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Effect of Sodium Chloride on Growth, Nodulation, Flowering & Yield of Pea Plant (*Pisum sativum* L.) under Photoperiods

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Authors' contributions

This work was carried out in collaboration between both authors. Author Gulafshan designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript and managed the analyses of the study. Author MAS managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Garden pea (*Pisum sativum* L.) is a popular nutritious vegetable crop grown in winter season through out of the world, belong to family Fabaceae .A study was made on the influence of sodium chloride upon the growth, chlorophyll content, nodulation, flowering and yield of Pea Plant (*Pisum sativum* L.) CV. P.Arkel under both photoperiod's i.e. Long day and short days. The finding revealed that plant length, plant fresh and dry weight, leaf no. ,leaf area/ plant, Chlorophyll pigments, carotenoids, root nodules number, root nodules fresh & dry weight, flower number & pod number were higher under long days irrespective to short days in control. No significant effect was observed in the leaf area & photosynthetic pigments with low concentration, while a significant decrease was noticed for each, with two higher concentrations (100,200mM) in photoperiods, ie.SD and LD. As evident from the data, the number of flowers was significantly higher under long days. Salt stress differentially affected the pod yields in both photoperiods. The number of pods was increased 61.5 % in long days, when compare to short days. The long day had more fresh and dry weight of pods in comparison to short days in CV. P. Arkel.

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Keywords: SD; LD; photoperiods; nodulation; plant length; NaCl.

1. INTRODUCTION

Abiotic stress factors of environment, especially drought and soil salinity, are the major cause for reduction of agriculture yields. Increasing human population and reduction in land available for cultivation are two threats for agricultural sustainability [1]. Soil salinity is a threat to agriculture production and a better understanding of the physiological basis underlying salt stress will be essential to improve the salt tolerance of crop plants [2-4]. From the results of the studies, which looked at the effect of salt stress on growth, one can notice a connection between the decrease in plant length and the increase in the concentration of sodium chloride [5-12]. World - wide, soil salinity is a great threat for the plant growth and yield [13-16]. The osmotic stress is caused by the excess of Na^+ and Cl^- ions in the soil that decrease the osmotic potential and hampers the water uptake and nutrients. Low molecular mass compounds known as compatible solutes are accumulated under salt stress. A decrease of biomass, leaf area, and growth has been observed in different vegetable crops under different salinity level [17,18]. According to this, salinity reduced root biomass in Broccoli and Cauliflower.

Thomos [19] reported that plant flowering in response to photoperiod have been classified as long –day (LD) ,short -day (SD) and day neutral(DN). Long day plants flower when the day length exceed their critical photoperiod. Day neutral plants are insensitive today length and short day plants flower when the day lengths are less than a critical photoperiod. Adams [20] investigated the effect of temperature on the time of floral initiation in Chrysanthemum. Mah [21] in rice reported that the growth were found to be increase under long day with high temperature as compared to short days Wang [22] reported that plants respond temperature photoperiod signals differently at various developmental stages. Increasing plant height under increased light intensity and long day may be due to increased irradiance received by the plants during a 24 h cycle and consequently increased growth rate resulting from more photosynthesis .Increased plant height under a higher light intensity in Cardinal flower (*Sinningia cardinalis*) has also been reported previously by Kim [23]. Young tomato plants to exhibited better photosynthesis capacity under 300 meo mol/m^2-s.reported by Fan [24].

The aim of the following study was to investigate the effect of sodium chloride on the growth, nodulation, photosynthetic pigments, flowering and yield of Pea plant CV. P. Arkel, under photoperiods, ie.SD and LD.

2. MATERIALS AND METHODS

A pot experiment was conducted to evaluate the effect of Sodium chloride on Plant growth, Photosynthetic pigment, Nodulation, Flowering and Pod yield in CV. P. Arkel of Pea (*Pisum sativum* L.) under photoperiods. The pots were divided in two lots exposed to natural day light (SD) followed by dark period of night while the second lot was exposed to 24 hours continuous light (LD). The dark period of night was replaced by artificial illumination of four fluorescent tubes of 60 watts and four 200 watts in candescent bulb from the sun set to sun rise next morning. The tubes and bulbs were kept 100 cm. away from the plants.

We used different concentration of sodium chloride (0, 50,100 and 200mM), according to [25] Pots were then separated in to four group namely control(C), mild (50 mM), moderate (100 mM) and severe (200 mM).Control plants were watered daily and salt stressed plants were treated with 250 ml of 50, 100 and 200 mM NaCl solution twice a day for a period of 1 week in both photoperiod (short day and long day). Three replicates were chosen for each morphological and physiological measurement (at an average of three plants per replica). Plants carefully removed from the pots at the end of the study (110 days after planting) that were washed with pure water and cleaned. Observations on morphological, parameters, nodulation, flowering and number of pods were recorded at 110 days. The height of the plants were measured with a ruler 110 DAP. Whole plants were taken as fresh weight and then put in oven at 65° C for 48 hours then dry weight was taken. The nodules were carefully removed by hand and counted. The fresh weight of root and root nodules were recorded .The fresh material was kept in hot air oven for 21 hours at 80°C. Leaf areas were determined according to [26].

Total chlorophyll and carotenoid content in fresh leaves were estimated using the method [27]. Chlorophyll a, chlorophyll b and total carotenoids were extracted from 0.1g of fresh leaf material by grinding in the presence of 30 ml. ice -cold 80 %

acetone, the sample was gently mixed over night in a orbital shaker, centrifuged and the absorbance of the supernatant was determined at 663,646, and 470 nm . Pigment concentrations were calculated using published equations and were expressed as 'mgg-^{1} DW. Flowers were counted from each plant. The pods were also counted from the plants after harvesting.

2.1 Statistical Analysis

Each pot was examined as replicate and all of the treatments were repeated three times. Statistical analysis of the data was done following the method of analysis of variance (ANOVA) [28]. The Critical difference (CD) values were calculated at 5% probability levels.

3. RESULTS AND DISCUSSION

Salinity can affect plant growth indirectly by Sodium's effect on the degradation of the soil's physical condition and by increasing the soil's PH.

3.1 Plant Length

The data in Table 1(a) and Fig. 1(a) indicate the plant length is affected by Sodium Chloride in CV P.Arkel under photoperiods. In general, the plant length significantly increased under LD (Continous light for 24 hours) conditions as compare to SD. When it's treated by sodium chloride the increase in plant length was 36.98 % under long day when compare to short days. Tanya [29] reported in -Chrysanthemum, cv. Snowball-, the vegetative growth of the plant i.e. plant height, number of leaves, and root suckers per plant were positively affected with increased night interruption duration. The salinity level of sodium chloride treatments generally decreased the length, but reduction with 50mM was insignificant while 100 mM and 200 mM sodium chloride significantly reduced the plant length in comparison to control in both photoperiods in CV P. Arkel.

Table 1. Effect of sodium chloride on plant morphology under photoperiods

Sodium Chloride	Plant length (cm)		Whole plant fresh weight (gm/ Plant)		Whole plant dry weight (gm/ Plant)	
	LD	SD	LD	SD	LD	SD
Control	100	73	17.20	15.65	5.05	4.15
50 mM	89	67	15.95	14.90	4.20	3.45
100 mM	72	46	12.20	11.20	3.00	2.60
200 mM	65	38	10.00	9.35	2.40	2.00
C.D.(P=0.05)	9.6		1.64		0.41	
S.Em	±1.5		±0.28		±0.18	

**CD-Critical Difference, *SEm-Standard Error of Means,* Significant at p<0.05*

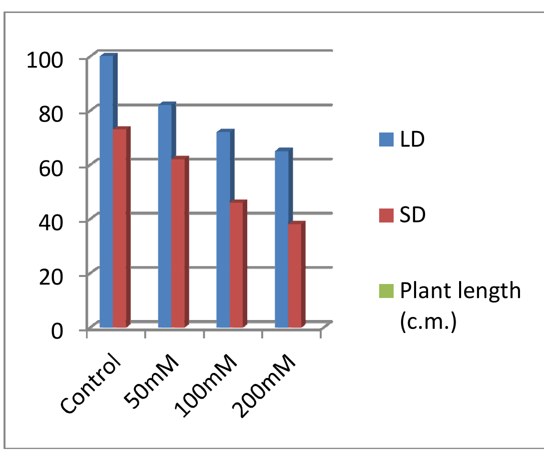
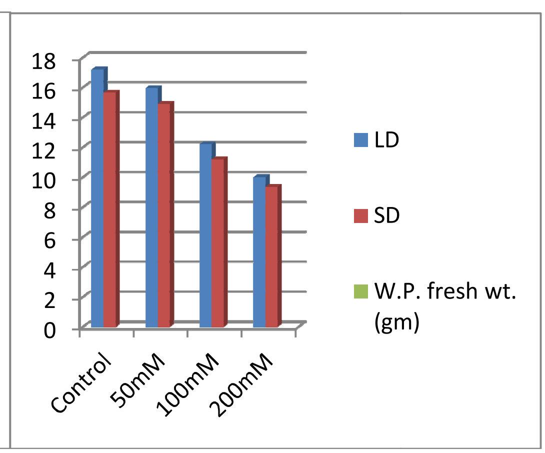


Fig. 1(a)



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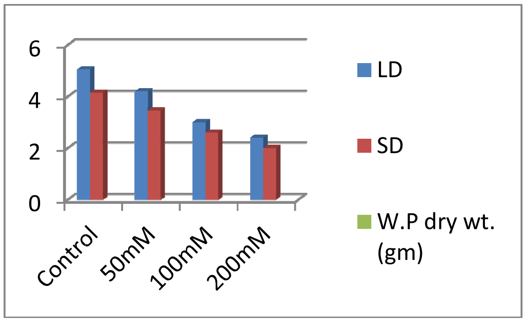

Fig. 1(c)

Fig. 1. Effect of NaCl on (a) plant length (c.m.) (b) whole plant fresh wt. and (c) whole plant dry wt.(gm)/ plant in Pea (*Pisum sativum* L.) under both photoperiods

Table 2. Effect of sodium chloride on plant nodulation under photoperiods

Sodium Chloride	Root nodules no. / plant		Root nodule fresh wt. (gm/plant)		Root nodule dry wt. (gm/plant)	
	LD	SD	LD	SD	LD	SD
Control	45	22	0.68	0.45	0.34	0.25
50 mM	41	18	0.57	0.32	0.29	0.21
100 mM	28	10	0.45	0.20	0.20	0.15
200 mM	20	08	0.40	0.15	0.16	0.11
C.D.(P=0.05)	1.150		0.270		0.053	
S.Em	±0.499		±0.120		±0.023	

**CD-Critical Difference, *SEm-Standard Error of Means, * Significant at p<0.05*

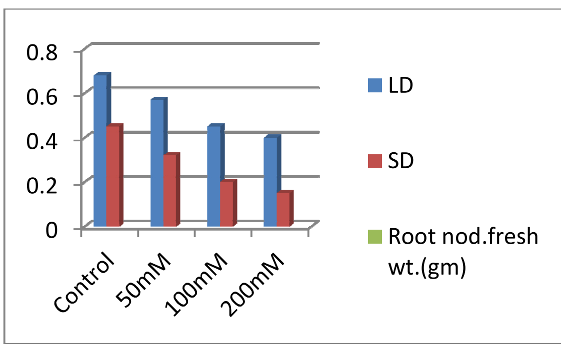

Fig. 2(a)

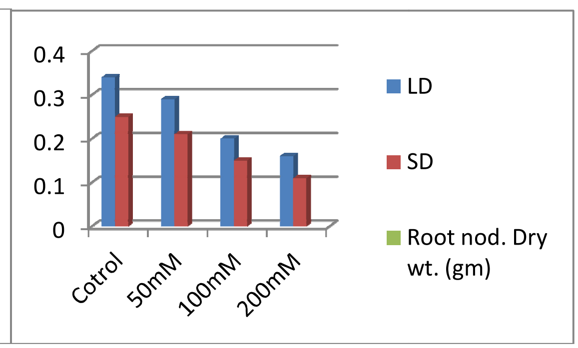

Fig. 2(b)

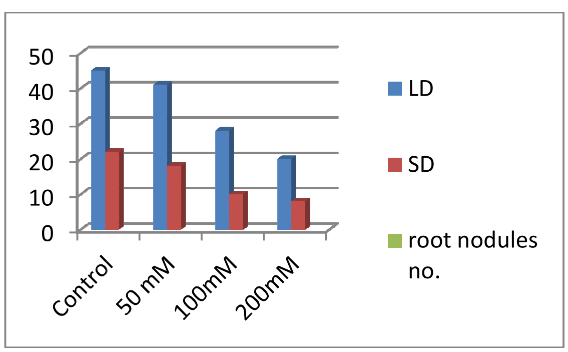

Fig. 2 (c)

Fig. 2. Effect of NaCl on (a) Root nod. Fresh wt (gm). (b) Root nod. Dry wt.(gm) and (c) Root nod. Number/ plant. in Pea (*Pisum sativum* L.) under both photoperiods

3.2 Fresh and Dry Weight of Plant

As shown in Table 1 and Fig. 1(b& c), total fresh weight / plant were affected by salt stress under both photoperiods. As evident from the data the total fresh weight /plant increased under LD in comparison to SD in Pea, however the increase was statistically significant. The maximum decrease in total fresh weight was noted with salinity level of 200 mM. Salinity can affect plant growth indirectly by sodium's effect on the degradation of the soil's physical condition and by increasing the soil's pH. The increase in total dry weight /plant under LD was 21.68% in CV P. Arkel in comparison to SD in control. Salt treatments differentially affected the total dry weight per plant. Ram Chandra [30] in carrot also reported that the long day photoperiod enhanced the plant height, leaf number, root length and its circumferences and shoot and root dry weight at 100 days. [31] reported that the shoot length and number of leaf increased with the increase of the photoperiod from 8 to 24 h.

3.3 Nodulation

The data given in Table 2 and Fig. 2(a) represents the number of root nodules is affected by treatments of sodium chloride. The No. of root nodules generally increased from 50 to 110 DAS in pea. In general the lower conc. of sodium chloride increased the root nodules No., while the higher conc. Of NaCl (200 mM) more reduced the No. of root nodules in CV. P. Arkel, in comparison to control in both photoperiods. The NaCl caused in a reduction root length, fresh and dry weight of roots, number of leaves and leaf area in pepper [32].

The data indicates in Fig. 2(b & c) that control had more fresh and dry weight of root nodules in comparison to salinity level of 100mM and 200mM of NaCl treatments in both LD and SD plants, but the root nodules fresh and dry weight were significantly higher under LDs- as compare to SDs. The reduction in fresh weight was 51.11% and in dry weight was 36% in CV P. Arkel respectively in comparison to Long days.

3.4 Chlorophyll Content and Leaf Area

As shown in Table 3 and Fig. 3(a, b, c & d) there was no significant difference in Chl. a content, Chl. (a +b) content & Carotenoid content under LDs as compare to SDs. These results suggested that Sodium Chloride did not have identical impacts on chlorophyll contents, but the chlorophyll contents decrease in response to high dose of NaCl treatments (200 mM). The data on leaf area is represented in Table 4 and Fig. 4(a). It is indicated that LD condition promoted the leaf area / plant. Although the individual leaves were smaller under LDs, but the total leaf area increased due to the significant increase in leaf No. /plant. The reduction of leaf area under SD was 29.48% in CV P. Arkel in comparison to respective LDs, with increase in the concentration of NaCl.

3.5 Number of Flower and Pods

Table 4 and Fig. 4(b & c) exhibits the number of flower and pod /plant as affected by salt stress in both photoperiods. No. of flowers were significantly higher under long days as compared to short days. The increase in No. of flower was 60% in CV P.Arkel when compare to SDs. But the salt stress in general reduced the No. of flower/plant in both photoperiods. A similar result was reported by [33] in which *Gardenia* spp. produced 30% fewer flowers when exposed to 67% shade. In most photoperiod plants, flowering occurs in response to a critical photoperiod, but [34] have been reported that optimum temperature and favorable photoperiod can accelerate flowering within critical limits.

Table 3. Effect of sodium chloride on chlorophyll contents under photoperiods

Sodium Chloride	Chl .a ($mgg^{-1}DW$)		Chl. b. ($mgg^{-1}DW$)		Chl.a+b (mgg^{-1} DW)		Carotenoids ($mgg^{-1}DW$)	
	LD	SD	LD	SD	LD	SD	LD	SD
Control	2.340	2.300	1.01	0.99	3.35	3.29	0.39	0.38
50 mM	1.820	1.765	0.84	0.81	2.66	2.575	0.33	0.29
100 mM	1.730	1.730	0.76	0.78	2.490	2.51	0.29	0.30
200 mM	1.744	1.725	0.69	0.71	2.434	2.435	0.28	0.275
C.D.(P=0.05)	0.350		0.114		0.450		0.012	
S.Em	±0.130		±0.050		±0.118		±0.002	

*CD-Critical Difference, *SEm-Standard Error of Means,* Significant at p<0.05*

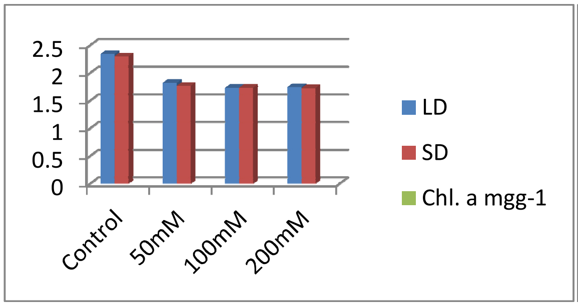

Fig. 3(a)

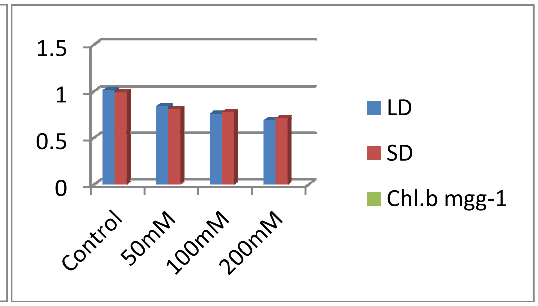

Fig. 3(b)

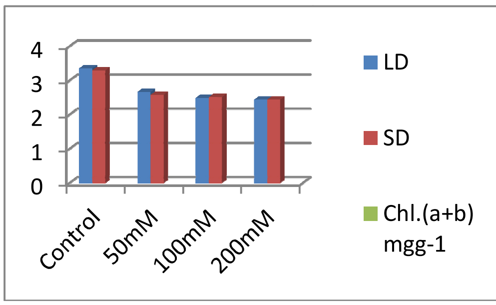

Fig. 3(c)

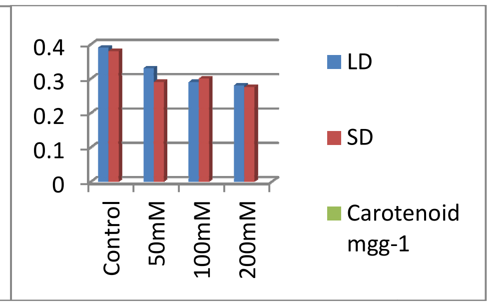

Fig. 3(d)

Fig. 3. Effect of NaCl on (a) Chl. a (mgg-1DW) (b) Chl. b (mgg-1 DW) (c) Chl. a+b (mgg-1DW) (d) carotenoids (mgg-1DW)/ plant in pea (*Pisum sativum* L.) under both photoperiods

Table 4. Effect of sodium chloride on plant leaf area, no. of flowers and number of pods under photoperiods

Sodium Chloride	Leaf area (cm2 / plant)		Number of flower/plants		Number of Pods/plants	
	LD	SD	LD	SD	LD	SD
Control	34.182	26.398	9	6	8	5
50 mM	23.50	22.500	7.4	5.7	7.66	5.5
100 mM	13.532	12.318	5.5	4.0	5	3
200 mM	10.831	8.838	4.66	2.66	3	2.33
C.D.(P=0.05)	2.467		1.380		1.980	
S.Em.	±1.070		±0.600		±0.860	

**CD-Critical Difference, *SEm-Standard Error of Mean, * Significant at p<0.05*

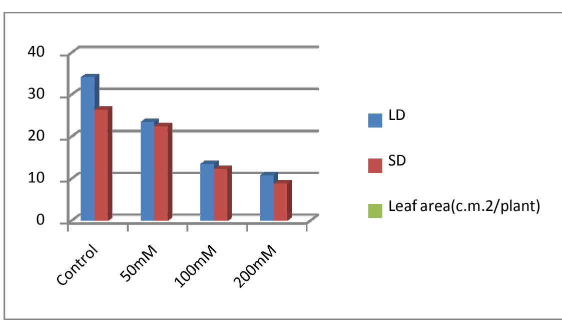

Fig. 4(a)

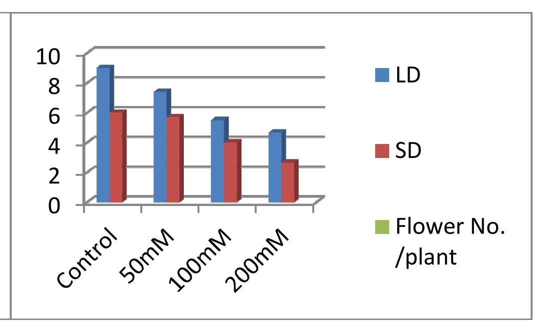

Fig. 4(b)

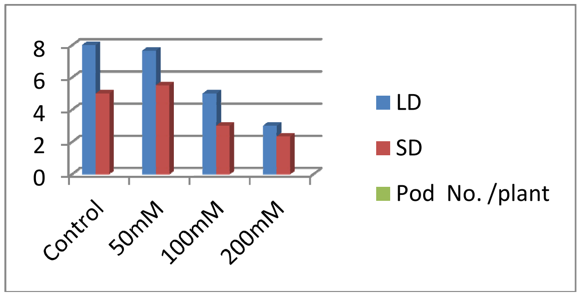

Fig. 4(c)

Fig. 4. Effect of NaCl on (a) leaf area c.m^{2} /plant (b) flower No./plant and (c) pod number/ plant. in pea (*Pisum sativum* L.) under both photoperiods

Table 5. Effect of sodium chloride on pods fresh and dry weight (gm/plant) under photoperiods

Sodium Chloride	Pods fresh wt. (gm/plant)		Pods dry wt. (gm /plant)	
	LD	SD	LD	SD
Control	20.00	15.20	8.20	7.50
50 mM	15.10	13.30	7.30	6.20
100 mM	8.70	7.30	4.50	4.05
200 mM	6.50	5.50	3.75	3.00
C.D.(P=0.05)	1.79		0.39	
S.Em	±0.78		± 0.17	

**CD-Critical Difference, *SEm-Standard Error of Means, * Significant at p<0.05*

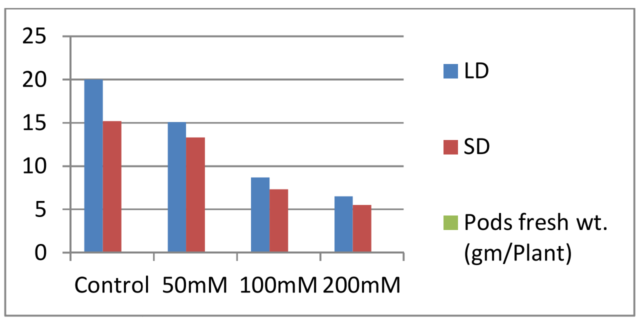

Fig. 5(a)

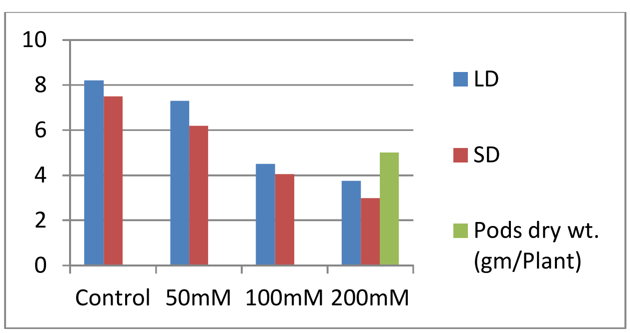

Fig. 5(b)

Fig. 5. Effect of NaCl on (a) pods fresh wt. (gm /plant) and (b) pods dry wt. (gm/plant) in pea (*Pisum sativum* L.) under both photoperiods

The No. of pod was increased 61.5% in pea when compare to short days in control. The lower concentration of NaCl treatments insignificantly decreased the pod numbers, while the higher conc. of NaCl significantly decreased the pod numbers/plant in CV P. Arkel under both photoperiods ie.SD and LD plants.

3.6 Yield

The data indicates in Table No. 5 and Fig. 5 (a & b) that long days had more fresh and dry weight of the pods/plant in comparision to short days. The reduction in fresh weight was 31.57% and in dry weight was 9.53% in CV P. Arkel, in comparision to long days. But the increasing the salinity levels of NaCl (100 mM & 200 mM) decreased the fresh and dry weight of the pods/plant in both photoperiod ie. LD & SD.A saline soil is generally defined as one in which the electrical conductivity (EC) of the saturation extract (EC_e) in the root zone exceeds 4 dS m^{-1} (approximately 40 mM NaCl) at 25°C and has an exchangeable sodium of 15%. The yield of most crop plants is reduced at this EC_e, though many crops exhibit yield reduction at lower EC_es [35], [36].

4. CONCLUSION

Soil salinity is becoming a major constraint to vegetable crop production. In the present investigation to study the effect of sodium Chloride on Plant growth, Photosynthetic pigments, Nodulation and Yield in the selected variety of pea (*Pisum sativum* L.) under photoperiods i.e. Long days and Short days. Although the vegetative parameters i.e. plant height, fresh & dry weight of Whole plant, physiological parameters i.e. Leaf area, photosynthetic pigments, number of root nodules, fresh and dry weight of root nodules, flowering and yield per plant increased with increase in duration of photoperiodic night interruption as compare to short days, yet these parameters were decreased with increase the concentration of Sodium Chloride in both the Photoperiods i.e. Long days and Short days.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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