins content in flag leaf (anthesis stage) measured according to Bradford analysis performed [21, 22]. The photosynthetic pigments (chlorophyll a, chlorophyll b, total chlorophyll (a+b) and carotenoids content in flag leaf (anthesis stage) were determined by Arnon method and calculated according to the Ashraf et al. formula [23]. Leaf area, total dry matter, yield and yield components, including fertile tiller number, spike number in plant, grain numbers in plant and grain weight were measured. The statistical analyses were conducted using SAS software and differences between means were determined based on Duncans multiple range test at p<0.05 [24].
RESULTS AND DISCUSSION

The effect of year and its interaction on all treatments were insignificant. The different nitrogen rates on chlorophyll a, chlorophyll b and total chlorophyll (a+b) content significantly increased (Table 1). Comparison made on different levels of nitrogen on chlorophyll a, b and total chlorophyll content. Nitrogen treatment with 160 kg N/ha as the highest, resulted 2.744 mg/g chlorophyll a, 1.431 mg/g of chlorophyll b and 4.174 mg/g total chlorophyll and treatment 40 kg N/ha was the lowest level of nitrogen used (Table 1). Given the amount of chlorophyll in plants is an important factor in maintaining the photosynthetic capacity, so to maintain optimum levels of this pigment to produce high yield is important [22]. The carotenoids were also affected by increasing nitrogen levels. Thus, comparison of maximum and minimum nitrogen levels showed that the maximum amount of carotenoids at high levels of nitrogen was 19.417 µg/g (Table 1). At high content of carotenoids prevent the chlorophyll degradationphoto-oxidative has increased their stability; as carotenoids are important in plant photo-oxidation. Besides the difference of cultivars in chlorophyll a and total chlorophyll content which was significant, but in terms of chlorophyll b and carotenoids content did not differ (Table 1).

The effect paclobutrazol concentrations as growth regulator on chlorophyll a, total chlorophyll and carotenoids contents were evaluated; however paclobutrazol did not have any significant impact on the amount of chlorophyll b (Table 1). Increased chlorophyll content in plants treated with paclobutrazol may minimize the damage caused by reactive oxygen and changes in the levels of carotenoids, ascorbate and the ascorbate peroxidase [10]. Changes in chlorophyll a, b, total chlorophyll and carotenoids content were certainly affected by different levels of nitrogen and paclobutrazol. The highest amounts with 160 kg N/ha and paclobutrazol concentration of 150 mg/l was obtained. Figs. 1-4 illustrate the interactions and effect of paclobutrazol and nitrogen levels on chlorophyll a, b, total chlorophyll (a+b) and carotenoids contents. The simultaneous application of nitrogen and paclobutrazol content more chlorophyll a, b, total chlorophyll and carotenoids were produced in a Star cultivar. The application of growth retardants, not only reduces plant size, but also allows better nutrient utilization by the plant in response to physiological changes [25].

Effect of nitrogen on soluble protein was significant (Table 1). Comparison of different nitrogen levels on the amount of soluble proteins showed that plants treated with 160 kg/ha nitrogen on average 11.258 mg/g had distinct advantages over the plant with other nitrogen levels (Table 1). Nielsen and Halvorson [26] and Riedell et al. [19] findings were consistent with the results of present study. The differences of cultivars in soluble proteins content was significant (Table 1). Star cultivar with total protein solution heated to 10.664 mg/g demonstrated superior Vee/Nac cultivar (Table 1). Paclobutrazol different concentrations on soluble protein content was influenced. The lowest amount of proteins content in level of 0 mg/l paclobutrazol and the highest at 150 mg/l paclobutrazol were obtained (Table 1). Correlation between chlorophyll a, b, total chlorophyll, carotenoids and soluble proteins content were positively significant (p < 0.01 ). The highest positively correlation between chlorophyll a and soluble proteins content, while the lowest positively correlation was between chlorophyll b and carotenoids content (Table 2). Close relation between chlorophyll a and b and nitrogen content has been proved by many investigators [19, 22, 25, 27]. It is understandable, because of the nitrogen is a structural

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Chl. a (mg.g⁻¹)</th>
<th>Chl. b (mg.g⁻¹)</th>
<th>Chl. (a+b) (mg.g⁻¹)</th>
<th>Carotenoids (µg.g⁻¹)</th>
<th>Soluble P. (mg.g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td></td>
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</tr>
<tr>
<td>40 kg N.ha⁻¹</td>
<td>2.001 b</td>
<td>0.877 b</td>
<td>2.879 c</td>
<td>14.858 b</td>
<td>7.686 b</td>
</tr>
<tr>
<td>80 kg N.ha⁻¹</td>
<td>2.289 b</td>
<td>1.118 a</td>
<td>3.407 b</td>
<td>18.125 a</td>
<td>9.321ab</td>
</tr>
<tr>
<td>120 kg N.ha⁻¹</td>
<td>2.402 a</td>
<td>1.287 a</td>
<td>3.688 ab</td>
<td>18.975 a</td>
<td>10.583 a</td>
</tr>
<tr>
<td>160 kg N.ha⁻¹</td>
<td>2.744 a</td>
<td>1.431 a</td>
<td>4.174 a</td>
<td>19.417 a</td>
<td>11.258 a</td>
</tr>
<tr>
<td>Cultivar Star Vee/Nac</td>
<td>2.732 a</td>
<td>1.291 a</td>
<td>4.025 a</td>
<td>18.719 a</td>
<td>10.664 a</td>
</tr>
<tr>
<td></td>
<td>2.058 b</td>
<td>1.165 a</td>
<td>3.223 b</td>
<td>18.015 a</td>
<td>8.660 b</td>
</tr>
<tr>
<td>Paclobutrazol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 mg.l⁻¹</td>
<td>1.502 b</td>
<td>0.701 a</td>
<td>2.204 b</td>
<td>11.918 b</td>
<td>5.283 b</td>
</tr>
<tr>
<td>50 mg.l⁻¹</td>
<td>1.740 a</td>
<td>0.856 a</td>
<td>2.597 ab</td>
<td>13.050 b</td>
<td>7.582 a</td>
</tr>
<tr>
<td>100 mg.l⁻¹</td>
<td>1.923 a</td>
<td>0.944 a</td>
<td>2.870 a</td>
<td>14.433 a</td>
<td>8.214 a</td>
</tr>
<tr>
<td>150 mg.l⁻¹</td>
<td>2.109 a</td>
<td>0.958 a</td>
<td>3.065 a</td>
<td>15.683 a</td>
<td>8.969 a</td>
</tr>
</tbody>
</table>

Means in each column followed by similar letter(s) are not significantly different (Duncan test, P < 0.05)
**Table 2: Correlation coefficient between the Chlorophyll a, Chlorophyll b, Total Chlorophyll (a+b), Carotenoids and Soluble Proteins content.**

<table>
<thead>
<tr>
<th>Traits</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorophyll a (1)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Chlorophyll b (2)</td>
<td>0.81”1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Chlorophyll (a+b) (3)</td>
<td>0.85”0.76</td>
<td>1</td>
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<td></td>
<td></td>
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<tr>
<td>Carotenoids (4)</td>
<td>0.72”0.81”0.69</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Soluble Proteins (5)</td>
<td>0.86”0.84”0.75”0.82”1</td>
<td></td>
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</tbody>
</table>

* Significant at 0.05 probability level. ** Significant at 0.01 probability level.

**Fig. 1:** Interaction effect of paclobutrazol and nitrogen levels on chlorophyll a content

**Fig. 2:** Interaction effect of paclobutrazol and nitrogen levels on chlorophyll b content

**Fig. 3:** Interaction effect of paclobutrazol and nitrogen levels on chlorophyll (a+b) content

**Fig. 4:** Interaction effect of paclobutrazol and nitrogen levels on carotenoids content

**Fig. 5:** Interaction effect of paclobutrazol and nitrogen levels on soluble proteins content

Although plant growth regulators initially served to reduce lodging in cereals [16], but in this study found that they could cause the changes of photosynthetic pigments and soluble proteins content in wheat cultivars. Results showed an increase in the amount of chlorophyll a, chlorophyll b, total chlorophyll (a+b), carotenoids and soluble proteins content which was due to paclobutrazol and nitrogen application. Since the amount of photosynthetic pigments in plants is one of the most important factors in maintaining of photosynthetic capacity and also there is a positive correlation between their photosynthetic pigments and yield [30]. On the other hand, the amount of photosynthetic pigments and the availability of soil nitrogen to plants are related [16]. It seems that paclobutrazol is effectively used as a management strategy to increase nitrogen uptake efficiency. In order to increase in photosynthetic pigments and soluble proteins content to improve yield paclobutrazol is used.

The interaction of paclobutrazol and nitrogen levels on soluble proteins content are shown in Fig. 5. In this study, combined treatments (Nitrogen × Cultivar and Cultivar × Paclobutrazol) significantly increased soluble proteins, So that Star cultivar was relatively superior to Vee/Nac cultivar.

**CONCLUSION**

It was concluded that an increase in the amount of chlorophyll a, chlorophyll b, total chlorophyll (a+b), carotenoids and soluble proteins content was directly related to concentration of paclobutrazol and nitrogen level in the soil. In addition the amount of photosynthetic element of chlorophyll and protein molecules and it affects the formation of chloroplasts and accumulation of chlorophyll [28, 29]. The most soluble proteins content interact treatments of 160 kg N/ha and 150 mg/l paclobutrazol and the lowest soluble protein was obtained.
pigments in plants act an important factor in maintaining of photosynthetic activities. There is a positive correlation between their photosynthetic pigments and the yield of plant. The amount of photosynthetic pigments is related to the rate of nitrogen uptake by plants. Effective concentration of paclobutrazol may assist on management of nitrogen uptake rate.

REFERENCES


