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Effect of salinity on growth, yield and yield attributes of summer groundnut (*Araches hypogaea* L.) in coastal saline belts of West Bengal

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ABSTRACT

Groundnut is an important oilseed crop and emerging as a food crop in India and the area of the crop is more than 26.0 million ha around the world (FAO, 2003).The crop grown in more than 100 countries across the world. However, the average yield of the crop 998q/ha mainly due to the majority of the crop (80%) is grown under rainfed condition. Also the crop encounters several biotic and abiotic stresses. Drought, high temperature and salinity are the most important factors effecting the yield of the crop. This crop agriculture faces three way problems in the sundarban blocks of South 24 Parganas district of West Bengal. These are i) soil salinity, ii) late release of land for *Rabi* crop due to poor drainage system along with low percolation rate of water and iii) poor irrigation facility as the ground water is saline and unfit for irrigation. In this perspective, it was tried to understand the response of summer groundnut to soil salinity and also which can grow with minimum irrigation facilities. Limited work has been attempted so far for identifying the threshold salinity level in coastal and saline belts of West Bengal. Present investigation was with an aim of finding the threshold salinity level for growing groundnut successfully and profitably in coastal saline areas of sundarbans (south 24 Parganas),W.B. It was observed that this crop can not grow successfully at high salinity of EC 2.4 dS/m and above. The mortality of seedlings increased with the advancement of plant growth and clear-cut differences were observed in high and low soil salinity level. The crop was grown in summer season and soil salinity (EC> 2.3dS/m) caused more than 50 per cent mortality, (average 35%) pod and kernel formation was severely reduced. In that situation the plant growth was good but on the other side root development, pegging and seed filling were severely hampered due to high soil salinity which ultimately led to the poor kernel yield of the crop. Also, with the increase in environmental temperature during the month of March-April, when the crop was in full growth stage, yellowing and scorching of leaf was observed.

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KEY WORDS : Salinity, Groundnut, Sundarban, Yield attribute

Groundnut (*Arachis hypogaea* L. is a very important oilseed /food crop in the world as well as India. In India out of 329 million ha of land 7.61 million ha of land is saline land out of which 2.0 million ha of land is coastal and saline belts (Singh and Basu 2004). The soil salinity is an emerging problem of this areas where ground nut is major crop and preferred by the farmers due to it's importance as oilseed /food and fodder crop. Salinity in these areas is emerging in alarming rate. The measuring electrical conductivity (EC) of ground water is mainly unsuitable for irrigation.

Groundnut is a self pollinated oil-yielding warm season crop. The nut contains 26 per cent protein and 45 per cent oil. India will need 34.64 million tons of oilseed production in the year 2020.But the present production as well as rate of annual increase in production is far away from the target. Presently, groundnut shares 32 per cent of total oilseed production in India. To meet the call of the future, the area under production and the productivity of groundnut should be increased. In west Bengal groundnut is largely grown as a summer crop under rainfed condition and yield is influenced due to erratic monsoon, the scope of increasing area under pre-*Kharif* ground nut is limited. In the southern parts of South 24 Parganas district, *i.e.* parts of Sundarbans, the agriculture faces three way hindrances. These are i) soil salinity, ii) late release of land for *Rabi* crop due to poor drainage system along with low percolation rate of water and iii) poor irrigation facility as the ground water is saline and unfit for irrigation. So, the farmers of this region have a very less mobility in crop selection for the *Rabi* season after aman paddy. In this crop selection process, one should keep in mind that the crop should bear the following characters, *i.e.* a) it is able to grow with minimum irrigation facilities and should survive water stress, b) can tolerate soil salinity to some extent and c) can protect the soil from direct sun by covering the soil surface, thus minimizing soil salinization process. Ground nut is one this type of crop. Like other crops, ground nut also prefers low saline and highly nutritious soil having one or two light irrigation, which facilitates haboc production. However, the yield potential of this crop grown during summer can be realized to a greater extent by adopting suitable water and nutrient management practices. But, unlike other crops, ground nut can grow well in moderate type soil with one or two light irrigation facility as groundnut is a somewhat drought tolerant crop. In sundarban soil, groundnut has enough scope because sundarban has its own peculiarity with respect to its salinity development. In any plant species sensitivity to salinity is known to vary between growth stages (Mass and Hoffman, 1977). It has been observed that, just after harvesting of paddy particularly in the month of December, there is very little or no salinity in the soil. But, gradually, when the upper surface of the soil starts drying, some of the plots become saline due to the upward movement of saline ground water. In this situation cultivation of ground nut immediately after harvesting of aman paddy, can save both the soil and the crop as well. Groundnut is a good economic crop in this situation, as it gives the farmer to earn some money at a time when no other crop was possible. Also it gives a good fodder during the drier months of March to May, when scarcity of green fodder is acute in this region. Thirdly, it improves soil health by minimizing soil salinity and by nitrogen fixation.

In Sundarban situation, groundnut has been tried sporadically, particularly by the farmers, for the last seven to ten years. It has been noticed that in less saline plots, bumper kernel production has been recorded; where as in saline plots though the plant growth is good, but kernel production is not satisfactory. In this condition, a systematic study was essential to find out the threshold level of salinity tolerance of this crop. Still now, no systematic study in this respect has been carried out to find out the optimum level of salinity which the crop can tolerate. In present investigation it was tried to find out the level of tolerance of the crop to salinity.

RESEARCH PROCEDURE

Present investigation was carried out during *Rabi* summer season at the Instructional farm of Ramkrishna Ashram Krishi Vigyan Kendra, nimpith,South 24 Parganas. The experimental site was situated 22 ^{0}343"N latitude and 89 ^{0} 4"E longitude at an altitude of 5.0m above mean sea level. The soil of experimental plots was clay loam. The site was subtropical humid climate with annual average rainfall1350mm and 80 per cent of rainfall occurs during second week of June to middle of October. The experiment was arranged in Randomized Block Design with three replications. Eight different plots having eight different salinity levels were selected for conducting this experiment. All the eight plots had more or less similar nutritional and pH level. Each of the eight plots was again subdivided into three parts and each part was treated as one replication. Thus, in each treatment (salinity level) six number of plot was developed and totally forty eight number of plot were prepared.

The variety of groundnut used in this experiment was cv. JL -24, which was collected from AICRP, Ground nut, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal.

Each plot was of 8m in width and 10 m in length. Seeds were drilled 30 cm apart during first half of February and row to row spacing was given 60cm. At the time of land preparation FYM was applied 15ton/ha.Common dose of 25 kg N and 50 kg P_2O_5/ha and 40 kg K_2O /ha was applied in the form of urea, SSP and MOP as basal. Through SSP 40 kg sulphur /ha was applied as basal. The crop was grown as rainfed and one irrigation at the time of 50 per cent flowering was applied. There was very little rain during the crop period. The meteorological data and soil nutrient status of 8 treatments is given in Table A and B.

Observations were recorded from ten representative plants selected randomly from each replication on the following set of characters *viz*., final plant height (cm), number of branches, leaf area (cm^2) per plant, days to 50 per cent flowering, days to maturity, number of pods per plant, number of seeds per pod, weight of pods per plant(g), kernel yield per plant (g), pod yield (kg/ha) kernel yield (kg/ha), haulm yield (kg/ha),shelling %, 100 kernel weight(g), total chlorophyll (g/m^2) and total sugar (%).

Leaf area was calculated by multiplying number of leaf in the plant and average individual leaf size.

Total chlorophyll was calculated by addition of the amount of chlorophyll a and chlorophyll b. Leaf was extracted in 80 per cent acetone and absorption at 663nm and 645 nm were read in a spectrophotometer. Using the absorption coefficients, the amount of chlorophyll was calculated (Sadasivam and Manikchand, 2008). Reducing sugar was calculated as per Nelson-Somogyi method (Somogyi, 1952).

Table A : Soil nutrient status of eight treatments

Treatments	pH	Salinity(EC) (dS/m)	%O.C.	N_2 (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
T_1	7.04	1.63	0.86	563.6	89.7	443.5
T_2	6.86	1.85	0.78	542.9	79.6	451.6
T_3	6.98	2.06	0.81	556.1	83.4	411.8
T_4	6.82	2.26	0.80	510.7	80.5	403.2
T_5	6.88	2.37	0.84	537.4	78.8	436.2
T_6	7.01	2.49	0.80	513.5	81.3	468.8
T_7	6.92	2.58	0.76	532.2	78.2	423.6
T_8	7.02	2.70	0.85	560.6	85.9	431.7

Table B : Weather data during the investigation period (2009-2010)

Month	Temperature(^{0}C)			Relative humidity (%)	
	Maximum	Minimum	Rainfall(mm)	Maximum	Minimum
Dec., 2009	228.8	10.0	-	94.5	29.5
Jan., 2010	27.5	10.2	-	93	26
Feb., 2010	32.5	11.9	-	98	26
Mar., 2010	38.5	21.5	-	98	23
Apr., 2010	39.5	22.6	4.0	99	30
May, 2010	38.6	23.0	180.5	99	31
June, 2010(1st week)	37.4	22.7	96.4	99	51

RESEARCH ANALYSIS AND REASONING

The data recorded during the course of investigation were tabulated, statistically analysed and results are intepreted here under appropriate heads:

Effect on germination:

From the experiment it is clearly observed that the germination of seed of groundnut was highly influenced by salinity status of the soil (Table 1). Higher EC level hindered germination of seeds. The germination of the groundnut decreased significantly with the consequent increase in EC level of the soil. In the present experiment minimum germination% of ground nut seed was recorded (30.34) where EC level was highest (2.70 dS/m), and the maximum (86.25) being with lowest EC level (1.63 dS/m). The experimental findings confirmed the importance of low to medium soil salinity for better seed germination and early seedling development. Similar type of findings were reported by Nandyal *at el*. (1994) and Mensah *at el*. (1977).

Effect on final plant height and leaf area:

The final plant height of groundnut was significantly influenced by the salinity level(EC)of the soil (Table 1). The plant height of the groundnut decreased significantly with the consequent increase in EC level of the soil. In the present experiment minimum plant height was recorded (38.1cm) where EC level was highest (2.70 dS/m), and the maximum (56.1cm) being with lowest EC level(1.63 dS/m); where pH, organic carbon, available nitrogen, phosphate and potash had insignificant variation in different treatment levels. Therefore, it can be concluded that, only the EC was limiting factor on the growth of the plant.

Leaf area significantly reduced with the increasing EC level from 1.63 to 2.70dS/m and the lowest leaf area was observed in treatment 8 (EC 2.70dS/m) followed by treatment 7 (EC 2.58dS/m) and treatment 6 (EC 2.49dS/m), respectively. Both final plant height and leaf area/plant showed same type of response to consequent increase in soil salinity level.

From the experiment it is clearly observed that the growth of plant, number of leaf per plant as well as individual leaf size of groundnut had been highly influenced by salinity status of the soil. Higher EC level hindered the growth and development of groundnut. Which confirms the importance of low to medium soil salinity for better growth and development of the plant.

Effect on number of branches per plant and Days to 50 per cent flowering:

From the Table 1 it may be inferred that number of branches per plant was significantly influenced by the level of salinity of the soil. In the present experiment minimum no. of branches per plant was recorded (3.1) where EC level of soil was highest (2.70 dS/m), and the maximum (8.8) being with lowest EC level (1.63 dS/m). From the above experimental findings it may inferred that the plant height and no. of branches per plant had significantly negative influence related to soil salinity.

The experimental results clearly indicate that the days to 50 per cent flowering were significantly influenced by the EC status of the soil. With increase of EC level the plants took less time to flower. From experimental findings it may be inferred that due to high salinity the plants flowered earlier than the plots where salinity was low. Kelm *et al.* (2000) reported that root development and water use efficiency of sweet potato was affected by the availability of nitrogen to the plants. From the results it may be concluded that in high salinity level (EC> 2.49 dS/m)due to low availability of nutrients to the plants they came to flower earlier than the fields where salinity was found low (EC< 2.49 dS/m). Therefore, it may be concluded that, high soil salinity impaired physiological development of the plants causing early flowering.

Effect on number of pods per plant and number of seeds per pod:

Number of pods per plant showed typical response to soil salinity. Significant difference was observed in number of pods per plant and number of seeds per pod. in different salinity level. With the increased soil salinity, the no. of pods per plant and the no. of seeds per pod decreased sharply. It may be due to a physiological pressure which is imparted upon the plant due to high salinity, which induces the plant to decrease number of pods and no. of seeds per pod.

From the Table A it may clearly be observed that all the treatments varied insignificantly except EC level of the soil. From the above studies it may be inferred that soil salinity had significant influence on uptake of nitrogen, phosphorus, potash and other macro and micro nutrients to the plant, thus in spite of presence good amount of nutrients and organic carbon in the soil, high EC level reduced the total leaf area which is the responsible for photosynthetic activity and indirectly influenced the storage of photosynthates in kernel and by that way it may influenced the no. of seeds per pod. Similar findings were reported by Greig and Smith (1962) who reported that Salinity effects on sweet potato growth. Similar findings were reported by Girdhar *et al.* (2005) in groundnut.

The uptake of phosphorus may hamper in high saline soil which ultimately cause poor growth and development of pods in groundnut. Luxuriant plant growth had been found in soil where EC level varies from 1.8-2.3 dS/m and in consequent higher EC level, the high soil salinity cause hindrance for the growth and development of groundnut which confirms the importance of low to medium soil salinity for better growth and pod development of the plant. Sankar (1997) reported positive effects of phosphorus in stimulating root growth, increasing resistance to drought and many quality parameters and increasing foliage production in mulberry.

Role of potassium for fatty acid synthesis had been reported by many workers. The no of seed /pod, kernel weight and oil per cent were significantly influenced by K_2O application in the soil. The experimental plots in present investigation varied insignificantly in respect of K_2O availability. Therefore, from the result it may inferred that the soil salinity plays a major role in the uptake of potassium by the plants. In high salinity level (EC> 2.4 dS/m) availability or uptake was reduce of significantly which ultimately led to the lower no. of seeds/ pod or low kernel yield of the plant.

From our experimental findings it may be pointed out that uptake of potassium is hampered in high salinity level which ultimately leads to the lower no of pods per plant as well as lower no. of seeds (Kernel) per pod at high salinity level.

Table 1 : Effect of different salinity levels on yield and yield attributing characters

Treatments EC: Salinity level	Germination %	Final plant height (cm)	No. of branches per plant	Avg. Leaf area (cm^2) /plant	Days to 50 % flowering	No. of pods per plant	Number of seeds per pod	Weight of pods per plant (g)
T_1 1.63	86.25	56.1	8.8	2347	32.6	32.6	4.25	23.5
T_2 1.85	81.66	54.8	8.4	2265	31.5	31.5	3.95	22.6
T_3 2.06	76.28	51.6	7.6	2137	29.6	29.6	3.78	20.8
T_4 2.26	70.36	49.5.	7.0	1968	28.5	27.9	3.46	19.1
T_5 2.37	55.25	47.2	6.3	1842	27.8	26.8	3.08	17.9
T_6 2.49	45.84	44.1	4.8	1156	25.6	22.6	2.62	14.8
T_7 2.58	39.25	41.5	3.8	1036	24.7	20.1	2.16	12.9
T_8 2.70	30.34	38.1	3.1	938	24.1	17.7	1.58	12.1
S.E. (±))	4.84	0.56	0.31	48.2	0.37	0.35	0.09	0.22
LSD (P=0.05)	12.66	1.5	0.9	148.6	1.1	1.4	0.28	0.6

Effect on no. of pods per plant, pod yield, kernel yield per plant and kernel yield /ha:

From the experiment it is clearly observed (Table 1) that in number of pods per plant as well as no. of seeds per pod was significantly influenced by the salinity status of the soil. With increase in EC level of the soil the pod as well as kernel yield per plant reduced sharply. According to Nautiyal *et al*. (1989) growth and initiation of secondary roots were affected adversely due to salinity. Pod yield and kernel yield per plant was significantly reduced with the increasing EC level of soil from 1.63 to 2.70dS/m. The available nutrients (nitrogen, phosphorus and potash) including organic carbon of all experimental plots showed no significant variations; therefore, it can be concluded that in high saline soil the nutrients become unavailable to the plants which were reflected in the individual pod and kernel yield. In the salinity level EC beyond 2.37dS/m, the kernel yield per plant reduced drastically, which confirms that this level of soil salinity may be the threshold limit for kernel yield of the groundnut. Similar type of result was reported by Hassam *et al.* (1970) reported that soil salinity has great influence on production, uptake and distribution of nutrients in barley (*Hordium vulgere* L.). Girdhar *et al.* (2005) also reported that performance of groundnut (*Arachis hypogaea* L.) was influenced by soil salinity and saline water irrigation in black clay soil.

Effect on shelling percentage and 100 kernel weight:

The experimental results clearly indicate that the shelling percentage was significantly influenced by the EC status of the soil. Maximum shelling percentage was recorded in treatment 1 (74.09%) where EC of the soil was1.63 dS/m followed by Treatment 2 (73.22%) and Treatment 3 (71.53%). The lowest shelling percentage was recorded in treatment 8 (47.90%). The shelling percentage was sharply reduced with the increasing salinity level of the soil. From the result it may be inferred that the salinity of the soil beyond EC 2.4dS/m was not suitable for groundnut cultivation. This findings is similar to Mensah *et al.* (1977) who reported that soil salinity has adverse effect on germination growth and yield of groundnut. Similar type of result was reported by Nandyal *et al.* (1994) who reported that seed production of groundnut was influenced by soil salinity and affect of salinity varied from genotype to genotype.

100 kernel weight was also significantly influenced by soil salinity. In high salinity level the seeds became shriveled which led to the lower 100 kernel weight. Potassium and sulphur play a major role for fatty acid synthesis in oilseed crop. These two macro nutrients also play a major role with other micronutrients for development of bold grain (seed).In high salinity level the uptake and transportation of these nutrients may be hampered which leads to the poor 100 kernel weight. Present findings are in confirmly with the findings show similar type of findings reported by Singh and Basu (2004). Sarma (1997) also reported that plant growth, photosynthesis and ion uptake in chickpea were influenced by salinity.

Effect on haulm yield (kg/ha):

Table 2 shows that haulm yield (kg/ha) of groundnut was significantly influenced by the salinity status of the soil. With increase of EC level of soil, the haulm yield per hectare reduced sharply. Haulm yield significantly reduced with the increasing EC level from 1.63 to 2.70dS/m. The available nutrients (Nitrogen, phosphate and potash) including organic carbon of all experimental plots had no significant variations; therefore, it can be concluded that in high saline soil the nutrients become unavailable to the plants which reflected the haulm, yield. From the experimental findings it may be inferred that the haulm yield had significant correlation with the pod and kernel

Table 2 : Effect of different salinity levels on quality characters of groundnut

Treatments	Kernel yield per plant (g)	Pod yield (kg/ha)	Kernel yield (kg/ha)	Shelling %	100 kernel weight (g)	Haulm yield (kg/ha)	Chlorophyll content (a+b) (g/m^2)	Protein content (%)
T_1	17.42	1305.5	967.7	74.09	37.54	6040	0.245	24.01
T_2	16.56	1255.4	919.9	73.22	36.38	5546	0.239	24.00
T_3	14.97	1155.4	826.2	71.53	35.00	5187	0.231	23.87
T_4	13.67	1061.0	748.0	70.49	33.52	4662	0.223	23.90
T_5	11.63	943.5	646.1	64.50	31.28	4283	0.191	23.77
T_6	8.73	822.1	485.0	59.00	28.52	3761	0.162	23.85
T_7	6.83	716.6	379.4	53.00	26.16	3258	0.157	23.9
T_8	5.80	672.1	322.2	47.90	24.09	2867	0.145	23.8
S.E. (±)	0.13	28.6	20.6	1.65	0.67	87.5	0.02	NS
LSD (P=0.05)	0.4	86.4	62.4	4.67	1.85	290.7	0.06	NS

NS=Non-significant

yield of the plant. Soil salinity beyond 2.37dS/m, haulm yield was significantly reduced which ultimately leads to the poor pod and kernel yield per plant of groundnut.

Effect on total chlorophyll content (a+b) (g/m^2) and protein content (%) in kernel:

Result indicated that the total chlorophyll content (a+b) (g/m^2) of groundnut was highly influenced by the EC level of the soil. The level of chlorophyll decreased with increase in EC level of the soil. The maximum total chlorophyll content was observed at lowest salinity level of the soil (1.63mmhos/cm) and lowest total chlorophyll content was observed at highest salinity level of the soil. The chlorophyll content of the leaf had significant correlation with no. of pods per plant, no. of seeds per pod, pod yield and kernel yield, indicating that, by influencing the chlorophyll synthesis, the salinity of the soils influences the pod and kernel yield of the groundnut.

The result also indicated total protein content in the kernel of the groundnut was not influenced by the salinity of the soil.

Conclusion:

From the above studies it may be inferred that the salinity of the soil has significant influence on yield and shelling percentage of groundnut and the groundnut is a crop which can tolerate medium soil salinity. From the experimental findings, it may be concluded that the salinity of the soil significantly influenced macro and micro nutrient uptake and transportation and by that way it may control the photosynthesis, source–shrink transportation, photosynthates accumulation in different storage organs (Kernel) and other physiological activities which are directly related to yield of the plants. The result of the experiment also indicated that the groundnut can be grown profitably in coastal and saline belts of sundarbans as a rain fed crop with minimum irrigation facilities (One irrigation at peak flowering stage) where the EC level of the soil not exceeds 2.37 dS/m and availability of soil nitrogen, phosphate, potash and organic carbon is medium to high. But the crop can not be recommended for cultivation in the areas where the EC level of the soil goes beyond 2.40 dS/m.

The result of experiment has clearly highlighted the feature that salinity has a key role on pod and kernel yield of groundnut. The seed/kernel yield of the crop was increasing with the lower salinity level of the soil. The kernel yield of the crop was significantly reduced in the soil where EC level >2.37 dS /m and the best soil for the cultivation of groundnut was observed where the EC level soil was below 1.85 dS/m. This finding is in close proximity with the findings of Greig and Smith (1962). The result also indicated that kernel yield of groundnut directly correlated with the no. of pods per plant, total leaf area per plant, amount of chlorophyll synthesis and no. of filled grain (shelling %) and all the traits are yield attributing and also influenced by soil salinity. Therefore, the yield of the crop was indirectly influenced by soil salinity.

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