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Evaluation and characterization of bidi and natu Tobacco (*Nicotiana tabacum*) germplasm lines

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Abstract
Nicotiana tabacum is the worldwide cultivating tobacco for its leaves for human use after processing. The demand for the tobacco crop is not compromising in the national and international markets and it is commercial in creating employment to the millions of people in the country. To meet the demand, there is a need to develop high cured leaf yielding varieties suitable to the particular environments and other challenges. To formulate the breeding objective, present study aims to characterise the available germplasm lines of bidi and natu tobacco types for the variation in plant, leaf and flower characteristics. Further to identify the genetic diversity present in tobacco germplasm lines. Out of 71 lines, 53 bidi and 18 natu tobacco lines for twenty-nine characters including both qualitative (visual examination) and quantitative characters during 2022-23 at tobacco field of Regional Agricultural Research Station (RARS), Nandyal of Acharya NG Ranga Agricultural University, Andhra Pradesh. The results showed a wide range of variation in the studied germplasm lines for most of the traits indicated that the lines can be further utilized in breeding programmes in development of high yielding tobacco varieties suitable in moisture stress regions in future.

Keywords: *Nicotiana tabacum*, after processing, flower characteristics, programmes, high yielding tobacco varieties, moisture stress regions

Introduction
Tobacco (*Nicotiana tabacum* L.) 2n=48, is majorly cultivated as commercial and medicinal crop worldwide (Flavell *et al.* 1992) [2]. The crop is commercially harvested for its leaf, further processes for human use. Worldwide, 5.8 mt of tobacco produced during 2022, while India is the second largest producer of tobacco crop following China. Different types of tobacco are growing in different states, covering 0.45 mha of area. According IBEF, 2025, in India, Andhra Pradesh is the largest producing state of tobacco, which is accounting almost 20% of production with 0.2 mt during 2023-24. Tobacco crop is commercial crop as it is contributing towards employment to millions of people like farmers and workers during processing and marketing also. To meet the stability in increasing demand, it is very essential to improve quality and yield. To develop the best genotypes, gaining knowledge on variation and diversity in the present available germplasm is very crucial. Based on the characterization of available germplasm lines, breeder can observe the variation present in characters and can identify the better parents to be utilized in further breeding programmes.

Materials and Methods
This trial was conducted with the available germplasm at Regional Agricultural Research Station (RARS), Nandyal of Acharya NG Ranga Agricultural University, Andhra Pradesh during 2022-23 for DUS characterization. The experiment was sown in augmented design with two local checks. Each genotype was sown in four rows with a spacing of 75 x 75 cm between rows and plants respectively. Observations recorded for twenty nine characters on 10 plants per genotype and mean of 10 plants were taken up. To assess the DUS characters, optimum plant growth stages were examined for the respected traits.

Results

Germplasm of any crop will be descripted by characterization, which determine the expression of heritable traits of either agronomic or morphological features (Namrata Dhirhi *et al.*, 2016) [7]. Hence, this is very important to provide the detailed information on different characters of distinctness (D), uniformity (U) and stability (S) for their effective utilization in the further crop improvement programmes. Once, the germplasm is characterized, it is very easy to analyse the diversity between lines for the desirable traits to be improved and can also possible for further use in breeding programmes to generate highly adaptable varieties with broad genetic base.

In this study, out of 71 germplasm lines, 53 bidi and 18 natu tobacco lines were assessed, which were taken from All India Network Project on Tobacco at RARS, Nandyal. All protection measures were taken up during the crop season, off types were rogued out and the data on characters were recorded in germplasm lines at their different growth stages. All accessions showed remarkable variation within them for recorded characters.

- **Plant characteristics:** Characters were noted on matured tobacco plants (Table. 1).
- **Plant growth habit:** It is classified as open, erect, semi-erect and squatting groups. Among 71 germplasm lines, twenty-one lines (29%) were grouped in erect and eleven lines (15%) were grouped into semi-erect whereas, thirty-nine lines (54%) were grouped under open type of plant growth habit. Hence, erect and semi-erect lines can be used for improvement of drought tolerant lines.
- **Plant height (cm):** The plant height was taken from the base to tip of the main stem, recorded in cm, further divided into three categories like, short (<100 cm), medium (100-160cm) and tall (>160 cm). Seven lines (10%) grown up to 100 cm height are short types, fifty-four lines (76%) were grouped under medium types and ten lines or 14% are tall types.
- **Internodal length (cm)**: Internodal length is classified into three classes *viz.*, short (<2cm), medium (3-4 cm) and long (>4 cm). Among 71 lines, thirty-three lines were grouped under short length and thirty-eight lines were grouped under medium internodal length.
- **Plant width (cm)**: Matured tobacco plant occupied a width of range 72 cm to 160 cm and differed over 71 germplasm lines.
- **Stem colour**: Stem colour is in either light green or dark green colour. Seventeen lines or 24% were having dark green whereas, 54 lines or 76% were having light green stem colour.
- **Suckering habit (without topping)**: Suckering habit is low in two (3%) lines, medium in sixty (84%) lines, high in two (3%) lines and very high in 7 lines (10%).
- **Suckering habit (on topping):** Suckering habit is low in one line, medium in sixty-four (91%) lines and high in six lines (9%).
- **Rooting habit:** All of the evaluated lines are having shallow to medium type of root system.
- **Leaf characteristics**: Characters were recorded on matured tobacco plants (Table 1).
- **Leaf colour**: Leaf colour is varied from light green to dark green. Four or 6% lines were having light green, ten lines or 14% were in dark green and most of the lines, *i.e*. fifty-seven lines or 80% were having green coloured leaves.
- **Gummyness on leaf**: Gummyness are low for seven lines (10%), high for five lines (7%) and most of the lines i.e. fifty-nine lines (83%) having medium gummyness on its leaves.
- **Stalk of the leaf**: All seventy-one germplasm lines (100%) were observed with no stalk *i.e.* sessile in nature.
- **Angle of leaf**: Angle may be upright, horizontal or drooping for tobacco. Forty-two lines (59%) were upright, six lines (9%) have been horizontal and twenty-three lines (32%) were having drooping natured leaves. Upright leaf character is desirable for adaptability in moisture stress/drought conditions.
- **Leaf shape**: Leaf shape is lanceolate for most of the germplasm lines.
- **Leaf surface**: Leaf surface is either hairy, smooth or puckered. Among 71 lines, five lines (7%) were hairy, fifty-seven lines (80%) puckering nature and nine lines (13%) were with smooth surface.
- **Leaf base**: Acute leaf base was recorded in maximum number of lines (68) *i.e.* 98% and three lines with round base (4%).
- **Leaf margin**: Out of 71 germplasm lines, 80% were having wavy and 20% were having entire type of leaf margin.
- **Leaf tip**: Most of the studied germplasm lines were showing acute leaf tip.
- **Leaf auricle development:** Among 71 lines, frilled auricles 59%, winged auricles 35% and well-developed auricles 4% observed.
- **Leaf venation**: Leaf venation is medium for all germplasm lines.
- **Leaf midrib**: Leaf midrib is thick in forty-six lines (65%) and medium thick in twenty-five lines (35%).
- **Leaf length (cm):** Leaf length at the bottom of plant were ranged from 20 cm to 75 cm. In middle of plant, the leaf length is varied from 31 cm to 80 cm whereas, at the top of plant, it ranges between 23 cm to 66 cm.
- **Leaf width (cm)**: Leaf width also, at the bottom of plant were ranged from 14 cm to 33 cm. In middle of plant, the leaf width is varied from 15 cm to 37 cm whereas, at the top of plant, it ranges between 10 cm and 22 cm.
- **Total of leaves**: Total no. of leaves ranged between 16 to 40. 94% of lines (67) were having >18 leaves.
- **Economic number of leaves**: Economic number of leaves ranged between 12 to 22. 85% of lines (61) were having >18 leaves.
- **Spangling:** It is visual trait of leaf and indicator of quality which can be observed as the brick red rusty spots/patches on the leaf surface. It is also can be described as wrinkling or puckering of leaf. It is medium in all germplasm lines at its maturity stage.

3. Flower characteristics: Data was recorded at the time of flowering (Table 1).

- **Days to first flowering**: Days to first flowering in all studied germplasm lines ranged between 105 to 130 days.
- **Days to 50% flowering**: It ranges from 120 to 158 days.

- **Inflorescence type**: Compact in nine lines (13%), highly branched in fifty-four lines (76%), and open in seven lines (10%).
- **Flower colour**: 90% of the germplasm lines having pink flowers and remaining were having white flowers.
- **Corolla type**: Corolla type is fluted in fifty-two lines (73%) and funnel type in nineteen lines (27%).

Table 1: Characterization of 71 germplasm lines based on plant, leaf and flower characteristics

Character	Class of scale	Distribution (In%)
Plant growth habit	Erect Semi-erect Open Squatting	21 (29%) 11 (15%) 39 (54%) -
Plant height (cm)	Short (<100cm) Medium (100-160cm) Tall >160cm	7 (10%) 54 (76%) 10 (14%)
Internodal length (cm)	Short (<2cm) Medium (3-4) Long (>4)	33 (46%) 38 (54%) -
Plant width (cm)	Medium	72-160 cm range
Stem colour	Dark Green Light green	17 (24%) 54 (76%)
Leaf colour	Light green Green Dark green	4 (6%) 57 (80%) 10 (14%)
Gummyness on leaf	Low Medium High	7 (10%) 59 (83%) 5 (7%)
Stalk of leaf	Sessile	71 (100%)
Angle of leaf	Upright Horizontal Drooping	42 (59%) 6 (9%) 23 (32%)
Leaf shape	Lanceolate	100%
Leaf surface	Hairy Puckered Smooth	5 (7%) 57 (80%) 9 (13%)
Leaf base	Rounded Acute	3 (4%) 68 (96%)
Leaf margin	Serrate Wavy	57 (80%) 14 (20%)
Leaf tip	Acute	71 (100%)
Leaf auricle development	Frilled Well developed Winged	42 (59%) 4 (6%) 25 (35%)
Leaf venation	Medium	71 (100%)
Leaf midrib	Medium Thick	25 (35%) 46 (65%)
Leaf length (cm)	Bottom range Middle range Top range	20-75 31-80 23-66
Leaf width	Bottom range Middle range Top range	14-33 15-37 10-22
Total no. of leaves per plant	Range	16-40
Economic no. of leaves	Range	12-22
Suckering habit (without topping)	Low Medium High Very high	2 (3%) 60 (84%) 7 (10%) 2 (3%)
Suckering habit (on topping)	Low Medium High	1 (1%) 64 (91%) 6 (9%)
Spangling	Medium	71 (100%)
Days to first flowering	Medium	105-130
Days to 50% flowering	Medium	120-158
Inflorescence	Compact Open Highly branched	9 (13%) 7 (10%) 54 (76%)
Flower colour	White Pink	10% 90%
Corolla shape	Fluted Funnel	52 (73%) 19 (27%)

Discussion

A range of characters were evaluated in seventy-one bidi and natu tobacco germplasm lines maintained at RARS, Nandyal during 2022-23. Lot of diversity towards plant, leaf and flower characters was found and it is very essential to meet the objectives of present plant breeding programmes including the improvement of leaf yield, leaf quality, adaptability and resistance to biotic and abiotic stresses. Detailed information on range and nature of different characteristic will help to formulate the programmes to target multi trait selection and also provides knowledge on identification of natural diverse group of genotypes. Further it is very helpful to explore new sources of genes for tobacco improvement. Mostafa Mehdizadeh, *et al.* (2023) [6], Rajan and Bhat (2022) [8], Choudhary and Datta (2021) [1], Lakshmanan and Jayaraman (2018) [4], Baghyalakshmi *et al.* (2018) [3] and Singh *et al.* (2016) [9] and also reported wide variation in the characteristics of germplasm material of tobacco.

In conclusion, among all studied characteristics, most of the germplasm lines showed desirable characters like semi erect type of plant growth habit, medium plant height (100-160 cm), medium internodal length (3-4 cm), light green coloured stems, green coloured upright position of leaves with lanceolate shape, puckered surface, acute base and tip, thick midribs, wavy margins and frilled auricle development in matured leaves. Maximum lines are having branched inflorescence and pink flowers with fluted corolla type. Minimum no. of germplasm lines showed the other classes of characters indicates different genes interacts for development of different phenotypic traits. Measurement of quantitative variation and qualitative traits will help to select distinguishable genotypes as parents to develop best tobacco varietal lines with higher leaf number, quality and stable lines with resistance to biotic and abiotic stresses. In this way diversity can be exploited to reach the future goals in tobacco crop and to increase the area, production and productivity in India.

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