Indian Journal of Ecology (2022) 49(5): 1719-1723
DOI: https://doi.org/10.55362/IJE/2022/3723

Manuscript Number: 3723
NAAS Rating: 5.79

Economic Perspective of Integrated Nitrogen Management under Teak (*Tectona grandis* L.f.) - Okra (*Abelmoschus esculentus* L.) based Silvi-Horticulture System

R.J. Mevada, M.B. Tandel*, V.M. Prajapati and N.K. Patel[1]

Department of Silviculture and Agroforestry, College of Forestry
[1]Department of Vegetable Sciences, ASPEE College of Horticulture and Forestry
Navsari Agricultural University, Navsari-396 450, India
**E-mail: tandelmb@nau.in*

***Abstract*:** Aim of present study to assess the profitable agroforestry model and economically best INM treatments under Teak based silvi-horticulture system for Okra. A field experiment was conducted during the year 2019 and 2020 in *summer* season. Okra (*Abelmoschus esculentus* L.) cv. GAO- 5 was sown in the inter spaces of 23-years old plantation of *Tectona grandis* planted at a spacing of 3m x 2m and applied the different integrated nitrogen management (INM) treatments under the teak and in open condition. The trial was framed with eleven treatments under teak plantation and open condition in Randomized Block Design (RBD) consisting of three replications. From the calculation of economics of experiment the result emerged that when only sole okra crop yield considered in economic estimation the highest net realization (₹2,17,022 ha^{-1}) was recorded in T_{11}: 75% RDN through Neem coated urea + 25% RDN through Vermicompost in open field while benefit cost ratio was recorded highest in $T_{10:}$ 100% RDF in open condition (2.61). Whereas, the lower net realization and BCR of okra were registered under teak-okra based silvi-horticulture system as compared to sole crop. However, if we considered the yield of both okra as intercrop with teak the highest net realization and BCR (₹ 5,05,797 and 6.95, respectively) were recorded in T_5: 75% RDN through Neem coated urea + 25% RDN through Vermicompost under teak-okra based silvi-horticulture system.

***Keywords*:** Economic, Okra, Silvi-horticulture system, Teak, Integrated nitrogen management

Agroforestry systems have multifunctional roles in enhancing agronomic productivity, co-production of diversity of food and non-food products and provision of ecosystem services (Lehmann et al 2020). One of the goals of agroforestry in economical aspect is to ensure improvement in the availability, diversification and sustainability of food (Magcale-Macandog et al 2010). Agroforestry plays a very important role in Indian economy by providing tangible and intangible benefits (Divya et al 2014). In agroforestry, many crops are grown traditionally or tested in improved systems are economically viable (Thakur et al 2014, Panchal et al 2017). Conventionally, vegetable crops are promoted as compatible understory crops, many of the best vegetables to grow in shade (Pleasant 2012). Commercially important vegetable crop have been effectively intercropped under tree and generated additional income (Patel et al 2018, Bhusara et al 2018). Okra is one of the commercially important vegetable crops with many medicinal properties. It requires large quantities of both macro and micro nutrients for economic yields but in market chemical fertilizer has high price and its deterioration of soil health (Solangi et al 2015). While, combination of organic manures and synthetic fertilizers has the advantage of restoring soil fertility and sustaining productivity (Mevada et al 2021). On the other hand, Teak is one of the valuable timber producing perennial crop and generating the most important income (Miassi et al 2021). New tree-crop combinations are evolving with time due to changes in industrial demand and nature of products needed. Such new agroforestry techniques need to be analyzed on economic parameters. Therefore, keeping in view the above facts and economic importance of the vegetable crops and teak the aim of present study to analyzes the economics of cultivation of integrated nitrogen management in Okra under Teak (*Tectona grandis* L.f.) - (*Abelmoschus esculentus* L.) based silvi-horticulture system.

MATERIAL AND METHODS

The present field experiment was conducted during summer season of 2019 and 2020, at Navsari Agricultural University, Navsari, Gujarat, India. Geographically it's located at 20.95° N latitude and 72.93° E longitude with an elevation of 9m 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. Okra (*Abelmoschus esculentus* L.) cv. GAO- 5 was sown in the inter spaces of 23-year-old plantation of *Tectona grandis* planted at a spacing of 3 x 2m. Experiment was designed in Randomized Block Design 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 Vermicompost. Recommended dose of nitrogen, phosphorus and potassium @150-50-50 kg ha^{-1} applied to okra form the vermicompost, neem cake, urea, single super phosphate and muriate of potash under Teak and in open condition. Cultivation practice and cultural operations carried out in okra (Kumar and Choudhary 2014). Teak wood volume was estimated using quarter girth formula. The individual tree volume (average of 9 trees under each land-use system) was converted to per hectare basis in each system considering 10% mortality (Table 3). The economic analysis of Teak

Table 1. Economic of okra crop as affected by different INM treatments under teak based horti-silviculture system and in open condition

Treatments	Marketable yield (t ha^{-1})	Okra				Teak		Total gross realization (₹ha^{-1})	Total cost of cultivation (₹ha^{-1})	Without teak		With teak	
		Fixed cost (₹ha^{-1})	Variable cost (₹ha^{-1})	Total cost (₹ha^{-1})	Gross realization (₹ha^{-1})	Total cost (₹ha^{-1})	Gross realization (₹ha^{-1})			Net realization (₹ha^{-1})	BCR (with teak)	Net realization (₹ha^{-1})	BCR
Under teak													
T_1	3.70	41663	5673	47336	111000	19969	401356	512356	67305	63664	1.34	445050	6.61
T_2	3.94	41663	14652	56316	118200	19969	425321	543521	76285	61884	1.10	467236	6.12
T_3	3.68	41663	23049	64712	110400	19969	386572	496972	84682	45688	0.71	412290	4.87
T_4	3.27	41663	31380	73043	98100	19969	479481	577581	93012	25057	0.34	484569	5.21
T_5	4.18	41663	11129	52792	125400	19969	453158	578558	72762	72608	1.38	505797	6.95
T_6	3.73	41663	15584	57247	111900	19969	418038	529938	77217	54653	0.95	452721	5.86
T_7	3.40	41663	20116	61779	102000	19969	435996	537996	81749	40221	0.65	456248	5.58
T_8	3.10	41663	24714	66377	93000	19969	457630	550630	86347	26623	0.40	464283	5.38
T_9	3.04	41663	39809	81472	91200	19969	424193	515393	101442	9728	0.12	413951	4.08
In open condition													
T_{10}	9.60	67301	12517	79818	288000	-	-	288000	79818	208182	2.61	-	-
T_{11}	10.07	67301	17777	85078	302100	-	-	302100	85078	217022	2.55	-	-

Table 2. Cultivation cost of teak (₹ha^{-1})

Operations	Rate (₹)	Total cost (₹ha^{-1})
Cost of planting (Planting material, preparation of pits, planting)	@ ₹8.75 Tree^{-1}	14583
	i.e. ₹ ha^{-1} Year^{-1}	634
FYM (2 kg plant^{-1})	@ ₹1.6 Tree^{-1}	116
Urea (50 g after six month and 75 g after 2 year)	@ ₹0.75 Tree^{-1}	54
SSP (30 g after six month and 60 g after 2 year)	@ ₹0.81 Tree^{-1}	59
Weeding and cleaning (20 labours 3 times per year)	@ ₹178 labour^{-1} day^{-1}	10680
Pruning (20 labours 2 times per year)	@ ₹178 labour^{-1} day^{-1}	7120
Total		18663
Interest on working capital @ 7 %		1306
Gross total (₹)		19969

(*Tectona grandis* L.f.) - Okra (*Abelmoschus esculentus* L.) based silvi-horticulture system was worked out by gross and net realization from okra fruits and timber volume production on the basis of prevailing market rates. The benefit-cost ratio (BCR) on account of yield of okra marketable fruits and timber volume were estimated.

RESULTS AND DISCUSSION

Economics without teak: The okra crop grown in open condition recorded highest net realization and BCR as compared to integrated nitrogen management under teak based silvi-horticulture systems (Table 1). The highest net realization (₹ 2,17,022.00 ha^{-1}) was in T_{11}: 75% RDN through Neem coated urea + 25% RDN through Vermicompost in open field condition. The benefit cost ratio (BCR) was maximum in $T_{10:}$ 100% RDF in open condition (1: 2.61). Moreover, in case of teak based silvi-horticulture system, the highest net realization and BCR was in T_5: 75% RDN through

Table 3. Estimation of volume (quarter girth formula) and income of teak

Treatments	Tree height (m)	GBH (cm)	GBH (m)	Volume (m^3) $(Girth/4)^2 * h$	Gross return $tree^{-1}$ (₹)	Gross return ha^{-1} up to 23 year (₹)	Gross return ha^{-1} $year^{-1}$ (₹)	Total cost ha^{-1} $year^{-1}$ (₹)	Net return ha^{-1} $year^{-1}$ (₹)
T_1	19.73	59.71	0.60	0.44	6154	9231183	401356	19969	381386
T_2	18.91	62.78	0.63	0.47	6522	9782387	425321	19969	405352
T_3	19.64	58.73	0.59	0.42	5927	8891157	386572	19969	366603
T_4	19.64	65.41	0.65	0.53	7352	11028072	479481	19969	459512
T_5	20.66	61.99	0.62	0.50	6948	10422637	453158	19969	433189
T_6	20.39	59.95	0.60	0.46	6410	9614875	418038	19969	398069
T_7	18.64	64.02	0.64	0.48	6685	10027914	435996	19969	416021
T_8	17.96	66.83	0.67	0.50	7017	10525494	457630	19969	437661
T_9	18.99	62.57	0.63	0.46	6504	9756437	424193	19969	404223

Note: Selling price of teak wood: ₹14000 m^{-3}, Trees ha^{-1}: 1600, Mortality 10% calculated from total trees

Table 4. Variable cost of various integrated nitrogen management treatments

Treatment	Total yield (t ha^{-1})	Quantity required (kg)			Cost (₹)					Total cost (₹ha^{-1})
		NCU	VC	NC	NCU	VC	NC	Harvesting	Transport	
Under Teak (cost calculation on the basis of 6000 m^2 area)										
T_1: 100% RDF (100:50:50 NPK kg/ha)	4.09	196	-	-	1174	-	-	4090	409	5673
T_2: 75% NCU + 25% NC	4.32	147	-	501	880	-	9020	4320	432	14652
T_3 : 50% NCU + 50% NC	4.02	98	-	1002	587	-	18040	4020	402	23049
T_4 : 25% NCU + 75% NC	3.66	49	-	1503	294	-	27060	3660	366	31380
T_5: 75% NCU + 25% VC	4.56	147	1047	-	880	5233	-	4560	456	11129
T_6 : 50% NCU + 50% VC	4.12	98	2093	-	587	10465	-	4120	412	15584
T_7 : 25% NCU + 75% VC	3.75	49	3140	-	293	15698	-	3750	375	20116
T_8 : 100 % VC	3.44	-	4186	-	-	20930	-	3440	344	24714
T_9 : 100 % NC	3.39	-	-	2005	-	-	36080	3390	339	39809
In open condition (cost calculation on the basis of 1 ha area)										
T_{10}: 100% RDF	9.6	326	-	-	1957	-	-	9600	960	12517
T_{11} : 75% NCU+ 25% VC	10.07	245	1047	-	1467	5233	-	10070	1007	17777

Price of various organic and inorganic

NCU (Neem coated Urea) (46% N)	₹6 / kg
NC (Neem cake) (4.49% N)	₹18 /kg
VC (Vermicompost) (2.15% N)	₹5 /kg
Harvest okra cost	₹1 /kg
Transportation cost	₹100 /t
Fresh Okra price	₹30/kg

Neem coated urea + 25% RDN through Vermicompost that is ₹ 72,608 ha^{-1} and 1:1.38, respectively and lowest net realization and benefit cost ratio was in $T_{9:}$ 100 % RDN through Neem cake (₹ 9,728 ha^{-1} and 1:0.12, respectively).

Economics with teak: The benefit cost ratio was maximum in teak based silvi-horticulture system as compared to open condition. The highest net realization and BCR (₹ 5,05,797 and 1: 6.95, respectively) were in T_5: 75% RDN through Neem

Table 5. Cost of cultivation okra (₹ha^{-1}) in under teak (on the basis of cultivation of 6000 m^2 area) and in open condition

Description	Rate	Cost (₹) under teak	Cost (₹) in open condition
Preparatory tillage			
Ploughing by tractor with (1time) M.B. plough	@ ₹400/ hr for 8 hours	1920	3200
Ploughing by tractor with (2 times) cultivator	@ ₹300/ hr for 6 hours	2160	3600
Ploughing by tractor with (1 times) Rotavator with planking	@ ₹650/ hr for 4 hours	1560	2600
Total		5640	9400
Lay out and Transplanting			
Layout, Preparation of channel, beds and earthing up	@ ₹178/ /labour/day	2136	2136
Seed requires (GAO-5)	@ ₹850/kg	4335	7225
Sowing	@ ₹178/ /labour/day	1602	2670
Gap filling	@ ₹178/ /labour/day	534	890
Total		8607	12921
Manures			
FYM	@ ₹800/t	7200	12000
SSP	@ ₹9/ kg	1687.5	2813
MOP	@ ₹15/kg	750	1249
Expenditure on manures application	@ ₹200/ t of FYM	1800	3000
Expenditure on fertilizer application	@ ₹178/ labour/day	712	1068
Total		12149.5	20130
Intercultural operations			
Weeding	@ ₹178/ /labour/day	2136	3560
Total		2136	3560
Irrigation application			
Irrigations (@ 12hr for 1 ha.)	@ ₹30 per hour	2880	6600
Labour charges	@ ₹178/ /labour/day	2848	3916
Total		5728	10516
Plant protection			
Labour for spraying (2 men per spray)	@ ₹178 /labour/day	2136	2136
Chloropayriphos 1 spray	@ ₹475/lit	285	475
Thimethoczam 2 spray	@ ₹895/kg	429.6	716
Imedachlor 2 spray	@ ₹1340/lit	482.4	804
Profenophos 1 spray	@ ₹460/lit	276	460
Total		3609	4591
Harvesting			
Uprooting the plants	@ ₹178/ /labour/day	1068	1780
Total		1068	1780
Grand Total		38938	62898
Interest on working capital @ 7 %		2726	4402
Gross total		41663	67301

coated urea + 25% RDN through Vermicompost under teak-based silvi-horticulture system. Among intercrop the lowest net realization and BCR were registered in $T_{9:}$ 100% RDN through Neem cake (₹ 4,13,951 and 1: 4.08, respectively). The net realization and benefit cost ratio of okra crop was higher when they were grown in open condition as compared to under teak based silvi-horticulture system. The highest net realization was registered when okra was grown in open with the application of T_{11}: 75% RDN through chemical fertilizer with 25% RDN from Vermicompost while highest BCR registered with T_{10}: 100% RDF through chemical fertilizer. The probable reason for highest net realization due to increase of growth and yield parameters in open condition as compared to under teak-based silvi-horticulture system (Table 1). The BCR ratio was maximum in T_{11}: 100% RDF from inorganic fertilizer it might be due to high cost of Vermicompost then chemical fertilizer. In case of teak based silvi-horticulture system highest net realization and BCR were in T_5: 75% RDN through inorganic fertilizer with 25% RDN from Vermicompost as compared to other treatments under teak and okra grown alone. These results are in line with earlier findings Hanif et al (2010) in okra under *Litchi chinensis*, Panwar and Wani (2014) in *Ipomoea batatas* under *Populus deltoides*, Yadav et al (2014) in *Triticum aestivum* under *Populus deltoides*, Kumar et al (2016) in *Ocimum spp*. under *Tectona grandis*, Rajalingam et al (2016) in vegetable crops under *Ailanthus excelsa*, Kazi et al (2017) in colocasia under *Borassus flabellifer*, Bhusara et al (2018) in okra under *Melia composita*, Patel et al (2018) in cucurbitaceous vegetable crops under *Tectona grandis* and Jilariya et al (2019) in *Aloe vera* under *Melia dubia*.

CONCLUSION

The application of 75% RDN through Neem coated urea + 25% RDN through Vermicompost to okra under teak based silvi-horticulture system to generate maximum net realization and BCR as compared to sole okra crop. Thus, Teak-Okra based silvi-horticulture system is much profitable and more sustainable than sole cropping.

REFERENCES

Bhusara JB, Dobriyal MJ, Thakur NS, Gunaga RP and Tandel MB 2018. Performance of Okra (*Abelmoschus esculentus* L. Moench) under different spatial arrangements of *Melia composita* based agroforestry system. *International Journal of Current Microbiology and Applied Science* **7**(5): 3533-3542.

Divya MP, Jamaludheen V and Rajalingam GV 2014 Profitable Agroforestry models for Industrial wood species, pp 175-187. In: Parthiban KT, Umarani R, Umeshkanna S, Sekar I, Rajendran P and Durairasu P (eds). *Industrial Agroforestry*. Scientific Publication, New Delhi, India.

Hanif MA, Amin MHA, Bari MS, Ali MS and Uddin MN 2010. Performance of okra under litchi-based agroforestry system. *Journal of Agroforestry and Environment* **4**(2): 137-139.

Jilariya DJ, Thakur NS, Singh N and Gunaga RP 2019. Economics of cultivation of *Melia dubia Cav.-Aloe vera* L. silvi-medicinal model. *Indian Journal of Agroforestry* **21**(2): 35-40.

Kazi AA, Tandel MB, Pathak JG and Prajapati DH 2017. Potentiality of colocasia intercrop under naturally occurring Palmyra palm (*Borassus flabellifer* L.). *Journal of Tree Science* **36**(1): 58-61.

Kumar A and Choudhary AK 2014 Scientific cultivation of Okra, pp 25-30. In: Rai N and Yadav DS (eds). *Advances in Vegetable Production*. Scientific Publication, New Delhi, India.

Kumar M, Thakur NS and Hegde H T 2016. Fresh herb, essential oil yield and net returns from *Ocimum spp*. grown under teak (*Tectona grandis* L.f.) based silvi-medicinal systems in South Gujarat. *Indian Journal of Ecology* **43**(1): 306-311.

Lehmann LM, Smith J, Westaway S, Pisanelli A, Russo G, Borek R, Sandor M, Adrian Gliga A, Smith L and Ghaley BB 2020. Productivity and economic evaluation of Agroforestry systems for sustainable production of Food and Non-food products. *Sustainability* **12**: 5429.

Magcale-Macandog DB, Ranola FMR, Ranola Jr RF, Anip AB and Vidal NB 2010. Enhancing the food security of upland farming households through agroforestry in Claveria, Misamis Oriental, Philippines. *Agroforestry Systems* **79**: 327-342.

Mevada RJ, Nayak D, Patel DP and Tandel MB 2021. Potential of tasar silkworm (*Antheraea mylitta*) excreta as fertilizer on growth, yield and quality of rice. *Journal of Environmental Biology* **42**: 1070-1077.

Miassi YE, Dossa FK, Akdemir S and Gültekin U 2021. Economics of Teak, pp 55-66. In: Ramasamy Y, Galeano E and Win TT (eds). *The Teak Genome.* Springer Nature, Switzerland.

Panchal JS, Thakur NS, Jha SK and Vikas K 2017. Productivity and carbon sequestration under prevalent agroforestry systems in Navsari district, Gujarat, India. *International Journal of Current Microbiology and Applied Sciences* **6**(9): 3405-3422.

Panwar S and Wani AM 2014. Effect of organic production on growth and productivity of Sweet Potato (*Ipomoea batatas* L.) under Poplar based Agroforestry system. *International Journal of Advanced Research* **2**(12): 229-232.

Patel SM, Tandel MB, Desai MK, Pathak JG, Behera LK and Parmar MR 2018. Economics of cucurbitaceous vegetable crops under teak (*Tectona grandis* L.f.) based silvi-horticultural system in South Gujarat. *International Journal of Chemical Studies* **6**(2): 119-123.

Pleasant B 2012. Gardening With Vegetables That Grow in Shade. Growveg, DOI: https://www.growveg.com/guides/gardening-with-vegetables-that-grow-in-shade/

Rajalingam GV, Divya MP, Prabaharan C and Parthiban KT 2016. Performance of vegetable crops under *Ailanthus excelsa* based agroforestry system. *Indian Journal of Agroforestry* **18**(1): 16-20.

Solangi MD, Memon SA, Buriro UA and Keerio MI 2015. Economic impact of macro and micro-nutrients management on okra production. *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences* **31**(2): 183-192.

Thakur NS, Verma KS and Rana RC 2014. Growth and yield performance of ashwagandha *Withania somnifera* under agroforestry. *Indian Journal of Agricultural Sciences* **84**(8): 937-941.

Yadav YS, Lal SB and Mehra BS 2014. Productivity and economics of wheat (*Triticum aestivum*) under poplar (*Populus deltoides*) plantation with different fertility levels. *Trends Biosciences* **7**: 2845-2848.

Received 22 May, 2022; Accepted 15 September, 2022