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*Research Article*

# Assessment of germination percentage and growth parameters of different varieties of Napiergrass (*Pennisetum purpureum*) on sodic soil of Thoothukudi district, Tamil Nadu, India

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**Abstract**
Napier grass (*Pennisetum purpureum*) is a fast-growing forage crop cultivated throughout the year in tropical and subtropical regions. A phytoremediation study was undertaken at the Agricultural College and Research Institute (AC & RI), Killikulam, Thoothukudi District, Tamil Nadu, India, during 2020-2021 to evaluate the performance of cumbu napier varieties on sodic and neutral soil. Four cumbu napier varieties, CO (BN) 6, CO (BN) 5, KKM 1 and CO (CN) 4, were tested in both soils. Pots were filled with 10 kg of soil. Three cuttings of cumbu napiers per pot were planted as per the treatment schedule. Germination and growth parameters were observed up to three harvests. The results of the present study revealed that the germination percentage of variety CO (BN) 6 was highest (100%) among the varieties under sodic conditions. Growth parameters such as plant height, leaf length, number of leaves, and number of clumps of this variety showed better efficiency under high sodic levels than other varieties. This variety CO (BN) 6 could tolerate and be established well under alkaline soil and produced amaximum plant height (134 cm) and a higher number of clumps (10) during the third harvest. The growth pattern of cumbu napier varieties was in the order of CO (BN) 6> CO (BN) 5 > KKM 1 > CO (CN) 4. Furthermore, the experimental results revealed that cumbu napier could be recommended as a suitable crop for sodic soil.

**Keywords:** Alkaline soil, Cumbu napier, Growth parameters, Germination percentage, *Pennisetum purpureum*, Sodic soil

## INTRODUCTION

Cumbu Napier or Bajra Napier (*Pennisetum purpureum*) is a robust perennial grass widely grown in tropical and subtropical regions of the world. It has a faster growth rate, high biomass production (Wang *et al.*, 2002) and good palatability in the leafy stage (Alam *et al.*, 2017) than other forages(Alvarez *et al.*, 2000). The crude proteincontent of Cumbu Napier ranges from 9.8 – 12.8% (Premaratne *et al.*, 2006). Therefore, it is one of the most valuable forages and silage crops (Seresinhe *et al.*, 2020). It also helps in erosion control or dune stabilization, soil conservation, windbreak, agroforestry, green manure, and fibres (Negawo *et al.*, 2017). Cumbu napier grows well in moist soil areas with rainfall between 750 and 2500 mm annually (Singh *et al.*, 2013). This grass can also tolerate drought conditions but is susceptible to water logging. Fertile loam soil and well-drained soil are the best soil conditions for the growth of Cumbu Napier. It can be easily cultivated

in all types of soil, from acidic to alkaline ranges. This fodder crop can be harvested 5 to 6 times per annum with high biomass (Alam *et al.*, 2017), and it is able to resist repeated cutting and regenerate quickly (Lowe *et al.*, 2003). These characteristic features make Cumbu Napier the best fodder crop.

India accounts, approximately 6.73 Mha of salt-affected land, in which 3.77 Mha was alkaline soiland 2.96 Mha was saline soil land. In Tamil Nadu, 0.37 Mha of land comes under alkaline (Chinchmalatpure, 2017). The utilization of salt-affected lands plays a vital role in the food demand of the Indian population. Yield reduction due to salinity and alkalinity for various crops ranges from 10 to 100% (Panta *et al.*, 2014) depending upon the intensity of salt hazard and the ability of the crop to tolerate salt conditions (Satir *et al.*, 2016).

Considering the importance of cumbu napier as a potential fodder crop and the lack of information on the suitability of this crop under sodic conditions, an attempt was made to assess the suitability and growth pattern of four cumbu napier (*Pennisetum purpureum*) varieties, viz., CO (BN) 6, CO (BN) 5, KKM 1 and CO (CN) 4 were developed by Tamil Nadu Agricultural University, Coimbatore.

## MATERIALS AND METHODS

The present work was performed at the Department of Soil Science and Agricultural Chemistry, AC&RI, Killikulam, Tamil Nadu, India, with the aim of evaluating the germination percentage and growth parameters of Cumbu Napier (*P. purpureum*) in different sodic soil (pH 8.72 and pH 9.76) and neutral soil conditions from 2020 to 2021. A study was conducted to check the efficiency of cumbu napier under sodic conditions. The experiment was laid out in a randomized block design with five varieties of KKM 1, CO 3, CO (CN) 4, CO (BN) 5 and CO (BN) 6. Cuttings were collected from the Department of Forage Crops, TNAU Coimbatore and sown in 12 pots replicated three times. The parameters of each soil are mentioned in Table 1. The treatment details were $T_1$ - Neutral soil + KKM 1; $T_2$ – Neutral Soil + CO 3; $T_3$ - Neutral soil + (CO (CN) 4); $T_4$ – Neutral soil + (CO (BN) 5); $T_5$ - Neutral soil + (CO (BN) 6); $T_6$ - Mild alkaline soil + KKM 1; $T_7$- mild alkaline soil + CO 3;$T_8$ - Mild alkaline soil + (CO (CN) 4); $T_9$ - Mild alkaline soil + (CO (BN) 5); $T_{10}$ - Mild alkaline soil + (CO (BN) 6); $T_{11}$ - High alkaline soil + KKM 1;$T_{12}$ – high alkaline soil + CO 3; $T_{13}$ - High alkaline soil + (CO (CN) 4); $T_{14}$ - High alkaline soil + (CO (BN) 5); $T_{15}$ - High alkaline soil + (CO (BN) 6). After confirming cumbu napier ability under sodic conditions up to the first harvest, further treatments were screened and continued experimentation. The treatment details were $T_1$ - neutral soil + KKM 1; $T_2$ - neutral soil + (CO (CN) 4); $T_3$ - neutral soil + (CO (BN) 5); $T_4$ - neutral soil + (CO (BN) 6); $T_5$ - sodic soil + KKM 1; $T_6$ - sodic soil + (CO (CN) 4); $T_7$ - sodic soil + CO (BN) 5);and $T_8$ - sodic soil + (CO (BN) 6).

Sodic soil was collected from the barren land of Deivaseyalpuram village (Latitude 8.735545 N and Longitude 77.931608 E), Thoothukudi district, Tamil Nadu. The collected soil sample was shade dried and passed through a2 mm sieve. The soil is typically black in colour, clayey in texture, and moderately and highly sodic. Neutral soil was taken as a control and was collected from the Agricultural College and Research Institute, Killikulam. The initial germination study was performed using a small plastic tray of height 4 inches and length of 45 cm. The soil was uniformly filled on the tray, and 10 cuttings were taken for planting. After one week, the cuttings were transferred into pots for pot culture experiments. Pots were filled with 15 kg soil

**Table 1.** Characteristics of soil utilized for pot culture experimentation

| Parameter | Normal soil | Mild sodic soil | Highly sodic soil |
|---|---|---|---|
| pH | 7.82 | 8.72 | 9.76 |
| EC (dS $m^{-1}$) | 0.23 | 0.17 | 1.04 |
| Exchangeable Ca (c mol ($p^+$)/kg) | 3.40 | 3.45 | 9.61 |
| Exchangeable Mg (c mol ($p^+$)/kg) | 1.20 | 3.21 | 6.70 |
| Exchangeable Na (c mol ($p^+$)/kg) | 1.12 | 15.2 | 25.0 |
| Exchangeable K (c mol ($p^+$)/kg) | 0.80 | 0.80 | 1.23 |
| CEC (c mol ($p^+$)/kg) | 16.5 | 26.00 | 28.00 |
| ESP (%) | 8.50 | 47.5 | 69.4 |
| Available N (kg/ha) | 200 | 312 | 336 |
| Available P (kg/ha) | 6.00 | 11.00 | 12.3 |
| Available K (kg/ha) | 212 | 134 | 156 |
| Organic carbon g/kg | 1.5 | 7.0 | 6.70 |
| $CaCO_3$ (g/kg) | 8.60 | 33.00 | 54.67 |
| Soil texture | Sandy Clay Loam | Clayey | Clayey |

with a height of 30 cm and a diameter of 15 cm.

**Statistical analysis**

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

## RESULTS AND DISCUSSION

**Germination**

Soil sodicity significantly influenced the germination percentage of Cumbu Napier cuttings. All four varieties of cumbu napier, CO (BN) 6, CO (BN) 5, KKM 1, CO (CN) 4and CO 3, germinated well (100%) under neutral soil conditions ($T_{1-5}$). Sodicity reduced germination, and the lowest germination percentage of 87.75 was obtained from the CO 3 variety ($T_2$). The CO (BN) 6 variety tolerated sodic conditions and produced 100% germination (Table 2a). A higher sodium concentration in the soil solution of alkaline soil increases the osmotic potential, which inhibits the germination process (Rajabi Dehnavi *et al.*, 2020). In addition, a higher concentration of sodium also results in toxicity to sprouting and emergence after germination (Yang *et al*., 2008). The reduced germination percentage of cumbu napier grass observed under alkaline soil might be due to this adverse effect of the higher exchangeable sodium present in the soil. The tolerance to sodicity by the variety CO (BN) 6 compared to other varieties used might be due to inherent genetic nature and fast-growing characteristics.

**Growth parameter**

The interaction effect of napier grass varieties and soil reaction was distinct. Plant height is one of the most important growth parameters governing the yield of forage crops (Imran *et al.,* 2007). The highest plant height (134.20 cm) was observed with CO (BN) 6 ($T_8$) from the neutral soil at the first harvest (Table 2a). The lowest plant height (51.50 cm) was recorded with CO (CN) 4 from the sodic soil ($T_2$).

During the first harvest, the plant height of cumbu napier varieties was comparatively lower in sodic soil than in neutral soil. Adverse sodic conditions affect seed germination and hinder initial establishment; hence, less plant height was noticed in sodic soil (Thu *et al.*, 2017). A similar decrease in plant height due to a high exchangeable sodium percentage has been reported in many crops (McDonald *et al.*, 2020).

A similar pattern of plant height was noticed during the second and third harvests, but the difference in plant height between neutral and sodic soil was appreciably reduced. The better performance of the cumbu napier variety under sodic soil in the later growth stage might be due to the extensive secondary root system and tolerance to sodicity by the crop in the later stages.

Among the varieties, CO (BN) 6 produced maximum height under a sodic environment due to its inherent tolerance to sodicity and fast-growing nature. The performance of cumbu napier varieties in terms of plant height was CO (BN) 6 > CO (BN) 5 > KKM 1 > CO (CN) 4.

Variety CO (BN) 6 plants produced lengthier leaves (77.00 cm) under neutral soil conditions ($T_8$) at first harvest. Variety CO (CN) 4 produced shorter leaves (56.10 cm) under neutral soil conditions ($T_6$). In the sodic environment, a relatively shorter leaf length was noticed than under neutral conditions. Under sodic soil conditions, the lengthiest (65.90 cm; $T_4$) and shortest leaf (39.60 cm; $T_2$) were observed in the CO (BN) 6 and CO (CN) 4 varieties (Table 2a).

Leaf breadth varied significantly with soil reaction and varieties. The maximum (3.20 cm; $T_8$) and minimum (3.07 cm; $T_6$) leaf breadth was noticed with CO (BN) 6 and CO (CN) 4 varieties, respectively, under neutral conditions (Table 2a). A similar trend was obtained from sodic soil as well as during different harvests. Leaf breadth increased slightly for each variety with the progress of harvest.

The shorter leaf length and breadth obtained under sodic conditions might be due to adverse soil conditions such as sodium toxicity, inappropriate physical conditions and imbalanced nutrients, which harm nutrient absorption and the physiological activity of plant growth, as also reported by Doula and Sarris (2016).

Variety KKM 1 produced the maximum stem girth (5.90 cm) under neutral soil conditions ($T_5$) at the first harvest. Variety CO (CN) 4 produced fewer stem girths (5.33 cm) under neutral soil conditions ($T_2$). In the sodic environment, relatively less stem girth was noticed compared to the neutral condition. Similar to neutral soil, the maximum (5.13 cm; $T_1$) and minimum stem girths (4.67 cm; $T_2$) were observed from the KKM 1 and CO (CN) 4 varieties in sodic soil (Table 2b). This indicates that KKM 1 has higher tolerance at initial growth stages than other varieties, and owing to this reason, KKM 1 noticed higher stem girth at first harvest. CO (BN) 6 was noticed to have a higher stem girth in the subsequent harvest than the other varieties under both soil conditions. This might be due to the higher tolerance of CO (BN) 6 to sodicity in the later stages and its fast-growing nature. The KKM 1 variety performed less than CO (BN) 6 due to its lower growth potential and tolerance to sodicity.

Lesser stem girth was noticed in sodic soil than in neutral soil, which was due to adverse physical conditions, such as soil compaction, hardening, crusting (Osman, 2018) andsodium ion toxicity (Martínez-Alvarez *et al.*, 2018),which reduced calcium availability (Peleg *et al.*, 2012) and imbalanced nutrients (Gomes *et al.,* 2011).

**Table 2 (a).** Growth parameters of cumbu napier varieties under neutral and sodic conditions (first harvest 75 days)

| Treatments | Germination percentage (%) | Plant height (cm) 1st harvest (75DAP) | Leaf length (cm) 1st harvest (75DAP) | Leaf breadth (cm) 1st harvest (75DAP) | Stem girth (cm) 1st harvest (75DAP) | No of leaves per clump 1st harvest (75DAP) | No of tiller per clump 1st harvest (75DAP) |
|---|---|---|---|---|---|---|---|
| $T_1$ KKM 1 | 100 | 92.61 | 71.66 | 3.62 | 4.86 | 56.77 | 7.02 |
| $T_2$ CO 3 | 100 | 80.12 | 59.45 | 3.00 | 4.21 | 53.98 | 6.53 |
| $T_3$ CO (CN) 4 | 100 | 85.45 | 62.31 | 3.28 | 4.51 | 56.23 | 6.83 |
| $T_4$ CO (BN) 5 | 100 | 117.31 | 77.97 | 3.88 | 4.90 | 57.64 | 7.08 |
| $T_5$ CO (BN) 6 | 100 | 120.98 | 85.26 | 4.50 | 5.82 | 60.67 | 7.25 |
| $T_6$ KKM 1 | 96.67 | 65.86 | 54.99 | 2.50 | 4.47 | 32.33 | 3.93 |
| $T_7$ CO 3 | 87.75 | 53.32 | 50.20 | 2.53 | 4.00 | 18.78 | 2.54 |
| $T_8$ CO (CN) 4 | 90.00 | 54.72 | 51.18 | 2.53 | 4.16 | 20.86 | 2.85 |
| $T_9$ CO (BN) 5 | 96.67 | 72.73 | 57.69 | 2.98 | 4.91 | 46.11 | 5.68 |
| $T_{10}$ CO (BN) 6 | 100 | 79.65 | 60.23 | 3.15 | 5.10 | 50.67 | 6.45 |
| $T_{11}$ KKM 1 | 90.00 | 44.97 | 55.80 | 1.96 | 3.22 | 17.97 | 2.52 |
| $T_{12}$ CO 3 | 78.50 | 40.32 | 41.87 | 1.00 | 2.30 | 15.00 | 2.00 |
| $T_{13}$ CO (CN) 4 | 87.50 | 41.36 | 43.13 | 1.09 | 2.49 | 15.32 | 2.33 |
| $T_{14}$ CO (BN) 5 | 93.33 | 48.88 | 48.96 | 2.09 | 3.39 | 19.04 | 2.87 |
| $T_{15}$ CO (BN) 6 | 100 | 51.52 | 50.23 | 2.49 | 4.05 | 20.11 | 3.33 |
| SEd | 1.89 | 1.43 | 1.50 | 0.07 | 0.08 | 0.70 | 0.10 |
| CD (0.05) | 3.87 | 2.93 | 3.07 | 0.14 | 0.16 | 1.43 | 0.20 |

**Table 2 (b).** Growth parameters of cumbu napier varieties under neutral and sodic conditions

| Treatments | Plant height (cm) | | Leaf length (cm) | | Leaf breadth (cm) | | Stem girth (cm) | | Number of leaves per clump | | Number of tillers per clump | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2nd harvest (120 DAP) | 3rd harvest (165 DAP) | 2nd harvest (120 DAP) | 3rd harvest (165 DAP) | 2nd harvest (120 DAP) | 3rd harvest (165 DAP) | 2nd Harvest (120 DAP) | 3rd har-vest (165 DAP) | 2nd har-vest (120DAP) | 3rd harvest (165 DAP) | 2nd harvest (120 DAP) | 3rd harvest (165 DAP) |
| $T_1$- Sodic soil + KKM 1 | $95.00^{d}$ | $102.00^{d}$ | $62.40^{e}$ | $76.50^{f}$ | $2.80^{d}$ | $3.20^{d}$ | $5.55^{c}$ | $5.76^{d}$ | $57.00^{e}$ | $62.00^{f}$ | $8.00^{f}$ | $9.50^{f}$ |
| $T_2$ - Sodic soil + CO (CN) 4 | $85.00^{e}$ | $97.00^{de}$ | $63.80^{e}$ | $66.50^{g}$ | $2.80^{b}$ | $3.20^{d}$ | $5.30^{d}$ | $5.43^{e}$ | $52.00^{f}$ | $58.00^{g}$ | $7.00^{g}$ | $8.00^{g}$ |
| $T_3$ - Sodic soil + CO (BN) 5 | $102.00^{b}$ | $122.00^{c}$ | $81.00^{c}$ | $103.00^{c}$ | $2.90^{b}$ | $2.90^{e}$ | $5.12^{d}$ | $5.82^{d}$ | $58.00^{e}$ | $67.50^{f}$ | $9.00^{e}$ | $9.25^{f}$ |
| $T_4$ - Sodic soil + CO (BN) 6 | $114.00^{ba}$ | $134.00^{b}$ | $85.60^{c}$ | $111.00^{b}$ | $3.40^{a}$ | $3.80^{c}$ | $5.75^{bc}$ | $5.98^{b}$ | $67.00^{d}$ | $76.56^{e}$ | $9.00^{e}$ | $10.00^{e}$ |
| $T_5$ - Neutral soil + KKM 1 | $115.00^{c}$ | $125.00^{c}$ | $85.60^{c}$ | $94.00^{d}$ | $2.90^{d}$ | $2.80^{e}$ | $5.90^{b}$ | $6.10^{b}$ | $80.00^{c}$ | $87.65^{c}$ | $15.00^{c}$ | $16.00^{c}$ |
| $T_6$ - Neutral soil + CO (CN) 4 | $85.90^{f}$ | $95.00^{e}$ | $78.50^{d}$ | $84.00^{e}$ | $3.80^{d}$ | $4.20^{b}$ | $5.88^{b}$ | $6.05^{b}$ | $78.00^{c}$ | $84.23^{d}$ | $14.00^{d}$ | $15.00^{d}$ |
| $T_7$ - Neutral soil + CO (BN) 5 | $125.00^{e}$ | $132^{b}$ | $95.60^{b}$ | $106.00^{c}$ | $3.80^{d}$ | $4.12^{b}$ | $6.30^{a}$ | $6.33^{a}$ | $89.00^{b}$ | $96.78^{b}$ | $17.00^{b}$ | $18.55^{b}$ |
| $T_8$ - Neutral soil + CO (BN) 6 | $147.00^{a}$ | $156^{a}$ | $105.10^{a}$ | $115.00^{a}$ | $4.20^{c}$ | $4.40^{a}$ | $6.12^{a}$ | $6.52^{a}$ | $95.00^{a}$ | $104.32^{a}$ | $19.00^{a}$ | $20.13^{a}$ |
| SEd | 2.84 | 2.48 | 1.74 | 1.7315 | 0.05 | 0.07 | 0.10 | 0.10 | 1.73 | 1.89 | 0.24 | 0.19 |
| CD (P=0.05) | 6.01 | 5.26 | 3.70 | 3.6708 | 0.10 | 0.15 | 0.20 | 0.21 | 3.67 | 4.00 | 0.50 | 0.40 |

*DAP – days after planting

In the present study, the sodicity effect had a considerable impact on the number of leaves per clumpof cumbu napier. In the first harvest, CO (BN) 6 ($T_8$) and CO (CN) 4 noticed the maximum (62.33) and minimum (12.33) number of leaves per clump from neutral soil. Similar to neutral soil, CO (BN) 6 produced a maximum number of leaves under sodic conditions, less than the number of leaves observed in neutral soil. The favorable physical and chemical properties might be the possible reason for higher leaf numbers from neutral soil. Adverse physical and chemical properties of soil associated with sodicity might be one of the reasons for the reduced number of leaves per clump (Odiyi Bridget and Amire, 2015). During the second and third harvests, a similar pattern of the number of leaves per clump was observed, but the difference in the number of leaves per clump between the crops grown under neutral and sodic soil was significantly reduced. CO (BN) 6 performed better both under neutral and sodic soil among the varieties. The performance of cumbu napier varieties in terms of the number of leaves per clumpwas CO (BN) 6 > CO (BN) 5 > KKM 1 > CO (CN) 4.

Under neutral soil conditions, varieties CO (BN) 6 and CO (BN) 5 developed the maximum number of tiller clumps (7; $T_8$ and $T_7$) during the first harvest, CO (CN) 4, and KKM 1 generated the minimum number of tillers (6; $T_5$ and $T_6$). The number of tillers produced by each variety was absent to be minimal in the sodic environment compared to the neutral state (Table 2b). The highest number of tillers produced by CO (BN) 6 in sodic and neutral soil conditions was due to its inherent genetic makeup and tolerance to sodicity. A lower number of tillers was observed from the CO (CN) 4 variety because of its intolerance to the sodic environment.

The number of tillers per clump steadily increased with crop growth as the crop grew up. This was due to the ability of cumbu napier grass to produce more tillers on the periphery of its main tuft via rhizomes, which grew to new groups of tillers, as reported by Kadam *et al.* (2017).

## Conclusion

The present study revealed that the CO (BN) 6 variety of cumbu napier (*P. purpureum*) tolerated sodic conditions and produced cent percent germination, whereas the germination percentage of other varieties (CO (BN) 5, CO (CN) 4 and KKM 1) decreased under sodic conditions. CO (BN) 6 exhibited superior growth performance under both neutral and alkaline conditions in terms of plant height, leaf length, stem girth, leaf breadth, number of leaves and number of tillers per clump. Sodic soil resulted in slightly less growth than neutral soil conditions due to the adverse physical and chemical conditions of sodic soil. The performance of the varieties was in the order of CO (BN) 6 > CO (BN) 5 > KKM 1 > CO (CN) 4. The difference in growth parameters observed between sodic and neutral soil conditions was reduced with the progress of the growth stages of cumbu napier. This indicates that cumbu napiers are susceptible to sodicity during the germination and initial establishment stages and tolerate sodicity well during the later growth stages. The results confirm that cumbu napier is suitable for sodic soil and has the potential to meet fodder demand under alkaline lands wherever sufficient water is available.

## Conflict of interest

The authors declare that they have no conflicts of interest.

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