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Effect of INM on quality of Okra (*Abelmoschus esculentus* L.) under teak (*Tectona grandis* L. f.) based agroforestry system

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Abstract
The investigation on 'Effect of INM (Integrated Nitrogen Management) on quality of Okra (*Abelmoschus esculentus* L.) under Teak based agroforestry system was conducted during *summer* season in the years of 2019 and 2020, at College Farm (Block-A, Plot No-21), N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India. The trial was framed with eleven different treatments comprised of combinations of vermicompost, neem cake and chemical fertilizers in various proportions *i.e.* 25 per cent, 50 per cent, 75 per cent and 100 per cent of recommend does of nitrogen in the form of organic and inorganic fertilizers under teak plantation and open condition in Randomized Block Design (RBD) consisting of three replications. The result showed that quality parameters *viz*., nitrogen (2.44%) and protein content (15.25%) in fruit of okra recorded maximum in T_6: 50% RDN through Neem coated urea + 50% RDN through Vermicompost under teak based agroforestry system. However, the lowest nitrogen (2.23%) and protein content (13.94%) of okra fruit were recorded in T_9: 100% RDN through Neem cake under teak based agroforestry system. While, crude fiber content of okra fruit was not significantly influenced by different INM treatments. However, INM treatments exhibited superior value regarding quality parameters as compared to the treatments receiving recommended dose of fertilizers through chemicals.

Keywords: Okra, quality, integrated nitrogen management, agroforestry system, teak, nitrogen

1. Introduction
Okra (*Abelmoschus esculentus* L.) is a fast growing, erect, herbaceous annual and belonged to the family Malvaceae. Okra is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. This crop is suitable for cultivation as a garden crop as well as on large commercial farms. Centre of origin of okra is Africa. Because of it starts very early stage to produces fruits and continues for long time period and also has richness in nutrition, taste, medicinal and industrial value okra is one of the most popular vegetables crop farmers grown in their farm in India. Aykroyd (1963) [3] stated that 100 g of consumable unripe okra fruits contains good nutritional value. In vegetable production, chemical fertilizers are being used increasingly because of the quick availability of the nutrients to the plants. Okra crop requires large quantities of both macro and micro nutrients for required economic yields. Nitrogen is an important and plays a key role in the production of both quantity and quality level in okra. Indiscriminate use of inorganic fertilizers has resulted in decreased nutrient uptake, poor quality of vegetables and deterioration of soil health (Agarwal, 2003) [2] to decline in yield and quality of vegetables and vegetable products, causing environmental pollution and finally the impairment of human health and also directly and indirectly effect on agricultural ecosystem. Therefore, need to applied adequate amount of organic and inorganic nitrogen fertilizer for good quality of okra.
Importance of optimum plant nutrition is well known for the production of good quality fruit. The production of better quality okra would help in a great way to tide over the problem of malnutrition which is wide spread in India and other developing countries. Fortunately, the agricultural scientists as well as nutrition experts all over the world have realized the importance of quality and therefore an effort have been made in the present investigation to know the effect of various integrated nitrogen management on quality parameters under teak based agroforestry system.

2. Materials and Methods

2.1 Site location and climatic condition: A field experiment was conducted during *summer* season of 2019 and 2020, at College Farm (Block-A, Plot No-21), N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India. Geographically it is located at 20.95° N latitude and 72.93° E longitude with an elevation of 9 m MSL. This area is typically characterized by humid and warm monsoon with rainfall of about 1500 mm, moderately cold winter, and fairly hot and humid summer. The average annual temperature is 27.1 °C.

2.2 FYM, Vermicompost and Neem cake

For experiment required quantity of FYM and Vermicompost were procured from Livestock Production Management, NAU, Navsari and Neem cake procured from the Horticulture Mandali, Navsari. Before the application of fertilizer, the FYM, Vermicompost and Neem cake were analyzed to know the N content by using Wet digestion (Chromic acid) method (Trivedi *et al.*, 1999) [15]. On the basis of N content of Vermicompost (2.15%) and Neem cake (4.49%) different treatments were formulated.

2.3 Treatment applications: Experiment was designed in Randomized Block Design (RBD) in three replications with eleven treatment combinations *viz*. Under Teak T_1: 100% RDF through Chemical Fertilizer (150:50:50 @ NPK kg ha-1), T_2: 75% RDN through Neem coated urea + 25% RDN through Neem cake, T_3: 50% RDN through Neem coated urea + 50% RDN through Neem cake, T_4: 25% RDN through Neem coated urea + 75% RDN through Neem cake, T_5: 75% RDN through Neem coated urea + 25% RDN through Vermicompost, T_6: 50% RDN through Neem coated urea + 50% RDN through Vermicompost, T_7: 25% RDN through Neem coated urea + 75% RDN through Vermicompost, T_8: 100% RDN through Vermicompost, T_9: 100% RDN through Neem cake, In open condition T_{10}: 100% RDF through Chemical Fertilizer and T_{11}: 75% RDN through Neem coated urea + 25% RDN through Neem cake.

The recommended dose of nitrogen, phosphorus and potassium @ 150-50-50 kg ha^{-1} for okra crop under Teak and open condition trial was applied in the form of Vermicompost, Neem Cake, Urea, Single Super Phosphate and Muriate of Potash. Nitrogen from organic fertilizer applied full does initially while from chemical recommended dose of N was applied at 30 days interval in three split doses (i.e. 50-50-50 N kg ha^{-1}) in aqueous form of urea. Phosphorus and potassium applied as basal dose. Randomly chosen ten fruits were collected from different plot for quality parameters analysis at 5th picking of fruit and nitrogen content of okra fruit were also analysed by Trivedi *et al*. (1999) [15] and Crude fibre content was determined by the method suggested by Anon. (1960) [1].

2.4 Statistical analysis: The recorded data were statistically analyzed by using software developed by Department of Agricultural Statistics, ACHF, NAU, Navsari and as per the methods prescribed by Panse and Sukhatme (1985) [10]. The treatment means were compared by using critical difference tests at 5% of probability and analysis of variance.

3. Results and Discussion

Quality parameters of okra fruit *viz*. nitrogen, protein and crude fiber content (%) in fruit of okra var. GAO 5 was recorded during the experiment and the results obtained are presented in Table – 1. The interaction effect of years over treatments was found non-significant in pooled analysis for all quality parameters under teak based agroforestry system.

In pooled analysis, among the different treatments, nitrogen and protein content in fruit was significantly influenced due to different treatments. Here, maximum nitrogen and protein content (2.44% and 15.25%, respectively) was recorded with T_6: 50% RDN through Neem coated urea + 50% RDN through Vermicompost under teak based agroforestry system which was at par with T_3: 50% RDN through Neem coated urea + 50% RDN through Neem cake (2.43% and 15.16%, respectively), T_5: 75% RDN through Neem coated urea + 25% RDN through Vermicompost (2.41% and 15.08%, respectively), T_2: 75% RDN through Neem coated urea + 25% RDN through Neem cake (2.41% and 15.04%, respectively) under teak and T_{11}: 75% RDN through Neem coated urea + 25% RDN through Vermicompost (2.36% and 14.72%, respectively) in open condition. However, the lowest nitrogen content in fruit (2.23% and 13.94%, respectively) was recorded in T_9: 100% RDN through Neem cake under teak based agroforestry system as compared to remaining treatments. From the results combined application of organic and inorganic i.e. T_6: 50% RDN through Neem coated urea with 50% RDN Vermicompost reported maximum quality parameters under teak based agroforestry system as compared to open condition. Many other scientists have also reported higher nitrogen and protein content under shady condition (Cruz, 1996 and Guenni *et al*., 2008) which is associated with this study. In present study, closure canopy of teak has lowered PAR intensity reaching to the under story crop. This microclimate condition retained higher moisture content under teak. Due to the higher moisture availability under teak based agroforestry systems boost rapid decomposed the organic matter and increase N availability (Wilson and Wild, 1995; Wilson, 1996) [18, 17]. The eventual availability of more nitrogen to the intercrops under teak based agroforestry system might have increased the nitrogen content in okra fruit. Whereas, crude fiber content in treatment differences was found non-significant in both the years of study and in pooled analysis.

Moreover, among the different treatments of integrated nitrogen managements under teak and in open condition quality parameters were registered higher with combined application of organic and inorganic fertilizer it might be due to the increase in nitrogen and protein content was pronounced with the higher level of organic form applied in combination of inorganic form, favored by intense protein synthesis and its efficient storage in presence of abundant supply of available nitrogen and protein content was increased significantly by the application of different organic manures with fertilizers (Gayathri and Krishnaveni, 2015) [5]. Highest protein content in treatment receiving conjunction of organic manure and inorganic fertilizer was found by Yadav *et al.* (2006) [19] and Wagh *et al.* (2014) [16]. Similar findings have been also reported by Poul *et al.* (2004) [11] in tomato, Singh (2004) [13] in okra, Mahmoud *et al.* (2009) [8], Tripathy *et al.* (2009) [14], Kumar (2016) [7] in brinjal, Sachan *et al.* (2017) [12] in okra and Mevada *et al.* (2018) [9] in paddy.

During first and second year of investigation it showed the same trend as per the results of pooled analysis (Table – 1).

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Table 1: Effect of different INM treatments on quality parameter of okra fruit under teak based agroforestry system and in open condition

Treatments	Nitrogen content (%)			Protein content (%)			Crude fiber content (%)		
	Year 1	Year 2	Pooled	Year 1	Year 2	Pooled	Year 1	Year 2	Pooled
Under Teak									
T_1	2.34	2.35	2.34	14.60	14.67	14.64	13.06	13.05	13.05
T_2	2.40	2.41	2.41	15.02	15.06	15.04	13.03	13.05	13.04
T_3	2.42	2.43	2.43	15.13	15.19	15.16	13.04	13.10	13.07
T_4	2.24	2.27	2.25	13.98	14.17	14.07	13.08	13.08	13.08
T_5	2.41	2.42	2.41	15.06	15.10	15.08	13.05	13.06	13.05
T_6	2.44	2.44	2.44	15.23	15.27	15.25	12.94	12.98	12.96
T_7	2.28	2.30	2.29	14.23	14.40	14.31	13.03	13.38	13.20
T_8	2.23	2.26	2.25	13.94	14.13	14.03	12.96	12.96	12.96
T_9	2.22	2.24	2.23	13.85	14.02	13.94	13.03	13.05	13.04
In open condition									
T_{10}	2.34	2.34	2.34	14.65	14.63	14.64	13.00	13.08	13.04
T_{11}	2.36	2.35	2.36	14.75	14.69	14.72	12.97	12.94	12.96
SEm (±)	0.05	0.04	0.03	0.31	0.28	0.18	0.32	0.16	0.16
CD @ 5%	0.15	0.13	0.08	0.91	0.82	0.53	NS	NS	NS
SEm (±) (Y×T)			0.05			0.29			0.25
CD @ 5% (Y×T)			NS			NS			NS
CV (%)	3.69	3.29	3.49	3.68	3.29	3.49	4.19	2.17	3.33

T_1 :-100% RDF through Chemical fertilizer (150:50:50 @NPK kg ha^{-1})
T_2:-75% RDN through Neem coated urea + 25% RDN through Neem cake
T_3:-50% RDN through Neem coated urea + 50% RDN through Neem cake
T_4:-25% RDN through Neem coated urea + 75% RDN through Neem cake
T_5:-75% RDN through Neem coated urea + 25% RDN through Vermicompost
T_6:-50% RDN through Neem coated urea + 50% RDN through Vermicompost
T_7:-25% RDN through Neem coated urea + 75% RDN through Vermicompost
T_8:-100% RDN through Vermicompost
T_9:-100% RDN through Neem cake
T_{10}:-100% RDF through Chemical fertilizer (150:50:50 @NPK kg ha^{-1})
T_{11}:-75% RDN through Neem coated urea + 25% RDN through Vermicompost

5. Conclusion

From the present study, it can be concluded that combined application of 50% RDN through Neem coated urea + 50% RDN through Vermicompost under teak based agroforestry system improved the quality traits of okra fruits as compared to other treatments. However, the combined application of organic and inorganic fertilizer from Vermicopost, Neem cake and Chemical fertilizer improved the quality traits of fruit as compared to alone organic and inorganic fertilizer application under teak based agroforestry system.

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