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Effect of integrated use of organic and inorganic nitrogen sources on growth, development and yield of young clonal tea (*Camellia sinensis* (L) O. Kuntze)

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Abstract

A field experiment was carried out at a Tea Estate in Sivasagar, Assam, India during 2012 to 2015 to study the effect of integrated use of organic and inorganic sources of nitrogen on young tea plants. Three organic nitrogen sources *viz.*, vermicompost, pig litter and *Azolla* biomass and one inorganic nitrogen (urea) were applied in 7 treatments. The experiment was laid out at Randomized Block Design with four replications. Clone TV22 was planted in 105 cm x 60 cm spacing. Nitrogen supply in YTD mixture through organic and inorganic and only through organic sources produced comparable results in the initial years as that of conventional treatment. Thereafter (+3 years), the integrated treatments showed better results. Higher number and thickness of pruning sticks, pruning litter weight, canopy spread, plucking point density and yield were recorded in treatment of vermicompost and urea (T_2), followed by pig litter and urea (T_4) and *Azolla* biomass with urea (T_6). Nitrogen when supplied through only organic sources, the highest record was in vermicompost (T_3), followed by pig litter (T_5) and *Azolla* biomass (T_7). Nitrogen in YTD mixture as 50% through organic and 50% through urea can be recommended for satisfactory growth, development and yield of young tea in an integrated nutrient management system.

Keywords: *Clonal tea, integrated use, nitrogen source, YTD, growth, development and yield*

1. Introduction

Proper growth and development of young tea lays the foundation of sustained higher productivity. Conventional tea growing depends heavily on chemical fertilizers and maintenance of soil organic matter status. Inorganic chemical fertilizers due to their readily soluble nature, they are easy to blend and control rate, timing and uniformity and frequency of application to meet nutrient need in any crop type and provide a predictable response (Srivastava, *et. al.*, 2008). Heavy dependence on chemical fertilizers, plant protection chemicals and improper attention devoted to the maintenance of soil health have triggered the process of degradation of the ecological foundation of agriculture (Thampan,1995). Fertilization of tea with nitrogen fertilizer is very important due to the nature of harvested portion (green leaf) which removes a major portion of the added nitrogen from soil plant system. Despite high doses of chemical fertilizers, the yield of many tea gardens has become limited and possible adverse environmental impact of growing tea with high input chemical fertilizers. Organic manure has many agronomic and environmental advantages over chemical fertilizer (Bouldin, 1988). Manuring from organic sources play a critical role in short term availability and long term maintenance of soil organic matter (Pany and Letey, 2000). There is little predictive understandings for the management of organic inputs in different agrosystems. SOM (soil organic matter), nutrients and biological activity are important for productivity through soil structural and fertility improvement (Palm *et. al*., 2001). Addition of organic manures in any form helps in maintaining organic matter and fertility levels of soil, thereby improving the efficiency of applied fertilizers. Integrated use of organic and inorganic fertilizers helps in raising productivity of various crops and improves soil health. Application of organic manures along with chemical fertilizers has been reported to increase absorption of N, P and K in sugarcane compared to chemical fertilizers alone and led to higher cane and sugar yield (Bokhtiar and Sakurai, 2005). Chand *et. al.* (2006) found that integrated supply of plant nutrients through FYM and nutrients NPK, along with *Sesbania* green manuring played significant role in sustaining soil fertility and crop productivity. The number of fruits per plant and fruit yield was significantly higher under INM (integrated nutrient management) compared with organic nutrient supply of bell pepper (*Capsicum annuum*) varieties (Gopinath *et. al.*, 2011). Vermicompost along with inorganic fertilizers were efficiently used by maize crop for growth and development and also maintained soil fertility and increased yield of the crop (Sanjivkumar, 2014). Maximum total yield was recorded under INM compared with chemical fertilizers in okra (Yadav *et. al.*, 2012).

2. Materials and Methods

2.1 Layout of field trial

The field experiment was carried out in randomized block design at the tea plantation of M/S Green Hillock Plantations, PO- Dholebagan, Sivasagar, Assam, India during September, 2012 to December, 2015 to study the effect of integrated use of organic and inorganic sources of nitrogen as soil application on growth, development and yield of young clonal tea. The manures were applied as conventional YTD mixture and integrated treatments of nitrogen in YTD mixture. One source of inorganic nitrogen, urea and three sources of organic nitrogen *viz.*, vermicompost (VC) and composted pig litter (PL) and *Azolla* biomass (AZ) were applied in various treatment combinations by calculating the percentage composition of nitrogen in the organic sources (Table 1).YTD is a mixture of NPK recommended for young tea at the rate of 2: 1: 3. In the integrated treatment plots, 50 percent requirement of nitrogen was supplied through organic source and 50 percent through inorganic source, *i.e.,* urea. In the only organic nitrogen treatment in YTD mixture, 100 percent nitrogen was supplied through organic source. There were seven treatments and each was replicated four times and tea clone TV22 was planted in September 2012 at 105cm x 90cm spacing in single hedge. Altogether there were 28 plots each of 8.25 m x 5.70 m dimensions. In each plot, there were 72 plants. Shade trees, *Indigoferra teysmanii* and *Melia azadiracta* were planted in the experimental area immediately after planting tea.

2.2 Monitoring and recording of parameters

All the initial parameters were at par just after planting of tea. The growth, development and yield of tea plants were monitored and recorded periodically by measuring the plant height, number of leaves, number and thickness of primary and secondary laterals, collar diameter, number and thickness of pruning stems and weight of pruning litter, canopy spread, plucking point density and yield. For the purpose, 20 plants were selected randomly in each plot for measurement and averages were calculated for all the parameters.

2.3 Statistical Analysis

The data obtained were analyzed statistically. The significance of the variance was determined by calculating the respective 'F' value (Panse and Sukhatame, 1985). The critical difference (CD) was tested at 5 percent level of significance. The CD was determined when 'F' test was significant. The Co- efficient of variation (CV) was calculated by the method of Cochran and Cox (1962). The analyses were performed using MS Excel (version 2007).

Table 1. The treatment details

Treatments	Inputs mixture
T_1	Conventional YTD mixture, Control
T_2	50% VC- N + 50% urea-N in YTD mixture
T_3	100% VC- N in YTD mixture
T_4	50% PL- N + 50% urea- N in YTD mixture
T_5	100% PL- N in YTD mixture
T_6	50% AZ- N + 50% urea- N in YTD mixture
T_7	100% AZ- N in YTD mixture

YTD is a mixture of NPK recommended for young tea@ 2: 1: 3. vermicompost (VC), pig Litter (PL), Azolla biomass (AZ) and urea contain nitrogen@ 1.70%, 1.10%, 2.78% and 46.00% respectively.

Table 2. Manuring programme for different years

Year	NPK kg/ ha/ year			Split	Application	
	N	P_2O_5	K_2O		Time	Method
0	20	10	30	1	Sept. end	Ring
+1	80	40	120	4	Mar/May/ Jul/Sept	Ring
+2	100	50	150	4	Mar/May/ Jul/Sept	Ring
+3	120	60	180	4	Mar/May/ Jul/Sept	Ring

3. Results and Discussion

Composted organic manures like vermicompost, pig litter and biofertilizer like *Azolla* biomass could be used along with conventional inorganic fertilizer as regards INM (integrated nutrient management) in tea cultivation. Higher growth, development and yield were recorded at the final year (+3) of study in the integrated treatments (Tables 4, 5 and 6). Almost similar plant height, number of leaves were recorded in at the end of +1 year (Table 3) in all the treatments. Thickness of primary branches and collar diameter were at par at the end of +1 year in all the plots. At the end of +2 year, significantly higher thickness of primary branches and collar diameter recorded in the integrated plots. But, at the end of final year higher collar diameters were found in plants under integrated plots followed by organic nitrogen treated plots. Integrated manure

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treated plots recorded significantly higher number and thickness of pruning sticks, higher weight of pruning litter after first frame formation prune (FFP- I) with the conventional treatment, followed by organic nitrogen treated plots (Table 5).
Higher canopy spread, plucking point density and yield of tea were recorded in the integrated plots followed by organic nitrogen treated plots over conventional plots at the end of final year (+3) of study (Table 6).
Vermicompost was proved as an indispensable part of INM in tea as observed in the investigation. Among the integrated treatments, vermicompost with urea plots produced higher plucking points, canopy spread and yield, followed by pig litter and urea plots and finally *Azolla* biomass with urea plots. These are followed by organic treatment plots of vermicompost, pig litter and *Azolla* biomass and conventional plot.
Vermicomposting is the bio- oxidation and stabilization of organic matter involving the joint action of earthworms and microbes (Aira *et. al.*, 2007).

Table 3. Effect of integrated use of nitrogen sources on number of leaves and branches

Treats.	Pl. height (cm)	No of Leaves	No of branches	
			Prim.	Secondaries	
	Mar. +1yr	Mar. +1yr	Dec. +1yr	Dec. +1yr	Dec. +2yr
T_1	52.63	22.61	3.60	21.03	25.44
T_2	52.76	22.47	3.53	20.90	32.20
T_3	52.42	20.91	3.45	20.10	29.40
T_4	55.37	21.34	3.38	20.19	32.01
T_5	53.74	22.27	3.39	21.07	28.07
T_6	53.47	22.17	3.60	20.09	31.25
T_7	55.20	22.63	3.29	19.97	26.69
CD (P=0.05)	NS	NS	0.15	NS	1.04
CV (%)	4.71	4.77	5.28	2.93	8.83

Year of planting is 0 year; NS- Not Significant; T_1- Conventional YTD mixture, T_2- 50% VC- N + 50% urea- N in YTD mixture, T_3- 100% VC- N in YTD mixture, T4- 50% PL- N + 50% urea- N in YTD mixture, T5- 100% PL- N in YTD mixture, T_6- 50% AZ- N + 50% urea- N in YTD mixture, T7- 100% AZ- N in YTD mixture.

Table 4. Effect of integrated use of nitrogen sources on collar diameter and thickness of branches

Treats.	Collar diameter (cm)			Thickness of primary branches (cm)			Thickness of secondary branches (cm)	
	Dec. +1 year	Dec. +2 year	Dec. +3 year	Dec. +1 year	Dec. +2 year	Dec. +3 year	Dec. +2 year	Dec. +3 year
T_1	1.71	2.36	2.60	1.30	1.41	2.12	0.44	0.71
T_2	1.55	2.62	3.01	1.42	1.57	2.23	0.46	0.80
T_3	1.54	2.50	2.81	1.36	1.47	2.20	0.45	0.74
T_4	1.57	2.51	3.00	1.40	1.60	2.20	0.44	0.76
T_5	1.51	2.35	2.75	1.35	1.49	2.18	0.44	0.72
T_6	1.52	2.52	2.85	1.37	1.59	2.20	0.45	0.74
T_7	1.51	2.39	2.69	1.34	1.44	2.15	0.44	0.72
CD (P=0.05)	NS	0.09	0.09	NS	0.06	NS	NS	NS
CV (%)	12.12	7.65	6.47	13.81	7.17	6.83	11.67	7.18

Year of planting is 0 year; NS- Not Significant; T_1- Conventional YTD mixture, T_2- 50% vermicompost- N + 50% urea- N in YTD mixture, T_3- 100% vermicompost- N in YTD mixture, T_4- 50% pig litter- N + 50% urea- N in YTD mixture, T_5- 100% pig litter- N in YTD mixture, T_6- 50% Azolla biomass- N + 50% urea- N in YTD mixture, T_7- 100% Azolla biomass- N in YTD mixture.

The compost is rich in macro- and micronutrients, N-fixers and humus forming microbes (Bano *et. al*, 1987). Besides influencing physico- chemical properties of soil, vermicompost is also known to contain growth promoting substances, enhance microbial activity and prevent nitrogen loss by leaching (Shinde *et. al.*, 1992; Sultan, 1995). Growth regulator analysis of earthworm casts by Grappelli *et. al.* (1985) found gibberellic acid (GA_3), cytokinins and indole acetic acid. The results of the investigation are in agreement with findings of many workers

Table 5. Effect of integrated use of nitrogen sources on pruning sticks and pruning litter after final frame formation prune (FFP- I)

Treatments	After FFP- I (January, 2015)		
	Number of pruning sticks	Thickness of sticks at pruning height (cm)	Dry weight of pruning litter (kg/plot)
T_1	10.04	0.83	21.06
T_2	10.84	0.93	25.86
T_3	10.44	0.88	23.22
T_4	10.65	0.90	24.47
T_5	10.35	0.86	23.04
T_6	10.58	0.88	23.60
T_7	10.14	0.84	22.13
CD (P=0.05)	0.32	0.05	1.27
CV (%)	3.32	5.81	7.09

T_1- Conventional YTD mixture, T_2- 50% vermicompost- N + 50% urea- N in YTD mixture, T_3- 100% vermicompost- N in YTD mixture, T_4-50% pig litter- N+ 50% urea- N in YTD mixture, T_5-100% pig litter- N in YTD mixture,T_6- 50% Azolla biomass- N + 50% urea-N in YTD mixture, T_7- 100% Azolla biomass- N in YTD mixture

(Phukon *et. al.*, 1994; Gogoi, 2002; Saikia, 2005). Informations on use of pig litter as composted manure in cultivation is very poor. In Korea, recommendation is to use 4.4 ton per hectare as pig manure- saw dust compost. Lee *et.al.* (2012) found, 6.0 ton of composted pig manure per hectare should be adequate for producing onions using an organic production system. In the present study, pig litter treatments could be able to produce comparable yield as that of the inorganic conventional treatment. From the present study, it was found that integrated application of 50 percent nitrogen through composted pig litter with 50 percent nitrogen as urea in YTD will be sufficient for young tea cultivation.

Information on role of *Azolla* as fertilizer in tea is not available. Use of *Azolla* as bio fertilizer on rice cultivation is a very age old practice in the South-East Asian countries.

Table 6. Effect of integrated use of nitrogen on canopy spread, plucking point density and yield

Treats.	Canopy spread (cm ^{2}/ plant)			Plucking point density (number/ 30 x 30 cm ^{2})			Yield (KMTH)		
	Dec. +1 year	Dec. +2 year	Dec. +3 year	Dec. +1 year	Dec. +2 year	Dec. +3 year	Dec. +1 year	Dec. +2 year	Dec. +3 year
T_1	2204.74	4143.32	4389.29	35.78	39.00	49.27	517	1269	1876
T_2	2215.36	4185.70	4474.59	33.83	39.32	52.97	505	1243	1936
T_3	2210.05	4181.07	4431.94	33.75	38.81	51.17	502	1227	1901
T_4	2204.79	4183.00	4454.77	32.31	38.30	51.87	498	1182	1921
T_5	2089.54	4179.08	4410.81	30.63	37.98	50.27	490	1180	1889
T_6	2150.60	4165.64	4450.75	30.90	39.24	51.79	500	1178	1916
T_7	1994.00	4140.43	4399.00	28.65	36.43	49.59	495	1174	1882
CD (P=0.05)	46.49	42.68	48.20	0.82	NS	0.40	18.21	NS	NS
CV (%)	3.85	3.79	3.23	7.19	4.09	2.27	8.68	4.33	3.00

Year of planting is 0 year ; NS- Not Significant ; T_1- Conventional YTD mixture, T_2- 50% vermicompost- N + 50% urea- N in YTD mixture, T_3- 100% vermicompost- N in YTD mixture, T_4-50% pig litter- N + 50% urea- N in YTD mixture, T_5-100% pig litter- N in YTD mixture, T_6- 50% Azolla biomass- N + 50% urea-N in YTD mixture, T_7- 100% Azolla biomass- N in YTD mixture ; KMTH- Kilogram Made Tea per Hectare.

Singh and Singh (1986) found that integrated application of 30kg nitrogen per hectare as urea with *Azolla* basal or dual gave the grain yield as obtained by 3 split application of 60 kg urea nitrogen per hectare, whereas, use of *Azolla* basal plus dual showed slightly higher grain yield in rice crop. In another study on rice, during first year, *Azolla* compost application produced lower grain and straw yields and panicles than 60 kg nitrogen per hectare as urea, but during the second year the treatment showed response equal to that of 60 kg nitrogen per hectare as urea (Singh, *et. al.*, 1988). The results of the present investigation on integrated and single application of *Azolla* biomass showed comparable yield as that of conventional treatment and integrated application showed higher growth, development and yield than single application in final year (+3) of study.

4. Conclusions

Integrated treatments of nitrogen in YTD could be able to produce higher growth, development and yield as that of conventional inorganic nitrogen treatment in the final year (+3) of study under the agro- climatic conditions of the study area. Among the integrated plots, the highest result was recorded in the plots treated with vermicompost and urea (T_2) followed by pig litter and urea (T_4) and *Azolla* biomass and urea (T_6). The plots with only organic nitrogen treatment in YTD followed the integrated treatment plots. Among these, the highest result was in vermicompost (T_3) followed by pig litter (T_5) and *Azolla* biomass (T_7). The lowest in conventional (T_1) plots. But, the yield results were at par in the final year of study. However, during initial (+1) year, significant higher yield was recorded in conventional plots (T_1). The following year (+2) recorded almost similar yield among the treatments. Nitrogen in YTD mixture as 50% through organic source and 50% through inorganic source urea can be recommended for satisfactory growth, development and yield of young tea in an integrated nutrient management system.

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