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SALINITY EFFECTS ON GROWTH AND PRODUCTIVITY OF TWO SOYBEAN (*Glycine max* L.) GENOTYPES

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ABSTRACT

Global crop production systems are challenged by the increasing areas of saline soil in arid and semiarid regions. A field experiment was conducted to test the salinity tolerance of two soybean genotypes (PK 416 & PS 1347) and was subjected to six levels of salt concentrations. Yield components were determined at 30, 60, 90 and 120 days after sowing. Dry weight of stem exhibited significant reductions in all the sets at different durations except PK 416 which exhibited non significant reductions at 3 EC at first harvest. Dry weight of root increases linearly with the advancement of plant age, however maximum increase was noticed between 60 and 90 days after sowing in all the cultivars. Among the yield components, numbers of pods, fresh and dry weight of pods per plant were significantly reduced with increasing salt concentrations. Our data indicated that salinity decreased the grain yield and biological yield in both the genotypes, the decrease being maximum in PS 1347. Thus PK 416 proved better under saline irrigation.

KEYWORDS : Salinity, Pod Characteristics, Yield, Soybean

Excess amount of salts in the soil adversely affects the plant growth and development. The increasing use of water of poor quality, the continuous addition of waste salts to our environment, as well as the increasing contamination of under water resources lead to gradual soil salinization. Global estimates are that more than 800 million hectares of land throughout the world are salt affected (Munns et al., 2008). This amount accounts for more than 6% of the world's total land area. Of the 1500 million ha of land farmed by dry land agriculture, 32 million ha (2%) are affected by secondary salinity to varying degrees. Of the current 230 million ha of irrigated land, 45 million ha (20%) are salt affected. Irrigated land accounts for only 15% of total cultivated land, but because irrigated land has at least twice the productivity of rain fed land, it produces one third of world's food (Munns et al., 2008).

Soybean is a strategic crop plant grown to obtain edible oil forage. High sensitivity to soil and water salinity is one of the biggest problems with soybean crop. Results have indicated that salinity affects growth and development of plants through osmotic and ionic stresses. Because of accumulated salts in soil under salt stressed condition plant wilts apparently while soil salts such as Na^+ and Cl^- disrupt normal growth and development of plant (Farhoudi et al., 2007; Khajeh-Hosseini et al., 2003). Chen et al. (1996) reported salt stress led to decreased seedling growth of soybean cultivars.

The aim of the present study is to fill the gap of our knowledge about the changes in agronomic and yield parameters of soybean in respect to salt stress. The soybean was selected for this study because it is an important oil and protein crop, which is indigenous to the cropping system of the semi-arid regions.

MATERIALS AND METHODS

The present experiment was conducted in the field to study the effects of saline water irrigation on plant growth and productivity in two varieties (PK 416 and PS 1347) of soybean. Traditional agronomic practices were followed for the preparation of field and seed sowing. The field was irrigated with normal water before ploughing and left for few days. The experimental field was harrowed and ploughed and thereafter suitable quantity of farmyard manure and organic compost was applied and mixed it thoroughly with the soil. The weeds were manually removed before preparation of plots. Soil was thoroughly mixed before making the plots and soil samples were collected randomly for analysis. The analysis was done at dept. of soil sciences, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.

The experimental field was divided into 42 plots (2 genotypes x 3 replicatesx7 treatments) of 1x1m size. Plots

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were lined with perforated polythene sheets of 1.5x1.5m size and 0.2mm thickness at a depth of 25cm to prevent leaching of salts. The experiment was designed in a complete randomized block with three replicates. The amount of water used for irrigation was decided after calculating the water holding capacity of the soil upto a depth of 10 cm. Before sowing, tube-well water was applied to the control plots and same quantity of saline water whose electrical conductivity was observed to be 0.67dSm^{-1} was applied to the salinized plots. Saline waters of 3, 6, 7.2,10,12,14 dSm^{-1} were prepared by adding a mixture of NaCl, $CaCl_2$, Na_2SO_4, $NaHCO_3$ in tube well water. Prior to sowing, uniform sized seeds of selected varieties were surface sterilized with 0.01% $HgCl_2$ for one minute and washed thoroughly in tube-well water to remove the traces of $HgCl_2$. The sterilized seeds were sown on 30 June, 2007 in the respective plots in three rows having a row to row distance of 35cm and seed to seed distance of 5.7cm. The seeds were sown at the rate of 45 per plot. The amount of water lost from the plots was also compensated by adding uniform quantity of tube-well water to the respective plots.

The seed germination was started after one week of sowing, however, it was affected with different saline irrigations. The seedlings were thinned out when reached the height of 4-5 inches. Eradication of weeds was done at regular intervals of 15 days. Next irrigation was provided at 15 DAS. After every rainfall, treatment was given to attain their respective EC levels as far as possible. The electrical conductivity and pH of each experimental plot were checked from time to time. Minimum and maximum temperature was also recorded regularly during the cropping season along with humidity and rainfall.

Observations were recorded at 30, 60, 90 and 120 days after sowing. on various parameters of plant growth and yield. Before sampling the experimental plots was well irrigated to moisten the soil particles so that they can be easily rooted out. The plants were selected randomly from different experimental plots irrigated with saline waters including control. Plants were uprooted carefully without injuring roots. The plant samples were washed under running tap water to remove soil particles. Root and shoot were separated by sharpened knife. Observations were recorded on fresh weight of shoot and root. For the dry weight, the plant material was kept in the hot air oven at 700c for 48 hours.

For the assessment of plant productivity under saline water irrigation biological yield were calculated at different growth stages while number of seeds per plant, grain yield was calculated at reproductive stage (final harvest).

RESULTS

The findings revealed that the irrigation with saline waters has increased the adverse effect as the level of salinity raised from 3 to 14 EC level at different durations in both the varieties. Stem dry weight recorded significant reductions in all the sets at 60, 90 and 120 DAS eg. PK 416 recorded non significant reductions at 3 and 6 EC levels at 30DAS while PS 1347 exhibited non significant decrease at all saline treatments at same duration. Cultivar PS 1347 registered higher reductions at 90 DAS as compared to 120 DAS. The findings also revealed that dry weight progressively and significantly increased with the advancement of plant age in both the cultivars (3-14 EC) at different growth stages (Figure 1 & 2). Root growth had been adversely affected under various salinity regimes but the cultivars evoked differential effects. Dry weight of roots was decreased as the levels of salinity increased (Figure 3 & 4).

Statistical analysis of the data on yield components i.e. number of pods, fresh and dry weight of pods per plant indicated significant decrease with increasing salinity among the accessions. It was also clear from the data that number of pods significantly decreased in both cultivars except in cv. PS 1347 at 10, 12 and 14 EC level and in cv. PK 416 at 6 and 10EC level (Figure 7 & 8). Perusals of the data indicate that fresh and dry weight of pods did not decrease significantly in cv. PS 1347 at 10 – 14 EC level while cv. PK 416 registered the same at 7.2 – 14 EC levels (Figure 9 & 10). The analysis of variance for seed characteristics i.e. number of seeds/plant, number of seeds per pod and seed yield per plant, indicated significant decrease with increasing salinity. The increasing salinity levels, decreased all the seed characteristics in all

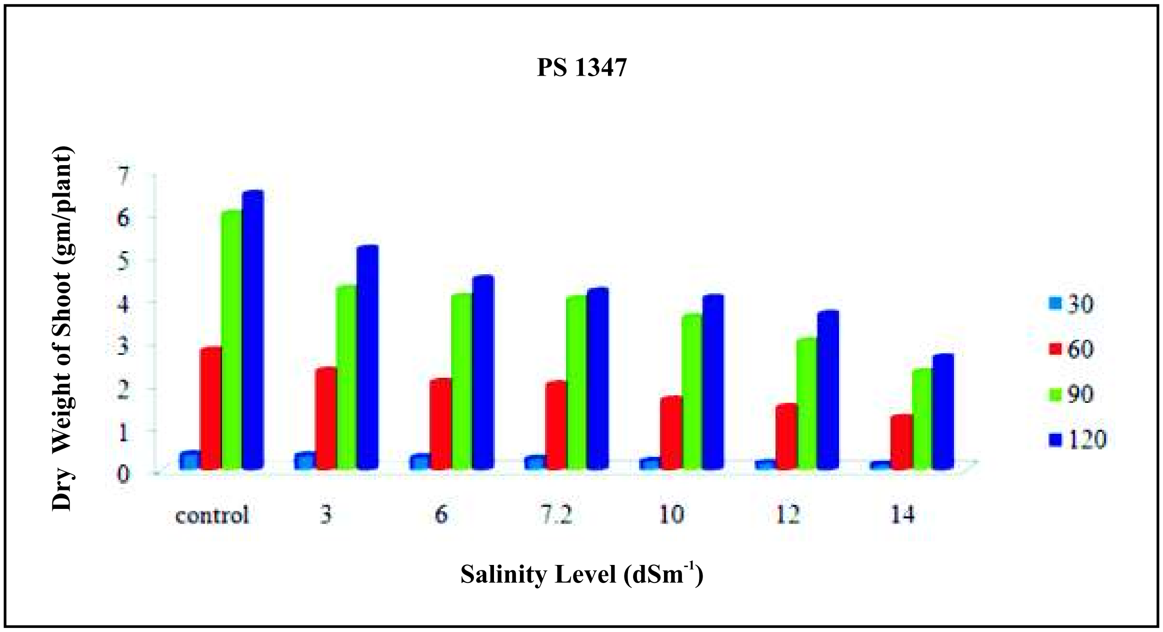

Figure 1 : Effect of Salinity on Dry Weight of Shoot in cv. PS 1347

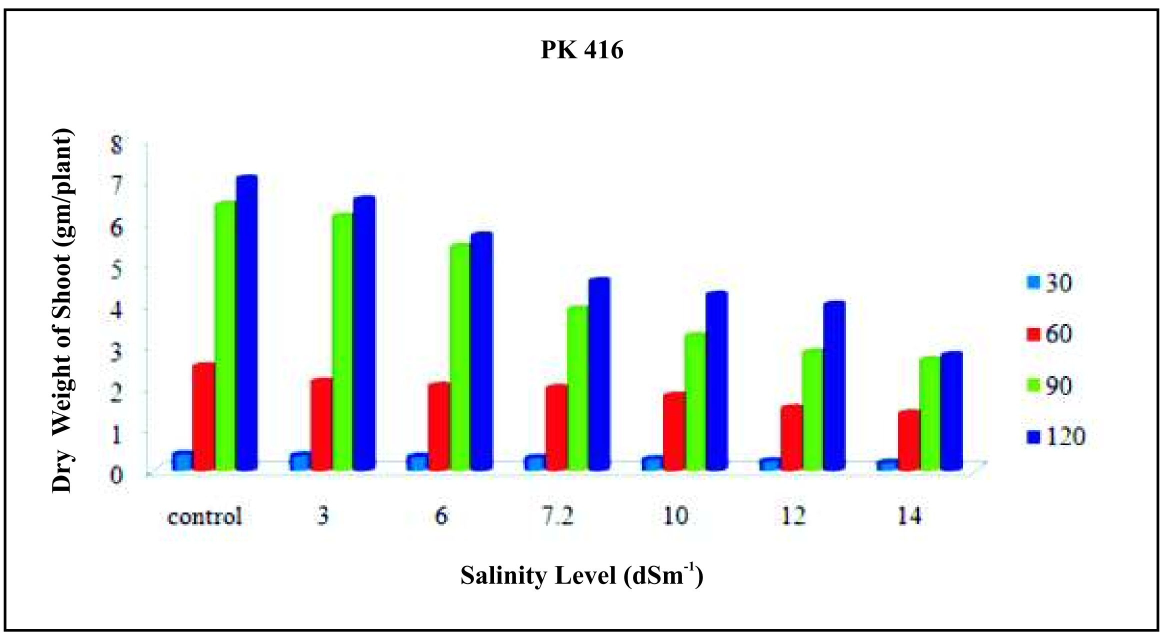

Figure 2 : Effect of Salinity on Dry Weight of Shoot in cv. PK 416

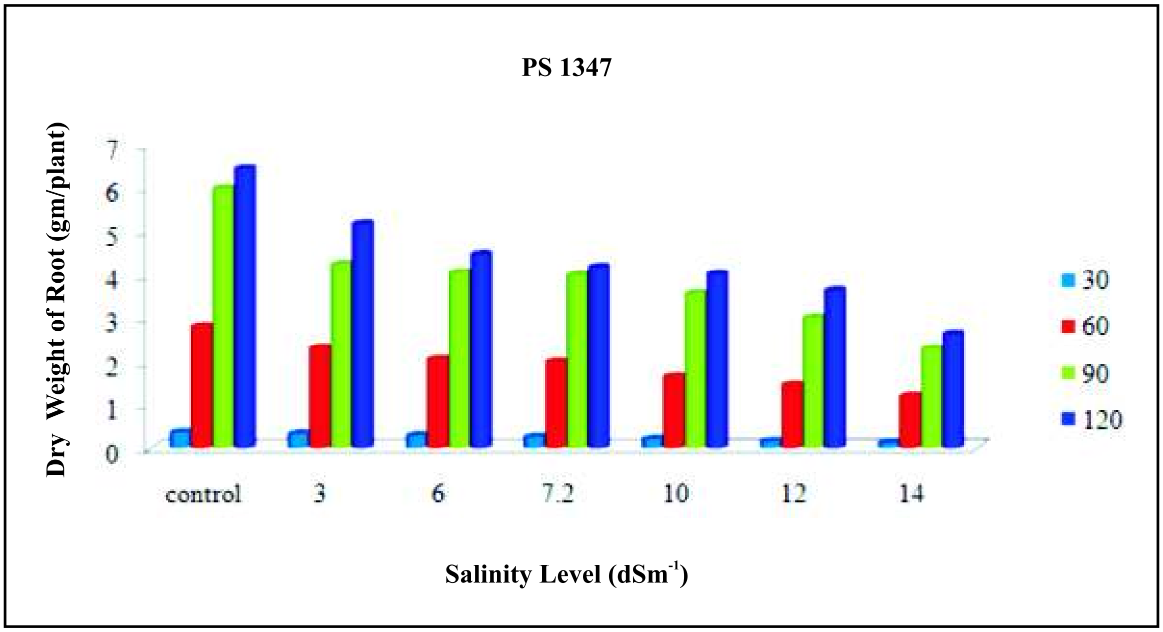

Figure 3 : Effect of Salinity on Dry Weight of Root in cv. PS 1347

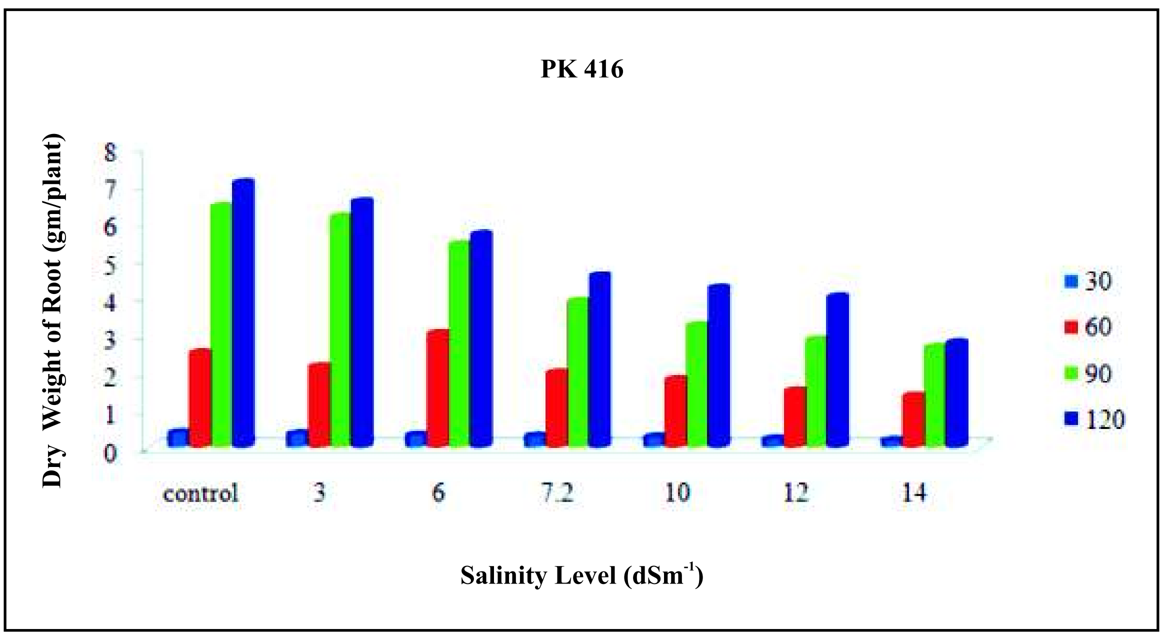

Figure 4 : Effect of Salinity on Dry Weight of Root in cv. PK 416

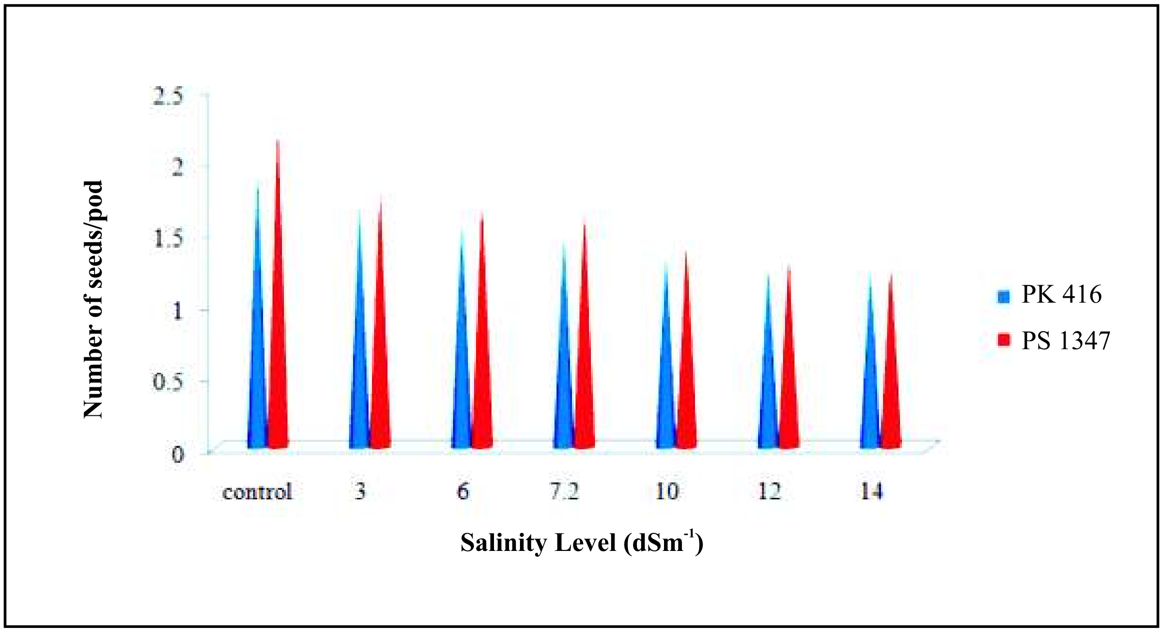

Figure 5 : Effect of Salinity on Number of Seeds Per Pod in cv. PK 416 & PS 1347

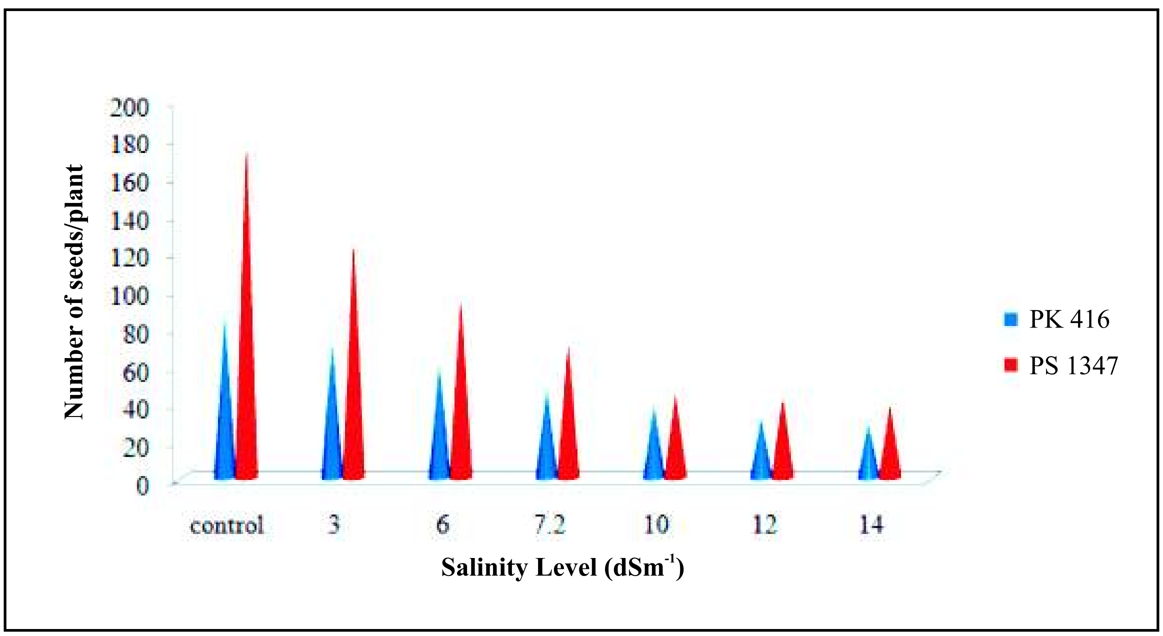

Figure 6 : Effect of Salinity on Number of Seeds Per Plant in cv. PK 416 & PS 1347

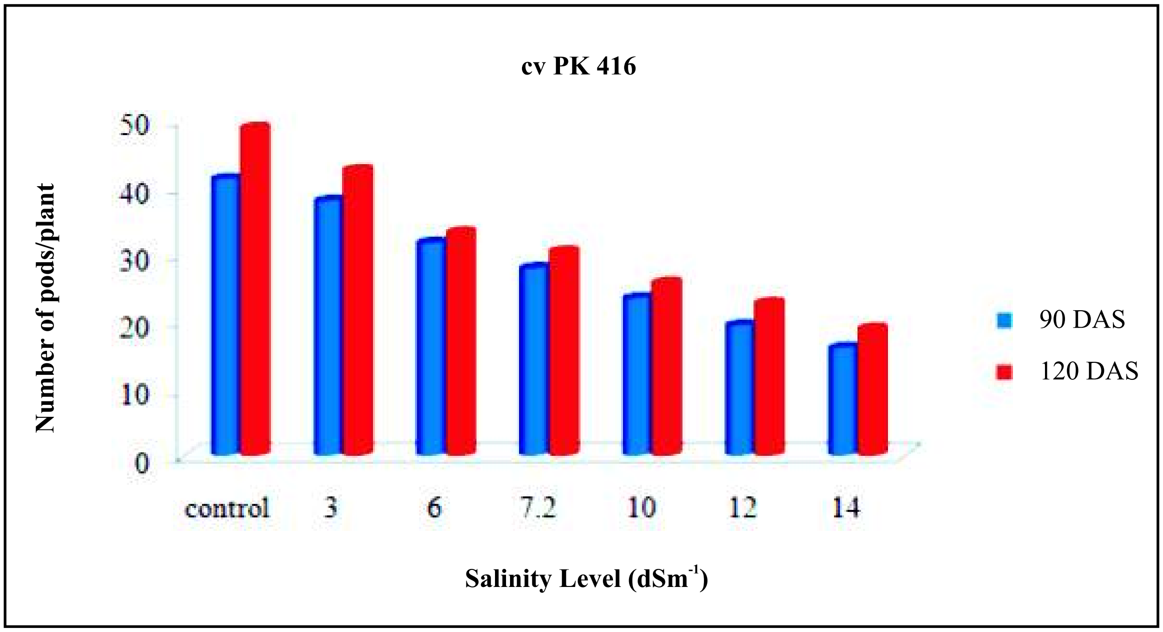

Figure 7 : Effect of Salinity on Number of Pods Per Plant in cv. PK 416

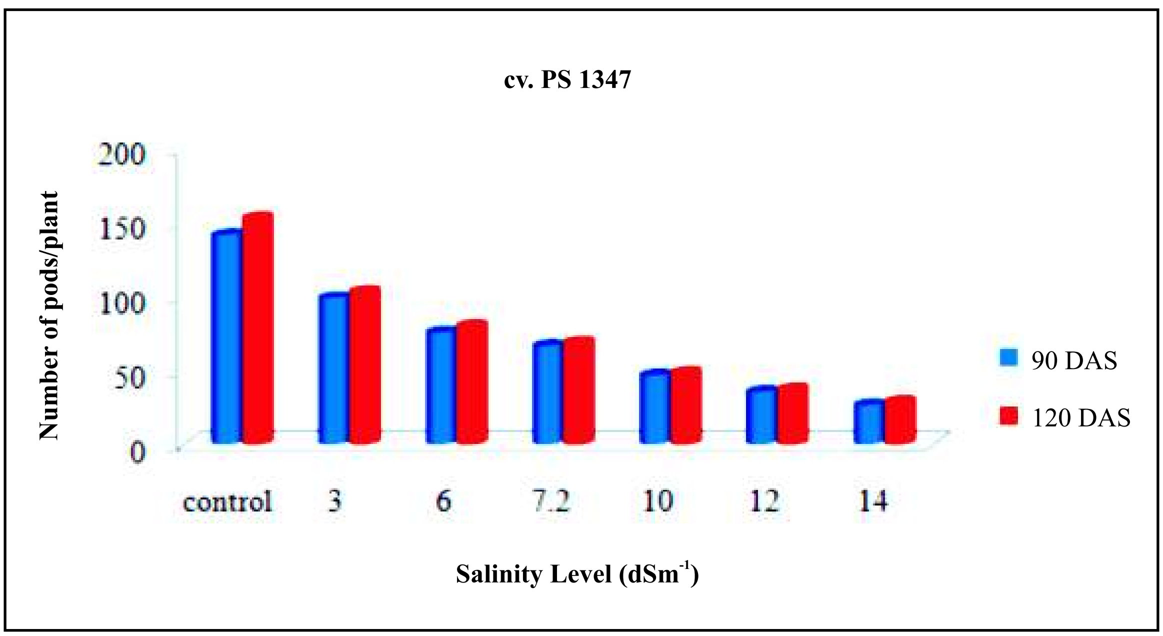

Figure 8 : Effect of Salinity on Number of Pods Per Plant in cv. PS 1347

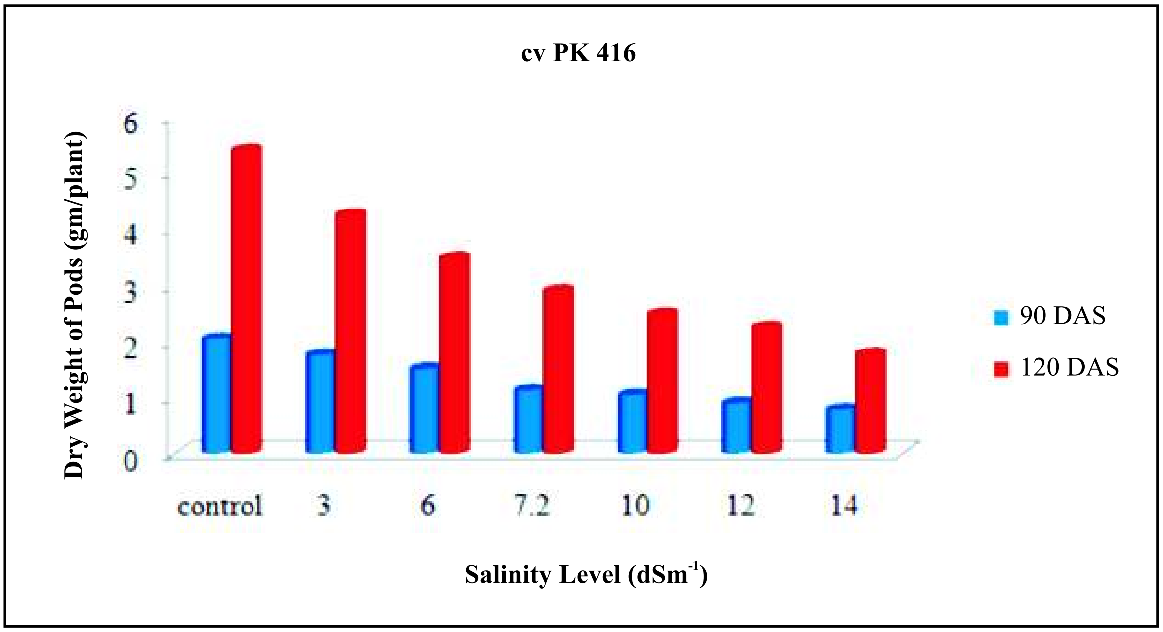

Figure 9 : Effect of Salinity on Dry Weight of Pods in cv. PK 416

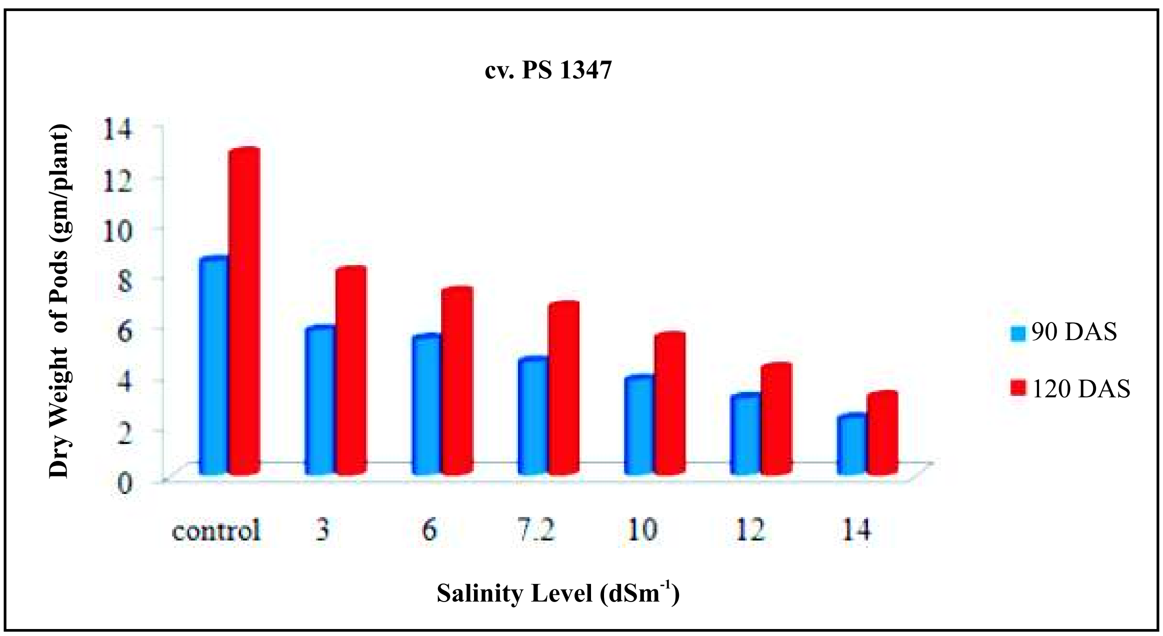

Figure 10 : Effect of Salinity on Dry Weight of Pods in cv. PS 1347

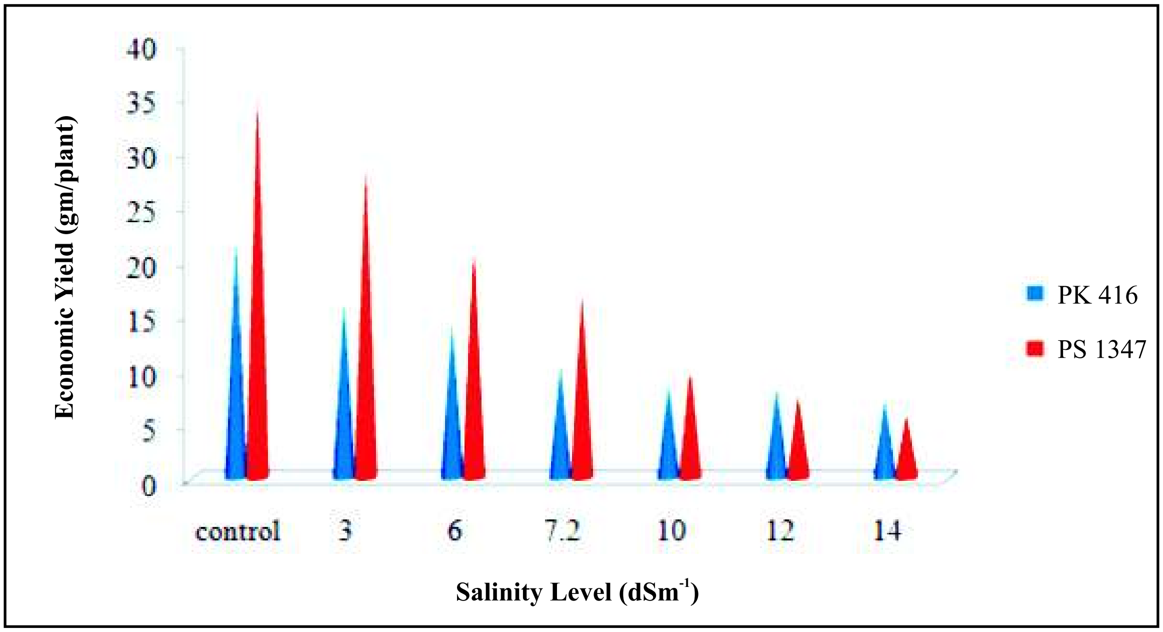

Figure 11 : Effect of Salinity on Economic Yield in cv. PK 416 & PS 1347

accessions at maturity in the present study (Figure 5 & 6). These results showed that decrease in various yield parameters was more severe in cv. PS 1347 in comparison to other cultivar, in control as well as in saline conditions which may be related to lower plant dry mass accumulation in PS 1347. Biological yield registered significant reductions at all durations with different saline irrigations. Irrigation with 6 to 14 EC of water had shown adverse effect on biological yield irrespective of cultivars and durations (fig. 11). However, the level of significance varied in different cultivars and at different durations. Biological yield increased with the advancement of plant age irrespective of saline irrigations in both the cultivars. However, the varietal differences are evident. Data indicate sharp decrease when the plant advanced to 90^{th} day stage.

DISCUSSION

The effect of saline water irrigation on growth and productivity in two selected genotypes of soybean (*Glycine max* L.) has been evaluated. Present findings indicate that significant reductions in dry weight were recorded in both the sets at different durations except at some places e.g. PK 416 at 3 and 6 EC level at 30DAS while PS 1347 exhibited insignificant decrease at 3 - 14 EC level at same durations. The growth of root and shoot is the most important parameter for salt tolerance because roots are in direct contact with the soil and absorb water from soil and shoot supply it to the rest of the plant. For this reason, root and shoot length provides an important clue to the response of plants to salt stress (Jamil et al., 2004). That salinity reduced the plant growth irrespective of the cultivar is evident from the decline in dry weight of both roots and shoots with increasing stress. As stated by Munns (2003), suppression of plant growth under saline conditions may either be due to the decreasing availability of water or to the increasing toxicity of NaCl associated with increasing salinity. Elsheikh and Wood (1990) had earlier observed decrease in root and shoot dry weight of seedling with increasing salinity levels, which is similar to the results of this present study.

The reduction in plant growth under saline conditions may either be due to osmotic reduction in water availability which resulted in increasing stomatal conductance as reported by Gunes et al., (1996), or to excessive ions , Na and Cl accumulation in the plant tissues (Cusido et al., 1987; Gunes et al., 1998 and Yousef and Al-Saadawi, 1997). Similar results were reported by Schuch and Kelly, (2008); Cicek et al., (2002) and Badr et al., (2002). The same negative effects have also been reported by Shereen et al. (2001) and Murat et al., (2008). Abd El-Samad et al., (2005) who reported inhibition in plant dry weight is due to decrease in field water capacity. This inhibition was associated with a decline in nitrate reductase (NR) and nitrogenase (NA) activities in both shoots and roots of wheat plants. Root growth had been adversely affected under various salinity regimes but cultivars evoked differential effects. Present data revealed that root dry weight of both the cultivars showed non significant reductions at 30 AS at different salinity of irrigation water and at 60 DAS at 3 EC level. Demir and Arif (2003) observed that root growth was more adversely affected as compared to shoot growth by salinity. Jeannette et al. (2002) reported that total fresh weight of root and shoot of radish was reduced with increased salt stress. These results were also in agreement of Jafarzadeh et al. (2007) who observed that root length was significantly affected by salt composition, cultivars and salinity levels. Present results, however, do not agree to Greenway and Munns (1980) who noticed increased growth at low salinity levels. This may be due to variable response of different plant species to salinity. Our results are also in agreement with the findings of Alam et al., (2015).

The analysis of variance for seed characteristics of economic yield i.e. number of seeds, number of seeds per pod, 100 seed weight and seed yield per plant, indicated highly significant differences. The increasing salinity levels, decreases all the seeds characteristics in both the accessions at maturity in the present studies. Similar results of reduction in yield under saline conditions have been reported in rapeseed (Valiollah et al. 2012; Valiolla, 2013). Final seed weight is the result of seed filling rate during the linear phase and the duration of this period. Seed filling rate was described as the accumulation of seed dry matter per unit time, which varied among varieties and had positive correlation with final seed weight (Guffy et al. 1991). Researchers showed that environmental stresses may hasten the seed filling rate and decrease grain filling duration (Yazdi-Samadi et al. 1977). This can influence final yield of all grain crops such as soybean. Seed filling period is under genetic control and it is sensitive to salt stress (Brevedan and Egli 2003). Netondo et al. (2004) reported that photosynthetic activity decreases when plants are grown under saline conditions leading to reduced growth and productivity. The reduction in photosynthesis under salinity can be attributed to a decrease in chlorophyll content (Jamil et al. 2007) and activity of photo-system II (Ganivea et al. 1998).

CONCLUSION

From the results of present investigation, we can conclude that increasing levels of salinity affected growth and productivity in both the varieties. However, for all physiological parameters (shoot and root dry weight, number of pods, fresh and dry weight of pods) varietal difference was recorded and it was maximum at high salt stress. From the two varieties analyzed PS 1347 was salt sensitive and PK 416 was salt tolerant.

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