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The effects of environment temperature and moisture to investigate seeds germination of jimsonweed

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Abstract

To investigate the variation of the germination in Datura in the soil after the seed spreading, a factorial experiment based on a randomized complete block design was conducted in three replications, in 2011-2012 in Karaj, Iran. The first factor was three moisture regimes (dryness treatment, H_1; alternate wetting and dryness, H_2; wetting, H3) and the second factor was temperature in four levels, representing the temperature of various months (integrated the December and January, T_1; February and March, T_2; April, T_3; and at the end of May and June, T_4) were simulated on data seeds population from spreading time to re-growth period. All treatments were applied during 30 days and then the germination test was done in 8-35°C. Thereafter, according to the estimated parameters, the relationship between temperature and moisture was investigated with germination models. Results indicated that an estimate of the sigmoidal function parameters with three parameters could be a demonstrator for germination patterns. The results of the functions showed that a gradual increase in environmental temperature caused an increase in germination coefficient when the seed were completely dried. However, this increase was negligible in comparison with the increase that observed in response to other treatments (H_2-H_3).In all moisture levels, the seeds of Datura did not have a suitable germination in 4 and 7°C, but the rate of germination was increased when the temperature was increased up to 15 and 23°C, especially for alternate wetting and drying conditions.

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Introduction

Datura (*Datura stramonium* L.) belongs to solanaceae and is generally named Jimsonweed. This plant is also one of the main weeds in the field of corn, soybean, cotton and vegetables which could decrease the crop yield in high values (El Bazaoui *et al.*, 2011).

Germination is one of the main processes for weeds success which this process is the result of the interaction between the internal and external factors (Forcella, 2000; Leon and Knapp, 2004).The seed dormancy mechanism of the weed is a general property that cause stability in seed bank and also cause a low ability in their control through normal methods (Fenner, 2000; Foley, 2002). According to this, the consideration to seed dormancy and germination are very important in the integrative control of weeds (Karlsson and Milberg, 2007; Ghersa *et al.*, 2000).There are several environmental factors including temperature, gases and light which could affect the seed dormancy and germination of the weed (Foley 2002; Hermansen *et al.*, 1999).In this case, temperature is more important (Mayank *et al.*, 2010; Probert *et al.*, 1985; Thompson *et al.*, 1977). Knowledge about the optimum temperature for seed germination of the weed is important in order to dormancy overcome and management of the weed (Zhou, 2005). Some of the researchers have believed that temperature is the first signal that affects the seed dormancy and germination of weeds. So, it has been used as a base for a forecast of weed germination (Battla and Bench-Arnold, 2003; Leblanc *et al.*, 2003).

Environmental factors, including temperature and humidity are effective on the order of occurrence and germination rate. The seed dormancy breaking is dependent on temperature fluctuations, as it observed that the seed dormancy of summer species has been induced during autumn and break gradually in winter with sense the temperature fluctuations (Benech-Arnold *et al.*, 2000). Harrington (2009) applied 0, 15, 30, 45 and 60 days-period on seed storage condition of *Cytisus scoparius* under growth chamber in order to determine the different temperature and cooling period and has demonstrated that there was a significant difference in germination rate under cooling conditionfrom0-60 days but was same from 60 up to 90 days. Colbach *et al.* (2002) studied the alternation of drought and wetting and reported that a long period of drought occurring after imbibition caused an increased in germination rate of *Alopecuru myosuroides* seeds. The effect of temperature and different water potentialson seed germination of pigweed, common lambsquarter, setaria, johnsongrass, bermudagrass, amaranthus and velvetleaf have been studied and it was shown that although the base temperature for mentioned species was approximately similar, a variation was observed in seed germination under different temperature and water potentials (Masin *et al.*, 2010). According to this, a lot of studies are needed to develop the models for germination forecast, which can help farmer in order to find the time and method the weed control (Grundy, 2003). So, the aim of this study was to survey the germination of Datura affecting by environmental factors such as moisture and temperature.

Materials and methods

Site and treatments

This experiment was conducted to survey and compare the germination variations of Jimsonweed (*Datura stramonium* L.) in Karaj, Iran, in 2011-2012. Datura seeds were obtained from the research field belonging to the College of Agriculture, University of Tehran, Karaj, Iran, (35°34´N, 50°57´E, 1361 m above the sea level). Seeds were cleaned and kept in a paper pocket for further analysis. The research was conducted as a factorial experiment based completely randomized design with three replications. Treatments included the wetting and temperature levels.

The wetting treatments were applied as dryness (H_1), alternation of wetting and dryness (H_2) and wetting (H_3). The dryness and wetting treatments were applied in four weeks and alternation treatment was applied in two weeks for each of the dryness and wetting condition. The pots were irrigated through a reference weight (Battela and Bench-Arnold, 2005).

In order to simulate temperature condition from seed maturity to re-growth, the bag containing seeds were put in the pot in three levels of moisture. Then samples were exposed to four cumulatively temperature treatment for 30 days (based on temperature means of different months for 30 years). In fact, the simulation was done for December and January (T_1 = 4°C), February and March (T_1 = 4 + 7°C), April (T_1 = 4 + 7 + 15°C) and end of the May and June (T_1 = 4 + 7 + 15 + 23°C, to investigate the warm condition effect on germination). The temperature treatments were equally applied at all moisture levels as a cumulative condition (Dorado *et al.*, 2009).

Germination test and functions

The germination tests were done after the application of the temperature and moisture treatments. The seeds were sterilized with sodium hypochlorite 7% and distilled water and then 25 seeds were put on the petri dish with 10 cm diameter. The petri dishes were kept on germinators temperature ranged from 8-35°C, for 15 days. During this stage, the germination was daily investigated and seeds germinated were removed after counting. The standard for germination was root appearance in 2 mm (Battela *et al.*, 2009). A sigmoidal function with three parameters was used for describing the cumulative germination in response to time as below:

$$Y= a/ (1+\exp (-(x-xo)/b)) \quad (1)$$

WhereY is cumulative germination; a, asymptote of top of the curve or maximum of the germination percentage; x, time (experiment temperature); Xo, necessary time to reach 10% of germination and b, curve slope of germination rate.

$$1/ X_o= \text{Rate} \quad (2)$$

In function 2, X_o is the germination rate (Benech-Arnold *et al.*, 2000).

A segmented function was used for describing the germination rate (1/ Xo= Rate) in response to different temperature for germination as below:

$$Tb<T\leq T_o \text{ if } f(T) = \frac{(T-Tb)}{(To-Tb)}$$

$$T_o<T< T_c \text{ if } f(T) = \frac{(Tc-T)}{(Tc-To)}$$

$$T\geq T_c \text{ or } \; T\leq T_b\, f(T)=0$$

In the mentioned functions, T was experiment temperature; T_b, base temperature; T_o, optimum temperature and T_c, maximum temperature. The area under a segmented curve is considered as seed germination (Soltani *et al*, 2006).

In order to estimate the integral under the curve, the below index was used:

Germination Coefficient (GC)= $(T_c-T_b)\times G_{max} (T_o)$ (3)

In this function, GC was Germination Coefficient or an index for germination under a defined range of temperature. The function parameters were included G_{max}, maximum of germination in optimum temperature; T_b, base temperature; T_c, maximum temperature. The analysis of variance was done with SAS software and fit of models was conducted by Sigmaplot (version 11) software.

Results and discussion

Table 1 shows an estimation of the sigmoidal function with three parameters for temperature and moisture levels, which is also demonstrator of a difference between treatments in germination patterns. The application of first of temperature treatment (T_1 = 4°C) in all moisture levels could not increase the germination levels in each five temperature (temperature range from 8-35°C) and the parameters became zero because of lowing the environmental temperature. It should be mentioned that in Table 1, the parameters became zero for germination tests (8-35°C) in the low temperature of seed storage (T_1 and T_2) and so were removed from the Table. According to this, in second temperature treatment (T_2), the germination was occurred just in wetting and alternation (wetting-dryness) and in optimum temperature (20°C).After a test of the temperature in the first (T_1) and second (T_2) month and consequently perform the germination test, the temperature of incubators was increased in two stages (T_3 and T_4) in order to do the simulation. The germination was increased in optimum temperature and also in other temperatures (14, 20 and 28) when humidity and temperature level increased as applied treatments. In addition, the coefficient of determination (R^2) was also increased. The variation of Xo, as a parameter of germination rate, didn't have a distinguished trend under environmental condition and the time to reach the 10% of the germination was reduced to increase the temperature in seed storage condition in all germination temperatures (Table 1).

Table 1. The parameter used in model for describe the germination of Datura seed and their standard error and coefficient of determination, R^2.

moisture treatment	Temperature treatment	Temperature germination	for a	b	X_0	R^2_{adj}
Alternation	T_2	8	-	-	-	-
		14	-	-	-	-
		20	0.26±3.02	11/4±22.5	13.3±149.7	0.56
		28	-	-	-	-
		35	-	-	-	-
Wetting	T_2	8	-	-	-	-
		14	-	-	-	-
		20	0.1±2.9	5.2±23.1	6.1±153.3	0.86
		28	-	-	-	-
		35	-	-	-	-
Dryness	T_3	8	-	-	-	-
		14	1/2±0.04	14.3±4.7	192.3±5.4	0.65
		20	4.3±0.1	16.4±2.8	148.6±3.2	0.74
		28	-	-	-	-
		35	-	-	-	-
Wetting	T_3	8	-	-	-	-
		14	-	-	-	-
		20	7±0.2	25.4±7	150.2±6.6	0.86
		28	2.7±0.4	29.9±23.4	137.7±27.3	0.55
		35	-	-	-	-
Dryness	T_4	8	-	-	-	-
		14	-	-	-	-
		20	5.5±0.2	21.7±5.5	136.1±6.3	0.84
		28	3±0.2	29.3±10.7	127.2±12.4	0.62
Alteration	T_4	8	-	-	-	-
		14	-	-	-	-
		20	8.3±0.1	330.2±3.1	135.7±3.6	0.95
		28	4±0.2	16.9±8.5	137.1±9.8	0.63
		35	-	-	-	-
Wetting	T_4 T4	8	-	-	-	-
		14	2.3±0.1	12.6±8.4	98.6±9.4	0.51
		20	15.7±0.7	37.1±6.7	148.8±7.9	0.96
		28	5.3±0.3	32±9.6	129.2±11.2	0.70
		35	-	-	-	-

H_1, dryness; H_2, alternation of dryness and wetting; H_3, wetting.

Storage temperatures ($4=T_1$), ($T_2= 4+7$), ($T_3= 4+7+15$), ($T_4= 4+7+15+23$).

The germination coefficient (GC) of Datura was negligible under three levels of moisture affecting by first month temperature even if the 10% of germination didn't observe in this condition. As it demonstrated, the germination did not occur when seeds were kept in dry condition and with an increase in environmental temperature (T_3 = 4 + 7°C) but the germination coefficient was slightly increased under this temperature (T_2) and by creating the wetting and alternation (wetting-drought).The germination coefficient had a remarkable increase in comparison with the first temperatures (T_1 and T_2) with increasing the temperature as gradually and under high environmental temperature such as April (T_3) and end of May and June (T_4). The germination coefficient became greater when condition shifted from drought to humidity and with an increase in environmental temperature (T_4 and T_3).

The base and optimum temperature and also the maximum temperature were approximately near to others and had an antiseptic range (Table 2).

Table 2. The base temperature, optimum and maximum temperature for Datura seed under different condition of moisture and temperature.

Seed storage temperature	Humidity treatments	T_b	T_o	T_c	G_{max}	RMSE	G.C
4 °C (T_1) December and January	H_1	-	-	-	-	-	-
	H_2	-	-	-	-	-	-
	H_3	-	-	-	-	-	-
4+7 °C (T_2) February and March	H_1	-	-	-	-	-	-
	H_2	8	21	35	0.0058	0.0018	0.157
	H_3	8	20	33	0.0051	0.0015	0.129
4+7+15 °C (T_3) April	H_1	9	19	30	0.0065	0.0015	0.136
	H_2	9	21	33	0.061	0.0016	0.147
	H_3	9	22	36	0.0076	0.0014	0.205
4+7+15+23 °C (T_4) End of May and June	H_1	9	21	36	0.0082	0.0015	0.223
	H_2	8	20	34	0.0090	0.0022	0.235
	H_3	9	19	33	0.010	0.0032	0.275

H_1, dryness; H_2, alternation of dryness and wetting; H_3, wetting.
GC, germination coefficient.

According to Figure 1, the dormancy levels were varied with pass the time and increasing the temperature. In other words, the germination rate was reduced in three levels of moisture when seeds affected by first temperature treatment (December and January), due to the lowing environmental temperature. However, the seed dormancy was gradually reduced and consequently the germination had remarkable increment with increase the seed storage temperature in other treatments (T_2 up to T_4), as at the end of May and June, a seed dormancy reduction was observed to increase the environmental humidity values. These observations were compatible with other experiments. In an experiment, the effect of seasonal variations on seed dormancy was investigated in two Datura species (*Datura stramonium* and *Datura ferox*) preserving in different condition (buried in the soil and stored in the store). The seed dormancy changes affecting by seasonal variation in buried seeds in the soil in *D. ferox* were similar to variation created by seed dormancy breaking in controlled condition (Reisman-Berman *et al.*, 1991).

Figure 2 shows the variation of the seed germination coefficient of Datura in response to temperature under three levels of moisture as separately (humidity for seed storage before the trials). The estimation of parameters for the sigmoidal function with three parameters was a demonstrator for differences in germination pattern between of temperatures. The triangular function also showed that a gradual increment in environmental temperature caused an increase in germination coefficient, especially when seed kept in complete dryness condition. However, this increase in germination coefficient was in lower value in comparison with the alternation condition (dryness-wetting).

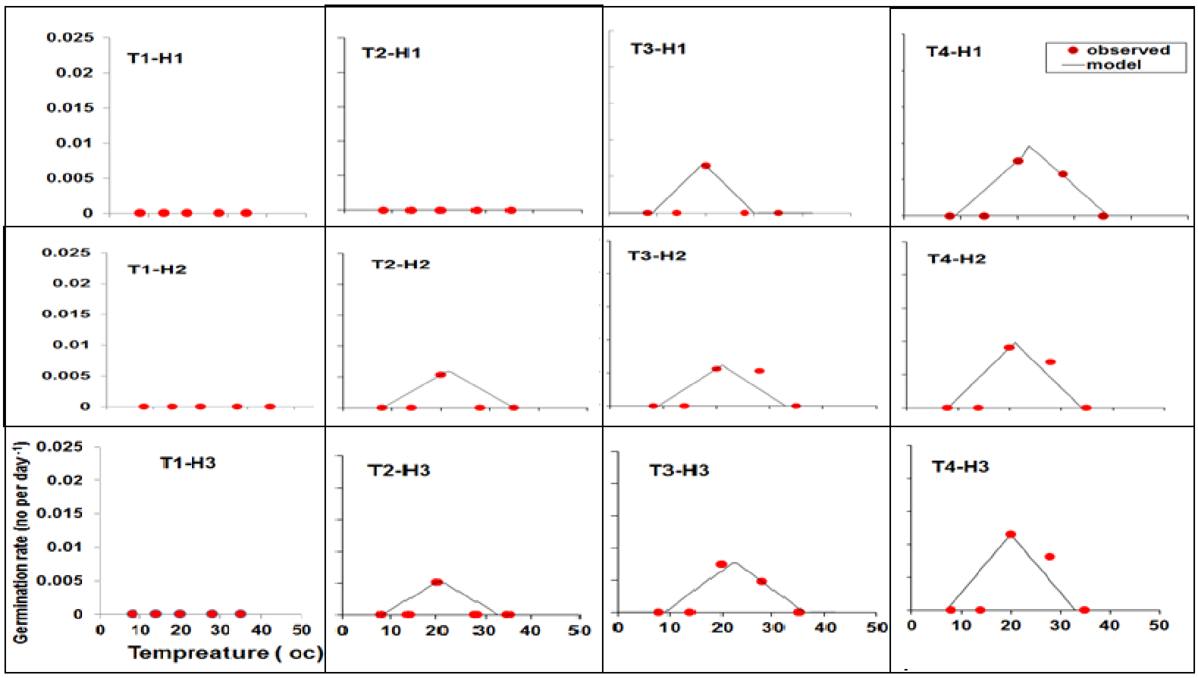

Fig. 1. Investigate the storage temperature (different months of the year) effect on dormancy breaking of Datura seeds in humidity levels (H_1, dryness; H_2, alternation of dryness and wetting; H_3, wetting).

The increment trend of germination in each three levels of moisture is showing that the seed dormancy level reduced and germination coefficient had a remarkable increase with an increase in environmental temperature (T_3 and T_4). In the case of alternation treatment (H_2) and when wetting condition was applied in two weeks (February and March), germination coefficient showed a negligible increase in comparison with condition that just witting was applied.

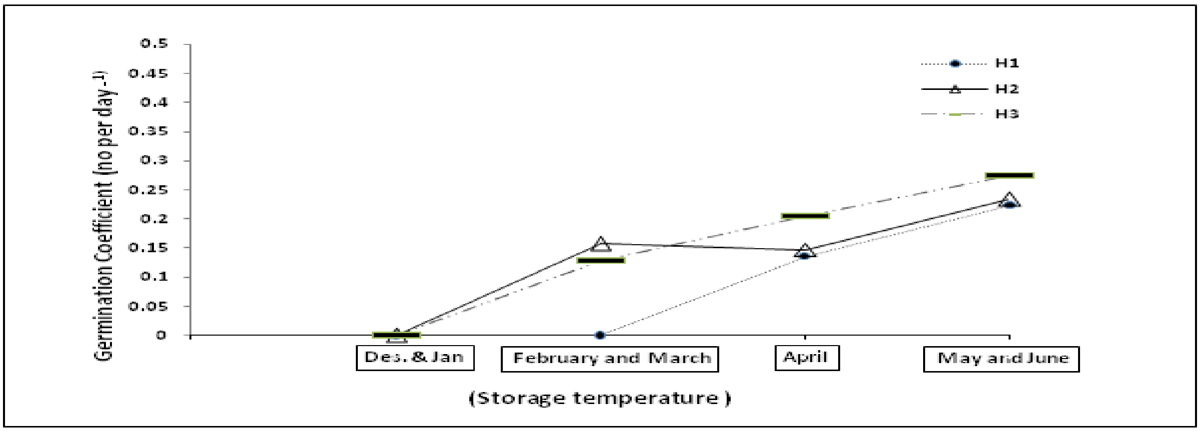

Fig. 2.

Conclusion

The recognition of factors affecting on seed germination of weeds gives the new mechanisms for their management and in this case the knowledge about the weed temperature need is important for design and operation the guidelines in their management (Zhou, 2005). Temperature is one of the environmental factors relating to success of seed germination and primary growth of seedlings that is also effective in the capacity and germination rate of seed (Sincik *et al.*, 2004).

The general results of this research were included as:
1) Results the analysis of variance showed that all of

the treatments and their interaction had significant difference on seed germination of Datura. 2) The estimation of parameters in a sigmoidal function with three parameters for different levels of moisture and temperature is a demonstrator for differences in germination pattern among the different treatments. 3) Results of segmented function showed that germination coefficient was gradually increased with cumulative increase in storage temperatures (T_3 and T_4) and when seeds were kept in complete dry condition, in comparison with first temperatures (T_1 and T_2, or temperature below the 10°C). In addition of temperature, these coefficients were also affected by moisture treatments. The Datura seed germination was higher when wetting condition was continually applied, in comparison with application of fluctuation temperature treatment. According to this, the Datura population can be reduced if we create a drought stress in field condition. By comparison of germination temperatures (35, 28, 20, 14 and 8°C) it has been observed that dormancy breaking was never occurred in low temperatures (8 and 14°C). It demonstrated that seeds have low optimum temperature for germination rate under low temperatures. On the other hand, it is related to Datura seed sensitivity to cold (El Bazaoui *et al.*, 2011). The time needed to reach to 10% of germination was reduced in 20°C temperatures with gradual increase in seed germination temperature. However, this trend became inverse with increase the germination temperature (28°C) and time needed to reach the 10% of germination was increased in order that germination was stopped in 35°C.

Datura belongs to plants which has a different base temperature under different regions and the application of models and also biological control need for an accurate investigation based on various geographical regions (Donato *et al.*, 2013). Consider to problems creating by Datura in field of corn, soybean and been it possible that its spread be controlled through research on its biology, phenology and various ecotypes and also the dormancy level of this weed.

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