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Influence of Natural and Synthetic Cytokinin on Physiological and Yield Contributing Parameters of Wheat (*Triticum aestivum* L.)

Botany

KEYWORDS : Kn, BAP, Wheat, Tillering

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ABSTRACT

A field experiment was conducted at the experimental area of Department of Botany, Punjab Agriculture University, Ludhiana during rabi seasons of 2014 and 2015 on two wheat (Triticum aestivum L.) cultivars (PBW 621 and HD 2967) in a randomized block design with three replications. Foliar application of Benzylaminopurine (BAP) and Kinetin (Kn) @ 10µg/ml and 20µg/ml was given separately at maximum tillering and boot leaf stages. BAP and Kn application increased the net photosynthetic rate in flag leaves of selected cultivars when applied at both stages but increase was more when given at maximum tillering stage. In control, photosynthetic rate was recorded more in HD 2967 as compared with PBW 621. Application at boot leaf stage did not promote photosynthetic parameter further. Grain weight per spike increased with Kn application and maximum value was recorded when applied with Kn at 10µg/ml. Grain weight per plant increased significantly with the individual application of BAP and Kn, the effect was more pronounced when given at tillering stage. Biological yield per meter square increased with the lower concentration of BAP application in both the cultivars and with increase in concentration of BAP no further increase in biological yield was observed. Kn application at 10µg/ml improved the yield more as compared with BAP. Thus it can be concluded that application of lower concentration (10µg/ml) of both BAP and Kn at maximum tillering stage improved biological yield in selected wheat cultivars and Kn was more effective.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most widely cultivated cereal in the world and has a prominent position in the international food grain trade. It is the second most important grain crop in india next to rice and was grown on an area of 31.19 million hectares with a production of 95.85 million tones during 2013-14 (Anonymous 2014). The important part of crop productivity is to manage balance between vegetative and reproductive growth. Plant growth regulators (PGRs) helps in managing this balance. Plant growth regulators at low concentration control various stages of plant growth and development (Shakirova *et al* 2012). Cytokinin helps in the regulation of cell division and storage of photosynthetic material (Poodineh and Shahraki 2015). An adequate CK supply is essential for normal plant development (Takei *et al* 2002). These are important group of plant bioregulators which play important role in greater partitioning of photosynthates towards reproductive sink thereby improving the harvest index (Sharma *et al* 2008). Cytokinin hormone (CK) has a direct influence on the growth process and wheat growing period becomes longer, because of that, or so as premature aging is delayed, and long-term growth period is created for the plants (Poodineh *et al* 2014). A high concentration of CK in the plant increases wheat grain significantly (Saeidi *et al* 2006). Cytokinin, delaying the aging of the tissues will yield increased photosynthetic capacity of the reservoir. Exogenous application of cytokinins results in delay in senescence, maintenance of chloroplast activity, decline chlorophyll degradation, production of proteins, nucleic acid synthesis and mobilization of nutrients into cytokinin treated area (Wingler *et al* 1998). A synthetic cytokinin, Benzylaminopurine (BAP) has been reported to have a positive effect on some growth factors as stimulating leaf growth (Ron'zhina 2003) and increasing net photosynthetic rates. BAP protects the cell membranes and the photosynthetic machinery from oxidative damage during delay of senescence in the dark. BAP stimulated chloroplast differentiation. Inclusion of BAP induced the formation of greater numbers of chloroplasts in the leaves, while plants cultivated in the presence of BAP demonstrated greater chlorophyll a and carotenoid content.

Kinetin (6-furfurylaminopurine), a plant hormone has the ability to stimulate cell division. Seedlings raised from seeds applied with kinetin exhibited characteristic morphological responses at only particular concentrations of the plant growth regulators. The physiological traits such as dry weight per plant, net photosynthetic rate, stomatal conductance and leaf chlorophyll content were significantly enhanced by Kn application (Shah 2007). The present investigation was carried out to study the effect of natural (Kn) and synthetic cytokinin (BAP) on various physiological and yield contributing parameters of wheat cultivars.

MATERIAL AND METHOD

Two wheat genotypes viz; PBW 621 and HD 2967 were sown in the experimental area of Department of Botany, Punjab Agricultural University, Ludhiana, during rabi season of 2014 and 2015. The experiment was plotted in Randomised Block Design with three replications. Foliar spray of Benzylaminopurine (BAP) and Kinetin (Kn) @ 10 µg/ml and 20 µg/ml respectively was given at maximum tillering stage and at booting stage. The observations for the following physiological parameters were recorded at anthesis stage. The yield contributing parameters were recorded at maturity.

Net photosynthetic rate

The net photosynthetic rate was recorded in each genotype for all treatments during the anthesis period. The flag leaves from five replicates of each condition (i.e. five plants per genotype) were sampled and photosynthetic rate was assessed using a portable photosynthesis system with a 6cm^2 clamp on leaf cuvette (LI-6400, LICOR Inc., Lincoln, NE, USA). Photosynthetic photon flux density (PPFD) was fixed at 800 µmol m^{-2} s^{-1} using a red blue LED light source built in the leaf cuvette though other environmental factors such as air, humidity, temperature were not controlled, that is natural variation was permitted.

Grain weight per spike

Five plants were taken randomly from each replication and grain weight per spike of each plant was measured in grams (gms) with the help of weighing balance and their average was recorded.

Grain weight per plant

Five plants were taken randomly from each replication and grain weight plant was measured in grams (gms) with the

help of weighing balance and their average was recorded.

Biological yield (g)/m^2

The above ground crop biomass harvested at maturity in a $1m^2$ area of all subplots was weighed to obtain biological yield/m^2.

RESULTS AND DISCUSSION

Net photosynthetic rate

Results summarized in Fig 1 indicate that the treatments of BAP and Kn at two different concentrations supplied at tillering and booting stages had non significant effect on photosynthetic rate of PBW 621 and HD 2967. The significant difference was observed among the genotypes. Net photosynthetic rate in flag leaves of HD 2967 was recorded more than in PBW 621 in all the treatments including control. Application of both BAP and Kn increased the net photosynthetic rate in comparison to control. Slight increase was observed in net photosynthetic rate at lower concentration (10 μg ml^{-1}) of BAP as compared with higher concentration (20 μg ml^{-1}) though the difference was non-significant among the various treatments. Similar results were observed with kinetin. The interaction between the genotypes and treatments was significant. Application given at the tillering stage resulted in more net photosynthetic rate than at booting stage. Kn performed better than BAP.

The BAP induced increase in photosynthesis and rubisco activity had been reported in wheat (Xie *et al* 2004). Rulcova and Pospisilova (2001) reported that application of BAP stimulated net photosynthetic rate in both control or stressed and rehydrated bean plants. Foliar application of BAP had the ability to increase carbohydrate content due to good effect on photosynthesis of wheat cultivars under water deficit conditions (Sarafraz-Ardakani *et al* 2014). Cks are important in the development of plants photosynthetic apparatus by directly effecting on chloroplast, increasing the photochemical activity of photosystem II (PS II) and reducing chlorophyll degradation (Goltsev *et al* 2001). Dwivedi et al (2014) indicated that exogenous application of BAP mitigated the adverse effects of drought on photosynthesis in the wheat genotypes.

Zhenquing *et al* (2000) reported that the photosynthetic rate was increased and photosynthetic active duration (PAD) extended with 6-BA or Kn in wheat flag leaves under water stress. Kn stimulated the pigment production and photosynthetic activity which in turn increased the carbohydrate accumulation in sorghum leaves (Alsokari 2009).

Grain weight per spike

Various treatments as well as genotypes varied significantly for the parameter (Table 1). Significant increase was observed with the application of BAP as well as Kn at both tillering and booting stages as compared with control. Grain weight per spike was more in HD 2967 than in PBW 621. When application was given at tillering stage, lower concentration of Kn increased the grain weight more effectively than that of higher concentration in both the selected genotypes. The two concentrations of BAP were almost equally effective in increasing the grain weight per spike in PBW 621 and HD 2967. The performance of Kn was better than that of BAP. When application was given at booting stage, BAP at 10 μg ml^{-1} slightly increased the grain weight per spike in comparison to BAP at 20 μg ml^{-1} in both PBW 621 and HD 2967. Application of Kn at lower concentration (10 μg ml^{-1}) obtained more value as compared with Kn at higher concentration (20 μg ml^{-1}). Kn at 10 μg ml^{-1} was the most effective application. Kn was more effective than BAP. Application given at tillering stage resulted in more grain weight than the application given at booting stage.

Foliar application of Kn increased the seed weight in salinity stressed maize plants (Kaya *et al* 2009). According to Gupta *et al* (2003) exogenously applied BAP enhanced wheat grain yield under normal and late sown conditions respectively. BAP could be used to improve the sink and source capacity of wheat to increase the grain yield.

Grain weight per plant

The results of the present study indicated (Table 2) significant increase in grain weight of wheat plants with the individual application of BAP and Kn in comparison to control. Significant difference was observed among the treatments as well as genotypes. Grain weight per plant was more in HD 2967 than in PBW 621. When application was given at tillering stage, BAP at 10 μg ml^{-1} were more effective in increasing the grain weight than at 20 μg ml^{-1} in the studied genotypes. Slight increase was recorded with lower concentration (10 μg ml^{-1}) of Kn than at higher concentration (20 μg ml^{-1}). In PBW 621, lower concentrations of BAP and Kn was equally effective but higher concentration of Kn was much more effective than higher concentration of BAP whereas in HD 2967, Kn showed much significant increase than BAP at different concentrations. When application was given at booting stage, BAP at lower concentration (10 μg ml^{-1}) was more effective in increasing the grain weight than at higher concentration (20 μg ml^{-1}) in the selected genotypes. Similarly, Kn at 10 μg ml^{-1} showed more value than Kn @ 20 μg ml^{-1}. Grain weight per plant was increased upto more extent with the application of Kn than that of BAP. Application given at tillering stage gave better results than at booting stage.

Mansour *et al* (1994) found that BAP application to soybean increased the number of pods/plant and seed weight/plant. According to Rukasz and Michalek (2004) foliar application of Kn increased the total grain mass per plant in barley cultivars. The application of Kn at anthesis stage in corn increased the grain yield (Vach 1999). Kn treatments caused significant increases in seed yield/plant of faba bean cultivars (Sadak *et al* 2013). These CKs by increasing the photosynthetic rate of the flag leaf increased the grain yield (Saeidi *et al* 2006). CKs by delaying in growing and aging process or in other words increasing the plant growing period leads to increased photosynthetic capacity, a factor of weight increasing and grain yield (Poodineh *et al* 2014).

Biological yield/m^2

Foliar application of BAP and Kn supplied at both tillering and booting stages resulted in increased biological yield in comparison to control in both PBW 621 and HD 2967 (Table 3). Biological yield was recorded more with the application given at tillering stage than at booting stage. Genotypic differences were significant for the parameter. Biological yield was recorded more in HD 2967 than in PBW 621. When application was given at tillering stage, BAP at 10 μg ml^{-1} was effective in increasing the biological yield as compared with BAP at 20 μg ml^{-1} in PBW 621 and HD 2967. Kn at lower concentration (10 μg ml^{-1}) was more effective than Kn at higher concentration (20 μg ml^{-1}) in both the selected genotypes. When application was given at booting stage, more increase was recorded at the lower concentration of BAP than at higher concentrations. Similarly, Kn at 10 μg ml^{-1} was more effective than at 20 μg ml^{-1}. Kn gave better results than BAP especially when sprayed at 10 μg ml^{-1} at tillering stage.

Nagar *et al* (2015) mentioned that water deficit stress sig-

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nificantly decreased yield and total biomass while BAP-treated wheat plants retained higher biomass and yield. Application of Kn promoted the growth by enhancing cell division and consequently improved biological yield/fed of lupine plants (Amin *et al* 2014). Kn treatments caused significant increases in seed yield/plant and yield attributes (Biological yield/plant) of faba bean cultivars (Sadak *et al* 2013). Bakhsh *et al* (2011) revealed a regulatory effect of Kn on growth yield and yield components of rice. Application of Kn improves the performance of field crops by establishing a strong source sink relationship (Solaimalai *et al* 2001). Foliar application of Kn increased yield of different crops due to reduction in stress induced inhibition of plant growth (El-wana and El-Hamabmyb 2009).

Fig 1: Influence of BAP and Kn on Net photosynthetic rate in flag leaves of wheat (*Triticum aestivum* L.) genotypes.

T1-Untreated control, T2- BAP (10µg/ml) at tillering stage, T3- BAP (20µg/ml) at tillering stage, T4- Kinetin (10µg/ml) at tillering stage, T5- Kinetin (20µg/ml) at tillering stage, T6- BAP (10µg/ml) at booting stage, T7- BAP (20µg/ml) at booting stage, T8- Kinetin (10µg/ml) at booting stage, T9- Kinetin (20µg/ml) at booting stage

Table 1 : Influence of BAP and Kn on Grain weight (gm) per spike in wheat (*Triticum aestivum* L.) genotypes.

Treatments	Genotypes	
	PBW 621	HD 2967
T1-Untreated control	1.82[b]	1.84[b]
Spray time	Tillering stage	
T2-T1+ BAP (10µg/ml)	1.97[b]	1.97[b]
T3-T1+ BAP (20µg/ml)	1.95[b]	1.94[b]
T4-T1+ Kinetin (10µg/ml)	2.31[a]	2.32[a]
T5-T1+ Kinetin (20µg/ml)	2.10[b]	2.27[a]
Spray time	Booting stage	
T6-T1+ BAP (10µg/ml)	1.84[b]	1.90[b]
T7-T1+ BAP (20µg/ml)	1.82[b]	1.89[b]
T8-T1+ Kinetin (10µg/ml)	2.04[b]	2.28[a]
T9-T1+ Kinetin (20µg/ml)	1.96[b]	1.98[b]
CD at 5%	Treatments (T)= 0.172, Genotype (G)= NS, G×T= 0.243	

Table 2 : Influence of BAP and Kn on Grain weight per plant (gm) in wheat (*Triticum aestivum* L.) genotypes.

Treatments	Genotypes	
	PBW 621	HD 2967
T1-Untreated control	17.78[d]	18.77[d]
Spray time	Tillering stage	
T2-T1+ BAP (10µg/ml)	19.62[a]	20.15[b]
T3-T1+ BAP (20µg/ml)	17.78[d]	18.95[d]
T4-T1+ Kinetin (10µg/ml)	19.62[a]	20.85[a]
T5-T1+ Kinetin (20µg/ml)	19.60[a]	20.25[b]
Spray time	Booting stage	
T6-T1+ BAP (10µg/ml)	17.89[d]	18.85[d]
T7-T1+ BAP (20µg/ml)	17.78[d]	18.04[e]
T8-T1+ Kinetin (10µg/ml)	19.01[b]	19.71[c]
T9-T1+ Kinetin (20µg/ml)	18.41[c]	19.51[c]
CD at 5%	Treatments (T)= 0.421, Genotype (G)= 0.052, G×T= 0.216	

Table 3 : Influence of BAP and Kn on Biological yield/m² (Kg) of wheat (*Triticum aestivum* L.) genotypes.

Treatments	Genotypes	
	PBW 621	HD 2967
T1-Untreated control	2.125	2.175
Spray time	Tillering stage	
T2-T1+ BAP (10µg/ml)	2.190	2.263
T3-T1+ BAP (20µg/ml)	2.134	2.183
T4-T1+ Kinetin (10µg/ml)	2.225	2.288
T5-T1+ Kinetin (20µg/ml)	2.200	2.283
Spray time	Booting stage	
T6-T1+ BAP (10µg/ml)	2.133	2.193
T7-T1+ BAP (20µg/ml)	2.120	2.180
T8-T1+ Kinetin (10µg/ml)	2.200	2.233
T9-T1+ Kinetin (20µg/ml)	2.135	2.200
CD at 5%	Treatments (T)= 5.330, Genotype (G)= 2.512, G×T= 7.538	

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