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# Germination Ecology of Marigold (*Tagetes erecta* L.)

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## Abstract

*Tagetes erecta* L. (Marigold) is an aromatic, branched, erect, annual herb. It is ideal for gardens and petals are used as a source of xanthophyll pigments.One of the greatest problems for marigold cultivation is poor germination under adverse field conditions. Present study evaluated theinfluence of environmental factors on germination and emergence of marigold,which help to develop effective management strategies. In this study, effect of temperature, light, salinity, drought, pH, flood and seed burial depth on germination were tested. Result showed that marigold germinate within the temperature of 25°C to 30°C, with a peak 25°C. The alternating light (day/night) and darkness tended to produce even higher germination rates indicate thatgermination was not influenced by light. The seeds were able to germinate over pH 4- 12, but germination rate was higher in pH 7 (neutral). The seed germination was 98.68% with pH 7. This data indicates that marigoldis not tolerant to both acidic and alkaline conditions. The seeds germinated well after being placed in saturated or flooded conditions (70%). The seedling emergence was higher on the soil surface compared to the seeds placed below 0.5 cm soil layer. This study indicates that marigold seed is capable of germinating over a range of environmental conditions.

**Keywords:** Marigold, *Tagetes erecta*, environmental factors, temperature, salinity, drought.

## INTRODUCTION

*Tagetes erecta* L. (Marigold) is a herbaceous plant of family Asteraceae and popularized as a bedding plant, cut flower, or as a coloring agent.It is an aromatic, branched, erect, annual herb. It is ideal for gardens. The species is grown around field crops to control pest activity. Poultry industry is extensively using marigold petals as a natural source of xanthophyll pigments to strengthen yellow colour of egg yolk (Scott *et al.,* 1986). Carotenoid pigments extracted from petals are used in food industry (Gupta, 2014). The aerial parts of the plant contain high quality of essential oil that can be used for scenting soaps, perfumery, cosmetic, and pharmaceutical industries (Heywood and Harborne, 1977).

One of the greatest constraints for marigold production is poor germination and seedling establishment under adverse field conditions. Therefore characterization of seed quality is important for the productivity of crops. Large scale plantations of marigold are largely dependent upon quality of seeds. Seed quality, in turn, comprises both the physiological viability and vigour of the seeds and their genetic quality. The ability to produce vigorous and healthy seedlings in the field, which are well adapted to the field, is an essential complement to genetic quality. Secondly, planted seedlings are intended to provide the necessary product due to its high viability and vigour (Bahru *et al.,* 2015). Hence, studying the germination ecology of seeds helps to select rapidly and vigorously germinating seeds under favourable environmental conditions that are capable of producing vigorous seedlings in the field.

Germination and seedling establishment are critical stages in the plant life cycle and plants are exposed to various abiotic factors throughout the course of their growth and development (Zhao *et al.,* 2005). The major abiotic stresses to which plants are exposed include extreme temperature, drought or high salinity. Several studies have been reported that the seed germination and seedling emergence of a species are influenced by factors such as seed size, seed age, sowing depth, soil type, pH, temperature, moisture and light (Hou and Wang, 2000; Hossain *et al.,* 2001). At sub-optimal environmental conditions, poor seed germination and subsequently poor field establishment, is a common phenomenon. Knowledge of the influence of climatic and edaphic factors is important for seed germination.

It is assumed that the seed germination and seedling emergence of marigolds are influenced by the characters of the seed and various climatic and edaphic factors, but comprehensive studies on germination ecology are not available in this species. Therefore, the present study aimed at investigating the effect of temperature, pH, light, salt, drought, seed sowing depth and flooding on germination of marigold (*Tagetes erecta* L.).

## MATERIALS AND METHODS

Marigold seeds were collected from single plant. Healthy seeds were selected and used for the germination studies. A general protocol was used for germination. Germination was evaluated by placing 25 seeds evenly in a 9 cm. diameter and 1.5 cm. depth petri dish containing one layer of sterilised filter paper, moistened with 5 ml. of water as control. Different treatment solutions were used instead of water according to the procedure mentioned below for each experiment. Dishes were sealed with parafilm and placed at room temperature, except for the temperature experiment. Seed germination characters were observed directly in petridishes in each 24 hours. To detect the suitable environmental condition for good germination, seeds were germinated in the laboratory under different conditions such as low and high temperatures, light and dark, different salt concentrations, different levels of drought and pH. Seed sowing depth and flooding effects were also detected.

### *Effect of temperature*

To test the optimum temperature on germination, the seeds were germinated at different temperature regimes (15°C to40°C). The germination experiment was conducted at Plant Growth Chamber (WiseCube, WTH-E155, Economic Temp./Humidity Chamber, 155 Lit., w 470xd 480 mm) at relative humidity of 60% with 12 h photoperiod. Plant growth chamber was adjusted to 10°C and petri dish with 25 seeds were placed in it. Constant temperature (10°C) was given for 7 days and germinated seeds were counted. Experiment was continued for 15°C, 20°C, 25°C, 30°C, 35°C and 40°C to test the effect of temperature on germination. For each treatment, four replicates of 50 seeds each were used.

### *Effect of Light*

Effect of light or darkness on the germination of marigold seeds was tested by germinating seeds in light and under dark condition. For dark treatment, Petri-dishes were immediately wrapped with aluminum foil to avoid exposure of seeds to light. For light treatment, petridishes were exposed to day light which is provided in the laboratory room. Petri-dishes of both treatments were placed on a table at room temperature (21/22˚C). Seed germination process was observed directly in petri dishes in each 24 hours.

### *Effect of salt stress*

To detect the effect of salt on germination, seeds were germinated in 0, 25, 50, 75, 100 and 125 mM salt (NaCl) solution in laboratory condition. Seeds were moistened with 5 ml treatment solution. Seed germination process was observed directly in petri dishes in each 24 hours.

### *Effect of drought stress*

To test drought on germination, seeds were germinated in aqueous poly ethylene glycol solution (PEG) with osmotic potential of 0, -0.1, -0.15, -0.20, -2.5, -0.30, -0.35,MPa. Different concentrations of polyethylene glycol-6000 (PEG) were prepared to obtain solutions of different osmotic potentials following the methods of Michel and Kaufmann (1973).

$$OP = (-1.18 \times 10^{-2}) \times C - (1.18 \times 10^{-4}) \times C + (2.67 \times 10^{-4}) \times CxT + (8.39 \times l0^{-7}) \times C^2T$$

Where C=PEG concentration; T=Temperature

For germination study,seeds were moistened with 5 ml of treatment solution. Germinated seeds were counted from each experiment.

### *Effect of pH*

To test pH on germination, seeds were germinated in different ionic solutions with pH 2, 4, 7, 10, 12 and 14. Solutions with different pH were prepared using 1N HCl or 1N NaOH. Seeds were exposed to these solutions separately. Germinated seeds were counted for each experiment.

### *Effect of Burial Depth*

To test seed sowing depth, seeds were germinated in pots filled with dark soil at 0, 0.5, 1.0, 2.0, and

4.0 cm depths. This experiment was conducted in glasshouse. Seeds were placed on the soil surface or covered to depths of 0.5, 1.0, 2.0, and 4.0 cm. Twenty five seeds were sown in each pot. Adequate water was applied throughout the observation period to allow normal seedling emergence. The average temperature in the glasshouse during the experiment was 29.5ºC. The ambient environmental conditions were maintained in the glasshouse by keeping the windows open. The emerged seedlings were counted.

### *Effect of Flooding*

Petri dishes lined with filter paper were maintained under saturated or flooded condition by applying distilled water as required. Twenty five seeds were used for each treatment. The other procedure and environmental conditions were followed as per the general protocol.

Observations were taken from each experiment. Seeds were counted as germinated when radical was emerged from seeds. Germination was evaluated for two weeks. Five replicas were tested for each experiment.

Final germination percentage (FGP) was calculated at the termination of experiment by dividing germinated seeds with total seeds and multiplying by 100.

Germination rate (GR) was calculated by the formula

$N_1/D_1+N_2/D_2+$................................$+Ni/Di$

Where, Ni is the number of seeds that germinated in days Di.

Coefficient of rate of germination (CRG) computed based on the equation of Kotowski (1926) as cited by Adegbuyi et al. (1981) as follows,

CRG= $\sum n/ ( D.n )$

Where D = no. of days from day of sowing

n = no.of seeds germinating at day D.

Uniformity of germination time (UGT) determined using the following formula,

UGT = (n.D)/ % germination.

## RESULTS AND DISCUSSION

The seed germination of *T. erecta* ranges from 34.64% - 96% for the temperature range of 20 – 25° C, and the seeds did not germinate at the extreme low and high temperatures of <10° C and >40° C. Germination percentage was maximum at 25˚C. Above 65% germination was observed at 30˚C. At 35˚C, germination was nearly 50%. Germination rate and Coefficient rate of germination (CRG) were high at 25˚C compared to other temperature treatments. Result is represented in Fig: 1 a, b and c. Different seeds have different temperature ranges within which they germinate. A rise in temperature does not necessarily cause an increase in either the rate of germination or on its percentage. Similar germination patterns have been reported in several other plant species (Benvenuti *et al.,* 2004; Zhou *et al.,* 2005; Chachalis *et al.,* 2008).

Germination was not influenced by light. Under light and dark condition germination was observed maximum. Under day/night condition maximum germination was attained second day itself. However, germination rate was quite low in dark condition. Result is represented in Fig: 2 a, b and c.

The seeds of *Tagetes erecta* germinated over pH 4- 12, but germination rate was higher in pH 7 (neutral). The seed germination increased from 34.68% - 98.68% with increased pH values from 4- 7. Result is represented in Fig: 3 a, b and c. This data indicates that *T. erecta* is not tolerant to both acidic and alkaline conditions.

The seedling emergence of *T. erecta* was 98.67% when seeds were placed on soil surface. The seedling emergence decreased drastically to 0% at a depth of 6 cm. Result is represented in Fig: 4 a, b and c. Similarly, Rao *et al.* (2008) and Lu *et al.* (2006) found highest seed germination for *Beckmannia syzigachne* and *Eupatorium adenophorum*, respectively, when the seeds were placed on soil surface. Decreased seedling emergence due to increased burial depth has been reported in several weed species (Boyd and Van Acker, 2003). There are several possible explanations for the lack of emergence from seeds buried at deeper depths. Light penetration is generally limited to the first few millimeters of the soil (Woolley and Stoller 1978) and seeds deeper in the soil would not receive light. Like other environmental factors, seeding depth also affects emergence (Cussans *et al.,* 1996; Koger *et al.,* 2004) by influencing the availability of moisture, temperature and light exposure (Begum *et al.,* 2006; Rao *et al.,* 2008).

Seeds were germinated under saturated and flooded conditions. However germination percentage was high in saturated condition. Result is represented in Fig: 5 a, b and c. Flooded condition showed 70% germination and low GR, indicating that the seeds of *T. erecta* are able to survive and germinate under flood conditions.

Similarly, *Ischaemum rugosum* seeds showed 98% emergence in flood conditions (Nabi and Baki, 1995). Rao and Moody (1995) found that the seeds of *Ischaemum rugosum* and *Echinochloa* sp. germinated on the water surface.

Germination percentage was very high in control (no stress) and 80% in 25mM NaCl. Seeds were germinated under severe stress condition but GP was quite low (15%).Result is represented in Fig: 6 a, b and c. GR was very low so that germination started 5th or 6th day of sowing. Differential germination response to salt has also been reported in other species of Asteraceae family.

Germination percentage was gradually decreased to 30% under severe drought. Result is represented in Fig: 7a, b and c. Seeds were germinated very slowly. Under severe drought,seeds were germinated at 5th day only. Lack of water import environmental stress, most often limiting seed germination. Mature seeds are dry enough and need to take considerable amount of water (relative to seed dry weight) for cellular metabolism and germination. Amount of water to imbibe seed varies from species to species (Larson and Kiemnec, 2005; Van Assche and Vandelook, 2006).This study concludes that different ecological factors such as temperature, salinity, drought, pH and sowing depth have important role in germination of *Tagetes erecta*.

## ACKNOWLEDGEMENT

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## Effect of temperature on Germination

***Fig: 1. Germination of seeds exposed in different temperature regimes***

Fig: 1a. Germination percentage of seeds exposed in different temperature regimes

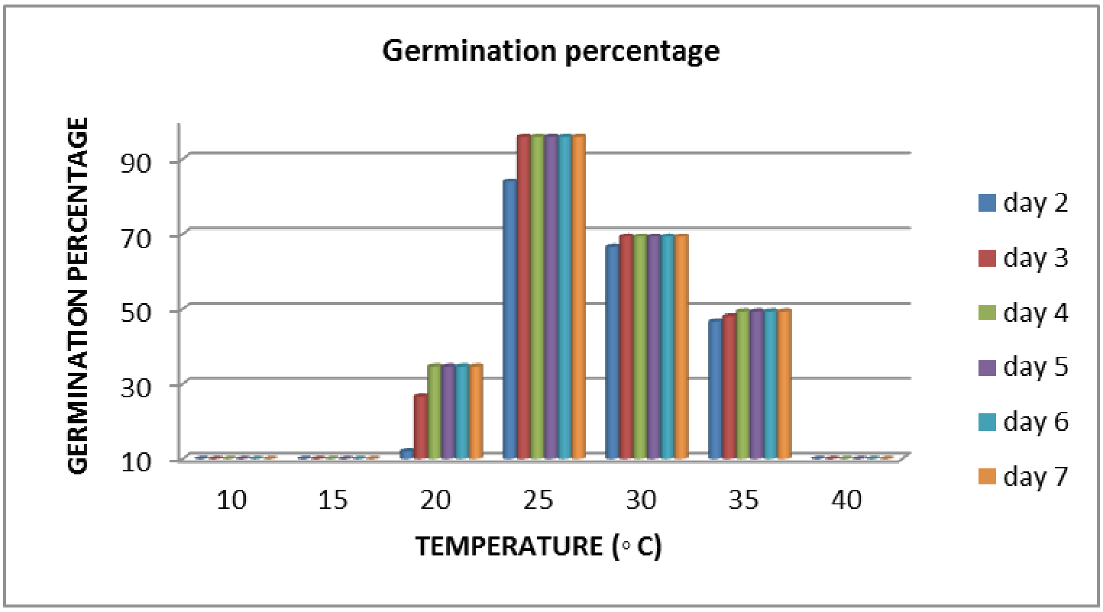


Fig: 1b. Germination rate of seeds exposed in different temperature regimes

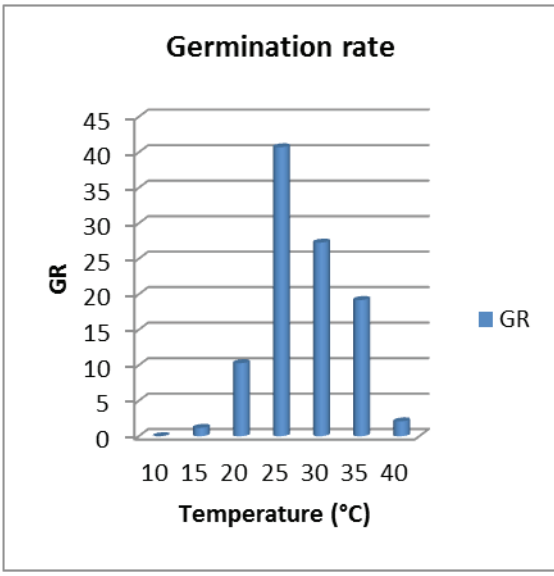
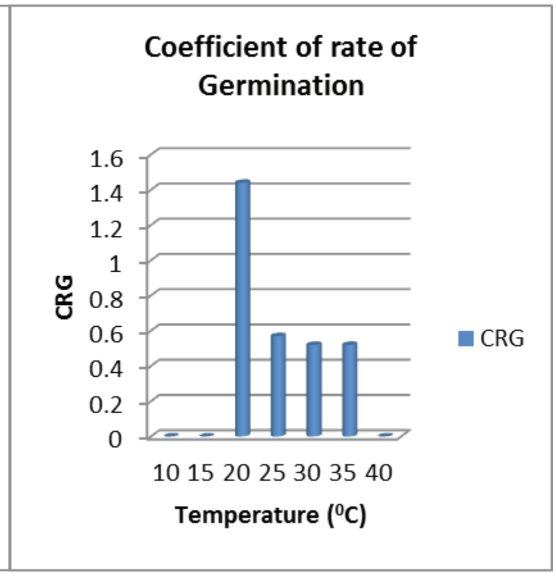



Fig: 1c. Coefficient rate of Germination of seeds exposed in different temperature regimes




### Effect of light on germination

***Fig:2. Germination of seeds exposed to dark and day/night condition***

Fig: 2a. Germination percentage of seeds exposed to dark and day/night condition

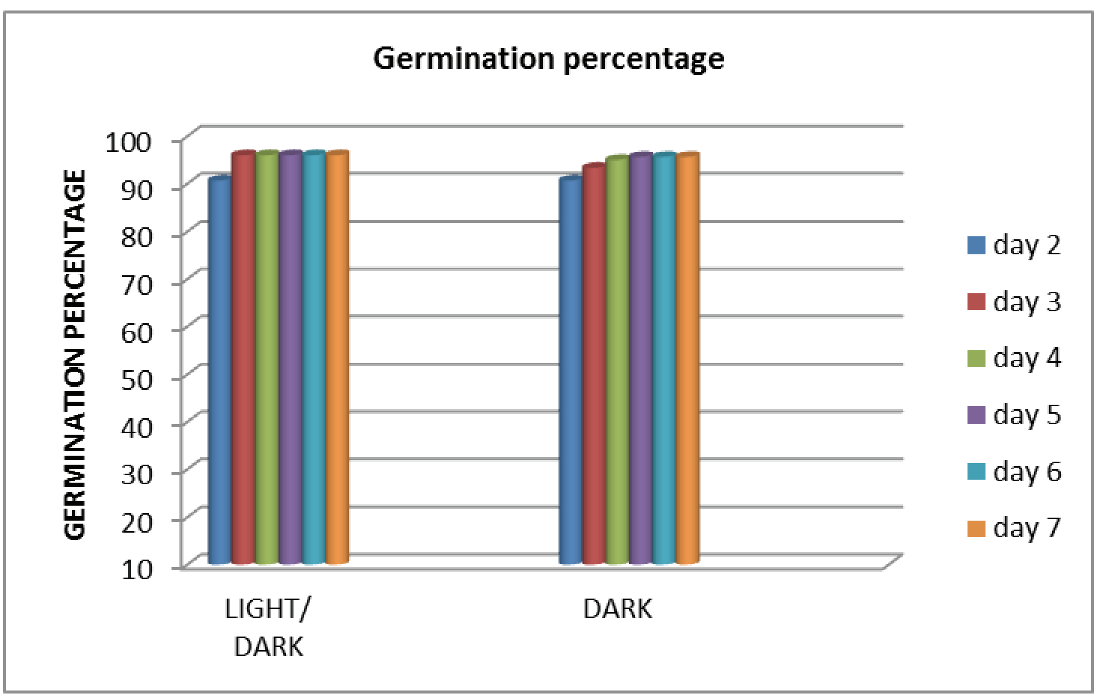


Fig: 2b. Germination rate of seeds exposed to dark and day/night condition

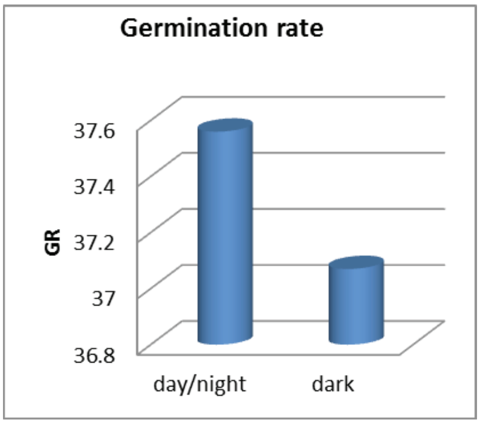
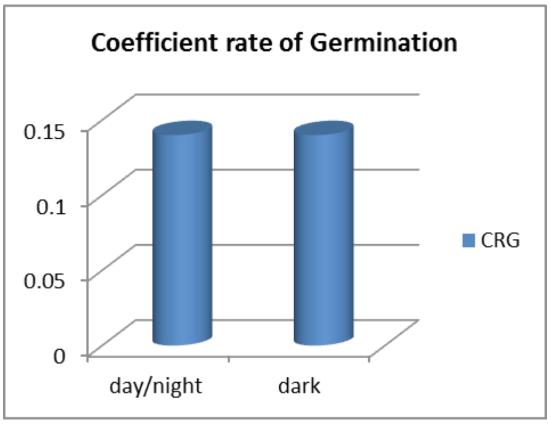



Fig: 2c. Coefficient rate of Germination of seeds exposed to dark and day/night condition




**Effect of pH on germination**

***Fig: 3. Germination of seeds exposed to different pH solutions***

Fig: 9a. Germination percentage of seeds exposed to different pH

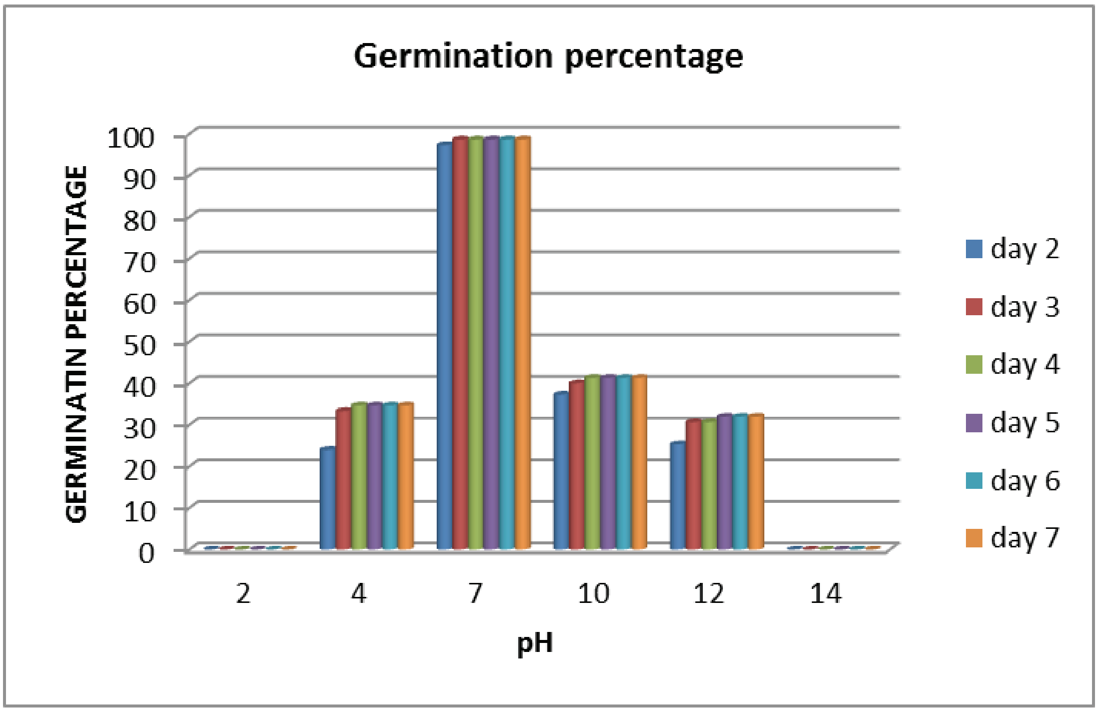


Fig: 3b. Germination rate of seeds exposed to different pH

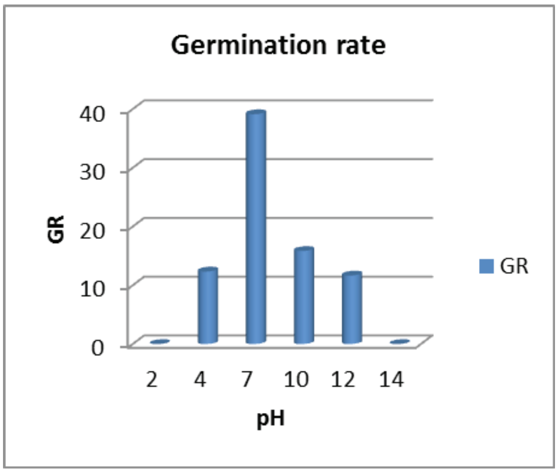
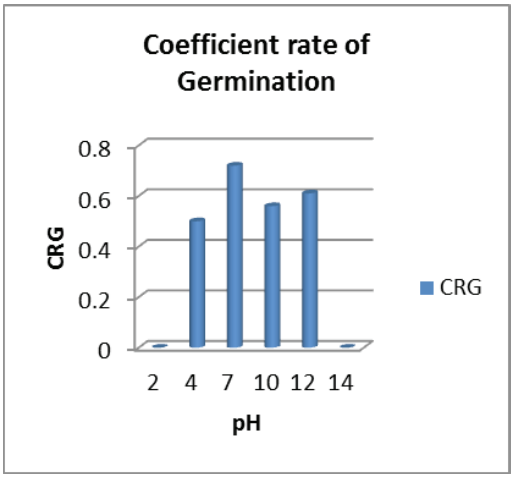



Fig: 3c. Coefficient rate of germination of seeds exposed to different pH




## Effect of seed burial depth on germination

***Fig: 4. Germination of seeds exposed to different soil levels***

Fig: 4a. Germination percentage of seeds exposed to different soil levels

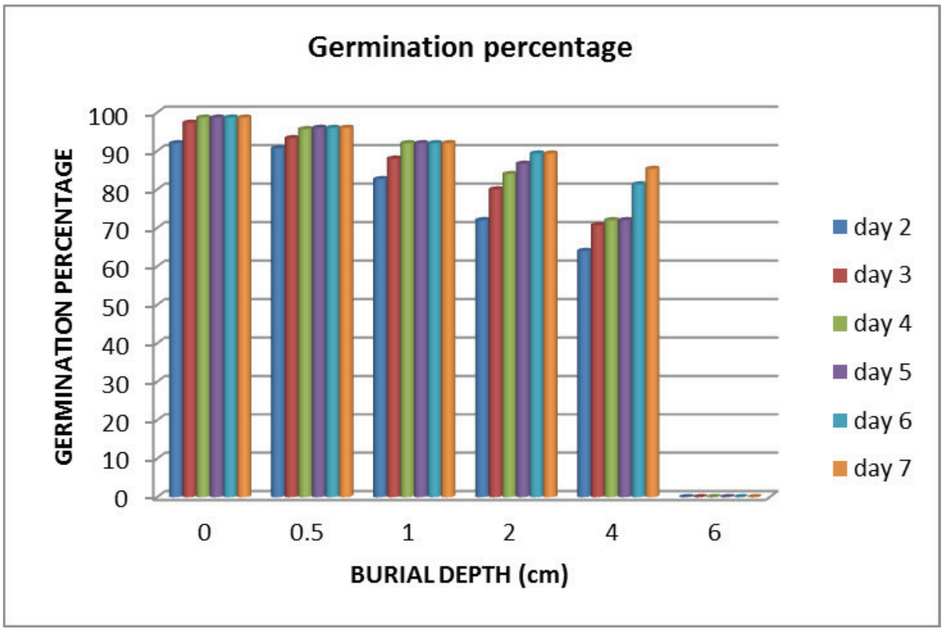


Fig: 4b. Germination rate of seeds exposed to different soil levels

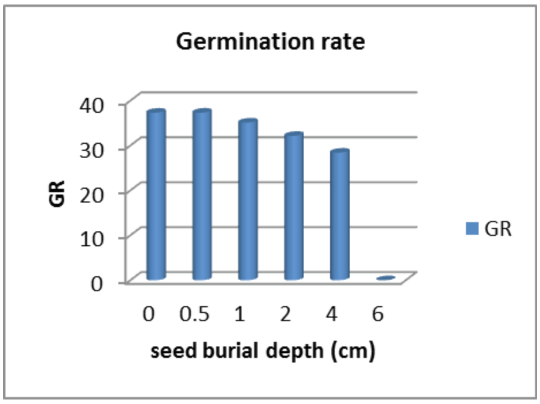
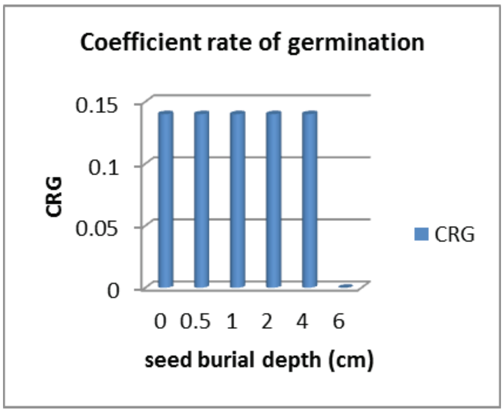



Fig: 4c. Coefficient rate of germination of seeds exposed to different soil levels




**Effect of flooding on germination**

***Fig:5. Germination of seeds exposed to different water levels***

Fig: 5a. Germination percentage of seeds exposed to different water levels

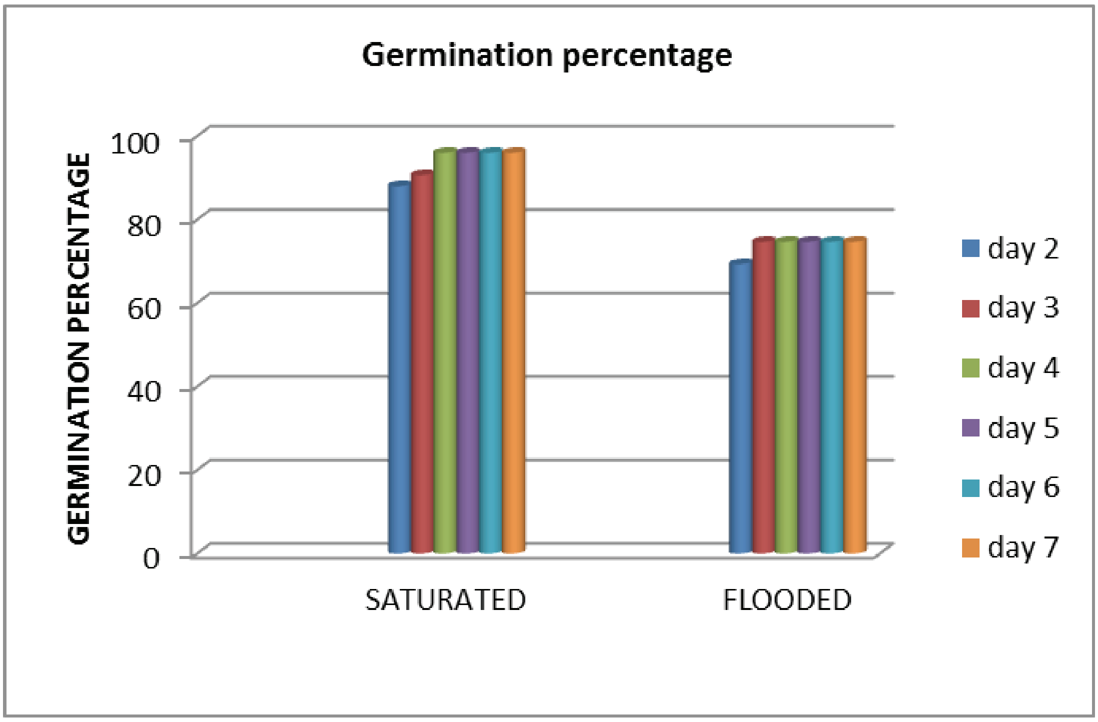


Fig: 5b. Germination rate of seeds exposed to different water levels

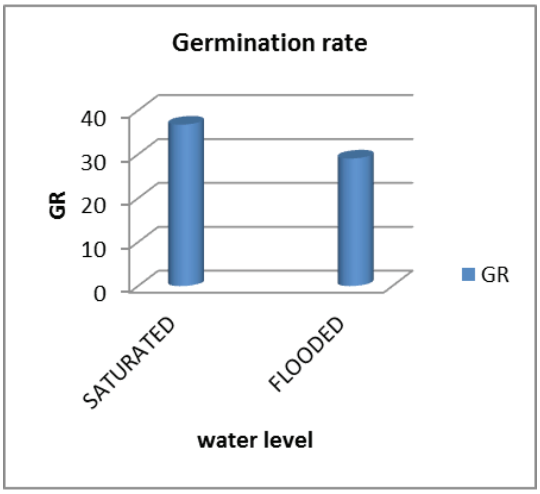
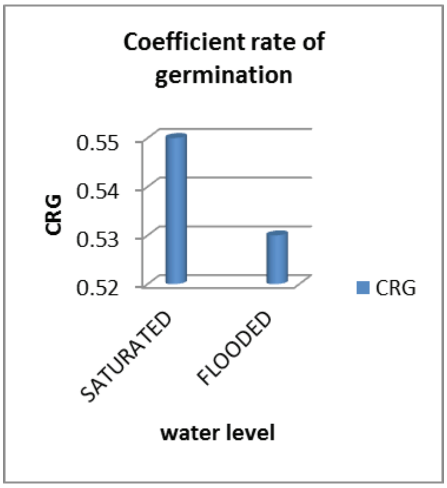



Fig: 5c. Coefficient rate of germination of seeds exposed to different water levels




## Effect of salt stress on germination

***Fig:6. Germination of seeds exposed to different levels of salt stress***

Fig: 6a. Germination percentage of seeds exposed to different levels of salt stress

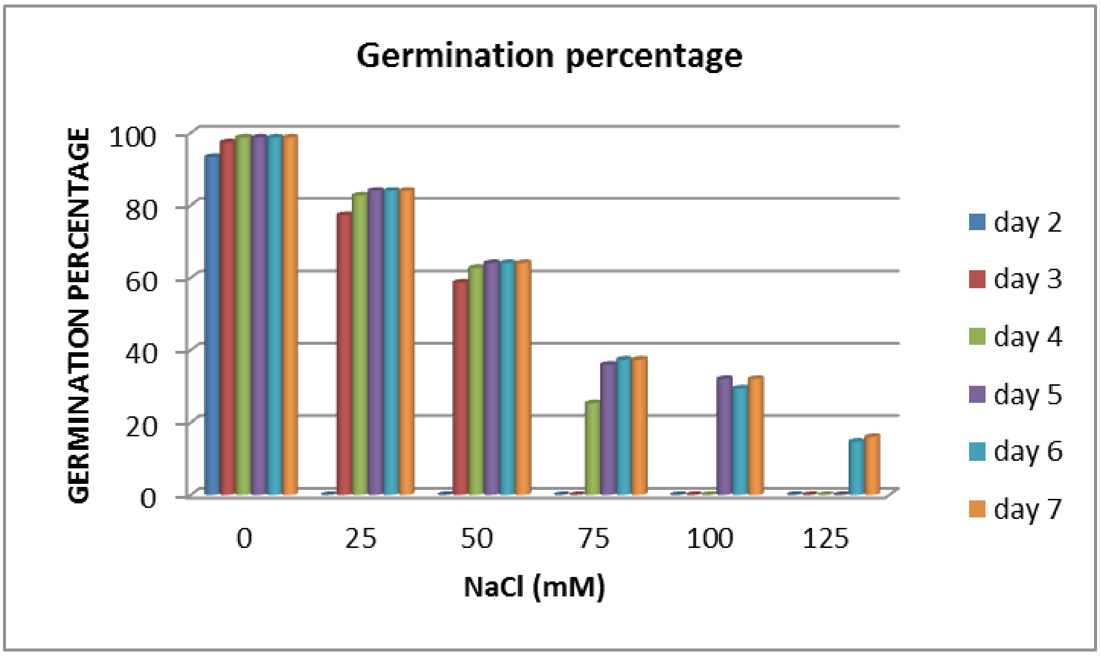


Fig: 6b. Germination rate of seeds exposed to different levels of salt stress

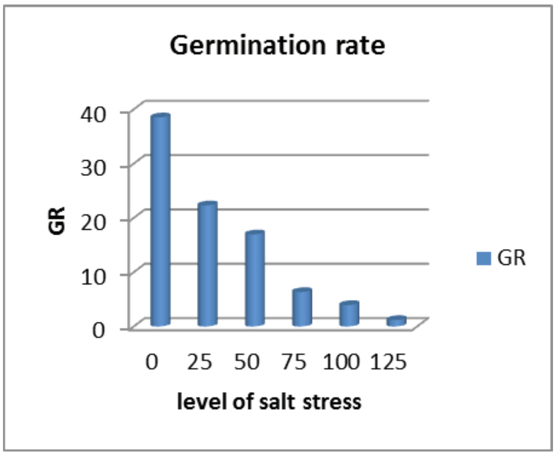
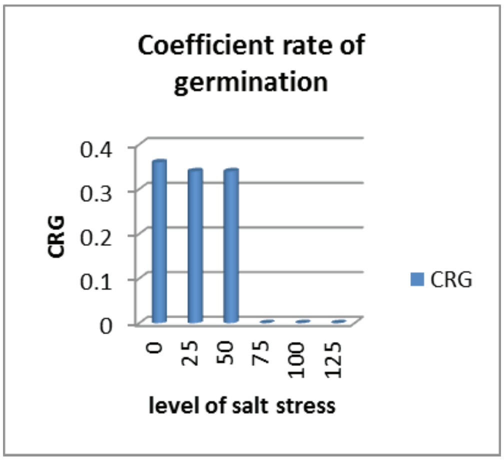



Fig: 6c. Coefficient rate of germination of seeds exposed to different levels of salt stress




### Effect of drought stress on germination

***Fig: 7. Germination of seeds exposed to different levels of drought stress***

Fig: 7a. Germination percentage of seeds exposed to different levels of drought stress

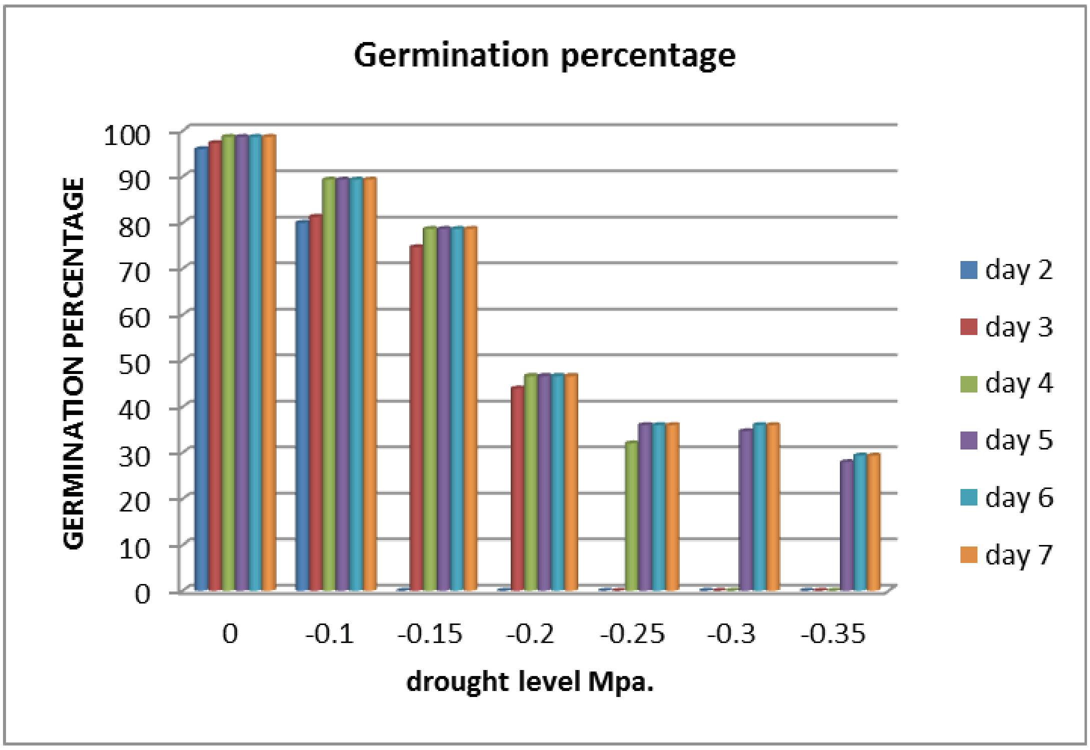


**Fig: 7b. Germination rate of seeds exposed to different levels of drought stress**

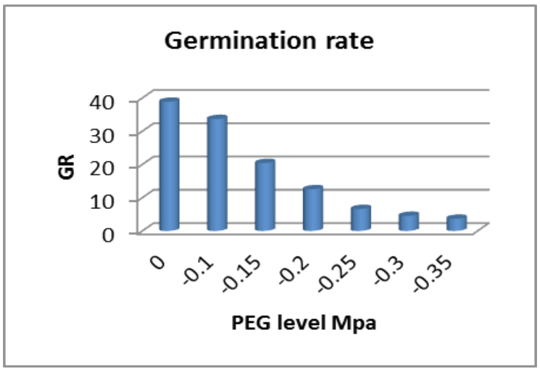
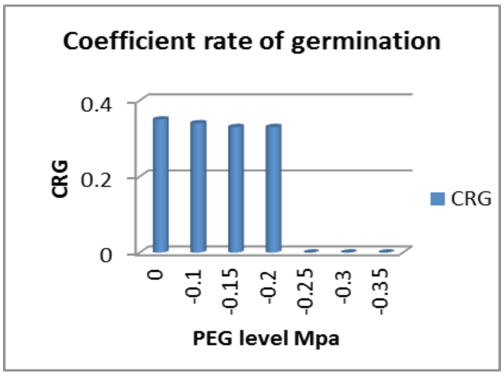



**Fig: 7c. Coefficient rate of germination of seeds exposed to different levels of drought stress**

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