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RESEARCH ARTICLE

IMPACT OF SALINITY ON SEED GERMINATION AND BIOMASS YIELDS OF FIELD PEA (PASUM *SATRIUM* L.)

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ABSTRACT

Salinity stress negatively affects seed germination and growth of different crops. There are reasonably adequate information on the effects of salinity on crops germination and emergence. However, scanty information is available on the impacts of salinity on crops biomass production during seedling growth. Thus, a series of two experiments: laboratory experiment to evaluate the effect of different salt concentration on seed germination percentage and germination rate of field pea and pot experiment to investigate the effect of salt on biomass yields of field pea were conducted. Both the experiments, laboratory and pot experiments, have six treatments (0, 10, 20, 30, 40 and 50 mM of salt concentration) and treatments were laid out in randomized complete design (CRD) with four and three replications respectively. The results revealed that the highest germination percentage and germination rate of 98 % and 2.15 seeds per day, respectively were scored from the control treatment. The highest plant height, leaf number, branch number and above ground dry biomass of 25.6 cm, 6.79 leaf per plant, 2.5 branch per plant and 1.93 g respectively were scored from control treatment that was statistically similar with 10 mM salt concentration, while the lowest value of these parameters were recorded from pots treated with 50 mM of salt concentrations . Therefore, salt content of irrigation water greater than 10 mM might reduce yields of field pea. However, the results presented here need to be confirmed through on farm research under various soil and agro climatic conditions.

INTRODUCTION

Filed pea (*Pasum satrium* L.) is one of the most important leguminous crops of the world. It is originated in Mediterranean region of Southern Europe and Western Asia. Currently the crop is growing in many countries including Ethiopia for both human consumption and animal feed (Chandrasekaran *et al.,* 2010). Filed pea is climbing annual legume with weak, vine and relatively seven lent stems. Vines often are 4 to 5 feet long, but when grown alone, filed peas weak steams prevent it from growing more than 1.5 to 2 feet tall. Leaves have two leaflets and tendril. Flowers are white, pink or purple. It has pods Carrey seeds; seeds are rounded and little angular with grayish to brown (green) yellow in color. The root system is relatively shallow and small, but well modulated (Hagedogen, 1986). Filed pea is grown as forage crop for cattle; as green manure crop for soil improvement and as cover crop to reduce soil erosion. Matured seeds are used as whole or split. Seeds are starchy, which can vary from 30 to 50%, but high in fiber, protein, vitamins, minerals and 1 % fat (Mekay, 2001; Chandrasekaran *et al.,* 2010). The major producing countries of filed pea are Russia and China, followed by Canada, Europe, Australia and the USA (Kallo, 1993).

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The total field pea coverage in Ethiopia is estimated at 214, 253.07 ha with average annual production of 2752 tones with a productivity of 12.85 quintals per hectare (CSA, 2011). However it is lower than the world average in 2011 (FAOSTAT, 2011). According to Munns and Tester (2008) more than 45 million hectares of irrigated land have been damaged by salt worldwide and 1.5 million hectares are taken out of production each year due to high soil salinity. In Africa, 1,899 million hectare of land is affected by salinity (FAO, 2008). In Ethiopia, salt-affected soils are prevalent in the Rift Valley and the lowlands. About, 200 ha of lands of the limited areas of irrigated lands in the rift valley system are abandoned for agricultural crop production every year due to sodicity and associated land drainage problems in the country (Heluf, 1987). The total land area affected by salinity and sodicity in Ethiopia is estimated at 11 million ha (Szabolcs, 1989). The Ethiopian government has plans to introduce and implement large-scale irrigation agriculture to increase agricultural productivity (Mamo *et al.,* 1996). Unless proper management strategies are designed, the prevailing salinity problem in the country is expected to become severe in the years to come (Kin femichael, 2011). Salinity is one of the factors limiting the productivity of crops like field pea, because most of the crop plants are sensitive to salinity caused by high concentrations of salts in the soil (Hasanuzzaman *et al.,* 2013). Seed germination is the first step of plant life, which determines when and where seedling growth begins (Jeannette

et al., 2002) and is very sensitive to salt stress. Shokohifared *et al.* (1939) have reported that salinity stress negatively affects seed germination either osmotically through reduced water absorption or ironically through the accumulation of sodium and chloride causing an imbalance nutrient uptake and toxicity effect. Seed germination, seedling emergence and early survival are particularly sensitive to salinity (Katembe *et al.,* 1998). There are reasonably adequate information on the effects of salinity on crops germination and emergence. However, there is only a little information on the impacts of salinity on crops biomass production during seedling growth (Katerji *et al*., 1994).

Therefore the present study was initiated with the objectives to:

- Evaluate the effect of salinity on seed germination of field pea
- Investigate the influence of salt on seedling biomass of field pea

MATERIALS AND METHODS

Description of the experimental site

A series of two experiment; laboratory and pot experiments were conducted from march to may, 2015 in Plant Science Laboratory of Mizan-Tepi University, Mizan Teferi, Ethiopia. The study area is found 561 km south west of Addis Ababa and 842 km from the regional capital Hawassa. It is located at an altitude of about 1400 meter above sea level with latitude of 6^{0} to 7^{0} north and longitude of 35^{0} east in the sub humid tropics of south western Ethiopia. The mean annual rain fall of the area is 2000 mm. The mean minimum and maximum temperature are 20^{0} and 28^{0} respectively (Mizan Metrology station, in Girma and Ashebir, 2008). The soil of the study area is represented by Nitisols (Mesfin 1998).

Source of filed pea seeds

Field pea seeds (*Pisum satrium*) were originally brought from Holeta Agricultural Research Center.

Experimental details

During the course of the study, a serious of two experiments: laboratory experiments to evaluate the effect of salinity stress on seed germination of filed peas and pot experiments to investigate the influence of salinity stress on biomass yields of filed pea were conducted as described below .

Experiment I: Seed germination of filed pea as influenced by salinity stress

Study on the effect of salinity stress on seed germination of filed pea was conducted in plant science laboratory of Mizan-Tepi University, Mizan Tefere Ethiopia. Treatment; six level of salt concentration; 0 mM, 10 m M, 20 mM, 30 mM, 40 mM and 50 mM) were arranged in Complete Randomized Design (CRD) with three replication. Tap water was used for the control treatment and NaCl was used as a source of salinity as described by (Kaymaknevea, 2009). Twelve uniform seeds of filed pea were placed petrdishe (9.5cm in diameter) and covered with lied to prevent loss of moisture through evaporation.

Filter papers were well soaked by adding 10ml with the respective solutions (5 treatment solutions and the control) at an interval of 48hrs as described by Naveed *et al.* (2001). Seed were allowed to germinate for 7 days at room temperature. The seed were considered germinated when radicals appeared and are visible when length reached 2mm (Habtam *et al.,* 2013).

Data collected

Number of germinated seeds

Number of germinated seeds was counted every 24 hours and germination percentage and germination rate were calculated as follows

$$\text{Germination percentage} = \frac{\text{Number of germinated seeds}}{\text{Total number of seed Sown}} \times 100$$

$$\text{Germination rate (germinated seeds per day)} = \frac{\text{Number of germinated seeds}}{\text{Times (days)}}$$

Experiment II: Growth parameters of field pea as influenced by salt concentrations

A pot experiment on the effect of different salt concentrations on biomass yields of field pea was conducted in Plant Science Laboratory of College of Agriculture and Natural Resource, Mizan-Tepi University. The six treatments, level of salt concentrations, (Table 1) were laid out in Completely Randomized Design (CRD) with three replications. Each replication had six pots and a total of 18 pots were used for this experiment. Each pot were filled with 3 kg of soil and used as experiment units. Treatments were assigned randomly for each experimental unit.

Table 1. List of treatments, level of salt concentration, used in experiment II

Treatment number	Description
1	0 mM
2	10 mM
3	20 mM
4	30 mM
5	40 mM
6	50 mM

Soil sample was thoroughly mixed with recommended rate of Urea and DAP and transferred to each pots prior to sowing. Six seeds per pots were sown to each pot and thinned to three plants at two leaf stages. Each pot was watered with tap water until the seed emergency. Treatment application was started just after the emergence of the seeds.

Data collected

Plant height: refers to mean length of field pea plants at harvest and measured by using ruler.

Number of leaf per plant: refers to mean number of leaves produced by field pea plants

Number of branches per plant: mean number of branches produced by field pea plants

Above ground dry biomass: shoot 45 days field pea plants were harvested and measured using sensitive balance.

Statistical analysis

Data were subjected to Analysis of Variance (ANOVA) using the method described in Gomez and Gomez (1984). Whenever significant difference detected in the F-test, means were compared using LSD at 5% level of significance.

RESULTS AND DISCUSSION

The present study consisted of two experiments including laboratory activities and pot experiment. All of the data collected from these experiments were subjected to statistical analysis and the results obtained are presented and discussed in the following sections.

Laboratory experiment

Germination percentage and rate of field peas as influenced by salinity stress

Germination percentage and germination rate of field peas were significantly ($P < 0.001$) influenced by salt concentrations. The highest germination percentage of 98 % was scored from the control treatment, which however was statistically at par with that obtained from 10 mM salt concentration (93.4 %). The lowest value of this parameter (70.67 %) was recorded from field pea seeds treated with 50 mM of salt concentration. Similar trend were obtained regarding germination rate, were seeds in the control treatment germinate rapidly (2.15 seeds per day) followed by seeds in 10 mM salt concentration (1.82 seeds per day). The lowest seed germination rate was recorded from 50 mM, which was statistically similar with that obtained from 30 and 40 mM of salts (Table 2). Our results are in agreement with the findings of, Asfaw (2010) in haricot bean, Mostafavi and Heidarian (2012) in sunflower who reported that germination percentage and germination rate decreases with an increase in salt concentration. Germination percentage and germination rate of field pea were significantly reduced with an increase in salt concentration (Table 2). This could be attributed to an increase in exterior osmotic potential with an increase in salt concentration which reduce water uptake at imbibitions, consequently reduce seed germination (Turhan and Ayaz 2004). Saline stress on seed germination might also be attributed to toxicity of Na^+ which alters particular seed enzymatic or hormonal activities and then reduce germination percentage and rate of the seed (Sayar *et al.,* 2011; Mostafavi and Heidarian 2012). In addition, salinity might also cause oxidative stress that is outcome of induced active oxygen species formation. Furthermore, cellular metabolism is disturbed by active oxygen species via oxidative damage to membrane lipid, proteins and nucleic acids Salama *et al.* (2011).

Pot Experiment

Growth parameters of field pea as influenced by salt concentrations

Number of branches and leaf per plant

Number of branches per plant was not significantly influenced by salt concentrations. However leaf number per plant was significantly ($P < 0.001$) influenced by salt concentrations. The result revealed that decrease in number of leaf with an increase in salt concentration.

The maximum leaf number per plant (6.79) was obtained from the control treatment, which was statistically similar with that scored from 10 mM salt concentration. The lowest leaf number of 3.13 was recorded from 50 mM, which was statistically at par with salt concentration of 30 and 40 mM (Table 3). The reduced in number of leaf per plant with an increase in salt concentration might be due to the fact that water consumption of pea decreased with an increase in salt, consequently photosynthetic activity decrease leading to reduced plant growth, leaf area, chlorophyll content. In addition NaCl salt has qualitative and quantitative effects like chlorosis of green parts and reduces expansion of growing leaf (Wahid *et al.,* 2004).

Table 2. Mean comparison of germination percentage and germination rate of field pea as influenced by salinity stress

Treatments	GP (%)	GR (NGS day $^{-1}$)
Salt Concentration (mM)		
0 (Control)	98.00^{a}	2.15^{a}
10	93.40^{ab}	1.82^{b}
20	88.50^{bc}	1.75^{b}
30	83.75^{cd}	1.39^{c}
40	78.75^{d}	1.36^{c}
50	70.67^{e}	1.25^{c}
LSD 5%	7.04	0.26
CV (%)	5.60	10.20

Means followed by the same letter in the same column are not significantly different at $p \leq 0.05$ probability level, GP: germination percentage, GR: germination rate, NGS day^{-1} number of germinated seeds per day.

Plant height

Analysis of variance (ANOVA) showed that salt concentration significantly ($P < 0.001$) influence plant height of field pea. The tallest plant of 25.6 cm was recorded from the control treatment, which however was statistically similar with that obtained from field pea seeds treated with 10 mM of salt concentration (24.5 cm). In contracts, the shortest field pea seedling (13 cm) was scored from the concentrated treatment (50 mM) which was similar with that obtained from 40 mM salt concentration (Figure 1).

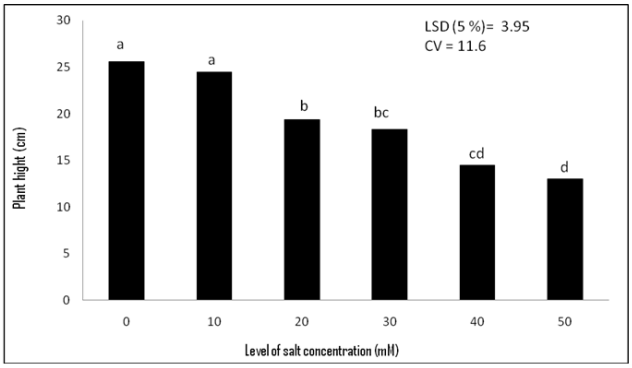

Figure 1. Height of field pea as influenced by different salt concentrations

This result is in line with the result of Karimi *et al.* (2011) who found that an increase in NaCl levels reduced shoot length in safflower. They attribute this to the toxicity of NaCl. Moreover Habtamu *et al.* (2011) reported that the highest shoot length of 14.87 cm from the control, and the lowest shoot length (9.47

cm) from the concentrated salt solution (2 mM). This might be attributed to the qualitative and quantitative effects of NaCl like stunted growth, chlorosis of green parts, dry mass reduction, elongation and expansion growth of leaves, tissue ionic and nutrient contents (Wahid *et al.,* 2004).

Above ground dry biomass of field pea as influenced by salt stress

Above ground dry biomass of field pea was very highly significantly ($p<0.001$) influenced by salt concentration . The highest above ground dry biomass of 1.933 g was scored from control treatment, which however was statistically at par with that obtained from 10 mM salt concentration (1.900 g).

Table 3. Mean comparison of number of leaf per plant and number of branch per plant of field pea as influenced by salinity stress

Treatments	Number of leaf per plant	Number of branch per plant
Salt Concentration (mM)		
0 (Control)	6.79[a]	2.50
10	6.57[a]	2.02
20	5.10[b]	1.80
30	3.84[c]	1.67
40	3.46[bc]	1.50
50	3.13[bc]	1.43
LSD 5%	0.6203	NS
CV (%)	7.24	24.37

Table 4. Mean comparison of above ground dry biomass of field pea as influenced by salinity stress

Treatments	AGFB (g)
Salt concentration(mM)	
0(control)	1.93[a]
10	1.90[a]
20	1.43[b]
30	1.27[bc]
40	1.03[cd]
50	0.6[e]
LSD 5%	0.33
CV%	13.05

Means followed by the same letter in the same columns are not significantly different at $p<0.05$ probability level, AGFB: Above ground dry biomass

The lowest value of this parameter (0.900 g) was scored from field pea plant treated with 50 mM of salt concentration (Table 3). Our results are agreement with the findings of, Greipsson and Davy (1996) in *Leymus arenarius*, who reported that above ground biomass decreases with an increases in salt concentration. Above ground dry biomass of field pea was significantly reduced with an increase in salt concentration (Table 4).This could be attributed to an increased Na+ actively secreted from leaves and retained in roots. Further it appears that their discrimination in the transport of k+ which is row material for growth of plant from root to leaves and rhizomes which decreases above ground dry biomass (Pfister, 1999).

Summery and Conclusion

Germination percentage of field pea decrease with an increase in salt concentration. The highest germination percentage and germination rate were scored from the control treatment. In contrast the lowest values of these parameters were scored from 50mM of salt concentration. Analysis of variance (ANOVA) of the pot experiment shows that all growth parameters decrease with an increase in salt concentration. The maximum leaf number per plant, number of branches per plant, plant height and above ground dry biomass were obtained from the control which however was statistically at par with 10 mM salt concentration. In general, the results suggested that the seed germination and growth of field pea were significantly influenced by higher salt concentration. Thus pointing that the potential effects of lower quality of irrigation water to reduce growth and consequently yield of field pea. Therefore, salt content of irrigation water greater than 10 mM might reduce yields of field pea. However, the results presented here need to be confirmed through on farm research under various soil and agro climatic conditions.

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