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SD Ninama
Ph.D. Scholar, Department of Agronomy, Anand Agricultural University, Anand, Gujarat, India

KM Gediya
Associate Research Scientist, Bidi Tobacco Research Station, Anand Agricultural University, Anand, Gujarat, India

MK Rathwa
Ph.D. Scholar, Department of Agronomy, Anand Agricultural University, Anand, Gujarat, India

GM Vaghela
Ph.D. Scholar, Department of Agronomy, Anand Agricultural University, Anand, Gujarat, India

Corresponding Author:
SD Ninama
Ph.D. Scholar, Department of Agronomy, Anand Agricultural University, Anand, Gujarat, India

Effect of integrated nutrient management on growth and yield parameters of Rustica tobacco (*Nicotiana rustica* L.) and its residual impact on succeeding summer green gram (*Vigna radiata* L.)

SD Ninama, KM Gediya, MK Rathwa and GM Vaghela

Abstract

The present research work entitled "Effect of integrated nutrient management on growth and yield parameters of rustica tobacco (*Nicotiana rustica* L.) and its residual impact of succeeding summer green gram (*Vigna radiata* L.)" a field experiment was conducted during *rabi* and summer season of years 2020-21 and 2021-22 at Bidi Tobacco Research Station, Anand Agricultural University, Anand, Gujarat. The experimental field had an even topography with a gentle slope having good drainage and sandy loam in texture. The soil of the experimental field at 0-15 cm depth was low in organic carbon and available nitrogen, medium in available phosphorus and potassium and slightly alkaline in reaction. The ten integrated nutrient management treatments *viz.*, T_1: 100% RDF (200-00-00 kg/ha), T_2: 75% RDF + 25% N from FYM, T_3: 75% RDF + 25% N from poultry manure, T_4: 75% RDF + 25% N from castor cake, T_5: 50% RDF + 50% N from FYM, T_6: 50% RDF + 50% N from poultry manure, T_7: 50% RDF + 50% N from castor cake, T_8: 50% RDF + 25% N from FYM + Azotobacter, T_9: 50% RDF + 25% N from poultry manure + Azotobacter, T_{10}: 50% RDF + 25% N from castor cake + Azotobacter were tested in Randomized Block Design with four replications. Rustica tobacco variety GCT 3 was considered as main *rabi* crop and green gram variety GAM 5 was considered as summer residual crop. The experiment was conducted on the same site during both the years without changing randomization of treatments. Results of the experiment showed that growth parameters *viz.* plant height of rustica tobacco at 30, 60 DATP and at harvest was found non-significant due to influence of integrated nutrient management treatments during the years 2020-21, 2021-22 and on pooled basis. However, pooled analysis at 30 DATP showed significant result. Integrated nutrient management manifested their non-significant effect on leaf length and leaf width of rustica tobacco recorded at 30, 60 DATP and at harvest for the years 2020-21, 2021-22 and in pooled analysis under application of 75% RDF + 25% N from poultry manure (T_3), respectively. In case of dry weight per unit leaf area the result was found non-significant during both the years (2022-21 & 2021-22), but pooled analysis showed significant result in rustica tobacco. Cured leaf yield of rustica tobacco manifested significant result during both years (2022-21 & 2021-22) and in pooled analysis under application of 75% RDF + 25% N from poultry manure (T_3), respectively. In residual summer green gram plant height did not affected significantly due to integrated nutrient management treatments during years 2021, 2022 and on pooled basis. However, number of branches per plant and length of pods were found non-significant during both individual years (2021 and 2022) in residual summer green gram. Although, in pooled analysis number of branches per plant (5.39) and length of pods (8.21 cm) showed their significant influence in residual summer green gram under application of 50% RDF + 50% N from FYM (T_5). Whereas in yield parameters of residual summer green gram *viz.* number of pods per plant, number of seeds per pod, test weight and harvest index was found non-significant due to integrated nutrient management during both the years (2021 & 2022) and in pooled analysis. However, number of seeds per pod was found significant during pooled analysis. Seed and haulm yield of residual summer green gram was found significant due to various integrated nutrient management during both the individual years (2021 & 2022) and in pooled analysis under application of 50% RDF + 50% N from FYM (T_5). Interaction effect (Y x T) was found non-significant on all the growth parameters during the experiment.

Keywords: INM, residual, FYM, poultry manure, caster cake, dry weight per unit leaf area

Introduction

Tobacco, an important non-food narcotic cash crop, belongs to the night shade family (Solanaceae), is believed to be introduced in India from its native Central America by Portuguese in 1603. Tobacco has long been used in Americas, with some cultivation sites in Mexico dating back to 1400-1000 BC.

Historically, people from Northeast Woodlands cultures have carried tobacco in pouches as a readily accepted trade item. Many species of tobacco are in the genus of herbs *Nicotiana.* Most nightshades contain varying amounts of nicotine, a powerful neurotoxin to insects. However, tobacco tends to contain a much higher concentration of nicotine than the others (Krishna Reddy *et al*. 2006) [9].

India is one of the principle tobacco producing countries in the world. Amongst the 66 known species of *Nicotiana,* mainly two species, *N. tabacum* and *N. rustica* are the cultivated ones. *N. tabacum* is grown all over the country while, *N. rustica* is confined mainly to the northern and north eastern areas of the country. Various types of tobacco grown in the country are mainly *Flue Cured Virginia* (FCV), *bidi, hookah, chewing, snuff, lanka, cigar-wrapper, cigar-filler, cheroot, oriental, pikka, natu,* Burley and HDBRG.

The crop occupies less than 0.23% of the net cultivated area and earns sizable amount of Rs. 21,919 crores to the nation as foreign exchange (Rs. 5869 crores; Anon., 2015[b]) [2] and central excise (Rs. 16050 crores; Anon., 2015[a]) [1] to the national exchequer besides providing direct and indirect employment to 36 million people including 6 million farmers and workers. In India, tobacco is grown mainly in Gujarat, Andhra Pradesh, Karnataka, Uttar Pradesh, West Bengal, Tamil Nadu, Orissa, Bihar and Maharashtra.

Gujarat occupies first place from productivity view point followed by Andhra Pradesh. 90% of tobacco grown in the state is accounted by bidi tobacco. Among the Gujarat state, Anand, Kheda, Mahesana, Banaskantha, Vadodara, Sabarkantha, Gandhinagar, Patan, Arvalli, Mahisagar and Ahemdabad are important tobacco growing districts of the state. Among all, Anand district stands first in production as well as hectrage. Tobacco is grown extensively as a commercial non-food crop throughout the world by both large and small holder farmers.

Rustica tobacco is locally known as culcatti tobacco. India is the only country, where mainly *tabaccum*, *rustica* and other types of tobaccos are grown under varied agro-climatic conditions throughout the country. *Rustica* types are used in chewing and snuff whereas *tabacum* type used for all purpose. It is very potent variety of tobacco, containing up to nine times more nicotine than common species of *Nicotiana* such as *Nicotiana tabacum*. More specifically, *N. rustica* leaves have a nicotine content as high as 9%, whereas *N. tabacum* contain about 1-3%. The high concentration of nicotine in its leaves makes it useful for producing pesticides, and it has a wide variety of uses specific to cultures around the world (Potter and Hotchkiss, 1997) [19].

Among the pulses, summer green gram is more cosmopolite and grown in most of the region of India, which shown very encouraging results and promises to have a far reaching significant in achieving a breakthrough in the pulse production. It is also grown for hay, silage and pasture for all types of stalk and as a source of protein, especially in lysine and tryphtophan in the staple cereal diets of the farming communities.

Green gram (*Vigna radiata* (L.) Wilczek) is one of the most ancient and extensively grown leguminous crops of India. It is a native of India and Central Asia and commonly known as mung bean. It is the third important pulse crop after chickpea and pigeon pea, cultivated throughout India for its multipurpose uses as vegetable, pulse, fodder and green manure crop (Kannaiyan, 1999) [8]. Green gram is an important pulse crop of India as it is grown in area of 3.44 M ha with total production of 1.4 MT and productivity of 406.98 kg/ha (Mohanty and Satyasai, 2015) [13].

In India, major green gram producing states are Odissa, Madhya Pradesh, Rajasthan, Maharshtra, Gujarat and Bihar. In Gujarat, it is cultivated in about 2.3 lakhs hectare with an annual production of 1.21 lakhs tonnes with average productivity of 526.09 kg/ha. Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses grown in the world. It is a good source of protein (20-24%), carbohydrates (60-62%), water (10%), fat (1.0%), fibre (4.0%) and ash (3.0%). It is consumed as whole grains as well as dal in a variety of homes, being easily digestable, it is preferred by patients. It is valued for its excellent taste, flavour, high digestibility and free from the "flatulency effect" which is associated with other pulses. When moong beans are allowed to sprout, ascorbic acid (vitamin C) is synthesized besides riboflavin and thiamine is also increased.

Integrated nutrient management refers to the maintenance of soil fertility and plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all the possible sources of organic, inorganic and biological components in an integrated manner. Integrated nutrient management involving conjunctive use of organic manures like farmyard manure, poultry manure, castor cake and bio-fertilizers improves the productivity and quality of tobacco and ensures greater returns to the farmers besides improving soil health (Rao *et al.*, 2009) [21].

FYM seems to act directly for increasing crop yield by accelerating the soil microbial activities, which supplies nitrogen, phosphorus, sulphur and other nutrients in available form to the plants through biological decomposition. Indirectly, it improves the physical properties of soil such as aggregation, aeration, permeability and water holding capacity (Chandramohan, 2002). FYM on an average contains 0.5 to 1.0 per cent N, 0.15 to 0.2 per cent P_2O_5 and 0.5 to 0.6 per cent K_2O (Gaur *et al.*, 1984) [6]. Poultry manure contains about 3.0 per cent N, 0.63 per cent P_2O_5 and 1.40 per cent K_2O (Gaur *et al*., 1984) [6]. It contains uric acid having 60.0 per cent nitrogen which change rapidly to ammonium form and hence efficiently utilized for better plant growth. Castor is one of the excellent source of organic manure. It contains about 4.4 per cent N, 2.0 per cent P_2O_5 and 1.5 per cent K_2O along with large quantity of organic matter, oil cakes are quick acting organic manure (Gaur *et al*., 1984) [6].

Biofertilizers, a component of integrated nutrient management and are considered to be cost effective, eco-friendly and renewable source of non-bulky, low cost plant nutrient supplementing fertilizers in sustainable agriculture system in India. The seedlings of tobacco were dipped in the azotobacter solutions with an objective of increasing their number in the rhizosphere and substantial increase in nitrogen availability for plant growth (Rao, 2007) [20].

Materials and Method

In order to achieve the pre-set objectives of the present exploration, a field experiment was conducted during the *rabi* and summer season of the year 2020-21 and 2021-22 on plot No. 4 A at Bidi Tobacco Research Station, Anand Agricultural University, Anand (Gujarat). The experimental field had an even topography with a gentle slope having good drainage and sandy loam in texture. The soil is representative of the region and locally known as *Goradu* soil, which is alluvial in origin and very deep. The texture of the soil is loamy sand. The soil is fairly moisture retentive. The soil responds well to manure, fertilizers and irrigation. It is quite suitable for variety of crops of tropical and sub - tropical regions. The depth of ground water table is being more than 10 meter. Hence, there is no problem of high water table in this area. The physic-chemical properties of the experimental plot were determined by drawing the soil samples randomly collected from the different spots in the field at a depth of 0-15 cm before commencement of the experiment and composite sample was prepared. After analysis physico - chemical properties of the soil. Data on initial soil analysis indicated that the experimental site was low in organic carbon (0.31%) and available nitrogen (218.6 kg/ha) while, medium in available phosphorus (42.56 kg/ha) and high in available potassium (302.53 kg/ha). The ten integrated nutrient management treatments *viz.*, T_1: 100% RDF (200-00-00 kg/ha), T_2: 75% RDF + 25% N from FYM, T_3: 75% RDF + 25% N from poultry manure, T_4: 75% RDF + 25% N from castor cake, T_5: 50% RDF + 50% N from FYM, T_6: 50% RDF + 50% N from poultry manure, T_7: 50% RDF + 50% N from castor cake, T_8: 50% RDF + 25% N from FYM + Azotobacter, T_9: 50% RDF + 25% N from poultry manure + Azotobacter, T_{10}: 50% RDF + 25% N from castor cake + Azotobacter were tested in Randomized Block Design with four replications. The simple technique of analysis of variance may not be valid under two different seasonal conditions as the error variances in the seasons and the treatments x season's interaction may be significant. Hence, pooled analysis of the preceding *rabi* tobacco and succeeding summer green gram analyzed for two years was worked out as per the method described by Panse and Sukhatme (1967) [17].

Results and Discussion

Growth parameters of Rustica tobacco

Plant height at 30, 60 DATP and at harvest (cm)

Growth and development of crop depends on the progressive initiation of cell differentiation, organ primordial and expansion of component cell until characteristics of the plant is realized. Plant height of tobacco increased progressively with advance in age of crop up to harvest. Plant height of tobacco at 30, 60 DATP and at harvest is given in Table 1 and graphically indicated in Fig. 1.

The plant height at 30 DATP was not influenced significantly due to integrated nutrient management treatments during years 2020-21, 2021-22, while pooled analysis showed significant result. Significantly taller plant of tobacco (22.0 cm) during pooled analysis was recorded under an application of 75% RDF + 25% N from poultry manure (T_3). Similarly, lower plant height of tobacco (18.80 cm) was recorded under treatment T_8 (50% RDF + 25% N from FYM + Azotobacter) during pooled analysis.

The significant difference was not observed in plant height at 60 DATP during both the years as well as in pooled results. Numerically higher plant height (37.70, 38.03 and 37.86 cm during the year 2020-21, 2021-22 and in pooled analysis, respectively) was recorded under the application of 75% RDF + 25% N from poultry manure (T_3) at 60 DATP. Meanwhile, numerically lower plant height of tobacco (35.05, 35.40 and 35.23 cm, respectively) was exerted under the treatment T_8 (50% RDF + 25% N from FYM + Azotobacter) during the years 2020-21, 2021-22 and in pooled analysis.

Alike above, data presented in Table 1 depicted a non-significant difference among the treatments with response to integrated nutrient management treatments at crop harvest. Numerically higher plant height of tobacco (55.28, 56.05 and 55.66 cm during the year 2020-21, 2021-22 and on pooled basis, respectively) was observed under treatment T_3 (75% RDF + 25% N from poultry manure) at harvest. However, numerically lower values (53.20, 53.70 and 53.45 cm) of plant height of tobacco was noticed under treatment T_8 (50% RDF + 25% N from FYM + Azotobacter) during the years 2020-21, 2021-22 and in pooled analysis.

The above result obtained might be due to rapid nutrient available from the poultry manures may leads to the increase in the plant height. These are in conformity with the results of Tekale *et al*. (2015) [23] and Nchang *et al*. (2018) [15].

Leaf length at 30, 60 DATP and at harvest (cm)

Leaf length is an important growth parameter which increased with an advancement of plant growth. A close examination of data furnished in Table 1 and graphically indicated in fig. 4.2 showed that integrated nutrient management manifested their non-significant effect on leaf length recorded at 30, 60 DATP and at harvest.

The statistical analysis of data presented in Table 1 indicated that there was not any significant difference exerted on leaf length at 30 DATP due to different integrated nutrient management. Though, numerically higher values (23.95, 24.20 and 24.08 cm) of leaf length of tobacco was found under the application of 75% RDF + 25% N from poultry manure (T_3) during the years 2020-21, 2021-22 and in pooled analysis. While, numerically lower values (22.68, 22.78 and 22.73 cm) were obtained under the treatment T_8 (50% RDF + 25% N from FYM + Azotobacter) during the years 2020-21, 2021-22 and in pooled analysis.

The data regarding the effects of different nutrient management on leaf length recorded at 60 DATP of rustica tobacco did not exert significant result presented in Table 1. Application of 75% RDF + 25% N from poultry manure (T_3) recorded numerically higher values (40.10, 40.85 and 40.48 cm) of leaf length of rustica tobacco during the years 2020-21, 2021-22 and on pooled basis. Perhaps, treatment T_8 (50% RDF + 25% N from FYM + Azotobacter) obtained numerically lower values of leaf length *i.e.*37.80, 38.13 and 37.96 cm of rustica tobacco during both the years (2020-21, 2021-22) and on pooled basis, respectively.

A perusal of data provided in Table 1 indicated that there was no significant difference observed on leaf length of rustica tobacco due to integrated nutrient management at harvest. Numerically higher values of leaf length (49.95, 50.30 and 50.13 cm) of rustica tobacco was noticed under treatment T_3 (75% RDF + 25% N from poultry manure) during the years 2020-21, 2021-22 and in pooled analysis. However, numerically lower values of leaf length (47.80, 48.05 and 47.93 cm) was observed under the application of 50% RDF + 25% N from FYM + Azotobacter (T_8) during both the years (2020-21, 2021-22) and on pooled basis, respectively.

The above mentioned result might be due to combined application organic and inorganic fertilizer promotes the vegetative growth of plant that leads to increase in leaf length of rustica tobacco. This finding is in agreement with that of Pariari and Khan (2013) [18] and Nchang *et al*. (2018) [15].

Leaf width at 30, 60 DATP and at harvest (cm)

The data pertaining to the effect of different integrated nutrient management on leaf width recorded at 30, 60 DATP and at harvest are presented in Table 1 did not exert their significant influence on leaf width of rustica tobacco.

The data recorded at 30 DATP was found numerically higher under an application of 75% RDF + 25% N from poultry manure (T_3) with values 19.93, 20.03 and 19.98 cm during years 2020-21, 2021-22 and on pooled basis, respectively. While, lower values (18.10, 18.35 and 18.23 cm) of leaf width of rustica tobacco was observed in treatment T_8 (50% RDF + 25% N from FYM + Azotobacter) during the years 2020-21, 2021-22 and on pooled basis.

The data on leaf width of rustica tobacco recorded at 60 DATP as influenced by integrated nutrient management treatments failed to showed significant difference. But somehow, treatment (T_3) 75% RDF + 25% N from poultry manure obtained numerically higher values (30.55, 30.73 and 30.64 cm) of leaf width of ructica tobacco for the years 2020-21, 2021-22 and on pooled basis, respectively. However, lower values were observed under the application of 50% RDF + 25% N from FYM + Azotobacter (T_8) for the years 2020-21, 2021-22 and on pooled basis, respectively.

The data recorded numerically higher values (38.98, 39.28 and 39.13 cm) in case of treatment T_3 (75% RDF + 25% N from poultry manure) during the years 2020-21, 2021-22 and on pooled basis, respectively. Perhaps, lower values (35.48, 36.28 and 35.88 cm) were indicated under the application of 50% RDF + 25% N from FYM + Azotobacter (T_8) for the years 2020-21, 2021-22 and on pooled basis, respectively.

Thus, higher leaf width might be due to combined application of organic and inorganic sources of fertilizer and higher plant height resulting into increase in vegetative growth of plant which seems to be increase in leaf width. This finding is in agreement with that of Pariari and Khan (2013) [18].

Dry weight per unit leaf area (mg/cm^2)

The perusal of data of dry weight of leaf per unit area presented in Table 1 and graphically indicated in Fig. 2 revealed that effect of integrated nutrient management on dry weight per unit area of leaf (mg/cm^2) was found non-significant.

The data regarding to the dry weight of leaf per unit area of rustica tobacco at harvest failed to express significant difference due to effect of integrated nutrient management treatments for the individual years. Eventhough, treatment T_3 (75% RDF + 25% N from poultry manure) recorded significantly higher values of dry weight per unit leaf area (9.05 mg/cm^2) only on pooled basis as compared to rest of the treatments.

Dry matter accumulation is a function of total plant stand, plant height, leaf length, leaf width, hence all these characters may ultimately affect dry matter per unit leaf area of crop. Better availability of nutrients from poultry manure to rustica tobacco crop translocate maximum photosynthesis from source to sink which accumulates to individual plant parts and results to higher dry matter production of rustica tobacco crop. The result was in close agreement with that of Manohar *et al*. (2013) [12] and Pandey and Chandra (2013) [16].

Yield parameter of rustica tobacco

Cured leaf yield (kg/ha)

Generally, cured leaf yield depends on the fruiting organ produced by a plant. In rustica tobacco crop, yield depends mostly on plant population, periodical plant height, dry weight per unit leaf area, leaf length and leaf width.

The data on cured leaf yield as influenced by integrated nutrient management treatments during the years 2020-21, 2021-22 and on pooled basis are given in Table 1 and graphically presented in Fig.2.

Among all treatments tested, treatment T_3 (75% RDF + 25% N from poultry manure) had recorded significantly higher cured leaf yield (2488 kg/ha) during 2020-21. However, it was comparable with treatments T_4 (75% RDF + 25% N from castor cake) (2206 kg/ha). In the year 2021-22, application of 75% RDF + 25% N from poultry manure (T_3) was reported significantly higher cured leaf yield of 2530 kg/ha. However, it was statistically similar with treatments T_1, T_2, T_4 and T_6.

Result of pooled analysis indicated that significantly the highest cured leaf yield of 2509 kg/ha recorded under the application of 75% RDF + 25% N from poultry manure (T_3). While, significantly lower values (1775, 1884 and 1829 kg/ha) of cured leaf of rustica tobacco was observed under the treatment T_8 (50% RDF + 25% N from FYM + Azotobacter) during both the years (2020-21 and 2021-22) and on pooled basis, respectively.

The increase in cured leaf yield was due to increase in yield attribute and the growth parameters. Increased supply of nitrogen to plant promotes fruiting, higher manufacture of food and its subsequent partitioning in sink. Thus, adequate supply of nitrogen and phosphorus nutrients from the poultry manure to plant in balance proportion improved the yield attributing characters and yield. Similar findings are in collaboration with Benerjee *et al.* (2016), Manohar *et al*. (2013) [12], Narayan *et al*. (2013) [14], Pandey and Chandra (2013) [16] and Kumar *et al*. (2015) [10].

Residual impact on succeeeding summer green gram

Growth parameters of residual summer green gram

Plant height at 30, 60 DAS and at harvest (cm)

The data pertaining to plant height at 30 DAS affected due to residual effect of integrated nutrient management on summer green gram crop for the year 2021, 2022 and pooled analysis is presented in Table 2 and graphically displayed in Fig.3. was found non-significant.

Results indicated non-significant differences for plant height at 30 DAS during both the years (2021 and 2022) and on pooled basis. However, application of 50% RDF + 50% N from FYM (T_5) obtained numerically higher values (24.95, 25.03 and 24.99 cm) of plant height at 30 DAS during the years 2021, 2022 and in pooled analysis. While, numerically lower values (21.70, 21.80 and 21.75 cm) of plant height at 30 DAS was examined under the treatment T_1 (100% RDF (200-00-00 kg/ha) during both the individual years (2021 and 2022) and on pooled basis, respectively.

The results indicated a non-significant influence on plant height at 60 DAS of residual summer green gram due to different residual effect of integrated nutrient management during the year 2021, 2022 and on pooled basis. Among the different treatments studied, numerically higher values (33.55, 32.90 and 33.23 cm) of plant height at 60 DAS summer of green gram was observed under application of 50% RDF + 50% N from FYM (T_5) during the year 2021, 2022 and on pooled basis. On the contrary, numerically lower values (31.65, 31.15 and 31.40 cm) of plant height at 60 DAS was observed under the treatment T_1 (100% RDF 200-00-00 kg/ha) during both the individual years (2021, 2022) and on pooled basis, respectively.

Alike above, data presented in Table 2 depicted a non-significant difference among the treatments with response to integrated nutrient management treatments at crop harvest. Application of 50% RDF + 50% N from FYM (T_5) reported numerically higher plant height of 42.02, 41.90 and 41.96 cm during the years 2021, 2022 and on pooled basis at harvest over rest of the treatments. However, lower values (38.98, 38.83 and 38.90 cm) of plant height at harvest was rectified under the application of 100% RDF 200-00-00 kg/ha (T_1) for the years 2021, 2022 and on pooled basis, respectively.

The higher values of height of residual summer green gram crop might be due to supply of all the essential mineral nutrients in a balanced amount through organic sources of fertilizer that was applied in preceding crop. These results were in conformity with the findings of Singh *et al*. (2017) [22] and Joseph *et al.* (2018) [7].

Number of branches at harvest

The data pertaining to number of branches per plant at harvest as influenced by different treatments during the years 2021, 2022 and on pooled basis are presented in Table 2. The results indicated a non-significant influence on number of branches per plant of residual summer green gram due to different integrated nutrient management treatments during the years 2021 and 2022 but significant difference was observed in pooled analysis.

There was no significant difference observed in number of branches per plant during both individual years (2021 and 2022). Among the different treatments studied numerically higher number (5.38 and 5.40 cm) of branches per plant of residual summer green gram was observed under application of 50% RDF + 50% N from FYM (T_5) during years 2021 and 2022. On pooled basis, treatment T_5 (50% RDF + 50% N from FYM) recorded significantly higher number (5.39 cm) of branches per plant of residual summer green gram and it was closely related with treatment T_8, T_9 and T_{10}. However, significantly lower number (4.31 cm) of branches per plant was observed under application of 100% RDF 200-00-00 kg/ha (T_1) on pooled basis, respectively.

The above mentioned result might be due to more nutrient availability under residual effect of integrated nutrient management resulted into increased conversion of carbohydrates into protein which in turn elaborated into protoplasm and cell wall material increased the size of the cell, which expressed morphologically number of branches. Cellulose is a highly persistent composition material, which requires longer time for decomposition. Thus, FYM have not been fully utilized by the rustica tobacco crop in first crop season and notably benefitted the succeeding summer green gram crop. It confirmed the findings of Manjhi *et al.* (2016) [11], Bilkis *et al.* (2017) [4], Singh *et al*. (2017) [22] and Joseph *et al.* (2018) [7].

Length of pods at harvest (cm)

The results failed to show a significant response on length of pods at harvest of residual summer green gram due to different integrated nutrient management treatments during the years 2021 and 2022 but significant difference was observed in pooled analysis (Table 2).

There was no significant difference observed in length of pods during both individual years (2021 and 2022). Among the different treatments tested, numerically higher length (8.19 and 8.23 cm) of pod was observed under application of 50% RDF + 50% N from FYM (T_5) during years 2021 and 2022 of residual summer green gram. On pooled basis, treatment T_5 (50% RDF + 50% N from FYM) recorded significantly higher length (8.21 cm) of pods of residual summer green gram and it was closely related with treatment T_2, T_7, T_8, T_9 and T_{10}. Whereas, significantly lower length (7.24 cm) of pods was found under application of 100% RDF 200-00-00 kg/ha (T_1) on pooled basis, respectively.

The increase in length of pod of residual summer green might be due to more availability of essential nutrients that required to increase vegetative growth of crop from the applied organic sources of fertilizer. It confirmed the findings of Manjhi *et al.* (2016), Bilkis *et al*. (2017) [4], Singh *et al*. (2017) [22] and Joseph *et al.* (2018) [7].

Yield parameters of residual summer green gram

Number of pods per plant

The results failed to express a significant response on number of pods per plant at harvest of residual summer green gram due to different integrated nutrient management treatments during the years 2021 and 2022 and on pooled basis, respectively (Table 2).

Numerically higher number (31.98, 30.91 and 31.44) of pods per plant was recorded under the treatment T_5 (50% RDF + 50% N from FYM) for the years 2021, 2022 and in pooled analysis in residual summer green gram at harvest. Meanwhile, numerically lower number (27.30, 27.55 and 27.43) of pods per plant in residual summer green gram at harvest was noticed under application of 100% RDF 200-00-00 kg/ha (T_1) during the years 2021 and 2022 and on pooled basis, respectively.

More vegetative growth of summer green gram and decomposed FYM might be reason for higher number of pods. These results are in the similar line obtained by Manjhi *et al.* (2016) [11] and Joseph *et al*, (2018) [7].

Number of seeds per pod

The results failed to show a significant response on number of seeds per pod of residual summer green gram due to different integrated nutrient management treatments during the years 2021 and 2022 but significant difference was observed in pooled analysis (Table 2). An appraisal of result revealed that application of 50% RDF + 50% N from FYM (T_5) observed numerically higher number (10.45, 10.95 and 10.70) of seeds per pod during the years 2021, 2022 and in pooled analysis, respectively. While, numerically lower number (8.80, 9.20 and 9.00) of seeds per pod of residual summer green gram was observed under the treatment T_1 (100% RDF 200-00-00 kg/ha) during years 2021, 2022 and on pooled basis.

The higher number of seeds per pod might be due to higher growth parameters of succeeding summer green gram and more availability of nutrients through residual effect. Moreover, FYM plays an important role in providing essential nutrients. These results are in accordance with Manjhi *et al.* (2016) [11] and Joseph *et al*, (2018) [7].

Test weight (g)

According to the data furnished in Table 2 there was no significant influence observed on test weight due to residual effect of integrated nutrient management treatments during the years 2021, 2022 and in pooled analysis. The appraisal of result revealed that application of 50% RDF + 50% N from

FYM (T_5) observed numerically higher test weight of 35.58, 35.68 and 35.63 g during the years 2021, 2022 and in pooled analysis, respectively. Though, treatment T_1 (100% RDF 200-00-00 kg/ha) recorded numerically lower values (33.88, 34.15 and 34.01 g) of test weight of residual summer green gram for the years 2021, 2022 and in pooled analysis, respectively.

In case of test weight, such effect may might be owing to increased availability of nutrient in soil from native pool as well as their residual effect through mineralization and improvement of physico-chemical properties of soil. These results are in accordance with Bilkis *et al*. (2017) [4] and Singh *et al*. (2017) [22].

Seed yield (kg/ha)

Generally, seed yield depends on the fruiting organ produced by a plant. In green gram crop, yield depends mostly on periodical plant height, number of pods per plant, number of seeds per pod and test weight. The data on seed yield as influenced by integrated nutrient management treatments on the years 2021, 2022 and in pooled analysis are given in Table 2 and graphically presented in Fig. 4.

Data mentioned in Table 2 showed that integrated nutrient management treatments significantly influenced the seed yield of residual summer green gram during both the years (2021 and 2022) as well as in pooled analysis. Among all treatments tested, treatment T_5 (50% RDF + 50% N from FYM) had significantly higher seed yield (1040 and 1052 kg/ha) during the years 2021 and 2022, respectively. However, it was comparable with treatments T_7, T_8, T_9 and T_{10} for both the years. Result of pooled analysis indicated that significantly higher seed yield of 1046 kg/ha recorded under an application of 50% RDF + 50% N from FYM (T_5), which was closely related to the treatments T_8, T_9 and T_{10}. In contrast to it, significantly lower seed yield of 878, 881 and 879 kg/ha of residual summer green gram was recorded under application of 100% RDF 200-00-00 kg/ha (T_1) during the years 2021, 2022 and pooled analysis, respectively.

It might be ascertained to the increased availability of nutrients due to mineralization of organic materials, release of CO_2 increasing fertilizer use efficiency, accumulation of organic carbon and improvement of soil physical properties. The increased green gram seed yield might be due to addition of FYM to preceding crop resulting in improvement in soil structure which reduced the soil crusting and also serves as a source of energy for soil microflora which resulted in better root nodulation and nitrogen fixation. It is confirmed by Manjhi *et al.* (2016) [11] and Joseph *et al*, (2018) [7].

Haulm yield (kg/ha)

The data pertaining to haulm yield as influenced by integrated nutrient management treatments during the years 2021, 2022 and on combined analysis which are presented in Table 2 and graphically depicted in Fig. 4. Among the different treatments studied, significantly higher haulm yield (1746 and 1753 kg/ha) of residual summer green gram was observed under application of 50% RDF + 50% N from FYM (T_5). Alike above, significantly at par relation was reported with treatments T_7, T_8, T_9 and T_{10} for the years 2021, 2022 and on pooled basis, respectively.

The results of pooled analysis showed that significantly higher haulm yield (1749 kg/ha) of residual summer green gram recorded under application of 50% RDF + 50% N from FYM (T_5). However, it was closely related to treatments T_8, T_9 and T_{10} during the years 2021, 2022 and in pooled analysis, respectively over other treatments. However, significantly lower haulm yield of residual summer green gram was displayed under the treatment T_1 (100% RDF 200-00-00 kg/ha) with values (1333, 1363 and 1348 kg/ha) during the years 2021, 2022 and in pooled analysis.

Higher haulm yield under above treatments might be due to increase in vegetative growth in terms of plant height (Table 4.28-4.30), number of branches (Table 4.31) and dry matter accumulation. Similar results were reported earlier by Manjhi *et al.* (2016) [11] and Joseph *et al*, (2018) [7].

Harvest index (%)

Data belongs to the influence of integrated nutrient management treatments on harvest index of residual summer green gram as recorded during the years 2021, 2022 and on pooled basis are presented in Table 2. Harvest index is a ratio between grain yield and biological yield expressed in percentage, results indicated equal influence of all the nutrient management treatments on grain and biological yield of residual summer green gram.

Scrutiny of data summarized in Table 2 indicated that different nutrient management treatments did not showed their significant influence on harvest index of residual summer green gram during both the individual investigational years 2021 and 2022 as well as in pooled analysis. Numerically higher values (39.75, 39.23 and 39.49%) of harvest index of green gram during 2021, 2022 and on pooled basis, respectively) was recorded under an application of 100% RDF 200-00-00 kg/ha (T_1). While, numerically lower values (37.50, 37.13 and 37.31%) of harvest index for the residual summer green gram was exhibited under treatment T_8 (50% RDF + 25% N from FYM + Azotobacter) during years 2021, 2022 and on pooled basis, respectively.

This might be due to equal ratio of economic and biological yield of residual summer green gram for all the treatments and it was supported by Bilkis *et al*. (2017) [4] and Singh *et al*. (2017) [22].

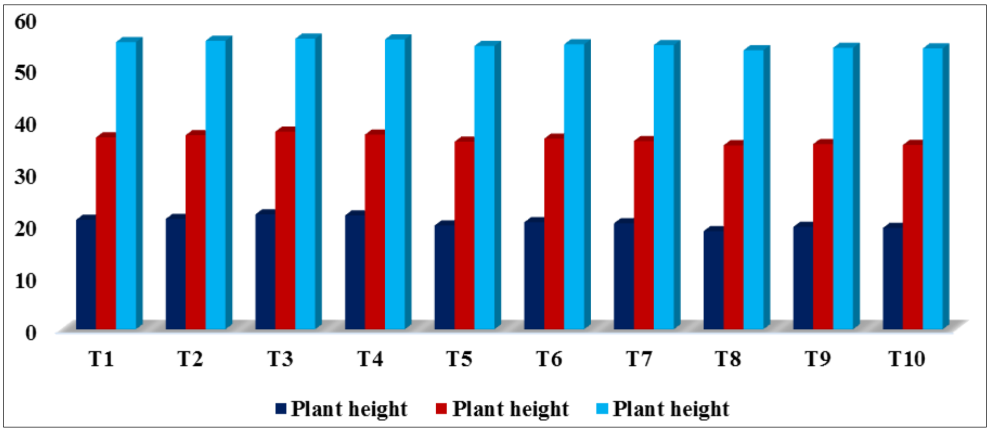

Fig 1: Plant height (cm) of rustica tobacco as influenced by different INM treatments on pooled basis

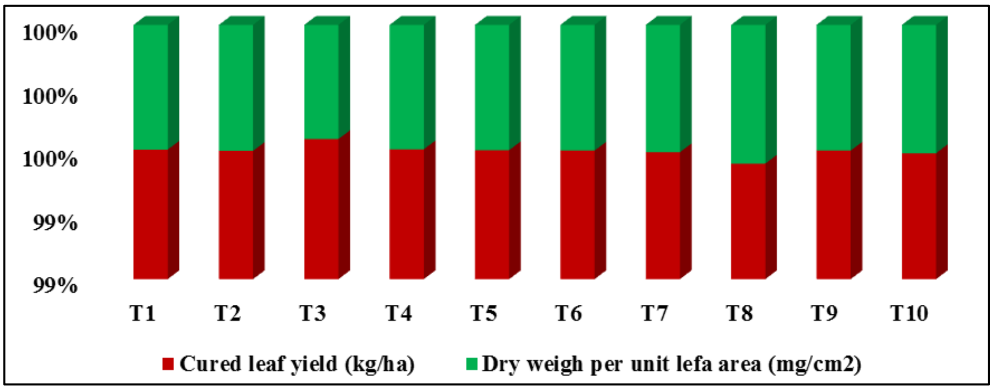

Fig 2: Cured leaf yield and DWPULA of rustica tobacco as influenced by different INM treatments on pooled basis

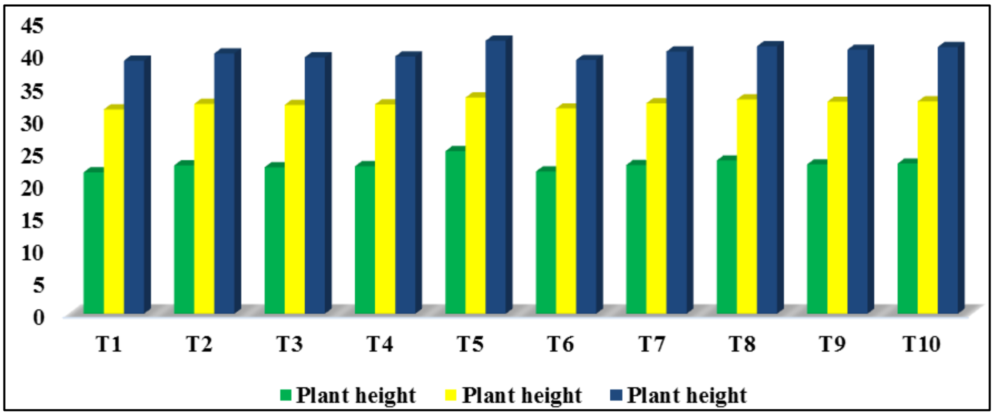

Fig 3: Plant height (cm) of residual summer green gram as influenced by different INM treatments on pooled basis

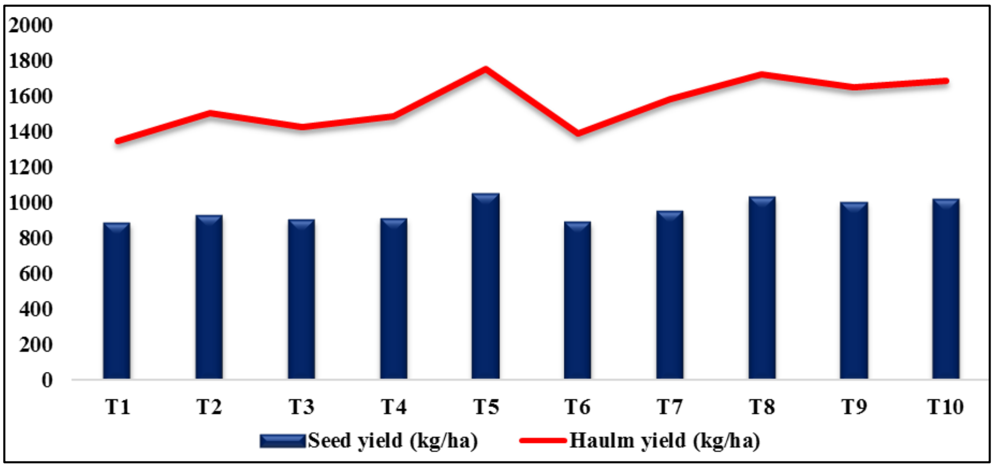

Fig 4: Seed and haulm yield of residual summer green gram as influenced by different INM treatments on pooled basis

Table 1: Effect of integrated nutrient management on growth and yield parameters of rustica tobacco on pooled basis

Sr. No.	Treatments	Plant height (cm)			Leaf length (cm)			Leaf width (cm)			DWPULA (mg/cm^2)	CLY (kg/ha)
		30 DATP	60 DATP	At harvest	30 DATP	60 DATP	At harvest	30 DATP	60 DATP	At harvest		
T_1	100% RDF (200-00-00 kg/ha)	20.96	36.75	55.01	23.33	39.26	49.21	19.48	28.93	37.46	8.69	2205
T_2	75% RDF + 25% N from FYM	21.13	37.18	55.26	23.74	39.51	49.43	19.75	29.21	38.10	8.79	2208
T_3	75% RDF + 25% N from poultry manure	22.00	37.86	55.66	24.08	40.48	50.13	19.98	30.64	39.13	9.05	2509
T_4	75% RDF + 25% N from castor cake	21.80	37.28	55.51	23.91	39.59	49.98	19.91	29.81	38.60	8.85	2252
T_5	50% RDF + 50% N from FYM	19.88	35.93	54.28	22.91	38.75	48.75	18.75	27.93	36.79	8.28	2092
T_6	50% RDF + 50% N from poultry manure	20.50	36.51	54.59	23.20	39.06	49.10	19.20	28.66	37.20	8.59	2162
T_7	50% RDF + 50% N from castor cake	20.30	36.06	54.45	23.03	38.70	49.01	19.10	28.18	37.03	8.50	2113
T_8	50% RDF + 25% N from FYM + Azotobacter	18.80	35.23	53.45	22.73	37.96	47.93	18.23	27.33	35.88	8.02	1829
T_9	50% RDF + 25% N from poultry manure + Azotobacter	19.60	35.48	53.91	22.88	38.58	48.33	18.61	27.80	36.50	8.22	2069
T_{10}	50% RDF + 25% N from castor cake + Azotobacter	19.40	35.29	53.79	22.78	38.30	48.18	18.45	27.68	36.13	8.06	1988
	SEm ±	0.69	0.96	1.55	0.74	1.28	1.55	0.67	0.97	1.23	0.20	76.6
	CD (P=0.05)	1.96	NS	NS	NS	NS	NS	NS	NS	NS	0.57	217.2
	CV%	9.58	7.47	8.04	8.96	9.27	8.96	9.95	9.59	9.33	6.66	10.12
	Y	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Y x T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of integrated nutrient management on growth and yield parameters of residual summer green gram on pooled basis

Sr. No.	Treatments	Plant height (cm)			No. of branches/plant	Length of pods (cm)	No. of pods/plant	No. of seeds/pod	Test weight (g)	Seed yield (kg/ha)	Haulm yield (kg/ha)	Harvest index (%)
		30 DAS	60 DAS	At harvest								
T_1	100% RDF (200-00-00 kg/ha)	21.75	31.40	38.90	4.31	7.24	27.43	9.00	34.01	879	1348	39.49
T_2	75% RDF + 25% N from FYM	22.80	32.25	40.01	4.88	7.65	28.57	9.81	34.99	923	1499	18.99
T_3	75% RDF + 25% N from poultry manure	22.51	32.10	39.41	4.68	7.39	28.29	9.37	34.51	896	1425	38.65
T_4	75% RDF + 25% N from castor cake	22.67	32.18	39.54	4.76	7.53	28.29	9.64	34.95	904	1481	38.11
T_5	50% RDF + 50% N from FYM	24.99	33.23	41.96	5.39	8.21	31.44	10.70	35.63	1046	1749	37.56
T_6	50% RDF + 50% N from poultry manure	21.86	31.55	39.00	4.53	7.32	28.15	9.25	34.25	883	1388	38.98
T_7	50% RDF + 50% N from castor cake	22.86	32.36	40.30	4.93	7.70	28.83	9.95	35.13	947	1580	37.45
T_8	50% RDF + 25% N from FYM + Azotobacter	23.56	32.95	41.11	5.16	8.13	30.79	10.38	35.55	1025	1719	37.31
T_9	50% RDF + 25% N from poultry manure + Azotobacter	22.96	32.58	40.58	5.04	7.83	29.62	10.13	35.33	997	1644	37.93
T_{10}	50% RDF + 25% N from castor cake + Azotobacter	23.08	32.63	41.00	5.10	8.05	30.70	10.16	35.41	1013	1682	38.35
	SEm ±	0.69	0.92	1.18	0.16	0.23	0.89	0.30	1.03	28	54	1.17
	CD (P=0.05)	NS	NS	NS	0.44	0.64	NS	0.84	NS	79	154	NS
	CV%	8.56	8.05	8.33	9.09	8.32	8.66	8.51	8.32	8.29	9.90	8.63
	Y	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Y x T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

It is well known fact that, agriculture mainly depends on soil and in present scenario, the main reason behind the low fertile soil is injudicious use of chemical fertilizers which has vast hazardous impact on soil health, human health and on biodiversity. Hence, from the above experiment it can be concluded that combined application of organic and inorganic fertilizers (75% RDF + 25% N from poultry manure) directly elevates crop growth and productivity of rustica tobacco. Further it also outcomed that applied organic and inorganic fertilizers in rustica tobacco had great influenced on crop growth and yield parameters of residual succeeding summer green gram.

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