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Effect of foliar application of phytohormones on barley yielding

ABSTRACT. The effect of IAA, GA_3 and kinetin applied three times per season as a foliar spray on the yield of barley (*Hordeum vulgare* L.) Cvs. Piast and Bomi was studied in a greenhouse experiment. IAA inhibited tillering and decreased the grain mass in 'Piast' and reduced the straw mass in Bomi, but increased the kernel number per plant in 'Piast' and the kernel number of the main stem ear in Bomi. GA_3 increased tillering and the straw mass in both cultivars and kinetin in Bomi cv. IAA and kinetin increased the grain mass per plant in this cultivar. GA_3 reduced the grain mass and kernel number per plant in both cultivars and decreased the harvest index but increased 1000 grain weight.

KEY WORDS: growth regulators, barley, yield

The most frequent growth regulators used in agriculture are synthetic substances such as retardants or ethephon [Ma, Smith 1992; Adamczewski, Praczyk. 1997; Rajala, Peltonen-Sainio 2001]. The natural growth regulators called phytohormones are the following growth stimulators: auxins, gibberellins and cytokinins. The advantage of the natural growth regulators over synthetic ones consists in the fact that they operate in trace quantities and are fully metabolised by plants. The response of barley plants to growth regulators depends on the genotype and the way of their application [Klusak, Zenisceva 1975; Rukasz 1996]. Some authors suggest that the application of growth regulators at anthesis in

corn can increase the grain yield [Ruckenbauer, Kirby 1973; Herzog, Geisler 1976; Włodkowski 1990; Vach 1999], because the a major portion of the carbohydrates accumulated in grain comes from photosynthesis during the post-anthesis period [Thorne 1974; Wagner 1974]. In addition, growth regulators can delay flag leaf senescence, leading to an increase in grain protein, an important factor in determining the grain yield [Mounla, Michael 1973; Johnston, Jeffcoat 1977; Caldiz et al. 1991]. The objective of the present studies was to establish the influence of IAA, GA_3 and kinetin, applied as a foliar spray three times over the season (at propagation, shooting and at heading) on the yield of barley. This work is part of a study concerning the effect of natural growth regulators applied in different ways on barley yielding.

METHODS

The experiments were conducted in pot culture, using the spring barley (*Hordeum vulgare* L.) cultivars 'Piast' and 'Bomi', in the years 1990-1992. The plants were grown in sand (10 plants per pot containing 5 kg of sand). Mineral nutrition was provided at the same rate for every pot (600 mg N, 300 mg P, 600 mg K, 200 mg Mg, 400 mg Ca and microelements). The plants were sprayed three times (at propagation, at shooting and at heading) with the following solutions: distilled water - control, Indole Acetic Acid (IAA) – 10 mg dm^{-3}, Gibberellic Acid (GA_3) – 15 mg dm^{-3} and kinetin – 10 mg dm^{-3}. There were 4 replications each year. At maturity stage barley was assessed by determination of the following crop elements: tillering, ear number, kernel number and grain mass, straw and chaff mass and total biomass. Yield values are mean based on 20 plants selected randomly in each year from each experimental series. The data concerning yield components were statistically analyzed and the significance of differences was established on the basis of Tukey's confidence intervals. From the collected data 1000 grain weight and harvest index (HI – the ratio of total grain mass to total biomass) were calculated. The results are the measurement mean covering 3 vegetative seasons (Tab. 1–5).

RESULTS

IAA inhibited tillering more in Piast, while GA_3 increased tillering in both cultivars and kinetin increased it in Bomi (Tab. 1). Johnston and Jeffcoat [1977] and Diaz-Miguel [1989] state that auxins, gibberellins and kinetin showed an inhibitory effect on tillering in cereals, and this was confirmed partly by our

results. Earlier work showed that when IAA was applied pre-sowing [Rukasz 1996] it promoted productive tillering in both cultivars, yet the grain yield increased only for Piast. However, two foliar sprays of IAA brought about an increase in productive tillering in both cultivars, leading to a greater grain yield. In these experiments IAA applied three times as a foliar spray increased the grain number per plant in Piast (Tab. 2) as well as the grain mass and the grain number of the main stem ear of Bomi (Tab. 3). However, it decreased the yield of Piast through a reduction of the grain mass, and reduced the straw mass of Bomi (Tab. 5). In both cultivars GA_3 and kinetin increased the straw mass, and in Bomi this led also to increased the total biomass. In addition, both IAA and kinetin increased the total grain mass per plant in this cultivar.

Table 1. Effect of foliar application of phytohormones on the tillering in barley

Treatment	Number of tillers per plant					
	Piast cv			Bomi cv		
	total	productive	sterile	total	productive	sterile
Control	3.9	2.3	1.5	3.1	2.0	1.1
IAA	3.4	2.2	1.2	3.1	1.8	1.3
GA_3	5.8	2.8	2.9	6.4	2.3	4.1
Kinetin	3.8	2.3	1.5	3.9	2.3	1.6
$LSD_{0.05}$ for Phytohorm.	1.2	0.5	0.9	2.2	0.4	1.0

Table 2. Effect of foliar application of phytohormones on barley kernel number

Treatment	Number per plant					
	Piast cv			Bomi cv		
	main shoot ear	lateral shoot ears	total grain number	main shoot ear	lateral shoot ears	total grain number
Control	17.3	15.6	32.8	17.3	13.3	30.6
IAA	18.5	16.6	34.5	17.5	7.3	24.7
GA_3	14.9	7.2	22.1	12.2	4.5	16.7
Kinetin	17.3	14.6	31.9	16.3	9.6	25.9
$LSD_{0.05}$ for Phytohorm.	2.9	1.4	3.1	3.3	2.6	3.9

Kinetin sprayed twice to the leaves of Piast and Bomi [Rukasz 1996], and in experiments on wheat and barley [Herzog, Geisler 1976; Vach 1999] showed a similar advantageous effect on the grain yield. Furthermore, cytokinins applied exogenously can control the process of growth and development in both, barley [Ruckenbauer, Kirby 1973] and wheat [Parkash, Joshi 1973]. GA_3 applied three-

Table 3. Effect of foliar application of phytohormones on barley grain mass

Treatment	Grain mass per plant mg					
	Piast cv			Bomi cv		
	main shoot ear	lateral shoot ears	total grain mass	main shoot ear	lateral shoot ears	total grain mass
Control	707	464	1171	568	306	874
IAA	642	379	1021	742	223	965
GA_3	662	251	913	562	163	725
Kinetin	707	433	1140	659	258	917
$LSD_{0.05}$ for Phytohorm.	16.0	24.0	30.0	43.0	34.0	47.0

Table 4. Effect of phytohormones on 1000 grain weight of barley

Treatment	1000 grain weight					
	Piast cv			Bomi cv		
	main shoot ear	lateral shoot ears	total grain mass	main shoot ear	lateral shoot ears	total grain mass
Control	40.9	29.8	35.7	32.7	23.0	28.5
IAA	34.7	23.7	29.6	42.4	31.1	39.1
GA_3	44.5	34.9	41.4	46.0	36.1	43.3
Kinetin	41.0	29.6	35.8	40.3	27.0	35.4

Table 5. Effect of foliar application of phytohormones on barley biomass

Treatment	Piast cv				Bomi cv			
	grain mg	straw and chaff mg	biomass mg	HI	grain mg	straw and chaff mg	biomass mg	HI
Control	1171	1155	2326	0.503	874	1090	1964	0.445
IAA	1021	1154	2175	0.469	965	934	1899	0.508
GA_3	913	1370	2282	0.400	725	1459	2184	0.332
Kinetin	1140	1189	2329	0.489	917	1123	2040	0.449
$LSD_{0.05}$ for Phytohorm.	29.0	33.0	41.0		42.0	30.0	62.0	

times as a foliar spray reduced the grain mass and the kernel number per plant in both cultivars but increased 1000 grain weight (Tab. 4) and decreased the harvest index (Tab. 5) despite an increase in the number of productive tillers. These relationships correspond to the results obtained by Heyland et al. [1975], Radley [1980] and Wojcieska [1992], who stated that barley, wheat and oats influenced by GA_3 showed a reduction in the kernel number. Furthermore, straw mass increased in both cultivars, connected with the effect of GA_3 on the growth of both productive and sterile tillers. Similar results were obtained when barley was sprayed twice with GA_3 [Rukasz 1996] and in the Diaz-Miguel experiment

[1989]. In this work IAA decreased the total plant biomass, in contrast to the situation when this growth regulator was sprayed twice [Rukasz 1996], when it brought about an increase of barley yield. The dose of IAA applied appeared to be too high and so it inhibited growth. However, kinetin and GA_3 administered at a higher dose (three-times spray) increased the yield particularly in 'Bomi'. These results indicate differences between barley cultivars as conditioned by their particular content of endogenous hormones. Growth regulators applied exogenously can influence the level of plant hormones [Herzog, Geisler 1976; Johnston, Jeffcoat 1977; Saleh 1981; Zeinab, Sallam 1996] and affect metabolism and yield. According to Herzog and Geisler [1976], in the future even greater attention will be paid to the use of cytokinins in agriculturally important *Graminae.*

Conclusions

1. Phytohormones applied three times as a foliar spray influenced tillering and the yield of barley plants to an extent depending on the genotype.

2. IAA inhibited tillering more in Piast, while GA_3 increased tillering in both cultivars and kinetin increased it in Bomi.

3. IAA decreased the grain mass in 'Piast' and the straw mass in 'Bomi'; GA_3 and kinetin increased the straw mass in both cultivars and that in turn influenced the increase of the total yield in 'Bomi'.

4. IAA exerted a favourable effect on the grain yield, increasing kernel number per plant in 'Piast', as well as the grain mass of the main stem ear of 'Bomi' on a similar level to kinetin.

5. GA_3 reduced the grain mass and kernel number per plant in both cultivars and decreased harvest index, but increased 1000 grain weight.

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