EFFECT OF ORGANIC SOURCES OF NUTRIENTS AND PLANT PROTECTION ON PRODUCTIVITY OF ORTHODOX TEA (*Camelia sinensis* Kuntz.)

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ABSTRACT

The growing demand of quality organic tea with increase in awareness on the deleterious effect of chemicals and its residue in human health has revived the need of organic tea management. Field experiments were conducted in 2006/2007 to 2007/2008 in Ilam and Dhankuta districts to study the effect of different organic sources of nutrients and pest management on Orthodox tea cv. Gumti Selection. In addition to productivity, the effect of nutrients on green leaf production trend, plucking intervals in different months and changes in composition of soil in the experimental plots were also studied. Four different organic sources of nutrients; vermi compost, azatobacter incorporated commercial organic fertilizer, improved ditch compost with EM, traditionally made compost and different organic plant protection methods; enanthole, parasitic fungi Trichoderma viride, mineral oil for management of blister blight disease and locally made botanical pesticide, mineral oil and ultineem for management of thrips were tested separately in a Randomized Complete Block Design (RCBD) with seven replications. The effect of different organic sources of nutrients was found significant on green tea leaf production. In both districts, highest production of green tea leaves was recorded in plots with azatobacter incorporated fertilizer and least in farmers' traditional compost in both years. The result showed green leaf production of 3125 and 3031 kg/hac in 12-15 year old plantation and 1822 and 1798 kg/hac in 8-10 year old plantation with yearly application of 495 gm/bush of azatobacter incorporated fertilizer. Different organic treatments did not differ significantly in the severity of blister blight disease. However, lowest infestation was observed in plots with Trichoderma application. Leaf damage percentage was found significantly lower in treatments other than control in both districts. The effect of organic thrips management was significantly different in green tea leaf yield. Non significant changes in soil chemical properties due to organic nutrients were found among the treatments. However, small increment in nitrogen and potassium content over the time was observed.

***Key words**: Gumti Selection,* mineral oil, enanthole, azatobacter incorporated fertilizer

INTRODUCTION

Orthodox tea is one of the important cash generating crops in the eastern Nepal. Orthodox tea essentially represents two leaves and a bud of the plant *Camelia sinensis* (L) O. Kuntz. The orthodox tea is the prioritized export commodity of Nepal with involvement of high number of small farmers in its production (Jha, 2004). The growing demand of quality organic tea with world wide increase in awareness on the deleterious effect of chemicals and its residue in human health has revived the need of organic tea management. Similarly, inadequate and imbalanced use of plant nutrients has become one of the major constraints hindering productivity of orthodox tea in Nepal. The productivity of Nepalese orthodox tea is very low (497.5 kg made tea per hectare) which is less than half in comparison to India (1000-1500 kg made tea per hectare) (Sharma, 1999). The escalation in the cost of chemical fertilizers coupled with low purchasing capacity of small farmers, persistent nutrition depletion from soil leading to lower productivity and the tightened regime of exports under the WTO obligations have also raised the need of organic management in orthodox tea. Since tea is a perennial plant, the same bush is repeatedly pruned at specific intervals; the flush shoots are plucked during the intermittent period at regular intervals depending on the season and growth, thereby removing a considerable amount of various nutrients from the plant and soil system. Hence, in a year, a large amount of nitrogen and potassium is removed from the soil, which require to be replenished to keep the tea soils fertile and thus nitrogen and potassium become the major limiting nutrients for tea productivity. In today's scenario, fertilizers being one of the costliest inputs as far as tea

plantations are concerned and with negligible habitual drinking of orthodox tea among the Nepalese consumers, efforts are imperative to direct producers towards increase production of organic orthodox tea for export markets.

Blister blight caused by *Exobasidium vexans* is a serious problem of tea cultivation in Nepal. The fungus is found to grow best in moderate temperatures (15-20° C) and high humidity (90% or more). It is also an obligate parasite with no alternative host; hence its life cycle completes in tea plant itself. The pathogen survives in necrotic leaf blisters during the off season and tea saplings beneath old bushes are the first to show new infections at the start of the season. Shiny gray or white colored blisters are seen on young leaves. The upper surface of the leaf above the blister is sunken and usually swells more on the lower surface. This disease was first reported in upper Assam in 1868 AD and was endemic to Assam till 1909, subsequently spread to the tea estates in Darjeeling and gradually entered Nepal (Yadav, 2008). The first outbreak of blister blight was noticed in south India in 1947 (Yadav, 2008). The disease was introduced in Nepal from adjoining tea land of India during 1977/78 with diseased planting material (Yadav, 2001).

Black tea thrips (*Heliothrips haemorrhoidales*) has been found to cause much economic damage to tea plants in Nepal. The nymphs are whitish or greenish in colour. They feed on leaves of all ages. Attacked buds are small, crisp and are brittle (easy to break). When the damaged bud unfolds, the leaves have a brown line of dry scars (like cork) along either side of the main rib. Even few thrips feeding on a bud lower the quality of the bud, making the dried buds brittle and the processed tea bitter.

The study was conducted on orthodox tea plantation in Ilam and Dhankuta districts to know the effect of different sources of nutrients and plant protection methods on green tea leaf production. In addition to plucking intervals, the effect of organic nutrients on productivity, green leaf production trend and changes in composition of soil in the experimental plots were also studied.

MATERIALS AND METHODS

Field trials were conducted on 'Gumti Selection', a widely grown orthodox tea variety in the eastern hills of Nepal. Three different organic sources of nutrients were studied against farmers' practice of organic soil management in a Randomized Complete Block Design (RCBD) with seven replications (Farmers as replication) in 12-15 year old tea plantations in Kolbung VDC of Ilam district and 8-10 year old plantations in Dhankuta district. Unit plot size was 25 Sq m with total experimental area in one replication for individual studies was 100 Sq m.

Field experimentation on organic nutrient management

T1: Commercial organic fertilizer containing azatobacter
T2: Vermi compost
T3: Improved ditch compost
T4: Farmers' practice

Parameters under study: Green tea leaf yield, Plucking interval, Changes in composition of soil (pH, N, P, K, organic matter)

The amounts of fertilizers were derived as per the nutrient requirement of orthodox tea bushes. The application of vermi compost was 350 gm/bush, commercial organic fertilizer 165gm/bush and improved ditch compost 1kg/bush thrice a year while in farmers' practice, farmers applied farmyard compost. During the period of experimentation, plot wise yield data were recorded at each plucking. The plucking interval was decided with the amount of new leaves formed. Before application of fertilizers and at the end of the experimental year, composite soil samples were taken by mixing three surface soil samples (0-15 cm) from the same plot. This kind of sampling was followed for all the experimental plots. Laboratory analysis was carried out for pH, organic matter, total nitrogen, available phosphorus and available potassium contents. The pH was measured with a pH-meter in 1:2.5 soil: water suspension. The soil organic matter content was determined by Spectrophotometric method. The total nitrogen was determined by Spectrophotometric method. The available phosphorus was determined colorimetrically by Bray method. Available potassium was extracted with normal neutral ammonium acetate and was determined flame photometrically in 1:5 dilutions.

For organic management of blister blight (*Exobasidium vexans*) and black thrips (*Heliothrips haemorrhoidales*) , three organic plant protection methods were tested individually against control in a Randomized Complete Block Design (RCBD) with seven replications (Farmers as replication) in 12-15 year old tea plantations in Kolbung VDC of Ilam district and in 8-10 year old plantations in Dhankuta district. Unit plot size was 25 Sq m and total experimental area in one replication for disease and insect management studies was 100 Sq m.

Field experimentation on organic management of blister blight disease.
T1: Bio fungi (Enanthole) (2.5ml/lit)
T2: *Trichoderma viride(2gm/lit)*
T3: Mineral oil (2%)
T4: Control
Parameters under study: Disease scoring in infected leaves
Spraying of bio fungi and mineral oil were done at the interval of 7 days from June to September. Soil drenching with Trichoderma viride was done after pruning in February and spraying of 2gm/lit spore suspension solution was done at the interval of 15 days in May.

Scale of disease scoring on blister blight (0-5)

- 0% infection---------0(Disease free)
- 1-10% infection---------1(Highly resistant)
- 11-30% infection---------2 Slightly resistant
- 30-50% infection----------3 Moderately resistant
- 50-70% infection----------4 Susceptible/Severe
- 70%-above infection------5 (Highly susceptible/very severe)

Field experimentation on organic management of black thrips (*Heliothrips haemorrhoidales*)
T1: Botanical insecticide (5%)
T2:Ultineem (0.5%)
T3:Mineral oil (2%)
T4: Control
Parameters under study: Insect count, Mean percentage of leaf damage, Green tea leaf yield under different treatments

Spraying with botanical insecticide, ultineem and mineral oil were done at the interval of 7 days from March-July

Preparation of botanical insecticide

- Fresh leaves of plants with proven insect repellant properties: titepati (3kg), banmara (2kg), sisnu (2 kg) bakaino (500gm), lemongrass (500gm)
- Other plants with insecticidal properties: Asuro, marigold leaves, bojho, timur, garlic, pepper: 2kg
- Chopped pieces dipped in3:1 mixture of cow urine and water.
- Mixture decomposed for 8-10 days in summer and 18-20 days in winter.
- Well decomposed mixture filtered in muslin clothes and sprayed in the interval of 7 days @5% (50ml/lit)

RESULTS AND DISCUSSION

Green leaf production trend and plucking intervals in different months
More or less similar trend in green tea leaf production was observed in Dhankuta and Ilam districts (Fig 1 and 2). In Ilam, dormancy in tea bushes was found from November, a month earlier than in Dhankuta district. Highest green tea leaf production was observed in the month of April followed by August. Shortest plucking intervals of 7 days were recorded from July to September in Dhankuta and from June to September in Ilam. This gradually increased to 12-15 days from the month of October. This could be due to lesser formation of new leaves with lower temperatures.

Fig 1 Monthly green tea leaf production trend in Dhankuta

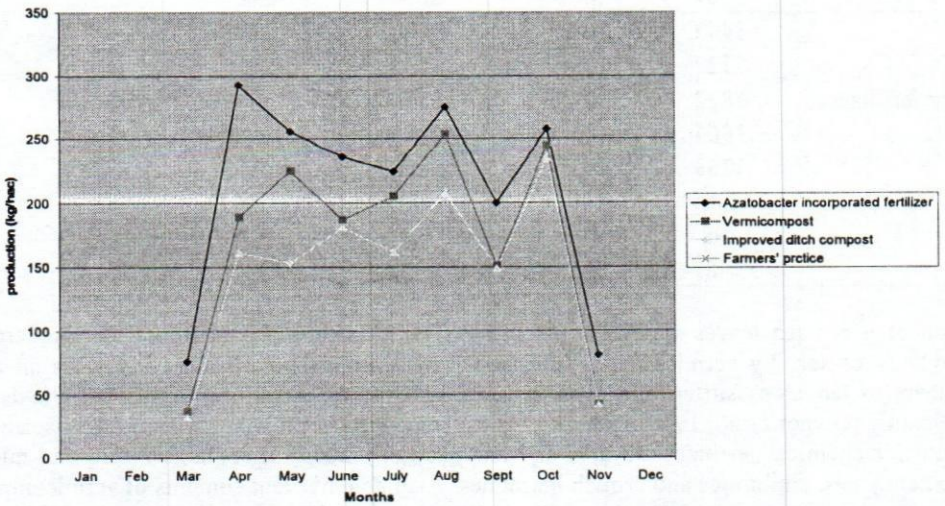
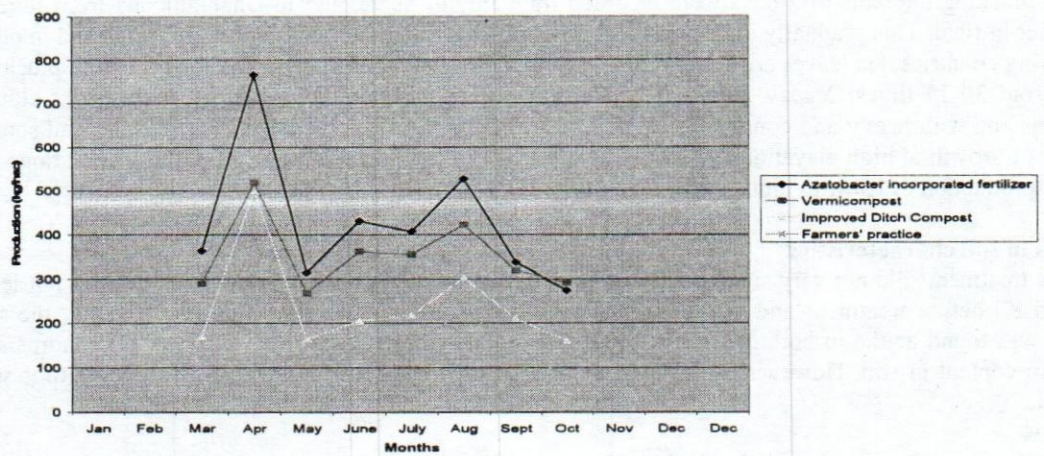


Fig 2 Monthly green tea leaf production trend in Ilam



Green tea leaf production

The effect of different organic sources of nutrients was found significant on green tea leaf production. In both districts, highest production of green tea leaves was recorded in plots with azatobacter incorporated fertilizer and least in farmers' practice in both years. The result showed an annual production of 3125 and 3031 kg/hac in 12-15 year old plantation and 1822 and 1798 kg/hac in 8-10 year old plantation in 2007 and 2008 respectively with yearly application of 495 gm/bush of azatobacter incorporated fertilizer (Table 1). This was followed by the annual production of 2940 and 2628 kg/hac in 12-15 year old plantation and 1443 and 1620 kg/hac green tea leaves in 8-10 year old plantation with yearly application of 1050 gm/bush of vermi compost. Lowest production of 2023 and 1923 kg/hac in 12-15 year old plantation and 1064 and 1058 kg/hac in 8-10 year old plantation were observed in farmers' practice.

Table 1. Effect of different organic sources of nutrients on annual production of green tea leaves (kg/ha)

Treatment	8-10 yr bushes		12-15 yr bushes	
	2007	2008	2007	2008
Vermicompost	1443	1620	2940	2698
Ditch compost	1122	1280	2303	2380
Commercial org fertilizer	1822	1798	3125	3031
Farmers' practice	1064	1058	2023	1923
Mean	1363	1439	2598	2508
P Value	<.001	0.001	<.001	<.001
LSD (0.05)	298	340	333	338
CV(%)	7.8	7.2	5.2	5.1

Highest production of green tea leaves was recorded in plots with azatobacter incorporated commercial fertilizer followed very closely by vermicompost application. In a study on the use of fertilizers on tea, applying N fertilizers to tea crops suffering deficiency increased the N content of leaves and yields of plucked tea significantly (Owuor *et al.*, 1990). Vermi compost being rich in NPK and other nutrients can be used as a substitute for chemical fertilizer (Jeyabal and Kuppuswamy 2001) It contains macro and micro nutrients, vitamins, enzymes, antibiotics and growth hormones. Available nutrient contents of vermicompost as well as their rate of release are much higher than that of FYM (Banik and Bejbaruah 2004).

Shortest plucking intervals of 7 days were recorded from July to September in Dhankuta and from June to September in Ilam. This gradually increased to 12-15 days from the month of October. In Nepal and in other tea growing countries, tea leaves are commonly plucked at the interval of 7 days. The total round of plucking ranges from 30-35 times (Yadav 2005). It was observed that tea yield drops significantly under cloudy conditions and with heavy and continuous rainfall, just like it does when the weather is hot, dry and sunny. The rate of growth at high elevations is markedly lower due to lower temperatures, but these conditions are ideal for production of tea with high quality (Owwor *et al.*, 1990).

Changes in soil characteristics

Different treatments did not vary significantly in the status of soil pH, OM content and major plant nutrients (N,P and K) before treatment and at the end of field experimentation. (Table 2 and 3). Overall, the soil reaction was found acidic in both districts with medium rating in organic matter, nitrogen, phosphorus and potassium content in soil. However, small increment in Nitrogen and potassium content over the time was observed.

Table 2. Chemical characteristics of soil of 12-15 year old plantation of Ilam before and in the third year of field treatments.

Treatment	pH	OM%	N%	P_2O_5 kg/hac	K_20 kg/ha
Vermi compost	6.27	4.47	0.16	105.9	336.8
Ditchcompost	6.12	4.26	0.15	97.7	332
Commercial organic ferti	6.26	4.35	0.18	107.6	352
Farmers' practice	5.89	4	0.14	94.7	328
Mean	6.14	4.27	0.16	101.5	338.3
Bench Mark analysis	6.1	4.08	0.14	95.6	330.8
F value	0.23	0.4	0.3	0.31	0.6
LSD (.05)	0.43	0.61	0.048	6.7	41.57
CV(%)	5.1	10.4	6	9.2	8.9

Table 3 Chemical characteristics of soil of 8-10 year old plantation of Dhankuta before and in the third year of field treatments.

Treatment	pH	OM%	N%	P2O5 kg/hac	K20 kg/ha
Vermi compost	5.01	6.73	0.21	94	150
Ditchcompost	4.88	6.02	0.15	65	136
Commercial organic ferti	5.45	4.11	0.25	116	237
Farmers' practice	5.1	3.88	0.13	61	126
Mean	5.11	5.19	0.18	84	162
Bench Mark analysis	4.6	3.88	0.16	68	128
F value	0.38	0.07	0.11	0.37	0.04
LSD (.05)	0.71	2.5	0.1	13.7	80.6
CV(%)	10.2	5.1	13	13.6	11

Blister blight disease occurrence

Different organic treatments did not differ significantly in the severity of blister blight disease. In both Ilam and Dhankuta, Lowest infestation was observed in plots with Trichoderma application followed by mineral oil spray (Fig 3 and 4). Highest disease infestation was recorded in non treated plots. In Ilam, disease severity was comparatively higher than in Dhankuta.

For organic management of blister blight disease, *Trichoderma viride* was found comparatively effective than other organic methods. During recent times Trichoderma treatment has also been found to be the best method of protecting the pruning cuts from the damage of both Poria and Tunstallia. The incidence of blister blight was recorded lower in Dhankua than in Ilam, could be due to heavy pruning in Dhankuta. Moreover, the experimental plots in Ilam have more shade and are comparatively denser bushy plantation, ideal for fungal spores to grow. Metabolites secreted by *Trichoderma viride* works as biological fungicides to fight plant diseases caused by pathogenic fungi (Spiegel and Chet Vinale *et al.*,2009).

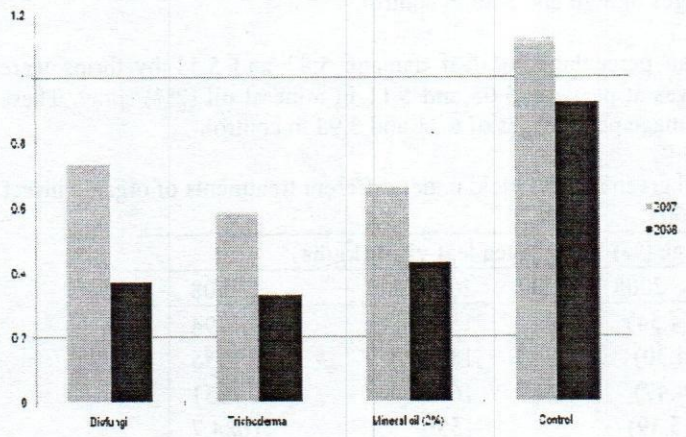


Fig 3 Severity of blister blight disease (0-5 scale) in Dhankuta

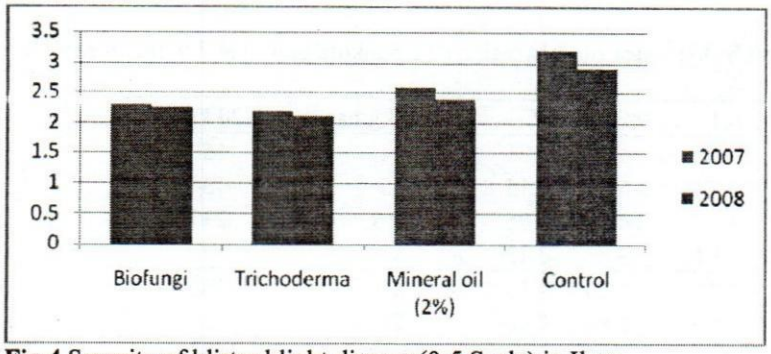


Fig 4 Severity of blister blight disease (0-5 Scale) in Ilam

Effect of organic insecticide on leaf damage and yield

In Dhankuta, significantly highest green tea leaf yield of 1841 and 1955 kg/ha was recorded in Ultineem (0.5%) spray followed by 1699 and 1851 kg/ha in mineral oil (2%) spray. Lowest yield of 1530 and 1684 kg/ha was recorded in control.

In Ilam, similarly significantly green tea leaf yield of 2728 and 2661 kg/ha was recorded in Ultineem (0.5%) spray followed by 2571 and 2512 in mineral oil (2%) spray. Lowest yield of 2220 and 2020 kg/ha was recorded in control.

For the control of thrips, the effect of Ultineem was found at par with mineral oil. The primary way mineral oil kills insects is by suffocating them. The oil blocks the spiracles through which insects breathe. Mineral oils also disrupt the metabolism of insect eggs and the ability of some insects to feed, causing them to starve to death.

In Dhankuta, significantly lowest mean percentages of leaf damage 4.43 and 4.30 were recorded in Ultineem (0.5%) spray which was at par with 4.47 and 4.57 in mineral oil (2%) spray. These numbers were quite lower than that of the damage percentages of 5.20 and 5.30 in control.

In Ilam, similarly significantly lowest mean percentages of leaf damage 5.43 and 5.11 by thrips were recorded in Ultineem (0.5%) spray which was at par with 5.05 and 5.11 in mineral oil (2%) spray. These numbers were quite lower than that of the damage percentages of 6.31 and 5.98 in control.

Table 5 Mean percentage of leaf damage and green tea leaf yield under different treatments of organic insect management in Dhankuta during 2007 and 2008.

	Leaf damage (%)		Green tea leaf yield (kg/ha)	
Treatments	2007	2008	2007	2008
Botanical ins	23.79(4.86)	20.65(4.54)	1573	1794
Ultineem	19.79(4.43)	18.7(4.30)	1841	1955
Mineraloil(2%)	20.25(4.47)	20.1(4.47)	1699	1851
Control	27.92(5.20)	29.27(5.39)	1530	1684.7
Mean	4.76	4.67	1661	1821
F-Value	<.001	<.001	<.001	<.001
LSD (.01)	0.2	0.55	105.3	79.94
CV (%)	4.8	6.9	3.7	2.6

Number in parenthesis is square root transformed means

Table 6 Mean percentage of leaf damage and green tea leaf yield under different organic insect management in Ilam during 2007 and 2008.

	Leaf damage (%)		Green tea leaf yield (kg/ha)	
Treatments	2007	2008	2007	2008
Botanical ins	34.55(5.86)	30.54(5.51)	2491	2443
Ultineem	25.62(5.43)	26.39(5.11)	2728	2661
Mineraloil(2%)	30.39(5.49)	25.62(5.05)	2571	2512
Control	39.96(6.31)	35.96(5.98)	2220	2020
Mean	4.76	4.67	1661	1821
F-Value	<.001	<.001	<.001	<.001
LSD (.01)	0.2	0.55	105.3	79.94
CV (%)	4.8	6.9	3.7	2.6

Number in parenthesis is square root transformed means

CONCLUSION

Results of field experiments with different organic sources of nutrients showed significant increment in production of green tea leaves with lesser nutrient removal from soil. Hence biofertilizer, vermicompost and EM incorporated ditch compost can be recommended for commercial cultivation of organic tea. Likewise, Ultineem, mineral oil and *Trichoderma viride* can be recommended for organic thrips and blister blight management.

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