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# Influence of Prohexadione-calcium on Photosynthetic and yield parameters in basmati rice (*Oryza sativa* L).

**Mamta Pal and Norah Johal**

**Abstract**
Basmati rice cultivars grow taller due to longer internodes but possess shallow rooting system and are thus prone to lodging during panicle development that may reduce yield and efficiency of mechanical harvesting. The main objective of the study was to make use of Prohexadione-calcium (Pro-Ca) to reduce internode elongation to avoid lodging without negatively affecting its yield potential. A field experiment was conducted on three cultivars of basmati rice (Punjab Basmati 2, Punjab Basmati 3 and Pusa Basmati 1121) with treatment allotted in split plot design and foliar application of Pro-Ca @5,10 and 20mg/l were sprayed at vegetative and anthesis stage. Yield contributing parameters (grain yield and plant height) were recorded at maturity. Pro-Ca had promoted the formation of total chlorophyll and carotenoid content in leaves at vegetative and anthesis stages. Plant height significantly decreased in Pro-Ca treated plants and subsequently decreased with increase in the concentration. Pro-Ca treated sets had significant increase in number of spikes/plant and grain/$m^2$. Pro-Ca (20ppm) hindered gibberellins formation reducing plant height in selected basmati rice cultivars, though had positive effect on photosynthetic rate and yield.

**Keywords:** Prohexadione-calcium, photosynthetic parameters, yield attributes

## Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crop of the world in terms of food, area and production. After wheat, rice (*Oryza sativa* L.) is the second most produced crop worldwide (FAO 2015) [3]. It is the most important staple food in Asia, providing average 32% of total calorie uptake. The majority of the rice (90%) is being produced and consumed in Asian countries and trends of global rice production have been steadily increasing over last decade (FAO 2014) [2] from about 360.2 million tons in 1960s-80s to about 491.6 million tons in 2015-2016. India is the world's second biggest rice producer with its annual production 159.3 million tons of rice (FAO 2014) [2] with productivity of about 3.6 tons/ha. India contributes 32% in world rice production (Anonymous 2011) [1]. To meet the increased demand for food grain of rapidly growing population, there are main yield boosting agronomic techniques like application of certain plant growth regulators which needs due attention. Although plant growth regulators have been used in agriculture for as long as crop cultivation, but their application is limited to some specific objectives like quality and quantity improvement. Plant growth regulators are synthesized indigenously by plants, however, plants can respond to exogenous hormonal pattern of the plant, either by supplementation of sub-optimal levels or by interaction with their synthesis, translation or inactivation of existing hormone levels.

Natural or synthetic compounds that are applied to plants to change its life processes and structure for the purpose of increasing yield, improving quality and facilitate harvesting are called plant growth regulators or plant hormones. Plant growth regulators play important role in amelioration of various abiotic stresses in cereals including rice (Gurmani *et al* 2013) [6]. Prohexadione-calcium regulates the later stages of gibberellins (GAs) biosynthesis by interfering with 3-hydroxylation (Kim *et al* 2007) [4]. The net effect is reduction of immobile, biologically active $GA_1$ and an increase in the levels of mobile but inactive $GA_{20}$, as it blocks the conversion of inactive $GA_{20}$ to active $GA_1$. It is well established that due to its short-term effect and persistency, Prohexadione-calcium is a conciliatory PGR for vegetative growth management that can be applied at a variety of timings and used to develop user-specific growth management strategies (Kim *et al* 2010) [5]. The present study was conducted to asses the effect of Pro-Ca on the internodal length and final yield parameters against various concentration levels.

**Materials and Methods**

The field experiment was conducted in the experimental area of Department of Botany, Punjab Agricultural University, Ludhiana during *kharif* season of 2015-2016. Sowing of cultivars PB-2, PB-3, PUSA-1121 of rice was done and the crop was raised and treatments were allotted in split plot design prior to germination, the soil is uniformly levelled to ensure even distribution of water. All the required field management practices were followed according to the specifications laid out in the 'package practices' for *kharif* crop 2015-2016 a handbook of Punjab Agricultural University, Ludhiana. Recommended dose of fertilizers was applied at the time of sowing. The seedlings were directly transplanted in water fed field. The weeds were removed from time to time manually to keep the crop free from weeds throughout the growth period. The observations for the morpho-physiological and biochemical parameters were recorded at vegetative and anthesis stage. Estimation of chlorophyll and carotenoids were extracted from the leaves of rice by placing 100 mg of fresh tissue used for dipping in 5 ml of the dimethylsulfoxide (DMSO) for 12 h in the dark. The concentrations of the extracted pigments were calculated from the absorbance values at 665, 645 and 480 nm. Chlorophyll and carotenoids estimated by method as given by Hiscox and Isrealstam (1979) [7].

$$\text{Chl a} = 12.19\ (\text{OD } 665) - 3.45\ (\text{OD } 645) \times \frac{V}{1000 \times W}$$

$$\text{Chl a} = 21.99\ (\text{OD } 645) - 5.32\ (\text{OD } 665) \times \frac{V}{1000 \times W}$$

$$\text{Total Chl} = 20.2\ (\text{OD } 645) - 8.02\ (\text{OD } 665) \times \frac{V}{1000 \times W}$$

$$\text{Carotenoids} = (\text{OD } 480) + 0.114\ (\text{OD } 665) - 0.638\ (\text{OD } 645)$$

$OD_{663}$ = OD at 663 nm, $OD_{645}$ = OD at 645 nm, $OD_{480}$ = OD at 480 nm and V = Total volume of solution made (ml).

The chlorophyll content was expressed as $mg^{-1}$ chl g fresh weight. Plant height was recorded at maturity along with Grain Yield/$m^2$. The grains were separated by threshing from each split plot and were dried under sun for three days. Later winnowed and cleaned and then weight of the grains was recorded by using weighing balance.

**Statistical analysis**

Mean values for each parameters were calculated from three replications per treatment for each cultivar. Post hoc tests under SPSS was used to analyze the differences within the mean values between treatments and cultivars.

**Results and discussion**

Analysis of variance showed that Prohexadione-calcium significantly ($P$<0.05) increased carotenoid content of all selected cultivars both at vegetative and anthesis stage (Table-1). Carotenoid content increased with increase in the concentration of prohexadione calcium. Maximum increase was recorded at the highest concentration. At highest concentration carotenoid content increased by 7.77%, 5.95% and 5.22% in Punjab basmati 2, Punjab Basmati 3 and Pusa Basmati 1121 respectively at vegetative stage. At anthesis stage carotenoid content increased by 3.40%, 3.67% and 3.61% Punjab basmati 2, Punjab Basmati 3 and Pusa Basmati 1121 respectively. Prohexadione-calcium significantly ($P$<0.05) increased total chlorophyll of all selected cultivars both at vegetative and anthesis stage (Table-2). Total chlorophyll increased with increase in the concentration of prohexadione calcium. Maximum increase was recorded at the highest concentration. At highest concentration total chlorophyll increased by 9.64%, 9.97% and 9.68% in Punjab basmati 2, Punjab Basmati 3 and Pusa Basmati 1121 respectively at vegetative stage. At anthesis stage total chlorophyll increased by 5.96%, 5.71% and 6.77% Punjab basmati 2, Punjab Basmati 3 and Pusa Basmati 1121 respectively. Grain yield was significantly ($P$<0.05) increased with the application of Prohexadione-calcium (Table-3). Post-hoc comparison showed that there was significant ($P$<0.05) difference in the different treatments of Prohexadione-calcium. Highest concentration caused 6.62%, 8.69% and 7.50% significant ($P$<0.05) increase in grain yield. These results are in agreement with Kim *et al* (2007) [4] observed that prohexadione-calcium significantly increased the milled rice yield both at 10ppm and 20ppm concentration, but more increase was observed in 20ppm concentration. It is observed that increase in the yield of prohexadione treated plant is due to the increased photosynthetic pigments such as total chlorophyll and carotenoids which leads to the increased photosynthetic activity in those plants and it was also recorded that prohexadione treated plants had shorter internodes as compared control. This is mainly due to inhibition production of GA1 by prohexadione-Ca. GA1 mainly controls the internodal growth in rice plants. due reduction internodal length the heights of plants reduced and this is more important to prevent the lodging which is one of the fundamental reason for the yield loss. Plant heights were decreased with increase in the concentration of Pro-calcium and maximum increase was observed at the highest concentration by 8.83% in Punjab Basmati 2 (Table-4). This result is consistent with that of previous investigation of Prohexadione-calcium effectively decreased the plant height of wet seeded rice and increased the lodging resistance Wahyuni *et al* (2002) [8]. Observation was made by Kim *et al* (2007) [4] the stem length was found to be significantly reduced by application of Prohexadione-calcium. The higher concentration (20ppm) was more effective in reducing plant height than that of lower concentration (10ppm).

**Table 1:** Effect of the kinetin (Kn) and prohexadione-calcium (BX-112) on Carotenoid content (mg gm$^{-1}$ fresh weight) in rice cultivars.

| Treatment / Cultivar | Carotenoid content (mg gm$^{-1}$ fresh weight) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Vegetative stage | | | | Anthesis stage | | | |
| | Punjab Basmati 2 | Punjab Basmati 3 | Pusa Basmati 1121 | Treatment | Punjab Basmati 2 | Punjab Basmati 3 | Pusa Basmati 1121 | Treatment |
| T1-Control | 0.296 | 0.336 | 0.421 | 0.351$^{d}$ | 0.528 | 0.491 | 0.644 | 0.554$^{d}$ |
| T2-BX-112 (5mg/l) | 0.301 (1.69%↑) | 0.341 (1.49%↑) | 0.429 (1.90%↑) | 0.357$^{c}$ | 0.532 (0.76%↑) | 4.99 (1.63%↑) | 0.675 (1.66%↑) | 0.587$^{c}$ |
| T3-BX-112 (10mg/l) | 0.310 (4.73%↑) | 0.348 (3.57%↑) | 0.438 (4.03%↑) | 0.365$^{b}$ | 0.540 (2.27%↑) | 0.503 (2.44%↑) | 0.683 (2.86%↑) | 0.575$^{b}$ |
| T4-BX-112 (20mg/l) | 0.319 (7.77%↑) | 0.356 (5.95%↑) | 0.443 (5.22%↑) | 0.373$^{a}$ | 0.546 (3.40%↑) | 0.509 (3.67%↑) | 0.688 (3.61%↑) | 0.581$^{a}$ |
| Cultivar | 0.306$^{c}$ | 0.345$^{b}$ | 0.433$^{a}$ | | 0.536$^{b}$ | 0.500$^{c}$ | 0.672$^{a}$ | |

**Table 2:** Effect of the kinetin (Kn) and prohexadione-calcium (BX-112) on total chlorophyll (mg gm$^{-1}$ fresh weight) in rice cultivars.

| Treatment / Cultivar | Total chlorophyll (mg gm$^{-1}$ fresh weight) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Vegetative stage | | | | Anthesis stage | | | |
| | Punjab Basmati 2 | Punjab Basmati 3 | Pusa Basmati 1121 | Treatment | Punjab Basmati 2 | Punjab Basmati 3 | Pusa Basmati 1121 | Treatment |
| T1-Control | 5.08 | 4.41 | 5.68 | 5.05$^{d}$ | 6.20 | 5.95 | 7.08 | 6.41$^{c}$ |
| T2-BX-112 (5mg/l) | 5.20 (2.36%↑) | 4.52 (2.49%↑) | 5.81 (2.28%↑) | 5.17$^{c}$ | 6.26 (0.97%↑) | 5.99 (0.67%↑) | 7.12 (0.56%↑) | 6.45$^{c}$ |
| T3-BX-112 (10mg/l) | 5.39 (6.10%↑) | 4.63 (4.99%↑) | 5.87 (3.34%↑) | 5.29$^{b}$ | 6.32 (1.93%↑) | 6.02 (1.17%↑) | 7.26 (2.54%↑) | 6.53$^{b}$ |
| T4-BX-112 (20mg/l) | 5.57 (9.64%↑) | 4.85 (9.97%↑) | 6.23 (9.68%↑) | 5.55$^{a}$ | 6.57 (5.96%↑) | 6.29 (5.71%↑) | 7.56 (6.77%↑) | 6.81$^{a}$ |
| Cultivar | 5.31$^{b}$ | 4.60$^{c}$ | 5.89$^{a}$ | | 6.34$^{b}$ | 6.06$^{c}$ | 7.25$^{a}$ | |

**Table 3:** Effect of the kinetin (Kn) and prohexadione-calcium (BX-112) on grain yield/ m$^{2}$ at maturity in rice cultivars.

| Treatment / Cultivar | Grain yield (gm) | | | Treatment |
|---|---|---|---|---|
| | Punjab Basmati 2 | Punjab Basmati 3 | Pusa Basmati 1121 | |
| T1-Control | 324.6 | 383.4 | 339.8 | 349.2$^{d}$ |
| T2-BX-112 (5mg/l) | 333.3 (2.68%↑) | 390.0 (1.75%↑) | 355.2 (4.53%↑) | 359.5$^{c}$ |
| T3-BX-112 (10mg/l) | 338.8 (4.19%↑) | 398.3 (3.91%↑) | 360.9 (6.20%↑) | 366.0$^{b}$ |
| T4-BX-112 (20mg/l) | 346.1 (6.62%↑) | 416.6 (8.69%↑) | 365.3 (7.50%↑) | 376.0$^{a}$ |
| Cultivar | 335.7$^{c}$ | 397.7$^{a}$ | 355.3$^{b}$ | |

**Table 4:** Effect of the kinetin (Kn) and prohexadione-calcium (BX-112) on plant height at maturity in rice cultivars.

| Treatment / Cultivar | Plant height (cm) | | | Treatment |
|---|---|---|---|---|
| | Punjab Basmati 2 | Punjab Basmati 3 | Pusa Basmati 1121 | |
| T1-Control | 126.8 | 103.8 | 122.6 | 117.8$^{a}$ |
| T2-BX-112 (5mg/l) | 125.6 (0.94%↓) | 102.6 (1.16%↓) | 118.1 (3.67%↓) | 115.4$^{a}$ |
| T3-BX-112 (10mg/l) | 120.8 (4.73%↓) | 100.6 (3.08%↓) | 114.6 (6.52%↓) | 112.0$^{b}$ |
| T4-BX-112 (20mg/l) | 115.6 (8.83%↓) | 97.7 (5.88%↓) | 112.8 (8.69%↓) | 108.6$^{c}$ |
| Cultivar | 122.1$^{a}$ | 117.0$^{b}$ | 101.1$^{c}$ | |

## Conclusion

Prohexadione-calcium, PGR for vegetative growth management was applied at vegetative and anthesis stage to reduce internodal length in Basmati cultivars (Kim *et al* 2010) [5]. The higher concentration (20ppm) was more effective in reducing plant height and increasing yield due to the increased photosynthetic pigments such as total chlorophyll and carotenoids leading to an increased overall photosynthetic activity by inhibiting production of GA1 by prohexadione-Ca.

## References


1. Anonymous Govt. mulls permitting wheat export, 2011. http://www.financialexpress.com
2. FAO Crop Prospects and Food Situation, 2014. http://www.fao.org/3/a-14256E.pdf
3. FAO World food situation: Cereal Supply and Demand Brief http://www.fao.org/worldfoodsituation/csdb/en/ 2015.
4. Kim HY, Lee IJ, Humanyun M, Kim JT, Won JG, Hwang IC *et al*. Effect of prohexadione calcium on growth components and endogenous gibberellins content of rice (*Oryza sativa* L.). J Agron Crop Sci. 2007; 193:445-451.
5. Kim YH, Khan AL, Hamayun M, Kim JT, Lee JH, Hwang IC *et al*. J Effects of Prohexadione Calcium on growth and gibberellins contents of *Chrysanthemum morifolium* R. cv Monalisa White. Sci Hortic. 2010; 123:423-427.
6. Gurmani AR, Bano A, Najeeb U, Zhang S, Khan SU. Flowers. Exogenously applied silicates and abscisic acid ameliorates the growth of salinity stressed wheat (*Triticum aestivum* L.) seedlings through $Na^{+}$ exclusion. Aust J Crop Sci. 2013; 7:1123-30.
7. Hiscox JD, Israelstam GF. A method for the extraction of chlorophyll from the leaf tissue without maceration. Can J Bot. 1979; 57:1332-34.
8. Wahyumi S, Sinniah UR, Yusop MK. Amarthalingam. Effect of paclobutrazol and Prohexadione-calcium on growth, lodging resistance and yield of wet seeded rice. J Agron Crop Sci. 2002; 8:23-28.