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THE EFFECT OF CHLORMEQUAT AND PACLOBUTRAZOL TREATMENT ON SAFFLOWER (*CARTHAMUS TINCTORIUS* L.) GROWTH AND FLOWERING

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Abstract

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The responses of six safflower varieties (*Carthamus tinctorius* L.) to chlormequat and paclobutrazol treatments were monitored. Although a chlormequat application did not bring about any significant differences in flowering or morphological traits, plants treated with paclobutrazol were shorter and had a higher number of flower heads. However, contrary to expectations, treatment by paclobutrazol also made flowering earlier. This does not appear to support the idea that safflower is a typical long-day plant, progressing to floral induction and stem elongation after vernalization in the winter at the leaf-rosette stage).

Safflower, *Carthamus*, chlormequat, paclobutrazol, growth retardants, days to flowering

Safflower is often considered to be a long-day plant (Zimmermann, 1973; Horowitz et Beech, 1974), but photoperiodic responses have not been confirmed by any precise data so far. These have not been properly elaborated due to their sensitivity to any increases in temperature (Weiss, 1983). On the other hand, especially in the initial growth period, low temperatures can prolong the vegetative phase by five or more weeks through delaying elongation (Knowles, 1989). Some safflower workers (Li et Mündel, 1996; Esendal, 1997) even consider safflower to be a photoperiodically neutral taxon, but some varieties can show an adaptation to specific photoperiods, with the rosette stage being prolonged by short-day conditions. Li et al. (1997) discovered, besides seven hundred entirely thermo-inductive varieties, only 23 photoperiodically sensitive ones. In evaluating the available data these authors also came to the conclusion that temperatures can be more important than daylength. In a number of long-day plants overwintering in the leaf rosette stage, floral induction is linked to the increasing levels of endogenic gibberellins and stem elongation, and application of exogenic gibberellin can evoke flowering (Hess, 1979; Bernier et al., 1985). However, in contrast to wild *Carthamus* species, the safflower has lost much of its ability to remain in the leaf rosette stage and data recording the effects of exogenic gibberellins on the flowering of safflower seem to be contradictory: some have observed earlier flower initiation (Yermanos et Knowles, 1960; Baydar et Yüce, 1996), and others have observed later flower development, after both GA_3 and GA_{4+7} applications (Potter et al., 1993; Uher, 2004). On the other hand, some studies investigating the effect of growth retardants (Kene et al., 1992; Refaat, 1996; Samaiya et al, 2000; Kubsad et al., 2004) did not start until flower initiation, and no studies of the effect of gibberellin-inhibitors on safflower flowering have been published.

MATERIAL AND METHODS

Two early-flowering safflower varieties (´Kinko´, ´Shiro´),threemedium-floweringvarieties(´Vierka´, ´Brněnka´ and ´Tangerine´) and one late-flowering variety (´Feuerschopf´) were sown at the end of the 16th week in un-irrigated plots. In the year of observation, average temperatures in May and June were 15.9 °C and 18.7 °C, respectively, and precipitations of 65.7 mm and 44.6 mm, respectively, were

recorded (no irrigations were installed) in a locality with sandy loam soils, at an altitude of 170 m above sea level. Individual plots (120 plants per 1.5 m^2) were treated before stem elongation at the beginning of the 20th week (24 days after the sowing date) and treated again before ramification (at the end of the 22nd week), or before ramification only, with chlormequat (0.4% Retacel) or paclobutrazol (0.1% and 0.2% Cultar). The number of days until flowering, plant height and the number of flower heads were recorded and evaluated.

RESULTS AND DISCUSSION

In comparison to the control plot, chlormequat applications at the concentration given above did not bring about any significant differences in either flowering time or in morphological traits. This is not altogether surprising, since although an increase in safflower seed yield has been recorded after treatment at the late development stage (Refaat, 1996; Samaiya et al., 2000; Kubsad et al., 2004), the effect of chlormequat is insignificant in many plants of the Asteraceae family.

Even though the effect of growth-retardant applications seems to significantly decline after ramification, independently from the number of treatments and the last treatment time, the plants treated by paclobutrazol remained rather shorter and they initiated a higher number of flower heads. Just as surprisingly, the time to flowering was slightly but significantly reduced after the paclobutrazol treatment. However, in some cases, after a gibberellin application as well, safflower did not respond by a shortening of the time to flower initiation; flowering was even delayed (Potter et al., 1993, Uher, 2004). Some authors, however, have observed the opposite effect (Yermanos et Knowles, 1960; Baydar et Yüce, 1996). Many authors (e.g., Deokar et al., 1984; Cholaky et al., 1999; Dadashi et Kajepour, 2004) have recorded a shortening of time to flowering after a delay in sowing, but Hayashi et Hanada (1985) reported

I A: *Mean height (m) in plants treated both before elongation and before ramification*

variety	control plot		Retacel (0.4 %)		Cultar (0.1 %)		Cultar (0.2 %)	
	x	s_x	x	s_x	x	s_x	x	s_x
´Brněnka´	0.831	3.63	0.824	3.11	0.797*	5.45	0.792*	5.75
´Kinko´	0.704	4.78	0.691	4.71	0.669*	6.97	0.661*	6.63
´Cremewit´	0.708	3.63	0.696	3.11	0.702	5.45	0.692	5.75
´Feuerschopf´	0.931	4.44	0.928	4.76	0.913	8.27	0.920	7.16
´Tangerine´	0.838	7.81	0.816	8.19	0.788*	9.89	0.790*	7.86
´Vierka´	0.699	4.01	0.701	4.26	0.674*	5.34	0.668*	4.65

I B: *Mean height (m) in plants treated before ramification only*

variety	control plot		Retacel (0.4 %)		Cultar (0.1 %)		Cultar (0.2 %)	
	x	s_x	x	s_x	x	s_x	x	s_x
´Brněnka´	0.832	3.56	0.829	3.11	0.816*	2.40	0.806*	4.76
´Kinko´	0.715	4.10	0.689	4.19	0.701	5.19	0.709	4.49
´Cremewit´	0.708	4.44	0.702	4.07	0.705	4.62	0.721	4.77
´Vierka´	0.708	4.51	0.695	3.96	0.713	3.68	0.622**	3.68

II A: *Days to flowering in plants treated both before elongation and before ramification*

variety	control plot		Retacel (0.4 %)		Cultar (0.1 %)		Cultar (0.2 %)	
	x	s_x	x	s_x	x	s_x	x	s_x
´Brněnka´	83.47	1.33	81.73	2.26	80.70**	1.93	83.40	1.20
´Kinko´	74.03	0.79	74.43	0.67	71.27**	1.21	71.33**	1.22
´Cremewit´	75.16	1.13	74.23 *	0.61	73.90**	0.70	71.63**	1.04
´Feuerschopf´	88.30	1.32	88.13	1.36	87.67 *	1.01	87.27	1.44
´Tangerine´	78.23	1.65	80.17**	1.77	79.37 *	2.00	79.60**	1.43
´Vierka´	80.03	1.74	80.97	2.18	79.83	1.73	79.77	1.56

* = statistically significant (P = 0.95), ** = statistically significant (P = 0.99)

a decreased number of heads and a delay in flowering at decreasing light intensities, which indicate that light and temperature availability can play a more important role that a photoperiode.

CONCLUSIONS

An decreasing time to flowering in safflower after the paclobutrazol treatment seem to be the opposite of those of most typical long-day plants, which graduate to floral induction, together with stem elongation, after vernalization at the leaf-rosette stage, and thus respond to gibberellin treatment in accelerating of flower development. However, safflower is an antropogenous taxon, developed (in contrast to wild species) for repressing of vernalization demand, and so decreasing of time production. The data presented here invites a comparison with plants which are more photo-cumulative and thermo-cumulative in their flower induction, than typical long-day plants, but corroboration of such premise will require more detailed studies on both a physiological and a biochemical basis.

II B: *Days to flowering in plants treated before ramification only*

variety	control plot		Retacel (0.4 %)		Cultar (0.1 %)		Cultar (0.2 %)	
	x	s_x	x	s_x	x	s_x	x	s_x
´Brněnka´	83.23	2.21	81.66	1.87	80.97	1.93	81.23	2.07
´Kinko´	73.23	1.29	72.07	0.70	73.09	1.14	71.97	0.79
´Cremewit´	76.03	1.04	75.46	0.79	73.09	0.79	72.27	1.39
´Vierka´	85.47	1.97	82.36	2.23	81.66	2.11	80.73	1.78

III A: *Number of heads in plants treated both before elongation and before ramification*

variety	control plot		Retacel (0.4 %)		Cultar (0.1 %)		Cultar (0.2 %)	
	x	s_x	x	s_x	x	s_x	x	s_x
´Brněnka´	3.7	0.64	4.5**	1.02	4.3*	0.74	4.6**	1.45
´Kinko´	3.3	1.20	3.8	2.08	3.7	1.32	4.3*	1.82
´Cremewit´	3.0	1.17	3.6	1.91	4.0**	1.39	4.6**	1.98
´Feuerschopf´	4.5	1.28	4.9	0.86	3.6*	1.27	5.2	1.14
´Tangerine´	5.7	1.27	4.7*	2.05	5.9	1.91	5.3	1.55
´Vierka´	5.0	1.05	4.5	1.56	5.3	1.49	5.4	1.70

III B: *Number of heads in plants treated before ramification only*

variety	control plot		Retacel (0.4 %)		Cultar (0.1 %)		Cultar (0.2 %)	
	x	s_x	x	s_x	x	s_x	x	s_x
´Brněnka´	3.5	1.12	4.2*	1.21	4.7**	1.14	4.9**	1.66
´Kinko´	3.8	1.20	3.6	2.08	3.7	1.32	4.5*	1.82
´Cremewit´	3.0	1.17	3.6	1.39	4.0**	1.29	4.6**	1.97
´Vierka´	5.0	1.44	4.6	1.29	5.6*	1.91	5.4	1.78

* = statistically significant (P = 0.95), ** = statistically significant (P = 0.99)

SOUHRN

Vliv ošetření chlormequatem a paclobutrazolem na růst a kvetení světlice barvířské (*Carthamus tinctorius* L.)

Reakce na ošetření chlormequatem a paclobutrazolem byly sledovány na šesti odrůdách světlice barvířské (*Carthamus tinctorius* L.). Ošetření chlormequatem nepřineslo průkazné změny v termínech kvetení ani v morfologických znacích. Rostliny ošetřené pac-lobutrazolem zůstávaly nižší a vyvíjely více úborů. V protikladu k předpokladům však ošetření paclobutrazolem vedlo k ranějšímu nakvétání. Takové výsledky nenasvědčují hypotézám vydávajícím světlici za typickou dlouhodenní rostli-

nu, přecházející v květní indukci ve spojení s prodlužováním stonku po vernalizaci ve stadiu listové růžice.

světlice, *Carthamus*, chlormequat, paclobutrazol, růstové retardanty, kvetení

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