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# Genetic variability in Napier grass (*Pennisetum Purpureum* L.)

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**Abstract**
The study at hand on Napier grass (*Pennisetum purpureum* L.) aimed to assess genetic variability, character associations, and the direct and indirect contributions of key traits to green forage yield. Forty the genotypes were assessed during the Kharif season 2024 following a randomized block design incorporating two replications, and data were measured for thirteen morphological and nutritional traits. The analysis of variance showed significant variability in all the studied traits, suggesting considerable scope for selection. Genotypes RN-2024-12, RN-2024-25, RN-2024-31, and RBN-16-61 showed superior green forage and dry matter yields. Phenotypic coefficients of variation slightly exceeded genotypic values for most traits. High genotypic and phenotypic variability was observed for leaf breadth, leaf length, plant height, number of leaves, number of tillers, leaf-to-stem ratio, dry matter content, dry matter yield, crude protein content, and crude protein yield. Green forage yield was negatively associated with days to flowering and oxalic acid content. All traits exhibited high broad-sense heritability; coupled with high genetic advance, traits such as crude protein yield, crude protein content, leaf width, green forage yield, and dry matter yield showed predominantly additive gene action. Path analysis identified dry matter yield per plant, crude protein yield, leaf length, plant height, and number of tillers as major contributors with strong positive direct effects on green forage yield. Considering correlation and path analyses together, plant height, leaf number, tiller number, leaf length, leaf width, dry matter yield, and crude protein yield emerged as the most reliable selection criteria for improving green forage yield in Napier grass.

**Keywords:** Napier grass, genetic variability, heritability, path coefficient, crude protein yield, forage improvement

## Introduction
Among the diverse fodder resources supporting India's livestock sector, Napier grass (*Pennisetum purpureum* L.) stands out being among the most significant perennial forage species. Commonly known as Elephant grass due to its impressive height and robust growth, it originates from tropical Africa and was introduced to India in 1912. Over the decades, it has become integral to fodder systems across tropical and subtropical regions, particularly in dry and semi-arid environments where many other forage crops fail to thrive. Napier grass is now cultivated across all major livestock-rearing states and serves as a principal source of green fodder for dairy animals. The species possesses several agronomically desirable characteristics: rapid regrowth, a tall and sturdy growth habit reminiscent of sugarcane, vegetative propagation through rhizomes, formation of dense clumps that aid in soil conservation, and the capacity for repeated harvests throughout the year. It adapts well to diverse environments, performing effectively under rainfall regimes of 750-2500 mm and at altitudes up to 2100 m, though frost limits productivity at higher elevations (Skerman & Riveros, 1990) [15]. Its notable drought tolerance (Butt *et al.*, 1993) [5], high biomass production, and ability to pair well with protein-rich forages such as legumes (Nyambati *et al.*, 2003) [10] make it a dependable fodder crop in variable climates. Improved selections such as Hybrid Napier have further enhanced the crop's utility. Hybrid Napier varieties hold value due to their perennial growth, multicut nature, profuse tillering, adaptability to saline soils and wastelands, and exceptional year-round fodder yield potential (Pandey & Roy, 2011) [11]. Their ability to thrive in a broad range of soil and climatic conditions and are widely accepted by farmers for their palatability, digestibility, and nutritional quality.

Hybrid Napier typically contains 8.7%-10.2% crude protein, 28%-30.5% crude fibre, and 10%-11.5% ash (Faruqui *et al*., 2009) [8], providing a balanced mineral profile suitable for dairy nutrition. Under optimal management—particularly sufficient nitrogen and irrigation—annual fodder yields can reach 200-250 tons per hectare. Despite these advantages, India continues to face a significant green fodder deficit, estimated at 35.6% nationally (Das *et al*., 2009) [4], which constrains milk productivity and overall livestock performance. Addressing this shortage requires not only increasing the land allotted to fodder crops but also improving per-unit productivity through the advancement of high-yielding, nutrient-rich varieties. Such progress depends fundamentally on understanding the degree of genetic variation present in available germplasm and the relationships among key agronomic and yield-contributing traits. Genetic variability provides the basic framework for effective selection and crop improvement, while the exploitation of genetic divergence between parent lines is central to heterosis breeding. Correlation studies help elucidate the relationships among multiple traits, and path coefficient analysis (Dewey & Lu, 1959) [7] enables the partitioning of these correlations into direct and indirect effects, facilitating evidence-based selection strategies. However, comprehensive studies exploring variability, trait associations, and trait contributions to yield in Napier grass remain limited. Given the increasing demand for quality fodder, the demonstrated variability in key morphological and nutritional traits—including tiller number, plant height, leaf dimensions, and protein content—and the ongoing need for superior genotypes, systematic assessment of existing germplasm is both timely and essential. Therefore, the current investigation aimed to evaluate genetic variability, trait associations, and the cause-and-effect relationships influencing green forage yield in different genotypes of Napier grass. The specific objectives were to assess genetic variability for green forage yield and its contributing characters, to determine the magnitude and nature of the association between different traits and forage yield, to analyze the direct and indirect effects of yield-contributing traits on green forage yield through path coefficient analysis.

## Materials and Methods

The present study, bearing the title "Genetic variability in Napier grass (*Pennisetum purpureum* L.)" was executed at the Grass Breeding Scheme, MPKV, Rahuri in the month of February 2024 to March 2025. The experimental material consisted of 40 genotypes of Napier grass, including advanced breeding lines and checks. The planting material was supplied by the Research Officer, Grass Breeding Scheme, MPKV, Rahuri. The study utilized a Randomized Block Design (RBD) comprising two replications. Each genotype was planted at a spacing of 90 × 60 cm in plots of uniform size. The standard recommended farming practices was undertaken for conduct of experiment. Data were collected on 13 morphological and quality parameters using five plants chosen at random per genotype in each replication, including yield-related parameters viz, Days to flowering, Plant height (cm), Leaves per plant (no.), Tillers per plant (no.), Leaf length (cm), Leaf width (cm), Leaf: stem ratio, Green forage yield (g/plant), Dry matter content, Dry matter yield (g/plant), Crude protein content (%), Crude protein yield (g/plant), Oxalic acid content (%). The recorded observations were processed through analysis of variance (ANOVA) as per the procedure for RBD (Panse & Sukhatme, 1995) [12]. From the mean squares, genotypic and phenotypic variances were estimated following Johnson *et al*. (1955) [9]. The genotypic (GCV) and phenotypic coefficients of variation (PCV) were computed according to Burton (1952) [4]. Heritability (broad sense) was estimated as suggested by Burton (1952) [4], while genetic advance (GA) was calculated using the method of Allard (1960) [1]. Correlation coefficients at both genotypic and phenotypic levels were estimated following Singh & Chaudhary (1977) [14]. Path coefficient analysis, partitioning correlations into direct and indirect effects, was executed following Dewey & Lu (1959) [7].

## Result and Discussion

### Genetic variability

A considerable amount of variation was detected among the genotypes for all the studied traits. Days to flowering exhibited substantial diversity, ranging from 151 days (RBN-16-61) to 177 days (RN-2024-32), suggesting a strong genetic influence on flowering behaviour. A notable degree of variation was also observed in plant height, with recorded values lying between 158.9 cm (RN-2024-29) to 205.4 cm (Gunwant), reflecting considerable scope for selecting taller and more vigorous genotypes. Leaves/plant extended from 18.54 (RN-2024-13) to 24.93 (RBN-16-61), while tillers/plant extended from 10.78 (RN-2024-1) to 15.41 (RBN-16-61), both demonstrating substantial genotypic differences influencing canopy development and forage production. Leaf length (74.85-93.35 cm) and leaf width (1.37-3.22 cm) also exhibited wide variability, suggesting strong genetic potential for improving total leaf area and photosynthetic efficiency. The leaf: stem ratio ranged from 0.57 (RN-2024-12) to 0.85 (RN-2024-13), indicating marked differences in biomass allocation patterns, while the dry matter percentage extended from 18.60% (RN-2024-1) to 24.65% (Gunwant), reflecting diversity in structural composition. Dry matter yield recorded highly significant variation, ranging from 36.68 g (RN-2024-9) to 96.48 g/plant (RBN-16-61), providing excellent scope for identifying high-yielding genotypes. Crude protein content (4.94-10.43%) and crude protein yield also varied significantly, indicating ample genetic diversity for enhancing forage quality and nutritional value. Oxalic acid content ranged from 1.97% to 3.49%, confirming genotypic differences in anti-nutritional factors. Green forage yield, the key economic trait, also displayed wide and significant variability, validating showing pronounced genetic variation and the potential for successful selection. The overall findings corroborate earlier reports by several workers and highlight the substantial scope for exploitation of these characteristics in subsequent breeding work.

### Genotypic and phenotypic coefficients of variation

A considerable range of differences were observed between the GCV and PCV values for the traits under study. The highest GCV was recorded for crude protein yield/plant (33.15), while the lowest was noted in days to flowering (3.59). Similarly, the PCV was highest for crude protein yield/plant (33.21) and lowest in terms of days to flowering (4.60). In all cases, the degree of PCV exceeded that of GCV, indicating a minor effect of environmental conditions on trait expression. High estimates of both GCV and PCV

values were recorded for crude protein yield/plant (GCV = 33.15, PCV = 33.21), leaf width (GCV = 23.32, PCV = 23.69) and dry matter yield (GCV = 22.90, PCV = 24.08), suggesting showing substantial genetic variation and potential effectiveness of improving these traits through selection. Moderate levels of variability were detected for green forage yield (GCV = 19.88, PCV = 20.41), crude protein content (GCV = 16.64, PCV = 16.79), leaf:stem ratio (GCV = 10.27, PCV = 11.41), number of tillers (GCV = 9.57, PCV = 10.27) and oxalic acid content (GCV = 7.45, PCV = 8.67), indicating moderate genetic control and reasonable prospects for advancement through selective breeding. Low GCV and PCV values were observed for the number of leaves (GCV = 6.42, PCV = 8.24), dry matter content (GCV = 5.84, PCV = 8.18), plant height (GCV = 5.55, PCV = 6.19) and days to flowering (GCV = 3.59, PCV = 4.60), reflecting limited variability for these traits. Overall, the observed trends highlight that traits with high GCV and PCV offer greater potential for genetic advancement, whereas those with low variability may require broader genetic resources for substantial improvement.

**Heritability and Genetic advance**

Heritability estimates for the evaluated traits in Napier grass were found to be high overall, extending from 47.90% (leaf length) to 99.60% (crude protein yield). All traits exhibited heritability above 30%, indicating strong genetic control and good prospects for improvement through selection. Particularly a high heritability estimate was obtained for crude protein yield (99.60%), crude protein content (98.20%), leaf width (96.90%), green forage yield (94.90%) and dry matter yield (90.50%), indicating that additive gene action largely governs their expression. Genetic advance also varied considerably among traits. Green forage yield/plant recorded the maximum genetic advance (109.95), followed by dry matter yield (27.54) and plant height (18.51), showing strong prospects for genetic advancement. Moderate improvement through genetics was noted for traits such as crude protein yield (15.04), days to flowering (9.96) and leaf length (5.37). Conversely, crude protein content, number of tillers, number of leaves, leaf width, dry matter content, oxalic acid content and leaf:stem ratio displayed minimal genetic advance, indicating limited improvement through simple selection. Genetic advance as percentage of the mean (GA%) further supported these trends. High GA% (>30%) was recorded for crude protein yield (68.16%), leaf width (47.28%), dry matter yield (44.88%), green forage yield (39.88%) and crude protein content (33.97%), making them promising targets for selection. Moderate GA% was observed for leaf: stem ratio (19.38%), number of tillers (18.38%) and oxalic acid content (13.22%), while characteristics such as leaf count, dry matter content, plant height, leaf length and days required for flowering showed low GA% (<10-10%), reflecting limited expected improvement. Overall, traits combining both heritability and genetic advance being high —particularly crude protein yield, green forage yield as well as dry matter percentage yield—are the most suitable for effective selection in Napier grass breeding programs.

**Correlation**

Correlation analysis revealed that several traits—dry matter yield, plant height, number of leaves, number of tillers, leaf length, leaf width, leaf-to-stem ratio, crude protein content and crude protein yield—showed significant positive associations with green forage yield. These relationships highlight the usefulness of these traits for indirect selection aimed at boosting green forage productivity. Dry matter content also displayed a positive relationship with forage yield, further supporting its relevance in selection programs. The present findings are consistent with earlier studies. Amirthadevarathinam and Dorairaj (1994) [2] reported positive correlations of plant height, number of leaves and dry matter yield with forage yield. Similarly, Thirumeni and Das (1994) [17] observed a positive association between number of tillers and green forage yield, while Sukanya (1998) [16] documented positive correlations of forage yield with leaf length, plant height and number of leaves in Napier grass. Zhang *et al*. (2009) [18] also confirmed the positive relationship between yield and plant height, and Shinde *et al*. (2010) [13] noted significant positive associations of forage yield with dry matter yield, number of tillers and plant height. In contrast, days to flowering showed a significant negative correlation with green forage yield, and oxalic acid content exhibited a non-significant negative association. These results align well with previous findings and further validate the trends observed in the current study.

**Path Coefficients Analysis**

Path analysis revealed considerable variation in the degree and orientation of direct and indirect effects of component traits on green forage yield (GFY) in Napier grass. Days to flowering (DF) exhibited a small positive direct effect on GFY, but a negative total correlation due to predominant negative indirect effects through plant height, leaf width, dry matter yield, crude protein content and oxalate content. Plant height (PH) indicated a positive direct contribution and strong positive total association, supported by favourable indirect effects via leaf width, dry matter yield, crude protein content and oxalate content. Number of leaves (NL) exerted a negative direct influence but positive total correlation, attributed to substantial positive indirect effects through plant height, leaf width, dry matter yield and crude protein content. Number of tillers (NT) also displayed a negative direct effect, with a positive total correlation resulting from beneficial indirect contributions via plant height, leaf width, dry matter yield and crude protein content. Leaf length (LL) exerted a negative direct effect, but a strong positive total association due to pronounced indirect effects through plant height, leaf width, dry matter yield, crude protein yield and oxalate content. Leaf width (LW) showed a positive direct impact and positive total correlation, further strengthened by favourable indirect influences via plant height, dry matter yield, crude protein content and oxalate content. Leaf-stem ratio (LSR) indicated a direct negative effect but positive total correlation owing to positive indirect effects through leaf length, plant height, leaf width, crude protein yield, dry matter yield and oxalate content**.** Dry matter content (DM) recorded a negative direct effect and a weak positive total association, indicating limited indirect influence mainly through dry matter yield and crude protein content. Dry matter yield (DMY) exhibited the highest level of positive direct contribution (1.66) and the strongest positive total correlation, confirming it as the major determinant of GFY. Crude protein content (CP) indicated a direct positive contribution

and moderate positive total association, reinforced by indirect effects via dry matter yield and oxalate content. Crude protein yield (CPY) exhibited a negative direct influence but a strong positive total correlation due to marked positive indirect effects through dry matter yield and plant height. Oxalic acid content (OX) indicated a direct adverse influence and negative total correlation, supported by negative indirect effects through dry matter yield and crude protein content, indicating its overall detrimental effect on forage yield. Overall, traits such as plant height, dry matter yield, leaf length, leaf width, and crude protein content emerged as the most influential contributors to GFY, acting predominantly through strong direct or indirect pathways. These observations are consistent with earlier findings in Napier grass (Sukanya, 1998) [16].

**Table 1:** Estimates of variability parameters for green forage yield and its contributing characters in Napier grass genotypes

| Sr. No. | Character | Range | Mean | GCV | PCV | ECV | Heritability (%) | Genetic Advance | GA as % of Advance |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Days to flowers (No) | 150-180 | 163.82 | 3.59 | 4.60 | 2.48 | 67.70 | 9.96 | 6.08 |
| 2 | Plant height (cm) | 150.2-210.7 | 180.91 | 5.55 | 6.19 | 2.75 | 80.20 | 18.51 | 10.23 |
| 3 | Leaves per plant (No) | 17.36-25.36 | 21.84 | 6.42 | 8.24 | 5.16 | 60.70 | 2.25 | 10.31 |
| 4 | Tiller per plant (No) | 10.33-15.45 | 12.25 | 9.57 | 10.27 | 3.72 | 86.90 | 2.25 | 18.38 |
| 5 | Leaf length (cm) | 70.70-94.20 | 83.10 | 4.54 | 6.56 | 4.73 | 47.90 | 5.37 | 6.47 |
| 6 | Leaf width(cm) | 1.32-3.28 | 2.20 | 23.32 | 23.69 | 4.17 | 96.90 | 1.04 | 47.28 |
| 7 | Leaf to stem ratio | 0.55-0.86 | 0.70 | 10.27 | 11.21 | 4.50 | 83.90 | 0.14 | 19.38 |
| 8 | Dry Matter content (%) | 17.80-26.20 | 22.19 | 5.84 | 8.18 | 5.73 | 50.90 | 1.90 | 8.58 |
| 9 | Dry matter yield per plant(g) | 32.85-98.95 | 61.36 | 22.90 | 24.08 | 7.43 | 90.50 | 27.54 | 44.88 |
| 10 | Crude protein content (%) | 4.95-10.50 | 7.92 | 16.64 | 16.79 | 2.23 | 98.20 | 2.69 | 33.97 |
| 11 | Crude protein yield per plant(g) | 10.16-40.98 | 22.08 | 33.15 | 33.21 | 2.07 | 99.60 | 15.05 | 68.16 |
| 12 | Oxalic acid content (%) | 1.97-3.49 | 2.99 | 7.45 | 8.67 | 4.43 | 74.00 | 0.39 | 13.22 |
| 13 | Green forage yield per plant (g) | 151.30-400.60 | 275.72 | 19.88 | 20.41 | 4.63 | 94.90 | 109.95 | 39.88 |

**Table 2:** Mean performance of Napier grass genotypes for various characters

| Genotype | Days to flowers (No) | Plant height (cm) | Leaves per plant (No) | Tillers per plant (No) | Leaf length (cm) | Leaf width (cm) | Leaf: Stem Ratio | Dry matter content (%) | Dry matter yield per plant (g) | Crude protein content (%) | Crude protein yield per plant (g) | Oxalic acid content (%) | Green forage yield per plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 10 | 11 | 12 | 13 | 8 |
| RN-2024-1 | 156.50 | 182.75 | 21.23 | 10.78 | 85.10 | 2.26 | 0.62 | 18.60 | 62.07 | 8.31 | 27.81 | 3.12 | 333.45 |
| RN-2024-2 | 158.00 | 186.95 | 21.29 | 11.96 | 81.35 | 2.37 | 0.61 | 19.20 | 60.58 | 8.34 | 26.36 | 3.08 | 315.30 |
| RN-2024-3 | 158.00 | 169.85 | 23.27 | 12.58 | 84.35 | 2.45 | 0.65 | 20.90 | 59.97 | 7.61 | 21.86 | 3.11 | 286.50 |
| RN-2024-4 | 155.50 | 174.60 | 21.20 | 11.72 | 83.95 | 1.37 | 0.58 | 22.00 | 63.48 | 8.88 | 25.66 | 2.98 | 288.20 |
| RN-2024-5 | 167.00 | 181.80 | 23.83 | 11.40 | 87.75 | 2.54 | 0.75 | 20.95 | 64.13 | 7.72 | 23.68 | 3.10 | 306.10 |
| RN-2024-6 | 165.00 | 177.40 | 23.63 | 11.56 | 83.35 | 2.08 | 0.67 | 22.80 | 53.03 | 7.32 | 17.09 | 2.85 | 232.50 |
| RN-2024-7 | 160.00 | 169.40 | 21.25 | 12.83 | 78.35 | 2.36 | 0.61 | 23.35 | 43.66 | 8.89 | 16.68 | 2.91 | 186.90 |
| RN-2024-8 | 158.00 | 168.60 | 19.93 | 12.56 | 82.15 | 2.35 | 0.63 | 23.50 | 36.86 | 8.29 | 13.06 | 2.76 | 156.95 |
| RN-2024-9 | 161.50 | 167.25 | 21.43 | 12.00 | 76.35 | 1.47 | 0.60 | 19.75 | 36.68 | 8.08 | 15.84 | 2.88 | 185.10 |
| RN-2024-10 | 163.50 | 168.40 | 22.92 | 12.16 | 80.60 | 1.61 | 0.64 | 18.95 | 48.13 | 7.29 | 18.59 | 3.07 | 254.15 |
| RN-2024-11 | 165.50 | 183.60 | 21.03 | 12.04 | 85.80 | 1.56 | 0.63 | 21.75 | 70.09 | 9.47 | 31.02 | 3.14 | 321.65 |
| RN-2024-12 | 154.00 | 198.90 | 23.66 | 13.64 | 90.37 | 2.92 | 0.57 | 24.15 | 84.53 | 9.80 | 33.79 | 3.13 | 350.00 |
| RN-2024-13 | 163.00 | 184.50 | 18.54 | 11.04 | 85.95 | 2.26 | 0.85 | 22.65 | 48.99 | 5.65 | 11.98 | 2.96 | 216.30 |
| RN-2024-14 | 163.50 | 165.50 | 20.24 | 10.79 | 79.30 | 2.46 | 0.84 | 22.45 | 54.47 | 5.83 | 13.88 | 2.99 | 242.25 |
| RN-2024-15 | 162.00 | 175.35 | 20.05 | 11.72 | 76.85 | 2.29 | 0.80 | 20.95 | 63.13 | 6.15 | 18.59 | 3.09 | 301.45 |
| RN-2024-16 | 163.00 | 182.10 | 20.82 | 10.83 | 75.30 | 1.80 | 0.75 | 22.00 | 63.58 | 6.85 | 19.87 | 3.06 | 289.25 |
| RN-2024-17 | 168.00 | 179.60 | 18.62 | 11.88 | 74.85 | 1.38 | 0.70 | 20.45 | 46.02 | 8.06 | 18.16 | 3.01 | 224.60 |
| RN-2024-18 | 171.50 | 179.90 | 21.02 | 11.08 | 80.50 | 2.36 | 0.71 | 21.60 | 48.74 | 7.51 | 16.97 | 3.00 | 225.20 |
| RN-2024-19 | 165.50 | 183.10 | 21.70 | 12.44 | 82.55 | 2.22 | 0.68 | 21.50 | 55.68 | 5.56 | 14.18 | 3.05 | 259.4 |
| RN-2024-20 | 171.00 | 188.80 | 21.35 | 11.75 | 86.65 | 2.39 | 0.75 | 22.85 | 49.91 | 4.94 | 10.47 | 3.02 | 218.70 |
| RN-2024-21 | 166.50 | 182.30 | 22.98 | 13.47 | 82.70 | 2.06 | 0.76 | 23.30 | 57.38 | 6.41 | 15.67 | 3.04 | 246.35 |
| RN-2024-22 | 168.50 | 179.20 | 20.38 | 13.34 | 87.30 | 1.55 | 0.81 | 23.60 | 56.66 | 5.76 | 13.57 | 3.03 | 239.90 |
| RN-2024-23 | 161.50 | 175.60 | 19.31 | 12.36 | 87.55 | 1.53 | 0.80 | 23.35 | 67.41 | 8.27 | 23.51 | 3.11 | 288.45 |
| RN-2024-24 | 167.50 | 180.45 | 21.27 | 12.49 | 80.50 | 1.55 | 0.68 | 23.55 | 54.42 | 8.41 | 19.51 | 3.06 | 231.15 |
| RN-2024-25 | 152.50 | 199.40 | 24.27 | 14.41 | 89.30 | 3.05 | 0.63 | 24.25 | 91.34 | 10.01 | 38.33 | 3.08 | 376.80 |
| RN-2024-26 | 171.50 | 191.40 | 23.54 | 10.83 | 82.30 | 2.33 | 0.75 | 21.50 | 61.05 | 8.19 | 22.52 | 3.09 | 285.15 |
| RN-2024-27 | 162.50 | 190.90 | 22.59 | 13.46 | 85.80 | 2.40 | 0.58 | 22.00 | 60.50 | 7.15 | 19.34 | 3.07 | 275.40 |
| RN-2024-28 | 162.50 | 169.80 | 20.51 | 10.79 | 86.15 | 1.48 | 0.70 | 23.05 | 63.02 | 9.44 | 24.95 | 3.10 | 273.60 |
| RN-2024-29 | 163.50 | 158.90 | 21.71 | 11.64 | 79.70 | 2.39 | 0.73 | 22.55 | 65.66 | 8.13 | 23.74 | 3.12 | 291.40 |
| RN-2024-30 | 164.00 | 172.00 | 20.46 | 11.08 | 78.85 | 1.39 | 0.73 | 22.95 | 68.07 | 8.20 | 24.36 | 3.13 | 296.45 |
| RN-2024-31 | 152.50 | 198.00 | 24.87 | 14.40 | 88.90 | 2.95 | 0.72 | 24.15 | 86.76 | 7.70 | 27.14 | 3.06 | 359.10 |
| RN-2024-32 | 177.00 | 182.00 | 22.53 | 12.08 | 84.40 | 2.37 | 0.66 | 24.50 | 82.25 | 9.08 | 31.06 | 3.05 | 336.45 |
| RN-2024-33 | 172.00 | 192.00 | 23.06 | 11.72 | 84.20 | 2.30 | 0.63 | 21.35 | 68.57 | 7.44 | 23.94 | 3.09 | 321.00 |
| RN-2024-34 | 174.00 | 179.50 | 21.98 | 12.44 | 82.35 | 2.57 | 0.82 | 20.60 | 61.59 | 8.26 | 24.80 | 3.11 | 299.35 |
| RN-2024-35 | 175.00 | 175.40 | 22.12 | 10.79 | 85.60 | 2.79 | 0.73 | 22.95 | 53.24 | 8.23 | 19.58 | 2.92 | 232.10 |
| RN-2024-36 | 169.50 | 172.50 | 21.73 | 11.23 | 76.35 | 2.31 | 0.73 | 20.45 | 47.62 | 7.32 | 16.33 | 2.89 | 232.25 |
| RN-2024-37 | 167.00 | 179.50 | 22.89 | 12.94 | 76.30 | 2.57 | 0.75 | 21.10 | 46.76 | 8.04 | 17.01 | 3.04 | 220.80 |
| RN-2024-38 | 170.00 | 180.60 | 20.99 | 12.96 | 78.25 | 1.67 | 0.69 | 22.75 | 58.62 | 9.43 | 23.31 | 3.07 | 257.80 |
| RBN-16-61 | 151.00 | 203.00 | 24.93 | 15.41 | 93.35 | 3.22 | 0.67 | 24.55 | 96.48 | 10.43 | 40.71 | 2.04 | 392.95 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P. GUNWANT (C) | 154.00 | 205.40 | 24.48 | 15.39 | 92.35 | 3.10 | 0.72 | 24.65 | 93.20 | 10.15 | 38.09 | 1.99 | 378.15 |
| Mean | 163.82 | 180.91 | 21.84 | 12.25 | 83.1 | 2.2 | 0.7 | 22.19 | 61.36 | 7.92 | 22.08 | 2.99 | 275.72 |
| S.E. | 2.87 | 3.52 | 0.79 | 0.32 | 2.7 | 0.06 | 0.02 | 0.89 | 3.22 | 0.12 | 0.32 | 0.09 | 9.03 |
| C.D. 5% | 8.22 | 10.07 | 2.28 | 0.93 | 7.96 | 0.19 | 0.07 | 2.58 | 9.23 | 1.24 | 0.96 | 0.27 | 25.84 |

**Table 3:** Estimates of genotypic correlation coefficients among green forage yield and yield contributing characters of Napier grass

| Characters | Days to flowers (No) | Plant height (cm) | Leaves per plant (No) | Tillers per plant (No) | Leaf length (cm) | Leaf width (cm) | Leaf : Stem Ratio | Dry matter content (%) | Dry matter yield per plant (g) | Crude protein content (%) | Crude protein yield per plant (g) | Oxalic acid content (%) | Green forage yield per plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to flowers (No) | 1 | -0.344* | -0.249 | -0.576** | -0.519** | -0.281 | -0.263 | -0.415** | -0.508 ** | -0.504** | -0.506 ** | 0.446 ** | -0.468** |
| Plant height (cm) | | 1 | 0.66** | 0.639 ** | 0.748 ** | 0.583** | 0.546 ** | 0.473** | 0.734** | 0.339* | 0.616** | -0.461** | 0.676** |
| Leaves per plant (No) | | | 1 | 0.631 ** | 0.616 ** | 0.766** | 0.134 | 0.371* | 0.680 ** | 0.464 ** | 0.626 ** | -0.434** | 0.630 ** |
| Tiller per plant (No) | | | | 1 | 0.605 ** | 0.468** | 0.403 ** | 0.635 ** | 0.567 ** | 0.445 ** | 0.500 ** | -0.585** | 0.428 ** |
| Leaf length (cm) | | | | | 1 | 0.593** | 0.5959** | 0.9104** | 0.8619** | 0.391* | 0.6895** | -0.591** | 0.716 ** |
| Leaf width (cm) | | | | | | 1 | 0.299 | 0.306 | 0.479 ** | 0.196 | 0.390* | -0.457** | 0.436 ** |
| Leaf to stem ratio | | | | | | | 1 | 0.414 ** | 0.598** | 0.071 | 0.410 ** | -0.324* | 0.531 ** |
| Dry matter content (%) | | | | | | | | 1 | 0.451 ** | 0.331* | 0.307 | -0.437** | 0.194 |
| Dry matter yield per plant (g) | | | | | | | | | 1 | 0.540 ** | 0.900 ** | -0.331* | 0.962 ** |
| Crude protein content (%) | | | | | | | | | | 1 | 0.798 ** | -0.366* | 0.495 ** |
| Crude protein yield per plant (g) | | | | | | | | | | | 1 | -0.373 * | 0.897 ** |
| Oxalic acid content (%) | | | | | | | | | | | | 1 | -0.208 |
| Green forage yield per plant (g) | | | | | | | | | | | | | 1 |

Significant at P = 0.05 and P = 0.01 level respectively. Residual effect: - 0.09.

**Table 4:** Estimates of phenotypic correlation coefficients among green forage yield and yield contributing characters of Napier Grass

| Characters | Days to flowers (No) | Plant height (cm) | Leaves per plant (No) | Tillers per plant (No) | Leaf length (cm) | Leaf width (cm) | Leaf: Stem Ratio | Dry matter content (%) | Dry matter yield per plan(g) | Crude protein content (%) | Crude protein yield per plant(g) | Oxalic acid content (%) | Green forage yield per plant(g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to flowers (No) | 1 | -0.229 * | -0.242 * | -0.458 ** | -0.307 ** | -0.244 * | -0.170 | -0.174 | -0.357 ** | -0.418 ** | -0.418 ** | 0.302 ** | -0.362 ** |
| Plant height (cm) | | 1 | 0.480 ** | 0.562 ** | 0.576 ** | 0.499 ** | 0.480 ** | 0.278 * | 0.638 ** | 0.283 * | 0.544 ** | -0.313 ** | 0.611 ** |
| Leaves per plant (No) | | | 1 | 0.498** | 0.424 ** | 0.550 ** | 0.083 | 0.105 | 0.495 ** | 0.341 ** | 0.482 ** | -0.255 * | 0.501 ** |
| Tiller per plant (No) | | | | 1 | 0.464 ** | 0.429 ** | 0.397 ** | 0.457 ** | 0.541 ** | 0.434 ** | 0.489 ** | -0.493 ** | 0.417 ** |
| Leaf length (cm) | | | | | 1 | 0.404 ** | 0.425 ** | 0.311 ** | 0.566 ** | 0.286 * | 0.5 ** | -0.239 * | 0.517 ** |
| Leaf width (cm) | | | | | | 1 | 0.280 * | 0.261 * | 0.459 ** | 0.192 | 0.371 ** | -0.370 ** | 0.413 ** |
| Leaf to stem ratio | | | | | | | 1 | 0.307 ** | 0.577 ** | 0.075 | 0.403 ** | -0.231 * | 0.517 ** |
| Dry matter content (%) | | | | | | | | 1 | 0.471 ** | 0.246 * | 0.223 * | -0.357 ** | 0.155 |
| Dry matter yield per plant (g) | | | | | | | | | 1 | 0.519 ** | 0.874 ** | -0.299 ** | 0.934 ** |
| Crude protein content (%) | | | | | | | | | | 1 | 0.797 ** | -0.308 ** | 0.489 ** |
| Crude protein yield per plant(g) | | | | | | | | | | | 1 | -0.319 ** | 0.889 ** |
| Oxalic acid content (%) | | | | | | | | | | | | 1 | -0.184 |
| Green forage yield per plant(g) | | | | | | | | | | | | | 1 |

Significant at P = 0.05 and P = 0.01 level respectively. Residual effect: - 0.141

**Table 5:** Estimates of genotypic direct (diagonal) and indirect effects (above and below diagonal) of characters on green forage yield of Napier grass

| | DF | PH | NL | NT | LL | LW | LSR | DM | DMY | CP | CPY | OX | GFY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DF | 0.021 | -0.023 | 0.060 | 0.025 | 0.101 | -0.039 | 0.038 | 0.090 | -0.844 | -0.073 | 0.201 | -0.025 | -0.4683 ** |
| PH | -0.007 | 0.067 | -0.158 | -0.028 | -0.146 | 0.080 | -0.078 | -0.103 | 1.219 | 0.049 | -0.245 | 0.026 | 0.6767 ** |
| NL | -0.005 | 0.044 | -0.239 | -0.027 | -0.120 | 0.106 | -0.019 | -0.081 | 1.129 | 0.067 | -0.249 | 0.024 | 0.6302 ** |
| NT | -0.012 | 0.043 | -0.151 | -0.043 | -0.118 | 0.064 | -0.058 | -0.138 | 0.943 | 0.065 | -0.199 | 0.033 | 0.4281 ** |
| LL | -0.011 | 0.050 | -0.147 | -0.026 | -0.195 | 0.082 | -0.086 | -0.197 | 1.431 | 0.057 | -0.274 | 0.033 | 0.716 ** |
| LW | -0.006 | 0.039 | -0.183 | -0.020 | -0.115 | 0.138 | -0.043 | -0.066 | 0.795 | 0.028 | -0.155 | 0.025 | 0.4367 ** |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LSR | -0.006 | 0.037 | -0.032 | -0.017 | -0.116 | 0.041 | -0.144 | -0.090 | 0.993 | 0.010 | -0.163 | 0.018 | 0.5314 ** |
| DM | -0.009 | 0.032 | -0.089 | -0.027 | -0.177 | 0.042 | -0.060 | -0.217 | 0.749 | 0.048 | -0.122 | 0.024 | 0.1944 |
| DMY | -0.011 | 0.049 | -0.163 | -0.025 | -0.168 | 0.066 | -0.086 | -0.098 | 1.66 | 0.078 | -0.361 | 0.018 | 0.962 ** |
| CP | -0.011 | 0.023 | -0.111 | -0.019 | -0.076 | 0.027 | -0.010 | -0.072 | 0.897 | 0.145 | -0.318 | 0.020 | 0.495 ** |
| CPY | -0.011 | 0.041 | -0.150 | -0.022 | -0.134 | 0.054 | -0.059 | -0.067 | 1.506 | 0.116 | -0.398 | 0.021 | 0.8978 ** |
| OX | 0.009 | -0.031 | 0.104 | 0.025 | 0.115 | -0.063 | 0.047 | 0.095 | -0.550 | -0.053 | 0.149 | -0.056 | -0.2089 |

*, **significant at P = 0.05 and P = 0.01 level respectively

## Conclusion

The genotypes exhibited notable variation across all traits, indicating a wide scope for improving Napier grass genetically. High GCV, PCV, heritability and genetic advance for green forage yield, dry matter yield, crude protein yield, number of tillers, leaf length, leaf width, leaf-to-stem ratio and crude protein content show that these traits are largely regulated by additive genetic effects and are suitable targets for direct selection. Dry matter yield and crude protein yield exhibited the strongest positively correlation with green forage yield, supported by favourable associations with number of tillers, plant height, leaf width and number of leaves. Number of days required for flowering and oxalic acid content exhibited negative associations with most yield traits, emphasizing the advantage of early flowering and low oxalate levels for enhanced productivity and quality. Path analysis identified dry matter yield as the trait with the greatest influence with the maximum positive direct influence on green forage yield, followed by crude protein yield, leaf length, number of leaves and crude protein content. Considering both correlation and path analyses, plant height, number of tillers, number of leaves, leaf length, leaf width, dry matter yield and crude protein yield emerged as key components for improving forage productivity. Among the 40 genotypes evaluated, RN-2024-12, RN-2024-25, RN-2024-31 and RBN-16-61 were considered the most promising, based on superior performance for green forage yield, dry matter yield and crude protein content. These genotypes merit advancement to multi-location trials for further evaluation and potential release.

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