Seed Biology of Summer and Winter Generations of *Parthenium hysterophorus* L.

Seerjana Maharjan[1,2*], Bharat Babu Shrestha[1], Anjana Devkota[1], Muniappan Rangaswami[3], Pramod Kumar Jha[1]

[1]Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal
[2]Department of Plant Resources, Thapathali, Kathmandu, Nepal
[3]IPM Innovation Lab, Virginia Tech, 526 Prices Fork Road, Blacksburg, VA 24061 USA
*Corresponding email: seerjana9@hotmail.com

Abstract

Parthenium hysterophorus L. is one of the successful invasive plant species in several countries of the world. Seed biology of two generations of Parthenium – summer and winter were studied. Mature seeds were subjected to seed germination experiment for 15 days. Germination Percentage (GP) and Germination Index (GI) were calculated. Seed size and seed mass were also measured. Seeds of summer and winter generations started to germinate on third and fifth day respectively. Higher germination (93%) was observed in seed lots of summer generation as compared to seed lots of winter generation (62%). Both GP and GI were found significantly higher in seeds of summer generation than winter generation. Extended flowering property of Parthenium along with high and continued germination potential in both summer and winter generation seeds could be some of the reasons for its rapid spread in Kathmandu valley.

Keywords: *Parthenium weed, seed germination, weed spread, weed biology, climate*

Introduction

Parthenium hysterophorus L. (Asteraceae) (hereafter *Parthenium*), one of the successful invaders in different parts of the world, was first recorded from Nepal in 1967 but spread significantly since 1990s (Shrestha et al., 2015; Bajwa et al. 2016). It is thought to have introduced unintentionally from India into Nepal via vehicles along the road connections (Shrestha et al., 2015, 2019; Bajwa et al., 2016). Relatively longer reproductive period with large number of seeds and its capacity to germinate and flower anytime when the condition is favorable have made *Parthenium* a successful invader in Nepal (Maharjan et al., 2014). In Kathmandu valley, there was the report of four cohorts of *Parthenium* seedling emergence every year at the same site i.e. in February, May, July and October (Pokhrel, 2013). Hence, the current study focused on its seed biology growing during two seasons i.e. summer and winter in the same site.

Materials and methods

Parthenium seeds from mature plants were collected from single population within 2 m × 2 m area in Kirtipur (27.67°N, 85.29°E, 1292m asl), Kathmandu in the month October 2017 and May 2018 (Figure 1a & b). Seeds collected in October (seedling emerged in July) were considered as 'summer seeds' and those collected in May (seedling emerged in February) as 'Winter seeds'. The seedlings during the month of July-September receive maximum rainfall whereas during the month of February-May receive less rainfall. So, these two months were selected for the seed collection. Seeds collected were placed in paper bag. They were air dried at room temperature under diffused light for 2-3 days and stored at room temperature.

Average monthly minimum temperature of the study area was 2.33°C during the month of January and average monthly maximum temperature was 28.7°C during month of June. The

study area received the total monthly maximum rainfall i.e. 285 mm during July and total monthly minimum rainfall i.e. 2 mm during November. The mean annual precipitation of the study area was 1221.4 mm. The maximum rainfall (884 mm) occur during the month June to September (Figure 2).

(a) (b)

Figure 1: (a) *Parthenium* infested area, (b) Flowering twig with mature flower

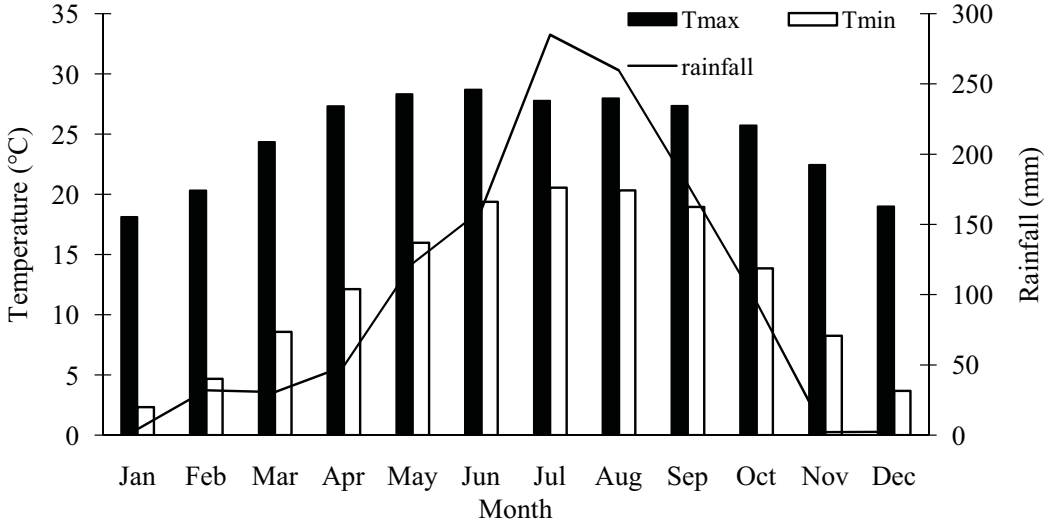

Figure 2: Average monthly minimum temperature (°C) and rainfall (mm) from 2007 to 2016 (ten years) recorded at Khumaltar Station (4 km north east from the study site), Lalitpur (27.67°N, 85.33°E, 1350m asl) (Source: DHM, 2016)

Seed germination experiment was carried out in the laboratory of Seed Science and Technology Division, Nepal Agricultural Research Council (NARC). Seeds were kept for

germination within a week of seed collection (during October for summer seeds and May for winter seeds) to avoid undergoing changes in their germination responses during dry storage at room temperature (Baskin and Baskin, 2014). The germination of seeds of both seasons was evaluated. Seeds of *Parthenium* were surface sterilized in 1% sodium hypochlorite solution for 5 minutes and washed with distilled water before transferred to the petri-plates. Twenty seeds were placed at equal distance in a petri plate containing double layered Whatman no. 1 filter paper moistened with 6 ml of distilled water. Replicates of thirty was maintained for both generations. All the petri plates were kept randomly in seed germinator (Accumax India AI-102) at constant temperature (25±2ºC). Appropriate moisture was maintained by adding distilled water as needed. Seeds were recorded as germinated when the radicle had broken through testa. The number of seeds germinated were counted and removed every day, to avoid any confusions while counting, till fifteenth day of the initiation of experiment. Seed germination percentage and modified Rozema index of germination index (GI) were calculated using following formula (Zheng et al., 2004).

$$\text{Germination percentage (GP)} = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds}} \times 100$$

$$\text{Germination index (GI) (\%)} = \Sigma(G_i/nt_i*100)$$

Where G_i is the number of seeds germinated at day t_i

t_i is the day 1, 2, 3, 4, 5, ……

n is the total number of seeds used

GP only reflects the final percentage of germination attained but do not provide the picture of speed or uniformity of germination whereas GI gives the most comprehensive measurement parameter combining both germination percentage and speed (Kader, 2005).

Seed size and seed mass

Air dried seeds that were collected for seed germination experiment were packed in airtight plastic bags before the measurement. Images of the 30 seeds per season were taken using a 10× objective lens fitted with camera (Excelis Unitron S/N 1505206) to the microscope (Biolam 2100-03) and the software CaptaVision version 3.6.9.1 (ACCU-SCOPE) was used to capture and measure the seed size (length and breadth) of the image (Fan et al., 2018). Before measurement the software was calibrated by using stage microscope for accuracy. Three batches of air-dried seeds, each containing 100, were weighed to determine mass using a digital balance with an accuracy of 0.0001g (KERN ALS220-4N).

Statistical analysis

All experiments were conducted in a randomized complete block design. All the analysis was performed by using R program 3.6.1 (R Core Team, 2019). Mann-Whitney-Wilcoxon test was performed to check statistical difference between germination percentage and germination index (GI) of two seasons as the data were not normally distributed. Seed size and seed mass data were normally distributed. t-test was performed to check the statistical difference between these data of two seasons.

Results and discussion

Germination percentage (GP) and germination index (GI) was found significantly higher in summer generation than in winter generation indicating increased speed of germination in summer seeds (w = 892.5, 856; p<0.001) (Kader, 2005) (Figure 3a and 3b). It has been reported that highly invasive biotype of *Parthenium* exhibited 100% germination in the laboratory without any physiological or physical dormancy mechanism (Bajwa et al., 2017; Adkins et al., 2019). The maximum germination ability of the seed without any seed dormancy is one of the important contributing factors in high invasiveness of *Parthenium*. Non dormancy in seeds of *Parthenium* is one of the major factors which help its extensive spread and establishment (Javaid et al., 2010).

First day of germination (FDG) in majority of the Petri plates (26) was the third day for the summer seeds while for the winter seeds the germination started only after fifth day. This indicates that the summer seeds have tendency to germinate faster in comparison to the winter seeds.

When we compared the day wise germination, maximum germination was recorded in fifth day for summer seeds (17%) and in sixth day for winter seeds (19%) (Figure 4). This indicates that the seeds of both generation of *Parthenium* have tendency to germinate earlier.

The average seed length and breadth for summer seeds was 2.43±0.2 mm and 1.35±0.1 mm and those for winter generation was 2.32±0.3 mm and 1.24±0.2 mm respectively. The seed size (length and breadth) of summer seeds were found significantly higher than those of winter seeds (t = 4.04, 5.14; p<0.001) (Figure 5). High rainfall during the summer season might be the reason behind the large seed size indicating favorable growth of the plant. The mass of *Parthenium* achene ranged from 43.8 to 54.4 mg per 100 achenes. Small seed size and mass is correlated with high seed output and seed dispersion by wind to the longer distance (Rejmánek and Richardson, 1996; Pysek and Richardson, 2007). The better and fast germination of larger achenes than small ones could be the result of greater food reserves as reported by Pandey and Dubey (1988).

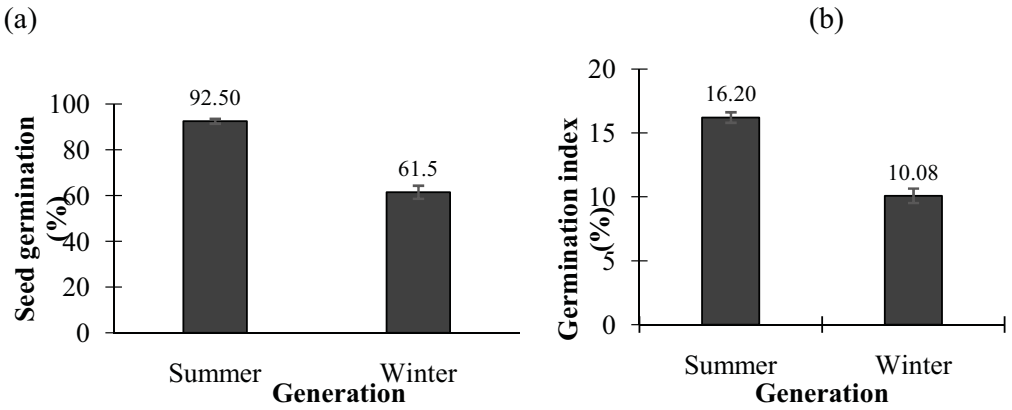

Figure 3: Seed germination percentage (a) and germination index percentage (GI) (b) of two different generations of *Parthenium*

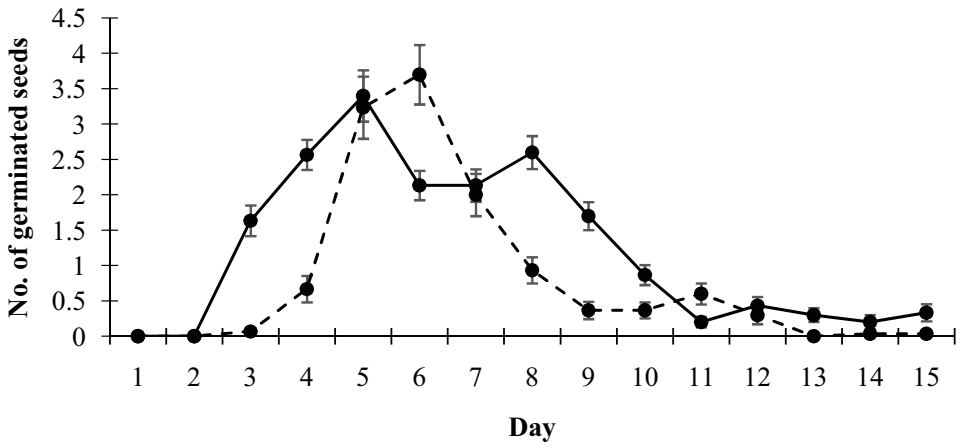

Figure 4: Average germination of summer generation (solid line) and winter generation (dashed line) *Parthenium* seeds. Bars indicate ±SE.

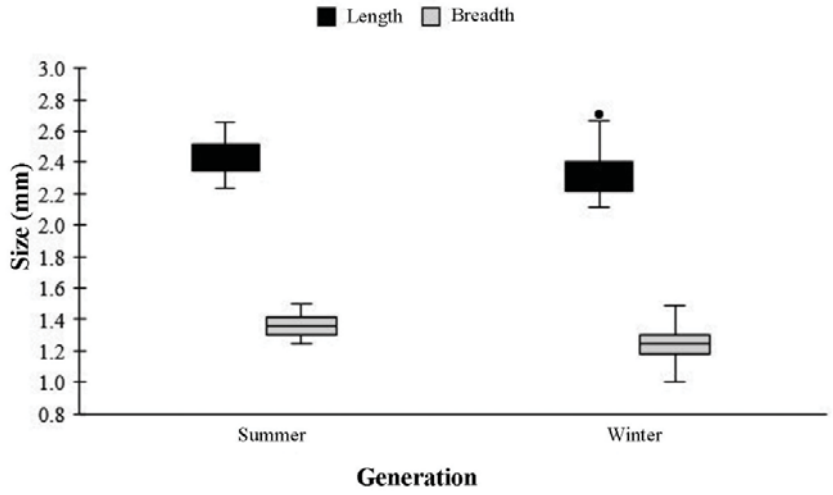

Figure 5: Seed size of two different generations of *Parthenium*

The rainfall reached to the maximum during the summer season (July-August) (Figure 2). Summer season is the most favorable season for the good growth of *Parthenium* in the study site (Pokhrel, 2013) which might be the reason for the development of larger seeds. Winter generation seeds are comparatively smaller in size which might be due to the colder temperature and less favorable environment as compared to the summer season (Figure 5). Studies of Roozrokh et al. (2005) showed that the large seeds have high germination percentage in compare with small seeds due to high protein production. There was the report of seed germination percentage with increase in seed size of *Parthenium* (Pandey and Dubey, 1988). Seed size is one of the most important characteristics of seeds that can affect the seed development duration (Rezapour et al., 2013). Hence, increased size of the seed could be the reason for the maximum germination of seeds with high germination speed in summer seeds compared to the winter seeds.

There is the report of the occurrence of *Parthenium* with the extended flowering period throughout the year producing large number of seeds from Ethiopia (Tamado et al., 2002), Nepal (Pokhrel, 2013), Pakistan (Fatimah and Ahmad, 2009). Extended flowering period is

considered as one of the important biological traits of invasive species that directly contributes to the fast spread in the new regions (Pyšek et al., 2009). This property of *Parthenium* along with more than 60% germination even in winter seeds and continued germination potential in both seasons could be some of the reasons for its rapid spread in Kathmandu in last 20-25 years.

Conclusion

Parthenium hysterophorus has ability to produce flower throughout the year with distinct generations in Nepal. Extended flowering property of *Parthenium* along with high, early and continued germination potential in both summer and winter generation seeds could be some of the contributing factors for its rapid spread in Kathmandu Valley.

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