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Performance of Cumbu Napier grass (*Pennisetum purpureum*) varieties under Sodicity and neutral soil condition

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Abstract
Growth and yield performance of four varieties of Cumbu Napier was assessed at Agricultural College and Research Institute, Killikulam, Tamil Nadu, India during 2021. Neutral and sodic soil conditions were imposed on pot culture. Four varieties of Cumbu Napier viz., KKM 1, CO (BN) 4, CO (BN) 5 and CO (BN) 6 were considered for this study. Crop raised from single node cutting. Recommended nutrient and irrigation management practices implemented. Among the varieties, CO (BN) 6 exhibited higher growth in terms of plant height, leaf length, leaf width, stem girth, number of tillers, and number of leaves followed by CO (BN) 5, KKM 1, and CO (CN) 4 under sodic soil condition. The experimental results confirmed that growth of Cumbu Napier grass was slower under alkaline conditions initially compared to sodic soil. No significant difference in growth observed during the later stages from both soil conditions.

Keywords: Sodic soil, alkaline soil, Cumbu Napier, growth parameter

Introduction
The geographical area occupied by sodic soils is increasing day by day. The total cultivated area in India was 159.7 million hectares (M ha). Out of that total area, the ICAR-Central Salinity Research Institute (CSSRI) has classified 6.73 million hectares (Mha) as salt impacted soils, 3.77 million hectares as alkali soil, and the rest 2.96 million hectares as saline soil. In Tamil Nadu, the alkaline soils cover about 0.37 million hectares (Chinchmalatpure, 2017), which accounts for 9.41% of the total area. If no reclamation measures are done, then salt affected area might be raised from 6.74 to 16.2 million hectares by 50% by 2050. Based on the intensity of the salt hazard and the crop's ability to withstand salt, yield reduction owing to salinity and alkalinity ranged from 10% to 100% (Panta *et al.*, 2014 and Satir *et al.*, 2016) [13, 14].
Cumbu napier is getting greater attentions in recent days in order to meet the fodder demand of the country. The most promising, high-yielding perennial fodder is Napier grass (Sathya bama *et al.*, 2004) which produces higher dry matter yields those other tropical grasses (Ansah *et al.*, 2010) [3]. It has the ability to grow faster and produce higher biomass . It has good palatability in the leafy stage than other forages. Mdziniso *et al.*, (2012) [10] studied that Napier grass is a tall perennial grass that grows to a height of 2–5 m, seldom reaching 7.5 m, with leaves that are 30–120 cm long and 1–5 cm wide. It can be easily cultivated in all type of soil and all around the year and can be harvested 5 to 6 times per annum with high biomass (Alam *et al.*, 2017) [1] and it is able to resist repeated cutting and regenerates quickly (Lowe *et al.*, 2003).
In view of utilizing sodic soil towards fodder cultivation an attempt was made in cultivation of different varieties of cumbu napier on sodic soil.

Materials and Methods
The study was conducted at the Department of Soil Science and Agricultural Chemistry, AC&RI, Killikulam, Tamil Nadu, India during 2021 with the goal of assessing growth performance of Cumbu Napier (*Pennisetum purpureum*) verities under neutral and sodic soil. KKM 1, CO (CN) 4, CO (BN) 5, and CO (BN) 6 were used in the experiment, which was set up in a randomised block design. Cuttings were collected from Department of Forage Crops, TNAU Coimbatore and sown in 8 pots (treatments) replicated thrice. The treatment details were T_1 - Neutral soil + KKM 1; T_2 - Neutral soil + (CO (CN) 4); T_3 – Neutral soil + (CO (BN) 5); T_4 - Sodic soil + (CO (BN) 6); T_5 - Sodic soil + KKM 1; T_6 - Sodic soil + (CO (CN) 4);

T_7 - Sodic soil + (CO (BN) 5); T_8 - Sodic soil + (CO (BN) 6).
Sodic soil was collected from barren land of Deivaseyalpuram village, Thoothukudi district, Tamil Nadu. The collected soil samples were shade dried and passed through 2 mm sieve for soil analysis. The nature of the soil was typical black in colour, clayey in texture, moderately and highly sodic condition. Neutral soil was taken as control and it was collected from Agricultural College and Research Institute, Killikulam. For the experiment, the cuttings were planted in pots having 10 kg soil.
The soil available nitrogen (Subbiah and Asija 1956), available P (0.5 M $NaHCO_3$), available potassium (Jackson, 1967) [8], organic carbon (Walkley and Black 1934), pH, and EC (Jackson, 1967) [8] content were analyzed from the initial soil. 1N neutral normal $CH3COONH_4$ at pH 7.0 was used to determine the CEC of the soil samples (Schollenberger *et al*., 1930) [15]. Ca^{2+} and Mg^{2+} (titration with standard versenate solution method), Na^+ and K^+ (flame photometer) were determined from the CEC leaching extract. By titrating with 0.1N H_2SO_4 the carbonates and bicarbonates in the leachate were determined. To test the presence of chloride the samples should be titrated with standard silver nitrate solution (Piper, 1944). Based on the turbidity principle, the concentration of sulphate was determined using the nephelometric method in (Richard, 1954). The quick titration method was used to determine the calcium carbonate concentration in (Piper, 1944).

Statistical analysis
The data obtained from the pot experiment were subjected to statistical analysis based on one way analysis of variance (ANOVA) and least square significance test for $p < 0.05$ was studied. The statistical analysis was carried out using AGRES software version 7.0.

Table 1: Initial soil characterization

Parameters	Neutral soil	Sodic soil
pH	7.82	9.76
EC (dS m^{-1})	0.23	0.97
Exchangeable Ca (c mol (p^+)/kg)	3.40	4.50
Exchangeable Mg (c mol (p^+)/kg)	1.20	4.10
Exchangeable Na (c mol (p^+)/kg)	1.12	22.0
Exchangeable K (c mol (p^+)/kg)	0.80	1.60
CEC (c mol (p^+)/kg)	16.5	32.00
ESP (%)	8.50	71.5
Available N (kg/ha)	200	336
Available P (kg/ha)	6.00	12.3
Available K (kg/ha)	212	156
Organic carbon (%)	0.15	0.67
$CaCO_3$ (g/kg)	8.60	18.67
Soil texture	Sandy clay loam	Clayey

Result and Discussion
Plant growth parameter
The growth performance of varieties of Cumbu Napier grass varieties under neutral and sodic soil conditions differed significantly.

a) Plant height
Sodicity significantly decreased the plant height of all Cumbu Napier varieties during the initial period. Accordingly, the highest plant height was observed in neutral soil rather than in alkaline soil conditions from first cutting (Fig 1.). Poor physical condition, salt rich soil water, excessive sodium and imbalanced nutrition causes stress to the germination and establishment of Cumbu Napier varieties. Accordingly, lesser height was exhibited by all Cumbu Napier varieties under sodic conditions. The height increment obtained after first harvest from both the soil remains equal. Among the varieties, CO (BN) 6 produced higher plant height both under neutral (134.20 cm) and sodic soil (81.07) (Table 2). This might be due to the inherent genetic potential of this variety.

b) Leaf length and Breadth
Varieties of Cumbu Napier grass exhibited significant variation in leaf morphology. At first cutting, lengthier leaf length was obtained from CO (BN) 6 both under neutral (77 cm) and sodic soil (65.90cm). Similar trend was obtained for leaf breadth too (Table 2.).
The result showed that leaf length and breadth was higher from the second harvest than the first harvest. The higher leaf length and breadth obtained from the second harvest were 105.1 cm and 4.2 cm, respectively from CO (BN) 6 under neutral soil conditions.
Physical processes (clay mineral slaking, swelling, and dispersion) and specific conditions such as surface crusting (Hardy *et al*., 1983) [6] and hard setting (Miller and Donahue, 1995) [11] that may affect water and air movement, plant-available water-holding capacity (Letey, 1984) [16] and root penetration (Shainberg and Letey, 1984) [16]. The above said factors makes plants difficult for plant establishment and growth. These adverse factors might be reason for the reduced leaf size under sodic conditions.

c) Stem girth
The experiment was significantly affected by soil sodicity and various stem girths were observed and presented in the table. 2.. The highest stem girth was noted in the treatment (T_5) of 5.70 cm. The stem girth of 4.77 cm was the lowest value in the treatment (T_4) in the first cutting. The results produced by second cutting were nearly identical to the first cutting stem girth.

d) Number of tillers and leaves per clump
The Cumbu Napier grass varieties performed differently under neutral and sodic soil conditions. The results shown that, highest number of tillers per clump (7) and the number of leaves (62.33) was obtained from T_8 during the first cutting. but the lowest number of leaves were 12nos., followed by a second cut, the results were no tiller per clump of 19, and no leaves were noted. The lowest and highest value were 7 and 67. But the second cutting of Cumbu Napier was significantly higher than first cutting. The values are presented in the Table 2.
High level of exchangeable Na and a high pH in the sodic soil enhanced swelling and dispersion of clay. Furthermore, certain physical processes (clay mineral slaking, swelling, and dispersion) and specific conditions such as surface crusting (Hardy *et al*., 1983) [6] and hard setting (Miller *et al*., 1995) [11] that may affect water and air movement, plant-available water-holding capacity, root penetration (Sheinberg and Letey, 1984) [16], seedling emergence, runoff and erosion (Ayers and Westcot, 1976).
The above said factors makes plants difficult for establish themselves, and their roots to get sufficient water and nutrients. These impacts have a detrimental influence on plant production and survival. These effects have a negative impact on plant productivity and survival (Hanson *et al*., 1999).
Under high Na^+ and Cl^- concentrations in the rhizosphere, the

metabolic activities and growth of crops were affected due to the competitive interactions with other nutritional ions such as K^+, NO_3^-, and $H_2PO_4^-$ in their binding sites (Tester and Davenport, 2003) [17]. The concentration of toxic elements, such as sodium, molybdenum, and boron in sodic soils, adversely affects crop growth, resulting in stunted growth and reduced leaf number and leaf area (Osman, 2018) [12].

The better growth under sodic soil after first harvest was due to the faster growth rate of Cumbu Napier, well developed fibrous root distribution and better adaptability of Cumbu Napier varieties.

The response of various cultivars varies depending on the soil conditions (Karimi *et al.*, 2015) [9]. Among the many kinds, CO (BN) 6 can perform well and has a higher resistance to sodicity. Furthermore, the sodium concentration in plant cells is diluted, which may indirectly lessen the cytotoxic impact of greater ionic concentrations and cause the plant to develop quicker. The enhanced water absorption capacity was linked to quicker development and was also responsible for ion dilution to prevent worrisome amounts inside the cytosol (Chelli-Chaabouni 2010) [5].

This research concluded that CO (BN) 6 can tolerate high sodicity level up to a pH of 9.76 and produce high growth rate compared with other varieties.

Conclusion

The outcome of this research suggests that Cumbu Napier has the ability to grow under moderate sodic condition. Growth of Cumbu Napier was slightly higher under neutral soil condition during initial days because of better condition for germination and establishment. In contrast, growth parameter remains constant at the time of second harvest. The growth performance of Cumbu Napier varieties is in the order of CO (BN) 6 > CO (BN) 5 > KKM 1 > CO (CN) 4.

Table 1: Growth performance of different varieties of Cumbu Napier

	1st cutting						2nd cutting					
Treatments	**Plant height (cm)**	**Leaf length (cm)**	**Leaf breadth (cm)**	**Stem girth (cm)**	**No of leaves per tiller (nos.)**	**No of tillers per clump(nos.)**	**Plant height (cm)**	**Leaf length (cm)**	**Leaf breadth (cm)**	**Stem girth (cm)**	**No of leaves per tiller (nos.)**	**No of tillers per clump (nos.)**
T_1	87.73	69.37	3.40	5.90	45.67	6	115	85.6	2.9	5.9	80	15
T_2	80.00	56.10	3.07	5.33	52.33	6	85.90	78.5	3.8	5.88	78	14
T_3	118.83	74.53	3.20	5.83	52.67	7	125	95.6	3.8	6.3	89	17
T_4	134.20	77.00	3.20	5.70	62.33	7	147	105.1	4.2	6.12	95	19
T_5	61.97	51.67	2.47	5.13	21.00	2	95	62.4	2.8	5.55	57	8
T_6	51.50	39.60	2.07	4.67	12.33	3	85	63.8	2.8	5.3	52	7
T_7	65.00	53.17	2.55	4.90	22.67	2	102	81.0	2.9	5.12	58	9
T_8	81.07	65.90	2.63	4.77	27.33	2	114	85.6	3.4	5.75	67	9
SEd	14.10	4.60	0.31	0.12	7.96	0.99	2.84	1.74	0.05	0.10	1.73	0.24
CD (0.05)	29.90	9.76	0.66	0.26	16.87	2.09	6.01	3.70	0.10	0.20	3.67	0.50

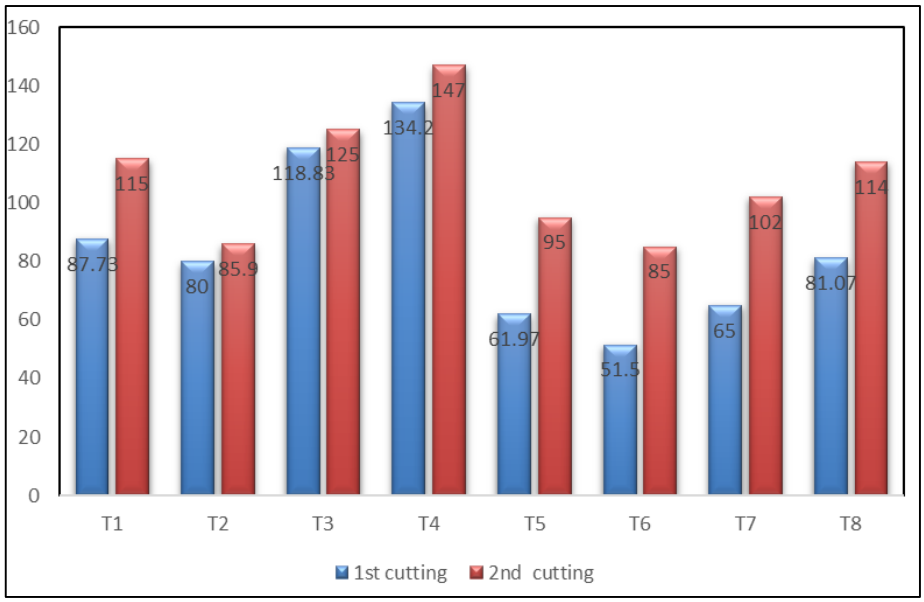

Fig 1: Treatment effect on Plant height of Cumbu Napier grass

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Conflict of interest

The authors declare that there is no conflict of interest.

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