# TOBACCO RESEARCH

VOLUME : 49, NUMBER 1 JUNE, 2023

INDIAN SOCIETY OF TOBACCO SCIENCE
RAJAHMUNDRY - 533 105, ANDHRA PRADESH, INDIA

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ISSN 0379 - 055X

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# TOBACCO RESEARCH

**Vol. 49, No. 1** **June, 2023**

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# VARIATION FOR SEED GERMINATION IN TOBACCO GENOTYPES STORED UNDER NORMAL CONDITIONS

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(Received on Jan. 14th, 2023 and accepted on Mar 12th, 2023)

**Quality seed is the critical input for raising adequate and healthy seedlings in the nurseries. Tobacco farmers, often face the problems of seed germination. Tobacco seed is also vulnerable to deterioration during field weathering, harvesting, and storage conditions leading to loss of seed viability. A set of eleven FCV drought breeding lines and three check varieties stored for twelve months period under normal storage conditions were assessed for their germination potential as per the ISTA guidelines. The considerable genetic variability for germination per centage and germination rate among genotypes indicates the differential response of genotypes to storage periods indicating the effect of prevailing temperature and relative humidity during the storage period. High PCV, GCV and high heritability estimates indicate the involvement of additive gene action and effectiveness of simple selection for genetic improvement of seed viability in tobacco. Three genotypes KDB 4, KDB 10 and KDB 11 showed the least reduction in germination percentage even after 12 months of storage, which will serve as potential donors for seed vaiability improvement.**

## INTRODUCTION

Tobacco (*Nicotiana tabacum* L.) is a major cash crop belongs to family Solanaceae. India stands second position in production and export of tobacco. Tobacco is grown in an area of 0.44 million hectares and production of 761 million kg tobacco with average productivity of 1699 kg/ha in India (FAOSTAT, 2020). From India, a quantity of 2,11,631 metric tonnes of tobacco and tobacco products worth of 6,305.94 crores during 2020-21 (Tobacco Board annual report, 2020-21). India is bestowed with diverse agro-climatic regions which made possible to produce the tobacco in two different seasons (*Kharif* season in Karnataka and *Rabi* season in Andhra Pradesh). Flue Virginia Cured tobacco is cultivated in Andhra Pradesh and Karnataka and having high export potential.

As tobacco is the most valued cash crop in India. The seeds of tobacco are very small, egg shaped slightly flattened and characterized by prominent raphe along one side. Seed germination in tobacco is positive photoblastic nature. Seed germination is also a major determinant of seed rate. High quality seed could significantly contribute to adequate establishment of seedlings in the nurseries for profitable seedling production and healthy seedlings. The quality of seed could be evaluated by testing its germination percentage. Tobacco seed is also vulnerable to deterioration during field weathering, harvesting and storage conditions leading to loss of seed vigour. The occurrence of high temperature and relative humidity during storage conditions are the main causes of seed viability in many seed crops. The studies on the germination of some commercial tobacco varieties (Pal and Gopalachari, 1957; Pal, 1958), mechanism of seed germination, effect of temperature (Pal *et al.,* 1958, Rao *et al.,* 2002), moisture content (Bangarayya and Ramam, 1979), biochemical changes during storage (Rao et al., 2003) and improvement of tobacco seed germination with low temperature treatments (Pal *et al.,* 1959) and hormones (Bangarayya and Sarma, 1974, Pal and Bangarayya, 1976) was reviewed periodically by various researchers in tobacco. Andrade (2018) revealed the morphological, physiological, and biochemical indicators of quality of tobacco fruits and seeds. The crop improvement programme majorly depends on variability in the germplasm/parent material. It is important to assess the genetic

**Key words:** seed viability, Flue Cured Virginia tobacco, seed germination, rate of germination

variability and selection of desirable donor sources for different economical traits like seed viability and germination potential. In this regards estimation of various genetic parameters like range, phenotypic coefficient of variation, genotypic coefficient of variation, broad-sense heritability, and genetic advance as a percent mean are helpful in assessing the variability in the germplasm accessions. Judicious use of donor parents in breeding programmes has a significant effect on genetic gains. Hence, an attempt has been made to assess the genetic variability for seed germination and germination rate of tobacco seeds stored under normal conditions, which will be useful for identifying the diverse parents for hybridization and further genetic improvement of FCV tobacco for enhanced seed viability.

## MATERIALS AND METHODS

The material for present study consists of eleven FCV breeding lines and three released varieties maintained at ICAR CTRI Research Station, Kandukur. Seeds of eleven FCV tobacco breeding lines along with three released varieties were stored under normal conditions to assess the seedquality. Fresh and twelve months old, stored seeds of fourteen genotypes were subjected to standard germination test. For each genotype, three replications of 100 seeds each were arranged in a randomized complete block design. The seeds of all the genotypes were put in 90 mm Petri dishes containing sterilized Whatman paper and maintained wet at regular intervals. The number of seeds germinated in each genotype was recorded daily till the end of the experiment. Time to 50% germination indicates the time required to achieve 50% of final germination (Coolbear *et al.,* 1984). Germination percentage and the rate of germination were determined by using following formula:

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

$$\text{Germination rate} = \frac{\text{Number of germinated seeds on 7th day}}{\text{Total number of seeds sown}} \times 100$$

### Statistical analysis

Mean values days to 50% percent germination, germination rate and total cumulative germination percentage at the end of each germination experiment was used for statistical analysis. Analysis of variance (ANOVA) for Randomized Block design was calculated using Proc GLM of SAS. Genotypic and phenotypic coefficients of variation were determined by using formula suggested by Burton and De Vane (1953), heritability and genetic advance were calculated according to Johnson (1955) and Robinson et al. (1949).

## RESULTS AND DISCUSSION

### Germination per centage

The percentage of germination indicates the viability of seeds. Seed germination is a basic and critical initial stage that significantly influences the population establishment. Seed rate depends on the quantity of seed required to sow unit area of land for optimum seedling production, which varied with the changes of germination per centage. There are significant differences among genotypes and genotype storage period interaction effects for germination percentage (Table 1). In the first experiment (fresh seed), the germination per centage varied from 64% (KDB 7) to 98 % (Siri) with an average of 86%. This wide range of germination percentage may be due to differential response of genotypes to prevailing temperature and relative humidity conditions during storage. Except KDB 7, all the genotype exhibited more than 80 % seed germination. In the second experiment (12 months after storage), the germination per centage ranged from 51 % (KDB 7, KDB 8) to 87 % (KDB 4) with an average of 75 %. Three genotypes (KDB 1, KDB 4 and Siri) showed more than 80 % germination even after 12 months of storage under normal conditions (Figure 1). High PCV, GCV estimates and high heritability coupled with high genetic advance as per cent of mean was observed in both the experiments (Table 2).

### Germination rate

The rate of germination suggests the time course of germination and is an indicator of seed vigour, which in turn determines the seedling establishment and stress tolerance in the field. The

length of time required for all seeds to germinate, and the speed of germination also impacts different cultural practices like transplanting of seedling, fertilizing, plant protection and harvesting in tobacco cultivation. Significant genotype and genotypes storage period interaction effects were observed for germination rate (Table 1). In the first experiment (fresh seed), germination rate varied from 44 % (KDB 7) to 98 % (Siri) with mean value of 81 %. The wide range of germination rate among genotypes indicates significant effect of storage conditions. The Siri variety exhibited 98 % germination rate. In second experiment (12 months after storage), germination rate ranged from 45 % (KDB 8) to 86 % (KDB 4, KDB 11) with an average of 71 %. Three genotypes, KDB 4, Siri and KDB 11 exhibited more than 80 % germination rate even after 12 months of storage under normal conditions

**Table 1: ANOVA for germination (%), germination rate and time to reach 50% germination of fourteen tobacco genotypes stored under normal conditions**

| Trait | Months | Source of variation | df | Sum of Squares | Mean Square | CV | LSD (0.05) |
|---|---|---|---|---|---|---|---|
| **Germination (%)** | **1MAS** | Genotype | 13 | 2140 | 164.6** | 4.3 | 6.2 |
| | | Replication | 2 | 15.5 | 7.79 | | |
| | | Error | 26 | 355.1 | 13.66 | | |
| | **12MAS** | Genotype | 13 | 5536 | 425.9** | 5.2 | 6.5 |
| | | Replication | 2 | 11.29 | 5.64 | | |
| | | Error | 26 | 390 | 15 | | |
| | **Pooled** | Genotype | 13 | 5765.9 | 443.5** | 4.72 | 4.39 |
| | | Months | 1 | 2742.8 | 2742.8 | | 1.66 |
| | | Replication(Months) | 4 | 26.86 | 6.71 | | |
| | | Genotype Months | 13 | 1911.4 | 147** | | 6.2 |
| | | Error | 52 | 745.1 | 14.33 | | |
| **Germination rate** | **1MAS** | Genotype | 13 | 6002.5 | 461.7** | 9.52 | 7.04 |
| | | Replication | 2 | 14.3 | 7.17 | | |
| | | Error | 26 | 837 | 32.19 | 7.51 | 9.03 |
| | **12MAS** | Genotype | 13 | 7101.9 | 546.3** | | |
| | | Replication | 2 | 47.2 | 23.6 | | |
| | | Error | 26 | 753.3 | 28.9 | | |
| | **Pooled** | Genotype | 13 | 9457.3 | 727.4** | 7.26 | 6.41 |
| | | Months | 1 | 1665.1 | 1665.1 | | 2.42 |
| | | Replication(Months) | 4 | 61.6 | 15.4 | | |
| | | Genotype Months | 13 | 3647.1 | 280.5** | | 9.06 |
| | | Error | 52 | 1590.3 | 30.5 | | |
| **Time to 50% germination (T50)** | **1MAS** | Genotype | 13 | 31.7 | 2.44** | 6.9 | 0.53 |
| | | Replication | 2 | 0.05 | 0.02 | | |
| | | Error | 26 | 2.62 | 0.1 | | |
| | **12MAS** | Genotype | 13 | 71.6 | 5.51** | 13.8 | 1.17 |
| | | Replication | 2 | 0.76 | 0.38 | | |
| | | Error | 26 | 12.57 | 0.48 | | |
| | **Pooled** | Genotype | 13 | 66.8 | 5.14** | 11.29 | 0.63 |
| | | Months | 1 | 4.76 | 4.76 | | 0.24 |
| | | Replication(Months) | 4 | 0.81 | 0.2 | | 0.89 |
| | | Genotype Months | 13 | 36.57 | 2.81** | | |
| | | Error | 52 | 15.19 | 0.29 | | |

1 MAS – 1 month after storage 12 MAS – 12 months after storage

(Figure 2). High PCV, GCV estimates, and high heritability coupled with high genetic advance as per cent of mean was observed in both the experiments (Table 2).

**Time to 50 % germination**

Time to 50% germination indicates the time

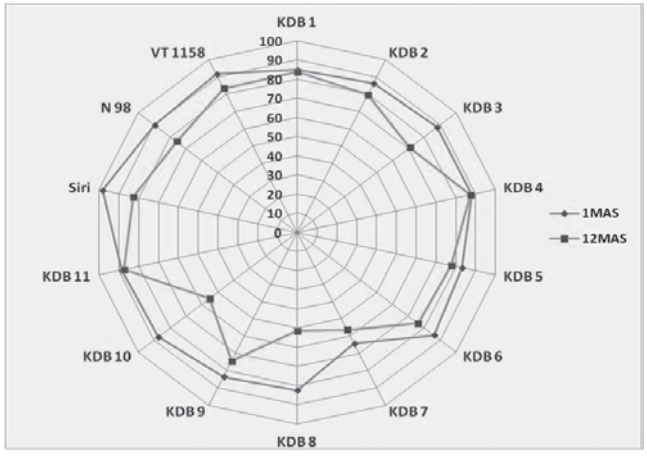


**Fig. 1: Radar plot showing germination (%) of fourteen tobacco genotypes tested for ermination after one and twelve months after storage**

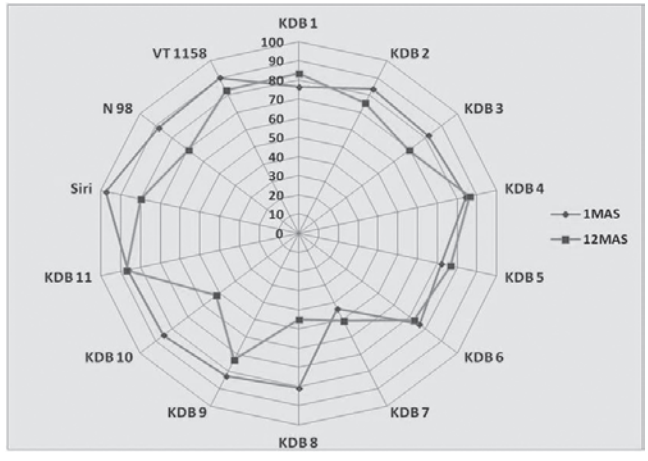


**Fig. 2: Radar plot showing germination rate of fourteen tobacco genotypes tested for ermination after one and twelve months after storage**

required to achieve 50 % of final germination. In the first experiment (fresh seed), time to 50 % germination ranged from 4 to 7 days with an average of 4 days. Except KDB 7, all the genotypes achieved 50 % seed germination within four days. High PCV, GCV estimates and high heritability coupled with high genetic advance as per cent of

**Table 2: Genetic parameters for germination (%), germination rate and time to reach 50% germination of tobacco**

| Parameters | Germination per centage | | Germination rate | | Time to 50% germination | |
|---|---|---|---|---|---|---|
| | 1 M | 12 MAS | 1 M | 12 MAS | 1 M | 12 MAS |
| Minimum | 63 | 50 | 31 | 36 | 4 | 4 |
| Maximum | 100 | 93 | 100 | 93 | 8 | 9 |
| Range | 37 | 43 | 69 | 57 | 4 | 5 |
| Mean | 85.8 | 74.4 | 80.6 | 71.7 | 4.55 | 5 |
| **ó e** | 13.6 | 15 | 32.1 | 28.9 | 0.10 | 0.48 |
| **ó g** | 50.3 | 136.9 | 143.1 | 172.4 | 0.78 | 1.68 |
| **ó p** | 63.9 | 151.9 | 175.3 | 201.4 | 0.88 | 2.16 |
| PCV | 9.3 | 16.5 | 16.4 | 19.7 | 20.6 | 29.2 |
| GCV | 8.2 | 15.7 | 14.4 | 18.3 | 19.4 | 15.17 |
| $h^2_{(bs)}$ | 78.6 | 90.1 | 81.6 | 85.6 | 88.5 | 77.6 |
| GAM | 15.1 | 30.75 | 27.6 | 34.82 | 37.6 | 46.7 |

ó g – Genotypic variance GCV- Genotypic coefficient of variance $h^2_{(bs)}$ – Heritability
ó p –Phenotypic variance PCV- Phenotypic coefficient of varianceGAM –Genetic advance as per cent of mean

1 MAS – 1 month after storage 12 MAS – 12 months after storage

mean was observed. In second experiment (12 months after storage), time to 50% germination ranged from 4 to 8 days with an average of 5 days. Two genotypes (KDB 7 and KDB 8) achieved 50 % seed germination after 7 days. This wider range of variability for days to 50 % germination may be due to loss of seed viability to prevailing temperature and relative humidity conditions during storage (Figure 3). High PCV, GCV estimates and high heritability coupled with high genetic advance as per cent of mean was observed (Table 2).

Loss of seed germination due to extreme storage enviorment conditions particularly temperature and relative humidity is a common

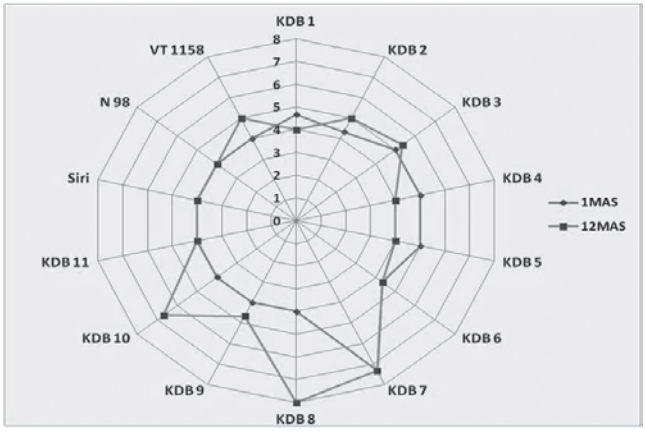


**Fig. 3: Radar plot showing time to 50% germination of fourteen tobacco genotypes tested for germination after one and twelve months after storage**

phenomenon in many crop sees parituclary commercial crops. The variability for germination and loss of seed viability due to adverse effects of temperature on seed viability was also recorde by various researchers (Pal and Gopalachari, 1957, Pal, 1958; Pal *et al.,* 1958, Li *et al.,* 2018) in tobacco.

it is conculded that the wide range of germination per centage, germination rate and time to 50% seed germination indicates the differential response of genotypes to storage periods and prevailing temperature and relative humidity during the storage period. In general, longer the storage period under normal conditions, the significant loss in seed viability was observed. High PCV, GCV and high heritability estimates indicates the involvement of additive gene action and effectiveness of simple selection for genetic improvement of seed viability in tobacco. Two genotypes KDB 4 and Siri showed considerable seed viability even after twelve months of storage under normal conditions, which needs to validation under controlled conditions with optimum levels of storage treatments and physio-molecular mechanism needs be elucidated in future line of work.

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# VALUE ADDITION IN A SUN CURED CHEWING TOBACCO (*NICOTIANA TABACUM* L) WITH NATURAL SWEETNERS AND ASTRINGENT TASTENERS

**M. KUMARESAN, D. DAMODAR REDDY, P. MANIVEL, S. KASTURI KRISHNA, M. VENKATESAN, ANINIDITA PAUL, AND V. ANNADURAI**

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(Received on Feb. 9th, 2023 and accepted on Mar. 27th,2023)

**Experiments were conducted at ICAR- CTRI Research station farm – bulking shed from 2020-21 to 2021-22 season to evaluate the different natural sweetners and astringent tasteners viz White sugar, Coconut palm jaggery, Sugarcane jaggery, Palmyrah jaggery at 10% solution and astringent tasteners viz., Coconut mesocarp, Banana peduncle, Banana pseudo stem at 5% solution with a control for value addition in chewing tobacco.The experiment was conducted in a CRBD design with 3 replications. The natural sweetners and astringent tasteners were treated as per the treatments. The cured leaf of chewing tobacco treated with Palmyra jaggery 10% solution in combination with 5% solution of banana peducle or banana pseudo stem or coconut mesocarp, increased the weight of treated cured leaves. The weight increased by 13-14 % over the control (untreated). Net return was also higher (Rs 2863 to 2881) with the palmyra jaggery 10 % solutioin with different astringent tasteners. The chewability scores tested revealed that palmyra jaggery 10 % solution with different astringent tasteners improved the body (8.0), aroma (7.92 -8.0), Incrustation (7.9-8.0), taste( 7.66-7.92), pungency( 7.67-7.83), saliva secretion (6.25-6.42), duration of pungency (6.58-6.83), stiffness in the mouth (7.83-8.0) with a total score of 75 -75.8 out of 80, which was found to be more preferable.**

## INTRODUCTION

Chewing tobacco is one of the important commercial crops grown in Tamil Nadu and is estimated to be cultivated in an area of about 10000 to 12000 ha with a production of 25000 to 30000 tonnes of cured leaf yield (Kumaresan *et.al.,*2019). Generally, after sun curing and fermentation the cured leaves are marketed. Marketing at this stage reduces the price of cured leaves. If the leaves are stored for long time, the moisture content in the leaves gets reduced, risk of pests attack, weight loss etc. No production system and production process can be viable without value addition. Value addition is a process that elevates a production into a product. There is a need to go inclusive and critical on value addition process for creating new market demands or indulging renewed demand from the set of conventional customers. The value addition in chewing tobacco prevents the moisture loss, increases the leaf weight, improves the chewing quality and reduces the pest attack. Even though considerable work on value addition was done in many crops, particularly vegetable crops(Pankaj *et al.,*2019), no work was done on value addition in chewing tobacco and hence the present study was taken up.

## MATERIALS AND METHODS

Experiments were conducted at ICAR- CTRI Research station farm – bulking shed from 2020-21 to 2021-22 season to evaluate the different natural sweetners and astringent tasteners *viz* White sugar, Coconut palm jaggery, Sugarcane jaggery, Palmyrah jaggery at 10% solution and astringent tasteners viz., Coconut mesocarp, Banana peduncle, Banana pseudo stem at 5% solution with a control in a CRBD design with 3 replications. The treatments comprised of White sugar 10% solution + Coconut mesocarp 5% solution, White sugar 10% solution + Banana peducle 5% solution, White sugar 10% solution + Banana pseudo stem 5% solution, Coconut palm jaggery 10% solution + Coconut mesocarp 5% solution, Coconut palm jaggery 10% solution + Banana peducle 5% solution, Coconut palm jaggery 10% solution + Banana pseudo stem 5%

**Key Words**: Value addition**,** Chewing Tobacco, Natural sweetners, Astringent tasteners

solution, Sugar cane jaggery 10% solution + Coconut mesocarp 5% solution, Sugar cane jaggery 10% solution + Banana peducle 5% solution, Sugar cane jaggery 10% solution + Banana pseudo stem 5% solution, Palmyra jaggery 10% solution + Coconut mesocarp 5% solution, Palmyra jaggery 10% solution + Banana peducle 5% solution, Palmyra jaggery 10% solution + Banana pseudo stem 5% solution and Control (Without sweetner or astringent tastners). The sun cured Tobacco leaves were collected during the season 2020-21 and 2021-22 . The natural sweetners and astringent tasteners were treated as per the treatments. The astringent tasteners *viz.*, coconut mesocarp, banana peduncle, banana pseudo stem were collected and chopped separately. Five kilograms of astringent tastener was soaked in 10 litres of water for 4 days. After 4 days the palmyrah jaggery 10 kg was soaked in the solution of astringent tasteners for one hour. Chewing tobacco cured leaves (10 bundles, 33 kg) were collected in the go down was dipped in the solution and the excess solution was drained and the leaves are bulked for 3- 4 weeks. The economics was worked out as per the prevailing market rate. The chewing quality was tested with three quality testers. The chewing quality *viz.,* body (10), Aroma (10), Incrustation (10), Taste(10), Pungency(10), Saliva secretion (10), Duration of pungency (10), Stiffness in the mouth (10) with a total score of 80, the procedure suggested by Palanichamy and Nagarajan ( 1989 ) was followed in this experiment.

**RESULTS AND DISCUSSION**

The cured leaf of chewing Tobacco treated with Palmyra jaggery 10% solution in combination with 5% solution of banana peducle or banana pseudo stem or coconut mesocarp, increased the weight of treated cured leaves. The weight increased by 13-14 % over the control (untreated). The price of treated leaves was Rs. 90/ kg with the Palmyra jaggery 10% solution treated with different astringent tasteners(Table 1). The increase in the weight could be attributed to the stickiness of the Palmyra jaggery solution which in turn formed a coating in the leaves, reduced the moisture loss in leaves, thereby increased weight of the treated leaves.

The expenditure was higher with coconut palm jaggery 10% solution with different astringent tasteners (Rs 416.77 for 33 kg leaves) followed by Palmyra jaggery 10% solution treatment with different astringent tasteners ( Rs 403.14 for 33 kg leaves). The lesser availability resulted in higher cost of the coconut as well as palmyra jaggery thereby higher expenditure. The lowest expenditure of Rs 123.3 for 33 kg leaves was recorded with white sugar 10 % solutioin with different astringent tasteners. The cheaper cost of white sugar resulted in lower expenditure.

The gross return was significantly higher (Rs 3276 to 3330) with the palmyra jaggery 10 % solutioin with different astringent tasteners treated leaves as compared to control.The higher weight and increased quality increased the price of the leaves thereby higher gross returns. The gross returns increased by 28 % with the palmyra jaggery 10 % solutioin with different astringent tasteners as compared to the control. Net return was also significantly higher (Rs 2863 to 2881) with the palmyra jaggery 10 % solutioin with different astringent tasteners as compared to the control. The higher gross return increased the net return also. The increase in the net return was 12 to 13 % as compared to the control.

The chewability scores tested revealed that palmyra jaggery 10 % solution with different astringent tasteners improved the body (8.0), aroma (7.92 -8.0), Incrustation (7.9-8.0), taste( 7.66-7.92), pungency( 7.67-7.83), saliva secretion (6.25-6.42), duration of pungency (6.58-6.83), stiffness in the mouth (7.83-8.0) with a total score of 75 -75.8 out of 80, which was found to be more preferable (Table 2). The phenols in the astringent tasteners and the sweetness in the palmyra jaggery improved the chewability scores.

It can be concluded that value addition in chewing tobacco can be done with palmyrah jaggery solution at 10% with 5% solution of coconut mesocarp or banana pseudo stem or banana peduncle for increased net return and improved the chewability scores viz., body, aroma, whitish encrustation, taste, pungency, saliva secretion, duration of pungency, stiffness in the mouth.

**Table 1: Economics of different treatments**

| Treatments | Cured leaf before treatment (kg) | Cured leaf after treatment (kg) | Price/ kg of leaf | Expen diture (Rs) | Gross return (Rs) | Net return (Rs) |
|---|---|---|---|---|---|---|
| White sugar 10% solution + coconut mesocarp 5% solution | 33 | 34.2 | 82 | 126.39 | 2804 | 2678 |
| White sugar 10% solution + banana peduncle 5 % solution | 33 | 34.8 | 82 | 126.39 | 2854 | 2727 |
| White sugar 10% solution + banana pseudo stem 5% solution | 33 | 34.25 | 82.5 | 126.39 | 2826 | 2699 |
| Coconut palm jaggery 10% solution + coconut mesocarp 5 % solution | 33 | 34.3 | 84 | 416.77 | 2881 | 2464 |
| Coconut palm jaggery 10% solution + banana peduncle 5% solution | 33 | 34.45 | 84 | 416.77 | 2894 | 2477 |
| Coconut palm jaggery 10% solution + banana pseudostem 5% solution | 33 | 34 | 84 | 416.77 | 2856 | 2439 |
| Sugar cane jaggery 10% solution + coconut mesocarp 5 % solution | 33 | 34.3 | 82 | 155 | 2813 | 2657 |
| Sugar cane jaggery 10% solution + banana peduncle 5 % solution | 33 | 34.35 | 82 | 155 | 2817 | 2661 |
| Sugar cane jaggery 10% solution + banana pseudostem 5% solution | 33 | 35.25 | 82 | 155 | 2891 | 2735 |
| Palmyrah jaggery 10% solution + coconut mesocarp 5% solution | 33 | 36.5 | 90 | 403.14 | 3285 | 2881 |
| Palmyrah jaggery 10% solution + banana peduncle 5 % solution | 33 | 36.45 | 90 | 403.14 | 3281 | 2877 |
| Palmyrah jaggery 10% solution + banana pseudostem 5% solution | 33 | 36.3 | 90 | 403.14 | 3267 | 2863 |
| Control | 33 | 32 | 80 | 0 | 2560 | 2560 |
| SEm+/- | | | | | 170.2 | 90.3 |
| CD@5% | | | | | 525.6 | 280.5 |

**Table 2: Effect of different treatments in Chewability Test**

| Quality Characteristics | Body (10) | Aroma (10) | Incrustation (10) | Taste (10) | Pungency (10) | Saliva secretion (10) | Duration of pungency (10) | Stiffness in the mouth (10) | Total score out of 80 |
|---|---|---|---|---|---|---|---|---|---|
| White sugar 10% solution + coconut mesocarp 5% solution | 7.66 | 7.23 | 7.75 | 7.08 | 7.0 | 5.83 | 5.5 | 7.08 | 68.9 |
| White sugar 10% solution + banana peduncle 5 % solution | 7.66 | 7.08 | 7.58 | 6.92 | 7.08 | 5.58 | 5.5 | 7.17 | 68.2 |
| White sugar 10% solution + banana pseudo stem 5% solution | 7.75 | 7.16 | 7.33 | 6.92 | 6.92 | 5.33 | 5.5 | 7.0 | 67.3 |
| Coconut palm jaggery 10% solution + coconut mesocarp 5 % solution | 8.0 | 7.23 | 7.17 | 7.08 | 7.46 | 5.33 | 5.75 | 7.0 | 68.7 |
| Coconut palm jaggery 10% solution + banana peduncle 5% solution | 8.0 | 7.50 | 7.75 | 7.17 | 7.08 | 5.58 | 5.66 | 7.17 | 69.8 |
| Coconut palm jaggery 10% solution + banana pseudostem 5% solution | 8.0 | 7.50 | 7.42 | 6.91 | 7.17 | 5.66 | 5.58 | 7.33 | 69.4 |
| Sugar cane jaggery 10% solution + coconut mesocarp 5 % solution | 8.0 | 7.33 | 7.5 | 6.33 | 6.58 | 5.67 | 5.5 | 7.25 | 67.7 |
| Sugar cane jaggery 10% solution + banana peduncle 5 % solution | 8.0 | 7.67 | 6.91 | 6.66 | 6.92 | 5.67 | 5.83 | 7.17 | 68.5 |
| Sugar cane jaggery 10% solution + banana pseudostem 5% solution | 7.92 | 7.5 | 7.42 | 6.83 | 7.0 | 5.75 | 6.0 | 7.17 | 69.4 |
| Palmyrah jaggery 10% solution + coconut mesocarp 5% solution | 8.0 | 8.0 | 8.0 | 7.83 | 7.83 | 6.42 | 6.58 | 8.0 | 75.8 |
| Palmyrah jaggery 10% solution + banana peduncle 5 % solution | 8.0 | 7.92 | 7.9 | 7.66 | 7.67 | 6.25 | 6.83 | 7.83 | 75.0 |
| Palmyrah jaggery 10% solution + banana pseudostem 5% solution | 8.0 | 8.0 | 8 | 7.92 | 7.66 | 6.42 | 6.83 | 7.83 | 75.8 |
| Control | 7.0 | 6.33 | 4.0 | 5.33 | 5.66 | 5.33 | 4.92 | 6.0 | 55.7 |

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Tobacco Research 49(1): 11-14, 2023

# BIO-EFFICACY OF NEW FUNGICIDE FENAMIDONE + MANCOZEB AGAINST DAMPING OFF DISEASE IN FCV TOBACCO NURSERIES

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( Received on Jan. 19th, 2023 and accepted on April 27th, 2023)

**Experiments were conducted to evaluate new fungicide fenamidone + mancozeb at three different concentrations for its efficacy against *Pythium aphanidermatum* (Edson) Fitzpatrick, the incitant of damping off disease, to select the most effective concentration for the management of the disease. Three fungicides were tested *in vitro* by poisoned food technique for their efficacy to inhibit mycelial growth of the pathogen. Fenamidone 10% + mancozeb 50% inhibited cent per cent mycelia growth at all the concentrations. Among the three fungicides tested under field conditions, fenamidone 10% + mancozeb 50% @ 0.3% was found to be the most effective dose in tobacco nurseries which could reduce the disease to an extent of 96.8 per cent with a corresponding maximum healthy transplantable seedlings (856 / sq. m.) when applied as a drench on the nursery beds at the time of sowing @ 0.1% followed by foliar spray @ 0.3% twice at 25 and 35 DAS. Metalaxyl 8% + mancozeb 64% when sprayed at 10 days interval could protect 95.6 per cent seedlings with a production of 793 / sq. m of healthy seedlings.**

## INTRODUCTION

Tobacco is one of the important commercial crops of India and contributes about Rs. 4,200 crores as foreign exchange and Rs. 17,100 crores revenue to the national exchequer annually. Diseases caused by fungal pathogens are major constraints in successful production of this exportable commodity. *Pythium aphanidermatum* (Edson) Fitzpatrick, causing damping off disease in tobacco nurseries is a major problem in the production of quality tobacco seedling (Nagarajan and Reddy, 1980). Heavy mortality of the seedlings in all types of tobacco including FCV tobacco nurseries due to this pathogen is a cause of concern.

Though effective management approaches are available, efforts are being constantly made to evaluate new class of fungicides for developing efficient IPM strategies. Metalaxyl + mancozeb have been recommended and is in use since three decades for the management of this disease in tobacco nurseries. To avoid resistance development and to find out alternative fungicides, the new fungicide was assessed for its bio-efficacy against damping off disease. The present studies on evaluation of a new fungicide Sectin 60 WG containing fenamidone 10% + mancozeb 50% against the pathogen, *P. aphanidermatum*, the incitant of damping off disease in FCV tobacco nursery were carried out with a view to select the most effective fungicide for the management of the disease.

## MATERIALS AND METHODS

### LABORATORY STUDIES

Poisoned food technique of Shervelle (1979) was followed to study the comparative efficacy of 3 fungicides at 100, 250, 500 and 1000 ppm of formulation against the virulent isolate of *P. aphanidermatum* in five replications. Required concentration of each of the fungicides from the commercial formulations was prepared with sterilized distilled water and added to autoclaved potato dextrose agar (PDA) medium to obtain desired dilutions. The medium without fungitoxicant served as control. The petri dishes containing PDA medium were inoculated with 5 mm discs from two days - old actively growing culture of *P. aphanidermatum* grown on PDA, the inoculated petri dishes were incubated at 28 ± $2^0$ C temperature and growth of the mycelial colony was measured 42 hours after inoculation. Extent of inhibition of mycelial growth by each fungicide

**Key words:** Damping off, FCV tobacco, fungicides, *Pythium aphanidermatum*

was calculated by estimating the per cent reduction in mean mycelial diameter over that of the control (Vincent, 1947). The data were subjected to statistical analysis.

**NURSERY EXPERIMENT**

The nursery experiment was conducted for two seasons 2008 and 2009 at ICAR- Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh to test the bio-efficacy of new fungicides against damping off disease, *P. aphanidermatum* in FCV tobacco nurseries. The seedlings were raised as per standard agronomic practices during the nursery season (September to November).

The fungicide fenamidone 10% + mancozeb 50% (Sectin) at different concentrations was applied to the nursery as drenching nursery beds @ 500 ml/$m^2$ at the time of sowing and spray @ 100 ml/$m^2$ at 25 and 35 DAS along with recommended check metalaxyl 8% + mancozeb 64% @ 0.2% and copper oxychloride 50% @ 0.2% for evaluation under nursery conditions. The experiment was laid out in a randomized block design (RBD) with an untreated check. There were 6 treatments with four replications with a plot size of 1 $m^2$. The popular cultivar Siri was used in the experiment. Regular disease observations on damping off and phytotoxicity were recorded, while healthy transplant count was recorded at each pulling of the seedlings. Germination count was taken at 15 days after sowing (DAS) at random in ten squares each with a dimension of 100 sq.cm. from which mean was calculated.

**RESULTS AND DISCUSSION**

**LABORATORY STUDIES**

Among the three fungicidal compounds evaluated against *P. aphanidermatum* all were found inhibitory to the fungus with varied degree of inhibition. The results presented in Table 1 indicate that out of the three fungicides evaluated against the test pathogen, fenamidone + mancozeb was most effective as it checked cent per cent growth of fungus even at 100 ppm followed by metalaxyl + mancozeb 87.56%. Whereas, copper oxychloride, was found to be less effective even at 1000 ppm concentration, which was in confirmity with the results of Yadav and Joshi (2012) who studied different concentrations of fenamidone + mancozeb against *P. aphanidermatum in vitro.* With the rise in concentration from 100 to 1000 ppm, effectiveness of the fungicide in respect to mycelial growth also increased in cases of metalaxyl + mancozeb and copper oxychloride. Whereas, fenamidone 10% + mancozeb 50% inhibited 100% growth of fungus even at 100 ppm concentration.

**NURSERY EXPERIMENT**

The pooled data (Table 2) indicated that among the different concentrations of the new fungicide fenamidone 10% + mancozeb 50% (Sectin 60 WG) @ 0.1% drench & 0.3% spray was effective and on par with the recommendation in vogue i.e. metalaxyl 8% + mancozeb 64% WP @ 0.2% two sprays as shown by reduced disease incidence and increase in the number of healthy transplants. Similar results were recorded by several workers; Vankar (1999) and Yadav and Joshi (2012) reported that fenamidone + mancozeb 60 WG was equally effective as metalaxyl + mancozeb 72 WP in completely suppressing the growth of *P. aphanidermatum* in bidi tobacco. The incidence of damping off was less in fenamidone 10% + mancozeb 50% @ 0.3% treatment as shown by significantly less damage of seedlings (2.74/$m^2$) as compared to control (17.85/$m^2$) and it was on par with metalaxyl 8% + mancozeb 64% WP @ 0.2% (3.68/ $m^2$). Numbers of healthy transplantable tobacco seedlings recorded were highest (856/$m^2$) with fenamidone 10% + mancozeb 50% @ 0.3% followed by metalaxyl 8% + mancozeb 64% WP @ 0.2% (793/$m^2$). The fungicide fenomidone 10% + mancozeb 50% (Sectin) did not show any phytotoxicity at any of the concentrations, even 3 days after spraying. No significant difference was observed among the treatments for seed germination.

Fungicide treatments reduced the intensity of disease, 51.54% in case of fenamidone + mancozeb drenching @ 0.1% and spray @ 0.1%, 66.95% in fenamidone + mancozeb drenching @ 0.1% and spray @ 0.2%, 82.69% in fenamidone + mancozeb drenching @ 0.1% and spray @ 0.3%, 79.38% for metalaxyl + mancozeb and in copper oxycloride 47.11% as compared to untreated plots.

The economic analysis (Table 3) revealed that a net returns of Rs. 1,05,204 per ha with a C:B ratio of 1.45 was recorded in fenamidone + mancozeb drenching @ 1g/lit and spray @ 3g/lit

**Table 1: Effect of different fungicides on the mycelial growth inhibition of *Pythium aphanidermatum***

| Fungicides | % inhibition of mycelial growth over control/ concentrations (ppm) | | | | Mean |
|---|---|---|---|---|---|
| | 100 | 250 | 500 | 1000 | |
| Fenamidone + Mancozeb 60% WG | 100 (90.00) | 100 (90.00) | 100 (90.00) | 100 (90.00) | 100 (90.00) |
| Metalaxyl + Mancozeb 72% WP | 87.56 (69.34) | 93.08 (74.73) | 97.30 (83.95) | 99.77 (88.75) | 94.43 (79.19) |
| Copper oxychloride 50% WP | 62.24 (52.08) | 92.64 (74.24) | 94.46 (77.77) | 94.62 (77.96) | 85.99 (70.51) |
| Mean | 83.27 (70.46) | 95.24 (79.65) | 97.26 (83.90) | 98.13 (85.56) | |
| | **Fungicides (F)** | **Conc. (C)** | **F x C** | | |
| SEm ± | 0.84 | 0.78 | 1.68 | | |
| C. D at 5% | 0.97 | 2.69 | 4.67 | | |
| C. V. (%) | 4.71 | | | | |

*Figures in parentheses are angular transformations

**Table 2: Bio-efficacy of Fenamidone + Mancozeb against damping off disease in FCV tobacco nurseries**

| Treatment details | Average germination at 15 DAS* /m² | | | No. of seedlings / m² | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Damped off | | | | Transplantable | | |
| | 2008 | 2009 | Pooled | 2008 | 2009 | Pooled | % control over check | 2008 | 2009 | Pooled |
| Fenamidone + Mancozeb drenching @ 0.1% and spray @ 0.1% | 42.5 | 58.5 | 50.5 | 110.00 (10.43) | 48.75 (6.87) | 74.87 (8.65) | 51.54 | 578 | 678 | 628 |
| Fenamidone + Mancozeb drenching @ 0.1% and spray @ 0.2% | 51.5 | 64.3 | 57.9 | 58.75 (7.62) | 18.50 (4.24) | 35.25 (5.93) | 66.95 | 616 | 679 | 648 |
| Fenamidone + Mancozeb drenching @ 0.1% and spray @ 0.3% | 47.3 | 59.5 | 53.4 | 17.25 (3.56) | 5.00 (1.90) | 7.48 (2.73) | 82.69 | 843 | 868 | 856 |
| Metalaxyl + Mancozeb spray @ 0.2% | 49.3 | 56.3 | 52.8 | 22.75 (4.65) | 7.50 (2.69) | 13.52 (3.67) | 79.38 | 812 | 775 | 793 |
| Copper oxychloride spray @ 0.2% | 48.3 | 59.8 | 54.0 | 74.50 (8.59) | 114.25 (10.29) | 89.16 (9.44) | 47.11 | 630 | 525 | 578 |
| Control (Untreated) | 47.0 | 59.3 | 53.1 | 188.00 (13.44) | 498.00 (22.26) | 318.76 (17.85) | - | 398 | 294 | 346 |
| SEm± | 2.21 | 3.43 | 2.04 | 0.79 | 0.93 | 0.33 | - | 33.22 | 58.83 | 33.78 |
| CD at 5% | NS | NS | NS | 2.40 | 2.80 | 0.96 | - | 100.11 | 177.31 | 97.56 |
| CV% | 9.30 | 11.54 | 10.79 | 19.80 | 23.16 | 11.74 | - | 10.28 | 18.47 | 14.89 |
| S x T interaction | | | | | | | | | | |
| SEm± | - | - | 2.89 | - | - | 0.47 | - | - | - | 47.78 |
| CD at 5% | - | - | NS | - | - | 1.36 | - | - | - | NS |

Figures in parentheses are square root transformations
* DAS = Days after sowing

**Table 3: Economics of damping off disease control in FCV tobacco nurseries with fenamidone + mancozeb**

| Treatment Details | Transplantable seedlings/ha | Cost of cultivation (Rs/ha) | Gross returns (Rs/ha) | Net returns (Rs/ha) | C : B Ratio |
|---|---|---|---|---|---|
| Fenamidone + Mancozeb drenching @ 0.1% and spray @ 0.1% | 35,79,600 | 2,31,140 | 2,50,572 | 19,432 | 1:1.08 |
| Fenamidone + Mancozeb drenching @ 0.1% and spray @ 0.2% | 36,93,600 | 2,33,740 | 2,58,552 | 24,812 | 1:1.11 |
| Fenamidone + Mancozeb drenching @ 0.1% and spray @ 0.3% | 48,79,200 | 2,36,340 | 3,41,544 | 1,05,204 | 1:1.45 |
| Metalaxyl + Mancozeb spray @ 0.2% | 45,20,100 | 2,30,240 | 3,16,407 | 86,167 | 1:1.37 |
| Copper oxychloride spray @ 0.2% | 32,94,600 | 2,28,440 | 2,30,622 | 2,182 | 1:1.01 |
| Check (untreated) | 19,72,200 | 2,27,240 | 1,38,054 | -89,186 | 1:0.61 |

followed by metalaxyl + mancozeb spray @ 2g/lit with a net returns of Rs. 86,167 and a C:B ratio of 1.37. The maximum economic loss was recorded in untreated check (Rs. -89,186 and C:B ratio of 0.61). In case of copper oxychloride, the economic analysis revealed a net returns of Rs 2,182 with C:B ratio of 1.01. The study clearly identified the economic advantage of using either fenamidone + mancozeb drenching @ 0.1% followed by spray @ 0.3% or metalaxyl + mancozeb spray @ 0.2%.

From the *in vitro* studies and the field experiments conducted during 2008 and 2009 nursery seasons on the efficacy of fenomidone 10% + mancozeb 50% (Sectin) at different concentrations in controlling damping off disease, it may be concluded that all the concentrations of the fungicide, controlled damping off disease and protected the transplantable seedlings. However, among the three concentrations, fenomidone 10% + mancozeb 50% @ 0.1% drench and 0.3% spray twice was superior over the other two concentrations and copper oxychloride and was found to be on par with metalaxyl + mancozeb @ 0.2% in terms of disease control as well as economics and hence can be recommended for management of the damping off disease in tobacco nurseries as an alternative to metalaxyl + mancozeb.

**ACKNOWLEDGEMENT**

Authors are thankful to M/s Bayer Crop Science Limited, Mumbai, India for providing financial support in conducting these studies.

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Tobacco Research 49(1): 15-17, 2023

# EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM ON YIELD POTENTIAL OF *MOTIHARI* TOBACCO

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(Received on Mar., 2023 and accepted on June 17th, 2023)

**Tobacco an important commercial cash crop of West Bengal grows mainly in the northern district of Cooch Behar, Jalpaiguri and Malda, covering an area of 14,000 ha. The present study was under taken to study effect of different inorganic and organic fertilization on yield and quality of *Motihari* tobacco during 2021-2022 crop season. A total of 10 treatment combinations were followed in RBD with three replications and the fertilizers were applied as Urea, SSP and MOP. The results showed that nutrients applied in the form of inorganic @ 112 kg N+ 112 kg $P_2O_5$+ 112 kg $K_2O$/ha plus50 kg N+ 20 kg $P_2O_5$+ 50 kg $K_2O$/ha in the form of FYM (10 t FYM/ ha) (NPKF) recorded in the cured leaf yield (2265.6 kg/ha), first-grade leaf yield (845.0 kg/ha), and quality outturn (38.0%). The result of this study will be useful for increasing yield of tobacco.**

## INTRODUCTION

Motihari tobacco (*N. rustica*) has been the major cash crop in *Terai* agro - ecological zone of North Bengal for small and marginal farmers since time immemorial. Its cultivation is distributed mainly in Cooch Behar and Jalpaiguri district in about 10,000 ha. The crop is unique for the reason that almost all portions of the plant have commercial value in the market. Leaf is popular for end users in the manufacture of khaini, Gurakhu, hookah paste, gul etc. and its dried stem is exported to Bangladesh for the manufacture of cigarette bidi i.e. the kandi (small bits ) of stem is blended with bidi tobacco and rolled in paper to enhance the burning quality of the product. A good soil quality is the key factor for higher yield and quality production (Arvidsson *et al.,* 2019). The traditional farming system and extreme use of chemical fertilizers affect the soil quality of cultivated land (Delpin Malvezi *et al.,* 2019), resulting in soil compaction, enhanced root resistance and deterioration of soil physical properties (such as soil aeration and water content) in many areas (Kuncoro *et al.,* 2014). Tobacco requires a large amount of nitrogen, phosphorus and potassium and the average nitrogen application rate is 180 kg $ha^{-1}$ (Zheng *et al.,* 2022). To improve crop growth and production, farmers use increased rate of NPK fertilizer. Cameron et al (2013) reported that excessive application of chemical fertilizers can reduce the nitrogen use efficiency and leads to nitrogen loss resulting in land pollution and less farmers' income. However there is no information about the response of *Motihari* tobacco variety to NPK fertilizer in Terai region of West Bengal. Therefore, the present study was under taken to study effect of different inorganic and organic fertilization on yield and quality of *Motihari* tobacco.

## MATERIALS AND METHODS

The present experiment was conducted from September to December 2021 at the experimental farm of ICAR-Central Tobacco Research Institute Research Station Dinhata, West Bengal. Field was layed out as permanent plot without disturbing with plot size of 6.3 m 5.4 m since beginning. A total of 10 treatment combinations were followed in RBD with three replications. All the fertilizers were applied as Urea, SSP and MOP. Well rotten cow dung manure was applied 15 days before planting. The seeds of *Motihari* tobacco was sown in the month of October, 2021 and one month old

**Key words:** Tobacco, yield, quality, NPK, FYM

seedling were transplanted. All other recommended intercultural practices and plant protection measures were followed in all the treatments. The layout of the trail is given in Figure 1. The observations were taken at maturity stage from 5 randomly selected plants for cured leaf yield, first grade leaf yield and quality out-turn. The data were analysed by adopting standard statistical package.

**Figure 1**: Layout of the experiment

## RESULTS AND DISCUSSION

The results showed that nutrients applied in the form of inorganic fertilizers @ 112 kg N+ 112 kg $P_2O_5$+ 112 kg $K_2O$/ha plus 50 kg N+ 20 kg $P_2O_5$+ 50 kg $K_2O$/ha in the form of FYM (10 t FYM/ha) (NPKF) recorded the maximum cured leaf yield (2265.6 kg/ha), first-grade leaf yield (845.0 kg/ha), and quality out turn (38.0%). Moreover, NPKF recorded 2.4-fold higher cured leaf yield, 5.8-fold higher first grade leaf yield compared to control. Furthermore, nitrogen applied plots found higher leaf yield than nitrogen omission plots. Thus, nitrogen fertilizer plays crucial role to determine the leaf yield and quality of *Motihari* tobacco. Optimizing nitrogen application methods can improve nitrogen use efficiency, and it has been proved that the best way to improve fertilizer use efficiency is to reduce nitrogen application rates (Beatriz Restovich *et al.,* 2019). It is concluded that balanced fertilizer can increase yield and quality of tobacco. In the specific case of tobacco production, both nutrients play a key role in controlling important quality parameters such as cured leaf yield, first grade leaf yield and quality out-turn. Monitoring N applications thoroughly for form, quantity, and timing of application is a

**Table 1: Effect of different inorganic and organic fertilization on cured leaf and first grade leaf yield, and quality out-turn**

| Treatment | Cured leaf yield (kg/ha) | First grade leaf yield (kg/ha) | Quality out-turn (%) |
|---|---|---|---|
| N | 1391.3 | 498.6 | 33.6 |
| NK | 1490.3 | 545.0 | 35.8 |
| NP | 1784.2 | 667.1 | 37.0 |
| NPKF | 2265.6 | 845.0 | 38.0 |
| PK | 1173.9 | 217.0 | 19.8 |
| P | 1100.2 | 355.9 | 11.6 |
| K | 1058.8 | 199.5 | 19.6 |
| 25t FYM | 1199.5 | 234.4 | 20.8 |
| 50 t FYM | 1300.7 | 300.4 | 25.8 |
| Control | 955.1 | 145.1 | 15.8 |
| SEm± | 43.26 | 13.37 | - |
| CD | 125.32 | 38.73 | - |

N: 112 kg/ha, $P_2O_5$: 112 kg/ha, $K_2O$: 112 kg/ha

prerequisite in modern agriculture. As in other field crops, balanced N-K fertilization enhances tobacco growth and improves the uptake of both nutrients, which in turn reduces nitrate losses during and after the cropping season. Marchand (2010) reported that more leaf production occur at early N application followed by a later application of K in response to plant requirement.

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Tobacco Research 49(1): 18-22, 2023

# EFFECTS OF ANTAGONISTIC CROP FOR MANAGEMENT OF ROOT-KNOT NEMATODE IN BIDI TOBACCO NURSERY

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(Received on Dec., 2023 and accepted on June 27th, 2023)

**Root-knot nematodes (*Meloidogyne* spp.) are economically damaging plant parasitic nematodes in bidi tobacco nurseries and act as primary source of inoculum which spreads into the main field. For control, chemical nematicides can be used, but the range of available compounds is limited. The available nematicides are expensive and their use have negative impact on the environment and on public health. As a result, there is growing interest in alternative methods for the management of root-knot nematode which are economically viable and non-polluting to the environment. Therefore, the main objective of the present study was to evaluate the effect of different crop residues on root-knot nematode in bidi tobacco nursery. The experiment was taken up for two years (2020-21 to 2021-22) at Bidi Tobacco Research Station, Anand Agricultural University, in randomized block design with six treatments *viz.*, mustard, sesamum, cluster bean, sunnhemp, marigold along with control. The pooled data on germination count revealed that results were non-significant among treatments in individual years and pooled data. The rove beetle counts remain at par with each other indicated that different biofumigant crop does not have any impact on its population. The fresh weight per 100 seedlings was registered in mustard (793 g) which numerically followed by sunnhemp (788 g) and marigold (678 g). The data of healthy transplantable seedlings revealed that maximum transplantable seedlings (618/m²) registered with sunnhemp followed by mustard (538/m²). The minimum transplantable seedlings were found in fallow treatment(388/m²) which is at par with sesamum (397/m²) and marigold (437/m²). Root-knot index was significantly reduced in all the treatments compared to control. The treatment of mustard as biofumigant crop significantly reduced root-knot disease compared to other treatments.**

## INTRODUCTION

Bidi tobacco (*Nicotiana tabacum* L.) is an important cash crop grown in middle Gujarat, Nipani area of Karnataka, some parts of Andhra Pradesh, and Maharashtra in India. Root-knott nematodes (*Meloidogyne* spp.) are economically damaging nematodes in bidi tobacco nurseries and act as primary source of inoculum which spread into the field. For control, chemical nematicides can be used, but the range of available compounds is limited. The compounds are expensive and their uses have negative impacts on the environment and on public health. As a result, there is growing interest in alternative methods of management that are economically viable and non-polluting. (Fourie, *et al.*, 2016). Its efficiency is maintained in time through its introduction into an integrated crop management (ICM) system. It has been demonstrated by various researchers that antagonistic crops lead to the significant reduction of various economically important nematode pest populations and the symptoms they cause to crops, with subsequent increases in yield/quality of such crops. Moreover, isothiocyanates (ITCs) released by Brassicaceae crops can, however, be equally or even more toxic than their synthetically-derived peers (Gimsing and Kirkegaard, 2009; Vervoort *et al.*, 2014). Potential modes-of-action of Brassicaceae crops against PPN include the production of nematotoxic GSL-degradation products, viz. ITCs, thiocyanates, nitriles or oxazolidinethiones (Lazzeri *et al.*, 1993; Sarwar *et al.*, 1998; Zasada and Ferris, 2003), stimulation of antagonistic microbial communities in amended

**KEYWORDS:** Root-knot nematode, antagonistic crop, bidi tobacco nursery

soil and the production of nitrogenous compounds that are toxic to nematodes (Cohen *et al.*, 2005; Kirkegaard and Matthiessen, 2004; Larkin and Griffin, 2007; Van Dam *et al.*, 2009). Therefore, the present research work was carried out to study on effect of different antagonistic crop to manage nematodes in bidi tobacco nursery.

## MATERIALS AND METHODS

The experiment was carried out at the nursery of Bidi Tobacco Research Station, AAU, Anand. Twenty four beds, each of 1.2 x 1.2m size, were prepared. Six treatments viz., mustard, french marigold, sunnhemp, clusterbean, sesamum and fallow were tried. All the treatments were replicated four times in randomized completely block design (RCBD). Each bed of 1.44 $m^2$ size for each of the above six treatments were grown according to season and after flowering the respective crop were chopped and incorporated into the soil by making furrow. After incorporation in furrow immediately cover it with soil and saturated through watering. Frequent watering allows the retention of gases by maintaining a thin impermeable layer on the surface. Each bed was seeded with bidi tobacco cv. GT 7 @ 5 kg/ha after complete decomposition of the respective crop treatments. All agronomic practices in vogue were followed. Soil samples from each bed were collected at the time of sowing and at the end of the experiment. For recording the RKI observations, twenty-five seedlings were randomly uprooted at each pulling from each net plot area and number of galls on seedlings were recorded as per (0-5) scale. Similarly, the observations on other parameters (germination count per 25 sq. cm, rove beetle per 25 sq. cm, seedling per $m^2$; number of transplants, fresh weight in gram) were recorded after following standard procedure. The data were statistically analyzed.

## RESULTS AND DISCUSSION

The data presented in Table 1 revealed results were non significant among treatments of different antagonistic crops for germination count. The rove beetle counts remain at par with each other indicating that different biofumigant crop does not have any impact on their population. The fresh weight per 100 seedlings was registered in mustard (793 g) which was numerically followed by sunnhemp (788 g) and marigold (678 g). The maximum transplantable seedlings (618/$m^2$) registered with sunnhemp followed by mustard (538/$m^2$). The minimum transplantable seedlings were found in fallow treatment (388/$m^2$) which is at par with sesamum (397/$m^2$) and marigold (437/$m^2$). Incorporation of crop residues and green leaves resulted in an increase in organic matter, water-holding capacity and nutrient status of soil. Root-knot index (Table 3) was significantly reduced in all the treatments compared to control. The treatment of mustard as antagonistic crop

**Table 1: Effect of different antagonistic crop on germination and rove beetle**

| Sr. No. | Treatment | Germination count/ 25cm² | | | Rove beetle count/ 25cm² | | |
|---|---|---|---|---|---|---|---|
| | | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled |
| 1 | Mustard | 4.75 | 5.05 | 4.90 | 1.05(0.88)* | 1.03(0.85)* | 1.04(0.86)* |
| 2 | Sesamum | 5.38 | 4.30 | 4.84 | 0.96(0.93) | 0.88(0.78) | 0.92(0.85) |
| 3 | Clusterbean | 4.90 | 3.83 | 4.36 | 0.96(0.93) | 0.93(0.88) | 0.95(0.90) |
| 4 | Sunnhemp | 4.68 | 5.70 | 5.19 | 0.91(0.83) | 0.95(0.90) | 0.93(0.86) |
| 5 | Marigold | 5.38 | 6.25 | 5.81 | 0.93(0.88) | 0.91(0.83) | 0.92(0.85) |
| 6 | Fallow | 5.38 | 5.00 | 5.19 | 0.93(0.88) | 0.91(0.83) | 0.92(0.85) |
| | S Em ± | 0.52 | 0.59 | 0.41 | 0.05 | 0.05 | 0.03 |
| | CD at 5 % | NS | NS | NS | NS | NS | NS |
| | C.V. % | 20.36 | 23.66 | 22.06 | 9.65 | 11.49 | 10.50 |

*Figure in parenthesis is original value, while outside is $\sqrt{x+1}$ transformation

**Table 2: Effect of different antagonistic crop on seedlings (Pooled)**

| Sr. No. | Treatment | Fresh weight of 100 seedlings (g) | | | Total transplantable seedlings | | | Total surviving seedlings | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled |
| 1 | Mustard | 805 | 780 | 793 | 477 | 509 | 493 | 520 | 557 | 538 |
| 2 | Sesamum | 575 | 665 | 620 | 369 | 360 | 364 | 391 | 404 | 397 |
| 3 | Clusterbean | 575 | 610 | 593 | 360 | 456 | 408 | 395 | 521 | 458 |
| 4 | Sunnhemp | 800 | 775 | 788 | 502 | 609 | 556 | 560 | 676 | 618 |
| 5 | Marigold | 675 | 680 | 678 | 366 | 405 | 385 | 412 | 462 | 437 |
| 6 | Fallow | 600 | 650 | 625 | 346 | 321 | 333 | 392 | 384 | 388 |
| | S Em ± | 73.67 | 61.60 | 45.27 | 31.43 | 29.81 | 22.46 | 31.21 | 31.33 | 22.90 |
| | CD at 5 % | NS | NS | 130.07 | 94.71 | 89.83 | 64.53 | 94.05 | 94.42 | 65.79 |
| | C.V. % | 21.94 | 17.77 | 19.90 | 15.59 | 13.46 | 14.48 | 14.04 | 12.51 | 13.23 |
| | Y x T | | | | | | | | | |
| | S.Em. ± | 30.63 | 30.63 | 31.27 | | | | | | |
| | CD at 5 % | NS | NS | NS | | | | | | |

**Table 3: Effect of different antagonistic crop on root-knot index (Pooled)**

| Sr. No. | Treatment | RKI (0-5) *, I Pulling | | | RKI (0-5) *, II Pulling | | | RKI (0-5) *, III Pulling | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled |
| 1 | Mustard | 1.05 (0.11)** | 1.05 (0.10) | 1.051 (0.11) | 1.38 (0.90) | 1.39 (0.95) | 1.385 (0.93) | 1.59 (1.54) | 1.65 (1.74) | 1.623 (1.64) |
| 2 | Sesamum | 1.09 (0.18) | 1.09 (0.18) | 1.086 (0.18) | 1.46 (1.13) | 1.47 (1.17) | 1.466 (1.15) | 1.73 (1.98) | 1.76 (2.09) | 1.741 (2.04) |
| 3 | Clusterbean | 1.08 (0.16) | 1.08 (0.16) | 1.077 (0.16) | 1.46 (1.12) | 1.48 (1.18) | 1.466 (1.15) | 1.75 (2.07) | 1.78 (2.18) | 1.767 (2.13) |
| 4 | Sunnhemp | 1.08 (0.17) | 1.09 (0.19) | 1.086 (0.18) | 1.44 (1.08) | 1.48 (1.18) | 1.459 (1.13) | 1.78 (2.17) | 1.79 (2.20) | 1.785 (2.19) |
| 5 | Marigold | 1.07 (0.14) | 1.08 (0.16) | 1.072 (0.15) | 1.46 (1.14) | 1.47 (1.16) | 1.466 (1.15) | 1.76 (2.11) | 1.77 (2.15) | 1.769 (2.13) |
| 6 | Fallow | 1.08 (0.16) | 1.07 (0.15) | 1.074 (0.16) | 1.48 (1.19) | 1.50 (1.24) | 1.488 (1.22) | 1.94 (2.77) | 1.98 (2.92) | 1.959 (2.84) |
| | S Em ± | 0.01 | 0.01 | 0.006 | 0.02 | 0.03 | 0.016 | 0.03 | 0.02 | 0.017 |
| | CD at 5 % | NS | NS | 0.016 | NS | NS | 0.046 | 0.09 | 0.06 | 0.048 |
| | C.V. % | 1.45 | 1.63 | 1.54 | 3.08 | 3.61 | 3.35 | 3.40 | 2.10 | 2.82 |
| | Y x T | | | | | | | | | |
| | S Em ± | 0.008 | 0.024 | 0.025 | | | | | | |
| | CD at 5 % | NS | NS | NS | | | | | | |

*0= free; 5= maximum disease intensity **Figure in parenthesis is original value, while outside is transformation

**Table 4: Effect of different antagonistic crop on nematode population**

| Sr. No | Treatment | Nematode population /200 cc soil | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Initial | | | | Final | | | |
| | | Root-knot | Reni form | Stunt | Total | Root-knot | Reni form | Stunt | Total |
| 1 | Mustard | 20 | 23 | 25 | 68 | 251 | 230 | 224 | 706 |
| 2 | Sesamum | 32 | 28 | 34 | 95 | 411 | 274 | 421 | 1107 |
| 3 | Clusterbean | 24 | 30 | 38 | 92 | 267 | 303 | 441 | 1010 |
| 4 | Sunnhemp | 29 | 26 | 26 | 81 | 328 | 275 | 352 | 954 |
| 5 | Marigold | 25 | 20 | 30 | 74 | 299 | 316 | 296 | 911 |
| 6 | Fallow | 14 | 21 | 33 | 68 | 313 | 240 | 259 | 812 |

**Table 5: Economics of the effective treatments**

| Treatments | Seed rate (kg/ha) | No. of TP/ha ('000) | Gross income Rs/ha | Cost of prod., Rs/ha | Net realiz., Rs/ha | Additional over control | | ICBR |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Income Rs/ha | Expen. Rs/ha | |
| Mustard | 25 | 3451 | 1035300 | 260250 | 775050 | 325750 | 10250 | 1:31.78 |
| Sunnhemp | 100 | 3892 | 1167600 | 264000 | 903600 | 454300 | 14000 | 1:32.45 |
| Fallow | - | 2331 | 699300 | 250000 | 449300 | | | |

significantly reduced root-knot disease compared to other treatments. Here in this study, incorporation of chopped mustard residues under anaerobic conditions resulted in liberation of methyl isothiocyanate which inhibited the activity of plant parasitic nematodes. Results are in conformity with findings of Nimisha and Nisha (2019) that using crop residues of cabbage significantly reduced nematode population in soil and root and it was reflected in improvement in the growth and yield of banana plants. Soil microbial activity have increased due to addition of organic matter that may have a direct effect on the plant parasitic nematode population (Widmer and Abawi, 2000). The economics worked out for effective treatments revealed an ICBR of 1:31.78 and 1:32.45 for mustard and sunnhemp, respectively. It is concluded that the present finding as growing mustard (25 kg seed/ha) in *rabi* OR sunnhemp (100 kg seed/ha) in summer season as antagonistic crops and incorporating in soil at 50% flowering stage will help the farmers raising tobacco nursery to manage root-knot disease and thereby increase number of healthy seedlings for transplanting.

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Tobacco Research 49(1): 23-28, 2023

# ASSESSMENT OF MAINSTREAM SMOKE CONSTITUENTS OF *BIDI*

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(Received on Jan. 25th, 2023 and accepted on July 12th,2023)

**In India, smoking accounts for majority of total tobacco consumption (72%), and among the total smoking habits, 73 % is in the form of bidi. Hence, in the present study mainstream smoke constituents were analysed in bidis prepared from different bidi tobacco (*Nicotiana tabacum* L.) lines. Tar (NFDPM), nicotine and carbon monoxide (CO) were determined by using 20 port Linear Smoking Machine, SM 450 of CERULEAN. GC-TCD/FID (HP 5890 Series II). The mean values and ranges of tar, nicotine and carbon monoxide content in smoke of bidi samples were 70.66 (40.60-92.05) mg $g^{-1}$, 5.36 (1.98-7.20) mg $g^{-1}$ and 43.01 mg $g^{-1}$, (25.78 – 61.06) respectively. While nicotine in leaf varied from 19.00 mg $g^{-1}$ to 55.00 mg $g^{-1}$ and the mean value was 34.80 mg $g^{-1}$. It was found that tar and carbon monoxide in bidi smoke had a linear positive and significant relationship ($R^2$ *value: 0.941).* Increased tar contents in bidi samples with increased CO levels was observed. The study indicated that low tar and low CO emitting bidis prepared from bidi tobacco with low tar levels would help in reducing the risk of direct & indirect health concerns, and also the environmental issues.**

## INTRODUCTION

"Bidis" or "beedis" are slim, hand-rolled, unfiltered tobacco smoking product. They are also called "beeris" in countries such as Bangladesh. Bidis are the most popular smoking form of tobacco in India and the cost of bidis are very less, thus bidis are known as the "poor man's cigarettes", as they are smaller and cheaper than cigarettes (Gupta *et al.,* 2008). Bidi tobacco occupies 30-35% of the total area under tobacco cultivation and is grown in Gujarat, Karnataka and Maharashtra with the yield ranging from 1000 to 1700 kg $ha^{-1}$ (Gupta *et al.,* 2004).

India accounts for more than 85% of the world's bidi production (Chaman Bidi Export., 2003) and 34 % of the tobacco produced in India is used for making bidis. In India, smoking accounts for majority of total tobacco consumption (72%), and among the total smoking habits, 73 % is in the form of bidi and 27% is in the form of cigarette (Chaudhry *et al.,* 2000). Bidis account for over 50 % of total tobacco use, compared with less than 20 % by the cigarette segment. Roughly eight bidis are sold for every cigarette (Srivastava *et al.,* 2000*).*

Dark and sun-dried tobacco varieties are used in bidi making. A bidi consists of about 200 mg of sun-dried and processed bidi tobacco flakes rolled in tendu leaf (*Diospyrus melanoxylon*) or *temburni* leaf belonging to the family *Ebenaceae* and held together by a cotton thread (Gupta *et al.,* 2004). The *tendu* leaf constitutes 60% of the weight of the bidi. Tendu leaf is considered as the most suitable wrapper on account of the ease with which it can be rolled, texture, agreeable flavour, flexibility, resistance to decay, capacity to retain fire and availability. The morphological characters on which leaves are selected and categorized for Bidi making are size, thickness of leaves, texture, relative thickness of midrib and lateral veins (Table.1).

The length of the bidi varies from 4 to 8 cm with a diameter of 6 - 8 mm at the closed end and a width of 7 - 9 mm at the smoking end. Bidis are puffed more frequently than cigarettes to prevent them from extinguishing. When inhaled, carbon monoxide, instead of oxygen, is picked up by the hemoglobin of your red blood cells. The result is less oxygen being transported around your body and tar is a toxic residue that coats and paralyzes the cilia of the lungs. Therefore, it is pertinent to study the smoke constituents in the locally developed bidi tobacco lines to identify low tar lines

**Key Words:** Bidi, Nicotine, TAR, Carbon monoxide and Smoke condensate.

**Table 1: Physicochemical characteristics of raw tendu leaf residues (mean ± SE).**

| Parameter | | | Parameter | | |
|---|---|---|---|---|---|
| pH | : | 8.2 ± 0.1 | Iron (ppm) | : | 35.0 ± 1.52 |
| Carbon (%) | : | 58.0 ± 2.07 | Copper (ppm) | : | 30.0 ± 1.00 |
| Nitrogen (%) | : | 1.38 ± 0.01 | Manganese (ppm) | : | 10.0 ± 0.01 |
| Phosphorus (%) | : | 0.084 ± 0.03 | Zinc (ppm) | : | 14 ± 1.52 |
| Potassium (%) | : | 0.43 ± 0.01 | C/N ratio | : | 42 |
| Calcium (%) | : | 1.20 ± 0.02 | | | |

Source: Dilip Kadam and Girish Pathade, (2014).

/ entries and the quantitative relationship between tar and carbon monoxide would help in producing bidis with lower levels of tar and carbon monoxide of tar and carbon-monoxide along with acceptable nicotine content.

## MATERIALS AND METHODS

*2.1 Sample preparation*

The bidi samples were prepared using bidi tobacco lines obtained from ARS, *Nandyal*, Andhra Pradesh, India. The bidi samples were conditioned in a desiccator cabinet at 25 C and 60 % RH (ISO 3402: 1999a) for 48 hrs. Bidis within the range of ± 30 mg of average weight were selected by using analytical balance measuring to the nearest 0.1 mg. Bidis within the range of ± 2 mm of average length were selected using a length measuring device measuring to the nearest 0.5 mm. The bidis thus selected were grouped out, butt length marked , and smoked on a 20-port Linear Smoking Machine (SM 450, Cerulean, UK) by adopting the standard parameters as per ISO methods. The major smoke parameters TPM and NFDPM (ISO 17175:2017(E)), Water (ISO 10362-1:19996), Nicotine (ISO 10315- 2000b) and CO (ISO 8454-2007) were determined.

*2.2 Determination of Total Particulate Matter (TPM)*

The machine was setup by warming up cycles and puff volume of each channel was checked by using soap bubble flow meter. Air flow velocity was checked by using air velocity meter. Standard conditions of Puff duration (2 ± 0.02) s and puff frequency (30 ± 0.5) s and puff volume 35±0.3 ml was maintained for smoke run. The selected, and grouped bidis were inserted into the smoke trap fixed to the bidi holder, Initially the weight of the smoke trap with Cambridge filter pad kept inside was recorded and the front and back apertures were sealed with sealing devices. Cotton thread was used to terminate smoking at the butt mark. When each butt mark has been reached, the burning coal was removed from the bidi holder. The smoking process was repeated until the predetermined number of bidis were smoked as per the smoking plan into the smoke trap. The smoke trap was removed and covered the front and back apertures with sealing devices and the final reading of the holders was recorded. Total Particulate Matter (mg per bidi) was calculated by taking the difference of readings of before and after smoking process and mg/bidi was expressed as mg/g. The values of the tar, nicotine and CO in mg /g were calculated by taking bidi weight as a whole (Replacing bidi with its weight in grams converting it to per gram). Since the length and weight of the bidi vary from brand to brand, to know the difference among the values of different brands the values were expressed in uniform unit i.e mg per gram.

*2.3 Determination of Water/moisture*

After removing the sealing devices from the smoke trap, the filter pads were transferred to 150 ml Erlenmeyer flasks and 20 ml of Propan-2-ol prepared with dried methanol and *n-hepta decane* as internal standards (Merck) was added for determination of water and nicotine, respectively. The flasks were tightly sealed with Teflon and were shaken in a horizontal shaker for 20 minutes. A blank smoke trap was taken for blank determination of water. Gas Chromatograph (HP 5890 Series II, Agilent, USA) with TCD and a column (Length: 6 feet) of internal diameter between 2 mm and 4 mm with stationary phase

porapak QS was used. GC programme was maintained as oven temp: 170 C (isothermal), injector temp: 250 C, detector temp: 250 C, carrier gas helium, with flow rate 30 ml/min and injection volume of 2 µl. The unknown concentrations (mg/bidi) were measured using a graph plotted by running the water (Millipore) standards and mg/bidi moisture was expressed as mg/g.

*2.4 Determination of Nicotine*

Similarly, Gas Chromatograph (HP 5890 Series II, Agilent, USA) with FID and a column (length: 6 feet) of internal diameter between 2 mm and 4 mm with stationary phase:10% PEG 20000 plus 2% potassium hydroxide on an acid washed salinized support material, was used. GC programme was maintained as oven temp: 170 C (isothermal), injector temp: 250 C, detector temp: 250 C, carrier gas helium, with flow rate 30ml/min, auxiliary gases hydrogen and air were used for flame. Injection volume was 2 µl. The unknown concentrations (mg/bidi) were measured using a graph plotted by running the pure nicotine (Merck) standards.

*2.5 Determination of Nicotine Free Dry Particulate Matter (NFDPM, or Tar)*

Nicotine Free Dry Particulate Matter (NFDPM) which is also termed as tar. NFDPM (mg /bidi) was calculated by subtracting the values of water and nicotine from TPM and mg/bidi tar was expressed as mg/g.

*2.6 Determination of Carbon monoxide (CO).*

Carbon monoxide (mg/bidi) was measured using NDIR principle by COA 205 Analyser (Cerulean, UK) which was inbuilt in Smoking Machine, SM 450 and mg/bidi Carbon monoxide was expressed as mg/g.

**RESULTS AND DISCUSSION**

The bidi samples under investigation were analyzed for smoke parameters tar, nicotine, and carbon monoxide. In bidi leaf nicotine and reducing sugars were also analyzed. The values of physical parameters of bidi samples, smoke parameters and leaf quality parameters (expressed in mg $g^{-1}$) of bidi samples were given in Table.2. The average weight of the samples varied from 0.4697 to 0.5730 g with a mean value of 0.530 g. The length of the samples varied from 65 to 76 mm with a mean value of 70.6 mm.

*3.1. Bidi mainstream smoke constituents*

Samples of different bidi lines of four seasons of the study were assessed and the mean values of tar, smoke nicotine, leaf nicotine and carbon monoxide were 70.66 mg $g^{-1}$, 5.36 mg $g^{-1}$, 34.92 and 43.01 mg $g^{-1}$, respectively (Table.2). Among the bidi samples of different lines studied, tar content varied from 40.60 to 92.05 mg $g^{-1}$ . Similarly, Carbon monoxide content ranged between 27.78 and 61.06 mg $g^{-1}$. Nicotine in smoke condensate varied from 1.98 to 7.26 mg $g^{-1}$. The nicotine concentration in the tobacco of bidi cigarettes was significantly greater than the tobacco from the commercial filtered and unfiltered cigarettes (Malson, et al. 2001). Bidi cigarettes can deliver high levels of tar (77.9±9.5 mg/bidi), nicotine (2.7±.4 mg/bidi), and CO (39.2±5.7 mg/bidi) (Clifford and Watson., 2003).

Moisture content in the smoke varied from 17.89 to 43.38 mg $g^{-1}$ with a mean value of 26.92 (Table.2). The smoke quality of a bidi depends on the quality of bidi leaf tobacco and the natural wrapper (*Tendu* leaf) that is used for bidi making. The non-porous nature and higher moisture content of tendu leaf in bidis compared to cigarette wrapping paper led to higher levels of carbon monoxide and tar in bidi smoke compared to regular cigarette smoke (Oladipupo, et al, 2019).

3.2. Bidi Leaf quality

Leaf nicotine varied from 19.0 to 55.0 mg $g^{-1}$. No relationship was found between smoke nicotine with leaf nicotine. Reducing sugars in leaf tobacco of bidi varied from 14.8 to 55.1 mg $g^{-1}$. Higher levels of reducing sugars in tobacco reduce the harshness of the smoke.

*3.3. Relationship of Tar to Carbon-monoxide in bidi mainstream smoke*

Correlation between tar and CO was studied was found to be highly positive and significant

(Pearson Correlation Coefficient R value: 0.9536, P-Value < .00001 (p<0.01), Table.3). Further the relationship of Tar content and Carbon monoxide in bidi mainstream smoke was established using linear regression analysis. A model was developed to indicate the relationship and to predict the CO levels through the equation (Fig.2).

Linear regression Model: Tar (mg $g^{-1}$) = 8.9169 + 1.439 * Carbon monoxide (mg $g^{-1}$).

A significant linear relationship between Tar content and Carbon monoxide content in the smoke of bidis was found ($R^2$: 0.941) (Table.4, Fig.1) It is inferred that bidi tobacco smoke with higher tar levels contribute to higher CO levels. It is concluded that tar, nicotine and carbon monoxide contents in smoke of bidi samples were relatively high compared to FCV tobacco smoking products. Higher tar contents in bidi samples correlated with higher CO levels indicated that *bidi tobacco*-based bidis having low tar and CO are preferable as it is well known that tar and carbon monoxide are not good for human health and the environment. As smoking habit in India is high in the form of bidi and consumption of this form of tobacco for smoking is increasing in other parts of the world, it is henceforth become an important researchable and health care subject to develop bidis and bidi tobacco types with low tar and CO which help in reducing these levels in mainstream smoke of *bidi*.

**Table 2: Physical, smoke and leaf quality parameters (mean) of different bidi lines.**

| Bidi tobacco lines code | Bidi weight (g) | BidiLength (mm) | Tar or NFDPM (mg $g^{-1}$) | Smoke Nicotine (mg $g^{-1}$) | Carbon monoxide | Leaf Nicotine (mg $g^{-1}$) | Leaf Reducing sugars (mg $g^{-1}$) | Moisture (mg $g^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| A 119 | 0.5730 | 71 | 64.84 | 5.27 | 38.74 | 29.7 | 33.18 | 21.66 |
| ABD 114 | 0.5176 | 72 | 85.49 | 6.30 | 52.07 | 23.0 | 31.00 | 21.12 |
| ABD 115 | 0.5309 | 72 | 72.91 | 4.84 | 46.54 | 19.0 | 29.90 | 17.89 |
| ABD 116 | 0.5000 | 72 | 78.70 | 4.92 | 50.96 | 20.7 | 23.90 | 26.26 |
| ABD 117 | 0.4904 | 72 | 87.38 | 4.28 | 54.63 | 21.0 | 24.40 | 32.12 |
| ABD 119 | 0.4697 | 70 | 82.53 | 7.26 | 44.01 | 24.2 | 16.50 | 24.35 |
| ABD 124 | 0.5144 | 70 | 73.91 | 6.30 | 42.20 | 31.6 | 14.80 | 26.54 |
| ABD 131 | 0.6315 | 67 | 40.60 | 4.96 | 25.78 | 43.2 | 42.10 | 24.21 |
| ABD 132 | 0.6373 | 65 | 51.70 | 5.57 | 26.28 | 42.3 | 55.10 | 28.16 |
| NBD 119 | 0.5794 | 71 | 46.65 | 5.78 | 30.30 | 55.0 | 27.27 | 20.71 |
| NBD 260 | 0.5380 | 67 | 64.96 | 6.02 | 37.71 | 51.7 | 31.30 | 18.55 |
| NBD 289 | 0.4454 | 73 | 79.70 | 5.34 | 47.69 | 53.1 | 38.80 | 41.92 |
| NBD 290 | 0.4126 | 73 | 92.05 | 6.23 | 61.06 | 39.6 | 38.90 | 43.38 |
| Nandyal Pogaku - 1 | 0.5200 | 73 | 67.85 | 1.98 | 44.19 | 34.8 | 32.00 | 30.08 |
| ***Mean*** | ***0.530*** | ***70.57*** | ***70.66*** | ***5.36*** | ***43.01*** | ***34.92*** | ***31.37*** | ***26.92*** |
| ***CV (%) :*** | ***12.197*** | ***3.59*** | ***22.11*** | ***23.15*** | ***24.37*** | ***36.44*** | ***33.24*** | ***28.08*** |
| ***SD (ó) :*** | ***0.0641*** | ***2.53*** | ***15.62*** | ***1.24*** | ***10.48*** | ***12.72*** | ***10.43*** | ***7.56*** |

**Table 3: Analysis of variance (Tar).**

| Source | DF | Sum of squares | Mean squares | F | Pr > F |
|---|---|---|---|---|---|
| Model | 1 | 1449.290 | 1449.290 | 79.348 | **0.000** |
| Error | 5 | 91.325 | 18.265 | | |
| Corrected Total | 6 | 1540.615 | | | |

*Computed against model Y=Mean(Y)*

**Table 4: Model parameters (Tar).**

| Source | Value | Standard error | t | Pr > \|t\| | Lower bound (95%) | Upper bound (95%) |
|---|---|---|---|---|---|---|
| Intercept | 8.917 | 5.817 | 1.533 | 0.186 | -6.037 | 23.871 |
| CO | 1.439 | 0.123 | 11.671 | **<0.0001** | 1.122 | 1.755 |

*$R^2$ value: 0.941, Adjusted $R^2$ : 0.929, MSE : 18.265, RMSE: 4.274*

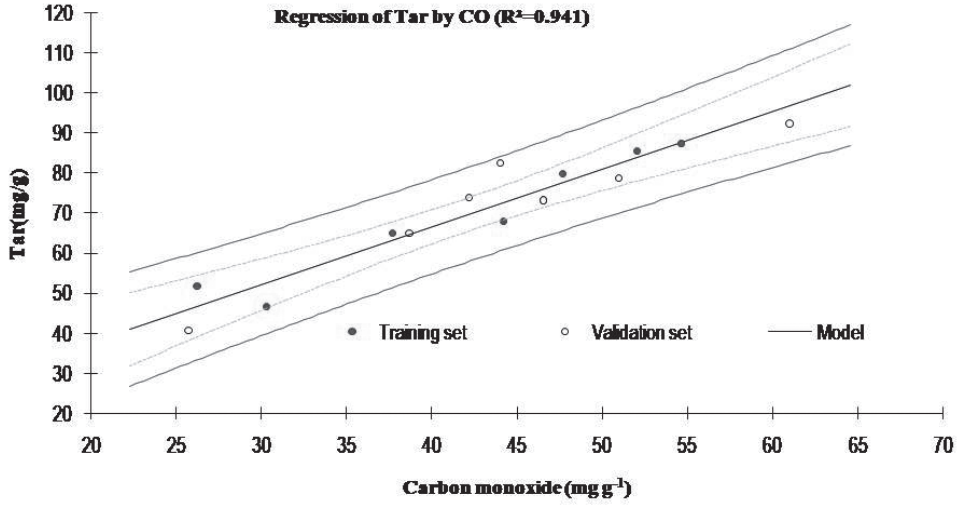


**Fig.1: Relationship between Tar and Carbon monoxide present in bidi smoke.**

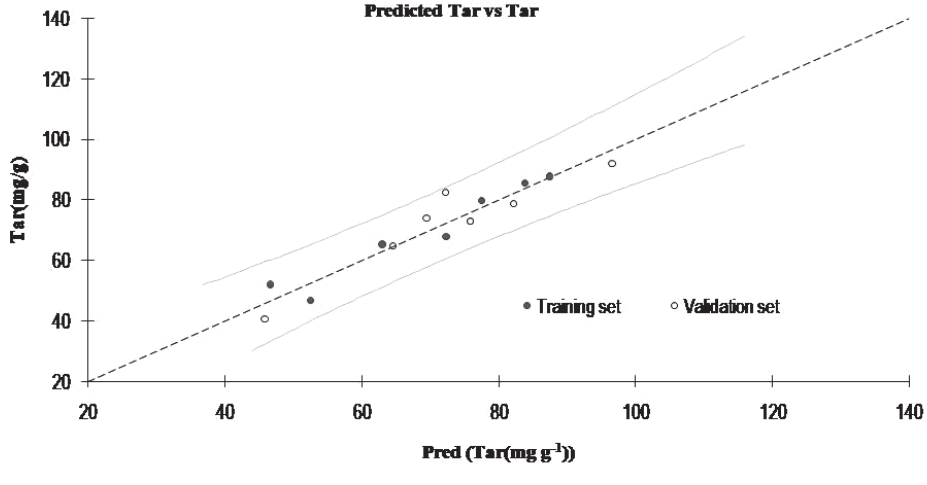


**Fig.2: Predicted Tar vs Tar content in Bidi smoke**

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Tobacco Research 49(1): 29-37, 2023

# "YASINI" - A NEW HIGH YIELDING BLACK SHANK DISEASE RESISTANT CHEWING TOBACCO VARIETY FOR TAMIL NADU

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(Received on Mar. 29th, 2023 and accepted on Jun 30th, 2023)

**Yasini (BSR-1) is a high yielding and Black Shank disease resistant chewing tobacco variety developed through back cross breeding ((VR-2 Beinhart1000-1) VR-2) at ICAR-CTRI Research Station, Vedasandur for Chewing tobacco farmers Tamil Nadu, more particularly for coastal area. It was tested in the name of BSR-1 in All India Coordinated Research Project on Tobacco, it consistently performed better in the Research station as well as in the black shank sick fields in Vedaranyam areas of coastal chewing tobacco belt (Hot spot area) in replicated yield trials and recorded 80% higher yield over check variety VR-2 (check -1) and >22% over Kaviri (check-2). In agronomic trials, it recorded 5.8% higher leaf yield over Kaviri. In on-farm trials conducted for three years, the Yasini recorded 30% higher yield over VR-2 and 19% over Kaviri. Yasini produces broad ovate leaves, dark green, sessile with moderately puckered, margins slightly wavy, tip acute, base cuneate, auricle prominent, leaf number vary from 24-25 with around 10 economic leaves, spangling medium, leaf length 70-75 cm and width 40-45 cm as compared to its parent VR-2 that has plants open, slightly drooping lamina, lanceolate, green leaves with medium auricle. By cultivating this variety, Tamil Nadu chewing tobacco farmers will raise a healthy crop without application of fungicide for black shank disease and thus cutting down the cost on chemical fungicides thereby reducing production costs and increasing net returns to the growers besides being environment friendly.**

## INTRODUCTION

Tobacco (*Nicotiana tabacum* L.) is one of the most important commercial crops of India. It is the major contributor for the Indian economy and earning foreign exchange.This crop was introduced to India from its originating places, South and North America through European traders(Sierrob*et al.*, 2014).Tobacco can be classified broadly into two categories, 'smoke' and 'smokeless. Chewing tobacco comes under smokeless category and are mainly cultivated in Tamil Nadu, West Bengal, Bihar, Assam and Uttar Pradesh. In Tamil Nadu, chewing tobacco is being cultivated as commercial crop for more than 10 decades in Dindigul, Karur, Erode, Coimbatore, Thirunelveli, Namakal, Salem, Vedaranyam, and Nagapattinam. The other tobaccos cultivated in Tamil Nadu are cigar and cheroot that are cultivated in smaller areas.

Black shank (*Phytopthoraparasitica*) disease is a devastating root and crown rot disease of all types of tobacco, causing yield losses up to 100%. Black shank occurs sporadically in every type of tobacco and causes more damage, to tobacco grown under high rainfall or irrigated conditions in light soils of Karnataka, Andhra Pradesh, Gujarat and some parts of Tamil Nadu. This disease can be dealt with two ways one by plant production & protection technologies and another by developing high yielding resistant varieties (Sullivan*et al.*, 2005). Sun-cured chewing tobacco is grown in about 2000 acres in Vedarnyam tract on the coastal belt of Tamil Nadu. VR 2 is the only popular variety being grown in this area. To overcome these issues, breeding programe for development of a superior chewing tobacco (Sun-cured type) with resistance to black shank disease has been launched during 1983-8 resistance to back shank disease. In this article the progress made in the project and a superior selection, BSR 1 developed, tested and released as new variety, "YASINI" is being reported.

**Key words:** Yasini, Black Shank, Chewing Tobacco and yield

## MATERIALS AND METHODS

In order to develop a high yielding and Black Shank disease resistant chewing tobacco variety, the popular chewing tobacco cultivar VR-2 was crossed with a promising tobacco line Beinhart1000-1 and the resultant segregating materials in the next generations were handled through Back-cross breeding method (Fig 1) . Among the advanced breeding lines, a promising chewing line, BSR-1 was identified based on yield and morphology. Further, the BSR-1 was tested All India Coordinated Research Project on Tobacco, CTRI, Rajahmundhry, black shank sick fields in Vedaranyam was evaluated. In view of its yield superiority over the check, BSR-1 in replicated trials, it was advanced for testing under bulk trial for four years (2006-2009) through multi location trials under All India network Project on Tobacco (AINPT).In order to assess the response of BSR-1 to agronomic variables a trial was conducted with different levels of nitrogen (0, 100, 150, 200 and 250 kg N). Observations on morphological characters and yield parameters were recorded. Cured leaf samples were analyzed for chemical leaf quality parameters *viz.,* nicotine (%), reducing sugars (%) and chlorides (%).The data recorded was used for standard statistical procedures as per Gomez and Gomez, 1984).

### DNA extraction and PCR

Genomic DNA was isolated from 30 days old seedlings by CTAB method, purified DNA was quantified by spectrophotometer (Nanodrop) and analyzed in agarose gel electrophoresis. The DNA isolated was amplified SSR markers from the list published by Bindler *et al.,* (2007) in thermal cycler (Eppendorf). For each PCR reaction 50ng of DNA was taken as template. The PCR was performed in 25µL final volume containing 1xPCR buffer (10 mM Tris-HCl pH 8.3, 50 mM KCl, 1.5 mM $MgCl_2$,0.2 mM dNTPs, 10 pmol of each forward and reverse primers and 1U of Taq polymerase PCR programme consisted of Initial denaturation at 94ÚC for 5 minutes, 34 cycles of consisting of denaturation at 94ÚC for 1 minute, annealing at 55ÚC for 1 minute, extension 72ÚC for 1 minute followed by final extension at 72ÚC for 10 minutes. The PCR products were analyzed QIAxcel Advanced (Qiagen) capillary system with QIAxcel ScreenGel Software.

## BACKGROUND

Yasini (Tested as BSR-1) is a high yielding and Black Shank disease resistant chewing tobacco variety developed through back cross breeding ((VR-2 Beinhart1000-1) VR-2)at ICAR-CTRI Research Station, Vedasandur for Chewing tobacco farmers Tamil Nadu, more particularly for coastal areas. The crosses were attempted during 1983-84 (total 5 crosses were made using VR 2 as female and Bhagyalakshmi, F2-7-1, CKV4, Beinheart, and Javiz as male) and $F_1$s were raised during 1984-85 at CTRI Research Station Vedasandur and farmers field (M/s Swasthic Company Farm) at Vedaranyam. The details of the crosses and progressive generation advancement are given in the Fig 1. (ICAR-CTRI, 2022).

A total of 1000 $F_2$ population of VR2 Beinheart were grown during 1985-86 at M/s Swasthic company in the blank shank sick field. During this season there was two cyclones in this area and plants withstand after two cyclones were selected and resistance to black shank was artificially tested at CTRI, Rajahmundry and natural condition at Vedaranyam.In 1986-87, the seeds of $F_2$ selections of VR-2 Beinhart1000-1 collected at Swastick Farm, Vedaranyam were artificially screened for black shank resistance at CTRI Rajahmundry. A total of 16 selections (6 plants in each selection) were screened and 3 selections (Selection-4, Selection-6 and Selection 14) showed 0 infection and these lines were again backcrossed with recurrent parent, VR 2 and progenies were tested under natural black shank sick filed at Vedaranyam. In $F_{3,}$ the resistant to black shunk disease were identified and again grown at Vedaranyam and repeated back crosses with parent VR 2 was made till $BC_6$and selections were made after that for yield and resistance to black shank disease. Among the derivatives, a promising line coded as BSR-1 was tested in replicated trials and multilocation trials under All India network Project on Tobacco (AINPT) during 2006-09. Simultaneously agronomic evaluation trials, bulk trials, pre-release trials and screening for resistance to major pest and diseases were also taken up.

Based on the performance of BSR-1, it was identified for release during VIII$^{th}$group meeting of

| Stage | Cross/Selection | Year |
|---|---|---|
| Crossing | VR 2 Beinheart | 1983-84 |
| $F_1$ | $F_1$-11 | 1984-85 |
| $F_2$ | $F_2$-6 | 1985-86 |
| $F_3$ | $F_3$-5-1 | 1986-87 |
| $BC_1$-12 | $F_3$-5-3 #2 X VR.2 | 1987-88 |
| $BC_1$-13 | $F_3$-5-3 #3X VR.2 | 1987-88 |
| $BC_2$-27 | $BC_1$-12#1X VR.2 | 1988-89 |
| $BC_2$-28 | $BC_1$-14#1X VR.2 | 1988-89 |
| $BC_2$-29 | $BC_1$-14#2X VR.2 | 1988-89 |
| $BC_2$-30 | $BC_1$-15#2X VR.2 | 1988-89 |
| $BC_3$—20 | $BC_2$-29#1X VR.2 | 1989-90 |
| $BC_3$-21 | $BC_2$-30#1X VR.2 | 1989-90 |
| $BC_3$-S1 | $BC_2$-27#1X VR.2 | 1989-90 |
| $BC_3$-S2 | $BC_2$-29#1X VR.2 | 1989-90 |
| $BC_3$-S3 | $BC_2$-30#1X VR.2 | 1989-90 |
| $BC_4$-17 | $BC_3$-20#1X VR.2 | 1990-91 |
| $BC_4$-18 | $BC_3$-20#2X VR.2 | 1990-91 |
| $BC_4$-19 | $BC_3$-31#1X VR.2 | 1990-91 |
| $BC_5$-10 | $BC_4$-17#2X VR.2 | 1991-92 |
| $BC_6$-1 | $BC_5$-10#4X VR.2 | 1992-93 |
| $BC_5$-10 | $BC_5$-S07 | 1995-96 |
| $BC_5$-11 | $BC_5$-S08 | 1995-96 |
| $BC_5$-12 | $BC_5$-S09 | 1995-96 |
| $BC_5$-13 | $BC_5$-S11 | 1995-96 |
| $BC_5$-14 | $BC_5$-S12 | 1995-96 |
| $BC_5$-S1 | $BC_5$-S10 | 1996-97 |
| $BC_5$-S2 | $BC_5$-S11 | 1996-97 |
| $BC_5$-S3 | $BC_5$-S12 | 1996-97 |
| $BC_5$-S4 | $BC_5$-S13 | 1996-97 |
| $BC_5$-S5 | $BC_5$-S14 | 1996-97 |
| $BC_5$-S1 | $BC_5$-S1#1 | 1997-98 |
| $BC_5$-S2 | $BC_5$-S4#4 | 1997-98 |
| $BC_5$-S3 | $BC_5$-S5#5 | 1997-98 |

**Fig. 1: Pedigree of the Yasini (BSR-1)**

AINPT held during 27-28 September 2021, recommended for its release. This was further discussed in the Tobacco Variety Release Committee of Tamil Nadu on May 2023 and recommended to release in the name of Yasini to chewing tobacco areas of Tamil Nadu.

**VARIETY DESCRIPTION**

The varietal description of Yasini is given in the table 1 and fig 2. Yasini produces broad ovate leaves, dark green, sessile with moderately puckered, margins slightly wavy, tip acute, base cuneate, auricle prominent, leaf number vary from 24-25 with around 10 economic leaves, spangling medium, leaf length 70-75 cm and width 40-45 cm as compared to its parent VR-2 that has plants open, slightly drooping lamina, lanceolate, green leaves with medium auricle.(Prasad Rao, 1999).Further DNA amplification profile with 12 SSR markers revealed that PT40035 marker has specific amplification at ~190 bp in BSR1 (Fig. 2) whereas other chewing tobacco varieties VR-2, Abirami and Kaviri has shown differential banding pattern.

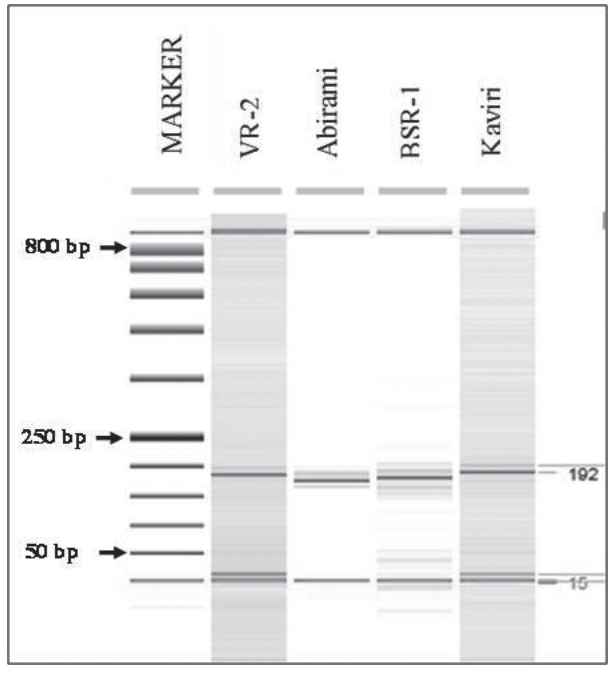


**Fig.2: PCR amplification profile of BSR1 along with other Chewing tobacco varieties VR-2, Abirami and Kaviri using SSR marker PT40035**

**Fig. 3. Photo of BSR-1 (Yasini) in comparison with its parent VR 2 and Check variety, Kaviri.**

**Table 1: Description of the Chewing tobacco proposed variety Yasini (BSR-1)**

| Traits | | Description |
|---|---|---|
| Name of the variety | : | Yasini (BSR-1) |
| Species | : | *Nicotiana tabacum* L |
| Type | : | Sun-cured |
| Use | : | Chewing |
| Plant habit | : | Open |
| Height upto crow foot | : | 1.4 to 1.5 m |
| Internodal length | : | Medium (5.8cm) |
| Stem colour | : | Green |
| Leaf character | : | |
| a) Shape | : | Broad ovate |
| b) Surface | : | Moderately puckered |
| c)Margin | : | Slightly wavy |
| d)Tip | : | Acute |
| e) Base | : | Cuneate |
| f) Auricle development | : | Prominent |
| g) Colour | : | Dark green |
| h) Angle of insertion | : | $45^{o}$ |
| i)Stalk | : | Sessile |
| j) Midrib and venation | : | Prominent |
| Size Length(cm) | : | 70 to 75 cm |
| Width (cm) | : | 40 to 45cm |
| Maturity | : | Medium (115 to 120 days) |
| Total leaf numbers | : | 24 to 25 |
| Economic leaf number | : | 8 to 10 leaves |
| Suckering habit | | |
| Without topping | : | Low |
| On topping | : | Heavy |
| Spangling | : | Medium |
| No. of days taken to flowering | : | 60-65 days |
| Inflorescence | | |
| Panicle | : | Semi open and branched |
| Peduncle | : | Thick and sparsely pubescent |
| Flower colour | : | Pink |
| Corolla shape | : | Funnel |
| Capsule shape | : | Elliptic |
| Seed colour, size and yield per plant (gms) | : | Brown, 10,000 to 10,500 per gram 15 to 20 gms |
| Rooting habit (Mention type of soil) | : | Deep Sandy soil |
| Reaction to diseases | : | Susceptible to TMV, Leaf curl and resistant to black shank. |
| Pests | : | Susceptible to tobacco leaf eating caterpillar *Spodoptera litura*and aphid attack(Comparable to parent VR 2 and check Kaviri) |
| Growing season | : | Rabi ($1^{st}$ week of October – $28^{th}$ February) |
| Yield data kg/ha | : | Green leaf Cured leaf Whole leaf<br>15,000 3391 75-80% |
| Quality characteristicsa) | | |
| a) Chemical | : | Nicotine : 5.0%<br>Chlorides : 4.2% |
| b) Physical | : | Cured leaf heavy bodied, dark brown elastic with whitish incrustation, sweet aroma and highly pungent. |

**YIELD PERFORMANCE**

**Bulk and Pre-release yield Trials**

In replicated three bulk, three pre-release and two agronomic trials were conducted during 2006 to 2009, BSR-1 found significantly superior mean leaf yield compared to two check varieties VR 2 and Kaviri (Table 2). In replicated bulk trials, Yasini recorded 3687 leaf yield which is 80 and 22.2% higher yield than the check varieties VR 2 and Kaviri, respectively. In location testing trials Yasini had 3391 kg leaf yield (average of three trials) which was 29.9% higher than VR 2 and 19.1% higher than Kaviri. In agronomic yield trial conducted with check Kaviri, it recorded 5.8% higher than Kaviri (Table 2). The increased yield advantage in Yasini as compared to check varieties may be due to the desirable recombination of genes from its parents and backcross progeny, the major yield advanced might have realised because of many characters like dark green leaves, leaf length and width, total number of economic leaves, etc. besides the resistance to black shank resistance.

**Agronomic Adaptability Trials**

The total leaf yield during 2011-12, 2012-13 and pooled data didn't show significant difference between the varieties *viz*. BSR-1 and Kaviri. There were no significant differences among the varieties for total leaf yield during 2011-12 and 2012-13 (Table 3). The response of nitrogen was up to 150 kg N/ha with respect to total leaf yield. The pooled total yield recorded was 2577 kg/ha. The yield with 150 kg N/ha and 200 kg N/ha was comparable.

**Table 2: Summary yield data of replicated bulk and pre-release testing trials of BSR-1 (Yasini).**

| S. No. | Item | Year of testing | No. of trials | Mean leaf yield Kg/ha (Percent increase over Check) | | |
|---|---|---|---|---|---|---|
| | | | | BSR-1 | Check I, VR-2 | Check 2, Kaviri |
| a. | Replicated yield trials | 2006 - 2009 | 3 | 3687 | 2045 (80.0%) | 3016 (22.2%) |
| b. | Location testing trials | 2006 - 2009 | 3 | 3391 | 2610 (29.9%) | 2847 (19.1%) |
| c. | Agronomic evaluation | 2011-2013 | 2 | 2624 | - | 2479 (5.8%) |

Frequency in the top group: Top in 8 trials.

**Table 3: Adaptability to changes in agronomic conditions for Yasini**

| | Item | BSR-1 | Check Kaviri |
|---|---|---|---|
| Sowing date Experiments | Yield kg/ha under the recommended Sowing date Percentage gain or Loss when sown under | 3687 Early Normal | 3016 Only one planting season commences in first week of October |
| | Recommended dose | Late | of October |
| | | Fertiliser | Yield kg/ha |
| Experiments | under recommended dose | | |
| | Percentage gain or | F0 Nil | |
| | Loss when under | F1 100 kg | 2410 |
| | Other doses - | F2 150 kg | 2577 - 6.9% increase over F1 |
| | | F3 200 kg | 2600 - 0.8% increase over F2 |
| Irrigation Experiments Wherever applicable | Yield kg/ha with adequate irrigation Percentage gain or loss | Adequate Irrigation level I Irrigation level II Irrigation level III | Not applicable |

The existing recommended N dose of 150 kg N/ha recommended for the coastal areas for achieving the higher yield (AINPT, Annual report 2017-2018).

**Testing against major disease and pests**

The testing of Yasini for black shank and other major diseases, Tobacco mosaic virus (TMV) and tobacco leaf curl (TLC) and major pests (aphid and caterpillar) were done artificially and field conditions and results are presented in Tables 4a and 4b. Under artificial condition for both TMV and leaf curl virus proved that it is mostly like control varieties (VR-2 and Kaviri). (Hoque Reza*et al.* 2019).

**Evaluation for quality parameters**

Chemical quality characteristics viz., nicotine, reducing sugars and chlorides are comparable to check varieties (Prasad Rao, 1999) (Table 5a and 5b).

**Table 4a: Reaction of BSR 1 (Yasini)to major diseases at Vedasandur conditions**

| Diseases | | Year | BSR-1 | VR-2 | Kaviri |
|---|---|---|---|---|---|
| Tobacco Mosaic Virus | Artificial | 2006-09 | Susceptible | Susceptible | Susceptible |
| | Natural | 2006-2007 | 5.4 | 6.8 | 4.5 |
| | Natural | 2007-2008 | 3.6 | 8.2 | 5.2 |
| | Natural | 2008-2009 | 2.0 | 5.0 | 4.0 |
| | | **Mean** | **3.7** | **6.7** | **4.6** |
| Tobacco leaf curl | Artificial | 2006-09 | Susceptible | Susceptible | Susceptible |
| | Natural | 2006-2007 | 2.0 | 4.6 | 3.0 |
| | | 2007-2008 | 1.2 | 3.6 | 2.0 |
| | | 2008-2009 | - | 2.0 | 1.8 |
| | | **Mean** | **1.6** | **3.4** | **2.3** |
| Black shank | Artificial | 2006-2009 | Resistant | Susceptible | Susceptible |
| | Natural | 2006-2007 | Nil | 60.5 | 12.8 |
| | | 2007-2008 | Nil | 56.0 | 13.0 |
| | | 2008-2009 | Nil- | 45.3. | 13.3 |
| | | **Mean** | **Nil** | **50.6** | **13.0** |

**Table 4b: Reaction of Yasini to insect pests at Vedaranyam condition**

| Insect Pests | Condition | Year | % of damaged/affected plants | | |
|---|---|---|---|---|---|
| | | | BSR-1 | VR-2 | Kaviri |
| Tobacco leaf | Artificial | 2006-2009 | Susceptible | Susceptible | Susceptible |
| eating caterpillar | Natural | 2006-2007 | - | 48.0 | 38.0 |
| | | 2007-2008 | 1.2 | 64.8 | 45.0 |
| | | 2008-2009 | 1.6 | 56.8 | 52.5 |
| | | **Mean** | **1.4** | **56.5** | **45.1** |
| Aphid | Artificial | 2006-2009 | Susceptible | Susceptible | |
| | Natural | 2006-2007 | 4.0 | 6.0 | 2.0 |
| | | 2007-2008 | - | - | - |
| | | 2008-2009 | 1.6 | 3.2 | 4.0 |
| | | **Mean** | **2.8** | **4.6** | **3.0** |

**Table 5(a): Data on quality characteristics -Physical quality / chewability of BSR-1**

| Qualityattributes | Year | Trader's opinion | | | Consumer's preference | | |
|---|---|---|---|---|---|---|---|
| | | BSR-1 | VR-2 | Kaviri | BSR-1 | VR-2 | Kaviri |
| Body (10) | 2007-2008 | 8.0 | 7.0 | 8.0 | 8.5 | 7.5 | 8.2 |
| | 2008-2009 | 8.5 | 7.0 | 8.5 | 8.5 | 7.5 | 8.2 |
| | **Mean** | **8.3** | **7.0** | **8.3** | **8.5** | **7.5** | **8.1** |
| Aroma (10) | 2007-2008 | 8.2 | 8.0 | 7.5 | 8.2 | 8.0 | 8.0 |
| | 2008-2009 | 8.2 | 7.0 | 7.5 | 8.2 | 8.0 | 8.0 |
| | **Mean** | **8.2** | **7.5** | **7.5** | **8.2** | **8.0** | **8.0** |
| Incrustation (10) | 2007-2008 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| | 2008-2009 | 6.0 | 7.0 | 7.0 | 6.0 | 6.0 | 6.0 |
| | **Mean** | **6.0** | **6.5** | **6.5** | **6.0** | **6.0** | **6.0** |
| Taste (10) | 2007-2008 | 8.4 | 8.0 | 7.0 | 8.4 | 7.4 | 8.2 |
| | 2008-2009 | 8.2 | 7.0 | 7.2 | 8.4 | 7.4 | 8.2 |
| | **Mean** | **8.3** | **7.5** | **7.1** | **8.4** | **7.4** | **8.2** |
| Pungency (10) | 2007-2008 | 6.4 | 6.0 | 7.0 | 6.4 | 6.5 | 6.5 |
| | 2008-2009 | 6.8 | 6.0 | 7.0 | 6.8 | 6.5 | 6.5 |
| | **Mean** | **6.6** | **6.0** | **7.0** | **6.6** | **6.5** | **6.5** |
| Saliva secretion (10) | 2007-2008 | 7.8 | 6.0 | 6.0 | 7.8 | 7.2 | 7.0 |
| | 2008-2009 | 7.8 | 6.0 | 6.0 | 7.8 | 7.2 | 7.0 |
| | **Mean** | **7.8** | **6.0** | **6.0** | **7.8** | **7.2** | **7.0** |
| Duration of ) | 2007-2008 | 6.0 | 7.0 | 7.5 | 6.0 | 7.0 | 7.5 |
| pungency (10 | 2008-2009 | 6.4 | 6.0 | 6.0 | 6.4 | 7.0 | 7.5 |
| | **Mean** | **6.2** | **6.5** | **6.8** | **6.2** | **7.0** | **7.5** |
| Stiffness in the | 2007-2008 | 6.2 | 6.0 | 7.0 | 6.2 | 6.2 | 6.2 |
| mouth(10) | 2008-2009 | 6.4 | 6.0 | 7.2 | 6.4 | 6.2 | 6.2 |
| | **Mean** | **6.3** | **6.0** | **7.1** | **6.3** | **6.1** | **6.2** |
| **Mean score out of 80** | | **57.7** | **53.0** | **56.3** | **58..0** | **55.7** | **57.5** |

**Table 5(b): Data on quality characteristics (Chemical quality characters-2008-09)**

| S.No. | Quality characteristics | BSR-1 | VR-2 | Kaviri |
|---|---|---|---|---|
| 1. | % Nicotine | 5.0 | 5.2 | 5.1 |
| 2 | % Chlorides | 4.2 | 4.3 | 3.8 |

**Table 6(a): Replicated evaluation (2006-2007 to 2008-2009)at CTRI RS, Vedasandur**

| Selection / variety | Total leaf (kg/ha) pooled |
|---|---|
| BSR-1 | 3687* |
| VR-2 (Check-1) | 2045 |
| Kaviri (Check-2) | 3016 |
| CD at 5% | 311 |
| CV% | 12.7 |

In the replicated evaluation BSR-1 recorded 80 % increased yield over the VR-2 and 22 % increased yield over Kaviri (Table 6a). In the bulk plot testing at Ayakaranpulam, BSR-1 recorded a mean yield of 29.9 and 19.1 % with VR-2 and Kaviri, respectively (Table6b).

**Fig. 4: Field view of Yasini at Periakuthagai, Ayakaranpulam-I, Vedaranyam taluk.**

The total leaf yield during 2011-12, 2012-13 and pooled data didn't showed significant difference between the varieties *viz*. BSR-1 and Kaviri. How ever there was a yield increase with the variety BSR-1 over Kaviri (Table 7). The response of nitrogen was up to 150 kg N/ha with respect to total leaf yield. The pooled total yield recorded was 2577 kg/ha. The yield with 150 kg N/ha and 200 kg N/ha was comparable. The existing recommended N dose of 150 kg N/ha recommended for the coastal areas is sufficient to get higher yield.

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**Table 6(b): Bulk plot testing from 2006-2007 to 2008-2009 at Ayakaranpulam(Mean)**

| S.No | Variety | Cured leaf yield (kg/ha) | % over Check1 | % over Check-2 |
|---|---|---|---|---|
| 1 | BSR-1 | 3391 | 29.9 | 19.1 |
| 2 | VR-2 ( Check-1) | 2610 | - | - |
| 3 | Kaviri (Check-2) | 2847 | - | |

**Table 7: Adaptability to changes in agronomic conditions**

| Treatments | Total leaf yield (kg/ha) | | |
|---|---|---|---|
| | 2011-12 | 2012-13 | Pooled |
| **Varieties :** | | | |
| BSR-1 | 2676 | 2624 | 2650 |
| Kaviri | 2505 | 2492 | 2479 |
| S.Em | 25.1 | 17.9 | 12.0 |
| C.Dat 5% | NS | NS | NS |
| N Levels | | | |
| 100 kg/ha | 2395 | 2402 | 2410 |
| 150 kg/ha | 2637 | 2607 | 2577 |
| 200 kg/ha | 2741 | 2650 | 2600 |
| S.Em | 42.2 | 32.0 | 37.0 |
| C.Dat 5% | 127.6 | 103.6 | 113.2 |

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Tobacco Research 49(1): 38-43, 2023

# EFFECT OF DIFFERENT ORGANIC MANURES AND BIO NPK IN CONJUNCTION WITH INORGANIC FERTILIZERS ON GROWTH, YIELD, QUALITY AND ECONOMICS OF *RUSTICA* TOBACCO VARIETIES UNDER MIDDLE GUJARAT CONDITIONS

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(Received on Dec., 2022 and Accepted on June 15th, 2023)

**A field experiment was conducted to study the effect of different organic manures in conjunction with inorganic fertilizers on growth, yield, quality and economics of *rustica* tobacco under middle Gujarat conditions. The experiment was conducted during 2017-18 to 2019-20 at Bidi Tobacco Research Station, Anand Agricultural University, Anand, in factorial randomized block design with two main plot treatments of varieties $V_1$: GCT 3 and $V_2$: DCT 4 and five sub plot treatments of Integrated nutrient management (INM) *i.e.* $F_1$: 100% RDN (200 kg N/ha), $F_2$: 75% RDN + Bio NPK (Root dip 15 minutes in 5 ml bio NPK/1 l water), $F_3$: 50% RDN + Bio NPK + FYM @ 12.5 t/ha, $F_4$: 50% recommended dose of nitrogen (RDN) + Bio NPK + Poultry manure @ 2 t/ha and $F_5$: 50% RDN + Bio NPK + Castor cake @ 1 t/ha replicated four times. Results revealed that significantly the highest *rustica* tobacco cured leaf yield was noticed in variety DCT 4 during 2017-18 and 2018-19. Among integrated nutrient management practices, treatment $F_2$ (75% @ RDN + Bio NPK) being at par with $F_1$ (100% RDN) produced significantly higher *rustica* tobacco cured leaf yield (2370 kg/ha) during 2017-18. While, treatment $F_3$ (50% RDN + Bio NPK + FYM @ 12.5 t/ha) being at par with $F_1$ (100% RDN) produced significantly higher *rustica* tobacco cured leaf yield (2349 and 2429 kg/ha) during 2018-19 and 2019-20, respectively. In pooled over three years data, leaf width and dry weight per unit leaf area were recorded significantly higher in varieties DCT 4 and GCT 3, respectively. Whereas, treatment $F_3$ (50% RDN + Bio NPK + FYM @ 12.5 t/ha) gave significantly the tallest plants over rest of treatments. Tobacco variety DCT 4 gave maximum monetary returns (Rs. 50049/ha) with benefit: cost ratio of 1.80. Among different integrated nutrient management practices, 100% RDN or 75% RDN + Bio NPK recorded maximum gross income, net realization and BCR values.**

## INTRODUCTION

Tobacco (*Nicotiana tabacum* L.) is the most widely grown commercial non-food crop in the world. It is an important commercial crop in view of revenue generation, export earnings and employment potential. Tobacco is grown over 0.40 million hectares in India having the production of 0.80 million tones with 1982 kg/ha average productivity in 2019-20 (Anonymous, 2021). Among various types of tobacco, *rustica* tobacco known as calcutti tobacco in Gujarat, the product of *rustica* tobacco either lamina flakes (*Bhuka*or *Chura*) or leaf bundles (*Chopadia*) are mainly used for *chewing*, *hookah*, *snuff* and also blending with bidi tobacco to a much lesser extent. *Rustica* tobacco is grown in north and middle Gujarat. The result of long-term experiment suggests that to sustain *Rustica* tobacco productivity and quality of crop and to maintain soil health, organic manure application is a must. The basic concept of INM system is the maintenance of plant nutrients supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients in an integrated manner, appropriate to each cropping system and farming situation. If the soil fertility has already eroded to a high degree by inappropriate management practices, one major task of integrated nutrient management (INM) system will be to at least stop the ongoing loss of surface or top soil nutrients (Mahajan and Sharma, 2005). Studies show that excessive application of nitrogen reduces the quality because the stem hardens, the color darkens and the strip yield decreases, therefore its commercial value decreases greatly (Marchetti

**Key words:** Bio NPK; FYM; Poultry manure; castor cake; fertilizer; Tobacco yield; economics

*et al.*, 2006). Biofertilizers play a vital role in increasing availability of nitrogen and phosphorus. It increases the biological fixation of atmospheric nitrogen and enhances phosphorus availability to crops. Therefore, the introduction of bio NPK consortium (*Azotobacter, Azospirillum* and three bacillus species) may be helpful. It is a liquid bio-fertilizer that saves costly chemical fertilizers by 25-30% with a 10-15% increase in crop production. Therefore, to substitute nitrogen requirement and find out alternate sources including bio NPK, there is a need to study integrated nutrient management interweaving organic manure and bio NPK in *rustica* tobacco.

## MATERIALS AND METHODS

Field experiment was conducted for three consecutive years at the same site during 2017-18, 2018-19 and 2019-20 at research farm of Bidi Tobacco Research Station, Anand Agricultural University, Anand. The experimental soil was sandy loam with pH 7.48, organic carbon 0.51%, available phosphorus 68.78 kg/ha and potassium 263.3 kg/ha. The experiment was laid out in factorial randomized block design (FRBD) with four replications. Treatments comprised ten treatment combinations of two varieties (GCT3 and DCT4) and five integrated nutrient management practices *viz*, 100 % RDN (200 kg N/ha); 75 % RDN + Bio NPK (Root dip 15 minutes in 5 ml bio NPK/1 l water.); 50 % RDN + Bio NPK + FYM @ 12.5 t/ha; 50 % RDN + Bio NPK + Poultry manure @ 2 t/ha and 50 % RDN + Bio NPK + Castor cake @ 1 t/ha were tested. FYM, poultry manure and castor cake were applied in main field one month before transplanting as per treatments. Nitrogen was applied in four equal splits, 1$^{st}$ as basal application through ammonium sulphate and remaining three splits of nitrogen applied through urea each at 30 days interval after transplanting. Tobacco seedlings were dipped for 15 minutes in 5 ml bio NPK/1 l water solution before transplanting. The gross plot size was 3.6 x 6.0 m and net plot size was 2.4 x 4.8 m with spacing of 60 x60 cm. Tobacco seedlings were planted in the second fortnight of November. The other recommended package of practices were followed to raise the crop. The leaf quality parameters (nicotine, reducing sugar, chloride, phosphorus and potash content) were analyzed as per standard analytical method. Economics was computed based on the prevailing market prices of the inputs and tobacco cured leaf.

## RESULTS AND DISCUSSION

### Tobacco Cured Leaf Yield

The data presented in Table 1 revealed that *rustica* tobacco cured leaf yield was significantly affected due to different varieties and integrated nutrient management practices only in individual years. Significantly the highest *rustica* tobacco cured leaf yield was noticed in variety DCT 4 during 2017-18 and 2018-19. Among integrated nutrient management practices, treatment $F_2$ (75% RDN + Bio NPK) being at par with $F_1$(100% RDN) produced significantly higher *rustica* tobacco cured leaf yield (2370 kg/ha) during 2017-18. While, treatment $F_3$ (50% RDN + Bio NPK + 12.5% FYM) being at par with F(100% RDN) produced significantly higher *rustica* tobacco cured leaf yields (2349 and 2429 kg/ha) during 2018-19 and 2019-20, respectively. These findings are in accordance with Arya *et al.* (2011). On the other hand, according to the results of Bilalis *et al.* (2010) and Ioanna Tabaxi *et al.* (2020), higher yields of Virginia tobacco in inorganic fertilization were recorded. However, *rustica* tobacco cured leaf yield was not altered due to different varieties and integrated nutrient management practices in pooled analysis. Gediya *et al.* (2020) also expressed similar views and mentioned that different manures and fertilizers failed to exert their significant effect on bidi tobacco cured leaf yield and quality parameters.

### Yield attributes

Tobacco morphological characters were not changed significantly due to different *rustica* tobacco varieties except, leaf width and dry weight per unit leaf area which were recorded significantly higher in variety DCT 4 and GCT 3, respectively (Table 2). Among integrated nutrient management practices, only tobacco plant height was affected significantly on pooled basis. Treatment $F_3$ (50% RDN + Bio NPK + FYM @ 12.5 t/ha) gave significantly the tallest plants over rest of treatments. Treatment $F_5$ (50% RDN + Bio NPK + castor cake @ 1 t/ha) gave significantly lower plant height followed by Treatments $F_1$ (100% RDN), $F_2$

**Table 1: Yield of *rustica* tobacco as influenced by variety and integrated nutrient management practices**

| Treatments | Yield (kg/ha) | | | |
|---|---|---|---|---|
| | **2017-18** | **2018-19** | **2019-20** | **Pooled** |
| **A. Variety** | | | | |
| $V_1$: GCT 3 | 2031 | 1915 | 1989 | 1978 |
| $V_2$: DCT 4 | 2330 | 2397 | 2100 | 2276 |
| S. Em. ± | 44 | 657 | 62 | 24 |
| C.D.0.05 | **128** | **188** | **NS** | **NS** |
| **B. Integrated nutrient management** | | | | |
| $F_1$: 100 % RDN(200 kg N/ha) | 2259 | 2300 | 2293 | 2284 |
| $F_2$: 75 % RDN + BioNPK | 2370 | 2282 | 1759 | 2137 |
| $F_3$: 50 % RDN + BioNPK + FYM @ 12.5 t/ha | 2042 | 2349 | 2429 | 2273 |
| $F_4$: 50 % RDN + BioNPK + Poultry manure @ 2 t/ha | 2146 | 2084 | 1928 | 2053 |
| $F_5$: 50 % RDN + BioNPK + Castor cake@ 1 t/ha | 2085 | 1765 | 1814 | 1888 |
| S. Em. ± | 70 | 102 | 97 | 37 |
| C.D.0.05 | **203** | **297** | **283** | **NS** |
| Int. Variety X INM | **NS** | **NS** | **NS** | **NS** |
| C.V. % | 9.1 | 13.4 | 13.5 | 12.1 |

**Table 2: Leaf size, plant height and dry weight per unit leaf area of *rustica* tobacco as influenced by variety and integrated nutrient management practices**

**(Pooled over three years)**

| Treatments | Leaf length (cm) | Leaf width (cm) | Plant height (cm) | Dry weitht per unit leaf area ($mg/cm^2$) |
|---|---|---|---|---|
| **A. Variety** | | | | |
| $V_1$: GCT 3 | 26.15 | 20.51 | 44.90 | 9.47 |
| $V_2$: DCT 4 | 27.00 | 21.48 | 45.39 | 8.93 |
| S. Em. ± | 0.45 | 0.30 | 0.60 | 0.14 |
| C.D.0.05 | **NS** | **0.86** | **NS** | **0.38** |
| **B. Integrated nutrient management** | | | | |
| $F_1$: 100 % RDN (200 kg N/ha) | 26.28 | 20.72 | 44.64 | 9.26 |
| $F_2$: 75 % RDN + Bio NPK | 28.18 | 21.35 | 45.27 | 9.39 |
| $F_3$: 50 % RDN + Bio NPK + FYM @ 12.5 t/ha | 27.11 | 21.21 | 48.67 | 8.99 |
| $F_4$: 50 % RDN + Bio NPK + Poultry manure @ 2 t/ha | 25.34 | 20.46 | 44.19 | 9.04 |
| $F_5$: 50 % RDN + Bio NPK + Castor cake @ 1 t/ha | 25.95 | 21.21 | 42.95 | 9.31 |
| S. Em. ± | 0.71 | 0.48 | 0.95 | 0.14 |
| C.D.0.05 | **NS** | **NS** | **2.67** | **NS** |
| Int. Variety X INM | **NS** | **NS** | **NS** | **NS** |
| C.V. % | 13.0 | 11.2 | 10.3 | 11.5 |

(75% RDN + Bio NPK) and $F_4$ (50% RDN + Bio NPK + poultry manure @ 2 t/ha). Karaivazoglou *et al.* (2007) stated that plant height of tobacco was affected by nitrogen fertilization and mainly by higher quantities applied. While Song *et al.* (2016) emphasized the fact that different concentrations of organic fertilizers affect the morphological characteristics of tobacco.

**Quality parameters**

Nicotine, reducing sugar and chloride contents in tobacco leaf lamina the important chemical quality parameters were not influenced significantly due to *rustica* tobacco varieties as well as different integrated nutrient management practices in pooled analysis of three years (Table 3). Earlier studied by Gediya *et al.* (2020), Ioanna Tabaxi *et al.* (2020) and Patel *et al.* (2011) revealed that organic fertilization did not affect quality characteristics of tobacco. Similarly, chloride content of FCV tobacco was not significantly changed due to organic manures and nitrogen levels (Giridhar *et al.*, 2003).

**Chemical parameters**

The pooled over three years data revealed that soil chemical parameters *i.e.* organic carbon, available phosphorus and available potassium were not affected significantly due to *rustica* tobacco varieties as well as different integrated nutrient management practices (Table 4).

**Interaction effect**

The pooled result illustrated in Table 1 to 4, highlighted that interaction action between varieties and different levels of fertilizer could not exert their significant effect on yield, yield attributes, quality parameters and chemical parameters of *rustica* tobacco varieties in pooled analysis. However, reducing sugar content was significantly affected due to interaction effect (Table 3). Significantly maximum reducing sugar content was noticed in treatment combination $V_2F_4$ (Variety: DCT 4 and integrated nutrient management practice: 50 % RDN + Bio NPK + Poultry manure @ 2 t/ha) compared to $V_2F_1$, $V_1F_1$ and $V_1F_4$ treatment combinations (Table 3.1).

**Economics**

Economics worked out and presented in Table 5 showed that maximum net return (50049 ₹/ ha) and BCR value (1.80) were observed in variety DCT 4. With regard to different integrated nutrient management practices, 100 % RDN and 75 % RDN + Bio NPK recorded maximum net realization (55217/ha, 48881/ha) and BCR values (1.93, 1.84), respectively. Treatment $F_4$ (50 % RDN + Bio NPK + FYM @ 12.5 t/ha) recorded significantly higher *rustica* tobacco cured leaf yields (2273 kg/ ha) in pooled over three years. Although the yields were higher, the net returns (35395/ha) and benefit: cost ratio (1.45) were found minimum. It might be due to unit cost of tobacco production with organics is higher than that raised with

**Table 3: Nicotine, reducing sugar and chloride contents as influenced by variety and integrated nutrient management practices**

**(Pooled over three years)**

| Treatments | Nicotine (%) | Reducing sugar (%) | Chloride (%) |
|---|---|---|---|
| **A. Variety** | | | |
| $V_1$: GCT 3 | 4.58 | 3.76 | 1.14 |
| $V_2$: DCT 4 | 4.52 | 3.80 | 1.17 |
| S. Em. ± | 0.03 | 0.03 | 0.01 |
| C.D.0.05 | **NS** | **NS** | **NS** |
| **B. Integrated nutrient management** | | | |
| $F_1$: 100 % RDN (200 kg N/ha) | 4.50 | 3.59 | 1.17 |
| $F_2$: 75 % RDN + Bio NPK | 4.61 | 3.86 | 1.17 |
| $F_3$: 50 % RDN + Bio NPK + FYM @ 12.5 t/ha | 4.52 | 3.85 | 1.16 |
| $F_4$: 50 % RDN + Bio NPK + Poultry manure @ 2 t/ha | 4.49 | 3.75 | 1.12 |
| $F_5$: 50 % RDN + Bio NPK + Castor cake @ 1 t/ha | 4.62 | 3.84 | 1.14 |
| S. Em. ± | 0.03 | 0.02 | 0.02 |
| C.D.0.05 | **NS** | **NS** | **NS** |
| Int. Variety X INM | **NS** | **Sig.** | **NS** |
| C.V. % | 5.2 | 5.9 | 8.6 |

**Table 3.1: Interaction effect of variety and integrated nutrient management on reducing sugar content of *rustica* tobacco after harvest in pooled results (Pooled Results)**

| Variety | Reducing sugar (%) Integrated nutrient management practices | | | | |
|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ |
| **$V_1$: GCT 3** | 3.63 | 3.87 | 3.88 | 3.59 | 3.82 |
| **$V_2$: DCT 4** | 3.55 | 3.85 | 3.82 | 3.92 | 3.87 |
| **S. Em. ±** | 0.06 | | | | |
| **C.D.0.05** | **0.18** | | | | |
| **CV %** | 5.9 | | | | |

**Table 4: Available nutrients in soil of *rustica* tobacco after harvest as influenced by variety and integrated nutrient management (Pooled over three years)**

| Treatment | Organic carbon (%) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) |
|---|---|---|---|
| **A. Variety** | | | |
| $V_1$: GCT 3 | 0.333 | 61.32 | 290 |
| $V_2$: DCT 4 | 0.328 | 61.53 | 295 |
| S. Em. ± | 0.003 | 0.354 | 3.3 |
| C.D.0.05 | **NS** | **NS** | **NS** |
| **B. Integrated nutrient management** | | | |
| $F_1$: 100 % RDN (200 kg N/ha) | 0.331 | 61.86 | 287 |
| $F_2$: 75 % RDN + Bio NPK | 0.330 | 61.39 | 290 |
| $F_3$: 50 % RDN + Bio NPK + FYM @ 12.5 t/ha | 0.330 | 61.86 | 289 |
| $F_4$: 50 % RDN + Bio NPK + Poultry manure @ 2 t/ha | 0.333 | 61.04 | 298 |
| $F_5$: 50 % RDN + Bio NPK + Castor cake @ 1 t/ha | 0.329 | 60.97 | 297 |
| S. Em. ± | 0.005 | 0.560 | 5.3 |
| C.D.0.05 | **NS** | **NS** | **NS** |
| Int. Variety X INM | **NS** | **NS** | **NS** |
| C.V. % | 6.7 | 4.5 | 8.9 |

**Table 5: Economics as influenced by variety and integrated nutrient management practices**

| Treatments | Yield (kg/ha) | Gross income Rs /ha | Common cost Rs /ha | Treatment cost Rs /ha | Total cost Rs /ha | Net income Rs /ha | BCR |
|---|---|---|---|---|---|---|---|
| **A. Variety (V)** | | | | | | | |
| $V_1$: GCT 3 | 1978 | 99109 | 48393 | 15569 | 63962 | 35148 | 1.56 |
| $V_2$: DCT 4 | 2276 | 114011 | 48393 | 15569 | 63962 | 50049 | 1.80 |
| **B. Integrated nutrient management** | | | | | | | |
| $F_1$: 100 % RDN (200 kg N/ha) | 2284 | 114430 | 48393 | 10821 | 59214 | 55217 | 1.93 |
| $F_2$: 75 % RDN + Bio NPK | 2137 | 107066 | 48393 | 9792 | 58185 | 48881 | 1.84 |
| $F_3$: 50 % RDN + Bio NPK + FYM @ 12.5t/ha | 2273 | 113884 | 48393 | 30096 | 78489 | 35395 | 1.45 |
| $F_4$: 50 % RDN + Bio NPK + PM @ 2 t/ha | 2053 | 102832 | 48393 | 14319 | 62712 | 40121 | 1.64 |
| $F_5$: 50 % RDN + Bio NPK + CC @ 1 t/ha | 1888 | 94589 | 48393 | 12816 | 61209 | 33380 | 1.55 |
| (Tobacco selling Price: 50.1 Rs. /kg) | | | | | | | |

chemical fertilizers, as the cost of organic inputs is prohibitively higher than chemicals (Krishna Reddy *et al.*, 2009). It is concluded that among *rustica* tobacco varieties, DCT 4 proved most impressive by recording significantly the highest tobacco cured leaf yield as compared to GCT 3. Application of nitrogen @ 200 kg/ha (100% RDN) or 75% RDN + Bio NPK or 50% RDN + Bio NPK + FYM @ 12.5 t/ha or 50% RDN + Bio NPK + Poultry Manure @ 2 t/ha recorded significantly higher *rustica* tobacco cured leaf yield with maximum net realization and BCR values as compared to an application of 50%RDN + Bio NPK + castor cake @ 1 t/ha.

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| | | | |
|---|---|---|---|
| 1. | Place of Publication | : | RAJAHMUNDRY - 533 105. |
| 2. | Periodicity of its Publication | : | Half-yearly |
| 3. | Printer's Name | : | **New Image Graphics** |
| | Nationality | : | Indian |
| | Address | : | Suryaraopet, Vijayawada-520 002. |
| 4. | Publisher's Name | : | **L. K. Prasad** |
| | Nationality | : | Indian |
| | Address | : | ICAR-Central Tobacco Research Institute |
| | | : | Rajahmundry - 533 105. |
| 5. | Editor's Name | : | **K. Viswanatha Reddy** |
| | Nationality | : | Indian |
| | Address | : | ICAR-Central Tobacco Research Institute |
| | | : | Rajahmundry - 533 105. |
| 6. | Names and address of individuals who own the newspaper and partners or shareholders holding more than one % of the total capital | : | **Indian Society of Tobacco Science** (Registered No.S. 120) |

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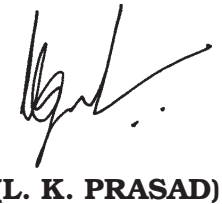

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**Vol. 49, No. 1** **June, 2023**

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