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Factors Affecting Seed Germination of *Convolvulus arvensis* and *Lathyrus aphaca*

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ABSTRACT

Laboratory and screen house experiments were conducted to evaluate the effect of temperature, salinity, osmotic potential, light/dark periods, seeding depth and flooding on germination of *Convolvulus arvensis* and *Lathyrus aphaca*. Maximum germination of *C. arvensis* (41%) and *L. aphaca* (91%) was recorded at 20°C which decreased with any increase or decrease from optimum temperature. *C. arvensis* and *L. aphaca* had maximum germination with distilled water compared with salt solution. *C. arvensis* and *L. aphaca* germination was 20 and 55%, respectively, at 200 mM NaCl conc. Osmotic potential of -0.8 MPa reduced the germination of *C. arvensis* to zero, whereas 3% *L. aphaca* germinated at this stress. Light was not pre-requisite for the germination of these weed species. Optimum depth for the germination of *C. arvensis* and *L. aphaca* was 1.0 cm where corresponding germination was 40 and 79%, respectively. Reduction in germination and growth was recorded with increase and decrease from the optimum depth. *L. aphaca* was able to germinate and emerge from higher depths of 8.0 cm. Tolerance towards flooding was significant for both species as *C. arvensis* tolerated 20 days of flooding, whereas *L. aphaca* germinated (17%) after 40 days of flooding and 2% after 80 days of flooding. These factors can be exploited for their management.

Key words : Temperature, salinity, osmotic potential, light, seeding depth, flooding, management

INTRODUCTION

Weed biology is concerned with taxonomy, genetics, establishment, growth and reproduction, whereas the ecology of weed is concerned with the development of a single species within a population of plants on a given site. The numerous environment factors have a pronounced influence on all of these processes and systems. Knowledge of weed biology and environmental management practices makes it possible to shift plant populations and communities in desired directions. At present, the weakest link in effective weed management programme is the lack of basic biological and ecological information. Advance information on weed biology and ecology is a key to improve weed management programme and biology of the species determines the strengths and weakness which allow for the development of robust weed control strategies to ensure the sustainability of our agricultural systems.

Field bindweed (*C. arvensis*) is a perennial vine native to Eurasia and belongs to Convolvulaceae family. Leaves are round to arrow-shaped, 2.5-5.7 cm long and alternate. It is a major weed of several winter and summer crops. Flowers are white to pale pink, funnel-shaped approximately 1.9-2.5 cm across and are subtended by small bracts. Fruits are light brown, rounded and 0.3 cm wide. Each fruit contains two seeds that can be eaten by birds and can remain viable in the soil for decades. It reproduces by seeds and creeping roots which may be as deep as 6-9 m. Each root fragment of bindweed can grow into an infestation upto 3 m in diameter in one season. It is a noxious perennial weed with deep tap root system usually competes for resources and also clings to the crop and makes the inter-culture operation difficult.

L. aphaca belongs to Leguminoseae family and is commonly known as the yellow pea or yellow vetch**.** It is native to southern Europe, parts of Asia and North Africa. It is glabrous, annual, 20-50 cm tall. The leaves composed of a stiff rachis tapering to a pre-hensile unbranched tendril and leaflets are generally lacking. Flowering occurs in Feb-April, usually single in the leaf axils, lemon yellow in colour and pods are 2-5 cm long and 3-5 mm wide.

L. aphaca and *C. arvensis* are major weeds of **rabi** season crops (Singh *et al.,* 1995). Manipulation of temperature (irrigation, mulch, fire and cropping system), pH and salinity (soil amendments), light (night plouging/ seeding, mulch), seeding depth (ploughings, zero or

minimum tillage) and flooding (holding rain water, irrigation) can significantly affect germination, emergence and growth of weed species thus affecting crop-weed competition to a large extent. Integration of these eco-biological factors with innovative agronomic practices and herbicides is desired for a sustainable weed management as single method is not effective in the long term.

So, present experiment was designed to study the effect of temperature, salt stress, osmotic potential, light, depth of sowing and flooding duration on germination of *C. arvensis* and *L. aphaca.*

MATERIALS AND METHODS

General Information

Experiments on *C. arvensis* and *L. aphaca* were conducted at CCS Haryana Agricultural University, Hisar during 2009-10 under screen house and laboratory conditions. There were seven factors for which germination and growth were studied. Pot studies were carried out to study the effect of sowing depth and flooding durations under screen house conditions and the rest of the factors were studied in weed science laboratory. Screen house experiments were conducted using plastic pots of 25 cm height and top diameter of 15 cm with 10 kg soil capacity. Soil used for filling the pots was in the ratio of 3 : 1 : 1 with field soil, dunal sand and vermicompost. The field soil was sandy loam in texture containing 0.45% organic carbon, 27 kg/ha P_2O_5 and 542 kg/ha K_2O with a pH value of 8.0 and was collected from fields where no herbicides were used for the last four years. Seeds were treated with 0.1% sodium hypochlorite immediately before each experiment for 30 min and washed 3-4 times with distilled water so as to ensure disease free seeds. In all studies, each treatment included four replications per treatment and each experiment was conducted twice in the same season. All the experiments were conducted in completely randomized block design and experimental data were analyzed using software SPSS version 7.5.

Effect of Temperature

To determine the effect of temperature on germination of the above mentioned weed species, 20 seeds of each weed were placed uniformly between two layers of filter papers (Whatman No. 1) of 90 mm in Petri dishes of 100 mm diameter (Borosil glass) and moistened with distilled water and then incubated at 5, 10, 15, 20, 25, 30 and 35°C±1.5°C in seed germinators (Khera Instruments (P) Ltd, Azadpur, Delhi). The filter paper and seeds were kept moist throughout the period by regular application of distilled water. Temperatures were maintained constantly in incubator without any diurnal fluctuations in temperature and germination was determined periodically.

Effect of Salt Stress

To determine the effect of salt stress on germination, the seeds were incubated in 0, 25, 50, 100 and 200 mM sodium chloride (NaCl) solution. The solution of 200 mM concentration was prepared first as stock solution and subsequent solutions were made by dilution.

Effect of Osmotic Potential

Aqueous solutions with osmotic potential of 0, -0.2, -0.4, -0.6 and -0.8 MPa were prepared by dissolving 0, 105.64, 161.29, 204.44 and 240.97 g of polyethylene glycol (PEG 8000) in distilled water as described by Michel (1983)**.** Disinfected seeds were incubated in the Petri dish filled with 10 ml of freshly prepared solution and germination was determined as previously described.

Effect of Light

To evaluate the effect of light on germination, seeds were placed in Petri dish with 10 ml distilled water and kept under six regimes of light periods (0, 3, 6, 12, 24 and 48 h). After the given light hour the Petri dishes were immediately wrapped up with double layer of aluminum foil to ensure no light penetration. Wrapped Petri dishes were kept for seven days undisturbed and then were unwrapped to observe germination. Germination was finally determined as described previously.

Effect of Sowing Depth

The effect of sowing depth on seedling emergence was studied in a screen house. Pots were filled with a 3 : 1 : 1 mixture of field soil, dunal sand and vermicompost. Twenty seeds of each weed species were placed on the soil surface or covered to a depth of 0.5,

1.0, 2.0, 4.0, 8.0 and 16.0 cm with the same soil. Pots were sub-irrigated initially to field capacity. Emergence counts were recorded at weekly interval. Plants were considered emerged when cotyledon could be visibly discerned.

Effect of Duration of Flooding

Twenty seeds of each species were sown 1 cm deep in plastic pots. There were six levels of flooding durations maintained for 0, 5, 10, 20, 40 and 80 days. Flooding was maintained by keeping the pot without hole at the bottom upto the desired days and watering the pots twice a day upto the top of the pot. The holes were made at the bottom after 0, 5, 10, 20, 40 and 80 days, respectively. Observations were made at weekly interval after making the holes i. e. after draining the standing water over the soil surface.

RESULTS AND DISCUSSION

A. Laboratory Experiments

Effect of temperature on germination : Maximum seed germination was reported at 20^{O}C (41%) in *C. arvensis* (Fig. 1) and minimum at 5°C (9%). The germination of *C. arvensis* at 10, 15 and 25°C was non-significant in comparison to the 20°C. The germination at 5°C significantly differed from all the temperature regimes. Germination of *L. aphaca* was also favoured by 20°C at which maximum germination (91%) was recorded. *L. aphaca* germinated well under wide range of temperature regimes. Germination followed a polynomial response for *C. arvensis* ($y=-3.404x^2+26.59x-8.714$ and $R^2=0.869$) and *L. aphaca* ($y=-5.357x^2+34.28x+42.14$ and $R^2=0.789$) where germination first increased from 5 to 20°C and thereafter decreased. These

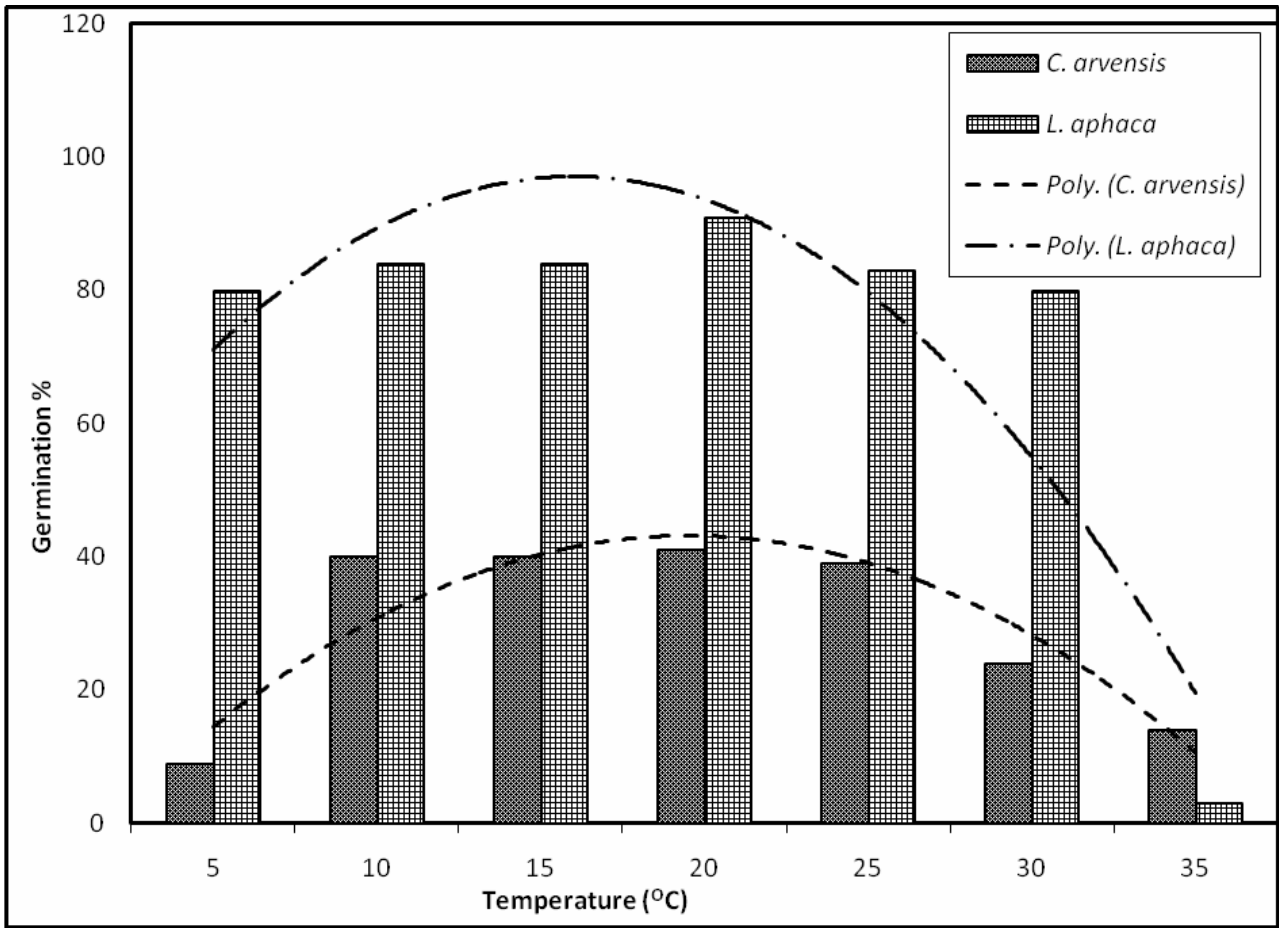

Fig. 1. Effect of temperature regimes on germination (%) of different weed species.

results are similar to those of Gresta *et al*. (2007) on different species of *Medicago* where 20°C was found optimum for germination.

The favourable temperature for *C. arvensis* was 20°C but it germinated with similar vigour at higher temperature of 35°C also (Fig. 1), which indicates its germination potential towards higher temperature which could assist it to grow throughout the crop season as well as beyond seasonal growth on roadside, fences, etc. Singh and Singh (2009a) reported maximum germination of 12 weed species at 30/20°C; higher temperature of 45/35°C was less inhibitory for *Desmodium tortuosum*, *Sorghum halepense* and *Amaranthus retroflexus* compared to lower temperature of 15/10°C.

In contrary to *C. arvensis* some seed (3%) of *L. aphaca* germinated at 35°C, it is supported by the fact that some of the weed species may germinate at a higher temperature, but may not grow at that high temperature, as the optimum temperature for the germination of small flower morningglory (*Jacqemontia tamnifolia*) was 35 to 40°C, but optimum growth was between 25 to 35°C (Shaw *et al*., 1987).

L. aphaca was able to germinate even at low temperature of 5°C (Fig. 1) that did not significantly differ from the maximum germination. It grew equally well from 5-30°C (Fig. 1). Lu *et al*. (2006) also reported that Crofton weed (*Eupatorium adenophorum*) seed also germinated over a range of 10-30°C temperature. Labouriau and Agudo (1987) suggested that cardinal temperatures were important for the understanding of plant species occurrences.

Effect of NaCl germination : Seed germination was significantly affected by salinity levels; germination was decreased significantly with increase in salt concentration species (Fig. 2). Maximum germination of 58 and 85% was noted in distilled water for both weed species, respectively. Salt concentration of 200 mM reduced the germination of *C. arvensis* to one third

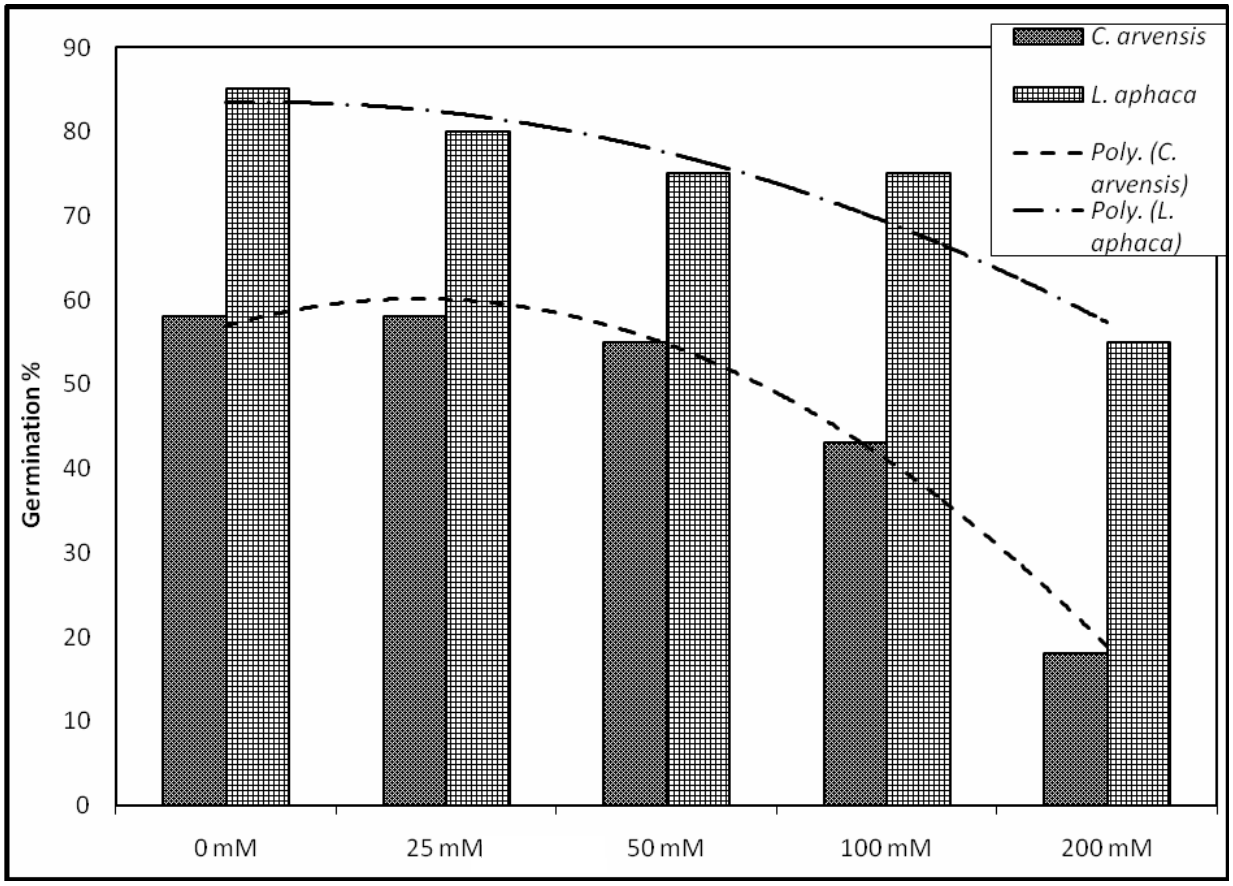

Fig. 2. Effect of NaCl (mM) on germination (%) of different weed species.

of the control, whereas *L. aphaca* was moderately tolerant to salt stress. Moderate salinity did not inhibit the germination of *L. aphaca* as 55% germination was observed even at 200 mM. It was clear from the polynomial model of *C. arvensis* ($y = -1.666x^3 + 13.21x^2 - 35.11x + 109$ and $R^2 = 0.975$) and *L. aphaca* ($y= -4.214x^2+15.78x+45.4$ and $R^2=0.991$) that germination was adversely affected with increase in NaCl.

C. arvensis and *L. aphaca* were fairly tolerant to the NaCl concentration. Seed of *C. arvensis* and *L. aphaca* germinated > 18 and 55%, respectively, at 200 mM NaCl (Fig. 2). Shaddad *et al.* (1990) reported that salinity had adverse effect on the germination of *Lupinous termis* and *Vicia faba* which are also non-halophytic leguminous plants similar to *L. aphaca*. Similar findings were reported by Koger *et al*. (2004) that even at high soil salinity of 160 mM NaCl, *Caperonia palustris* seed could germinate. In this study, the germination of *C. arvensis* and *L. aphaca* occurred over a relatively broad salinity range from 0 to 200 mM NaCl (Fig. 2). This result is similar to the findings of El-keblawy (2004) who showed that the seed germination of *Panicum turgidum* was greatly reduced by increasing the salt concentration and completely inhibited at 300 and 400 mM NaCl and KCl. The tolerance in *C. arvensis* and *L. aphaca* towards salinity shows that these species have potential for development as a serious weed which could grow with soil or waters of higher than normal salinity. However, more trials at different stages of the life cycle are required before this possibility can be confirmed.

Effect of osmotic potential on germination : As osmotic potential decreased from 0 to -0.8 MPa, seed germination of *C. arvensis* and *L. aphaca* decreased substantially. Germination of *C. arvensis* and *L. aphaca* was maximum (60 and 88%, respectively) with no water stress (Fig. 3). At -0.2 MPa, germination of *L. aphaca* was similar to distilled water, whereas *C. arvensis* germination differed significantly at each level of osmotic stress with minimum 15% at -0.6 MPa and no germination in -0.8MPa. A polynomial regression of *C. arvensis* ($y= -5E-14x^3+0.428x^2-17.57x+77.4$ and $R^2=0.997$) and *L.*

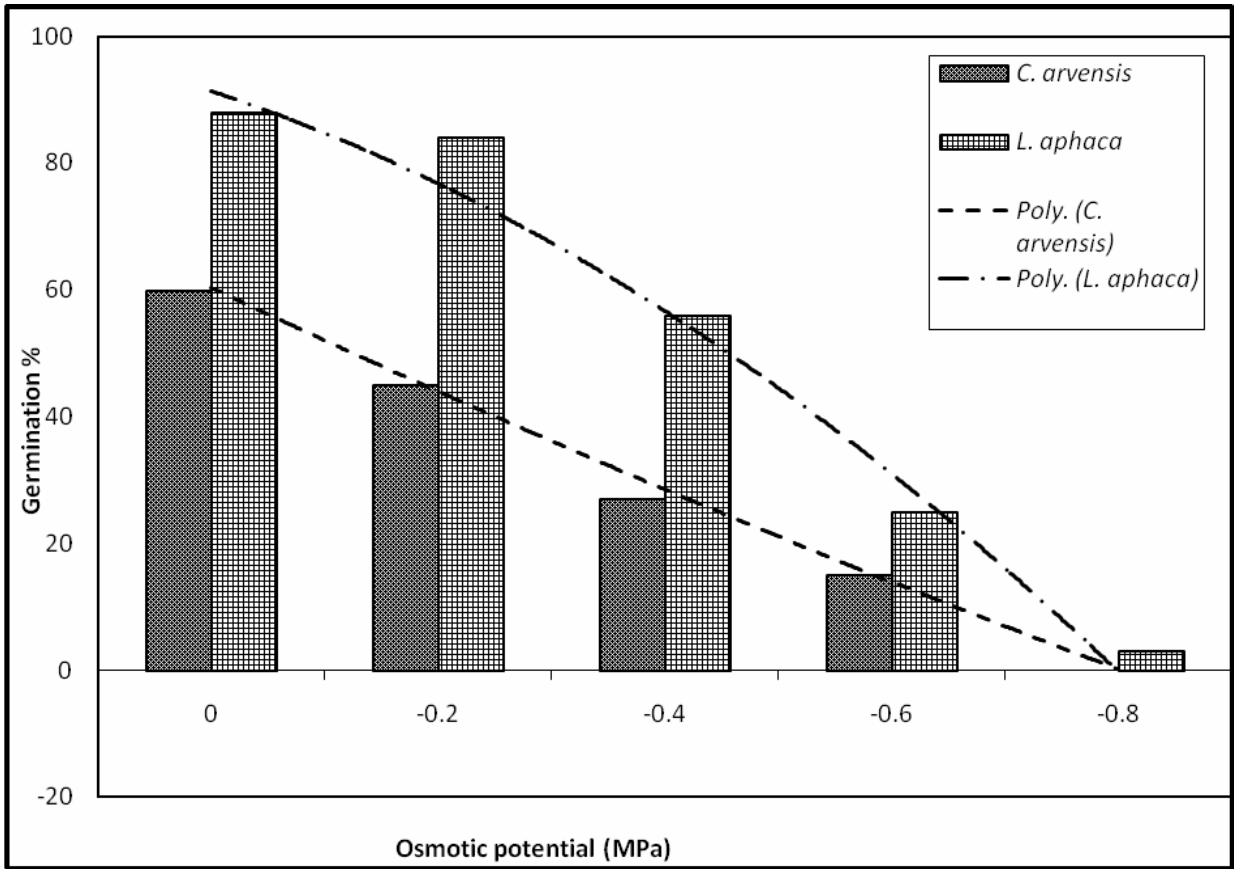

Fig. 3. Effect of osmotic potential (MPa) on germination (%) of different weed species.

aphaca ($y=-52.17x^2+127.7x$ and $R^2=0.977$) showed that the germination decreased with increasing the osmotic stress from 0 to -0.8 MPa (Fig. 3).

Low osmotic potential was found to inhibit germination of *Campsis radicans* (Chachalis and Reddy, 2000), *Caperonia palustris* (L.) (Koger *et al*., 2004) and Cadillo (Wang *et al.,* 2009). Singh and Singh (2009b) reported that a low water stress of -0.1 MPa was able to significantly reduce the germination of *Ambrosia artemisiifolia*, *Morrenia odorata*, *Bidens pilosa* and *Amaranthus retroflexus*.

L. aphaca was able to germinate at -0.8 MPa, though germination was reduced by 97% compared to no stress, which shows its ability to tolerate mild stress. Similar to *L. aphaca* some hairy beggerticks seed germinated (3%) at a water potential of -0.75 MPa (Reddy and Singh, 1992). Singh and Singh (2009b) reported 28, 9 and 3% germination of *Desmodium tortuosum*, *Cyperus esculentus* and *Ipomoea purpurea*, respectively, at -0.8 MPa. Germination over a broad range of osmotic potential indicated that *L. aphaca* could emerge and compete under low soil moisture conditions.

Effect of light periods on germination : Results indicated that light was not a pre-requisite for germination of *C. arvensis* and *L. aphaca* (Table 1). These results are similar to sicklepod (*Senna obtusifolia*) which was not responsive to light (Norsworthy and Oliveira, 2006), while dissimilar to *Celosia argentea* which was stimulated by light for higher germination (Chauhan and Johnson, 2007)**.** Singh and Singh (2009a) reported that light stimulated germination of *Richardia brasiliensis*, but had no effect on *A. artemisiifolia*, *D. tortuosum*, *I. hederacea*, *I. purpurea*, *M. odorata*, *S. halepense*, *B. pilosa*, *A. retroflexus*, *Cassia obtusifolia*, *Sida spinosa* and *C. esculentus*.

Table 1. Effect of light period (h) on germination (%) of different weed species

Light periods (h)	4 WAS	
	C. arvensis	*L. aphaca*
0	51 (46)	89 (70)
3	50 (45)	88 (70)
6	48 (44)	86 (68)
12	50 (45)	86 (68)
24	49 (44)	88 (69)
48	49 (44)	88 (69)
Mean	49	87
LSD (P= 0.05)	NS	NS

Transformed values in parentheses. NS–Not Significant.

Seed germination response to light varies from species to species. Seeds of some species require light to germinate (Chauhan and Johnson, 2008a) and others can germinate equally in light and dark (Chauhan and Johnson, 2008b). Effect of light on germination is an indicator to conform whether seed can germinate from deeper depths. Higher germination under both the conditions i. e. light and dark shows that these weeds can germinate from deeper depths.

B. Screen House Experiment

Effect of sowing depth on emergence : Surface placed seed of *C. arvensis* did not germinate; it was also unable to emerge from 8 and 16 cm depths (Fig. 4). Maximum number of seeds germinated within a period of two weeks in *C. arvensis*. Highest number of seedlings (63%) emerged from 1 cm depth, which were significantly different from other depths. Emergence was around 40% for 0.5 cm, and 2 and 4 cm which were statistically at par.

L. aphaca emerged in regular flush upto three weeks from surface upto 4 cm depth and then no further emergence was noticed.Though *L. aphaca* also emerged from 8 cm depth during fourth week but could not emerge from 16 cm depth (Fig. 4). The maximum emergence of *L. aphaca* was 88% from 1 cm depth, seed emerged within 4 cm of the soil surface, but delayed emergence could occur from as deep as 8 cm. *C. arvensis* ($y=-4.681x^2+28.20x$ and $R^2=0.681$) and *L. aphaca* ($y=-3.298x^2+37.18x$ and $R^2=0.922$) followed a quadratic response to increasing depth, with increasing emergence from surface to optimum depth of 1.0 and 2.0 cm and then decreasing emergence with increasing depth (Fig. 4).

Significantly reduced emergence with increased seeding depth could be by poor gas exchange created by the oxygen consumption of germinating seed as demonstrated by Benvenuti (2003). Thus, deep tillage operation might be needed to invert the soil and bury the seeds deeper than 8 cm, where seed would be unable to emerge. Similarly, placing the seed on surface by field preparation may help reduce their weed seed bank as many weeds fail to emerge from surface (Singh *et al*., 2007; Singh and Punia, 2008; Singh, 2010).

No seedlings emerged beyond the placement depth of 4 cm in *C. arvensis* and beyond 8 cm in case of

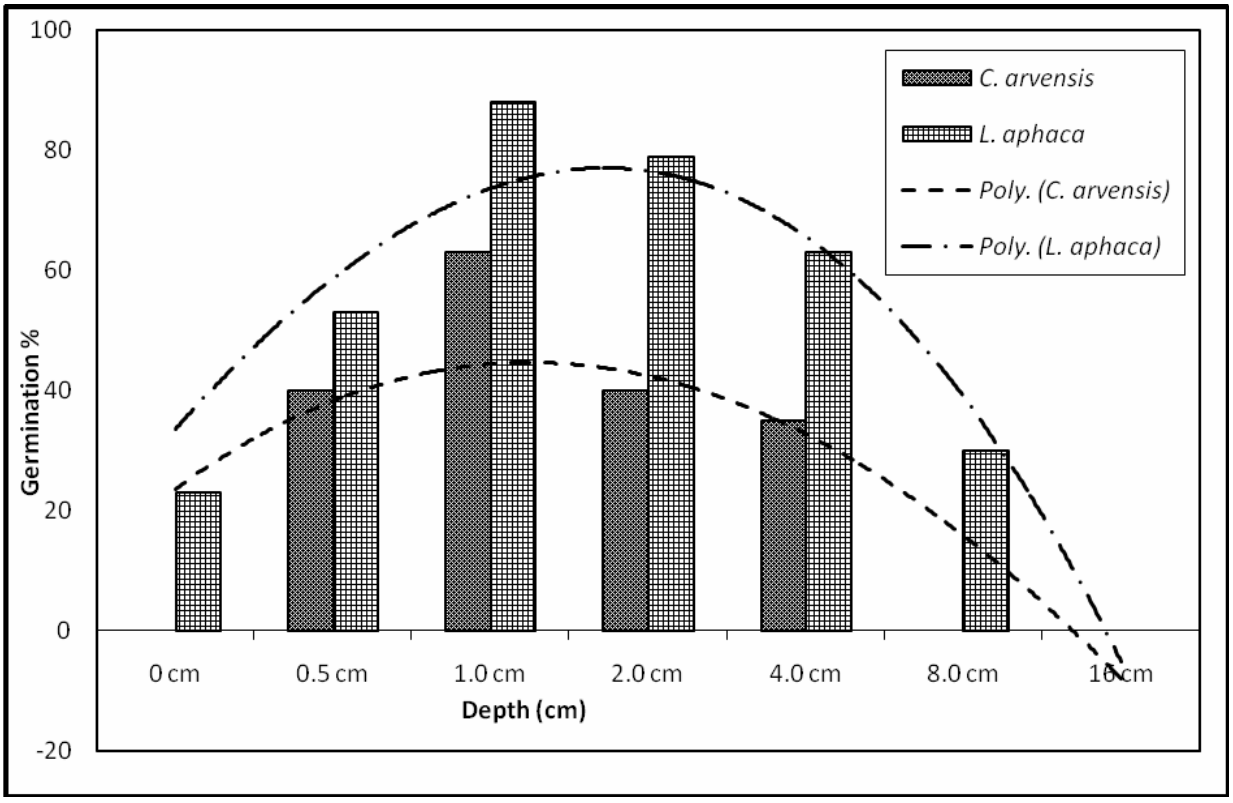

Fig. 4. Effect of seeding depth (cm) on emergence (%) of different weed species.

L. aphaca (Fig. 4). Larger seed with greater carbohydrate reserves can emerge from greater depths of burial (Baskin and Baskin, 1998; Singh *et al*., 2007). *L. aphaca* seed was comparatively larger than *C. arvensis* and hence germinated from 8 cm depth, whereas *C. arvensis* could not germinate at this depth. Limited soil to seed contact, light conditions on the surface and water availability may be some environmental conditions limiting emergence of seed on the soil surface (Ghorbani *et al.,*1999). Seeds placed just below the surface receive adequate water for emergence initiation and emergence (Webb *et al.,* 1987; Ghorbani *et al.,* 1999).

Effect of flooding on emergence : It was observed that flooding adversely affected the emergence of *C. arvensis* and *L. aphaca* (Fig. 5). Emergence declined from 63% in *C. arvensis* under control to 13% with 20 days of flooding and no emergence was reported after 20 days of flooding (Fig. 5). *C. arvensis* and *L. aphaca* had maximum emergence from no flooding condition and it was significantly higher over flooding conditions. *L. aphaca* was more tolerant to flooding than *C. arvensis* as it emerged even from 40 and 80 days of flooding treatments (Fig. 5). Five days of flooding (62%) did not affect emergence of *L. aphaca* significantly as it was statistically similar to the control pots. None of the species in the experiment preferred the flooding conditions; however, some seedlings emerged after draining of water. The emergence data were regressed with logarithmic model for *C. arvensis* ($y=-27.6\ln(x)+48.64$ and $R^2=0.882$) and *L. aphaca* ($y=-34.3\ln(x)+74.81$ and $R^2=0.850$) and found that the emergence decreased with increase in flooding days (Fig. 5).

The data showed that flooding period of more than five days adversely affected emergence (delayed) and also affected growth of both of the weed species (data not included).

The per cent emergence under flooding was reduced probably as a result of the anaerobic conditions created by the flooding. According to Opic (1980), artificial prolongation of natural anaerobiosis leads to death in a few days of the seeds of some species though it can be endured by others.

The decreased seedling emergence under flooding was due to reduced oxygen level and accumulation of certain toxic substances due to anaerobic

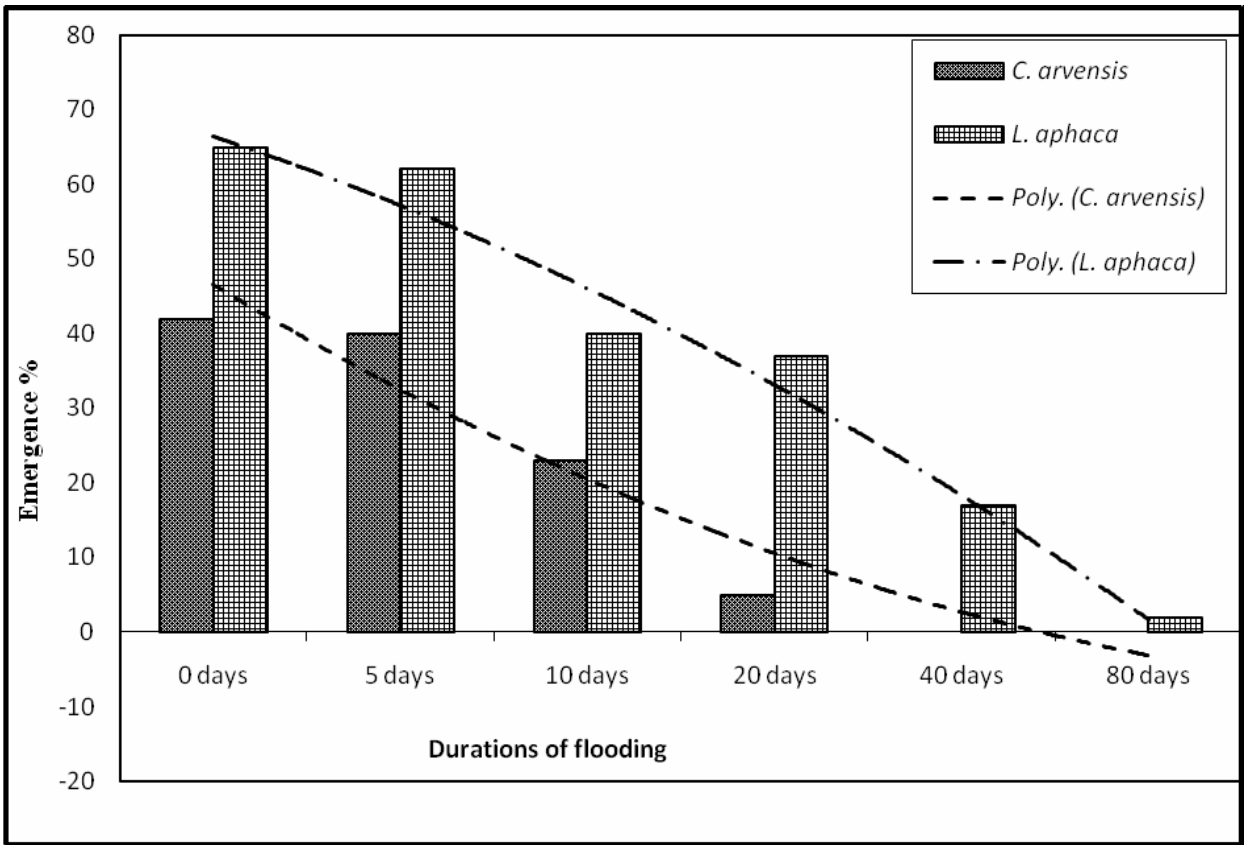

Fig. 5. Effect of flooding durations on emergence (%) of different weed species.

decomposition (Smith and Fox, 1973). Benvenuti and Macchia (1995) reported that oxygen deficiency in soil due to flooding also restricted diffusion of toxic metabolites into surrounding environment affecting seed emergence. Flooding has been found to adversely affect emergence of several weed species, though emergence of some is stimulated by flooding (Singh *et al.,* 2007; Singh and Punia, 2008; Singh, 2010). Flooding thus can be selectively used to control weeds which are sensitive to higher moisture in exhausting their seed bank and lowering the competition with crops.

Both, *C. arvensis* and *L. aphaca* are bold seeded weeds, but their response to temperature, moisture and salt stress, seeding depths and flooding periods varies significantly. These findings can selectively be used in the management strategies based on the dominance of particular weed species in the field.

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