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Effect of seed position on parental plant on seed germination and seedling growth of common cocklebur (*Xanthium strumarium L.)*

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Key words: Common cocklebur (*Xanthium strumarium L.)*, germination rate, germination percentage, heteroblasty.

Abstract

The aim of this study was to determine the effect of seed position on a parental plant on germination characteristics and early seedling growth of common cocklebur (*Xanthium strumarium L.).* The laboratory experiment was conducted in laboratory of weed ecology of Faculty of Agriculture, University of Tabriz, Iran in 2012. The common cocklebur seeds were harvested from different seed positions and height of parental plants. The experiment was arranged based on complete randomized design with four replications. Treatments consisted of three seed positions of common cocklebur parental plant (the bottom, middle and top of the canopy). Germination percentage, germination rate, shoots and root dry weight and shoots and root length were assessed. The results showed that middle position of seed on parental plant had higher germination percentage (67%) in comparison to other seed position on parental plant. Middle position of parental plant by 4.67 day^{-1} had the highest germination rate than that of other parts. Also, seeds of lower position of parental plant had higher germination rate in compared to upper position. In comparison to other parts of parental plant canopy layers, middle position had the highest shoot and root length and dry weight. A combination of reproductive traits such as high fecundity, high germination capacity and opportunistic behaviour associated with limited effect of fruit position on a plant on germination characteristics could affect on ability of this weed to successfully invade new habitats.

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Introduction

Plants growing in unpredictable environments have evolved adaptations related to seed morphology and physiology, such as dormancy, seed size variability and the presence of special structures for dispersal to cope with uncertain conditions (Venable & Brown, 1988). Seed traits are determined both by seed genotype and parental environment (Donohue & Schmitt, 1998; Galloway, 2001a, b). Parental environment can influence the proportion of seeds that enter dormancy and become part of the seedbank (Baskin & Baskin, 1998; Munir *et al.*, 2001), the frequency distribution of seed weights produced by a plant (Fenner, 1991a; Sultan, 1996), as well as seed germinability (Fenner, 1991; Paolini *et al.*, 1999).

There are numerous cases recorded of seed germinability being modified by environmental factors operating during development and maturation. Examples parental photothermal environment (Kigel *et al.*, 1977); and altitude (Dorne, 1981). Several studies with species such as melon (Incalcaterra and Caruso, 1994), carrot (Nagarajan *et al.*, 1998) and tomato (Dias *et al.*, 2006) have shown that fruit position on the parental plant can lead to difference in seed size and viability. In pepper previous studies are contradictory in this respect. Osman and George (1984) reported that seeds obtained from lower level on the plant giving the highest mean seed weight, germination and shortest time to germination and seedling emergence. In different plant species, maternal factors, such as the position of the inflorescence on the parental plants or the position of the seeds in the inflorescence or in the fruit, can markedly influence the germinability of seeds (Jacobsohn and Globerson, 1980; Gutterman, 1996; Grey and Thomas, 1982).

Achenes of *Lactuca serriola* (which mature during summer and autumn), as well as summer- and wintermaturing seeds on the same parental plants of some biseasonal-flowering perennial shrubs of the *Aizoaceae*, have been found to differ in germinability (Gutterman, 1992). Fenner (1991) reviews environmental effects on seed size, chemical composition and germination. The position of a seed in an individual bur or capitulum can influence its germinability. For example, in *Xanthium canadense* (= *X. strumarium* var. *canadense*), the upper seed of two in the dispersal unit germinates before the lower one (Crocker, 1960). However, in *X. strumarium*, after 12 weeks of cold stratification, the two seeds germinated together in 18% of the dispersal units or burs (Baskin and Baskin, 1998). In *Trifolium subterraneum* (*Fabaceae*), the larger seed in the bur germinates before the small one. In the three seeded spikelet burs of *Cenchrus longispinus* (*Poaceae*), the seed in the central spikelet is largest and comes out of dormancy after dry storage much earlier than the smaller seeds of the lateral spikelets (Baskin and Baskin, 1998).

There is a little information about the seed germination characteristics of this invasive weed. Evaluating the germination ecology of common cocklebur will be helpful for integrated management of this weed in the field. Therefore the aim of present study was to evaluate the effects of position of the seed on *X. strumarium* plants on its germination characteristics and early seedling growth.

Material and methods

Common cocklebur seed collection and preparation

The harvested common cocklebur seed were obtained from the Research Farm of the University of Tabriz, Iran (latitude 38.050 N, longitude 46.170 E, Altitude 1360 m above sea level), Iran in October 2012. 10 plants were randomly selected and their seed collected as it ripened on several occasions. From each plant, seed was collected from three morphological positions (the bottom, middle and top of the canopy). The seeds of common cocklebur after being removed from the parental plant were stored in the laboratory in labeled paper bags. For complete germination the seeds were stored at 5 °C for 20 weeks until the beginning of the germination experiment (Biswas 1981).

Seed germination protocol

The experiment was arranged based on complete randomized design with four replications. Treatments consisted of three seed positions of common cocklebur parental plant (the bottom, middle and top of the canopy). Seed germination was assayed by germinator in Petri dishes with two layers of sterile filter paper. Before the germination the seeds were rinsed in tap water and then dipped into a sodium hypochlorite solution (1% v/v) for sterilization. Common cocklebur seeds that decayed during the experiment were considered dead, viable seeds that did not germinate were considered to be dormant. The viability of dormant seeds was tested by squeezing the fruit (achene) using forceps. The Petri dishes were routinely placed in germinator at a variable air temperature of night 25°C and day 32°C with a 16-h day and 8-h night. Filter papers were kept soaked during the whole experimental period (21 days) and every 3 or 4 days seeds showing radicle emergence were counted and thereafter removed from the Petri dishes.

Measurement of germination and seedling growth

The number of common cocklebur seeds that germinated in each treatment was determined 21 days after water imbibition. Three replicates of 50 seeds were used for each measurement.

Germinatoin percentage

The number of normal seedlings at the end of the twenty-first day germination period under in germinator, as the germination percentage was recorded.

Germination rate

The germination rate was calculated by following equation (ISTA, 1999).

Germination rate =

$$\frac{\text{number of normal seedlings}}{\text{days to first count}} + \cdots + \frac{\text{number of normal seedlings}}{\text{days to final count}}$$

After growing the common cocklebur for twenty one days, the plants were exit and cleaned, using a stream of tap water. The shoot and root length of common cocklebur seedlings were measured to the nearest 0.1 cm. After measuring, the roots of the plants were cut off with a razor blade. Then, all the plants were placed in an oven drier at 70 ° C for 24 hours. After the plants were dried, they were weighed to the nearest 0.000 1 g.

Statistical analysis

Analysis of variance was performed based on complete randomized design with four replications with SPSS (ver. 16) and the mean comparison was conducted by Duncan's multiple range tests.

Results and discussion

Table 1. Analysis of variance of the seed germination and seedling growth of common cocklebur.

S.O.V	df	Germination percentage	Germination rate	Shoot length	Shoot dry weight	Root length	Root dry weight
Replication	3	0.002 ^{ns}	0.58 ^{ns}	0.52 ^{ns}	0.044 ^{ns}	0.58 ^{ns}	0.02 ^{ns}
Canopy layer	2	0.220 **	15.07 **	39.76 **	0.126**	21.4 **	0.1 **
Error	6	0.001	0.11	1.67	0.010	0.881	0.009
CV (%)	-	7.29	12.95	13.8	14.44	15.64	18.11

*=Significant at 5% probability level, **= Significant at 1% probability level, ns=Non-significance, CV= Coefficient of variation

Analysis of variance showed that the effect of seed position on parental plant on germination percentage, germination rate and other traits of seedling growth were significant (Table 1.). The results indicated that seeds the highest of middle position of parental plant had the highest germination percentage (67%) than that of other parts of plant which, the difference between the two common cocklebur canopy layers were significant (Fig.1.).

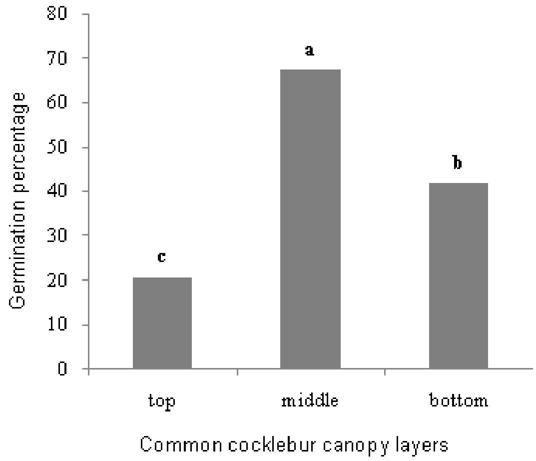

Fig. 1. Germination percentage for seeds from different canopy layers of common cocklebur. Different letters indicate significant difference at P≤0.05.

On the other hand, the lowest germination percentage (20%) obsereved in the upper position of the parental plant (top canopy layer) that presumably was due to reduction of plant photosynthetat in the end of common cocklebur growth and produces the tiny seed in this condition. Similar result also was observed in germination percentage of seeds from different part of the canopy in wheat (*Triticum aestivum* L.) (Ries and Everson, 1973). Also, study on the carrot indicated that seeds of primary and secondary umbel in comparison to third one had higher germination percentage. Hence, the seeds of later umbel which are immature have lower germination (Carbineau, *et, al.* 1995). Similar result was observed by Tieu *et al.,* (2001) on *Anigozanthos manglesii*. This species is perennial pasture plant and growing in Australia that this plant has spike inflorescence and seeds of lower position in the inflorescence matured earlier than that of seeds in upper position of inflorescence and seeds of lower position have higher germination percentage that differences in seed germination of inflorescence have an important role in survival of this plant. Also, seeds of the upper position of inflorescence had lower weight that caused the differences in seed germination and seedling vigor (Tieu, *et al.* 2001). Also, Adkins *et al.*, (2000) reported that in *Avena fatua* the seeds that were produced from lower florets of inflorescence had higher germination and vigor percentage in comparison to seeds of middle and upper florets of inflorescence. The seeds of upper parts of inflorescence had lower seed weight and more inhibitory substance for germination than lower seeds due to later formation (Adkins, *et al.* 2000).

In our studt, the middle position of parental plant canopy layer by 4.67 day-1 had the highest germination rate among the common cocklebur canopy layers. Also, seeds of lower position of parental plant canopy layer had higher germination rate in compared to upper position in canopy layer (Fig. 2.).

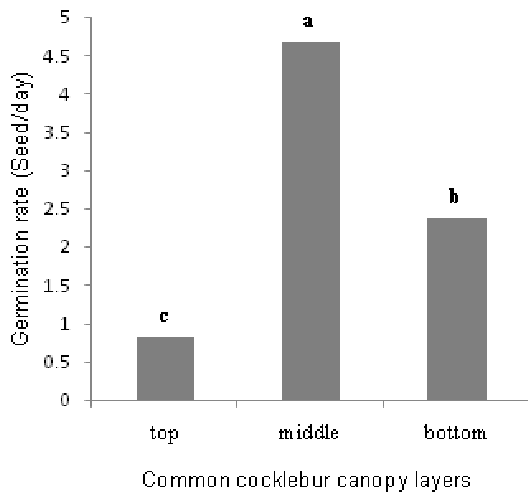

Fig. 2. Germination rate for seeds from different canopy layers of common cocklebur. Different letters indicate significant difference at *p* ≤0.05.

Environmental condition during the seeds formation had significantly effect on seeds dormancy, rate and percentage of germination (Miao, *et al.*, 1991a; Wulff and Bazzaz, 1992; Schmid and Dolt, 1994; Galloway, 2001b).

The seeds that were produced from middle part of parental plant canopy layer, had the highest shoot and root length among canopy layers of parental plant (Fig. 3.).

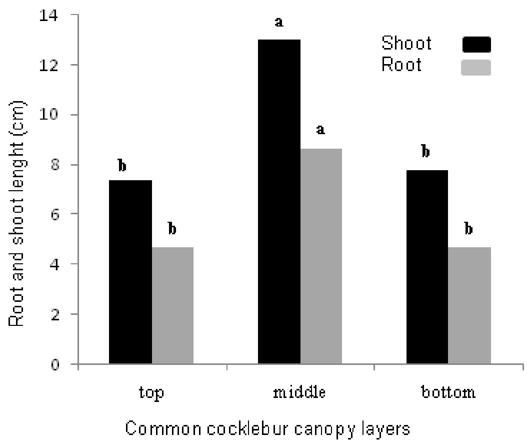

Fig. 3. Shoot and root length for seeds from different canopy layers of common cocklebur. Different letters indicate significant difference at P≤0.05.

Haar (2002) also reported that seeds of middle part of *Setaria faberii* spikes that planted in the pot had maximum seedling emergence and plant high. Also minimum seedling emergence and plant high was observed in seeds of upper position of spikes due to these seeds have low weight and more inhibitor substance such as ABA and finally these seeds had quiescence (Haar, 2002). In *Bromus tectorum* seeds of middle parts of inflorescence had higher shoot and root length in comparison to seeds of upper parts of inflorescence. Also, seeds weight of lower position were twice than that of upper parts (Beckstead, *et. al.*, 2001).

Results indicated that in all position of the canopy layers, the shoot dry weight was higher than root dry weight. In comparison to other parts of parental plant canopy layers, middle position of the plant had the highest shoot and root dry weight. But the shoot and root dry weight of seedligs from the top and bottom canopy layers of common coclebur were not significantly different (Fig. 4.).

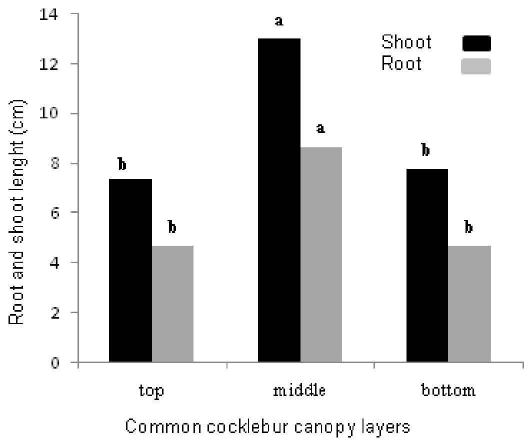

Fig. 4. Shoot and root dry weight for seeds from different canopy layers of common cocklebur. Different letters indicate significant difference at *p* ≤0.05.

Position and seed size are important factor in seed germination and seedling vigor. Also other environmental factors such as temperature and photoperiod affected height and seed mature on parental plant, that have important role in weed seeds survival. Some researches also have indicated that a hormonal mechanism affects final seed size and germination which some of them are unknown and need to more research in these case (Grey and Thomas, 1982).

As a result of this research seed position in inflorescence have significant effect on quiescence and germination of common cocklebur seeds as, seeds of middle and lower position had a higher germination percentage and seedling growth. In contrast, seeds of upper position due to later formation and less of reserves materials, these seeds had low germination percentage and seedling growth. Common cocklebur produces seeds with different germination percentage (heteroblasty) at different canopy layers that finally causes to increase the distribution of seeds in time. Therefor such seeds will be able to germinate at different time of growing season and it is crucial that growers have to manage this weed countiniously in the field and also use integrated weed management strategies to reduce its population and damage.

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