NARDI FUNDULEA, ROMANIA
www.incda-fundulea.ro

ROMANIAN AGRICULTURAL RESEARCH, NO. 29, 2012
Print ISSN 1222-4227; Online ISSN 2067-5720

TEMPERATURE EFFECTS ON COMMON COCKLEBUR (*XANTHIUM STRUMARIUM* L.) SEED GERMINATION

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ABSTRACT

A better understanding of the seed ecology can be helpful for prediction of the potential of weed species to spread, for prediction of their invasiveness, and for development of more effective weed management strategies. In Serbia, in agricultural areas, edges of crop fields, as well as in uncultivated areas, more and more populations of common cocklebur (*Xanthium strumarium* L.) were detected. Seeds from two populations (P_1 and P_2) of this species were collected for testing temperature effects on germination. Germination tests were conducted in an incubator set to 10, 15, 20, 25, 30 and 35°C, in the dark. The seeds were considered to be germinating at the moment of radicle emergence. The number of germinated seeds was recorded daily (germination rate) during 7 day period and germination rate (sum of germinations per day) was calculated. Final percentage of germination and seedlings length and weight were measured after 7 days of incubation. Seeds of the both common cocklebur populations did not germinate when incubated at 10°C. The lowest germination occurred at 35°C for population P_1 and at 15°C for population P_2, while the maximum germination occurred at 25°C for both populations. The highest length of seedlings were recorded at 25°C and 30°C for population P_1 and P_2, respectively, while the highest seedlings weight was at 35°C for both populations. The lowest seedlings length, as well as weight, was measured at 15°C for both populations.

Key words: temperature, common cocklebur (*Xanthium strumarium* L.), seed germination.

INTRODUCTION

Common cocklebur (*Xanthium strumarium* L.) is one of the most common and competitive weeds found in row crops throughout Serbia (Vrbnicanin et al., 2009). Its significance as a weed in maize is increasing across the Balkan area (Nakova et al., 2004). It is a large-seeded annual broadleaf weed that has been reported to reduce soybean yields up to 80% (Bloomberg *et al*., 1982) and maize yield 30 to 40% (Karimmojeni et al., 2010). Baldoni et al. (2000) in Italy found that average fruit production of *Xanthium* species is more than 2200 burs per plant, while Weaver & Lechowicz (1983) in Canada reported even higher reproductive potential (up to 5400 burs/plant).

Common cocklebur seed is contained in burs with unique characteristics in comparison to other weeds. Burs are partitioned into upper and lower sections, each containing one seed. The lower seed is non dormant and the upper seed is considered dormant and may not germinate for months to years after maturity (Barton, 1962). Common cocklebur, which is photoperiod-sensitive, emerges late in the season (Bloomberg et al., 1982). Seedlings emerge from as deep as 15 cm in the soil (Oliver, 1975). The magnitude of its emergence is influenced by tillage and crop presence (Norsworthy, 2004).

Knowledge about germination would be very helpful for understanding the potential of weed species for spread and invasiveness. Additionally, weeds emergence patterns dictate the extent to which herbicides and nonchemical methods must remain effective to minimize deleterious impacts on crop yield and quality (Norsworthy and Oliveira, 2007). Due to its emergence and seedling characteristics, common cocklebur is difficult to control by either soil-applied herbicides (Baldwin and Frans, 1972) or mechanical means (Gunsolus, 1990). Predicting the start and the duration of seedling emergence can contribute to taking better weed control decisions (Berti et al., 1996) and facilitate optimal timing of control practices (Grundy,

Received 6 December 2011; accepted 20 April 2012

2003). Results about effects of environmental factors on germination and emergence can be very useful in that context.

Several environmental factors, such as temperature, light, pH and soil moisture, are known to affect seed germination (Chauhan et al., 2006; Nandula et al., 2006). Many studies have shown these factors have variable effects on different populations of the same species (Beckstead et al., 1996; Milberg and Andersson, 1998). Although effects of different factors (Zimmerman and Weis, 1983; Norsworthy and Oliveira, 2007), including temperature (Norsworthy and Oliveira, 2007), on common cocklebur germination were studied, to our knowledge there is no information about the effect of environmental factors on germination of common cocklebur from Balkan Peninsula. As it is well known that one of the most important factors which affect seed germination and seedlings emergence is temperature, the objective of this research was to determine the effects of different temperatures on common cocklebur seed germination and seedlings length and weight.

MATERIAL AND METHODS

Mature burs (two achenes per bur) of two populations (P_1 and P_2) of common cocklebur were collected on 2009 from ruderal (P_1) and corn field (P_2) areas for testing effects of temperatures on germination. Germination was evaluated at six stable temperatures of 10, 15, 20, 25, 30 and 35°C using separate incubators. Burs were used for testing because seeds of this species do not free out from the fruit after maturity and it is difficult to separate them from the fruit without damage. Five burs of common cocklebur were selected and randomly placed in 9 cm diameter Petri dishes, lined with disc with filter paper at the bottom. In each Petri dish 5 ml of distilled water were added. Six dishes were used for each treatment. Germination took place in an incubator (Binder CE), in the dark. The seeds were considered to be germinating at the moment of radicle emergence. As it is well known, common cocklebur burs contain two seeds, one non-dormant and the other dormant (Barton, 1962). But, Hicks (1971) recorded that in some populations as many as 73% of sown fruits may produce "twin" seedlings. In this study both seeds germinated in about 0.5% of burs only and in those cases second germinated seedling was neglected. The number of germinated seeds was recorded daily (germination rate), and the final percentage of germination, seedling length and weight were measured after 7 days. Germination rate (GR, sum of germinations per day) was calculated using the formula described by Maguire (1962):

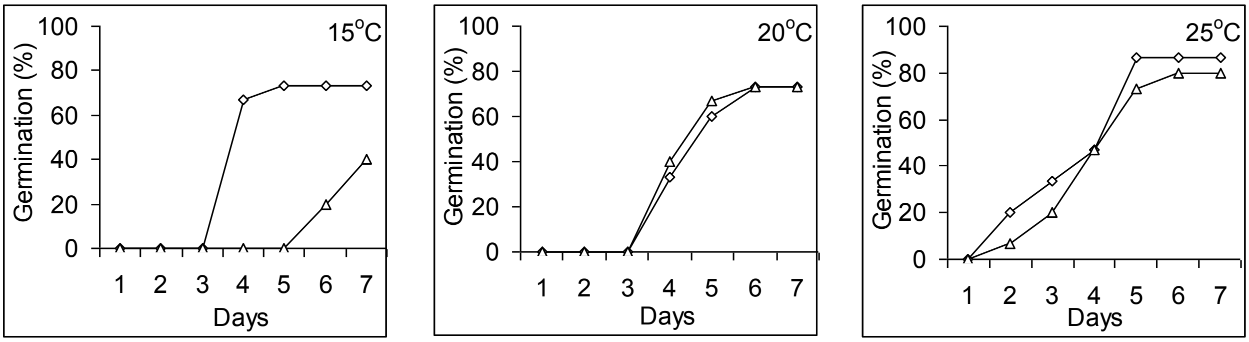
$$GR = n_1/t_1 + n_2/t_2 + \ldots + n_x/t_x,$$

where n_1, n_2, ...n_x are the numbers of the germinated seeds at times t_1, t_2, ...t_x in days. Each experiment was conducted three times.

All data was analyzed by one-way ANOVA (F-values) using statistical software Statistica 5.0. Differences between populations were tested using t-test.

RESULTS AND DISCUSSION

The germination results obtained with seeds of common cocklebur at different temperatures between 10 and 35°C are presented in Figures 1 & 2 and Table 1. Dynamic of germination differed between temperatures and populations, whereas differences between populations were the highest at 15°C. Seeds of the both common cocklebur populations did not germinate when incubated at 10°C. At 15 and 20°C, seeds needed longer period for germination than at higher temperatures (25, 30 and 35°C). Namely, seeds of population P_1 started to germinate after four days of incubation at 15 and 20°C, while germination of population P_2 was recorded after six and four days incubation at the same temperatures, respectively. At higher temperatures seeds started to germinate the next day after establishment of the experiment. The response of germination speed to temperature was similar with *Chenopodium album* L., for which germination of seeds were very fast at relatively high temperatures, but slows down as the temperature decreases (Tanveer et al., 2009).



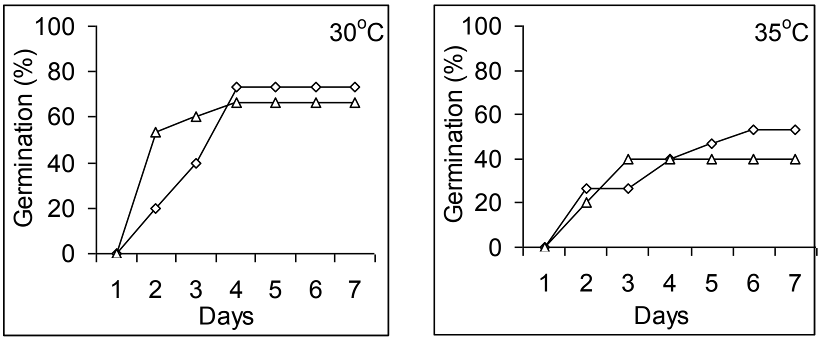


Figure 1. Dynamic of seed germination of common cocklebur on different temperatures (◊ - population P_1; Δ - population P_2. There was no germination at 10°C, so results from this temperature were not presented)

Temperature significantly (P<0.05) affected common cocklebur germination, as seen in Table 2 and Figure 2, which is consistent with the previous report by Norsworthy & Oliveira (2007). Generally, differences between populations were present, but were not significant (*P*>0.05). After seven days the maximal percentage of germination occurred at 25°C for both populations (P_1: 86.67%; P_2: 80.00). Norsworthy & Oliveira (2007) concluded that germination of common cocklebur is optimal at constant temperatures of 35 or 40° C in the field experiments. This relatively high temperature requirement for germination is probably one reason why this species emerges later in the growing season than many other weed species. Contrary to results obtained by Norsworthy & Oliveira (2007), the lowest germination occurred at 35°C for population P_1 (53.33%), while the lowest germination of population P_2 (40%) was recorded at 15°C.

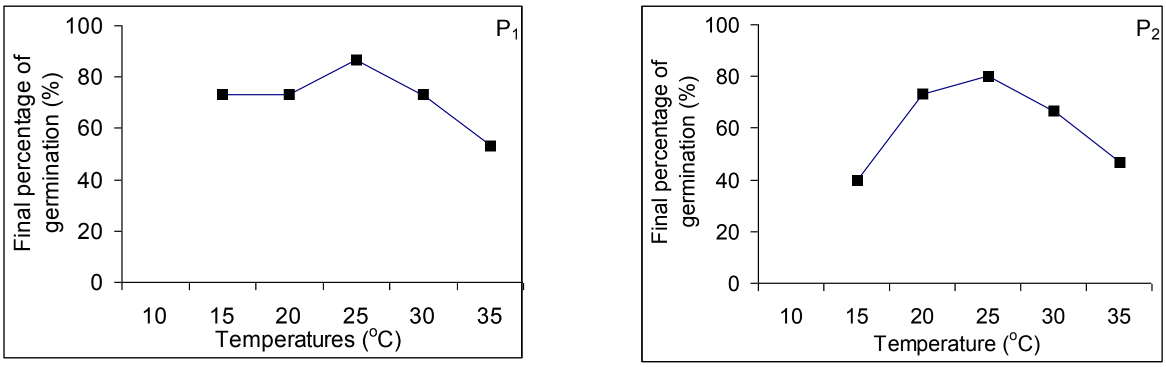


Figure 2. Final percentage of seed germination (%) of common cocklebur at different temperatures (°C) (at P_1 and P_2)

Germination rates (Table 1), which represents the sum of germinations per day, depended significantly (P<0.05) on temperature (Table 2), but the values were not parallel with final percentage of germination. Namely, the highest germination rate occurred at 25°C for population P_1 (3.85) and at 30°C for population P_2 (4.85), while the lowest germination rate occurred at 20°C for population P_1 (2.15) and at 15°C for population P_2 (0.45). Similarly, dependency of germination rate on temperature was confirmed for different species (Washitani, 1985; Arnold et al., 1990).

Table 1. Effects of different temperatures on germination rate, seedlings length and weight of common cocklebur

Population	Temperature (°C)	Germination rate (no. day^{-1})	Seedling length (cm)	Seedling weight (g)
P_1	10	0.00±0.00	0.00±0.00	0.00±0.00
	15	2.70±0.30	5.65±0.44	0.18±0.03
	20	2.15±0.15	10.12±0.89	0.32±0.01
	25	3.85±0.22	10.80±0.14	0.31±0.04
	30	3.54±0.11	6.77±0.32	0.20±0.02
	35	2.90±0.31	6.77±0.56	0.34±0.01
P_2	10	0.00±0.00	0.00±0.00	0.00±0.00
	15	0.45±0.06	1.89±0.03	0.07±0.01
	20	2.30±0.13	14.99±0.10	0.37±0.01
	25	3.05±0.27	12.20±0.08	0.47±0.06
	30	4.85±0.54	19.80±0.12	0.45±0.02
	35	2.73±0.16	16.60±0.04	0.51±0.07

The ability of a germinated weed seed to successfully establish as a seedling will depend greatly on the depth of the seed burial and hence the requirement for pre-emergence growth of the seedling (Grundy, 2003). Therefore, evidence about temperature effects on length and weight can be very useful. Many researchers (Vleeshouwers, 1997; Shrestha et al., 1999) studied the temperature effects on seedling growth of different species. In our study (Table 1) seedlings of population P_1 had the highest length at 25°C (10.80 cm), followed by 10.12 cm at 20°C, while seedling length of population P_2 was the highest at 30°C (19.80 cm).

The highest seedlings weight was recorded at 35°C for both populations (P_1: 0.34 g; P_2: 0.51 g). The lowest seedlings length, as well as weight, was measured at 15°C for both populations (length – P_1: 5.65 cm, P_2: 1.89 cm; weight – P_1: 0.18 g, P_2: 0.07 g). Therefore, temperature showed more significant ($P<0.01$) effect on length and weight of seedlings than on germination (Table 2).

These results closely match findings of other research, showing that germination is a process driven by the combination of temperature and water potential (Gummerson, 1986), whereas radicle and shoot elongation are driven by the temperature alone (Wheeler & Ellis, 1991; Dahal & Bradford, 1994).

Table 2. F-values of one-way ANOVA for determining the main effects of temperature on seed germination and on length and weight of seedlings of common cocklebur

Parameter	P_1	P_2
Germination (%)	3.771429*	3.893333 *
Germination rate	3.618014*	9.948441**
Seedling length (cm)	11.18775**	37.734850**
Seedling weight (g)	5.382520**	7.199111**

**) $P<0.01$; *) $P<0.05$.

CONCLUSIONS

The results of these studies indicate that common cocklebur has the ability to germinate under a broad range of temperatures, while requirements for maximum germination are high. Effects of temperature are more expressed on seedlings length and weight than on seed germination.

Acknowledgements

We thank the Ministry of Education and Science of Serbia for support in this investigation, Project III46008.

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