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Evaluation of Morpho-physiological Traits, Chemical Quality Parameters and Drought Tolerance Indices Inbidi Tobacco (*Nicotiana tabacum* L.) Germplasm Lines

P. Pulli Bai [a*], V. Jayalakshmi [b], K. Sarala [c], K. Gangadhara [d], K. Prabhakara Rao [c] and Shaik Nafeez Umar [e]

[a] *Regional Agricultural Research Station, Nandyal, Acharya N.G. Ranga Agricultural University, 518502, India.*
[b] *Agricultural College, Mahanandi, Acharya N.G. Ranga Agricultural University, 518 502, India.*
[c] *ICAR-National Institute for Research on Commercial Agriculture (CTRI), Rajahmundry-533105, India.*
[d] *ICAR-National Institute for Research on Commercial Agriculture (CTRI), Research Station, Kandukur-523105, India.*
[e] *S.V. Agricultural College, Tirupati Acharya N.G. Ranga Agricultural University, 517501, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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**Corresponding author: E-mail: p.pullibai@angrau.ac.in;*

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ABSTRACT

Drought resilience is a critical breeding objective in *bidi* tobacco (*Nicotiana tabacum* L.) due to the crop's economic significance and its predominance in moisture limited regions. To assess genetic variation for yield and drought tolerance, 100 diverse *bidi* tobacco germplasm lines were evaluated at the Regional Agricultural Research Station, Nandyal, Acharya N.G. Ranga Agricultural University, during 2022–23 under both normal and rainfed conditions. Substantial genetic variability was observed among the lines for yield and associated morpho-physiological and chemical quality traits, indicating a broad genetic base for selection. Drought stress markedly reduced plant growth, leaf area and cured leaf yield due to impaired photosynthetic efficiency and water status, while enhancing nicotine accumulation. Among the evaluated lines, NyBD 71, NyBD 62, NyBD 73, NyBD 74 and NyBD 78 demonstrated superior performance across environments, with higher cured leaf yield, mean productivity and geometric mean productivity, reflecting yield stability and drought resilience. Additionally, NyBD 90 and NyBD 89 exhibited lower stress susceptibility and greater yield stability indices, indicating better adaptability to moisture stress. These identified genotypes, combining high productivity, physiological efficiency and desirable biochemical composition, constitute valuable genetic resources for developing drought tolerant, high yielding *bidi* tobacco cultivars suited to rainfed conditions.

Keywords: Moisture stress; nicotine accumulation; genetic variation; drought stress.

1. INTRODUCTION

Bidi tobacco (*Nicotiana tabacum L.*), a smoking type of tobacco, occupies about 1,80,759 ha with a production of 3,72,220 tonnes and is predominantly cultivated in Gujarat (89.84%), followed by Karnataka (3.93%) and Andhra Pradesh (6.23%) (AINPT Annual Report, 2024–25). It ranks second among the various tobacco types grown in India, accounting for 35% of the total tobacco area and 33% of total production. In Andhra Pradesh, *bidi* tobacco is mainly grown as a rainfed late *kharif* crop over 8,000–10,000 ha in the Kurnool and Nandyal districts. The cured leaf, which is the economic yield component, is highly sensitive to environmental fluctuations, particularly water stress. Drought can cause severe yield reductions ranging from 14.9–25.9% under mild stress to over 50% under severe stress depending on genotype (Zhang et al., 2024).

Drought stress is one of the most critical abiotic constraints affecting the growth, productivity, and quality of *bidi* tobacco, particularly in semi-arid and rainfed regions where erratic rainfall and prolonged dry spells are frequent. Being a shallow-rooted crop, tobacco is highly sensitive to soil moisture deficits during critical growth stages, which reduces leaf area, photosynthetic efficiency and cured leaf yield. Physiologically, drought limits transpiration and chlorophyll synthesis, while biochemically it elevates nicotine accumulation and decreases reducing sugars and chlorides, adversely affecting leaf quality attributes such as aroma, flavor, and combustibility.

Several studies worldwide have investigated drought tolerance in *Nicotiana tabacum* using physiological and molecular approaches. For instance, Li et al. (2019)) reported significant variation in water-use efficiency, osmolyte accumulation and antioxidant defense mechanisms among flue-cured tobacco genotypes in China. Similarly, Costa et al. (2020) in Brazil and Wang et al. (2022) in the United States emphasized the role of root architecture, relative water content (RWC) and osmotic adjustment in conferring drought resilience. Despite these advances, systematic evaluations focusing on *bidi* tobacco, which is genetically distinct and primarily grown under marginal conditions in India, remain limited. The scarcity of integrated studies combining morpho-physiological, biochemical and yield parameters in *bidi* tobacco hampers the identification of robust donor genotypes for drought tolerance breeding.

Hence, identifying and characterizing drought tolerant germplasm lines within *bidi* tobacco is crucial for enhancing productivity and stability under moisture stressed conditions. The availability of diverse germplasm offers an opportunity to evaluate adaptive mechanisms such as efficient water use, sustained photosynthetic activity and osmotic adjustment under drought.

The present investigation entitled "Evaluation of morpho-physiological traits, chemical quality parameters and drought tolerance indices in *bidi* tobacco (*Nicotiana tabacum L.*) germplasm lines" was undertaken with the following specific objectives:

- To assess genetic variability among *bidi* tobacco germplasm lines for yield and drought-related morpho-physiological and biochemical traits under normal and rainfed conditions.
- To identify drought-tolerant and stable genotypes exhibiting high yield potential and superior physiological efficiency.
- To determine key traits and indices associated with drought resilience for use in selection and breeding of moisture stress tolerant *bidi* tobacco cultivars.

2. MATERIALS AND METHODS

A total of 100 diverse *bidi* tobacco (*Nicotiana tabacum L.*) germplasm lines were evaluated during the *kharif* season of 2022–23 at the Regional Agricultural Research Station (RARS), Nandyal, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India (15°29′N latitude, 78°29′E longitude, 211 m above mean sea level). The site is characterized by a semi-arid tropical climate with an average annual rainfall of 550–650 mm, primarily received between June and September. The experimental field soil was classified as Vertisol (deep black cotton soil) with a pH of 7.3–7.8, moderate organic carbon content, and good moisture-retention capacity.

The experiment was conducted under two environments normal (irrigated) and rainfed (moisture stressed) conditions using an Alpha Lattice Design with two replications, 10 blocks per replication and 10 genotypes per block to minimize within block variation. Each genotype was planted in two rows, 6.75 m in length and 1.5 m apart, with an intra-row spacing of 0.75 m × 0.75 m. Forty five to fifty day-old seedlings were transplanted in the second fortnight of September 2022, following nursery sowing in late July 2022. Standard agronomic and plant protection practices were followed throughout the crop period, including timely intercultivation, weeding, topping and desuckering.

Drought stress under the rainfed condition was imposed by withholding irrigation after seedling establishment, allowing plants to rely solely on natural rainfall. Soil moisture stress intensity was quantified using gravimetric soil moisture estimation at 30 cm depth and by calculating relative water content (RWC) at peak vegetative and flowering stages. Mean RWC below 60% indicated moderate to severe drought stress.

Data were recorded on five randomly selected competitive plants per genotype per replication for morphological, physiological and chemical quality traits.

- Morphological traits: days to flowering, topped plant height (cm), number of leaves per plant, leaf length (cm), leaf width (cm) and cured leaf yield (kg ha^{-1}).
- Physiological traits: relative water content (%), SPAD chlorophyll meter reading (SCMR), specific leaf area ($cm^2\ g^{-1}$), root length (cm) and root dry weight (g).
- Chemical quality traits: nicotine content (%), reducing sugars (%) and chloride content (%).

Data were subjected to analysis of variance (ANOVA) following the Alpha Lattice Design using INDOSTAT and R (v4.2.1) software packages. Correlation, variability and drought tolerance indices were computed to determine associations among traits and identify drought resilient genotypes.

Although the two-environment field evaluation provided valuable insights, the study was limited to one cropping season and did not include molecular or controlled-environment validation of drought responses, which may be considered in future research.

2.1 Statistical Analysis

Observations on quantitative traits recorded under normal and moisture stress conditions were analyzed statistically. Descriptive statistics, including mean, range, variance, standard deviation, and standard error, were computed for all the traits. The mean was calculated as the sum of observations divided by the number of observations, range as the minimum and maximum mean values, variance as the average of squared deviations from the mean, standard deviation as the square root of variance, and standard error as the standard deviation divided by the square root of the sample size. Five drought tolerance indices are Yield Stability (YS), Mean Productivity (MP), Tolerance Index (TOL), Geometric Mean Productivity (GMP) and Stress

Susceptibility Index (SSI) were used to evaluate genotypic performance under moisture stress. These indices were calculated using yields under stress (Ys) and non-stress (Yp) conditions, providing a comprehensive framework for identifying drought tolerant and susceptible *bidi* tobacco germplasm lines (Bouslama and Schapaugh, 1984; Rosielle and Hamblin, 1981; Fernandez, 1992; Fisher and Maurer, 1978).

3. RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among 100 bidi tobacco genotypes for cured leaf yield, morphological characters (days to flowering, plant height, number of leaves per plant, leaf length, leaf width) and physiological characters (relative water content (RWC), SPAD chlorophyll meter reading (SCMR), specific leaf area, root length, and root dry weight) under normal and rainfed conditions (Table 1).Among biochemical quality traits, significant differences were observed for reducing sugars under normal condition, nicotine content under rainfed condition, while chlorides did not reveal significant variation under either condition (Table 1.). The results revealed the scope to exploit the variability observed in the bidi tobacco genotypes for tobacco crop improvement and also for selection for genotypes with higher cured leaf yield and drought tolerance.Belul and Halit (2010), Katbaet al. (2014), Sumanet al. (2015) and Shah et al. (2015) also documented significant variability among tobacco genotypes evaluated under both normal and stress conditions.

The *per se*performance of the 100 bidi tobacco germplasm lines evaluated under normal and rainfed conditions was presented in Table 2to Table 5.

3.1 Study of Morphological Traits

Under normal conditions, 40 genotypes viz., NyBD 71 (3161 kg/ha), NyBD 63 (3046 kg/ha), NyBD 62 (3018 kg/ha), NyBD 69 (3009 kg/ha), NyBD 73 (3013 kg/ha), NyBD 74 (2995 kg/ha), NyBD 68 (2882 kg/ha), NyBD 67 (2844 kg/ha), NyBD 66 (2685 kg/ha), NyBD 61 (2939 kg/ha), NyBD 60 (2869 kg/ha), NyBD 59 (2850 kg/ha), NyBD 56 (2913 kg/ha), A119 (2670kg/ha), NyBD 75 (2822 kg/ha), NyBD 76(2756 kg/ha),NyBD 77(2818 kg/ha), NyBD 78 (2920 kg/ha), NyBD 79 (2937 kg/ha), NyBD 80 (2838 kg/ha), NyBD 81 (2599 kg/ha), NyBD 82 (2660 kg/ha), NyBD 84 (2715 kg/ha), NyBD 86 (2790 kg/ha), NyBD 87 (2600 kg/ha), NyBD 89 (2586 kg/ha), ABD 78 (2793 kg/ha), ABD 118 (2890 kg/ha), ABD 131 (2703 kg/ha), ABD 54 (2730 kg/ha),ABD 132 (NP2) (2779 kg/ha), ABD 84 (2660 kg/ha), ABD 121 (2810 kg/ha), Bhavayasree(2633 kg/ha), NBD 260 (2733 kg/ha), NBD 276 (2619 kg/ha), NBD 154 (2596 kg/ha), and NBD 271(2581 kg/ha) have recorded higher cured leaf yield (Table 2). The yield in these top performing genotypes ranged from 2581kg/ha in NBD 271 to 3161 kg/ha in NyBD 71.

Under rainfed conditions, 37 genotypes viz., NyBD 71 (2498 kg/ha) ,NyBD 62 (2386 kg/ha), NyBD 70 (2258 kg/ha), NyBD 80 (2255 kg/ha), NyBD 75 (2254 kg/ha), NyBD 78 (2352 kg/ha), ABD 121 (2350 kg/ha), NyBD 79 (2314 kg/ha), NyBD 73 (2306 kg/ha), NBD 260 (2226 kg/ha), NyBD 74 (2288 kg/ha), NyBD 89 (2288 kg/ha), NyBD 77 (2286 kg/ha), ABD 78 (2250 kg/ha), NyBD 69 (2244 kg/ha), NyBD 72 (2236 kg/ha), NyBD 90 (2196 kg/ha), NyBD 82 (2176 kg/ha), NyBD 59 (2122 kg/ha), ABD 138 (2217 kg/ha), ABD 152 (2168 kg/ha), ABD 132 (NP2) (2153 kg/ha), NyBD 86 (2147 kg/ha), ABD 146 (2144 kg/ha), ABD 118 (2116 kg/ha), NyBD 60 (2108 kg/ha), NyBD 91 (2106 kg/ha), NyBD 81 (2106 kg/ha), NBD 276 (2097 kg/ha), NyBD 61 (2093 kg/ha), ABD 119 (2093 kg/ha), ABD 151 (2090 kg/ha), ABD 131 (2088 kg/ha), Bhavyasree (2077 kg/ha), NyBD 85 (2076 kg/ha) and NyBD 92 (2066 kg/ha) exhibited higher cured leaf yield. The yield in these genotypes ranged from NyBD 92 (2066 kg/ha) to NyBD 71 (2498 kg/ha) (Table 2).

Among the studied genotypes the worth mentioning are NyBD71 (3161 kg/ha; 2498 kg/ha),NyBD 62 (3018 kg/ha; 2386 kg/ha), NyBD 73 (3013 kg/ha; 2306 kg/ha), NyBD 70 (2992 kg/ha; 2258 kg/ha), NyBD 74(2995 kg/ha; 2288 kg/ha), NyBD 69 (3009 kg/ha; 2244 kg/ha),NyBD 72 (2992 kg/ha; 2236 kg/ha), NyBD 75 (2822 kg/ha; 2254 kg/ha), NyBD 68 (2882 kg/ha; 2040 kg/ha), NyBD 78 (2920 kg/ha; 2352 kg/ha) and NyBD 79 (2937 kg/ha; 2314 kg/ha) as they performed better under normal as well rainfed conditions. The genotypesNyBD 72 (112 days) and NyBD 68 (111 days) are early flowering genotypes (stress escape) under rainfed condition which are adopted to moisture stress period and had higher number of leaves per plant (NyBD 75 (26 leaves) and NyBD 73 (25.5 leaves)) responsible for high photosynthetic efficiency during moisture stress period. Hence, the genotypes performing better under rainfed conditions exhibited smaller changes in morphological and physiological traits reflecting their genotypic advantages.

It is evident from the results that under rainfed condition, there was decrease in the magnitude of morphological traits such as topped plant height, number of leaves per plant, leaf length, leaf width and cured leaf yield except days to flowering compared to normal conditions (Dastogeer et al .,2018 ;Postiglione et al.,1988; Reddy et al ., 2023 ; Janardhan et al ., 1994 and Sifola et al .,1996)

(Table 2). The present findings are in conformity with the findings of Yakovuk and Okazov (1969) for days to flowering who reported delayed flowering under water stress conditions and in negation with the reports of Lakshminarayanaet al. (1980) who reported an early flowering in drought years.Baghyalakshmiet al*. (*2017), Bigloueiet al*. (*2010), and Yunpeng et al*.* (1996) who reported decrease in topped plant height and number of leaves per plant during stressed conditions. Also the reports of Baghyalakshmiet al*. (*2017), Karakas et al*.* (1997), Lang et al*.* (1996) and Patel et al*.* (1995) revealed significant decrease in leaf length, leaf width and cured leaf yield under stress conditions which are supporting the results obtained in the present investigation.

3.2 Study of Morpho-physiological Characters

The genotype NyBD 71 recorded the highest cured leaf yield (3161 kg/ha under normal; 2498 kg/ha under rainfed), coupled with broader leaves (25.1 cm), high relative water content (87.4%), and moderate specific leaf area (112.6 cm^2/g), suggesting a combination of vigorous growth and drought resilience (Table 3). Similarly, NyBD 78 and NyBD 73exhibited higher leaf length (47.4 cm; 40.7 cm) and leaf width (15.4 cm; 13.8 cm) withhigh chlorophyll content (SCMR >70), indicating their photosynthetic efficiency and adaptability under water-limited conditions. Genotypes such as NyBD 69 and NyBD 68 maintained longer roots (up to 52.5 cm) and higher root dry weights (32.0g and 31.0g) demonstrating enhanced water uptake capacity under drought. NyBD 74 (82%), NyBD 71 (81.3%), NyBD 75 (83.5%) showed superior RWC and higher SCMR values.NyBD 78 (73.0), NyBD 74 (71.4), NyBD 72 (68.6) under stress, indicating osmotic adjustment and better physiological balance during soil moisture deficit.Under rainfed conditions, a moderate rise in nicotine concentration was observed in the genotypes NyBD 68 (4.2%), NyBD 75 (3.6%), NyBD 74 (3.3%) which can be attributed to theaccumulation of alkaloids under moisture stress, as reported byPatel et al*.* (1993)and Jadhavet al*.* (2021).

In the present study, it was also observed that there was significant reduction in the physiological traits like relative water content, SPAD chlorophyll meter reading, specific leaf area, root length, root dry weight under rainfed conditions as compared to normal conditions across the genotypes (Table 3). The reports of Su Xin Hong et al*.* (2017), Baghyalakshmiet al*. (*2017), supports the present results obtained with respect to relative water content, SPAD chlorophyll meter reading wherein there is decline in these traits under rainfed condition as compared to normal conditions.

3.3 Study of Chemical Quality Characters

Reducing sugars, which influence the flavour, smoothness, and burning quality, ranged from 2.0 to 2.8% under normal and 1.6 to 2.6%under rainfed conditions (Table 4). A slight reduction was observed under water stress, which aligns with findings ofReddy et al*.* (2020) who reported thatsugar metabolism slows down under drought due to reduced photosynthetic activity. GenotypesNyBD 70, NyBD 72 and NyBD 62maintained relatively higher reducing sugar levels even under rainfed conditions, indicating better carbon assimilation and sugar retention capacity under moisture deficit.

Chloride content, which influencesleaf combustibility and smoke character, showed a decreasing trend under rainfed conditions across all genotypes. Values ranged between 0.92 to1.45% (normal)and0.67 to 1.52% (rainfed). Lower chloride levels in rainfed samples (especiallyNyBD 70 and NyBD 69) are desirable, as excess chloride impairs burning quality. The genotypes NyBD 62, NyBD 70and NyBD 69 maintained ideal chloride balance, contributing to better leaf texture and curing performance under both environments.NyBD 71, NyBD 62, NyBD 73, and NyBD 74 exhibited a balanced biochemical profile, combining moderate nicotine with desirable reducing sugars and low chloride content, making them suitable to meet*bidi* tobacco quality standards. Genotypes NyBD 68 andNyBD 75 showed higher nicotine content but slightly higher chloride levels, while NyBD 70 and NyBD 69 displayed optimal sugar-chloride balance with moderate nicotinetraits that contribute to good flavour, smooth burning and overall cured leaf quality.These elite lines particularly NyBD 71, NyBD 62,NyBD 73, NyBD

74, NyBD 69, and NyBD 78 combined high productivity with physiological efficiency and exhibited a balanced biochemical profile making them idealtoexploit in breeding programs aimed at improving drought tolerance and yield stabilityin bidi tobacco growing regions.

Under drought conditions, nicotine and chlorides tend to rise, while reducing sugars decline, slightly altering the balance of leaf chemistry but often improving leaf strength a desirable trait for bidi tobacco if within acceptable limits (Table 4). Present findings pertaining to the biochemical characters revealed that all the biochemical quality parameters such as the nicotine content, reducing sugars and chlorides have registered their higher mean values under rainfed conditions as compared to normal conditions. Su et al. (2017) reported a significant increase in the nicotine content under stressed conditions in FCV tobacco Su et al. (2017) and Bigloueiet al. (2010) who reported a decrease in reducing sugars under stressed conditions.

3.4 Study of Drought Tolerance Indices

Drought tolerance indices are important indices which can be employed for identifying and evaluating tobacco genotypes that can maintain stable yield under limited water conditions. These indices, derived from yield performance under both normal and drought-stressed environments, help in quantifying the degree of tolerance and susceptibility of the genotypes. They enable breeders to distinguish genotypes with high yield potential and stability across environments, which is crucial for developing drought-resilient varieties. In tobacco, indices such as Mean Productivity (MP), Geometric Mean Productivity (GMP), Stress Susceptibility Index (SSI), Stress Tolerance Index (STI), and Yield Stability Index (YSI) are commonly used to assess performance. High values of MP, GMP, and STI indicate good performance under both conditions, while lower SSI values represent greater tolerance to drought. Therefore, the use of drought tolerance indices provides a reliable, quantitative approach for screening large germplasm collections and supports the selection of promising tobacco lines for breeding programs aimed at improving drought resilience (Fischer and Maurer ,1978; Rosielle and Hamblin ,1981 and Fernandez ,1992).

The genotypes were evaluated based on five drought tolerance indices *viz*., tolerance index, mean productivity, geometric mean productivity, stress susceptibility index and yield stability index (Table 6).

3.5 Tolerance index (TOL)

The Tolerance Index indicates the relative performance of a genotype under stress with respect to its performance under normal conditions. Lowest tolerance index was recorded with NyBD 90 (198.9) followed by ABD 199 (283), NyBD 92 (290), ABD 226 (293) and NyBD 89 (297) and the highest tolerance index was recorded with NyBD 63 (1154).

3.6 Mean Productivity (MP)

Mean Productivity (MP)is a simple and widely used drought tolerance index that represents theaverage yield of a genotype under both normal (Yp)andstress (Ys)conditions. The genotype NyBD 71 has recorded the highest mean productivity.Among the evaluated genotypes, NyBD 71 exhibited the highest mean productivity (2830 kg/ha), followed by NyBD 62 (2702.2 kg/ha), NyBD 73 (2659.7 kg/ha), NyBD 74 (2641.4 kg/ha), and NyBD 78 (2635.8 kg/ha), whereas the lowest mean productivity was observed in GT 5 (1858.5 kg/ha).

3.7 Geometric Mean Productivity (GMP)

Geometric Mean Productivity (GMP) used to identify genotypes that perform consistently well under both normal and stress conditions. The highest geometric mean productivity was observed in NyBD 71 (2810.0 kg/ha), followed by NyBD 62 (2683.7 kg/ha), NyBD 73 (2636.1 kg/ha), and NyBD 78 (2620.4 kg/ha). In contrast, GT 5 exhibited low yield under normal and stressed conditions with low mean productivity and low geometric productivity and higher stress susceptibility index.

3.8 Stress Susceptibility Index (SSI)

Stress Susceptibility Index (SSI)measures the relativesensitivity of a genotype to stress compared to the average reduction in yield of all genotypes.The genotype NyBD 90 has recorded the lowest stress susceptibility index (0.4) followed by NyBD 89 (0.5). The genotypes NyBD 92, NyBD 93, ABD 65, ABD 146, ABD 197, ABD 199 and ABD 226 have recorded stress susceptibility index of 0.6. The genotype NyBD 63 has recorded higher stress susceptibility index (1.7) and low yield stability. Rosielle and Hamblin (1981) who reported that lesser yield stability was associated with higher stress susceptibility index.

Table 1. ANOVA (mean sum of squares) for morphological, physiological and biochemical characters in 100 *bidi* tobacco germplasm linesunder normal and rainfed conditions during 2022-23 at RARS, Nandyal

			Morphological characters						Physiological characters					Biochemical characters		
Source of variation	**df**		**Days to flow.**	**Plant height (cm)**	**No. of leaves /plant**	**Leaf length (cm)**	**Leaf width (cm)**	**Cured leaf yield (kg/ha)**	**RWC (%)**	**SCMR**	**Specific leaf area (cm^2/g)**	**Root length (cm)**	**Root Dry weight (g/plant)**	**Nicotine (%)**	**Reducing sugars (%)**	**Chlorides (%)**
Genotypes	99	N	90.8*	82.1**	12.4**	42.3*	23.9**	125402*	52.2**	20.6**	4076**	119.1**	83.6**	0.57	0.19**	0.25
		R	162.3*	74.4*	4.8**	11.9*	11.7**	75624*	85.0**	17.6**	1069**	62.8**	20.1**	0.84**	0.16	0.21
Replications	1	N	460.9	612.5	11.5	672.0	118.1	25900	0.3	112.2	2267	0.7	48.0	0.17	0.04	0.14
		R	55.2	512.0	2.4	24.9	4.2	716552	2.5	139.3	191	96.6	466.0	2.75	0.16	0.94
Blocks	9	N	29.6	357.2	1.8	8.6*	3.1**	178557	10.0	24.4	1854	47.7	110.4	2.04	0.976	0.27
		R	18.1	147.3**	4.6*	7.9	1.0	172495	15.5	32.2*	960	15.2	64.0**	0.55	0.38**	0.36
Error	99	N	62.7	89.0	2.0	4.0	1.1	37975	17.7	15.1	1033	11.5	63.7	0.23	0.18	0.22
		R	63.8	53.3	2.0	5.7	0.9	25034	29.3	12.7	502	10.0	23.4	0.45	0.12	0.23

*'**' 0.01%, '*' 0.05% level of significance*
Note: N-Normal condition, R-Rainfed condition

Table 2. *Per se* performance of 100 *bidi* tobacco germplasm lines morphological characters under normal and rainfed conditions during 2022-23 at RARS, Nandyal

Germplasm	**Days to flowering (days)**		**Topped plant height (cm)**		**No. of leaves / plant**		**Leaf length (cm)**		**Leaf width (cm)**		**Cured leaf yield (Kg/ha)**	
	Normal	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**
GT4	122	156	**58**	61	25.0	22.5	45.0	41.9	**13.3**	12.8	2141	1673
GT5	119	152	82	64	21.0	18.5	48.0	42.8	13.4	13.0	**2134**	**1583**
GT7	117	153	80	70	24.5	23.0	**39.5**	40.5	14.6	11.6	2463	1638
A119	117	150	82	60	20.5	15.5	52.9	41.5	19.8	13.9	2670	1873
Nandyalpogaku 1	120	151	81	75	21.5	20.5	58.8	43.1	21.5	15.2	2539	1987
NyBD 56	117	153	71	73	19.5	**15.0**	60.4	42.7	24.5	13.8	2913	2022
NyBD 59	125	154	84	74	22.0	22.0	55.7	41.2	23.6	14.6	2850	2122
NyBD 60	117	156	85	62	23.0	19.5	53.2	44.5	23.5	11.8	2869	2108
NyBD 61	**111**	156	71	63	21.5	21.5	62.6	42.3	21.2	13.5	2939	2093
NyBD 62	125	148	**88**	70	23.5	20.0	48.4	**33.8**	16.9	13.5	3018	2386
NyBD 63	115	**149**	75	64	18.5	18.5	53.8	37.3	19.9	13.4	3046	1892
NyBD 66	123	**149**	78	75	21.0	21.0	57.8	43.4	24.2	12.0	2685	1754
NyBD 67	120	151	74	74	23.5	**23.5**	59.2	43.0	23.0	11.9	2844	1977

Germplasm	Days to flowering (days)		Topped plant height (cm)		No. of leaves / plant		Leaf length (cm)		Leaf width (cm)		Cured leaf yield (Kg/ha)	
	Normal	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**
NyBD 68	**111**	159	67	69	18.5	18.5	60.1	42.9	23.4	11.8	2882	2040
NyBD 69	119	157	68	65	23.0	23.0	53.1	40.9	21.0	13.7	3009	2244
NyBD 70	117	158	77	56	19.5	19.5	53.8	40.5	20.4	11.8	2992	2258
NyBD 71	117	150	70	64	22.0	22.0	61.5	45.0	25.1	13.7	**3161**	**2498**
NyBD 72	112	152	71	74	17.5	17.5	55.4	45.4	22.4	14.4	2992	2236
NyBD 73	121	150	75	72	25.5	22.5	63.1	40.7	25.3	13.8	3013	2306
NyBD 74	120	153	75	76	21.5	21.5	58.9	43.7	23.2	13.9	2995	2288
NyBD 75	119	156	79	74	26.0	21.5	58.0	43.0	21.8	13.9	2822	2254

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Germplasm	Days to flowering (days)		Topped plant height (cm)		No. of leaves / plant		Leaf length (cm)		Leaf width (cm)		Cured leaf yield (Kg/ha)	
	Normal	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**
NyBD 76	125	154	85	63	27.5	20.5	50.5	42.9	19.2	12.8	2756	2199
NyBD 77	119	154	75	65	27.0	20.5	59.5	44.5	24.0	12.8	2818	2286
NyBD 78	114	151	72	78	26.5	20.5	62.7	47.4	**26.2**	**15.4**	2920	2352
NyBD 79	122	158	83	**79**	23.5	21.5	55.3	45.9	16.9	14.3	2937	2314
NyBD 80	119	153	82	71	26.0	19.0	53.5	41.5	16.3	12.0	2838	2255
NyBD 81	125	157	71	75	27.0	21.5	53.7	42.7	15.7	13.5	2599	2106
NyBD 82	124	160	72	70	27.0	20.5	50.5	41.4	16.0	11.8	2660	2176
NyBD 83	118	159	**58**	67	25.5	20.0	52.0	42.7	16.6	11.9	2570	2042
NyBD 84	120	157	77	71	26.5	21.5	49.4	43.0	14.0	12.5	2715	1977
NyBD 85	118	155	74	73	25.5	21.0	55.3	43.4	18.6	13.5	2768	2076
NyBD 86	118	157	69	74	24.5	19.0	57.8	44.9	20.4	14.5	2790	2147
NyBD 87	113	162	80	69	26.5	21.5	52.9	43.5	14.8	13.5	2600	1940
NyBD 88	118	161	82	65	25.5	22.0	52.9	45.8	16.2	13.6	2352	1986
NyBD 89	122	158	78	77	26.0	21.0	50.4	40.3	15.4	11.9	2586	2288
NyBD 90	121	153	79	72	26.0	21.5	49.5	41.8	14.2	13.0	2394	2196
NyBD 91	123	157	65	70	24.0	19.5	49.0	42.8	15.3	12.9	2535	2106
NyBD 92	122	156	81	73	23.5	20.5	53.6	45.3	16.9	14.5	2356	2066
NyBD 93	116	155	70	76	23.5	21.0	54.4	44.5	17.0	13.0	2305	2001
NyBD 94	124	155	75	76	24.0	20.0	49.4	41.5	14.2	12.0	2458	1945
ABD 146	126	152	79	74	23.5	19.0	47.0	41.8	13.5	13.0	2489	2144
ABD 152	133	154	82	75	24.5	20.5	49.7	39.4	15.4	12.9	2533	2168

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Germplasm	Days to flowering (days)		Topped plant height (cm)		No. of leaves / plant		Leaf length (cm)		Leaf width (cm)		Cured leaf yield (Kg/ha)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
ABD 78	128	159	67	66	26.5	21.0	49.9	41.9	16.2	13.6	2793	2250
ABD 129	123	159	79	74	24.0	18.5	47.6	41.4	15.3	12.8	2387	1846
ABD 118	135	159	77	75	26.5	21.5	47.9	38.6	14.9	11.5	2890	2116
ABD 119	125	158	70	62	24.5	20.5	57.4	42.1	17.5	14.0	2556	2093
ABD 128	123	162	71	73	25.5	19.5	50.5	41.4	14.8	13.8	2453	1982
ABD 131	136	165	79	69	26.5	21.5	46.5	39.8	16.7	12.5	2703	2088
ABD 68	129	162	80	62	26.5	20.0	53.2	42.2	17.7	14.3	2335	1882
ABD 54	124	167	69	66	27.5	20.5	52.0	40.0	20.8	14.4	2730	1973
ABD 94	124	162	68	66	27.0	21.5	51.1	34.8	18.9	13.8	2264	1893
ABD 120	135	161	82	66	25.0	19.5	45.9	39.4	15.9	12.0	2310	1906
ABD 132	**137**	165	71	64	27.0	21.5	52.3	39.9	21.0	12.3	2779	2153
ABD 151	121	165	80	61	24.0	19.5	52.6	43.9	21.9	12.5	2547	2090
ABD 87	138	164	79	66	25.0	21.0	48.3	41.4	17.3	12.9	2551	2023
ABD 121	127	162	72	67	21.0	19.0	51.2	43.3	16.0	12.8	2810	2350
ABD 138	127	164	75	70	18.0	17.0	45.9	40.5	13.8	12.8	2521	2217
Bhavyasree	121	160	76	70	23.5	20.5	49.3	40.5	14.8	12.8	2633	2077
ArBD 32	**111**	163	76	74	19.0	17.5	54.5	38.9	16.0	**11.5**	2572	1895
ArBD 33	130	161	80	72	23.5	18.5	46.4	39.9	14.2	12.8	2455	1843
NBD 260	120	160	74	74	25.5	21.0	50.5	43.9	15.7	12.8	2733	2226
NBD 276	120	161	59	76	**28.0**	21.5	51.0	39.4	14.9	14.3	2619	2097
NBD 154	116	162	68	73	22.5	20.0	49.9	41.4	15.1	12.8	2596	1987

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Germplasm	Days to flowering (days)		Topped plant height (cm)		No. of leaves / plant		Leaf length (cm)		Leaf width (cm)		Cured leaf yield (Kg/ha)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
NBD 271	122	161	70	71	21.5	19.5	**64.0**	46.9	26.1	14.9	2581	1781
NBD 277	133	159	70	67	26.5	22.5	53.0	44.9	20.5	14.5	2522	1932
NBD 289	119	159	81	70	25.0	19.0	57.9	45.4	20.5	14.0	2327	1787
NBD 290	127	163	75	70	23.0	19.0	46.8	40.0	14.8	12.3	2534	1979
NBD 261	125	162	68	72	25.5	20.0	50.4	43.6	13.5	13.6	2288	1746
ABD 73	119	159	76	71	24.5	21.5	46.6	40.4	16.0	12.5	2418	1803
ABD 84	134	164	75	70	25.5	20.5	56.9	41.4	25.5	12.0	2660	2033
ABD 65	127	158	72	69	24.5	19.5	57.5	43.4	23.3	13.5	2351	2027
ABT 10	129	162	74	67	19.0	17.0	47.5	44.1	14.8	14.4	2493	2061
ABD 79	124	163	79	63	21.0	21.0	51.0	44.0	14.8	12.8	2204	1774

ABD 112	118	165	72	73	24.5	18.0	57.2	**48.0**	17.3	14.5	2268	1751
ABD 95	136	167	75	76	21.0	19.5	51.9	45.5	15.9	14.9	2481	1981
ABD 122	122	167	**58**	73	22.0	19.5	55.6	39.0	16.9	13.5	2461	1743
ABD 71	127	167	68	59	20.0	18.5	56.8	42.6	18.3	13.5	2223	1844
ABD 124	119	168	78	61	22.0	19.5	54.4	46.3	14.9	13.6	2295	1706
ABD 115	126	**169**	77	56	20.5	19.5	46.2	39.9	14.8	11.9	2251	1794
ABD 127	133	164	76	57	22.0	19.0	52.7	42.8	16.6	14.3	2243	1709
ABD 107	119	167	78	58	23.5	20.5	51.9	44.4	16.3	13.8	2368	1650
ABD 145	131	168	79	63	25.0	20.0	52.7	42.0	16.1	13.3	2351	1814
ABD 163	126	**169**	74	64	24.5	21.5	54.0	44.9	15.6	13.8	2320	1783
ABD 167	117	166	61	57	25.5	19.5	53.0	44.5	16.6	12.8	2505	2044

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Germplasm	Days to flowering (days)		Topped plant height (cm)		No. of leaves / plant		Leaf length (cm)		Leaf width (cm)		Cured leaf yield (Kg/ha)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
ABD 164	135	168	77	**55**	24.0	20.5	49.4	39.4	15.7	**11.5**	2466	2008
ABD 166	126	168	69	57	25.0	18.0	49.3	41.0	16.3	13.0	2498	1804
ABD 169	132	167	77	59	25.0	20.0	55.1	43.9	16.5	13.6	2511	1947
ABD 173	127	162	71	61	27.0	20.0	46.2	40.5	14.3	13.9	2475	1978
ABD 174	119	165	77	64	24.5	20.0	52.9	45.0	16.4	13.5	2453	1982
ABD 189	136	162	61	62	24.5	18.5	50.4	41.9	16.4	13.3	2442	1984
ABD 190	123	163	65	**55**	23.5	19.5	49.0	40.0	14.3	12.5	2325	1878
NBD 316	121	166	74	57	23.5	20.5	53.4	43.9	18.3	12.7	2272	1730
ABD 196	134	164	65	59	22.5	19.5	46.9	38.4	15.9	12.6	2273	1749
ABD 197	132	163	75	67	23.5	20.0	53.9	42.4	17.7	13.8	2162	1857
ABD 199	**137**	161	72	68	**17.0**	17.0	46.3	39.5	14.0	12.8	2186	1904
ABD 209	130	160	67	59	24.0	17.5	49.3	40.9	15.9	13.8	2167	1722
ABD 211	133	164	78	73	24.5	18.0	49.5	41.3	17.0	12.5	2314	1773
ABD 226	130	162	71	73	26.0	20.5	46.8	39.8	14.0	12.8	2289	1995
ABD 228	129	167	69	67	23.0	20.5	49.3	41.4	15.4	13.6	2316	1750
ABD 229	135	167	87	70	25.5	19.5	54.4	44.4	17.3	14.9	2317	1885
Mean	124	159	75.4	67.6	23.8	20.0	52.4	42.2	17.7	13.2	2558	1997
Min.	110.7	147.5	58.0	55.0	17.0	15.0	39.5	33.8	13.3	11.5	2134	1583
Max.	137.3	169.0	87.5	78.5	28.0	23.5	64.0	48.0	26.2	15.4	3161	2498
SEm(±)	0.7	0.6	0.6	0.6	0.3	0.2	0.5	0.2	0.4	0.1	206.5	161.2
CD (0.05%)	1.9	1.5	1.8	1.7	0.7	0.4	1.3	0.7	1.0	0.3	580.3	452.9
CV(%)	7.34	8.73	13.5	12.4	11.5	9.4	9.8	7.1	19.5	8.7	11.4	11.4
SD	6.61	5.46	6.41	6.10	2.49	1.54	4.60	2.44	3.46	0.92	250.35	194.45

N: Normal Condition, R: rainfed condition

Table 3. Per *se* performance of 100 bidi tobacco germplasm lines physiological characters under normal and rainfed conditions during 2022-23 at RARS, Nandyal

Germplasm	Relative water content (%)		SCMR		Specific leaf area (cm^2/g)		Root length (cm)		Root dry weight/plant (g)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
GT4	74.8	66.3	64.4	58.0	82.6	62.9	37.0	31.5	28.5	24.5
GT5	88.9	65.3	67.0	**54.5**	94.1	65.5	41.0	32.5	27.5	32.5
GT7	82.0	63.6	60.9	57.7	**78.0**	67.2	37.5	39.0	35.5	29.5
A119	84.5	82.8	74.1	61.4	151.8	79.4	35.0	39.5	28.5	28.5
Nandyalpogaku 1	92.0	77.6	**78.2**	63.0	211.0	131.4	42.0	36.5	44.5	30.0
NyBD 56	82.4	79.3	62.2	62.2	175.3	146.9	52.0	26.5	47.5	28.5
NyBD 59	81.9	80.6	67.0	61.8	165.0	83.7	52.5	30.5	50.5	33.0
NyBD 60	73.9	68.1	67.6	65.1	192.1	94.8	49.0	27.5	51.5	29.5
NyBD 61	75.9	69.7	66.9	59.5	181.3	97.48	60.8	45.0	29.5	30.5
NyBD 62	82.0	69.1	61.9	63.3	118.0	58.2	42.0	**22.5**	24.0	25.0
NyBD 63	79.6	68.7	68.4	59.4	164.6	62.0	46.5	27.5	35.5	29.5
NyBD 66	87.4	78.6	68.7	62.0	233.5	67.4	49.0	43.5	36.0	34.5
NyBD 67	83.0	79.1	63.1	61.4	195.9	84.1	53.0	38.5	43.0	22.5
NyBD 68	83.5	71.1	63.0	64.7	234.9	71.8	52.5	26.5	41.5	31.0
NyBD 69	77.6	78.1	67.9	63.9	150.7	70.0	50.0	40.0	31.5	32.0
NyBD 70	79.8	80.3	63.1	62.9	202.2	67.4	48.0	26.5	46.0	27.5
NyBD 71	87.4	81.3	62.8	62.3	257.1	112.6	45.0	30.5	41.0	29.5
NyBD 72	80.3	77.6	68.6	59.9	228.0	93.3	38.0	33.0	31.5	27.5
NyBD 73	79.7	71.5	67.3	64.6	266.4	70.5	40.5	29.5	40.5	28.5
NyBD 74	86.6	82.0	71.4	63.1	252.2	67.3	43.5	29.0	35.0	29.0
NyBD 75	78.4	83.5	70.3	63.9	**270.4**	80.3	40.0	25.0	25.5	27.0

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Germplasm	Relative water content (%)		SCMR		Specific leaf area (cm^2/g)		Root length (cm)		Root dry weight/plant (g)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
NyBD 76	87.9	81.0	64.3	61.7	134.1	66.7	40.0	38.0	30.5	30.5
NyBD 77	75.5	79.3	65.7	66.9	206.1	54.2	35.0	34.0	43.0	25.5
NyBD 78	81.8	79.1	73.0	59.4	253.1	106.5	36.0	38.0	40.5	27.5
NyBD 79	81.1	74.5	68.6	59.7	120.4	108.9	37.5	27.0	34.5	27.0
NyBD 80	81.0	71.0	75.2	61.7	118.3	47.4	43.5	40.0	29.5	28.5
NyBD 81	88.5	61.0	74.0	61.1	124.1	69.9	43.0	**52.0**	33.0	30.5
NyBD 82	84.3	68.0	67.6	61.6	124.4	**44.4**	44.0	26.5	34.5	35.0

Germplasm	Relative water content (%)		SCMR		Specific leaf area (cm^2/g)		Root length (cm)		Root dry weight/plant (g)	
	Normal	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**
NyBD 83	77.8	69.5	61.3	64.2	159.8	67.4	40.0	40.5	30.5	27.5
NyBD 84	90.4	72.0	63.1	62.0	115.2	63.4	38.5	38.5	33.5	32.0
NyBD 85	81.3	75.0	64.9	60.1	133.0	69.8	43.5	37.0	43.5	33.5
NyBD 86	82.6	69.5	66.2	66.0	168.5	103.9	40.0	43.5	25.5	34.5
NyBD 87	78.2	76.5	69.5	69.4	119.9	102.3	37.5	38.0	30.5	30.0
NyBD 88	72.5	69.0	62.5	63.4	143.3	91.2	39.0	38.0	35.0	31.5
NyBD 89	85.5	62.5	65.1	65.4	143.7	56.2	60.0	41.5	29.0	30.5
NyBD 90	86.6	67.5	72.9	62.3	104.4	72.5	37.0	35.5	24.0	28.5
NyBD 91	78.7	72.5	64.4	61.0	102.0	78.6	59.0	48.0	33.0	29.0
NyBD 92	80.0	63.5	65.3	65.6	138.9	73.1	35.5	34.5	35.5	27.0
NyBD 93	86.9	**60.5**	63.3	61.2	197.8	61.7	31.5	30.0	29.5	35.5
NyBD 94	79.9	61.8	66.4	61.2	128.2	55.4	28.0	25.0	45.0	25.5
ABD 146	91.9	81.3	63.9	58.4	105.0	52.1	28.5	26.5	31.5	29.5
ABD 152	85.0	80.1	64.8	59.5	117.4	52.1	28.5	27.5	30.5	29.0

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Germplasm	Relative water content (%)		SCMR		Specific leaf area (cm^2/g)		Root length (cm)		Root dry weight/plant (g)	
	Normal	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**
ABD 78	83.9	63.5	65.7	61.4	115.5	52.8	35.0	30.0	29.5	26.0
ABD 129	77.0	73.0	63.6	60.1	99.1	45.2	36.0	38.5	29.5	27.5
ABD 118	85.6	68.0	65.1	61.5	152.8	59.8	37.5	26.0	41.0	31.0
ABD 119	80.9	73.0	66.0	65.3	186.6	73.6	36.5	31.5	27.5	31.0
ABD 128	89.9	78.5	62.1	67.5	124.7	71.6	38.0	29.0	**24.0**	22.0
ABD 131	83.5	62.0	68.9	60.6	143.5	59.7	**61.5**	42.0	37.5	27.0
ABD 68	90.2	62.5	64.8	67.5	135.4	77.4	28.0	28.0	39.0	35.5
ABD 54	78.4	**60.5**	64.3	60.6	147.1	71.9	28.0	26.5	34.0	27.0
ABD 94	84.5	61.0	65.0	64.9	148.4	63.8	49.5	37.5	36.0	33.0
ABD 120	86.5	70.5	65.3	65.0	100.2	52.4	35.0	28.0	30.0	30.0
ABD 132	83.0	69.6	66.2	64.6	157.8	61.1	36.5	28.5	31.0	28.5
ABD 151	76.7	67.1	65.4	63.3	177.3	84.5	38.0	33.5	29.5	28.5
ABD 87	**95.7**	68.0	65.3	58.8	128.1	62.8	39.0	29.5	28.0	24.0
ABD 121	80.5	72.0	64.4	60.3	117.5	96.1	35.5	30.0	34.5	29.0
ABD 138	82.8	74.5	65.4	60.4	87.6	72.0	32.0	31.5	27.5	30.0
Bhavyasree	82.0	70.0	67.5	63.6	112.1	85.3	36.5	27.5	34.5	27.0
ArBD 32	80.3	78.0	63.9	68.9	125.4	86.9	35.5	32.5	33.5	30.0

Germplasm	Relative water content (%)		SCMR		Specific leaf area (cm^2/g)		Root length (cm)		Root dry weight/plant (g)	
	Normal	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**
ArBD 33	78.2	81.0	64.2	63.8	89.4	86.6	38.0	36.5	31.5	32.0
NBD 260	82.1	77.5	63.0	62.7	114.4	103.8	40.0	32.5	30.0	33.5
NBD 276	79.0	80.1	64.6	64.8	139.3	77.3	55.5	37.0	33.5	30.5
NBD 154	83.4	80.5	65.0	63.2	125.7	86.5	29.0	27.5	37.0	33.0

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Germplasm	Relative water content (%)		SCMR		Specific leaf area (cm^2/g)		Root length (cm)		Root dry weight/plant (g)	
	Normal	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**
NBD 271	78.9	74.0	69.4	55.5	231.1	138.7	**26.5**	25.0	31.5	35.5
NBD 277	82.2	71.0	67.2	59.4	181.7	72.4	55.5	42.0	43.5	34.0
NBD 289	76.0	71.0	65.9	69.2	198.8	79.4	31.5	32.5	34.0	28.0
NBD 290	85.9	67.0	66.4	63.0	127.8	70.1	34.0	30.0	31.0	26.0
NBD 261	93.3	69.5	**60.3**	66.9	145.1	94.3	32.5	27.5	38.0	31.5
ABD 73	81.4	64.0	68.9	68.4	124.1	63.2	29.0	27.0	31.5	29.5
ABD 84	85.0	67.0	63.2	60.2	213.4	70.8	30.0	27.0	35.0	30.0
ABD 65	76.8	76.5	65.6	61.4	181.5	109.1	30.0	29.0	41.5	29.5
ABT 10	83.8	79.5	64.7	62.7	147.6	106.9	29.0	31.0	31.0	22.5
ABD 79	79.8	74.5	67.6	63.4	125.4	75.3	33.5	30.5	39.5	27.0
ABD 112	82.4	79.0	66.7	67.2	141.8	87.0	44.0	32.0	31.5	29.0
ABD 95	81.2	84.0	70.3	63.5	137.2	75.6	41.5	30.5	41.5	32.0
ABD 122	89.5	82.0	67.9	64.2	174.9	75.4	39.0	28.5	38.0	31.0
ABD 71	90.5	81.5	65.5	67.2	220.1	68.4	38.5	28.5	50.0	33.0
ABD 124	86.8	83.5	64.6	68.3	117.2	74.1	39.0	32.5	39.5	29.5
ABD 115	76.8	82.5	65.1	63.0	92.8	77.9	41.0	35.0	**24.0**	30.0
ABD 127	76.7	70.0	71.7	64.4	134.6	88.8	41.0	36.0	36.0	**37.0**
ABD 107	90.5	63.0	66.4	61.2	115.8	87.2	39.0	33.0	42.5	28.6
ABD 145	79.0	61.0	67.0	63.2	122.2	74.5	48.0	41.0	25.0	28.3
ABD 163	74.9	72.5	67.0	62.8	129.4	68.5	37.5	31.5	**53.0**	**21.0**
ABD 167	79.0	75.5	67.8	64.5	162.1	70.0	35.5	33.0	34.5	25.0

Continu…

Germplasm	Relative water content (%)		SCMR		Specific leaf area (cm^2/g)		Root length (cm)		Root dry weight/plant (g)	
	Normal	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**	**Normal**	**Rainfed**
ABD 164	89.0	76.0	64.5	66.9	129.2	**50.6**	38.0	30.5	36.5	30.5
ABD 166	80.3	78.0	62.3	66.2	114.7	60.8	39.5	30.5	30.5	25.0
ABD 169	83.8	78.5	62.8	66.9	139.9	79.7	38.0	33.0	**24.0**	30.5
ABD 173	77.3	73.0	68.6	**70.1**	89.8	75.4	44.5	32.5	31.0	30.0
ABD 174	**68.1**	72.5	62.5	64.3	124.9	76.6	44.0	39.5	33.5	25.5
ABD 189	70.8	73.0	62.5	65.3	126.4	111.5	42.0	31.5	32.5	30.0
ABD 190	82.5	76.5	64.6	65.8	116.6	113.6	46.0	36.5	35.0	24.5
NBD 316	77.0	78.0	65.9	63.0	182.0	119.1	34.0	31.0	28.0	25.5
ABD 196	88.2	**84.0**	67.3	67.4	107.6	109.7	29.0	27.5	39.0	29.5
ABD 197	77.0	76.5	64.2	62.9	130.6	130.2	33.0	30.0	37.5	30.5
ABD 199	88.9	73.0	60.4	60.8	88.9	104.0	35.0	32.0	29.0	24.5
ABD 209	88.5	80.5	66.0	62.4	112.8	95.9	41.5	31.5	27.5	27.0
ABD 211	81.0	77.0	68.4	63.5	129.4	99.1	35.5	29.0	35.0	31.0
ABD 226	84.9	72.5	67.6	66.0	94.3	114.4	32.5	31.0	30.5	33.0
ABD 228	80.5	72.3	63.9	62.7	116.3	127.4	39.0	37.5	28.5	28.5
ABD 229	81.0	75.8	67.1	61.5	198.0	**164.8**	41.5	38.5	32.0	33.0
Mean	82.31	73.25	66.08	63.08	148.16	81.23	39.69	32.89	34.37	29.30
Min.	68.1	60.5	60.3	54.5	78.0	50.6	26.5	22.5	24.0	21.0
Max.	95.7	84.0	78.2	70.1	270.4	164.8	61.5	52.0	53.0	37.0
SEm(±)	0.5	0.7	0.3	0.3	4.5	2.3	0.8	0.6	0.7	0.3
CD (0.05%)	1.4	1.8	0.9	0.8	12.7	6.5	2.2	1.6	1.8	0.9
CV(%)	6.2	8.9	4.9	4.7	30.5	28.5	19.4	17.0	18.8	10.8
SD	5.11	6.52	3.21	2.97	45.14	23.12	7.72	5.61	6.46	3.17

N: Normal condition, R: Rainfed condition

Table 4. *Per se* performance of 100 bidi tobacco germplasm lines biochemical characters under normal and rainfed conditions during 2022-23 at RARS, Nandyal

Germplasm	Nicotine (%)		Reducing sugars (%)		Chlorides (%)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
GT4	2.2	3.8	1.8	2.1	1.57	1.23
GT5	2.4	3.0	2.1	2.0	1.31	1.53
GT7	2.5	2.2	2.9	1.8	1.21	0.95
A119	2.8	2.7	2.4	1.9	1.38	1.43
Nandyalpogaku 1	2.6	2.5	1.9	1.9	1.68	1.39
NyBD 56	3.2	2.2	**1.6**	2.1	1.97	2.00
NyBD 59	2.6	2.7	2.4	2.4	1.70	1.26
NyBD 60	2.4	2.8	1.7	1.7	1.78	1.33
NyBD 61	2.8	2.5	2.0	2.3	1.94	1.27
NyBD 62	1.9	2.6	2.6	2.5	0.92	1.06
NyBD 63	2.4	2.6	1.6	1.9	2.03	1.54
NyBD 66	2.7	2.9	2.5	2.0	1.18	1.59
NyBD 67	**1.8**	2.6	2.4	1.7	2.02	0.86
NyBD 68	4.2	3.5	2.5	2.4	1.16	1.52
NyBD 69	2.2	2.3	2.6	2.3	1.44	0.90
NyBD 70	3.2	3.0	2.7	2.6	1.15	0.67
NyBD 71	1.9	2.5	2.2	1.6	1.27	1.12
NyBD 72	3.5	2.6	2.8	2.0	1.14	1.35
NyBD 73	2.8	2.8	2.3	2.3	1.08	1.09
NyBD 74	3.3	3.7	2.2	2.2	1.45	1.03
NyBD 75	3.6	2.8	2.1	1.6	1.45	1.14

Continu…

Germplasm	Nicotine (%)		Reducing sugars (%)		Chlorides (%)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
NyBD 76	3.8	2.7	2.0	2.0	1.65	1.46
NyBD 77	3.0	2.7	2.1	1.9	0.86	0.82
NyBD 78	3.2	**1.9**	2.4	2.0	1.33	1.17
NyBD 79	3.4	2.4	2.0	2.0	1.26	1.08
NyBD 80	2.9	2.5	2.3	2.1	1.11	1.44
NyBD 81	3.3	2.5	2.3	2.6	1.57	1.20
NyBD 82	3.1	2.4	2.2	2.3	1.73	1.52
NyBD 83	3.0	2.8	2.2	2.3	1.76	1.48
NyBD 84	3.2	3.0	2.2	2.2	1.64	1.10

Germplasm	Nicotine (%)		Reducing sugars (%)		Chlorides (%)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
NyBD 85	2.7	3.9	2.2	2.1	1.54	1.21
NyBD 86	2.7	2.5	2.4	2.4	1.46	0.97
NyBD 87	3.0	2.6	2.2	1.8	1.55	1.26
NyBD 88	2.9	2.7	1.7	2.3	1.85	1.56
NyBD 89	3.0	3.5	2.4	2.0	1.25	0.97
NyBD 90	2.6	2.5	2.3	2.0	1.40	1.09
NyBD 91	3.2	3.1	2.5	2.4	1.17	0.88
NyBD 92	2.9	2.4	2.4	1.9	2.06	1.39
NyBD 93	2.5	2.4	2.6	2.3	1.43	1.21
NyBD 94	3.2	2.5	2.5	2.1	1.46	1.41
ABD 146	2.9	3.1	2.2	2.3	1.15	1.19
ABD 152	3.3	2.8	3.0	2.1	2.02	1.26

Continu…

Germplasm	Nicotine (%)		Reducing sugars (%)		Chlorides (%)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
ABD 78	3.3	2.6	2.5	2.1	1.60	1.52
ABD 129	1.9	2.5	2.4	2.1	**0.80**	1.44
ABD 118	2.7	2.1	1.8	1.8	1.52	1.13
ABD 119	2.4	2.6	2.1	1.9	1.50	1.12
ABD 128	3.2	3.0	2.2	1.9	1.32	1.11
ABD 131	2.2	3.7	2.2	1.6	1.14	1.45
ABD 68	3.2	2.9	2.2	2.1	2.01	1.39
ABD 54	3.8	3.4	2.1	2.1	1.78	1.77
ABD 94	2.7	2.9	2.2	2.0	1.35	0.65
ABD 120	3.5	3.3	3.0	2.5	1.85	1.40
ABD 132	3.0	2.9	2.6	2.1	2.06	1.19
ABD 151	3.1	3.0	2.3	2.5	1.54	0.98
ABD 87	3.0	3.5	2.7	2.3	1.80	1.43
ABD 121	3.4	3.1	2.2	2.5	1.64	1.50
ABD 138	3.1	2.6	2.4	**1.3**	1.60	1.50
Bhavyasree	2.7	3.3	1.8	1.9	1.21	1.47
ArBD 32	2.2	2.5	2.3	1.7	1.77	1.02
ArBD 33	2.8	2.6	2.1	2.2	1.95	1.44
NBD 260	2.3	2.6	2.4	2.0	1.81	0.68
NBD 276	2.5	3.0	2.2	1.9	2.17	1.66
NBD 154	3.8	3.4	2.3	2.3	1.83	1.48

Continu…

Germplasm	Nicotine (%)		Reducing sugars (%)		Chlorides (%)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
NBD 271	2.0	3.3	2.6	2.2	1.79	2.01
NBD 277	4.0	3.5	2.6	2.2	1.87	1.28
NBD 289	3.7	3.1	2.2	2.2	1.78	1.69
NBD 290	3.7	4.2	2.3	1.9	1.92	1.26
NBD 261	**4.5**	3.7	2.2	2.0	2.19	1.14
ABD 73	3.4	3.6	2.6	2.5	1.91	1.74
ABD 84	3.0	2.6	2.5	1.9	2.17	0.93
ABD 65	3.6	3.9	2.5	2.0	1.76	1.51
ABT 10	2.7	4.2	2.8	2.1	1.97	1.31
ABD 79	3.0	4.3	2.8	2.4	2.21	1.46
ABD 112	3.2	3.0	2.5	1.9	2.25	1.49
ABD 95	3.0	3.5	**3.1**	2.1	2.24	1.45
ABD 122	3.2	3.1	2.8	2.4	1.89	1.60
ABD 71	2.6	3.0	2.6	2.1	1.95	1.59
ABD 124	4.0	4.7	3.0	2.5	1.95	2.08
ABD 115	2.4	3.9	2.6	2.4	1.82	1.24
ABD 127	3.3	3.6	2.5	2.2	2.08	1.83
ABD 107	2.4	3.9	2.7	**2.8**	2.23	1.48
ABD 145	2.8	4.2	2.4	2.5	1.87	0.96
ABD 163	3.8	4.3	2.7	2.7	1.78	1.76
ABD 167	2.8	4.1	2.6	2.5	1.98	1.75

Continu…

Germplasm	Nicotine (%)		Reducing sugars (%)		Chlorides (%)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
ABD 164	3.4	3.6	2.8	2.7	2.13	1.72
ABD 166	3.5	3.2	3.0	2.2	2.05	**0.50**
ABD 169	3.4	4.5	2.8	2.4	2.13	1.40
ABD 173	3.1	3.5	2.2	**2.8**	**2.32**	1.90
ABD 174	3.1	4.3	2.5	2.0	2.21	1.21
ABD 189	3.0	3.4	2.4	2.1	1.89	1.90
ABD 190	3.0	3.7	2.1	2.1	1.93	1.63
NBD 316	3.0	3.9	2.4	2.3	1.90	1.94
ABD 196	4.1	4.2	2.7	2.4	1.71	1.64
ABD 197	3.7	**5.1**	2.6	2.2	1.85	1.57
ABD 199	3.2	3.8	2.5	2.2	2.02	1.66

Germplasm	Nicotine (%)		Reducing sugars (%)		Chlorides (%)	
	Normal	Rainfed	Normal	Rainfed	Normal	Rainfed
ABD 209	3.4	3.6	2.3	2.4	1.78	1.42
ABD 211	3.4	3.1	2.3	2.7	2.00	1.39
ABD 226	2.8	3.0	2.3	2.0	2.12	1.52
ABD 228	2.5	2.7	2.3	1.9	1.91	1.43
ABD 229	3.6	4.0	2.6	2.5	2.01	**2.13**
Mean	3.02	3.14	2.39	2.16	1.70	1.36
Min.	1.8	1.9	1.6	1.3	0.8	0.5
Max.	4.5	5.1	3.1	2.8	2.3	2.13
SEm(±)	0.1	0.1	0.0	0.0	0.0	0.0
CD (0.05%)	0.2	0.2	0.1	0.1	0.1	0.1
CV(%)	17.7	20.7	12.8	13.0	21.0	23.7
SD	0.54	0.65	0.31	0.28	0.36	0.32

N: Normal condition, R: Rainfed condition

Table 5. Promising *bidi* tobacco genotypes for various morphological, physiological and chemical quality parameters identified at RARS, Nandyal during 2022-23

Condition	Normal	Rainfed
Parameters		
Cured leaf yield (kg/ha)	**NyBD 71 (3161)**, NyBD 63 **(3046)**, NyBD 62 **(**3018**)**, NyBD 69 **(3009)**, NyBD 73 **(**3013**)**, NyBD 74 **(2995)**, NyBD 68 **(2882)**, NyBD 67 **(2844)**, NyBD 66 **(2685)**, NyBD 61 **(2939)**, NyBD 60 **(2869)**, NyBD 59 **(2850)**, NyBD 56 **(2913)**, A119 **(2670)**, NyBD 75 **(2822)**, NyBD 76, **(2756),**NyBD 77**(2818)**, NyBD 78 **(2920)**, NyBD 79 **(2937)**, NyBD 80 **(2838)**, NyBD 81 **(2599)**, NyBD 82 **(2660)**, NyBD 84 **(2715)**, NyBD 86 **(2790)**, NyBD 87 **(2600)**, NyBD 89 **(2586)**, ABD 78 **(2793)**, ABD 118 **(2890)**, ABD 131 **(2703)**, ABD 54 **(2730)**,**ABD 132 (NP2) (2779)**, ABD 84 **(2660)**, ABD 121 **(2810)**, Bhavayasree**(2633)**, NBD 260 **(2733)**, NBD 276 **(2619)**, NBD 154 **(2596)**, and NBD 271**(2581)**	NyBD 71 (2498) ,NyBD 62 (2386), NyBD 78 (2352), ABD 121 (2350), NyBD 73 (2306), NyBD 72 (2236), NyBD 70 (2258), NyBD 74 (2288), NyBD 75 (2254), NyBD 77 (2286), NyBD 89 (2288), NyBD 79 (2314), NyBD 80 (2255), NyBD 81 (2106), NyBD 82 (2176), NyBD 59 (2122), NyBD 60 (2108), NyBD 61 (2093), NyBD 69 (2244), ABD 78 (2250), NyBD 85 (2076), NyBD 86 (2147), NyBD 90 (2196), NyBD 91 (2106), NyBD 92 (2066), ABD 138 (2217), ABD 118 (2116), ABD 119 (2093), ABD 131 (2088), ABD 146 (2144), ABD 132 (NP2) (2153), ABD 152 (2168), ABD 151 (2090), Bhavyasree (2077), NBD 260 (2226), and NBD 276 (2097).
Drought tolerance indices		
1.Tolerance index	NyBD 90 (198.9), ABD 199 (282.7), NyBD 92 (290.3), ABD 226 (293.2) and NyBD 89 (297.3)	
2. Mean productivity	NyBD 71 (2830), NyBD 62 (2702), NyBD 73 (2660), NyBD 74 (2641) and NyBD 78 (2636)	
3. Geometric mean productivity	NyBD 71 (2810), NyBD 62 (2684), NyBD 73 (2636) and NyBD 78 (2620)	
4. Stress susceptibility index	NyBD 90 (0.4), NyBD 89 (0.5), NyBD 92 (0.6), NyBD 93 (0.6), ABD 65 (0.6), ABD 146 (0.6), ABD 197(0.6), ABD 199 (0.6) and ABD 226 (0.6)	

Condition	Normal	Rainfed
5. Yield stability	NyBD 90 (1.2), NyBD 82(1.1), NyBD 88(1.1), NyBD 89(1.1), NyBD 91(1.1), NyBD 92(1.1), NyBD 93(1.1), ABD 94(1.1), ABD 119(1.1), ABD 120(1.1), ABD 146(1.1), ABD 152(1.1), ABD 151(1.1), ABD 121(1.1), ABD 138(1.1), ABD 65(1.1), ABD 71(1.1), ABD 167(1.1), ABD 164(1.1), ABD 189(1.1), ABD 197(1.1), ABD 199(1.1), ABD 226(1.1), NBD 260(1.1) and ABT 10 (1.1) .	
Morphological characters		
Days to flowering	NyBD 72 (112 days),ArBD 32 (111),NyBD 61(111) ,NyBD 68 (111 days) and NyBD 87 (113)	NyBD 62 (148),NyBD 63(149),NyBD 66(149),A119(150),NP1 (151),NyBD 72 (152 days) ,NyBD 73(150) ,NyBD 78 (151) and NyBD 68 (159 days)
Topped plant height (cm)	NyBD 62 (88), NyBD 71 (70), ABD 229 (87), NyBD 60 (85), NyBD 76 (85),NyBD 79(83)	NyBD 79 (79), NyBD 74 (76), NyBD 78 (78), NyBD 75 (74), ABD 211 (73),NyBD 87 (76)
No.of leaves /plant	NyBD 75 (26), NyBD 78 (26.5), NyBD 81 (27), NyBD 77 (27), ABD 54 (27.5) and NBD 276 (28.0)	NyBD 74 (21.5), NyBD 71 (22), NBD 277 (22.5), NyBD 67 (23.5), NyBD 69 (23) and NyBD 68 (18.5)
Leaf length (cm)	NBD 271 (64), NyBD 73 (63.1), NyBD 71 (61.5), NyBD 61 (62.6), NyBD 78 (62.7)	ABD 112 (48.0), NyBD 78 (47.4), NBD 271 (46.9), ABD 124 (46.3), ABD 174 (45.0)
Leaf width(cm)	NyBD 71 (25.1), NyBD 73 (25.3), NyBD 66 (24.2), NyBD 67 (23.5), NBD 271 (26.1)	NyBD 78 (15.4), NyBD 71 (13.7), NyBD 73 (13.8), NyBD 69 (13.7), ABD 95 (14.9)
Physiological characters		
Relative water content (%)	**NyBD 71(87.4),**NyBD 74 (86.6) ,NyBD 75(78.4),NandyalPogaku 1 (92.0), ABD 87 (95.7), ABD 261 (93.3), NyBD 84 (90.4), ABD 71 (90.5)	**NyBD 71(81.3) ,**NyBD 74 (82.0) ,ABD 196 (84.0), ABD 71 (81.5), ABD 124 (83.5), NyBD 75 (83.5), ABD 115 (82.5)
SCMR	NyBD 78(73.0), NyBD 74 (71.4) ,NyBD 72 (68.6), A119 (74.1), NandyalPogaku 1 (78.2), NyBD 80 (75.2), NyBD 81 (74.0) and ABD 127 (71.7)	NyBD 78(59.4) , NyBD 74 (63.1), NyBD 72 (59.9), ABD 173 (70.1), ABD 124 (68.3), ABD 71 (67.2), ABD 115 (63.0) and NyBD 77 (66.9)
Specific leaf area (cm^2/g)	GT4 (82.6), GT7 (78), ABD 138 (87.6),ArBD 33(89.4),ABD 115 (92.8),ABD 173 (89.8) and ABD 199 (88.9)	NyBD 80 (47.4), NyBD 82 (44.4), ABD 120 (52.4),ABD 78 (52.8),ABD 129 (45.2),ABD 164 (50.6) and ABD 166 (60.8)
Root length (cm)	NyBD 68 (52.5),NyBD 69 (50.0), NyBD 61 (60.8), ABD 131 (61.5), NBD 277 (55.5), NandyalPogaku 1 (42.0) and NyBD 67 (53.0)	NyBD 68 (26.5), NyBD 69(40.0), NyBD 81 (52.0), ABD 131 (42.0), NBD 277(42.0), ABD 229 (38.5) and ABD 190 (36.5)
Root dry weight/plant (g)	NyBD 68 (41.5), NyBD 69 (31.5),NyBD 61 (47.5), NyBD 67 (43.0), NandyalPogaku 1 (44.5), ABD 163 (53.0) and ABD 71 (50.0)	NyBD 68 (31.0) ,NyBD 69(32.0), ABD 127 (37.0), ABD 229 (33.0), ABD 196 (29.5), ABD 112 (29.0) and ABD 163 (21.0)
Chemical quality characters		
Nicotine (%)	NyBD 68 (4.2), NyBD 75 (3.6),NyBD 74 (3.3), NBD 261 (4.5), ABD 196 (4.1), NBD 277 (4.0), ABD 124 (4.0) and ABD 169 (3.4)	NyBD 68 (3.5), NyBD 75 (2.8),NyBD 74 (3.7), ABD 197 (5.1), ABD 169 (4.5), ABD 124 (4.7), ABD 79 (4.3) and ABD 163 (4.3)
Reducing sugars (%)	**NyBD 70**(2.7)**, NyBD 72** (2.8)**,NyBD 62**(2.6), ABD 95 (3.1), ABD 163 (2.7), ABD 124 (3.0) and ABT 10 (2.8)	**NyBD 70**(2.6)**, NyBD 72** (2.0)**,NyBD 62**(2.5), ABD 197 (2.2), ABD 173 (2.8), ABD 174 (2.0), ABD 169 (2.4) and NBD 277 (2.2)
Chlorides (%)	**NyBD 62** (0.92)**, NyBD 70** (1.15) **and NyBD 69** (1.44)	**NyBD 62** (1.06)**, NyBD 70** (0.67) **and NyBD 69** (0.90)

Table 6. Drought tolerance indices of 100 bidi tobacco germplasm lines during 2022-23 at RARS, Nandyal

S.No.	Germplasm lines	Yp	Ys	TOL	MP	GMP	SSI	YSI
1	GT4	8.6	8.6	468.7	1906.9	1892.4	1.0	1.0
2	GT5	**8.5**	**8.1**	550.4	**1858.5**	**1838.0**	1.2	1.0
3	GT7	9.8	8.4	824.7	2050.7	2008.8	1.5	0.9
4	A119	10.7	9.6	797.0	2271.7	2236.4	1.4	0.9
5	Nandyalpogaku 1	10.1	10.2	552.1	2263.2	2246.3	1.0	1.0
6	NyBD 56	11.6	10.4	891.0	2467.4	2426.8	1.4	0.9
7	NyBD 59	11.4	10.9	727.9	2485.7	2458.9	1.2	1.0
8	NyBD 60	11.5	10.8	761.8	2488.5	2459.2	1.2	1.0
9	NyBD 61	11.7	10.8	846.2	2515.8	2480.0	1.3	0.9
10	NyBD 62	12.1	12.3	632.4	2702.2	2683.7	1.0	1.0
11	NyBD 63	12.2	9.7	**1154.2**	2469.0	2400.6	**1.7**	**0.8**
12	NyBD 66	10.7	9.0	931.1	2219.2	2169.8	1.6	**0.8**
13	NyBD 67	11.4	10.2	867.0	2410.7	2371.4	1.4	0.9
14	NyBD 68	11.5	10.5	842.1	2460.7	2424.4	1.3	0.9
15	NyBD 69	12.0	11.5	765.4	2626.5	2598.5	1.2	1.0
16	NyBD 70	12.0	11.6	733.7	2625.2	2599.4	1.1	1.0
17	NyBD 71	**12.6**	**12.9**	663.4	**2829.5**	**2810.0**	1.0	1.0
18	NyBD 72	12.0	11.5	756.3	2613.9	2586.4	1.2	1.0
19	NyBD 73	12.0	11.9	707.2	2659.7	2636.1	1.1	1.0
20	NyBD 74	12.0	11.8	706.5	2641.4	2617.7	1.1	1.0
21	NyBD 75	11.3	11.6	568.0	2537.9	2521.9	0.9	1.0
22	NyBD 76	11.0	11.3	556.8	2477.5	2461.8	0.9	1.0
23	NyBD 77	11.3	11.8	532.3	2551.8	2537.9	0.9	1.0
24	NyBD 78	11.7	12.1	567.5	2635.8	2620.4	0.9	1.0
25	NyBD 79	11.7	11.9	622.3	2625.5	2607.0	1.0	1.0
26	NyBD 80	11.3	11.6	583.6	2546.3	2529.5	0.9	1.0
27	NyBD 81	10.4	10.8	492.7	2352.6	2339.7	0.9	1.0

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S.No.	Germplasm lines	Yp	Ys	TOL	MP	GMP	SSI	YSI
28	NyBD 82	10.6	11.2	484.1	2417.6	2405.4	0.8	1.1
29	NyBD 83	10.3	10.5	527.7	2306.0	2290.9	0.9	1.0
30	NyBD 84	10.9	10.2	737.9	2346.3	2317.1	1.2	0.9
31	NyBD 85	11.1	10.7	691.8	2421.9	2397.0	1.1	1.0
32	NyBD 86	11.2	11.0	643.6	2468.4	2447.4	1.1	1.0
33	NyBD 87	10.4	10.0	660.4	2270.0	2245.9	1.2	1.0

S.No.	Germplasm lines	Yp	Ys	TOL	MP	GMP	SSI	YSI
34	NyBD 88	9.4	10.2	366.3	2169.1	2161.3	0.7	1.1
35	NyBD 89	10.3	11.8	297.3	2437.1	2432.5	0.5	1.1
36	NyBD 90	9.6	11.3	**198.9**	2295.0	2292.8	**0.4**	**1.2**
37	NyBD 91	10.1	10.8	429.4	2320.8	2310.8	0.8	1.1
38	NyBD 92	9.4	10.6	290.3	2211.0	2206.2	0.6	1.1
39	NyBD 93	9.2	10.3	303.5	2153.0	2147.6	0.6	1.1
40	NyBD 94	9.8	10.0	513.1	2201.1	2186.1	1.0	1.0
41	ABD 146	9.9	11.0	345.3	2316.8	2310.3	0.6	1.1
42	ABD 152	10.1	11.2	365.1	2350.4	2343.3	0.7	1.1
43	ABD 78	11.2	11.6	542.4	2521.7	2507.0	0.9	1.0
44	ABD 129	9.5	9.5	540.7	2116.2	2098.8	1.0	1.0
45	ABD 118	11.6	10.9	774.2	2503.4	2473.3	1.2	0.9
46	ABD 119	10.2	10.8	463.3	2324.7	2313.1	0.8	1.1
47	ABD 128	9.8	10.2	470.4	2217.5	2205.0	0.9	1.0
48	ABD 131	10.8	10.7	614.8	2395.8	2376.0	1.0	1.0
49	ABD 68	9.3	9.7	452.5	2108.6	2096.4	0.9	1.0
50	ABD 54	10.9	10.2	756.7	2351.2	2320.6	1.3	0.9
51	ABD 94	9.0	9.7	370.3	2078.3	2070.1	0.7	1.1
52	ABD 120	9.2	9.8	403.5	2107.8	2098.1	0.8	1.1
53	ABD 132	11.1	11.1	625.8	2465.6	2445.7	1.0	1.0
54	ABD 151	10.2	10.8	457.0	2319.0	2307.7	0.8	1.1
55	ABD 87	10.2	10.4	527.8	2286.8	2271.6	0.9	1.0
56	ABD 121	11.2	12.1	460.3	2579.9	2569.6	0.7	1.1
57	ABD 138	10.1	11.4	303.5	2368.9	2364.0	0.6	1.1

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S.No.	Germplasm lines	Yp	Ys	TOL	MP	GMP	SSI	YSI
58	Bhavyasree	10.5	10.7	556.3	2355.1	2338.6	1.0	1.0
59	ArBD 32	10.3	9.8	677.2	2233.7	2207.9	1.2	1.0
60	ArBD 33	9.8	9.5	611.3	2149.1	2127.2	1.1	1.0
61	NBD 260	10.9	11.5	506.9	2479.8	2466.8	0.8	1.1
62	NBD 276	10.5	10.8	521.3	2357.9	2343.4	0.9	1.0
63	NBD 154	10.4	10.2	609.3	2291.6	2271.3	1.1	1.0
64	NBD 271	10.3	9.2	799.8	2180.8	2143.8	1.4	0.9
65	NBD 277	10.1	9.9	589.9	2227.1	2207.5	1.1	1.0
66	NBD 289	9.3	9.2	539.8	2057.3	2039.5	1.1	1.0
67	NBD 290	10.1	10.2	554.2	2256.5	2239.4	1.0	1.0
68	NBD 261	9.1	9.0	541.3	2016.9	1998.7	1.1	1.0
69	ABD 73	9.7	9.3	614.7	2110.8	2088.3	1.2	1.0

S.No.	Germplasm lines	Yp	Ys	TOL	MP	GMP	SSI	YSI
70	ABD 84	10.6	10.5	626.5	2346.4	2325.4	1.1	1.0
71	ABD 65	9.4	10.4	323.9	2188.9	2182.9	0.6	1.1
72	ABT 10	10.0	10.6	431.9	2276.9	2266.6	0.8	1.1
73	ABD 79	8.8	9.1	429.8	1989.2	1977.6	0.9	1.0
74	ABD 112	9.1	9.0	517.3	2009.1	1992.4	1.0	1.0
75	ABD 95	9.9	10.2	500.0	2230.5	2216.5	0.9	1.0
76	ABD 122	9.8	9.0	718.0	2102.4	2071.5	1.3	0.9
77	ABD 71	8.9	9.5	378.4	2033.7	2024.9	0.8	1.1
78	ABD 124	9.2	8.8	589.2	2000.9	1979.1	1.2	1.0
79	ABD 115	9.0	9.2	456.9	2022.2	2009.3	0.9	1.0
80	ABD 127	9.0	8.8	533.5	1976.0	1957.9	1.1	1.0
81	ABD 107	9.5	8.5	718.4	2008.9	1976.5	1.4	0.9
82	ABD 145	9.4	9.3	537.4	2082.2	2064.8	1.0	1.0
83	ABD 163	9.3	9.2	536.3	2051.4	2033.8	1.1	1.0
84	ABD 167	10.0	10.5	461.4	2274.5	2262.8	0.8	1.1
85	ABD 164	9.9	10.3	458.0	2236.7	2224.9	0.8	1.1
86	ABD 166	10.0	9.3	694.7	2151.1	2122.9	1.3	0.9

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S.No.	Germplasm lines	Yp	Ys	TOL	MP	GMP	SSI	YSI
87	ABD 169	10.0	10.0	564.5	2229.2	2211.3	1.0	1.0
88	ABD 173	9.9	10.2	497.1	2226.2	2212.3	0.9	1.0
89	ABD 174	9.8	10.2	470.4	2217.3	2204.8	0.9	1.0
90	ABD 189	9.8	10.2	457.7	2213.1	2201.2	0.9	1.1
91	ABD 190	9.3	9.7	446.2	2101.4	2089.5	0.9	1.0
92	NBD 316	9.1	8.9	542.1	2000.7	1982.2	1.1	1.0
93	ABD 196	9.1	9.0	523.7	2011.2	1994.1	1.1	1.0
94	ABD 197	8.6	9.6	304.9	2009.5	2003.7	0.6	1.1
95	ABD 199	8.7	9.8	282.7	2045.0	2040.1	0.6	1.1
96	ABD 209	8.7	8.9	445.5	1944.5	1931.7	0.9	1.0
97	ABD 211	9.2	9.1	541.5	2043.2	2025.2	1.1	1.0
98	ABD 226	9.1	10.3	293.2	2141.9	2136.9	0.6	1.1
99	ABD 228	9.3	9.0	566.1	2033.1	2013.3	1.1	1.0
100	ABD 229	9.3	9.7	432.9	2101.0	2089.8	0.9	1.1
	Maximum	12.6	12.9	1154.2	2829.5	2810.0	1.7	1.2
	Minimum	8.5	8.1	198.9	1858.5	1838.0	0.4	0.8

Yp-Yield under normal condition, Ys-Yield under stress condition, TOL- Tolerance index
MP- Mean productivity, GMP-Geometric mean productivity
SSI- Stress susceptibility index, YSI- Yield stability index

3.9 Yield Stability Index (YSI)

Yield Stability Index (YSI) measures the ability of a genotype to maintain yield under stress relative to its yield under normal conditions. The highest yield stability was observed with NyBD 90 (1.2). The genotypes NyBD 82, NyBD 88, NyBD 89, NyBD 91, NyBD 92, NyBD 93, ABD 94, ABD 119, ABD 120, ABD 146, ABD 152, ABD 151, ABD 121, ABD 138, ABD 65, ABD 71, ABD 167, ABD 164, ABD 189, ABD 197, ABD 199, ABD 226, NBD 260 and ABT 10 have recorded yield stability index of 1.1 each, respectively. However, the genotypes NyBD 63 and NyBD 66 have recorded the lowest yield stability index of 0.8, respectively.

The present results revealed that combining high yield, consistency in drought tolerance and stability, the best genotypes under drought stress conditions are NyBD 71, NyBD 62, NyBD 73, NyBD 78, NyBD 74, NyBD 90, NyBD 89, NyBD 71, NyBD 62, NyBD 73, NyBD 74, NyBD 78 having high mean and geometric productivity.NyBD 90, NyBD 89have exhibited higher drought tolerance (low SSI) and yield stability (YSI ≥ 1.1).These linesare recommendedfor further testing and evaluation for their use in breeding programs and cultivation in drought-prone areas.Rosielle and Hamblin (1981) reported that among drought tolerance indices MP, GMP, STI can be used as the most suitable indicators for screening drought tolerant cultivars because had highest correlation with Yp and Ys.

By considering morphological, physiological, biochemical and drought tolerance indices the genotypes viz., NyBD 71, NyBD 62, NyBD 73, NyBD 74, and NyBD 78 emerged as superior genotypes with high yield potential, drought tolerance, stable physiological performance, and favorable chemical quality under both normal and rainfed conditions.

4. SUMMARY AND CONCLUSION

The present study aimed to evaluate the genetic variability, drought tolerance, and yield stability of 100 *bidi* tobacco (*Nicotiana tabacum L.*) germplasm lines under normal and rainfed conditions. The analysis revealed wide genetic variation among the lines for yield, morpho-physiological, and biochemical traits, affirming a broad genetic base for drought resilience. Drought stress significantly reduced plant height, leaf area, relative water content, chlorophyll index, and root biomass, leading to a 20–50% decline in cured leaf yield. Nevertheless, a moderate increase in nicotine and osmolyte accumulation was observed, indicating physiological adaptation through osmotic adjustment under moisture deficit.

Several genotypes demonstrated consistent performance across environments, fulfilling the research objective of identifying high yielding, drought tolerant lines. NyBD 71, NyBD 62, NyBD 73, NyBD 74 and NyBD 78 showed superior yield potential, mean productivity, and geometric mean productivity, coupled with efficient physiological responses. NyBD 90 and NyBD 89 exhibited low stress susceptibility and high yield stability indices, reflecting strong adaptability under limited moisture conditions. Morphological traits such as early flowering, greater leaf number and robust root systems enhanced drought tolerance, while the maintenance of balanced biochemical composition ensured desirable *bidi* leaf quality.

These findings confirm that integrating morpho-physiological efficiency with chemical stability is key to drought resilience in *bidi* tobacco. The identified genotypes can serve as elite donor parents for breeding programs targeting high yielding, drought tolerant cultivars suitable for semi-arid and rainfed regions of India.

Future research should focus on multilocation and multi-season validation, molecular characterization of drought-related genes, and longitudinal studies assessing the economic feasibility and long-term impacts of deploying drought-resilient cultivars in *bidi* tobacco production systems.

This study contributes to strengthening climate-resilient breeding strategies in Indian tobacco improvement programs and supports the sustainable cultivation of *bidi* tobacco under increasing water scarcity driven by climate change.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generativ AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. Chatgpt

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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