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SEASONAL PATTERN OF SEED DORMANCY IN *PARTHENIUM HYSTEROPHORUS* L.

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Abstract

Earlier non-conclusive results have been reported on the initial dormancy status of parthenium (*Parthenium hysterophorus* L.) seeds. The present study reports the seasonal dormancy pattern of parthenium in Lahore, Pakistan where there are four distinct seasons viz. summer, autumn, winter and spring in a year. Mature parthenium seeds were collected on the last day of each month from January to December 2006 and investigations for their germination percentage and rate of germination were started on the next day. Parthenium seeds collected during coldest months of January and December showed highest germination of 100% with germination rate of 33.3% per day. Conversely, seeds collected in summer months of April to September exhibited lowest germination of 0–7% and germination rate of 0–1.75% per day. Seeds collected in rest of the months showed variable final germination percentage and germination rate ranging from 30–97% and 3.8–17.4%, respectively. Both the final germination and germination rate showed a highly significant negative correlation with the solar radiation and environmental temperature during the seed development period. The present study concludes that dormancy in parthenium seeds depends upon the temperature and solar radiation during the seed development period.

Introduction

During the last century parthenium weed (*Parthenium hysterophorus* L.) has spread from its endemic habitat, mainly the region around the Gulf of Mexico including West Indies and presumably central Argentina (Picman & Towers, 1982), throughout the tropics and has become a serious problem in many parts of the world like Pakistan, India, China, Australia, Kenya and Ethiopia (Navie *et al*., 1996; Javaid *et al.,* 2006, 2009; Riaz & Javaid, 2009). Most of the weed scientists focused their research on management of parthenium (Dhileepan & Senaratne, 2009; Javaid & Adress, 2009), while knowledge about its regeneration biology is rather limited and conflicting. For instance, non-conclusive results have been reported on the initial dormancy status of parthenium seeds. According to Ramaswami (1997) non dormancy in seeds of parthenium is one of the major factors which help its extensive spread and establishment. Similarly, Butler (1984) and McFadyen (1992) reported absence of a primary dormancy mechanism in the seeds. By contrast, the study by Navie *et al*., (1998) showed initial inhibition of germination in freshly shed seeds.

The conditions under which seeds mature on the mother plant can determine the level of seed germinability and dormancy and consequently affect time of seed germination and fate of next generation (Meyer & Allen, 1999). Several studies have reported the importance of temperature during seed development and maturation as an important factor affecting seed germination. Higher temperatures during seed development increase seed germinability in many species (Alexander & Wulff, 1985; Drew & Brocklehurst, 1990; Llorens *et al*., 2008). However, in some cases an inverse relationship has been found, where higher temperatures caused increased seed dormancy (Keigley & Mullen, 1986; Biddulph *et al*., 2007). Germination response has also been shown to be affected by day length experienced by maternal plants (El-Keblawy & Al-Ansari 2000; Munir *et al*., 2001). In addition, moisture condition at which maternal plants are growing has been shown to affect seed germination in some species (Allen & Meyer 2002). During various germination studies, we found different percentage and rate of germination of parthenium seeds in different seasons round the year. We hypothesized that initial dormancy in parthenium seeds could be dependant on various environmental factors viz. light, temperature, rainfall, humidity etc. during the seed formation period. The present study was, therefore designed to test this hypothesis.

Materials and Methods

Description of study area: Study was carried out in University of the Punjab, Quaid-e-Azam Campus, Lahore, Pakistan during January to December 2006. The city of Lahore is located on latitude 31.57 N and longitude 74.31 E. The climate of the region presents extremes of heat and cold. There are four well defined seasons viz. winter (December - February), spring (March - April), summer (May - September) and autumn (October - November). The area receives highest rainfall during monsoon months of July and August. The soil of the experimental site (University of the Punjab, Lahore) is generally loam or sandy loam in texture with pH 7.5 - 8.0, average N 0.05%, available phosphorus 22 mg kg^{-1}, exchangeable potassium 190 mg kg^{-1} and organic matter 1%.

Environmental data collection: Data regarding temperature, precipitation, relative humidity and light intensity in the experimental area (Lahore) during various months of year 2006 was obtained from Pakistan Meteorological Department, Islamabad, Pakistan and is presented in Tables 1-3.

Collection of parthenium seeds: Seeds of parthenium were collected from University of the Punjab, Quaid-e-Azam Campus, Lahore, Pakistan on last day of each month from January to December, 2006. Parthenium is a prolific seed producer and can continue to flower profusely until senescence. In the present study mature seeds were collected from plants which were neither senescencing nor close to senescencing. The collected seeds along with the pappus were sun-dried for few hours and threshed by hand.

Germination bioassays: Germination bioassays were started on 1st of every month from February 2006 to January 2007, one day after collection of the seeds. Ten seeds were distributed on filter paper (Whattman No. 1) in 90 mm diameter Petri plates adequately wetted with distilled water (3 ml). Plates were covered with lids and incubated at 25±5 °C for 10 days. There were three replicates of each treatment. Germination was recorded daily for 10 days. Seeds were considered germinated when radical emergence was visible. Germination rate was calculated by applying the following formula:

$$\text{Germination rate (\%)} = \frac{\text{Final germination percentage}}{\text{No. of days taken to reach final germination}}$$

Statistical analysis: Data regarding rate of germination was subjected to analysis of variance followed by Duncan's Multiple Range Test to delineate the means (Steel & Torrie, 1980).

Results and Discussion

Final germination percentage: There was a great variation in final seed germination percentage of seeds collected in different months of the year 2006. Environmental conditions especially temperature and solar radiation during the formation of seeds seem to be the major contributing factor of parthenium seed dormancy. There was highly significant negative correlation between final germination percentage of parthenium seeds and prevailing environmental temperature conditions during the seed formation (Table 4). Maximum germination was recorded in the seeds collected during the coldest months of January and December when the mean daily temperature dropped to 14.1 and 15.1°C, respectively. Germination was slightly decreased to 97 and 87% during November and October with the rise of temperature to 21.1 and 26.6°C. Lowest germination of 0 – 7% was recorded in seeds collected during summer months of April to September when the mean daily temperature raised from 29.2 to 33.6°C (Fig. 1, Table 1). Higher temperature during seed development also increases seed dormancy in some other plant species viz. *Stylosanthes hamata,* soybean, *Fumana ericoides* and *Thlaspi arvense* (Keigley & Mullen, 1986; Llorens *et al*., 2008).

Final germination percentage was also negatively and significantly correlated with solar radiation (Table 4). Seeds formed under high solar radiation (SR) of 18.74 – 23.25 MJ/MF/day during April to September showed dormancy while those under low solar radiation of 9.28 – 16.83 MJ/MF/day during October to December and January do not (Fig. 1, Table 3). Dormancy and germination are complex traits that are controlled by a large number of genes, which are affected by both developmental and environmental factors. Seed dormancy and germination depend on seed structures, especially those surrounding the embryo and on factors affecting the growth potential of the embryo. The latter may include compounds that are imported from the mother plant and also factors that are produced by the embryo itself, including several plant hormones. Genetic analysis has identified the crucial role of abscisic acid (ABA) in seed dormancy, as well as the requirement for gibberellin (GA) for germination (Koornneef *et al*., 2002). Specific signals from the environment such as temperature, light and nutrient availability control the levels of GA and ABA in the seed and these hormones in turn regulate the transition from dormancy to germination. Furthermore, environmental signals, GA and ABA regulate cotyledon expansion inside the seed coat and proposed a model in which environmentally controlled cotyledon expansion breaks dormancy by breaking the seed coat and that this initiates events subsequently leading to seed germination (Penfield *et al*., 2007).

The final germination percentage exhibited an insignificant negative correlation with wind velocity, total precipitation, number of rainy days and relative humidity (Table 4). In the present study seeds produced by parthenium at higher temperature and long days showed lowest germination and exhibited dormancy. However, in most of the earlier studies, seeds produced by plants at higher temperatures, water stress and shorter days have higher germination percentage and/or rates (i.e., lower dormancy) than those produced at lower temperatures, long days and favourable moisture conditions. It has been proposed that the environmental conditions under which plants are grown can affect seed germination by affecting their chemical composition and seed provisioning (eg., mineral, photosynthetic and phytohormone resources) throughout the growing season (Baskin & Baskin, 1998; Galloway, 2002).

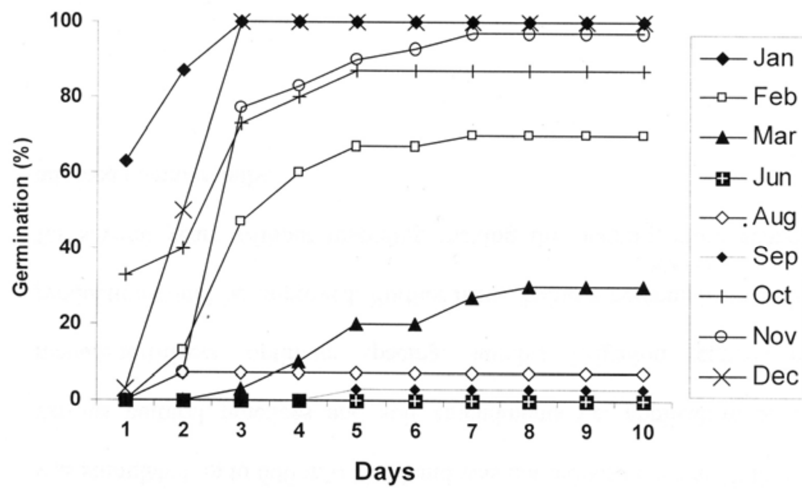

Fig. 1. Daily germination percentage of parthenium seeds collected in different months of the year 2006. Germination of seeds collected in April to July was zero.

Table 1. Temperature regime in different months of year 2006.

Months	Temperature (°C)					No. of stress days with		
	Daily	Maximum		Minimum		Minimum temp. ≤ 0 °C	Maximum temp. ≥ 35°C and R.H. ≤ 30%	Maximum temp. ≥ 40°C and R.H. ≤ 30%
	Mean	Mean	Highest	Mean	Lowest			
January	14.1	19.9	25.2	8.4	3.6	0	0	0
February	20.7	26.7	29.1	14.7	11.6	0	0	0
March	21.5	27.0	34.0	16.1	13.9	0	0	0
April	29.2	35.7	41.8	22.7	16.5	0	17	17
May	33.6	39.7	43.8	27.4	21.5	0	04	04
June	31.8	37.6	42.4	25.9	20.6	0	06	06
July	31.3	35.0	40.3	27.6	22.7	0	0	0
August	30.5	34.0	37.1	26.9	21.2	0	0	0
September	29.1	33.3	35.6	24.9	19.5	0	0	0
October	26.6	31.5	36.0	21.6	17.0	0	0	0
November	21.1	26.0	29.6	16.1	10.8	0	0	0
December	15.1	20.2	23.4	9.9	6.7	0	0	0

Source: Pakistan Meteorological Department, Islamabad, Pakistan.

Table 2. Moisture regime in different months of year 2006.

Months	Precipitation			Reference crop evapo-transpiration (mm/day) ET0	Relative humidity	
	Total	No. of days	Of ≥ 5 mm/day		mean	No. of days with mean R.H. ≥ 80%
January	18.9	06	11.0	1.7	64	02
February	4.9	03	0.0	2.8	61	0
March	42.1	11	37.0	3.2	57	0
April	0.01	05	0.0	6.0	29	0
May	22.4	06	15.4	7.2	40	0
June	87.7	11	84.7	7.3	44	01
July	185.5	10	173.1	4.6	70	07
August	145.7	15	56.3	4.2	74	05
September	157.6	08	114.6	4.5	67	03
October	46.0	03	46.0	4.6	63	01
November	9.0	04	5.0	2.6	67	00
December	30.8	06	28.3	1.6	71	16

Source: Pakistan Meteorological Department, Islamabad, Pakistan.

Table 3. Solar radiation regime during 2006.

Months	Bright sunshine duration		Solar radiation MJ/MF/day	Wind	
	Total (Hrs)	Relative		Mean speed (Km/Hr)	Prevailing direction
January	199.8	0.63	9.92	4.8	NW
February	200.4	0.64	12.28	3.7	NW
March	237.5	0.64	15.84	5.7	NW
April	288.0	0.74	20.25	7.0	NW
May	304.2	0.71	20.89	6.1	SE
June	276.9	0.65	23.25	3.4	SW
July	208.7	0.48	19.55	5.0	SE
August	210.2	0.51	18.74	4.4	SW
September	248.0	0.67	19.00	4.1	NW
October	269.2	0.75	16.83	3.3	W
November	203.5	0.65	12.42	3.2	NW
December	195.1	0.62	9.28	2.8	NW

Source: Pakistan Meteorological Department, Islamabad, Pakistan.

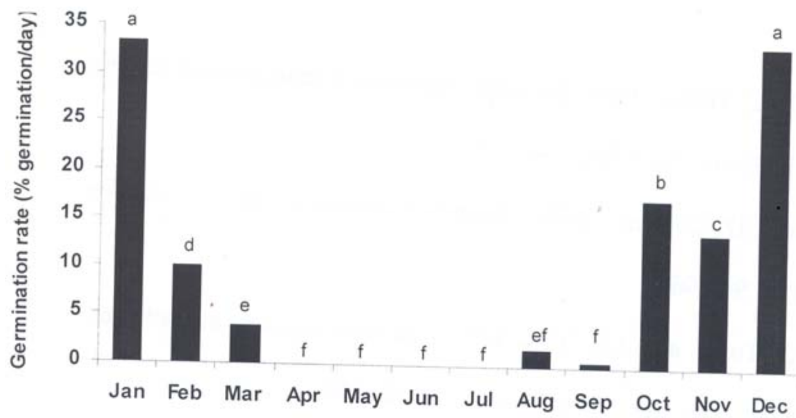

Fig. 2. Percentage germination rate of parthenium seeds collected in different months of the year 2006. Bars with different letters show significant difference as determined by Duncan's Multiple Range Test at p≤0.05.

Rate of germination: There was a significant variation in rate of germination of parthenium seeds in different months. Highest germination rate of 33.3% was recorded in seeds collected during December and January. Germination rate during February, October and November was 10, 17.4 and 13.8%, respectively. Seeds collected during rest of the months showed very low germination rate of 0–3.8% (Fig. 2). Similar to that of final germination percentage, germination rate also showed a highly significant negative correlation with mean daily, mean minimum and mean maximum environmental temperatures and a significant correlation with solar radiation during the seed formation period.

The present study concludes that parthenium seeds show a variable dormancy during different months of the year. Seed dormancy depends on the prevailing environmental conditions during the seed formation period and is negatively correlated with solar radiation and prevailing temperature. Further studies in this regard are suggested to investigate the biochemical processes that occur during the seed formation under different regimes of temperature and solar radiation which are responsible for this seasonal variation in seed dormancy in parthenium.

Table 4. Correlation of maximum germination percentage and germination rate of parthenium seeds with different environmental factors.

	Maximum germination	Germination rate
Mean daily temperature	–0.86*	–0.87**
Mean maximum temperature	–0.86*	–0.87**
Mean minimum temperature	–0.85*	–0.86*
Precipitation	–0.55	–0.44
No. of rainy days	–0.59	–0.43
Relative humidity	–0.44	–0.41
Bright sunshine duration	–0.56	–0.53
Solar radiation	–0.90**	–0.86*
Wind speed	–0.58	–0.48

*, **, Significant at $p \leq 0.01$ and 0.001, respectively.

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References

Alexander, H.M. and R. Wulff. 1985. Experimental ecological genetics in Plantago. X. The effects of maternal temperature on seed and seedling characters in *P. lanceolata*. *J. Ecol.,* 73: 271-282.

Allen, P.S. and S.E. Meyer. 2002. Ecology and ecological genetics of seed dormancy in downy brome. *Weed Sci.,* 50: 241-247.

Baskin, C.C. and M. Baskin. 1998. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination.* Academic Press, San Diego

Biddulph, T.B., J.A. Plummer, T.L. Setter and D.J. Mares. 2007. Influence of high temperature and terminal moisture stress on dormancy in wheat (*Triticum aestivum* L.). *Field Crops Res.,* 103: 139-153.

Butler, J.E. 1984. Longevity of *Parthenium hysterophorus* L., seed in the soil. *Aust. Weed*, 3: 6.

Dhileepan, K. and K.A.D.W. Senaratne. 2009. How widespread is *Parthenium hysterophorus* and its biological control agent *Zygogramma bicolorata* in South Asia? *Weed Res.,* 49: 557-562.

Drew, R.L.K. and P.A. Brocklehurst. 1990. Effects of temperature of mother-plant environment on yield and germination of seeds of lettuce (*Lactuca sativa*). *Ann. Bot*., 66: 63-72.

El-Keblawy, A. and F. Al-Ansari. 2000. Effect of site of origin, time of seed maturation and seed age on germination behavior of *Portulaca oleracea* L. from old and new world. *Can. J. Bot.,* 78: 279-287.

Galloway, L.F. 2002. The effect of maternal phenology on offspring characters in the herbaceous plant. *Campanula americana*. *J. Ecol*., 90: 851-858.

Javaid, A. and H. Adrees. 2009. Parthenium management by cultural filtrates of phytopathogenic fungi. *Nat. Prod. Res*., 23(16): 1541-1551.

Javaid, A., S. Shafique and S. Shafique. 2009. Invasion of noxious alien weed *Parthenium hysterophorus* L. in grazing lands of Lahore, Pakistan. *J. Anim. Plant Sci*., 19: 149-153.

Javaid, A., S. Shafique, R. Bajwa and S. Shafique. 2006. Effect of aqueous extracts of allelopathic crops on germination and growth of *Parthenium hysterophorus* L *South African J. Bot*., 72(4): 609-612.

Keigley, P.J. and R.E. Mullen. 1986. Changes in soybean seed quality from high temperature during seed fill and maturation. *Crop Science*, 26: 1212-1216.

Koornneef, M., L. Bentsink and H. Hilhorst. 2002. Seed dormancy and germination. *Curr. Opin. Plant Biol.,* 5: 33-36.

Llorens, L., M. Pons, L. Gil and H. Boira. 2008. Seasonality of seed production and germination trends of *Fumana ericoides* (Cistaceae) in the west semiarid Mediterranean region. *J. Arid Environ*., 72: 121-126.

McFadyen, R.E. 1992. Biological control against parthenium weed in Australia**.** *Crop Prot*., 11: 400-407.

Meyer, S.E. and P.S. Allen. 1999. Ecological genetics of seed germination regulation in *Bromus tectorum* L. I. Phenotypic variance among and within populations. *Oecologia*, 120: 27-34.

Munir, J., L.A. Dorn, K. Donohue and J. Schmitt. 2001. The effect of maternal photoperiod on seasonal dormancy in *Arabidopsis thaliana* (Brassicaceae). *Am. J. Bot*., 88: 1240-1249.

Navie, S.C., F.D. Panetta, R.E. McFadyen and S.W. Adkins. 1998. Behaviour of buried and surface-sown seeds of *Parthenium hysterophorus*. *Weed Res*., 38: 335-341.

Navie, S.C., R.E. McFadyen, F.D. Panetta and S.W. Adkins. 1996. The Biology of Australian Weeds 27. *Parthenium hysterophorus* L. *Plant Prot. Q*., 11: 76-88.

Penfield, S., I. Graham and K. Halliday. 2007. Control of seed dormancy and germination by environmental signals. *Comp. Biochem. Physiol. - Part A: Mol. Integ. Physiol*., 146 (Supplement 1): 274.

Picman, A.K. and G.H.N. Towers. 1982. Sesquiterpene lactones in various populations of *Parthenium hysterophorus*. *Biochem. System. Ecol*., 10: 145-153.

Ramaswami, P.P. 1997. Potential uses of *Parthenium*. In: *Proc. First Int. Conf. Parthenium Manage.,* pp. 77-80.

Riaz, T. and A. Javaid. 2009. Invasion of hostile alien weed *Parthenium hysterophorus* L. in Wah Cantt, Pakistan. *J. Anim. Plant Sci*., 19(1): 26-29.

Steel, R.G.D. and J.H. Torrie. 1980. *Principles and Procedures of Statistics.* McGraw Hill Book Co., Inc, New York, USA.

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