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Logo Description: It symbolizes an elephant within an ecological frame of peace and harmony moving towards prosperity and posterity.

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CONTENTS

e-planet **18** (1): 1-5 (June 2020)

Organic farming, a better option for enhancing farm income: A study on ginger crop in North Eastern Hill Region of India

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ABSTRACT

Organic farming is recognized as one of the most reasonable alternative farming systems for overcoming the challenges of climate change and for its positive effect on human health, sustainability of soil, water and crop yields. The study was conducted in North Eastern Hill Region (NEHR) adopting multistage sampling technique. Sikkim was selected purposively as the control state and Meghalaya was selected based on the highest production of ginger in the region. East Sikkim district and East Garo hill were selected out of which Nangdok block from east Sikkim district and Dambo-Rongjeng block from East Garo hill were selected randomly. A cluster of 1-2 villages were selected randomly from each block. At the last stage 60 respondents, 30 organic adopters and 30 non-adopters were selected using probability proportional to size method. Standard defined techniques, independent t-test and Cohen's d test were applied. The study revealed that the cost of cultivation was lower for the organic adopter (₹ 69797.31 ha^{-1}) as compared to the non-adopter (₹ 71974.50 ha^{-1}). The net income of the organic adopter was Rs 10569.35 per ha, which was higher than the non-adopter (₹ 5500.50 ha^{-1}). The yield was also found to be significantly higher for the organic adopters (7209.96 kg ha^{-1}).

Key words: Cost of cultivation, net income, North Eastern Hill Region, organic farming, yield

INTRODUCTION

Organic farming is often perceived to be a better option for the environment than conventional farming as it has significant advantages like increasing farmers' income, reducing external input cost, increasing employment opportunities and enhancing food security by increasing the purchasing power of the people (Ramesh et al., 2005; Jouzi et al., 2017). It is also recognized as one of the most reasonable alternative farming systems for overcoming the challenge of climate change (Gomiero et al., 2008) due to its positive effect on human health, sustainability of soil, water and crop yields (Blaise, 2006). The organic farming has an enormous potential in generating beneficial effects socially and environmentally. However, it is essential to assess its performance in terms of its economics which ultimately influences the adoption of any technology. Economic advantages of organic farming were reported by various researchers, lower cost of cultivation on organic farming (Kumar et al., 2006), productivity differences between the organic and the conventional farming, gross return and net returns were higher in organic farming (Singh and Grover, 2011; Laxmi et al., 2017). Organic farming also offers a solution for sustainable agricultural as well as the reduction in the cost of production during long run (Thakur and Sharma, 2005; Laxmi et al., 2017).

India is bestowed with lot of potential to produce all varieties of organic products due to its various agro-climatic regions. In various regions of the country, the inherited tradition of organic farming is an added advantage. India's organic share of total agricultural land is 0.7% as per 2015 data (FIBL and FOAM, 2017). The total area under organic certification during 2015-16 was 5.71 million hectares. The North Eastern Hill Region (NEHR) contributes about 6.53% of the total area under organic certification in India (APEDA, 2017). Among the NEHR, Sikkim contributes 5.21% of the organic land (since it is the organic state), Meghalaya (0.67%). Despite of being an organic sector by default, studies related to the economic benefits of organic farming are lacking. So, the study has been undertaken with the objective to assess the economics of ginger crop in the NEHR.

MATERIALS AND METHODS

The study was conducted in North Eastern Hill Region (NEHR) adopting multistage sampling technique. Sikkim being an organic state was selected purposively as the control state and Meghalaya was selected based on the highest production under ginger. East Sikkim district from Sikkim and East Garo hill district from Meghalaya were selected for the study. Nangdok block from east Sikkim district and Dambo-Rongjeng from East Garo hill were selected randomly. From the selected blocks a cluster of 1-2 villages were selected randomly. At the last stage 60 respondents (30 organic adopters and 30 non-adopters) were selected from a cluster of villages using probability proportional to size method.

Costs and return of respective crops taken for the study were worked out by applying the well-defined standard techniques (Johl and Kapur, 2015). The independent t-test was applied to determine the significant difference between the means. Cohen's 'd' test was conducted to determine the effect size of the standardized difference between two means. Cohen's d was determined by calculating the mean difference between two groups and then dividing the result by the pooled standard deviation.

$$\textit{Cohen's}\ \mathrm{d} = \frac{\text{(Mean difference)}}{\text{(Pooled standard deviation)}}$$

Description of the study area

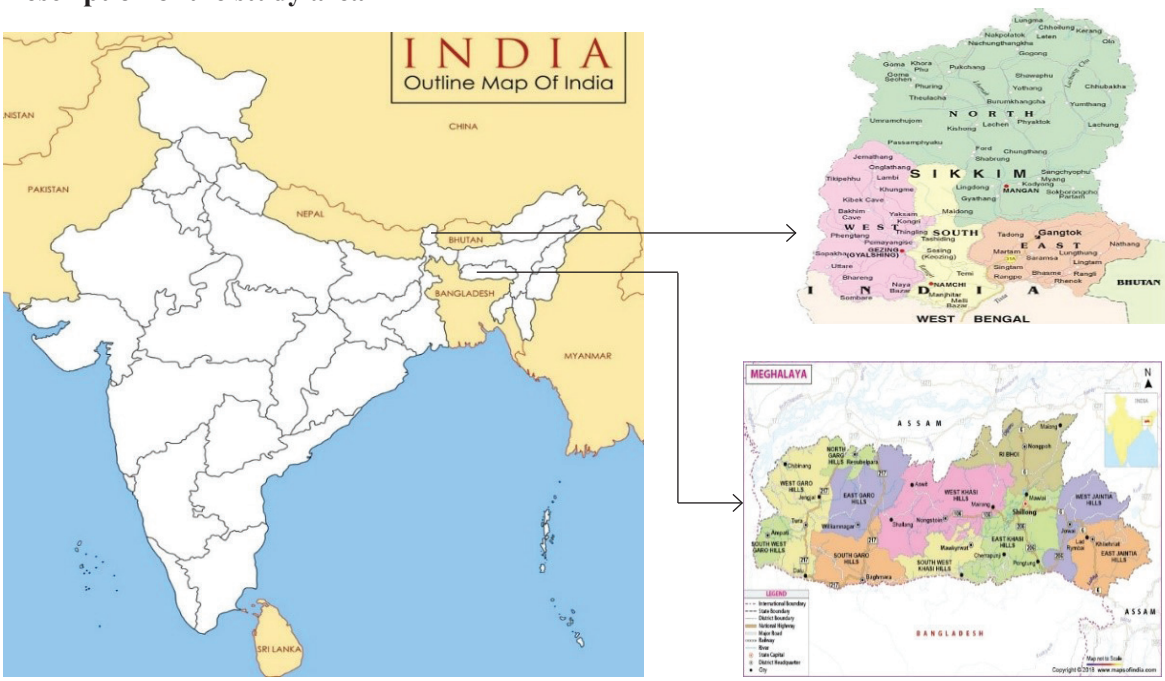

Fig. 1. Location map of Sikkim and Meghalaya, India

Sikkim

Sikkim borders Tibet in the north and northeast, Bhutan in the east, Nepal in the west, and West Bengal in the south. Gangtok is the capital of Sikkim. As a part of Himalayan region, Sikkim is notable for its biodiversity, including alpine and subtropical climates. About 15.36% of the total geographical area is devoted to agriculture. The net cultivated area of the state is 56.64 thousand ha and 11.31% is under irrigation (GoS, 2014). Maize is the major cereal crop, being cultivated in an area of 0.39 mha, followed by rice (0.11 mha) and buck wheat (0.03 mha). Majority of the farmers belongs to small and marginal category (GoS, 2014).

East Sikkim district

East Sikkim district occupies the south-east corner of Sikkim at a latitude of 27° 30' N and longitude of 88° 67' E and with a geographical area of 954 sq. km. Teesta is the major river in the district. The district ranks first in population (2.83 lakh) where about 58.81% of the population are rural based (Anonymous, 2011). It also ranks first in literacy rate in Sikkim (83.85%). Lepchas and Bhutias are the major tribes found in the district. Temperatures range from the maximum of 22°C in summer to a minimum of 4°C in winter. The district receives an annual rainfall of 3894 mm. The net sown area of the district is 18.10 thousand ha (GoS, 2014).

Meghalaya

Meghalaya covers an area of 22,430 square kilometers approximately. The population of Meghalaya is estimated to be 29.67 lakh with the literacy level of 74.43 (Anonymous, 2011). The state with its capital Shillong, located at an elevated range of 1,496 metres above the sea level is famous for its beauty. The western part of the plateau, comprising the Garo Hills region with lower elevations, experiences high temperatures for most of the year. The Shillong area, with the highest elevations, experiences generally low temperatures. The maximum temperature in this region rarely goes beyond 28 °C, whereas sub-zero winter temperatures are common. Khasis, Jaintias and Garos are the major tribes of the state. Unlike the other states, Meghalaya followed a matrilineal system where the lineage and inheritance are traced through women.

East Garo Hills district

In 2012, East Garo Hills district was reorganized to form a new district out of the erstwhile Resubelpara sub-division. The district is bounded by South Garo hills on the south, West Garo hills on the west, West Khasi hills on the east and North Garo hills on the north. The total geographical area of the district is 2603 sq km with population of 3.18 lakh (GoM, 2017). Williamnagar is the capital of the district. The district is divided five blocks namely, Resubelpara, Dambo- Rongjeng, Songsak, Samanda and Kharkutta block (GoM, 2017).

RESULTS AND DISCUSSION

Economics of ginger cultivation

The total cost of ginger cultivation for the organic adopters were ₹ 69797.31 ha^{-1} which was lower compared to the non-adopter (₹ 71974.5 ha^{-1}). The cost incurred on human labour was found to be one of the major cost components in both the organic and inorganic farms. For the organic adopter, cost incurred on labour was Rs 30214.68 ha^{-1} constituting 43.29% of the total cost while for non-adopters cost incurred on human labour was ₹ 32548.41 ha^{-1} accounting 45.22% of the total cost. Cost incurred on seeds was the major cost component for the organic adopter constituting 44.21% while for the non-adopter it constituted 42.19%. The rental charges accounted 8.01% and 7.70% for organic adopter and non-adopter respectively. The rental charges were followed by manure (4.13% for organic adopter and 1.39% for non-adopter respectively. Depreciation of farm assets constituted 0.36% and 0.28% of the total cost respectively. The per cent difference on organic farm compared to inorganic has also been worked out and found that the cost on human labour and fertilizer were lower in organic by 7.17% and 100%. The cost on manure, seed, depreciation of farm assets were found to be higher in organic farming but the total cost of ginger cultivation was lower in case of organic by 3.02% (Table 1). Lower cost incurred in organic cultivation for various crops

were reported by Kshirsagar (2008), Singh et al. (2006), Kumar et al. (2006) and Waykar et al. (2006). Mawthoh et al. (2019) in their study on Potato found better yield while applying organic manure.

Significant difference was observed only in fertilizer and manure but human labour and seed were found to be statistically not significant. The effect size d was estimated at 0.69 and 0.82, which is a very large size effects in the FYM and fertilizers.

Table 1. Cost of ginger production

Particulars	Organic (₹ ha^{-1})	Inorganic (₹ ha^{-1})	Per cent difference (Over inorganic)
Human labour	30214.68 (43.29)	32548.41 (45.22)	-7.17
Manures	2883.33 (4.13)	1002.78 (1.39)	187.53
Fertilizers	0.00 (0.00)	2320.00 (3.22)	-100.00
Seed	30860.13 (44.21)	30363.08 (42.19)	1.64
Depreciation	251.67 (0.36)	198.57 (0.28)	26.74
Rental charges	5587.50 (8.01)	5541.67 (7.70)	0.83
Total cost	69797.31 (100.00)	71974.50 (100.00)	-3.02

Note: Figures in the parentheses indicate the percentage to the total

Table 2. Results of independent t test for mean difference of paid out cost

Particulars	Organic	Inorganic	Mean difference	t value	Effect size d
Human labour	30214.68	32548.41	-2333.73	1.31NS	
Manures (FYM)	2883.33	1002.78	1880.55	2.65**	0.69
Fertilizers	0.00	2320.00	-2320.00	3.17***	0.82
Seed	30860.13	30363.08	497.05	0.40 NS	
Total	63958.15	66234.27	-2276.12	0.92 NS	

Note: *** and ** indicate 1 per cent and 5 per cent level of significance, NS indicates Non significance respectively

There was a significant difference in the average yield of ginger for the organic adopter and non-adopter with the mean difference of ₹ 1387.89 kg ha^{-1}. The organic adopter earned a gross income of ₹ 80366.67 ha^{-1} while the non-adopter earned ₹ 77475.00 ha^{-1}. The net income of the organic adopter was ₹ 10569.35 per ha^{-1} which was higher than the non-adopter (₹ 5500.50 ha^{-1}), but it was statistically not significant. The effect size 'd' was estimated at 0.89, signifying a large effect for yield (Table 3). Risk attitudes of organic and non-organic farmers was compared with a Bayesian random coefficient model and positive traits were observed for organic farmers (Gardebroek, 2006).

Table 3. Returns from organic and inorganic cultivation

Particulars	Organic	Inorganic	Mean difference	t value	Cohen's d
Yield (kg ha^{-1})	7209.96	5822.06	1387.89	3.46***	0.89
Gross income ha^{-1}	80366.67	77475.00	2891.67	0.57 NS	
Net income ha^{-1}	10569.35	5500.50	5068.85	0.84 NS	

Note: *** indicate 1 per cent and NS indicates non significance respectively

CONCLUSION

The study has assessed the economic viability of organic farming in the NEHR, taking ginger as a reference crop. The study concluded that the cost of cultivation was lower for the organic adopters compared to the non-adopters. The net income of the organic adopter was ₹ 10569.35 per ha^{-1} which was higher than the non-adopter (₹ 5500.50 ha^{-1}). The yield was significantly higher for the organic adopters (₹ 7209.96 kg ha^{-1}). Thus, the study concluded that the organic ginger cultivation was economically more profitable and can enhance farmers income.

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Effectiveness and efficiency of physical and chemical mutagens in greengram [*Vigna radiata* (L.) Wilczek]

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ABSTRACT

A field experiment was conducted to study the effectiveness and efficiency of one physical mutagen i.e. gamma rays and three chemical mutagens i.e. ethyl methane sulfonate (EMS), nitrosoguanidine (NG), maleic hydrazide (MH) and their combinations in greengram. To study the nature and effect of mutagens in greengram, the percentage of lethality, pollen sterility, frequency of chlorophyll mutations, mutagenic effectiveness, mutagenic efficiency and mutation rates of each mutagen were estimated. The result from the study indicated that the values of mutagenic effectiveness gradually decreased with increases in dose or concentration of mutagens. NG exhibited as the most effective mutagen, whereas EMS found as the most efficient mutagen. Among combined treatments, gamma rays with NG found as more effective than other mutagenic combinations. Among all the mutagenic treatments the maximum efficiency observed in EMS 0.2% treatment (based on pollen sterility) and NG 0.01% treatment (based on lethality), whereas the lowest efficiency observed in MH 0.03% treatment basing on lethality as well as pollen sterility. Among all mutagens, the maximum mutation rate based on lethality observed in NG treatments, whereas a higher mutation rate based on pollen sterility observed for EMS treatments which can further be increased in combination with gamma rays.

Key words: Chemical mutagens, gamma rays, greengram, mutagenic effectiveness, mutagenic efficiency, mutation rate

INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] is one of the most important pulse crops in India. One of the bottlenecks in its improvement has been the lack of variability. The induction of mutation by different physical and chemical mutagens provide a powerful means of creating new and useful variability in crop plants. However, it is observed that only a few mutagenic treatments have been effective in inducing a high frequency of mutation while in others the frequency of induced mutation is low leading to wastage of resources. Thus, early knowledge of relative biological effectiveness and efficiency of various mutagens and their selection is essential to recover the high frequency of desirable mutations (Das et al., 2006). The term "mutagenic effectiveness" is a rate of mutations produced by the mutagen concerning its dose whereas the "mutagenic efficiency" is an estimate of mutation rate in relation to the damage (Konzak et al., 1965). An effective mutagen doesn't need to be an efficient one also. Both of these though are two different properties, the use of any mutagen in a plant breeding program depends on both of them. Hence a study was undertaken to assess the effect of different doses of physical as well as chemical mutagens on the frequency of chlorophyll mutation, lethality, and pollen sterility to evaluate the

relative effectiveness of mutagenic treatments and efficiency and mutation rate in different mutagens.

MATERIALS AND METHODS

Dry and well-filled seeds of a greengram variety, namely Sujata were administered mutagenic treatments with three doses each of gamma rays (20, 40 and 60 kR), ethyl methane sulphonate (EMS; 0.2, 0.4 and 0.6%), nitroso guanidine (NG; 0.005, 0.010 and 0.015%) and maleic hydrazide (MH; 0.01, 0.02 and 0.03%) singly and combine mutagens of 40 kR gamma rays with 0.4% EMS or 0.01% NG or 0.02% MH. The twelve single mutagenic treatments of gamma rays, EMS, NG, and MH were coded as G1, G2, G3, E1, E2, E3, N1, N2, N3 and M1, M2 and M3, respectively. Three combined treatments of 40 kR gamma rays + 0.4% EMS, 40 kR gamma rays + 0.01% NG and 40 kR gamma rays + 0.02% MH were coded as GE2, GN2 and GM2, respectively. Dry seeds were irradiated with gamma ray treatment at Bhaba Atomic Research Centre, Trombay. For treatment with EMS, NG, and MH, the seeds were pre-soaked in distilled water for six hours, blotted dry and then treated with a freshly prepared aqueous solution of above chemical mutagens for 6 hours, with intermittent shaking. For combination treatments, seeds were first irradiated with 40 kR gamma rays and then treated with 0.4% EMS or 0.01 % NG or 0.02% MH solution in the same manner as described above. After treatment, the seeds were thoroughly washed with running water to bleach out the residual chemicals and then dried on blotting paper after treatment. To grow the M_1 generation, the treated seeds (400 of each treatment) were sown in RBD in two replications with a spacing of 25 × 10 cm^2. Observations on survival were recorded in each plot at the time of maturity and were calculated as the percent of control from which the lethality percentage was calculated. Mean pollen sterility was determined based on acetocarmine stainability. The selfed seeds of all survived plants harvested were used to grow the M_2 generation in RBD with three replications with spacing of 25 × 10 cm^2. Different types of chlorophyll mutants were recorded daily from 5th to 12th day after sowing. The treated and control populations were screened for different chlorophyll mutations such as Albina, Xantha, Chlorine, Striata, Viridis. The frequency of chlorophyll mutants was calculated according to (Gaul, 1960), i.e. Number of mutants per 100 M_2 plants.The formula proposed by Konzak et al. (1965) was followed for the calculations of mutagenic effectiveness and efficiency by incorporating the mutation frequency values recorded for each mutagenic treatment. Mutation rate (MR) which provides the knowledge of mutations induced by a particular mutagen irrespective of dose or concentration was calculated as follows.

$$\text{Mutagenic effectiveness (Physical mutagen)} = \frac{\text{Mutagenic Frequency (Mf)}}{\text{Dose in kR}}$$

$$\text{Mutagenic effectiveness (Chemical mutagens)} = \frac{\text{Mutagenic Frequency (Mf)}}{\text{Conc. (c) in \% } \times \text{ duration of treatment (hrs)}}$$

$$\text{Mutagenic effectiveness (Combination)} = \frac{\text{Mutagenic Frequency (Mf)}}{\text{Dose of physical Mutagen (kR)} \times \text{Conc. of chemical mutagen (\%)} \times \text{duration (hrs)}}$$

$$\text{Mutagenic efficiency} = \frac{\text{Mutagenic Frequency}}{\text{Biological damage (\% Lethality or \% Pollen sterility) in } M_1 \text{ generation}}$$

$$\text{Mutation rate} = \frac{\text{Sum of values of efficiency of particular mutagen}}{\text{Number of treatments of a particular mutagen}}$$

RESULTS AND DISCUSSION

In the present study, the biological damages like lethality and pollen sterility were recorded in M_1 generation (Table 1). Both parameters were found to increase with increasing doses of mutagens (Fig. 1). In gamma- rays treatments recorded the maximum lethality 26.7% and pollen sterility 7.81% at 60kR whereas the minimum lethality 16.5% and pollen sterility 2.11% at 20kR. In the case of EMS treatments, the maximum lethality (58.7%) observed at 0.6% and the minimum (31.5%) at 0.2%. The pollen sterility increased with increasing doses of EMS i.e. 2.46% at a low dose to 7.43. Similar trends were also found in other chemical mutagens NG and MH. In NG recorded the maximum lethality 28.0% and pollen sterility 10.51% at 0.015% dose whereas the minimum lethality 14.5% and pollen sterility 3.87% at 0.005%. In MH the lethality varies from 50.0% at 0.01% dose to 71.0% at 0.03% dose and pollen sterility from 4.27% to 12.19%. In combined treatments of gamma-ray with NG recorded the minimum lethality (35.7%), whereas gamma-ray with EMS recorded the minimum pollen sterility (3.41%). The maximum lethality (69.0%) and pollen sterility (9.7%) observed in gamma rays with MH combinations. The increased lethality and pollen sterility with increasing doses of mutagens also reported by several investigators Das et al. (2006) and Tah (2006) in greengram, Bhosle and Kothekar (2010) in clusterbean, Sonone et al. (2008) in groundnut and Khan and Tyagi (2010) in soybean. They proved that most of the higher doses of mutagens showed increased pollen sterility and lethality. The probable reason for increased pollen sterility might be meiotic irregularities such as translocations. The lethality and pollen sterility increased in combined treatments indicating the additive or synergistic effects of mutagen.

Since chlorophyll deficient mutants could not survive long and observed in treated population for a variable-length period depending on the deficiency of chlorophyll. Therefore, these mutants are of no agronomic value but their frequency in different mutagenic treatments of M_2 generation was considered to be a standard measure for estimation of effectiveness, efficiency, and rate of induced mutation by different mutagens which would ultimately provide the information about the dose for inducing mutations in greengram. The data on chlorophyll mutation frequency and effectiveness of different mutagenic treatments are presented in Table 1. The frequent of chlorophyll mutation in different treatment in M_2 generations varied from 0.88 (M3) to 2.57 (E2). In general, there was an increase in chlorophyll mutation frequency with an increase in the dose of the physical mutagen (gamma-rays) whereas in chemical mutagens there was no dose-dependency relationship. In combine treatments, maximum chlorophyll mutation (2.15) recorded in GN2 followed by GE2. The occurrence of chlorophyll mutations had reported earlier by several researchers in greengram (Vikram et al., 2014), blackgram (Thilagavathi and Mullainathan, 2009; Goyal and Khan, 2010) and in horse gram (Kulkarni and Mogle, 2013). The occurrence of chlorophyll deficient mutant was noticed due to change in gene and a set of genes responsible for chlorophyll mutations (Monika and Seetharaman, 2017).

Mutagenic effectiveness showed a decreasing trend with the increase in doses or concentration of mutagens. Among the different doses of gamma rays irradiated, the mutagenic effectiveness was the maximum (0.057) at 20kR followed by 40kR (Table 1). In EMS, the mutagenic effectiveness was the maximum (1.19) at 0.2% followed by 0.4%. In the case of NG, the mutagenic effectiveness was the maximum (58.67) at 0.005% followed by 0.01% (39.83) and in MH, the mutagenic effectiveness was the maximum (25.33) at 0.01% followed by 0.02% (18.5) treatment. Hence, it could be concluded that NG has higher mutagenic effectiveness compared to all other mutagens and lower doses are more effective among different doses of each mutagen. Similar results previously reported by Rao and Rao (1983), Reddi and Rao (1988), Sharma et al. (2005), Khan and Tyagi (2010) and Girija and Apparao (2011). On the contrary to the present study, Siddiq and Swaminathan (1968) found that EMS was most efficient mutagen followed by gamma rays and Nitroso-Guanidine. Among the combine treatments, the maximum effectiveness observed

in gamma-rays (40kR) + NG (0.01%) combination followed by gamma-rays (40kR)+MH (0.01%). In this study, it was observed that an increase in dose or concentration of the mutagen did not increase the relative frequency of chlorophyll mutants; rather a decreasing trend was observed at higher doses. Nilan and Konzak (1961) and Konzak et al. (1965) opined that higher efficiency at the lower concentration of a mutagen is due to the fact that biological damage (lethality and sterility) increased within dose at a faster than the mutations. The greater effectiveness of chemical mutagens over physical mutagen has also been reported by Shah et al. (2008) and Satpute and Fultambkar (2012).

Konzak et al. (1965) showed that mutagenic efficiency provides the best available measure to evaluate different mutagenic treatments. It varies depending upon the criteria selected for its estimation. In the present investigation, mutagenic efficiency based on the lethality in M_1 varied from 0.012 (M3) to 0.122 (N1) and observed that there is no dose-dependent relationship i.e. it did not follow any particular (increasing or decreasing) trend in mutagenic treatments. Similar results were obtained by Gaikwad and Kothekar (2004) in lentil and Bhosle and Kothekar (2010) in clusterbean. The mutagen efficiency based on pollen sterility demonstrated concentrations of dependent enhancement in the majority of the mutagenic treatments in the M_1 generation of greengram. The value of efficiency decreased as there were increases in doses of mutagens (Table 1, Fig. 2). It ranged from 0.256 to 0.536 in gamma- rays treatment. In EMS treatments, the range was 0.292 to 0.581 whereas in NG, the range was 0.155 to 0.455 and in MH it was 0.072 to 0.356. The efficiency based on pollen sterility varied from 0.151 to 0.531 in the case of combination treatments. Among all the fifteen treatments the maximum efficiency based on lethality and pollen sterility observed in NG 0.005% and EMS 0.2% treatment, respectively whereas the lowest efficiency based on lethality as well as pollen sterility observed in MH 0.03% treatment. Higher efficiency at lower doses of mutagen as observed in the present study might be due to the fact that pollen sterility increased with an increase in doses at a rate faster than the frequency of mutation. Mutagenic efficiency increased with an increased dose similar results were also noticed by Awnindra (2007) and Velu et al. (2008) in greengram and Sharma et al. (2005) in blackgram.

The mutation rate was calculated by taking the mean values of efficiency for each treatment. This provides an idea of the average rate of mutation induction per mutagen. The mutation rates estimated from the value of mutagen efficiency based on lethality and pollen sterility (Table 2). Based on lethality the mutation rate varied from 0.021 (MH) to 0.100 (NG) whereas the mutation rate based on the mutagenic efficiency calculated from pollen sterility value varied from 0.151 (Gamma-rays + MH) to 0.531 (Gamma-rays + EMS). It could be noted that when the mutation rates based on efficiency were considered, the order of mutagens changes as the mutagens have varied values based on lethality and pollen sterility (Fig. 3).

A mutagen is useful only if it is effective as well as efficient. Efficient mutagenesis is the production of desirable changes with minimum undesirable effects. In a mutation breeding program, a high mutation rate accompanied by minimal deleterious effects is desired. But generally, the mutagen that gives the higher mutation rate also induces a high degree of lethality, sterility and other undesirable effects. In this study, among all the mutagens EMS, NG, and Gamma-ray treatments were found to be most efficient. With respect to lethality the order of efficient mutagens could be framed as *NG > Gamma rays> Gamma rays + NG > EMS > Gamma rays + EMS > MH > Gamma rays + MH*. When the mutation rate for pollen sterility is taken into consideration, the order of mutagens could be framed as *Gamma rays + EMS > EMS > Gamma rays>NG > Gamma rays + NG > MH > Gamma rays + MH*. Many researchers have been reported that the effectiveness and efficiency of mutagens vary to a greater extent in different pulse crops like in Urdbean (Sharma et al., 2005), in Chickpea (Shah et al., 2008), in Pea (Dhulgande et al., 2011), in Clusterbean (Bhosale, 2010) and in French bean (More and Borkar, 2016).

Table 1. Effectiveness and efficiency of different mutagenic treatments on greengram variety cv. Sujata

Code	Mutagen	Percentage of lethality (L)	Percentage of pollen sterility	Frequency of chlorophyll mutation	Mutagenic effectiveness	Mutagenic efficiency	
						Based on lethality	Based on sterility
G1	Gamma-rays 20kR	16.5	2.11	1.13	0.057	0.068	0.536
G2	Gamma-rays 40 kR	22.0	4.56	1.92	0.048	0.087	0.421
G3	Gamma-rays 60 kR	26.7	7.81	2.00	0.033	0.075	0.256
E1	EMS 0.2 %	31.5	2.46	1.43	1.192	0.045	0.581
E2	EMS 0.4 %	43.7	4.79	2.57	1.071	0.059	0.537
E3	EMS 0.6 %	58.7	7.43	2.17	0.602	0.037	0.292
N1	NG 0.005 %	14.5	3.87	1.76	58.667	0.122	0.455
N2	NG 0.010 %	19.7	7.74	2.39	39.833	0.121	0.309
N3	NG 0.015 %	28.0	10.51	1.63	18.111	0.058	0.155
M1	MH 0.01 %	50.0	4.27	1.52	25.333	0.030	0.356
M2	MH 0.02 %	66.0	9.03	2.22	18.500	0.034	0.246
M3	MH 0.03 %	71.0	12.19	0.88	4.889	0.012	0.072
GE2	Gamma-rays 40 kR + EMS (0.4 %)	51.0	3.41	1.81	0.019	0.035	0.531
GN2	Gamma-rays 40 kR + NG (0.010 %)	35.7	7.97	2.15	0.896	0.060	0.270
GM2	Gamma-rays 40 kR + MH (0.02 %)	69.0	9.70	1.46	0.304	0.021	0.151

***** All mutagenic treatments found significant (at 5 % level) for lethality and pollen sterility

Table 2. Mutation rate of different mutagens in greengram

Mutagens	Mutation rate based on lethality	Mutation rate based on pollen sterility
Gamma-rays	0.077	0.404
EMS	0.047	0.470
NG	0.100	0.306
MH	0.025	0.225
Gamma rays +EMS	0.035	0.531
Gamma rays +NG	0.060	0.270
Gamma rays+ MH	0.021	0.151

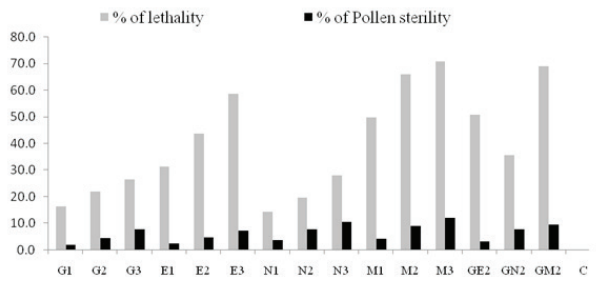

Fig. 1. Effect of different mutagenic treatments on lethality and pollen sterility in greengram

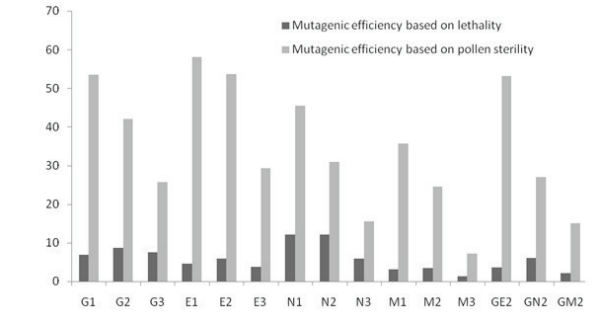

Fig. 2. Mutagenic efficiency (%) of different mutagens in greengram

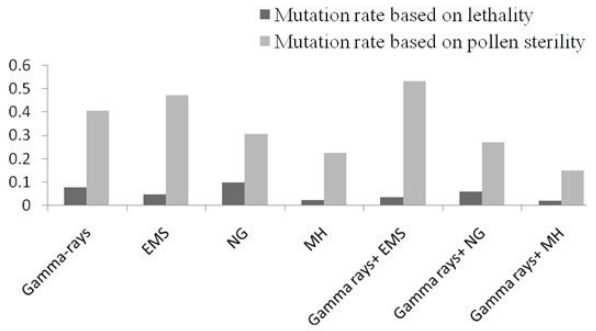

Fig. 3. Mutation rate of different mutagens in greengram

CONCLUSION

The effectiveness and efficiency of mutagen based on leaf chlorophyll, lethality and pollen sterility in greengram are useful in identifying the genetic effect of mutagen. In the present study, it can be inferred that the values of effectiveness gradually decreased with increases in dose or concentration of mutagen. The lower to moderate concentrations of the mutagens are more effective than the higher concentrations. The study also reveals the Gamma rays, EMS, NG, and their combinations have a higher potential to induce significant mutations in greengram. It was noted that when the mutation rate based on efficiency was considered, the order of mutagen changes as according to the lethality and pollen sterility. Lethality studies indicate that NG treatments maximum mutation rate followed by gamma-rays and gamma rays + NG treatment whereas maximum mutation rate (based on pollen sterility) found in gamma rays + EMS treatment followed by EMS and Gamma rays.

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Use of customized leaf colour chart for input saving and disease occurrence in rice var. *Swarna* (MTU-7029)

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ABSTRACT

A field experiment was conducted in three villages of Cuttack district, during kharif 2014 and 2015, to study effects of application of nitrogenous fertilizer basing on use of customized leaf colour chart (CLCC) in transplanted rice var. *Swarna* on time of N application, incidence of disease and pest, grain yield, and economics. Nitrogen fertigation time differed from conventional time when CLCC was used by nearly 3-5 days along with saving of N fertilizer. Severity index for sheath blight was less in trial plots (0.6) than in farmer practice (1.8). The incidence of leaf folder also decreased by 57.49% in the trial plots as compared to farmers practice. However, the grain yield did not increase significantly in the CLCC based N applied plots as compared to farmers practice. These findings indicated that judicious use of nitrogenous fertilizer by using CLCC based recommendation could improve nitrogen use efficiency, saves N, reduces incidence of leaf folder and sheath blight without affecting the economical attributes in the farmers' fields.

Key words : Disease, leaf colour chart, nitrogen, pest, rice

INTRODUCTION

Among essential nutrients for plants, nitrogen (N) plays an important role in plant growth, seed quality and quantity. As farmyard manure availability is decreasing, use of nitrogenous fertilizer is increasing. If not used judiciously, urea or other N fertilizer use results in loss as plant has certain capacity to uptake the amount of N applied to the soil. The nitrogen use efficiency (NUE) reduces when N is not applied in proper time and quantity, mostly when used in excess amount. Traditionally, nitrogen is applied in rice as basal dose along with 2-4 splits at specified growth stages of rice (Sarangi et al., 2019). However, about less than 40% N supplied from applied fertilizer meets the crop demand due to large variations in crop N requirements, soil N supply and the lack of synchrony of plant demand and nutrient supply (Ladha et al., 2005; Yogendra et al., 2017; Subedi et al., 2018). Excess of nitrogen also leads to overgrowth of vegetative plant affecting grain production along with an increase in disease and pest incidence (Teng et al., 2016). In field conditions, site-specific nutrient management has been proved to be more efficient than the traditional farmers practice (Dobermann et al., 2002; Bhatia et al., 2012). Leaf colour chart (LCC) is an instant, easy and low-cost technique used for N diagnosis of a standing crop and N topdressing in crops particularly rice (Singh et al., 2007; Valynejad et al., 2010; Premalatha and Angadi, 2017). The customized leaf color chart (CLCC), developed by the National Rice Research Institute

(NRRI) for real-time N management in rice for Indian conditions. It enhances productivity, NUE, and farmer's profit (Singh et al., 2007; Moharana et al., 2017; Premalatha and Angadi, 2017) along with preventing fertilizer contamination of surface and ground water leading to nitrous oxide emission (Ladha et al., 2005; Bhatia et al., 2012). Thus, use of LCC may help to rationalize the use of urea and other nitrogenous fertilizer as per the need of the crop (Powlson et al., 2011). Considering all the above aspects, we tested the CLCC in transplanted rice as a resource conservation technology in farmers' fields in Tangi, Baramba and Nischintakoili blocks of Cuttack district for its effect on nitrogen fertilizer use, disease and pest incidence along with production performance in rice var. Swarna and compared the performance with existing farmers practice.

MATERIALS AND METHODS

A participatory rural appraisal was conducted to understand the farmers' practice of fertilizer application followed by a focused group discussion involving the farmers of Uchhapada (Tangi), Mangarajpur (Baramba) and Kulbadakshiri (Nischintakoili) village clusters of Cuttack district in 2014 and 2015 during pre-monsoon time. The farming situation was analyzed and 15 farmers were selected at random from each village cluster. They were trained to use CLCC and application of CLCC based N fertilizer. The rice var. Swarna was used for this trial. Rice cultivated with the existing agronomical practices was taken as control (T_1) and that with inclusion of CLCC based nitrogen use was treated as treatment group (T_2). In each cluster, every farmer used certain fields as their conventional practice, whereas in the test plots they followed the CLCC based application of nitrogenous fertilizer, particularly urea with total land holding of 6 ha for both the control and treatment groups. In control fields, farmers visually assessed the need for nitrogen and applied fertilizers as per their own assessment. In the control group, fertilizer dose of 60:30:30 was used by the farmers, whereas in the treatment group plots the nitrogen (N) dose was selected as per recommendations arising from using CLCC. Regular field visits were conducted to the treatment fields to technically assist the farmers under participatory trial and monitor the CLCC based N application. The data on time of application of N fertilizer and quantity of N along with diseases and pest incidence during the crop and final yield of paddy were recorded. In LCC based treatments, nitrogen was applied through urea based on average LCC readings taken from 21 days after sowing (DAS) to heading at every 10 days interval. In each reading, the plots with average LCC reading (taken from 10 randomly selected upper profile healthy leaves) below the critical value i.e. 4, received nitrogen at the rate of 30 kg ha^{-1} through urea topdressing (Devkota et al., 2013).

The customized leaf color chart (CLCC), developed by the National Rice Research Institute for real-time N management in rice for Indian conditions was used for this study. The disease and pest incidence, particularly sheath blight was recorded as per guidelines given by SES (2002) where disease severity index was calculated as sum of scores per number of samples, whereas for leaf folder the following method was used. To record the leaf infestation, 10 × 5 hills were selected randomly from each plot and the total leaves and leaf folder damaged leaves per 10 randomly selected hills were counted. Thereafter, percentage of infestation due to leaf folder was worked out by formula given below.

Leaf folder damage (%) = (Number of infested leaves per hill / Total number of leaves per hill) × 100

Number of pesticide spray done in the control and trial fields were also recorded. At the time of harvest the grain yield was recorded in 25 m^2 and expressed in quintals. The data generated were statistically analyzed by students' t-test as per Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

In LCC, the color panels are designed to indicate whether rice plants are hungry or overfed by nitrogen fertilizer. It can be observed by matching the color of the rice leaf to the color on the LCC and proper time and amount of N fertilizer

for application can be decided ensuring need-based optimum use N (Shukla et al., 2004; Ladha et al., 2007; Ali et al., 2015; Kumar et al., 2018a,b). In practice, farmers apply N fertilizer basing on own instinct and experience along with comparison with nearby fields (Sarangi et al., 2019). Nitrogen application was differed from their normal practice in most of trial plots using CLCC (Table 1) and a difference of about 4-5 days was found from the normal farmers practice.

Table 1. Effect of using N fertilizer in rice using customized NRRI leaf colour chart

Parameters	Farmers practice	Trial Plots	Percent changes
Nitrogen used (kg ha^{-1})	71.3±4.5	58.6±2.5	18.3
Nitrogen application time	As per farmer perception	4-5 days delay to farmer practice	

The quantity of N fertilizer utilized in farmers practice was higher (13 kg N ha^{-1}) than the recommended practice indicating a saving in N fertilizer. As N was applied when the plants really needed it, this ensured optimal utilization of N and minimized water pollution (Guo et al., 2017). Saving of N fertilizer by the CLCC used group averaged at 13 kg N ha^{-1} (28 kg urea ha^{-1}) or 18.3% of the N applied previously with their own practice or N applied by the non-CLCC adopted farmers.

Table 2. Effect of using nitrogenous fertilizer in rice using customized NRRI leaf colour chart on incidence of pest and disease

Parameters	Farmers practice	Trial Plots	Per cent changes
Sheath blight (severity index)	1.8±0.2	0.6±0.1	-66.7%
Leaf folder (%)	4.14±0.54	2.38±0.36	-57.49
Spraying of insecticide (no.)	2.5	1.5	40

Excess use of N promotes more vegetative growth, making the plant more succulent and susceptible to pests and diseases (Teng et al., 2016). Sheath blight is of very common occurrence in our trial variety, i.e. Swarna. In our study, severity index for sheath blight was 66.7 per cent less in trial plots (0.6) where CLCC based N application was done than that of farmer practice (1.8)[Table 2]. Similarly, the incidence of leaf folder decreased by 57.49% in the trial plots as compared to farmers practice indicating the role of nitrogen synchrony in disease monitoring. The average number of spraying of insecticides done in trial plots were 1.5 per season as compared to control plots where about 2.5 sprays were done on an average per season resulting in reduction of spray (40%). In a similar study, Islam et al. (2007) observed 50% reduction in number of insecticide spray after adoption of LCC and also when compared with those who did not adopt the LCC.

Table 3. Effect of using CLCC for nitrogenous fertilizer application on yield and other parameters

Parameters	Farmers practice	Trial Plots	Per cent increase
Plant height (cm)	91.7±2.18	91.9±3.75	0.22
No. of effective tiller	10±1.24	11±1.41	10
Yield per hectare (q ha^{-1})	48.5±3.52	50.7±2.87	4.54

The plant height and effective tiller number were similar in both the groups indicating CLCC based N fertilizer application had no adverse effect on plant growth and other parameters influencing yield attributes. In a similar study, Kumar et al. (2018b) observed significant increase in tiller

number when recommended dose of nitrogen and CLCC were used. The yield also reflected a similar trend of yield in both the CLCC based N applied plots and farmers practice indicating minor role of CLCC in increasing the grain yield as it basically saves nitrogenous fertilizer by preventing its excess use. However, in some earlier studies higher grain yield and gain protein content were observed when recommended dose of nitrogen and CLCC were used (Kumar et al., 2018b). In a similar study, LCC based nitrogen management in dry direct seeded rice increased nitrogen use efficiency, total N uptake and grain yield (Subedi et al., 2018). The positive effect on tiller number and yield attributes may be attributed to the real time N uptake and utilization by the plant when N was applied with the help of CLCC (Thind et al., 2010). Economics Farmers practice is affected by economics of technological application. The economics of cost saving through less use of N fertilizer and less labour and chemical cost for pest control along with yield advantage has been summarized in Table 4.

Table 4. Economics of using CLCC for nitrogenous fertilizer application (Rs ha^{-1})

Parameters	Farmers practice	Trial Plots	Input saved/ extra income
N saving through urea saving (@13 kg^{-1} N) considering basal application same	13×13=169	-	169
Money saved in chemical and labor cost for spraying @Rs. 1550 per spray ha^{-1}	3875	2325	1550
Sale of rice @Rs. 1750 per q	84875	88725	3850
Total			5569

The price of urea in the trial year was Rs. 6 kg^{-1} or Rs 13 kg^{-1} N. Thus, the cost saving on nitrogen fertilizer in monetary terms is therefore estimated at Rs. 169 ha^{-1} in kharif season (Table 4). The cost saving on reduction of spray and use of pesticide in monetary terms is estimated at Rs. 1550 ha^{-1}. In terms of increase in yield, the extra grain will fetch about Rs. 3850 for the 2.2 q. So, the total saving due to CLCC based N application would be about Rs. 5569 ha^{-1}. Most of the studies indicated improvement in economic grain by use of CLCC (Kumar et al., 2018b; Subedi et al., 2018).

CONCLUSION

Use of customized leaf colour chart delayed the nitrogen fertilizer application day in almost all the cases in treatment groups as compared to control groups by nearly 4-5 days along with saving of N fertilizer. The incidence of leaf folder and severity index for sheath blight was less in trial plots than that of farmer practice indicating decrease in disease incidence. The grain yield and other yield parameters were not significantly influenced by CLCC based N applied plots as compared to farmers practice indicating no influence in yield attributes. However, the net benefit to farmers was improved by about Rs. 5569 ha^{-1} than that of the farmer practice indicating the usefulness of the technology.

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Performance of ginger and turmeric as intercrops in mango based agroforestry system in the Eastern Ghat high land zone of Odisha

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ABSTRACT

Performance of two rhizomatous spice crops i.e. ginger (var. Suprava) and turmeric (var. Roma) in pure stands and as intercrops with 7-year-old mango plantation at 8 m × 8 m was investigated under rainfed conditions of Eastern Ghat High Land Zone of Odisha. The experiment was laid out in randomized block design with four treatments and seven replications. Both crops performed better as intercrops than as pure stands. Plant height, tillers per plant, leaves per plant and leaf length in ginger and turmeric were significantly enhanced when intercropped. The rhizome length, yield per plant and yield per ha in both the crops also increased under mango grove as compared to sole cropping. Due to shade loving nature of ginger and turmeric, plant growth and yield was significantly higher in mango intercropping.

Key words: Agroforestry, ginger, mango, rhizome, turmeric

INTRODUCTION

Ginger and turmeric are most suitable spice crops for intercropping in agro-forestry systems in pre-humid to sub-humid and semi-humid to semiarid regions from lowlands (up to 500 m) to medium elevation (500-1000 m) (Nair, 1993; Behera and Sial, 2019). India is the largest producer of ginger and turmeric in the world. Ginger (*Zingiber officinale* Rosc.) is the most popular 'hot spice' in the world. Ginger rhizomes and their products are consumed as a special vegetable in daily diets in culinary and medicinal use. In India, It is grown in an area of 1,25,347 ha with a production of 9,24,417 tonnes of ginger (Pandey et al., 2016). Karnataka, Odisha and West Bengal account for more area under ginger though it is grown in almost all states of India. India is the largest producer (70% of world production) and exporter to more than 50 countries. India, China, Taiwan, Sierra and Nigeria are the major exporters of dry ginger.

Turmeric (*Curcuma longa* L.) is a herbaceous plant, native to tropical South-East Asia. In India, it is grown in an area of 2,51,824 ha producing annually 13,98,862 tonnes (Sajjan et. al. 2018). India is leading in its production (75% of world output), but export is approximately 10-15% (best quality only). In India, Andhra Pradesh is the leading state (area wise) followed by Tamil Nadu, Odisha, Maharashtra, Kerala and Bihar. In India, Odisha has 14.6% of the national turmeric area and 23.24% of annual production (Ministry of Agriculture, 2014). The state of Odisha has annual production of 2,21,700 MT from 28,140 ha turmeric area with productivity of 7878 kg ha^{-1} (Directorate of Agriculture and Food Production, 2014).

Mango (*Mangifera indica* L.) is an indigenous fruit crop of India and also known as national fruit of the country because of its wide edaphic and climatic adaptability, high nutritive value, species of agro-forestry importance, attractive appearance and gains popularity among growers. Moreover, the foliage density of mango is sparse, maintains a uniform crown which permit required light for the under storey intercrops and makes more compatible for mixed cultivation. It is a multipurpose fruit tree suitable for agro-forestry, which yields nutritious fruits, timber, fuels, etc. (Musvoto and Campbell, 1995). The fruits are also considered, protective food as it contains anti-oxidants, essential vitamins, minerals and enzymes, which are required for better functioning and maintaining resistance against many diseases of human beings (Chattopadhyay, 2001). Despite of several benefits of mango cultivation with or without intercrops, the area under mango is insufficient to meet out domestic demand. It compels establishment of mango orchards on degraded gullied or ravines and pasture lands, as extension of area under mango, which is least possible due to increasing population pressure in the country. It also has long gestation period, which allows intercropping at pre-bearing stage in order to utilize interspaces and generate additional income. Most of the research works on mango based agri-horticultural system have been done on arable land with assured input supply (Saroj et al. 2004), but limited information is available on utilization of degraded lands with resource conservation to sustain the livelihood of poor farmers through intercropping. Thus, present study was conducted in a mango based agro-forestry system in order to evaluate the performance of ginger and turmeric in the Eastern Ghat high land zone of Odisha, India.

MATERIALS AND METHODS

An on-farm trial was conducted in a plain land of red lateritic soil by Krishi Vigyan Kendra, Koraput, Odisha, during 2018-2019. Four treatments were used namely T_1-mango + ginger, T_2-mango + turmeric, T_3 - sole ginger and T_4 - sole turmeric. The trial was carried out on a 7-year-old existing mango orchard (cv. Totapori) along with ginger and turmeric. The mango trees were planted with a row spacing of 8m × 8m and the intercrops were planted in between the lines of mango trees. Ginger rhizomes (var. Suprava) and seed rhizome of turmeric (var. Roma) were sown at a spacing of 40 cm × 25 cm and maintained a row to row distance of 40 cm, a plant to plant distance of 25 cm and a depth of 10 cm respectively in the last week of April 2018. The crop was harvested in the last week of December and yield per hectare was estimated. The data on plant height, number of tillers per clump, number of leaves per plant, leaf length, rhizome length, rhizome yield per plant and rhizome yield per ha were recorded. The data obtained during the investigation was statistically analyzed as per the procedure and design given by Panse and Sukhatme (1985). The statistical significance was tested applying 'F' test at 0.05 level of probability and critical differences were calculated for those parameters which turned significant (*$P < 0.05$) to compare the effects of different treatments.

RESULTS AND DISCUSSION

The data on growth parameters viz., plant height, number of tillers per plant, number of leaves per plant and leaf length of intercrops (ginger and turmeric) are presented in Table 1. Ginger and turmeric grown under intercropping produced significantly higher plant height (90.11 cm and 124.7 cm), number of tillers per clump (14 and 4.86), number of leaves (141.57 and 13.28) and length of leaves (23.67 cm and 79.14 cm), when compared to corresponding data in open area as sole cropping of ginger and turmeric. This might be due to tree-crop association providing better micro-habitat conditions than pure crop. Secondly it might be due to less light intensity (partial shade loving nature of ginger and turmeric plants) under intercropping as compared to open condition. These results are in conformity with the findings of several workers, recorded the higher plant height of turmeric intercropping with tamarind plantation compared to sole cropping, Parihar et al. (2015) in turmeric under agri-silvi-horticulture system, Chaudhary et al. (1998) in ginger under mango orchard, Alam et al. (2014) under different regimes of shade in turmeric.

Table 1. Growth parameters of intercrops under mango based agroforestry system

Treatments	Plant height (cm)	No. of tillers per plant	No. of leaves per plant	Length of leaves (cm)
T_1	90.11	14	141.57	23.67
T_2	124.7	4.86	13.28	79.14
T_3	59.44	9	78.14	20.04
T_4	105.96	3.71	9.71	70.92
SE (m)±	2.83	0.61	3.34	0.62
CD at 5%	8.42	1.81	9.91	1.85
CV	7.89	20.32	14.55	3.41

Significantly maximum length of rhizome in T_1 (16.4) and T_2 (11.13) and rhizome yield per plant in T_1 (200.06 g) and T_2 (278.96 g) was recorded under mango based agroforestry respectively compared to sole planting . Probably with regard to fresh rhizome yield (q ha^{-1}) of ginger var. Suprava and turmeric var. Roma, there was significantly higher T_1 (21.3 t) and T_2 (23.53 t) under mango based agroforestry system than sole cropping (Table 2). This may be due to their capability to grow better in partial shade conditions (shade loving nature of ginger and turmeric plants) and in establishing better root system, ability to retain more soil moisture provided better microclimate in intercropping as compared to open condition. It may also be due to good compatibility, interaction and greater biological efficiency of crop grown in association. These results are in conformity with the findings of Vanlalhluna and Sahoo (2009) in ginger and turmeric under intercropping., Prajapati et al. (2007) in ginger, Vanlalhluna and Sahoo (2010) in ginger, turmeric and maize, Singh et al. (1997) in turmeric and Saroj et al. (2003) in groundnut, wheat, cluster bean and mustard.

Table 2. Yield of intercrops under mango based agroforestry system

Treatments	Length of rhizome (cm)	Rhizome yield $plant^{-1}$ (g)	Rhizome yield ha^{-1} (t)
T_1	16.4	200.06	21.3
T_2	11.13	278.96	23.53
T_3	13.1	175.66	16.04
T_4	7.24	242.26	16.64
SE (m)±	0.43	9.37	0.53
CD at 5%	1.27	27.85	1.59
CV	9.45	11.06	7.31

CONCLUSION

On the basis of present investigation, it may be concluded that, growing of ginger and turmeric crop with mango resulted in significant increase in the growth as well as the yield as compared to growing ginger and turmeric as sole crop. Significantly higher value in the attributes viz. plant height, number of leaves, length of leaves, length of rhizome, rhizome yield per plant and rhizome yield per hectare was observed under intercropping with mango, as compared to pure crop.

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Effect of irrigation frequency on growth and yield of wheat (*Triticum aestivum* L. var. Chonte 1) under Kabul agro-climatic conditions, Afghanistan

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ABSTRACT

A field experiment was conducted under Kabul agro-ecological conditions at the Agriculture faculty research farm and Botanical garden, Faculty of Agriculture, Kabul University to study the effects of different irrigation frequency on growth, yield and yield components of wheat (*Triticum aestivum* L.) during 2018-2019, wheat cultivar (Chonte 1) was grown with different irrigation intervals in every 5, 7, 9, 11 days. The experimental design was Randomized Complete Block Design (RCBD) with three replications. The parameters studied were plant height, dry matter, number of tillers per m^2, number of spikes per m^2, number of spikelets per spike, number of grains per spikelet and spike, 1000-grain weight, grain yield and spike length. The results showed that there were highly significant differences in the studied parameters due to irrigation intervals, where the irrigation in every seven days recorded higher values. Hence seven days' irrigation interval (T_2) treatment would be the most advantageous for finding better growth and higher yield in spring wheat production in the studied region and among the morphological and yield attributing characters. Through the treatment 4, the minimum values in the traits like grains per spike, shortest spike, the lowest weight of 1000-seed, the lowest yield of grain and dry matter content were obtained.

Key words: Growth, irrigation frequency, wheat variety Chonte 1, yield

INTRODUCTION

Wheat is one of the oldest and most vital of the cereal crops for the majority of world's population. In 2019, the world's main wheat-producing countries were China, India, Russian Federation, United States, France, Australia, Canada, Pakistan, Ukraine and Germany. According to the statistics of Food and Agriculture Organization (FAO, 2010), the cultivated land of wheat equals 217 million hectares, with production amounted to 653 million tons and about 44% of its production is in Asian countries. This staple crop is grown each year under irrigated and rainfed conditions. More than 85% of the population of Afghanistan is dependent on agriculture and related activities for livelihood. About 12% of the country's total land is arable, 3% is under forest cover, 46% under permanent pastures, and the remaining 39% is mountainous and habitable (Anonymous, 2019). Afghanistan's wheat production has ranged from 2.6 to 5.2 million tons during the last decade (FAO, 2016).

Agricultural production in Afghanistan is highly dependent on rain and snowfall. Approximately 45 per cent of Afghanistan's wheat area in a normal year is irrigated, while the remaining 55 per cent depends entirely on rainfall. The timing and quantity of the annual snowmelt is a key factor in determining the quantity and duration of water availability for irrigation throughout the cultivated areas of Afghanistan. The productivity of wheat differs significantly between irrigated and rain-fed areas (Asian Development Bank, 2003; Ahmad and Mahwash, 2004). Irrigation plays a vital role in terms of bringing good growth and development of wheat. Insufficient soil moisture affects both the germination of seed and uptake of nutrients from the soil. Irrigation frequency also has a significant influence on growth and yield of wheat (Khajanij and Swivedi, 1988).

MATERIALS AND METHODS

This experiment was carried out at two locations, in the Agriculture faculty research farm and in the Botanical garden, Faculty of Agriculture, Kabul University during 2018-2019. The total area for each location was 48 m^2. The experiment was consisting of four treatments T_1 (Irrigation every 5 days), T_2 (Irrigation every 7 days), T_3 (Irrigation every 9 days) and T_4 (Irrigation every 11 days) and laid out in Randomized Complete Block Design (RCBD) with three replications. There were 12 plots for each location of the experimental area, having the size of each plot 2 m × 2 m. This area falls under the semi-arid climatic zone. The Faculty research farm is situated between 34° 31' 0.61" N latitude and 69° 08' 21.7" E longitude, whereas the Botanical Garden is lying between 34° 30' 44.5" N latitude and 69° 0.8' 08.8" E longitudes. The soil of the experimental area was sandy loam to clay loam and the pH range was 8-8.5. The elevation of the site ranges between 1791 to 1800 m above sea level and the depth of water table was 10 - 11 m from the soil surface.

The seed sown rate was 150 kg ha^{-1}, the plant to plant distance was 3 cm and row to row distance was 30 cm. Phosphorus (DAP) fertilizer was used at 175 kg ha^{-1} and the nitrogen (urea) fertilizer at the rate of 200 kg ha^{-1} was applied in three split doses (at times of sowing, tillering and heading stage). All the phosphorus fertilizer and one third of urea were applied in each plot at final land preparation and were mixed thoroughly with the soil. The rest two thirds of urea were top-dressed in two equal splits, one at the active tillering stage and the other at the heading stage.

RESULTS AND DISCUSSION

Generally, the results indicated that the growth and yield attributes of wheat variety Chonte 1 under different irrigation intervals were the highest when irrigation intervals were short. The statistical analysis data showed a significant effect on plant height due to different irrigation intervals in both the locations.

Plant height

The plant height in centimetre was compared between the treatments at the faculty farm and at the botanical garden that the treatment 1 produced the highest plant height and treatment 4 had the lowest plant height (Fig. 1; Table 1). This is in agreement with Moursi et al. (1979) in Egypt who reported that, the shorter the irrigation interval, leads to taller the plant. On the other hand, increased irrigation amount, irrespective of interval showed a highly significant difference in plant height. These results agreed with the studies of Thompson and Chase (1992), who reported that irrigation treatments significantly influenced plant height. Several investigations from different parts of the world reported that plant height increased with more frequent irrigation and decreased with less irrigation frequency (Elmonyeri et al., 1982). Haikle and Melegy (2005) reported that the positive effect of irrigation on plant height may be attributed to the effect of irrigation on the activities of cell elongation, cell division and consequently increased meristematic growth.

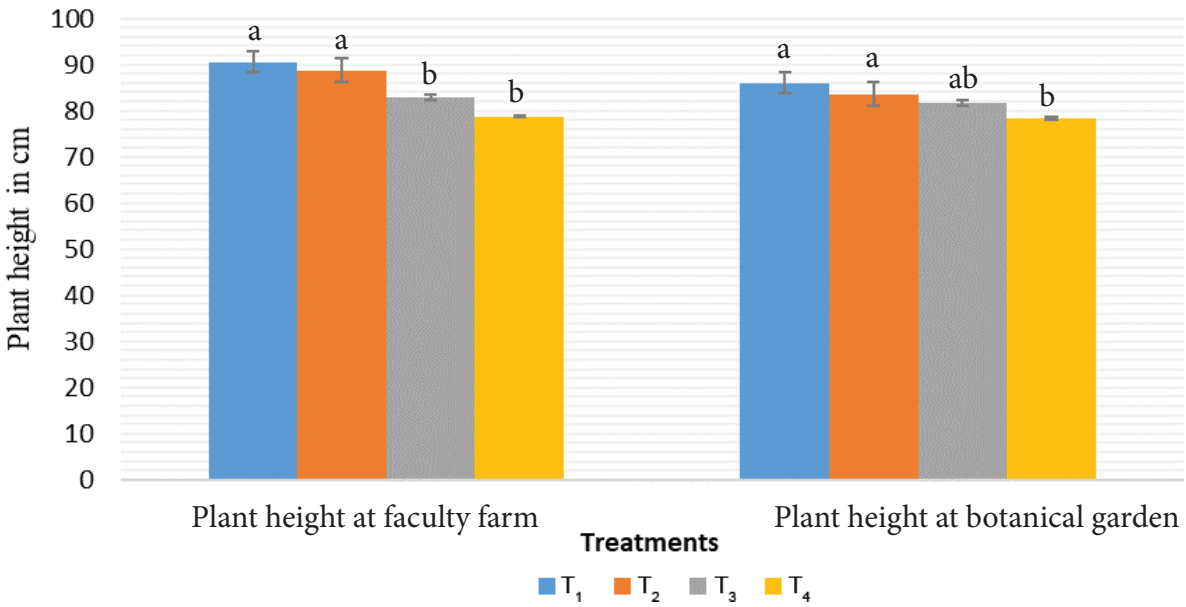

Fig. 1. Effect of different irrigation frequency on plant height (cm) of wheat at harvest time at faculty farm location and botanical garden

Table 1. Effect of irrigation frequency on plants height per cm and tillers per m^2 of wheat at faculty farm and botanical garden

Treatments	Faculty farm location		Botanical garden location	
	Plant height (cm)	No of tillers m^{-2}	Plant height (cm)	No of tillers m^{-2}
T_1	90.62_a	322.22_b	86.08_a	377.78_a
T_2	88.75_a	474.07_a	83.67_a	403.70_a
T_3	83.04_b	440.74_a	81.85_{ab}	392.59_a
T_4	78.75_b	311.48_b	78.38_b	268.81_b
CV (%)	3.02	5.84	2.61	12.20
SE	2.10	18.46	1.76	35.93
LSD	5.14	45.17	4.29	87.92

Means followed by the same letter in each column are not significantly different according to (LSD) test
T_1=irrigation every 5 days, T_2 = irrigation every 7 days, T_3=irrigation every 9 days and T_4=irrigation every 11 days

Number of tillers per m^2

The number of tillers per m^2 were compared between the treatments that the treatments 2 and 3 produced the highest number of tillers per m^2 compared to all and the treatment 4 obtained the lower number of tillers per m^2 in both locations (Table 1). The beneficial effect of frequent irrigation may be due to availability of nutrients in the upper surface of the soil where the nodal roots and rootlets usually spread. The higher number of tillers may be attributed to adequate moisture supply, particularly at the tillering stage. The survival of productive tillers was reported to be positively correlated with grain yield (Shanahan et al., 1985). However, the different irrigation treatments in this study showed different effects on the components of yield. So, Bajwa et al. (1993) observed a significant effect on

varying levels of irrigations on the number of tillers per m^2. The final yield of wheat is the product of the number of spikes per m^2 × spikelets per spike × grains per spike × weight of grains.

Number of spikes per m^2

The crops produced a greater number of spikes per m^2 under treatment 2 (irrigation interval 7 days) and the treatment 4 produced a lower number of spikes per m^2 in the faculty farm (Table 2). So, at Botanical Garden location, it was observed that the highest number of spikes per m^2 was obtained by 7 days' irrigation interval, however, 11 days' irrigation interval produced the lowest number of spikes per m^2 (Table 2). These results are in agreement with the Matsunaka et al. (1992) and Ghazal et al. (1998), who reported that the number of spikes per m^2 increased as irrigation increased.

Number of spikelets per spike

There was a significant difference of irrigation intervals on spikelets per spike in both the locations and the treatment 2 (Irrigation interval 7 days) produced greater number of spikelets per spike (11.50) at the faculty farm location and after that (T_3 and T_1) treatments gave the highest number of spikelets per spike and treatment 4 produced the lower number of spikelets per spike (Table 2). Moreover, at botanical garden location lower number of spikelets per spike were recorded by irrigation interval 11 days (Table 2). These results are in agreement with those obtained by Dencic et al. (2000).

Number of seeds per spikelet

The number of seeds per spikelet were compared between the treatments. The treatment -T_2 (Irrigation interval 7 days) gave the highest number of seed per spikelet at faculty farm and botanical garden locations, while 11 days' irrigation interval produced lowest number of seed per spikelet but the varying levels of irrigations have no significant effect on the number of seeds per spikelet (Table 2).

Spike length (cm)

The length of the spike was significantly influenced by different irrigation treatments. At the faculty farm the treatment 2 and 3 produced a greater length of the spike but followed the (T_1 and T_4) treatments revealed the lowest length of spike and also at the Botanical Garden. It has appeared that the longest spike (11.06 cm) was obtained by 7 days' irrigation interval (Table 2), so many workers have reported similar effect of irrigation on spike length in wheat (Swati et al., 1985).

Table 2. Effect of irrigation frequency on yield components of wheat at Faculty farm location and Botanical garden

	Faculty farm location				Botanical garden location			
Treatments	Spikes m^{-2}	Spikelets per spike	Seeds per spikelet	Spike length (cm)	Spikes m^{-2}	Spikelets per spike	Seeds per spikelet	Spike length (cm)
T_1	322.22_c	8.33_{bc}	2.33	7.83_b	344.56_a	11.33_{ab}	2.47	9.26_b
T_2	461.22_a	11.50_a	2.83	10.62_a	394.48_a	12.67_a	3.00	11.06_a
T_3	407.41_b	10.33_{ab}	2.40	8.88_b	378.67_a	12.50_a	2.46	10.12_{ab}
T_4	257.70_d	7.67_c	2.33	7.83_b	266.67_b	9.67_b	2.42	9.79_b
CV (%)	5.67	13.27	19.48	9.23	8.42	7.47	18.15	5.27
SE	16.77	1.03	0.39	0.66	23.79	0.70	0.38	0.43
LSD	41.03	2.50	1.62	58.21	1.72	1.05		

Means followed by the same letter in each column are not significantly different according to (LSD) test

T_1= irrigation every 5 days, T_2 = irrigation every 7 days, T_3 = irrigation every 9 days and T_4=irrigation every 11 days

Number of grains per spike

The treatment 2 through 7 days' irrigation interval revealed the highest number of grains per spike at the Faculty farm location (55.67) and also at the Botanical Garden (53.92) (Table 3). Hence Ngwako and Mashiqa (2013) found that irrigation throughout the growth stages recorded the more grains per spike. A similar observation was also found by Mubeen et al. (2013). Many workers reported a range of grain number varying from 40 to 59 grains per pike among various genotypes of wheat (Musaddique et al., 2000).

1000-grain weight

At Faculty farm location 1000-grain weight was significantly influenced by irrigation frequency. The heaviest grain weight of 1000 grains (45.77 g) was weighed in (T_2) at the faculty farm and also at Botanical Garden (36.13 g) was obtained with 7 days' irrigation interval (Table 3). These results are in agreement with Singh et al. (1980), Ibrahim (1980, 1995) and Martin (1982) who reported increased grain weight (1000-grain weight) with frequent irrigation.

Grain yield (kg ha^{-1})

At the faculty farm, the treatment (T_2) revealed the highest yield (4160.67 kg ha^{-1}) but treatment (T_4) produced the lowest grain yield (2989.67 kg ha^{-1}) Similarly at the botanical garden the (T_2) treatments revealed the highest yield (3658.00 kg ha^{-1}) and treatment (T_4) produced the lowest grain yield (2841.33 kg ha^{-1}), (Fig. 2 and Table 3). Grain yield was significantly reduced under longer irrigation intervals due to lower number of tillers per plant, number of spikes per m^2, number of spikelets per spike, number of grains per spike and 1000-grains weight and these results were in agreement with the Khajanij and Swivedi (1988), who reported that increase of irrigation frequencies can be increased the grain yield of wheat.

Dry matter (g)

The present finding at the sites of faculty farm and the botanical garden locations showed that dry matter accumulation was consistently greater with shorter irrigation intervals (5 days) than the longer ones (11 days), (Fig. 3 and Table 3). This result showed that the increased growth is due to frequent irrigation and decreased growth is with less irrigation frequency. Increasing soil moisture depletion by decreasing the amount of irrigation progressively from ear-emergence to harvest, reduces the straw and grain yields. This was in conformity with the findings of Omer and Aziai (1993), Gajri and Prihar (1983) and Talukder (1985) who reported that water stress at any stage of crop growth and development reduced the dry matter. Wang et al. (2012) also found a significant irrigation effect on straw yield.

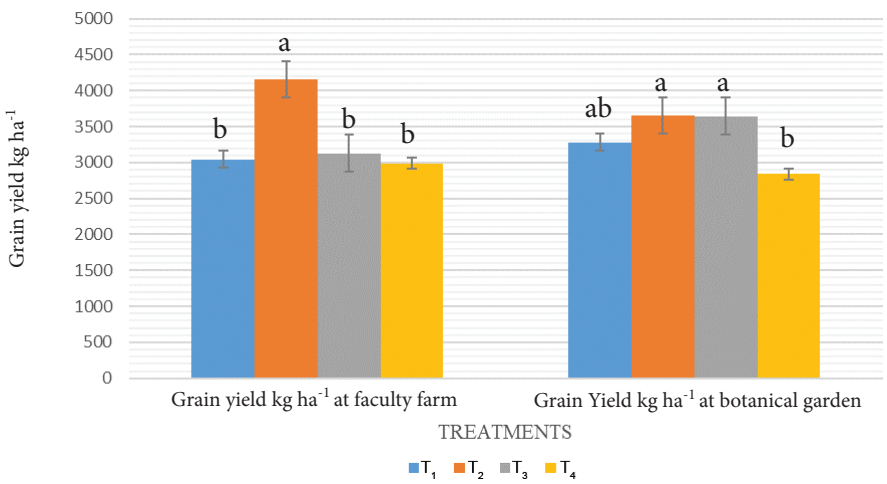

Fig. 2. Effect of different irrigation frequency on grain yield (kg ha^{-1}) at faculty farm location and botanical garden

Table 3. Effect of irrigation frequency on grains per spike and 1000 grain weight (g), grain yield kg ha^{-1} and dry matter gr m^2 of wheat at Faculty farm location and Botanical garden.

	Faculty farm location				Botanical garden location			
Treatments	Spikes m^{-2}	Spikelets per spike	Seeds per spikelet	Spike length (cm)	Spikes m^{-2}	Spikelets per spike	Seeds per spikelet	Spike length (cm)
T_1	43.50_{bc}	34.77_b	3045.67_b	1152.48 a	43.83_b	30.67_b	3282.33_{ab}	1418.89_a
T_2	55.67_a	45.77_a	4160.67_a	1127.78 ab	53.92_a	36.13_a	3658.00_a	1393.33_a
T_3	45.08_b	37.03_b	3127.33_b	969.55 bc	45.08_b	35.57_a	3645.00_a	1185.11_b
T_4	37.00_c	38.43_b	2989.67_b	926.30 c	45.42_b	29.63_b	2841.33_b	1122.22_b
CV (%)	8.41	7.33	9.82	8.57	4.45	5.13	7.82	6.98
SE	3.11	2.33	267.11	73.07	1.71	1.38	214.30	72.91
LSD	7.61	5.70	653.59	178.79	4.18	3.38	524.37	178.41

Means followed by the same letter in each column are not significantly different according to (LSD) test
T_1=irrigation every 5 days, T_2 = irrigation every 7 days, T_3=irrigation every 9 days and T_4=irrigation every 11 days

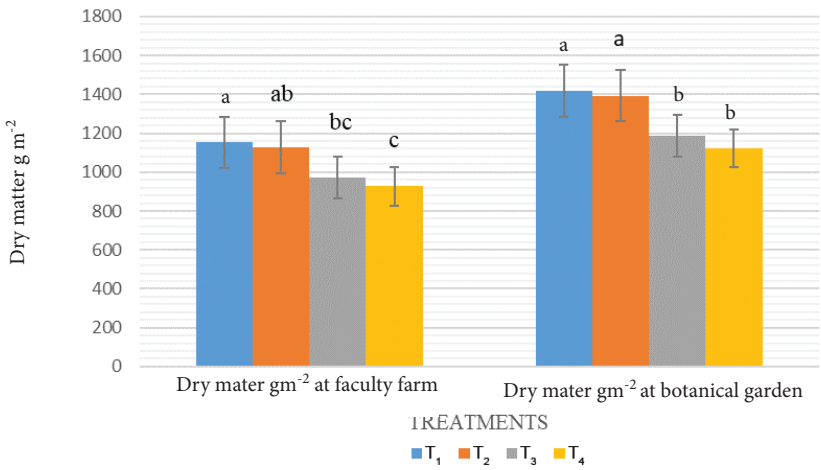

Fig. 3. Effect of different irrigation frequency on dry matter (g per m^2) at faculty farm location and botanical garden

CONCLUSION

Among the studied morphological and yield attributing characters, the lowest result was obtained by treatment 4 such as shortest plant height, minimum tillers, minimum grains per spike, shortest spike, lowest weight of 1000-seed, the lowest yield of grain and dry matter. From the aforementioned result, it is clear that irrigation frequency the whole morphological, growth and yield attributing traits where the treatment (T_2) (irrigation interval 7 days) performs better over other irrigation treatments. So, at seven days' irrigation interval it is infored that treatment (T_2) would be the most advantageous irrigation intervals for spring wheat production under the studied region.

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Organic amendments on soil nutrient balance under mid hills of Meghalaya

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ABSTRACT

To assess the soil nutrient balance under different organic sources, an experiment was conducted during 2018-19 at the experimental farm, College of Agriculture, Kyrdemkullai, Meghalaya. The treatments were in the combination of priming, mulching and manuring. FYM (Farmyard manure), pig manure, poultry manure and maize stover mulch were used as organic inputs. Seed priming was done with liquid washes of manures and water as control. The apparent N and P balance was estimated and was observed that the apparent N balance i.e. N build up at 0-15 cm was higher under T_9 (66.45 kg ha^{-1}) followed by T_8 (61.95 kg ha^{-1}) and at 15-30 cm T_9 (62.23 kg ha^{-1}) followed by T_8 (55.63 kg ha^{-1}). In P balance, the P loss was found under T_{10} (3.51 and 2.25 kg ha^{-1} at 0-15 and 15-30 cm respectively). In all the other treatments, there was gain i.e. no loss in P and was higher under T_9 (12.70 kg ha^{-1}) followed by T_3 (11.19 kg ha^{-1}) at 0-15 cm and at 15-30 cm, T_9 (16.47 kg ha^{-1}) and T_8 (16.01 kg ha^{-1}) had the maximum gain in P. The results revealed that poultry manure had the maximum gain in N and P followed by pig manure and FYM along with mulching and may be preferred over others.

Key words: Black gram, mulching, north-eastern India, nutrient balance, organic agriculture, seed priming

INTRODUCTION

Among various pulses, black gram is one of the important pulse crops grown throughout the country. The protein content of black gram is 26%, which is almost three times that of cereals and other minerals and vitamins (Anon., 2006, Khan et al., 2007). It fixes nitrogen (N) an equivalent of 22.10 kg N ha^{-1}, which has been estimated to supplement of 59,000 tonnes of urea annually (Anon., 2006). In North East Hill (NEH) Region, the average productivity of pulses is 848 kg ha^{-1} is higher than the national average, which is 764 kg ha^{-1}. This shows the pulses production potential of NEH, despite the region is deficit of 82% of its pulses requirement (Das et al., 2016). To meet the protein requirement in the daily diet, the plant protein may be emphasized due to its low cost potential. One of the factors of low crop productivity in North East Region is the nutrient content in the soil and its use efficiency. Therefore, an effective nutrient management needs to be developed to increase the crop productivity in a sustainable manner (Thakuria et al., 2009). It demands in crop residues recycling and efficient nutrient management including the different organic sources. Application of inorganic sources of nutrients will not result in a sustainable soil, as it is not a profitable management strategy. Therefore, organic sources might be the right choice to maintain the soil nutrient balance by incorporating organic manures along with crop residues application.

In this study, we presumed that seed priming with manure leachate, incorporation of organic manures along with application of crop residues, will maintain the soil nutrient balance apart from increasing the crop yield. The application of organic manures improves the nitrogen fixation of black gram by releasing some phyto-chemicals, which is beneficial for root nodulation (Anbuselvi and Rebecca, 2013) and also the soil physical constraints can also be alleviated by the application of organic manures, which improves the soil physiochemical properties and increased the soil available nitrogen and potassium (Pal et al., 2017). Mulching had a positive role in maintaining the soil nutrients, besides maintaining soil temperature and physical properties (Shashidar et al., 2009; Sharma et al., 2010; Kumar et al., 2014). However, the evaluation of soil nutrient balance under different organic sources is limited. Blackgram, being a nitrogen fixing legume, the loss or gain in nutrients needs to be estimated. With this view, the present study has been taken up with the objective of assessing apparent soil nutrient balance of nitrogen and phosphorus and with the hypothesis of soil fertility status may be improved by different sources of organic manuring and mulching by enhancing the soil nutrient status.

MATERIALS AND METHODS

A field experiment was conducted at the College of Agriculture, Kyrdemkulai, Ri-bhoi district, Meghalaya with "*Uttara*" black gram variety during April-July, 2018. The red clay loam soil has initial organic carbon and pH of 1.8% and 5.1, respectively. The available nitrogen (N) and phosphorus (P) at 0-15 cm and 15-30 cm were 227.81 and 16.25 kg ha^{-1} and 202.5 and 14.20 kg ha^{-1}, respectively. Manures were incorporated before sowing. The total N, P and K content of FYM, pig manure, poultry manure and maize stover mulch were 0.47, 0.19 and 0.75%, 0.8, 0.57 and 1.3%, 1.8, 0.61 and 1.2% and 0.5, 0.16 and 1.26% respectively. FYM, pig manure, poultry manure and maize stover mulch were applied at the rate of 10 t ha^{-1}, 8 t ha^{-1}, 1.5 t ha^{-1} and 5 t ha^{-1} respectively (Das et al., 2016). Seed priming was done with the three organic manure leachates and water. Leachates were obtained by soaking the manures in water in the ratio of 1: 10 for 24 hours with intermittent soaking (Kanto et al., 2014). Later the slurries were filtered and seeds were soaked overnight in the respective manure leachates. The seeds were shade dried before sowing. Seed rate and spacing was adopted at 25 kg ha^{-1} and 30 × 10 cm respectively. First irrigation was given after sowing and later on it was followed at flowering and pod filling stages, when required. A total of 12 treatments consisted of seed priming (SP), three organic manures and maize stover application along with control was replicated thrice adopting Randomized Block Design (RBD). The treatments were,

i. T_1 - Farm Yard Manure (FYM)
ii. T_2 - FYM + Mulch
iii. T_3 - FYM + SP (FYM W.) + Mulch
iv. T_4 - Pig manure
v. T_5 - Pig manure + Mulch
vi. T_6 - Pig manure + SP (PM W.) + Mulch
vii. T_7 - Poultry manure
viii. T_8 - Poultry manure + Mulch
ix. T_9 - Poultry manure + SP (PoM W.) + Mulch
x. T_{10} - Control
xi. T_{11} - Control + Mulch
xii. T_{12} - Control + SP (Water) + Mulch
xiii. FYM W. - FYM wash
xiv. PM W. - Pig manure wash
xv. PoM W. - Poultry manure wash
xvi. SP - Seed priming

Soil samples were collected after the harvest at 0-15 cm and 15-30 cm depth and were analysed for the evaluation of apparent nutrient balance by using the following formula given in the equation (1), (2), (3) and (4).

Nitrogen (N) build up in post-harvest soil:

Expected N balance = (initial soil N + applied N) – crop N uptake at harvest … (1)

N build up (kg per ha) = Post harvest soil N status – Expected N balance … (2)

Phosphorous (P) loss in post-harvest soil:

Expected P balance = (initial soil P + applied P) – crop P uptake at harvest … (3)

P loss (kg per ha) = Expected P balance - Post harvest soil P status … (4)

Inputs through manures and mulch were only considered. The nutrient balance indicates the apparent loss or gain in N and P in the post-harvest soil to compare the different nutrient management treatments. The data obtained from various studies during investigation were statistically analysed using the technique of analysis of variance for randomized block design. The difference between the treatment means was tested as for their statistical significance with appropriate critical difference (C.D) value at 5% level of significance as explained by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Organic amendments on nodule number

Black gram is nitrogen fixing legume crop and the amount of nitrogen fixation depends on nodule number in the root. Nodule numbers per plant was significantly influenced by the organic amendments in black gram. The probable reason might be due to that higher nutrients supply from organic manure might have increased the root growth and nodule numbers (Kausale et al., 2009). Apart from soil amendments, indigenous population of soil microorganisms also determine the nodulation response of host plant (Javaid, 2009).

Table 1. Effect of organic amendments on nodule numbers per plant

Sl No	Treatments	Number of nodules per plant
1	T_1 - FYM	40.55
2	T_2 - FYM+ Mulch	44.00
3	T_3 - FYM+ SP (FYM L) + Mulch	48.47
4	T_4 - Pig manure	41.85
5	T_5 - Pig manure + Mulch	44.40
6	T_6 - Pig manure + SP (PM L) + Mulch	50.43
7	T_7 - Poultry Manure	55.80
8	T_8 - Poultry Manure + Mulch	61.37
9	T_9 - Poultry Manure + SP (PoM L) + Mulch	66.54
10	T_{10} – Control	30.87
11	T_{11} - Control + Mulch	32.90
12	T_{12} - Control + SP (Water) + Mulch	38.13
	S.E.(m) ±	2.53
	C.D(P=0.05)	7.41

Crop nutrient uptake and expected nutrient balance

The crop nutrient uptake is one of the parameters for analysing the soil nutrient supplying capacity. As it considers the dry matter, it serves as an indicator of nutrient requirement of crop. Also, the crop response to organic manure will vary and it depends on location, soil type and time of application (Sawyer, 2001). Table 2 shows the N and P uptake by black gram under different treatments. Nitrogen uptake by black gram was higher (61.03 kg ha^{-1}) from T_9 (Poultry manure + SP (PoM W) + Mulch) followed by T_6 (59.88 kg ha^{-1}) which is pig manure incorporated along with mulching and priming. It was observed that P uptake by black gram was higher under T_3 (5.41 kg ha^{-1}) and T_9 (5.22 kg ha^{-1}) which are at par. The crop N and P uptake under all the manure incorporated, seed primed and mulch applied were superior over all the control treatments. As the added manures results in increased availability besides acted as source of nutrients. This is probably due to the incorporation of manure into the soil and improves the soil environment. It allows for better root growth in soil and enhances the nutrient uptake, as supported by Kundu et al. (1996). The continued availability and decreased loss of nutrients during decomposition might have enhanced the N uptake and due to the solubility action of organic acids on native and applied phosphorous which might have enabled the higher P uptake (Rao et al., 2013; Amanullah et al., 2006). Priming strengthened the plants and increased the concentration of nutrient and nutrient uptake (Shah et al., 2012). Umair et al. (2011) reported that priming of seeds improved the nutrient uptake when soil moisture and fertility status are favourable. Apart from manuring and priming, mulching is also one of the factors for increased nutrient uptake which is attributed due to availability of utilizable nutrients and beneficial effects of decomposition of organic material. This was in accordance with the findings of Awopegha et al. (2017). Manuring along with mulching not only resulted in availability of nutrients but also in the more efficient use of nutrients from the soil (Mitra and Mandal, 2012). Sharma and Abraham (2010) also revealed that organic manure increased the adsorptive power of soil for phosphate (cations) and nitrate (anions) and were released slowly throughout the crop growing period.

Post-harvest soil available nitrogen and N build up

The post-harvest soil available nitrogen at 0-15 cm was shown in the Table 2 differed significantly among all the treatments, recorded highest in T_6 (269.99 kg ha^{-1}) followed by T5 (267.89 kg ha^{-1}) and T_4 (265.78 kg ha^{-1}). The treatment under control T_{10} and T_{12} recorded the lowest soil available nitrogen of 213.04 kg ha^{-1}. The post-harvest soil available N noticed at 15-30 cm depth in the Table 3 shows that T_5 (263.67 kg ha^{-1}) and T_4 (255.23 kg ha^{-1}) and followed by T_6 (253.12 kg ha^{-1}) and the treatment T_{12} (189.84 kg ha^{-1}) holds the least.

The data in the Table 2 and 3 described the N build up in the soil, calculated from the post-harvest status of N and expected N balance at 0-15 cm and 15-30 cm depth, respectively was found significant. The N build up indicates the apparent gain or loss of N in the soil. N build up, i.e., positive balance of N at 0-15 cm was noticed highest in T_9 (42.32 kg ha^{-1}) followed by T_6 (35.81 kg ha^{-1}) which is at par with T_8 (35.66 kg ha^{-1}) and the least was in T_{10} (13.74 kg ha^{-1}). At 15-30 cm depth, T_9 (57.09 kg ha^{-1}) gained more N followed by T_8 (48.31 kg ha^{-1}) and T_{10} (17.96 kg ha^{-1}), gained the least amount of N.

Results of the study showed that the apparent balance of N build up under poultry manure was greater than pig manure and FYM. From the Fig. 1, It can be seen that N build up was more at 15-30 cm as compared to 0-15 cm. This positive balance might be attributed to the slower decomposition rate of poultry manure which maintained the continued availability of nitrogen in the soil and met the crop demand in spite of depletion of nutrients by the crop (Rayar, 1984). This was in well agreement with the findings of Bouldin (1988) who reported that even after the completion of the crop; mineralization of N could be continued and added to the soil. This higher availability of nutrients also might be attributed

to rate of mineralization of manures, reduction in fixation and complex properties of decomposition of manures (Reddy and Reddy, 1998). The higher mineralization rate of poultry manure was due to low C: N ratio followed by pig manure and FYM, i.e., higher the C: N ratio slower the mineralization rate and this difference influence the nutrient supply from manures. This was supported by Chadwick et al. (2000). Higher nodulation in N gain in manure incorporated treatments was resulted in increased N fixation. Thus, manure incorporation increased the soil available N by mineralization of manure and fixation of N by the crop. This was in relation with the findings of Nimje and Steth (1987).

Table 2. Effect of organic amendments on apparent soil N balance at 0-15 cm

Treatments	Initial soil N + applied N (kg ha^{-1})	Crop N uptake at harvest (kg ha^{-1})	Expected N balance (kg ha^{-1})	Post- harvest soil N status (kg ha^{-1})	N build up (kg ha^{-1})
T_1 - FYM	249.50	50.15	199.34	236.25	36.90
T_2 - FYM+ Mulch	251.75	51.97	199.78	236.25	36.47
T_3 - FYM+ SP (FYM L) + Mulch	251.75	55.87	195.87	236.25	40.37
T_4 - Pig manure	266.50	47.17	219.32	255.23	35.91
T_5 - Pig manure + Mulch	268.75	52.57	216.18	261.56	45.38
T_6 - Pig manure + SP (PM L) + Mulch	268.75	59.88	208.87	255.23	46.36
T_7 - Poultry Manure	229.50	47.42	182.08	227.81	45.73
T_8 - Poultry Manure + Mulch	231.75	52.25	179.49	227.81	48.31
T_9 - Poultry Manure + SP (PoM L) + Mulch	231.75	61.03	170.72	227.81	57.09
T_{10} – Control	202.50	28.50	173.99	191.95	17.96
T_{11} - Control + Mulch	204.75	29.80	174.95	194.06	19.11
T_{12} - Control + SP (Water) + Mulch	204.75	33.68	171.07	191.95	20.88
S.E.(m) ±		2.91	2.91	2.65	3.67
C.D(P=0.05)		8.52	8.52	7.78	10.77

With respect to the control treatment T_{10}, the N build up is only from the N fixation by black gram which was lower. The low N fixation was probably due to the low pH of soil. Nodulation in legumes was restricted when pH of the soil was low. This was supported by Yoshida and Yatazawa (1967). In T_{11} where only application of mulch was done, the N build up is from N fixation by the crop and also from the addition of mulch material which added N in the soil after decomposition. The T_{12} observed greater N build up when compared with T_{10} and T_{11} this might be probably because of seed priming with water which helps in increased nodulation of black gram when compared with non-primed seeds as stated by Umair et al. (2011).

The higher availability of nutrients under T_9 was attributed to the combination of priming, manuring and mulching. N build up was the result of N fixation by black gram, decomposition of residues and mineralization of organic manures. The effect of the interaction of all the three organic amendments was significantly differed with respect to manures. Nitrogen fixation by black gram was enhanced by priming, as it strengthened the root system, increases nodulation and nitrogen fixation. Apart from this, soil nutrient status might have influenced at molecular level and determined the amount of N fixation. This result was in accordance with the findings of Umair et al. (2011). Also, there was a difference in priming treatment in which priming with manure leachates gained more N

build up than hydro-priming. Among the washes, poultry manure wash was found to be more effective than other manure washes as it contains more nutrient and hormones. This helps the plant to uptake more nutrient and strengthened the root system and increased the N fixation. The nutrient uptake might be determined by the amount of nutrient in seed priming. This was in correlation with Shah et al. (2012). Mulching also contributed to the N build up in the soil by the decomposition and deposition of organic matter, as supported by Awopegha et al. (2017) .

Table 3. Effect of organic amendments on apparent soil N balance at 15-30 cm

Treatments	Initial soil N + applied N (kg ha^{-1})	Crop N uptake at harvest (kg ha^{-1})	Expected N balance (kg ha^{-1})	Post- harvest soil N status (kg ha^{-1})	N build up (kg ha^{-1})
T_1 - FYM	274.81	50.15	224.65	246.79	22.14
T_2 - FYM+ Mulch	277.06	51.97	225.09	248.90	23.81
T_3 - FYM+ SP (FYM L) + Mulch	277.06	55.87	221.19	251.01	29.82
T_4 - Pig manure	291.81	47.17	244.63	265.78	21.14
T_5 - Pig manure + Mulch	294.06	52.57	241.49	267.89	26.39
T_6 - Pig manure + SP (PM L) + Mulch	294.06	59.88	234.18	269.99	35.81
T_7 - Poultry Manure	254.81	47.42	207.39	240.46	33.07
T_8 - Poultry Manure + Mulch	257.06	52.25	204.81	240.46	35.66
T_9 - Poultry Manure + SP (PoM L) + Mulch	257.06	61.03	196.03	238.35	42.32
T_{10} – Control	227.81	28.50	199.30	213.04	13.74
T_{11} - Control + Mulch	230.06	29.80	200.26	215.15	14.89
T_{12} - Control + SP (Water) + Mulch	230.06	33.68	196.38	213.04	16.66
S.E.(m) ±		2.91	2.91	1.46	3.12
C.D(P=0.05)		8.52	8.52	2.47	9.16

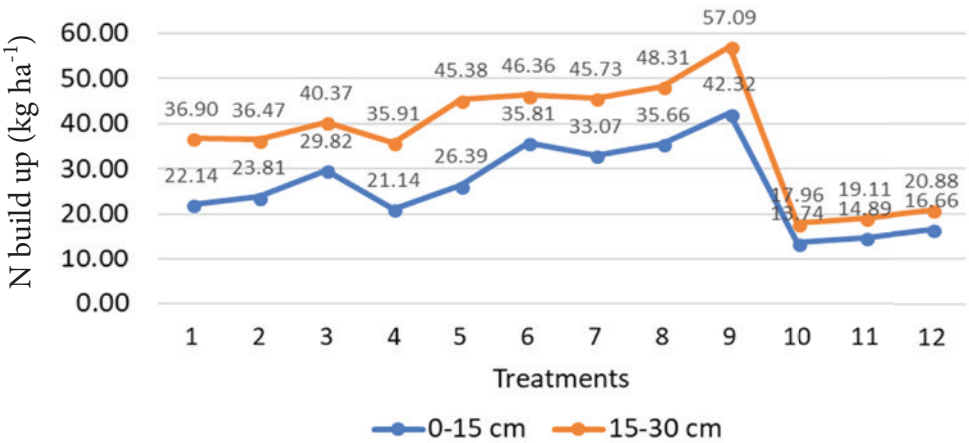

Fig. 1. Comparison of apparent N build up at two different depths in post-harvest soil

Post-harvest soil available phosphorus and P loss

The post-harvest soil available phosphorus at 0-15 cm was shown in the Table 4 differed significantly among all the treatments, recorded the highest in T_6 (69.63 kg ha^{-1}) and T_5 (68.22 kg ha^{-1}) which are at par followed by T_4 (66.29 kg ha^{-1}). The treatment under control recorded the lowest soil available phosphorus of 11.17 kg ha^{-1}. The post-harvest soil available P noticed at 15-30 cm depth was shown in the Table 5 shows that T_6 (69.68 kg ha^{-1}) and T_5 (69.13 kg ha^{-1}) and followed by T_4 (67.76 kg ha^{-1}) and the treatment T_{10} (10.38 kg ha^{-1}) holds the least. The data in the Table 4 and 5 stated the P loss from the soil, calculated from the post-harvest status of P and expected P balance at 0-15 cm and 15-30 cm depth respectively was found significant.

Table 4. Effect of organic amendments on apparent soil P balance at 0-15 cm

Treatments	Initial soil P + applied P (kg ha^{-1})	Crop P uptake at harvest (kg ha^{-1})	Expected P balance (kg ha^{-1})	Post- harvest soil P status (kg ha^{-1})	P loss (kg ha^{-1})
T_1 - FYM	35.25	4.20	31.05	38.74	-7.69
T_2 - FYM+ Mulch	36.15	4.22	31.93	40.80	-8.87
T_3 - FYM+ SP (FYM L) + Mulch	36.15	5.41	30.74	43.14	-12.40
T_4 - Pig manure	61.85	4.25	57.60	66.29	-8.70
T_5 - Pig manure + Mulch	62.75	4.43	58.32	68.22	-9.90
T_6 - Pig manure + SP (PM L) + Mulch	62.75	4.52	58.23	69.63	-11.40
T_7 - Poultry Manure	25.40	4.43	20.97	30.00	-9.03
T_8 - Poultry Manure + Mulch	26.30	4.66	21.64	33.28	-11.64
T_9 - Poultry Manure + SP (PoM L) + Mulch	26.30	5.22	21.08	34.72	-13.64
T_{10} – Control	16.25	2.19	14.06	11.17	2.90
T_{11} - Control + Mulch	17.15	2.50	14.65	14.77	-0.12
T_{12} - Control + SP (Water) + Mulch	17.15	3.11	14.04	14.47	-0.43
S.E.(m) ±		0.38	0.38	0.34	0.54
C.D(P=0.05)		1.11	1.11	1.00	1.58

With respect to P loss, surprisingly there was a gain in P in all the treatments except T_{10} control. The loss in T_{10} was 2.90 kg ha^{-1} at 0-15 cm and 1.63 kg ha^{-1} at 15-30 cm. The gain in P was more under T_9 at 0-15 cm (13.64 kg ha^{-1}) and 15-30 cm (17.41 kg ha^{-1}) followed by T_8. The loss in post-harvest soil available P in control was due to the crop uptake and no addition of any external sources. The role of priming may be negligible because there were no significant results in P status under priming. The increase in P might be in lesser quantity (Gohil et al., 2017). The apparent positive balance of P in mulched treatments was more than the unmulched treatments. The reason might be during the decomposition of organic materials, the production of organic acids reduced the fixation or adsorption of phosphorus by soil or the rate of desorption of phosphate has been increased and it increased the P in soil. This was similar to the report of Othieno (1973) and Nziguheba et al. (1998).

Table 5. Effect of organic amendments on apparent soil P balance at 15-30 cm

Treatments	Initial soil P + applied P (kg ha^{-1})	Crop P uptake at harvest (kg ha^{-1})	Expected P balance (kg ha^{-1})	Post- harvest soil P status (kg ha^{-1})	P loss (kg ha^{-1})
T_1 - FYM	33.20	4.20	29.00	39.83	-10.83
T_2 - FYM+ Mulch	34.10	4.22	29.88	42.32	-12.44
T_3 - FYM+ SP (FYM L) + Mulch	34.10	5.41	28.69	43.14	-14.45
T_4 - Pig manure	59.80	4.25	55.55	67.76	-12.22
T_5 - Pig manure + Mulch	60.70	4.43	56.27	69.13	-12.86
T_6 - Pig manure + SP (PM L) + Mulch	60.70	4.52	56.18	69.68	-13.50
T_7 - Poultry Manure	23.35	4.43	18.92	34.19	-15.27
T_8 - Poultry Manure + Mulch	24.25	4.66	19.59	36.08	-16.49
T_9 - Poultry Manure + SP (PoM L) + Mulch	24.25	5.22	19.03	36.44	-17.41
T_{10} – Control	14.20	2.19	12.01	10.38	1.63
T11 - Control + Mulch	15.10	2.50	12.60	13.86	-1.26
T_{12} - Control + SP (Water) + Mulch	15.10	3.11	11.99	14.08	-2.08
S.E.(m) ±		0.38	0.38	0.54	0.68
C.D(P=0.05)		1.11	1.11	1.58	1.98

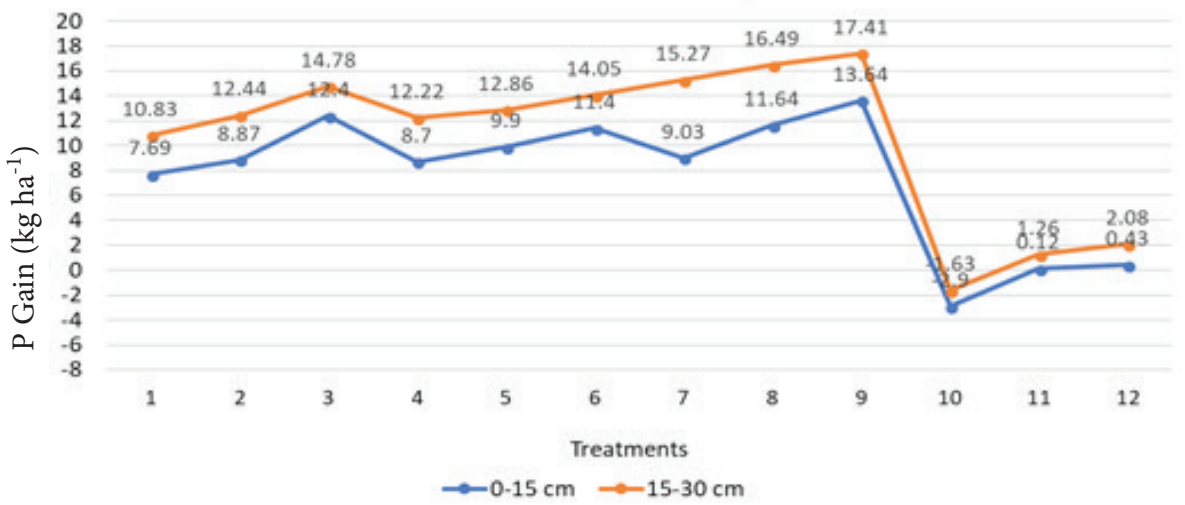

Fig. 2. Comparison of apparent P balance at two different depths under different treatments

The study showed that there was no loss in phosphorus and the positive balance of phosphorus i.e. gain in P was noticed higher under poultry manure incorporated treatments followed by pig manure and FYM. Fig. 2 shows that the apparent P balance was found to be higher at 15-30 cm, as compared to 0-15 cm. This might be due to the supremacy of poultry manure as it can supply soluble nutrients for longer period of time by not allowing the entire nutrients into soil solution, thereby reducing the precipitation and fixation of phosphorus. The release of hydroxyl ions from the organic acid production during decomposition acted as chelates and also stabilized the insoluble native P and made available for longer period of time by mobilizing the native P. Similar results were

observed by Sangeetha (2013) and Pazhanivelan et al. (2006). The rate of mineralization was determined by C: P ratio of the organic manures which was in the descending order of FYM, pig manure and poultry manure. The result was in accordance with Pal et al. (2018).

CONCLUSION

The apparent N and P balance was estimated to assess the influence of organic amendments on soil nutrient status. It was observed that the apparent N balance, i.e., gain in N, N build up at 0-15 cm was higher under T_9 followed by T_8 and at 15-30 cm T_9 followed by T_8. In P balance, the P loss was found under T_{10}. In all the other treatments there was gain i.e. no loss in P and was higher under T_9 followed by T_3 at 0-15 cm and at 15-30 cm, T_9 and T_8 had the maximum gain in P. It may be concluded that organic amendments improved the crop growth by increasing the nutrient uptake and soil available nutrients were increased by maintaining the apparent nutrient balance. The study showed that poultry manure had the maximum gain in N and P followed by pig manure and FYM along with mulching. Therefore, poultry manure may be preferred over the other treatments.

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Socio-economic factors affecting the role of women in family poultry production: A case study at Paghman district, Kabul province, Afghanistan

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ABSTRACT

Although several studies have been carried out globally on the factors influencing the marketable eggs of women chicken farmers (WCFs), the studies in Afghanistan remain scarce. Therefore, this study was carried out to ascertain the main socioeconomic factors affecting their level of weekly eggs sold to the market (WESM). For accomplishment of this study, secondary and primary data were utilized. For data collection, two field surveys were conducted in 2015 and 2016, and interviews were made with 120 WCFs using semi-structured questionnaires. Descriptive statistics and multiple linear regression techniques were applied to determine the relationship between dependent and independent variables. The sociodemographic results of the study revealed that 90% of the households were male-headed with no formal education (90.8%). Their flock size ranged from a maximum number of 50 to a minimum of 3 birds with an average number of 26. Their WESM varied from 5-280, with a mean of 117 eggs per week. The econometric results of the study illustrated that F-value for the model is 49.803 and significant at 1% significance level. R^2 Value of the model was equal to 0.820 and adjusted R^2 = 0.804. However, the relationship among WESM and the independent dummy variables of land access (r = 0.033), project membership (0.014), poultry experience (1-3 years) (0.022), and age (less than 30 years) (0.024) were positive and insignificant. On the contrary, model showed negative coefficient signs for the other insignificant variables family jobholders (r = - 0.011), married (r = - 0.042), and illiteracy (r = - 0.030). Regression analysis of the dataset ultimately revealed that 3 independent variables viz: flock size (r = 0.013), family size (r = -0.024), and feeding cost (r = 0.001) out of ten were significantly correlated with WESM at 1% level of confidence.

Key words: Kabul province, marketable eggs, Paghman district, socio-economic factors, women chicken farmer

INTRODUCTION

Family poultry production (FPP) is considered to be crucial for many rural households in the third world countries. It makes essential contribution to eradication of poverty, securing food and women empowerment in many countries. Indigenous breeds of chickens still contribute enormously to meat and egg production and consumption in developing countries. According to Pym (2006), family poultry makes up to 80% of poultry stocks in low-income countries. Similarly, the role of FPP as an integral sub-sector of livestock has been important in the

rural economy of Afghanistan. The importance of FPP to rural people is not hidden among scholars due to its high nutritional value (particularly in terms of animal protein), easy adaptation, little investment requirements, and rapid economic return. As FPP is important for the rural population across the country, Ministry of Agriculture, Irrigation and Livestock (MAIL) of Afghanistan, in parallel with global strategy for poverty alleviation, women empowerment, food security and improvement of rural livelihoods, has designed and implemented a number of gender sensitive small-scale poultry production projects.

Globally, several studies on rural-based poultry and women have already been carried out. For instance, Czech et al. (2005) attempted to study the case of Indian backyard poultry. Similarly, the case of Pakistan by Shafiq (2008), the case of Nigeria by Garba et al. (2013), Oladunni and Fatuase (2014), and Guary et al. (2015) were already been studied. However, in Afghanistan, a meager of researches attempted to study gender issues. For instance, Nessar (1999) concentrated on principles of raising small-scale practical-based poultry. His study, somehow, focused on feeding, breeding, disease and technical principles of poultry. Also, attention was given by FAO (2015) to highlight the participation of Afghan women in raising cattle, sheep and goat.

In spite of massive investments on family poultry, this small-scale business not only experiences remarkable fluctuations but, official figures show that the total number of indigenous chickens has significantly decreased by about 3 million from 2005 to 2013 (FAO, 2016). It is assumed that a number of socioeconomic factors affect the level of FPP. However, internationally several studies have been carried out to statistically identify the major socioeconomic factors affecting FPP, while studies with respect to Afghanistan remain scarce. Therefore, attention was given to ascertain the main socioeconomic factors affecting the level of WESM by WCFs in the study area.

MATERIALS AND METHODS

For accomplishment of this study, secondary and primary data were utilized. Secondary data were accumulated through reviewing both published and unpublished relevant literature. The main sources of secondary data were books, journals papers, research papers and articles, and national and international reports. For collection of primary data, two field surveys were conducted using qualitative and quantitative methods. A brief description of both surveys however is given below.

The reconnaissance survey based on a qualitative method was conducted during August to September 2015. Within the first field survey, aside from interviewing poultry producers, a number of marketing agents were also interviewed in order to obtain a general information of poultry production situation in the country. In addition, for conducting the first field survey (reconnaissance) two types of semi-structured questionnaires were developed. The first type was purposefully administered to a number of professors, researchers, and national and international agricultural development specialists, particularly those were concerned with the subjects of women in poultry. The main objectives were to, in one side, broaden our knowledge and to understand their perspectives with regard to gender relations in livestock and poultry, and on the other side to obtain local available information on poultry circumstances which were unavailable in public sphere. To sum up, during the first field survey, aside from semi-structured questionnaire technique, field observation and notes were other data collection techniques from the study area. The reconnaissance survey indeed paved the way and enabled us for conducting the second field survey.

The second field survey which makes the core of this study in terms of primary data, was carried out in Paghman district from April-May 2016. During this field survey, mainly a quantitative method of data collection was employed. Also, a multi-stage sampling technique was applied in order to select target farmers. Then, face to face interviews were made with 120 women poultry raisers using semi-structured questionnaires. Based on the reconnaissance (field) survey which was conducted in August to September 2015, Paghman district was purposefully selected to be the main site for this study. As the district was targeted by

Improved Backyard Poultry Production (IBPP) of Ministry of Agriculture, Irrigation and Livestock (MAIL), and agricultural and livestock activities form one of the main income generation sources of the people, it was a suitable area for primary data collection. In addition, as insecurity is a big concern in Afghanistan, a relative security status of the district, encouraged us for selecting it as our study site.

Ethical consideration and consent

The identity of the researcher and the purpose of the study were expressed to the stakeholders, local officials, and interviewees. Then, official permission was given for site entry and data acquisition. Based on the commitment we made, the data collected will be confidentially used only for this study, and will not be shared with the third parties.

Limitation

It is important to mention that the study area was unknown for the researcher, and as a norm it was tough to interview rural women for data acquisition. However, due to MAIL official permit, and coordination of the project personnel between the researcher and the villagers, it was possible to complete the interview survey.

Selection of the sample size

Daniel et al. (2009) suggested that the minimum appropriate sample size for conducting factor analysis studies include 3 to 20 times more than the number of variables and absolute ranges from 100 to over 1000. Similar studies were also undertaken by Arshad et al. (2013). The authors too herein followed the above concept and similar studies.

Selection of the villages and respondents

Based on the statement of project staff, 420 households in 34 villages were targeted by IBPP across Paghman district. The sample size was mainly planned based on the similar studies mentioned previously. As the total capacity of our sample size on a pre-planned basis was interviewing 120 WCFs consisted of equal numbers of IBPP and non-IBPP beneficiaries, therefore, we were supposed to choose only 12 villages. Among all, 12 villages were randomly selected, in order to reduce bias. The selected villages included Quli Baba Noor, Qalai Malik, Saia Bagh, Qalai Adih, Qalai Mirdad, Qalai Aghir khan, Esakhil, Qalai Saqi, Miakhil, Doda Mast, Tati, and Pushta Bala. Based on the project list from each 12 chosen villages, 10 women poultry keepers were selected using simple random sampling technique. Then, face to face interviews were made with the selected poultry keepers using semi-structured questionnaires.

RESULTS AND DISCUSSION

Socio-economic characteristics of WCFs: The socio-demographic analysis (as showed in Table 1) of the study revealed that a vast majority of 72.5% of the respondents lies between the age group of 31-50 years. According to NRVA (2011-12), Ike and Ugwumba (2011), and Jatto (2012) arguments, they are still considered to be in their most productive age range for poultry and farming production purposes. Also based on the argument of Adisa and Akinunmi (2012), one can say that majority of the WCFs in the study area are in a virile age bracket for active participation in overall poultry operations. As Jatto (2012) previously stated, another implication is that as superiority of the farmers is young, therefore they are still in a certain age group that are likely to adopt new technologies or innovations.

Results shown that most of (82.5%) the WCFs were married. This agrees with CSO (2013) report that a vast majority of women in Paghman district are married. Also it confirms the result of Jatto (2012) that married farmers with larger family sizes are feeling responsible and are likely to have some experiences of life. Women in general and married women in particular, aside from bearing child and houseworks, are strongly willing to take part in an economic activity to contribute to food security of their households.

The results also showed that nearly 13% of WCFs were widows whereas only around 4% were singles. This means that a number of WCFs experienced death of their husbands due to several decades of wars (1978-2001) in the country. Based

on the observation, they seemed to be highly interested in FPP to feed the family members and to generate income to purchase basic needs of life. Single women and girls who were within the age group of 30 or less than 30 years old, due to limited poultry experiences and small family sizes, were considered to be less likely to practice FPP. Majority (77.5%) of the WCFs' households were headed by male, while nearly a quarter of the families were headed by female. The implication is that, in a patriarchal society, male in major socioeconomic aspects dominates female.

Based on the study results, a vast majority (90.8%) of the respondents were with no formal education, while shares of the farmers with primary (6.7%) and secondary education (2.5%) were much less. However, perhaps the main reason behind the higher illiteracy rate (90%) of the interviewees can be age above 31years and being war generation who have suffered 3 decades of civil wars in the country. The willingness to raise poultry among the illiterate women was superbly strong as they due to lack of competency and skills seemed to be unable to benefit from full or part-time formal job opportunities. Education is considered to be fundamentally important for women empowerment and rural development. Meanwhile, schooling seems to be one of the crucial variables in achieving economic growth, agricultural development and human progress. Also according to FAO (2007) education is widely recognized as one of the key dimensions of the development. That is because Millennium Development Goal 2 (MDG) is directly associated with it.

The result also revealed that majority (64.1%) of the farmers had family size of 6-10 members. Rural households in the study area tend to have larger family sizes, as more than 90% of the farmers had a family size of greater than 6 people. The sociodemographic results further indicated that the family size of WCFs ranged from the minimum of 4 persons to a maximum of 17. The average household size of the respondents was 8.7. The data clearly illustrated that WCFs with larger family sizes, in order to contribute to fulfillment of nutritional requirements of their families, turn to FPP.

With respect to poultry experience of WCFs, the results revealed that nearly 46% of the farmers had poultry experience of 1-3 years. The implication is that, since IBBP was implemented from late 2013 in the study area, they might have started involving in FPP earlier. However, considering the poultry experience, WCFs were then distributed to nearly 18%, around 20%, and 16% with 1-6 years, 7-9 years, and 10 years and over respectively. Based on the results, majority (67%) of the WCFs had no access to agricultural land. The implication is that, as poultry activity can be practiced even in a limited space, poor rural households with no arable land often tend to engage in FPP. Perhaps the main reason that a vast majority of women are landless in the study area can be the topographic structure of the district. However, the results further indicated that 23% and 10% of the WCFs had access to one or less than one Jerib1, and 2-3 Jeribs of land respectively. Farmers with larger piece of land turn to alternative agricultural activities including cattle and sheep raising, rather than involvement in FPP only. The flock size of WCFs ranged from 50 to a minimum of 3 birds with an average number of 26. Their WESM varied from 5-280, with a mean number of 117 eggs per week. On an average the number of eggs laid by each layer chicken reached to nearly 4 eggs per week.

ECONOMETRIC RESULTS

Prior to the econometric analysis of data, attention was given to check a number of the potential assumptions with the multiple regression model. However, no serious multi-collinearity and auto correlation problems were found with the predicted independent variables. Breusch Pagan Godfrey test was applied to detect the problem of heteroscedasticity. Since α (p-value) was equal to 0.011 which is below the threshold of significance level of 0.05 it indicated that the model is heteroscedastic. Hence, to overcome the problem of heteroscedasticity in our data and to make it statistically robust, logarithmic transformation technique ($\log Y_i = \alpha + \beta_i x_i + \epsilon_i$) was applied for WESM.

Table 1. Socio-economic characteristics of the women poultry keepers, N=120

Sl. No.	Variables	Frequency	Per cent (%)	Cumulative percentage
1.	Age			
	Less than 30	19	15.8	15.8
	31-40	49	40.8	56.7
	41-50	38	31.7	88.3
	More than 51	14	11.7	100
2.	Marital status			
	Single	5	4.2	4.2
	Married	99	82.5	86.7
	Widow	16	13.3	100.0
3.	Family head			
	Male	93	77.5	77.5
	Female	27	22.5	100.0
4.	Education level			
	No formal education	109	90.8	90.8
	Primary education	8	6.7	97.5
	Secondary education	3	2.5	100.0
	Higher education	0	0	100.0
5.	Family size			
	1-5	11	9.2	9.2
	6-10	77	64.1	73.3
	11-15	28	23.4	96.7
	16 and over	4	3.4	100.0
6.	Family jobholders			
	1 job holder	16	13.3	13.3
	2 jobholders	92	76.7	90.0
	3 jobholders	10	8.3	98.3
	4 jobholders	2	1.7	100
7.	Poultry experience			
	1-3 years	55	45.8	45.8
	4-6 years	21	17.5	63.3
	7-9 year	24	20.0	83.3
	10 years and over	20	16.7	100
8.	Land access			
	Landless	80	66.6	67
	1 [1]Jerib or less	27	22.5	89.16
	2-3 Jeribs	12	10	100.0
	4 Jeribs and over	0	0	100.0

[1]Jerib is a traditional unit of land measurement in Afghanistan where [1]Jerib equals to 2000 m^2

The F-value for the model after correcting the heteroscedasticity was 49.803 and significant at 1% significance level. This indicated that the model fit is good. R^2 Value of the model was equal to 0.820, Adjusted R^2 = 0.804. This result indicated that about 80.4% of the variability in WESM by WCFs was attributed to the hypothesized variables.

Regression analysis of the dataset revealed that 3 independent variables viz: flock size (r = 0.013), family size (r = -0.024), and feeding cost (r = 0.001) out of ten were significantly correlated with WESM at 1% level of confidence. Regression findings of the study indicated that family size, as hypothesized, significantly but inversely is correlated with WESM. In other word, one unit increase in family size, keeping the other factors constant, decreases WESM by nearly 2.5%. It is logical that as the household size becomes larger, the chance for consumption of eggs to fulfill their protein requirements within the family increases, and therefore, WESM decreases. It makes sense that larger family size in the rural areas consumes a part of the produced eggs and consequently limits the chance for WCFs to supply surplus eggs to the market.

Table 2. OLS estimation of factors affecting the dependent variable weekly eggs sold to the market in the study area, after correction of heteroscedasticity

Variables	Coefficients	Standard error	t-value	Sig.
Constant	1.633	0.104	15.678	0.000**
Family size	-0.024	0.006	-3.751	0.000**
Family jobholders	-0.011	0.032	-0.356	0.722
Flock size	0.013	0.002	5.576	0.000**
Feeding cost	0.001	0.000	4.938	0.000**
Land access	0.033	0.031	1.037	0.302
Pro. membership	0.014	0.030	0.470	0.639
Age	0.024	0.031	0.765	0.446
Married	-0.042	0.048	-0.878	0.382
Education	-0.030	0.038	-0.798	0.427
Poultry Exp	0.022	0.052	0.430	0.668

** Significant at 1% level of significance; F= 49.803, R^2=0.820, Adj R= 0.804, N=120

Flock size, as predicted, had a positive and significant relationship with WESM. The results predicted that one additional unit in flock size, keeping the other factors fixed, increases WESM nearly by 1.5%. The implication is that the larger the flock size, as the more the level of production and increased WESM. This result therefore, is supported by Kawsar et al. (2013) that the flock size has a significant correlation with poultry production. The findings disagree with Adisa and Akinkunmi (2012) that flock size has no significant relationship with the participation of women in poultry activities. It makes sense that as the flock size enlarges, WCFs find the chance to supply additional quantity of eggs to the market to get more income. In other words, it is suggested (by this study) that income generation can be a good incentive to encourage rural women to be involved in FPP activities.

Result of the study then indicated that the continuous variable of feeding cost has a positive and statistically significant correlation with WESM. It implies that a unit increase in feeding cost, keeping the other factors constant, would contribute to an increase of WESM by 0.1%.

Though, the coefficient 0.001 seems to be a small value, but since it refers to the total number of WESM, it becomes a greater number. The result corroborates with the work of Akter et al. (2015). However, the relationship among WESM and the independent dummy variables of land access (r = 0.033), project membership (0.014), poultry experience (1-3 years) (0.022), and age (less than 30 years) (0.024) were positive and insignificant. On the contrary, model showed negative coefficient signs for the other insignificant variables family jobholders (r = - 0.011), married (r = - 0.042), and illiteracy (r = - 0.030).

Also the survey results disclosed the main constraints that WCFS were struggling with. Their challenges included burden of unpaid houseworks, plurality of children, lack of educational and technical knowledge, poor infrastructures, unavailability of credit and formal loans, weak market competitiveness and unfamiliarity with cooperatives or poultry unions. Also chicken mortality, chicken eggs eating, diseases outbreaks, unavailability of veterinary clinics, high cost and low quality of poultry feeding, summer and winter poultry care, and after all poor farm management skills were a number of limiting factors for WCFs in the study area.

CONCLUSION

FPP is known to be crucial for strengthening rural economy and gender equality in Afghanistan. It was found that even though the productivity level of FPP is low, it plays an essential role in food security, income generation, and women empowerment in the study site. This small-scale business is mainly owned and run by married and poor rural women particularly who are landless, illiterate, and with larger family sizes. In addition, FPP is considered to be a culturally acceptable practice for women segment in the study area. Accessibility and willingness to participate in poultry practice among female farmers were strong, and the opportunities such as family support and high demand in market were available. Since majority of WCFs were in their most active economic age period, requisite encouragements by practitioners through family poultry channel can accelerate livelihood and the socioeconomic empowerment of women in the study site and rural areas in Afghanistan.

RECOMMENDATION

Based on the results, the following main recommendations are drawn up towards strengthening FPP and women empowerment in the study area:

1. Considering the econometric results, the variable flock size, family size, and feeding cost were significantly correlated with WESM. Therefore, government supportive policies in the areas of poultry input and output, and provision of credit services are strongly recommended. However those policies must empower women to in one side increase their market competitiveness, and on the other side to maintain the cost and quality of poultry input and outputs in the free market as well.

2. Since the variable family size was significant but inversely correlated with WESM, government supports in the areas of credit and extension services, provision of day old chicks (DOCs), medication, and other poultry inputs at a lower price, can help farmers to in one hand increase their accessibility to food security through expanding their production level, and on the other hand to enlarge their amount of WESM and poultry income generation.

3. Most importantly since a vast majority of WCFs were illiterate or with lower level of formal education, it is strongly recommended to provide educational services to improve FPP and women empowerment in the study area.

4. As social stigma and barriers were critical challenges that socioeconomically exclude and marginalize women from a commercial based poultry activity, therefore, policy makers, should initiate ways to bring these enterprising women to the mainstream to contribute significantly to the Animal Husbandry sector.

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Impact of fly ash on germination and initial seedling growth of vegetable hummingbird [*Sesbania grandiflora* (L.) Poiret]

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ABSTRACT

Impact of fly ash (FA) was studied on germination and initial seedling growth performance of *Sesbania grandiflora* during 2016-2017. Growing media was prepared by admixing FA to forest soil (S) at five concentrations (%) 20, 40, 60, 80 and 100 (w/w). The experimental design was CRD with six treatments and three replications. Freshly collected seeds were washed with cold water and sown at 2.0-3.0 cm depth in germination trays filled with media of different treatments. Significant ($P<0.05$) variation in germination period, rate, capacity and index with respect to FA concentration in media was observed (n=100). Maximum rate (86.67%) and index (2.04) were found in media having 20% FA after 30 days of sowing. After 90 days of transplanting significant difference ($P>0.05$) in seedling survival rate, plant height, diameter growth, nodules per plant and seedling quality index were observed. The survival rate (91.57%), plant height (62.07 cm) and root nodule number was (31.67) and seedling quality index (0.66) were maximum at 40% FA. It is concluded form the present investigation that FA can be admixed @ 20% (w/w) in forest nurseries for improving germination and @40% (w/w) for promoting seedling growth and quality improvement.

Key words: Forest nursery, fly ash added substrate, germination catalyst, pollution control

INTRODUCTION

Coal fired thermal power plants have been the backbone of power supply in India. Lignite is the prime grade used in these power plants which generates about 30-45% ash as compared to imported high quality coal which has low ash content in the order of 10-15%. Thus, huge quantities of fly ash (FA) are being produced at thermal power stations requiring large area of precious land for proper disposal. India ranks fourth in the world in the production of coal ash as by-product waste after USSR, USA and China, in that order (Kishor et al., 2010; Senapati, 2011). About 196.44 million tons of Fly ash is being generated from 167 thermal power stations, during the year 2017-18. Tough there is a stringent government regulation for cent percent utilization of FA, only 67.13% have been utilized (CEA, 2018).

FA is ultrafine in nature and contains a number of toxic metals such as arsenic (As), barium (Ba), mercury (Hg), chromium (Cr), nickel (Ni), vanadium (V), lead (Pb), zinc (Zn) depending upon the source of coal (Dwivedi and Jain 2014). Thus, proper disposal and management of such a huge quantity of FA possessing potential threats of air and water soil pollution is a great challenge (Rawat et al., 2018). Utilization of FA for a particular purpose depends up on its elemental content which is primarily controlled by type of coal and its source. FA is being used in manufacturing cement, concrete, bricks, wood substitute products, in road construction, wasteland reclamation, filling of

underground mine spoils etc. (Kaur and Goyal, 2015). In India major sectors include construction of roads and embankments, production of cement, mine-filling, reclamation of low-lying areas, making bricks and tiles (Environment Annual Reports, 2014-15).

Various studies indicate that, there is scope for utilization of FA in agriculture and forestry sector. Indian FA is having low bulk density, high water holding capacity and porosity, rich silt-sized particles, alkaline nature, negligible solubility, and reasonable plant nutrients. FA contains almost all the plant nutrients except nitrogen, phosphorous and humus, which can be supplemented by organic matter (Sharma and Karla, 2006). Many researchers have explored its potential use in agriculture. Beneficial effects of FA on plant nutrition have been studied and it was found beneficial for growth of many plants. Crop plants of the families *Brassicaceae, Chenopodiaceae, Fabiaceae, Leguminoceae* and *Poaceae* are most tolerant to FA toxicity (Cheung et al., 2000). Still then a large quantity of FA is being dumped in ash ponds and lagoons. Some of the FA contains deadliest toxic metals like arsenic, mercury, cadmium, chromium and selenium. These toxic metals along with other toxicants can cause cancer and neurological damages in humans. They can also harm and kill wildlife, especially fish and other water-dwelling species (Ahmad et al., 2014). The current status of utilization of FA in India is only 60-70% (CEA, 2018), providing a wide scope for searching new avenues.

One of the most potential areas of utilization is in forestry sector where it can be consumed either in nursery or for tree plantation activities. This will help in locking the toxic heavy metals in the wood biomass for longer period of time. FA as planting material in forest nursery is not a new concept. Goyal et al. (2002) reported its use in nursery as growing media but commercial use is scanty or absent. Hence attempt is made to know its impact on seed germination and growth of seedlings at early stages. *Sesbania grandiflora* (Fabaceae) was selected because of its nitrogen fixing ability and multiplicity of products. The plant is valued for medicine, food, fibre, gum, fuel wood, soil improvement and ornamental plantation. It is an ideal species for rehabilitating eroded soils, degraded waste land and mine spoils (Karmakar et al., 2016). Sesbania species is tolerant to metal toxicity and used to remediate lead, zinc, copper and chromium polluted soils (Chan et al., 2015).

MATERIALS AND METHODS

The experiment was conducted in College of Forestry, Odisha University of Agriculture and Technology, Bhubaneswar situated at 20° 15' N latitude and 85° 52' E longitude with altitude 25.9 m amsl. Fly ash (FA) was collected from one of the silages of Indian Metals and Ferro Alloys (IMFA) Limited, Choudwar, Cuttack (Odisha). The mean monthly temperature, relative humidity and rainfall of the experimental site given in Fig.1.

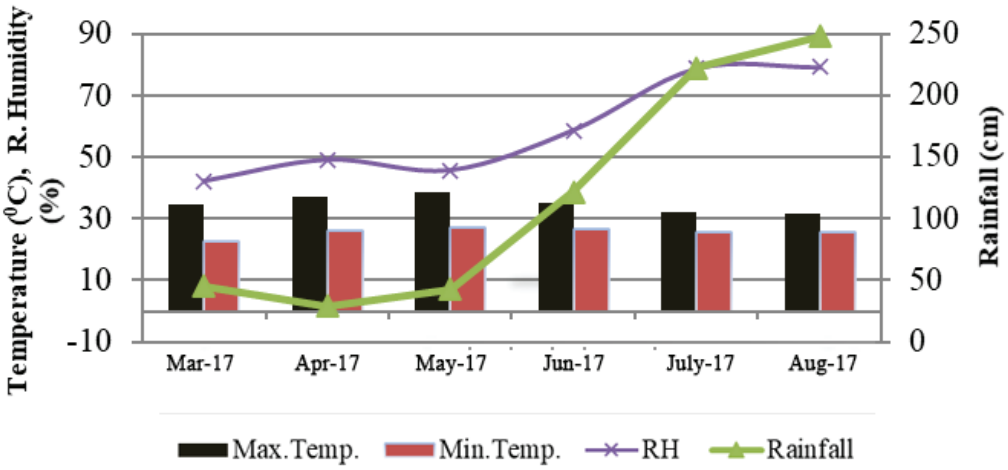

Fig. 1. Climatic parameters of the experimental site

Growing media preparation and analysis for physicochemical properties

Growing media was prepared by mixing FA to forest soil (S) at concentrations (%) 20, 40, 60, 80 and 100 weight by weight. There were six treatments (T_1-20% FA+S, T_2-40% FA+S, T_3-60% FA+S, T_4-80% FA+S, T_5-100% FA) including control (T_6-S). The growing media was analysed for physical and chemical properties. Bulk density (BD) and water holding capacity (WHC) was determined by using the protocol given by Piper (1966). pH and electrical conductivity (EC) were measured following protocol given by Jackson (1967), organic carbon (OC) was estimated as per Walkley and Black (1934). Available nitrogen, phosphorus and ammonium acetate extractable potassium were estimated as per the procedure given by Subbiah and Asija (1956), Olsen et al. (1954) and Merwin and Peech (1951) respectively. The physical and chemical properties of growing media are given in Table 1.

Table 1. Physicochemical properties of fly ash, forest soil and fly ash substratum

Property	Forest soil (S)	Fly ash (FA)	FA substrate (Forest soil + FA % (w w^{-1})			
			S+ 20% FA	S + 40% FA	S + 60% FA	S+ 80% FA
pH		8.12	7.06	7.26	7.39	7.65
EC(dS m^{-1})	6.41	0.68	0.62	0.93	1.11	1.28
N (kg ha^{-1})	0.21	0.002	106.15	92.67	79.17	37.50
P (kg ha^{-1})	125.50	6.70	48.23	33.59	18.91	14.69
K (kg ha^{-1})	56.13	146.43	496.41	506.12	539.53	613.15
OC (%)	474.36	0.005	0.519	0.464	0.382	0.261
BD(g cm^{-3})	0.570	0.69	1.38	1.21	0.95	0.76
Pore space (%)	1.48	49.52	43.2	44.4	46.25	49.35
WHC (%)	32.8	58.2	43.25	45.84	48.72	54.33

Values are mean (N=Arithmetic mean); FA- Fly ash; FS- Forest soil, EC- Electrical conductivity, NPK- Available nitrogen, phosphorous and potash, OC- Organic carbon, BD- Bulk density, WHC- Water holding capacity.

Seed treatment and sowing

Germination study

Freshly collected seeds were gently scrapped in sand paper and soaked in cold water for 24 hours prior to sowing (Shafiq et al., 2019). Eighteen germination trays having dimension 90 cm (L) × 45 cm (B) × 15 cm (H) were filled with above six mentioned growing media to the brim leaving 3.0 cm. Hundred seeds per replication (totalling 300 seeds per treatment) were sown at 2.0-3.0 cm depth, covered with paddy straw and kept at open nursery condition. Regular watering was made as per the requirement. Observations pertaining to germination parameters were recorded daily up to 30 days after sowing. Germination period was determined by observing the day taken for first germination (DTFG) to 30th day when about 80-85% seeds have germinated. Based on the number of seeds germinated the following parameters were calculated as per the standards given by Czabatore (1962) and AOSA (1983).

Germination percentage = (Number of seeds germinated) / (Number of seeds sown) × 100

Germination capacity = (Total seeds germinated + viable seeds) / (Total No of seeds sown in all replications) × 100

Germination Value = PV × MDG

Where, PV = Peak value of Germination

MDG = Mean daily Germination

Germination Index = (No.of germinated seeds) / (Days of first count) + Σ of no.of germinated seeds / (Days of final count)

Seedling growth study

After completion of germination study, seedlings were transplanted into poly pots (22.86 × 12.7 cm) containing growing media of above mentioned treatment combinations. Growth parameters such as shoot length, collar diameter and number of leaves were assessed monthly after 30 days of transplanting for 3 months. Total shoot length was measured by using ruler (taken from the apical bud of the plant to the base of the shoot) and stem diameter by using electronic digital calliper (6"/150 mm, accuracy ± 0.01 mm, Mitutoyo- CD-6″ASX: 500-196-30).

For recording the quantitative parameters pertaining to root growth, the entire seedling was dipped in a bucket of water at 90 days to remove adhering soil from it. It was then carefully washed so that no damage was made to root system. Length of roots (starting from collar region to the end point) and number of root nodules were recorded. Thoroughly washed seedlings (without damage to root and shoot) were dried under sun for 30 minutes. The shoot was cut from the collar portion and weighed. Then the root and shoot samples were put in paper bags separately and were oven dried at 80°C until constant weight observed. Growth observation was based on 45 numbers of randomly selected plants from each treatment. The seedling quality index (SQI) was calculated by using the formula as described by Dickson et al. (1960).

SQI = Seedling dry wt. (g)/[Height (cm)/Diameter (mm) + Shoot dry wt. (g)/Root dry wt.(g)]

The experiment was completely randomized design with three replications. The collected data were analysed with a general linear model using SPSS software version 20 for windows operating system. Means were analysed according to the Duncan Multiple Range Test (DMRT) at $P < 0.05$.

RESULTS AND DISCUSSION

Fly ash is a noxious solid waste seeking proper disposal and management. It has some multifarious utility. Still ample amount left unutilised at disposal sites of thermal power plants polluting air and water. There exists a vast scope for utility in forestry sector as potting mixture ingredient and soil improvement material at difficult sites prior to plantation. The matrix of application depends upon the elemental composition of FA to be used, tolerance limit of plant species selected and physiochemical property of plantation site soil or growing media in which FA need to be added. Fertility status of poor degraded waste lands and problematic soils are successfully improved by FA addition to varying degrees in different agro-climatic situation. Enhancement in crop yield and vegetative growth tree species have been reported by many workers when applied judiciously (Kumar et al., 2002; Sinha et al. 2005; Ramesh et al., 2008; Chaudhary et al., 2009; Krzaklewski et al., 2012; Behera et al. 2018)

Effect of substrate on seed germination

The biochemical process of seed germination is affected by a number of intrinsic and environmental factors. Effective pre sowing treatment of seed reduce unfavourable endogen window. The exogenous variable mainly the substrate and climatic condition can be managed successfully to achieve maximum germination rate. Substrate property especially pH and water retention capacity have a marked impact on germination. pH affects germination either by increasing the osmotic pressure of the media to a plant that will retard or prevent the intake of water or by causing toxicity to the embryo (Rashid, 2004).

During this course study, it was revealed that FA have a significant ($P < 0.05$) impact on seed germination parameters like germination period, rate, capacity and index, however did not have any impact on the number of days taken for first germination (NDFG) and germination value (Table 2). Addition of FA to growing media reduced germination period in a dose-depended manner due to an increase in pH towards alkalinity. Similar type of observations was reported by Behera et al. (2020) in *Leucaena leucocephala*.

The highest seed germination percent (86.67%) was observed in growing media

having 20% fly ash (T_1) and was significantly (P>0.05) higher than other treatments (Table 2). The germination rate of 79.33% in T_2, 69.33% in T_3 and 66.67% in control (T_6) respectively are statistically at par (P>0.05) with each other. Minimum germination rate (34.67%) was observed in substrate having 100% FA (T_5, Table 2). The increased germination rate (86.67%) in 20% FA admixed growing media was attributed to the improvement in the physicochemical condition of germinating media over control (66.67%, Table 2). The reduction in germination rate beyond 60% FA addition (w/w) in media was due to enhanced pH and elemental toxicity. Higher pH and metals like Cu^{2+}, Zn^{2+} at higher EC are reported toxic to embryo and reduces biological activity during germination process (Gupta et al., 2000). There existed negative relationship between FA rate with germination percentage, germination capacity but it was positive with DTFG, germination period and germinative index (Table 2).

Table 2. Effects of substrates on germination of *S. grandiflora* seeds at 30 days after sowing

Parameters→ / Treatments↓	DTFG	G. Period	GP (%)	GC	GV	GI
T_1	8.67_{cd}	6.67_{b}	86.67_{d}	89.33_{cd}	25.33_{cd}	2.04_{c}
T_2	8.33_{bcd}	6.0_{ab}	79.33_{bc}	85.33_{cd}	26.00_{d}	1.94_{c}
T_3	7.67_{abc}	4.66_{ab}	69.33_{bc}	72.00_{bc}	17.67_{bcd}	1.73_{bc}
T_4	7.33_{ab}	4.67_{ab}	54.67_{b}	58.67_{b}	12.00_{ab}	1.35_{bc}
T_5	7.0_{a}	4.0_{a}	34.67_{a}	40.00_{a}	7.33_{a}	0.34_{a}
T_6	9.0_{d}	9.33_{c}	66.67_{bc}	93.33_{d}	16.67_{bc}	1.00_{ab}
Statistical analysis						
P (0.05)	0.01	0.001	0.001	0.001	0.004	0.03
SE	0.21	0.48	11.94	14.47	7.4	0.17
F	4.8	9.35	4.51	4.93	1.87	6.9
Linear Regression analysis (y = concerned parameter, x = FA rate)						
y=	9.04-0.81x	8.32-0.84x	84.2-0.69x	99.68-0.89x	24.29-0.6x	1.8-0.4x

Treatments T_1=(20% FA+S), T_2=(40% FA+S), T_3=(60% FA+S), T_4=(80% FA+S), T_5=(100% FA), T_6=(Soil/Control), FA- fly ash, S- Forest Soil, DTFG- Days taken for first germination, GP- Germination Percentage, GC- Germination Capacity, GV- Germination Value, GI- Germination index, Mean values followed by same letter are statistically indifferent.

Effect of substrate on seedling growth

After 90 days of transplanting significant difference (P>0.05) in survival rate, plant height, diameter growth, mean root length, nodules per plant and seedling quality index of *S. grandiflora* was observed. But no significant difference (P>0.05) in number of leaves was recorded (Table 3).

Highest seedling survival rate (91.57%) was found in substrate containing 40% FA (T_2) which and was statistically (P>0.05) indifferent from treatment T_2 (87.16%) and control (83.2%). The maximum survival rate (91.57%) of seedlings in substrate containing 40% FA (T_2) was due the improved aeration and water retention capacity of substrate. The survival rate decreased linearly with increased concentration of FA up to minimum 37.90% in growth media having 100% FA (Table 3).

The maximum height (62.07 cm) was found in treatment having 40% FA and it was statistically at par with Treatment T_1 (58.83 cm), T_3 (56.06 cm) and control (54.8 cm). The diameter growth was maximum in treatment T_2 (5.89 cm) and statistically at par with control (5.37 cm), T_1 (5.02 cm) and T_3 (4.5 cm). Longer mean root length was recorded

in treatment T_3 (23.50 cm) and statistically at par with Treatment T_1 (22.25 cm), T_3 (21.27 cm) and control (22.50 cm). 31.67 numbers of root nodules were found in growing media having 40% FA (T_2) and statistically at par with T_1 (17.33) and control (16.25). A similar trend in growth of seedlings with respect to FA concentration was also reported by Gupta et al. (2000) and Pandey et al. (1996).

The vigour in seedling height, diameter and root growth of this species at 40% FA was due to light alkali pH, improvement in availability of nutrients in ionic form at rhizosphere solum and improved nitrogen fixation rate (Table 2), and reduced or no attack of nursery insect and pest. Goyal et al. (2002) observed 10% increase in the growth of *Eucalyptus tereticornis, Acacia auriculiformis* and *Casuarina equisetifolia* during early 6 months, grown in FA amended soils [ESP FA@18–24% (v/v)]. Good root nodulation per plants (31.67) in substrates having 40 % FA could be attributed to uptake of optimum amount of metals by the roots. However, the nodulation rate decreased after 40% FA linearly up to 100% FA which is due to the reduced ability of nitrogen fixing bacteria with increasing stress level (Faizan and Kaushar, 2010). The depressive nodulation effect was substantiated by reduced plant height, collar diameter growth, and seedling quality index. Further the plants grown in 40% FA were observed to be very healthy. Better seedling quality index in T_2 (0.66) was obviously due to the improved availability of micronutrients that supported higher biomass production and shoot: root ratio (Gupta et al., 2000).

Table 3. Effects of substrate on growth and quality of *Sesbania grandiflora* seedlings at 90 DAT

Parameters→ / Treatments↓	Survival (%)	Plant height (cm)	Collar diameter (cm)	Number of leaves	Mean root length (cm)	Nodules per plant (No.)	SQI
T_1	87.16_{cd}	58.83_{c}	5.02_{bc}	9.37_{c}	22.25_{b}	17.33_{ab}	0.64_{c}
T_2	91.57_{d}	62.07_{c}	5.89_{c}	10.63_{cd}	23.50_{ab}	31.67_{b}	0.66_{c}
T_3	72.14_{bc}	56.06_{bc}	4.5_{bc}	11.73_{d}	21.27_{b}	10.50_{a}	0.52_{bc}
T_4	56.30_{b}	45.27_{b}	3.69_{ab}	6.87_{ab}	14.83_{a}	3.67_{a}	0.38_{ab}
T_5	37.90_{a}	32.60_{a}	2.6_{a}	6.03_{a}	12.17_{a}	2.0_{a}	0.21_{a}
T_6	83.2_{cd}	54.8_{bc}	5.37_{c}	8.83_{c}	22.50_{b}	16.25_{ab}	0.54_{bc}
Statistical analysis							
P (0.05)	0.001	0.001	0.002	NS	0.008	0.01	0.004
SE	4.93	2.73	1.2	0.53	0.72	0.50	0.04
F	15.48	8.64	7.87	9.8	5.45	5.14	6.4
Linear Regression analysis (y = concerned parameter, x = FA rate)							
y =	95.6-0.81x	62.0-0.63x	6.0-0.82x	-	24.4-0.1x	23.1-0.2x	0.66-0.03x

Treatments T_1=(20% FA+S), T_2=(40% FA+S), T_3=(60% FA+S), T_4=(80% FA+S), T_5=(100% FA), T_6=(S Control-1), FA- fly ash, S- Forest Soil, SQI-Seedling Quality Index, Mean values followed by same letter are statistically indifferent.

CONCLUSION

S. grandiflora being a rhizobial legume tree is well accomplished for improving barren waste land. The results of present investigation recommends FA should be admixed at 20% (w/w) level in nursery beds for early sprouting and improving germination percentage. However, it should be admixed at 40% in potting mixture for production of healthy and quality planting material. Further study is necessary to quantify the economic benefit or net profit gain from utilizing FA in forest nursery.

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Molecular diagnosis and therapeutic management of EEHV HD in a free ranging Asian elephant (*Elephas maximus*): A case study at chandaka, Odisha

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ABSTRACT

A free ranging sub-adult elephant of about 9 years age was found in comatose condition inside Chandaka Elephant Sanctuary, Odisha without any gross external lesions. Rectal temperature was 95.2°F. Blood sample was collected in EDTA and clot activator vials for haematological and molecular investigation as recent cases of death were reported in four captive juvenile elephants in Nandankanan Zoological Park due to elephant endotheliotropic herpes virus (EEHV) 1. Blood parameters such as haemoglobin, total leucocyte count, differential leucocyte count and total platelet count were performed following standard procedures. Initial haematology was indicative of leucocytosis (TLC- 22,000 per cubic mm) and thrombocytopenia (platelet count 80,000 per cubic mm). Molecular diagnosis of EEHV haemorrhagic disease was carried out through real time and conventional PCR for detection of terminase and E36A/EE6/U79 genes. The blood sample was found positive in real-time PCR with the cycle threshold (Ct) value of 26.53 for Terminase gene as against the Ct value of 21.07 in positive control. An aggressive therapy was followed. Parenteral administration of acyclovir @ 5.0 mg kg^{-1} body weight i/v and methyl-prednisolone @ 1.0 mg kg^{-1} body weight i/v showed progressive signs of improvement in the recumbent animal. The elephant calf responded positively by control of body temperature along with frequent attempts to get up and intake of leaves, fruits and fodders. However, the elephant succumbed on the 6 th day. The post-mortem examination revealed tongue cyanosis and haemorrhages in internal organs. As endotheliotropic herpes virus haemorrhagic disease is mostly fatal, a correct treatment regimen with management practices need to be practised for successful overcoming and need to attempt as early as possible.

Key words: Asian elephant, herpes virus, molecular diagnosis, therapy

INTRODUCTION

Elephant endotheliotropic herpes virus hemorrhagic disease (EEHV HD) is a fatal disease especially when acute clinical form appears in young Asiatic elephant. First death due to EEHV HD infection was recorded in 1988 in Swiss circus (Ossent et al. 1990). Since then, more than 100 confirmed deaths have been reported in Asia, Europe, and North America. It is caused by double-stranded DNA virus belonging to the subfamily *Betaherpes virinae* under the genus Proboscivirus (Richman et al., 1999; Wilkie et al., 2013). Eight different genotypes of Elephant endotheliotropic herpes virus (EEHV) have been reported (Ehlers et al., 2001; Latimer et al., 2011), of which EEHV 1A and EEHV 1B are considered to be the most

common cause of high mortality in captive Asian elephants (Richman et al., 1999; Fickel et al., 2001). Disease spreads by all mucosal secretions. However, trunk to trunk contact considered common means. Elephant calves between 1-8 years of age are most vulnerable with case fatality rate of 80% (Ossent et al., 1990; Richman et al., 1999; Richman et al., 2000; Garner et al., 2009).Virus has high affinity for endothelial lining of small blood vessels and capillaries of internal organs. Three forms of the disease have been recognized i.e. peracute, acute and subacute. Generalized edema of the head, cyanosis of tongue, gastrointestinal signs including constipation and mild diarrhea and, death within a week are characteristic features of EEHV HD (Kendall et al., 2016). Adult Asian elephants carry EEHV HD without getting sick. But some predisposing factors such as squeezing of vegetation, man animal conflict, unsafe habitat, high environmental temperature increase stress, thereby help precipitate infection. In India, the incidence of EEHV HD has also been reported from Kerala, Karnataka, Tamil Nadu and Assam in the year 1997 (Zachariah et al., 2013; Barman et al., 2017). Treatment consisting of antivirals, antibiotics, antipyretics, blood or plasma transfusion etc. have been tried in different occasions with variable success rate. Present case is the first report of EEHV HD in a free range elephant of Odisha, India that deals with molecular diagnosis employing polymerase chain reaction followed by therapy.

MATERIALS AND METHODS

Case history

On September 26, 2019 early morning, one free ranging sub-adult elephant age about 9 years was detected in a comatose condition inside Chandaka Elephant Sanctuary, Odisha. Over all body condition was normal with absence of any gross external lesions. Rectal temperature was 95.2°F.

Blood sample collection

Blood sample was collected in EDTA and clot activator vials for haematological and molecular investigation. Blood parameters such as hemoglobin (Hb), total leucocyte count (TLC), differential leucocyte count (DLC), total platelet count were performed following standard procedure. Molecular diagnosis of EEHV HD was carried out through real time and conventional PCR

Molecular diagnosis of EEHV from blood sample

Blood sample was processed for DNA extraction using DNeasy Blood and Tissue Kit (Qiagen, Hilden, Germany) Real-time PCR was done targeting terminase gene (Table 1) as described by Ackermann et al. (2017) and Hardman et al. (2012). Each individual PCR was run in a volume of 25 µl that included 5 µl of DNA. The primers was used at a concentration of 20 pM μl^{-1} and the probe at 5 pM μl^{-1}. The PCR reaction was performed at 96° C forthree minutes, followed by 45 cycles of 96° C for five seconds and 60° C for 24 seconds in a Rotor Gene Q real-time PCR machine (Qiagen, Germany). The amplicon size was 91 bp .

Table 1. Primers and probes used for the molecular detection of EEHV1

Sl No	Target gene	Oligo name	5' to 3' sequences and labels
1	Terminase Gene	P-TG	FAM-TCAACGAGGAGATATTAGGCACCACCAACA-BHQ1
		F-TG	ACTGCAAAYGCATTCTTAAAAGAT
		R-TG	AGAATGGGATTRGCTAAGAAGCT
2	E36A/EE6 /U79 gene	F-E36	TCCAGGGATTTCTCCAGTTG
		R-E36	GCCACCTTCTTCTGCTTTTG

The threshold was set to a maximum of 0.08. A sample, which surpassed this threshold prior to cycle 45 (Ackermann et al., 2017).

The target EE6 gene (Ling et al., 2013), also designated as U79 or E36A, was selected to differentiate between EEHV1A and EEHV1B.

By conventional PCR, a relatively short 120 bp sequence was amplified that contained signature differences between EEHV1A and 1B. The PCR were run in a volume of 25 µl, containing 5 µl of template DNA, Taq PCR Master mix (Qiagen, Germany) and primers at a concentration of 20 pM. The PCR was performed with an initial denaturation for 2 min at 98°C, followed by 40 cycles of 98°C for 10 sec, 58.4°C for 20 sec, and 72°C for 7 sec and the run was completed with 10 min at 72°C before cooling to 4°C in a ProFlex PCR system (ThermoFisher Scientific, USA). The PCR product (approximately 120 bp) was evaluated by agarose gel electrophoresis followed by sequencing.

Therapeutic management

On the basis of laboratory report ailing elephant was administered intravenously with acyclovir @5.0 mg kg^{-1} body weight 12 hourly and methylprednisolone @ 1.0 mg kg^{-1} body weight i/v once daily. The latter drug was administered at half dose from day 3. Additional parenteral medication comprised of antibiotic (Cetriaxone), NSAID (Meloxicam), diuretic (Furesamide), vitamin B complex, polyionic fluid (Ringer's Lactate) and dextrose. About 20 L of clean water was intubated into rectum for first day of treatment. Attempt was also made to change the side 1-2 times daily using mechanical device. Elephant was treated aggressively for 5 days and daily response to therapy was recorded.

RESULTS AND DISCUSSION

Odisha lost four captive juvenile elephants in Nandankanan Zoological Park during August-September, 2019 due to EEHV1. This stimulated to diffrentiate EEHV HD in the present case.

Diagnosis of EEHV HD is usually based on the clinical signs, hemato-biochemcal alterations, post-mortem lesions, molecular tests, histopathology, and immune-histochemistry (Pavulraj et al., 2019). However, identification of viral DNA in body fluid by PCR is considered gold standard for confirmatory diagnosis. In our study, blood sample was found positive in real-time PCR with the cycle threshold (Ct) value of 26.53 for Terminase gene as against the Ct value of 21.07 in positive control (Fig. 1). TaqMan real-time PCR is a novel approach to screen EEHV1 in clinical samples like blood, tissue, swabs of the conjunctiva and palate and trunk wash (Hardman et al., 2012; Stanton et al., 2010).

EEHV-1 has two genetically distinct subtypes i.e. EEHV1A and 1B (Richman et al., 1999; Fickel et al., 2001). Major differences between these two has been mapped, that codes a distinct protein in EEHV1A. , In the present study, we selected U79 as conserved sequence primer-binding regions in order to produce an approximately 120 bp (Fig. 2) amplicon. Both conventional PCR and real time PCR confirmed EEHV HD due to EEHV1.

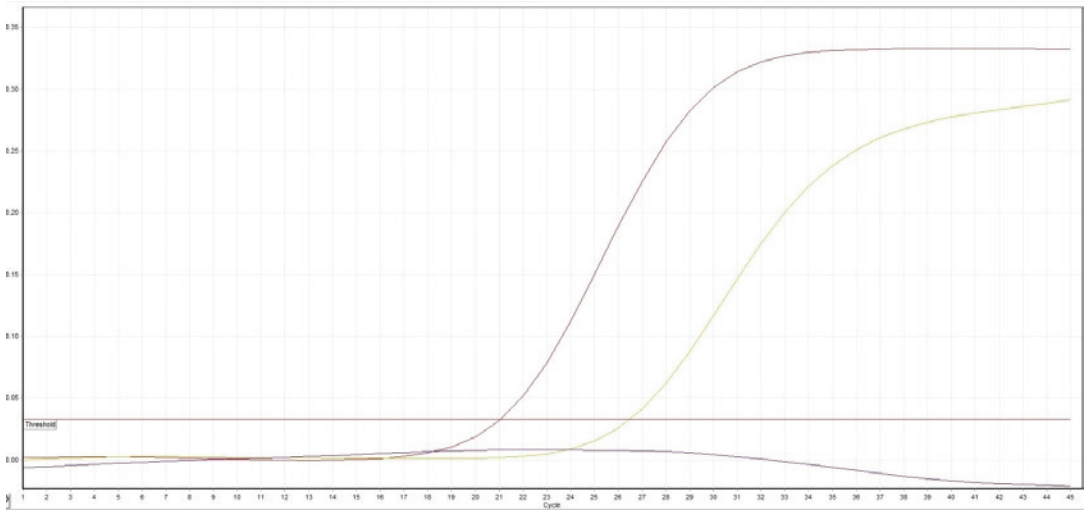


Fig. 1. Graph showing amplification for terminase gene in blood sample and positive control and negative in NTC

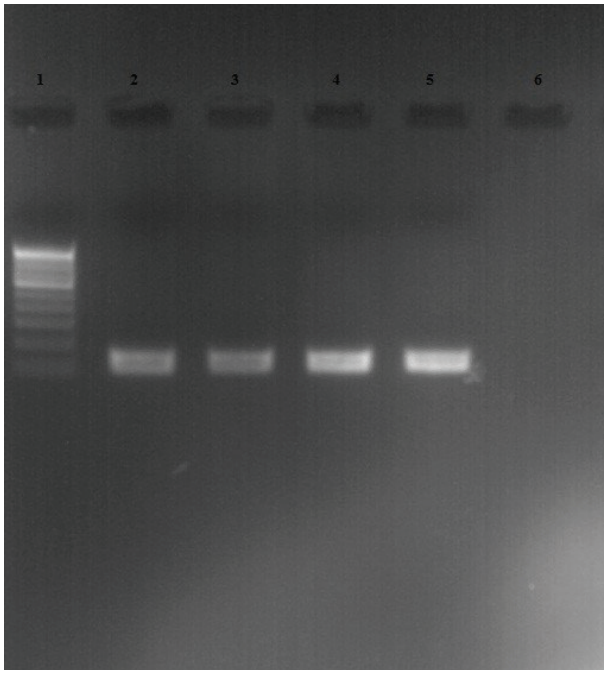


Fig. 2. Visualization of U79 gene of blood sample and positive control (Lane 1: 100 bp marker; Lane 2 and 3: Blood sample; Lane 4 and 5: Positive control; Lane 6: Negative control**)**

Treatment with antiviral drug acyclovir @ 5.0 mg kg^{-1} bw and methyl prednisolone @ 1.0 mg kg^{-1} bw intravenously showed progressive signs of improvement. Methyl prednisolone is a proven drug in medical practice to enhance platelet count (Fig. 3). Such effect was also recorded where the platelet count was increased from 0.8 lakhs cu mm^{-1} in day 1 to 2.4 lakhs cu mm^{-1} in day 4. Total leucocyte counts were 22,000 and 10,000 per cu mm on first and fourth day, respectively. The initial leukocytosis and thrombocytopenia changed towards normal range on day 4. Fragmentation of monocytes and netrophillia with shift to left were recorded during the blood smear examination. Plasma transfusion is highly recommended and practisd in selected zoos for instant avaialbility of platelets. However, it could not be included in the present therapeutic regimen because of nonavailbility of logistic support at the time of need.

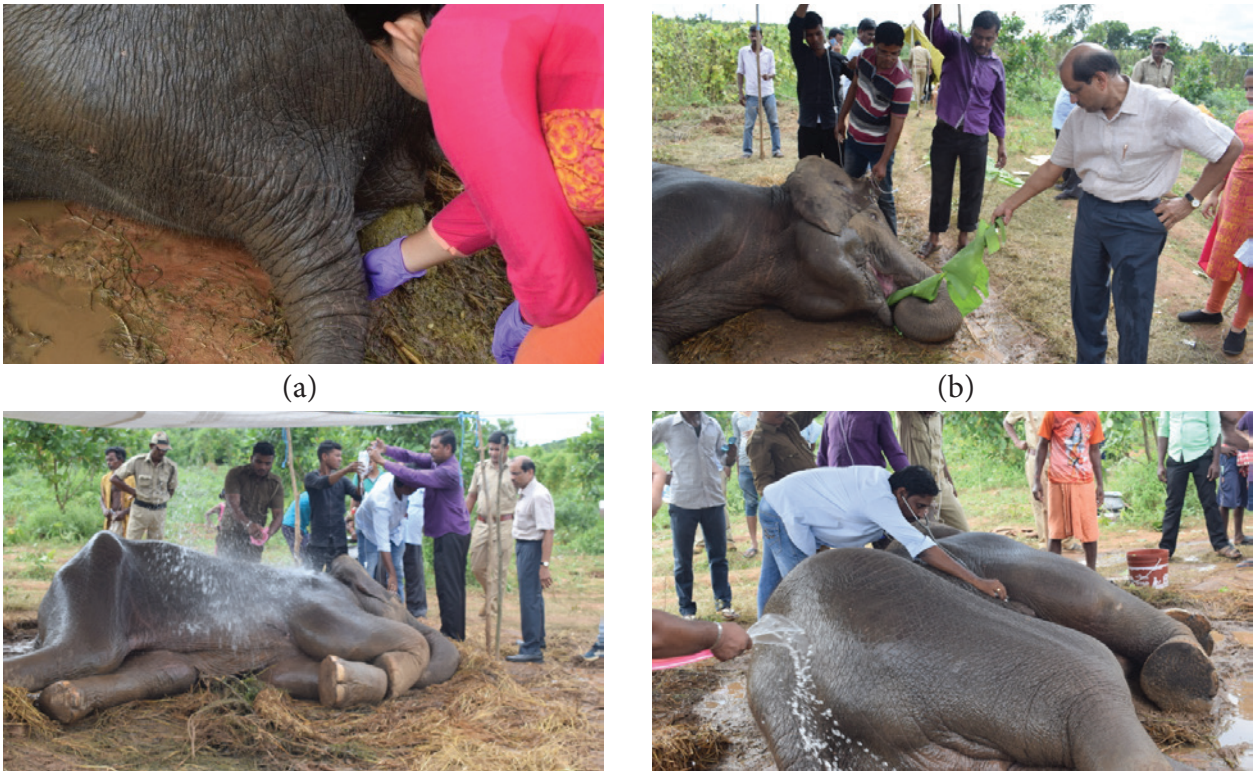
Management of EEHV HD is a difficult task especially in the free range system. Further, the short time frame between the appearance of clinical signs and death in acute conditions made the prognosis much unfavorable. Some Asian elephants have survived severe EEHV-associated disease (Stanton et al., 2010; Zachariah et al., 2013). The survival of these animals was assisted in part by aggressive supportive therapies, administration of anti-herpes viral medications and platelet transfusion

The elephant calf responded positively to the aggressive therapy as shown in Table 2. On September 27, 2019, elephant showed mild limb movement in recumbence position. Sudden rise of rectal temperature up to 102.5°F was managed successfully with continuous sprinkling of water for about four hours. Transient rise of body temperature is an antiviral drug related side effect. On September 28, 2019, there were frequent attempts to get up with intake of leaves, fruits and fodders. Next two days elephant showed progressive response to treatment. However, unfortunately, on 6th day of treatment (October 01, 2019), elephant succumbed. Post-mortem examination revealed toungue cyanosis and haemorrhages in internal organs

The report of such EEHV HD in free ranging elephant is first of its kind in this region that triggered both *in-situ* and *ex-situ* preparedness.

Table 2. Day-wise observation of elephant treated against EEHV HD

Sl no.	Days	Clinical observation
1.	Sept 26,2019	Comatose, rectal temperature was 95.2°F
2.	Sept 27,2019	Recumbence with mild body movement, rectal temperature was 97.2°F to 102°F
3.	Sept 28,2019	Recumbence with attempts to get up, fodder intake Rectal temperature 97.0°F
4.	Sept 29,2019	Frequent attempts to get up, intake of fruits and fodder Rectal temperature 97.0°F
5.	Sept 30,2019	Frequent attempts to get up, intake of fruits and fodder, Rectal temperature 97.0°F



(a) (b) (c) (d)

Fig. 3 (a, b, c, d). Therapeutic mangement of EEHV HD infected elephant on different days of treatment

CONCLUSION

RT PCR as well as cPCR confirmed the presence of EEHV1 in a free range elephant. Parenteral administration of acyclovir @ 5.0 mg kg^{-1} body weight i/v and methyl-Prednisolone @ 1.0 mg kg^{-1} body weight i/v showed progressive signs of improvement.

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Birds of Balukhand-Konark Wildlife Sanctuary, Puri, Odisha, India

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ABSTRACT

The study on bird diversity of Balukhanda-Konark Wildlife Sanctuary of Puri, District, Odisha was carried out between February 2017 to January 2018. During the study period, a total of 230 species of birds belonging to 59 families and 20 orders were recorded. Out of 230 species a total 49% (n=113) species resident bird, 44% (n=100) species winter visitor, 5% (n=12) species passage visitor and 2% (n=5) species summer visitor were recorded in the study area. According to the frequency of sighting of birds recorded in study area, 111 species (48%) were common, 65 species (28%) were uncommon, 31 species (14%) were rare and 23 species (10%) were occasional.

Key words: Abundance, avifauna, Balukhanda-Konark Wildlife Sanctuary, migratory bird

INTRODUCTION

The avifauna of Odisha have mainly studied by Acharya and Kar (1996), Acharya et al. (1997, 1999), Kar and Sahu (1999), Kar et al. (1999), Sahu and Kar (2000), Gopi and Pandav (2007a, b), Sahu and Rout (2005). Almost all previous information on the birds of Odisha is based on the studies and surveys from its costal region (Ball, 1877, 1878; Mukherjee, 1952; Singh, 1993; Kar and Sahu, 1993), and most of the studies were focused on water birds (Kar and Sahu, 1993). Despite those and other recent works dealing with bird species richness in different areas of Odisha (Palei et al., 2011a, b; Palei et al., 2012a, b; Pradhan, 2012; Sahu et al., 2012; Palei et al., 2013; Palei et al., 2014a, b, c; Pradhan et al., 2014; Palei et al., 2015; Palei et al., 2017; Rajguru, 2017; Bal et al., 2018; Palei et al., 2018; Payra et al., 2019a, b), no specific checklist of birds of Balukhanda-Konark Wildlife Sanctuary was prepared except, some common birds enlisted in the Sanctuary Management Plan.

MATERIALS AND METHODS

Study area

Balukhanda-Konark Wildlife Sanctuary is a manmade forest tract along the Bay of Bengal situated between 19° 48" to 19° 55" North and 85° 51" to 86° 14" East (Fig. 1). This sanctuary is situated longitudinally along Bay of Bengal between Banki Muhan near Puri in the west and Keluni Muhan (Prachi mouth) near Daluakani in the East. The altitude varies from 0 to 15 m from mean sea level. The terrain is mostly flat, draining gently from north to south with occasional sand dunes formed by shifting sand subsequently stabilized through plantation. The sanctuary is typical representative forest patch of coastal ecosystem of eastern Indian coastal plain. The entire area is full of shifting sand dunes with alluvial patches along the rivers and on the river mouths as well. The average annual rain fall is around 1900 mm and temperature ranges from 15° C to 38° C in a year. The maximum temperature

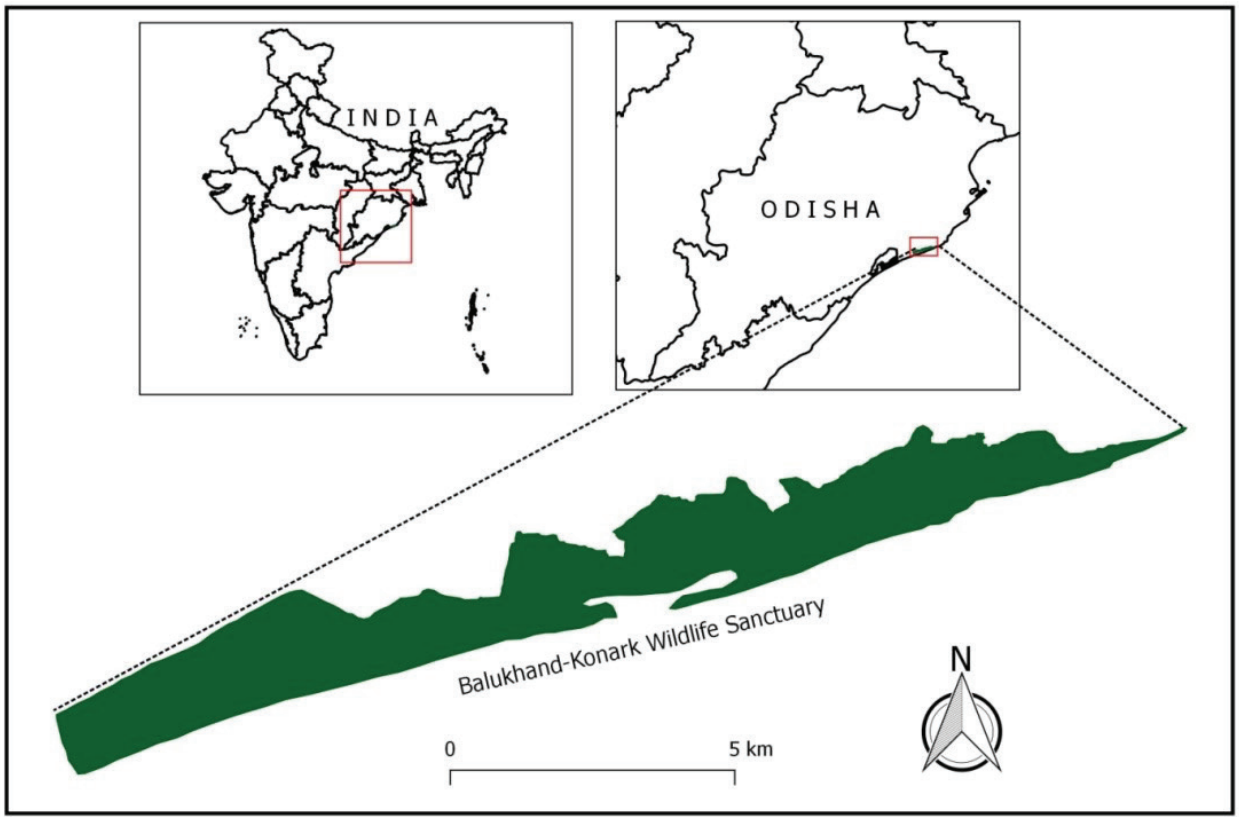


Fig. 1. Location map of Balukhanda –Konark Wildlife Sanctuary, Puri, Odisha, India

is noticed during May and the minimum at about end of December or early January. But winter, as in case of other beaches of the region, is mild.

The source of water in this sanctuary is the tributaries of Mahanadi, i.e. Kushabhadra, Nuanai and Kadua flowing through the sanctuary and draining into the bay. Being close to the sea, the water table is high and water is available even in smaller water bodies. The total geographical area of this sanctuary is 87 km^2, out of which forest land is 69.18 km^2. The sanctuary is close to the temple town of Puri and the archaeological heritage of Konark. The sanctuary is surrounded by 59 villages with more than 45,000 populations and about 17,000 heads of cattle (Mishra, 2007). Bio-geographically the vegetation of the sanctuary can be classified as Coastal Casuarina plantation, Canes brakes and Literal Swamp Forest. The forest of this sanctuary is mainly consisting of planted trees of casuarina, cashew, eucalyptus and Acacia sps. The natural vegetation of this sanctuary mainly consists of *Azadirachta indica, Ziziphus xylopyrus, Diospyros embryopteris, Ziziphus mauritiana, Maba elegans, Eugenia jambolana, Phyllophylum spinosa*, kanta boansa, beta, ketki, khirkoli etc. Mangroves are confined to river banks and consist of keruan (*Sonneratia apetala*), harkanch (*Acanthus* sp.), rai (*Rhizophora* sp.) and gan (*Excoecaria agallocha*) etc. A large population of spotted deer (*Axis axis*) inhabit the sanctuary. Other major species of wildlife found in this sanctuary includes hyena (*Hyena hyena*), jackal (*Canis aureus*), fox (*Vulpes bengalensis*), jungle cat (*Felis chaus*), fishing cat (*Prionailurus viverrinus*), rhesus monkey (*Macaca mulatta*), langur (*Presbytis entellus*), hare (*Lepus nigricollis*), mongoose (*Herpestes edwardsii*), porcupine (*Hystrix indica*) and smooth-coated otter (*Lutrogale perspicillata*) etc.

Methodology

Observations were made, usually for a full day between the months of February 2017

to January 2018. Regular surveys were done by walking on fixed routes throughout the study area. Observations were made in the morning and 18:00 hr, depending on the light condition. Recordings were not made at the time of heavy rains. Surveys were conducted on foot in different type of habitat, where sighting chances are more. The study was carried out on day time during the study period to encounter the maximum numbers of birds. All identifications were based on Balachandran et al. (2009) and Naik and Mishra (2017). Only those species with conformed identification are listed in this paper. Surveys were conducted twice a week. Birds were observed using 7 X 50 and 7 X 42 Bushnell binoculars. Photographs were taken by Canon EOS 7D Mark II digital SLR and refined APS-C sized 20.2 megapixel CMOS sensor with dual DIGIC 6 image and Mark II 100-400 mm lens with Canon EF100-400 mm f/4.5-5.6l IS II USM Telephoto Zoom Lens. At each site, birds were counted using a binocular before moving to the next point as rapidly as possible without disturbing the birds. We observed details on habitat type, season and status (resident per migrant). In case of doubtful identification, photographs were taken and the species were identified later by consulting experts. The abundance status and migratory status of birds were categorized into different groups such as

Common (C): Observed throughout the study in fairly good numbers and abundant in a particular locality. In general, if the percentage of recording was more than 50 times they were grouped in this category. Uncommon (UC): Found in small numbers and less frequency. Sightings were less than 50% and more than 10% (Mostly seasonal migratory birds were taken in this category). Rare (R): Seen in very small numbers and their frequency of sightings were less than 10%. Occasional (O): Locally distributed but depending on food or nesting purpose visit occasionally. Winter visitor (WV): A bird which visited a particular area during winter (from October 2017 to January 2018) season and did not breed there. Summer visitor (SV): A bird which visited a particular area during the summer season (from March 2017 to June 2018). Partial Visitor (PV): Partial visitors were taken as a part of population of a same species only migrated to another part. Resident (Re): Non migratory birds were taken here as Resident birds.

RESULTS AND DISCUSSION

During the study period a total of 230 sp. of birds belonging to 59 families and 20 orders were recorded from Balukhanda-Konark Wildlife Sanctuary. Detail status, scientific and common names of birds, which shows that the area shows high diversity of birds in the sanctuary (Table 1). A total 49% (n=113) sp. were resident birds, 44% (n=100) sp. winter visitors, 5% (n=12) sp. passage visitors and 2% (n=5) sp. summer visitors recorded in the study area (Fig. 2).

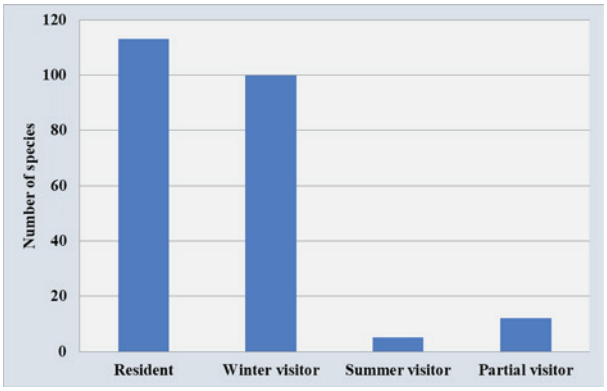


Fig. 2. Migratory bird status of Balukhand-Konark Wildlife Sanctuary, Puri, Odisha.

According to frequency of sighting of birds 111 sp. (48%) were common, 65 sp. (28%) were uncommon and 31 sp. (14%) were rare and 23 sp. (10%) were occasional recorded from study area (Fig. 3).

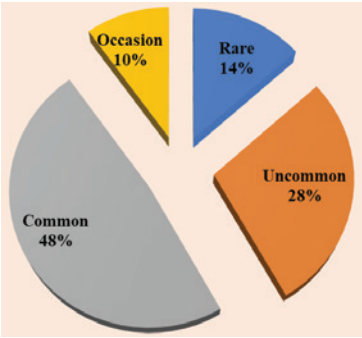


Fig. 3. Abundance of bird species in Balukhand-Konark Wildlife Sanctuary, Puri, Odisha.

Table 1. Birds of Balukhand-Konark Wildlife Sanctuary with their residential and breeding status

Sl no.	Family	Common name	Scientific name	Abundance	Migratory status
Order: Galliformes					
1	Phasianidae	Grey francolin	*Francolinus pondicerianus*	C	Re
2		Red Jungle Fowl	*Gallus gallus*	UC	Re
3		Indian Peafowl	*Pavo cristatus*	C	Re
4		Rain quail	*Coturnix coromandelica*	UC	Re
5		Jungle bush quail	*Perdicula asiatica*	UC	Re
Order: Anseriformes					
6	Dendrocygnidae	Lesser Whistling Duck	*Dendrocygna javanica*	C	SV
7	Anatidae	Ruddy shelduck	*Tadorna ferruginea*	*C*	WV
8		Cotton pigmy goose	*Nettapus coromandelianus*	UC	SV
9		Gadwall	*Mareca strepera*	C	WV
10		Bar headed goose	*Anser indicus*	R	WV
11		Eurasian Wigeon	*Mareca penelope*	R	WV
12		Spot bellied duck	*Anas poecilorhyncha*	C	WV
13		Northern Shoveler	*Spatula clypeata*	R	WV
14		Northern Pintail	*Anas acuta*	C	WV
15		Common Teal	*Anas crecca*	UC	WV
16		Red crested pochard	*Netta rufina*	UC	WV
17		Tufted Duck	*Aythya fuligula*	R	WV
18		Knob billed duck	*Sarkidiornis melanotos*	UC	WV
19		Mallard	*Anas platyrhynchos*	UC	WV
Order:Podicipediformes					
20	Podicipedidae	Little Grebe	*Tachybaptus ruficollis*	C	Re
Order:Ciconiiformes					
21	Ciconiidae	Painted stork	*Mycteria leucocephala*	R	WV
22		Asian Openbill	*Anastomus oscitans*	C	Re
Order: pelecaniformes					
23	Threskiornithidae	Glossy ibis	*Plegadis falcinellus*	UC	WV
24		Black headed Ibis	*Threskiornis melanocephalus*	UC	WV
25	Ardeidae	Striated Heron	*Butorides striata*	*R*	WV
26		Black crowned Night Heron	*Nycticorax nycticorax*	UC	Re
27		Cinnamon Bittern	*Ixobrychus cinnamomeus*	UC	Re
28		Yellow bittern	*Ixobrychus sinensis*	UC	Re
29		Black bittern	*Ixobrychus flavicollis*	UC	Re
30		Indian pond Heron	*Ardeola grayii*	C	Re
31		Grey Heron	*Ardea cinerea*	C	WV
32		Purple Heron	*Ardea purpurea*	C	WV

Sl no.	Family	Common name	Scientific name	Abundance	Migratory status
33	Ardeidae contd.	Cattle Egret	*Bubulcus ibis*	C	Re
34		Great Egret	*Ardea alba*	C	Re
35		Intermediate Egret	*Ardea intermedia*	C	Re
36		Little Egret	*Egretta garzetta*	C	Re
Order: Suliformes					
37	Anhingidae	Darter	*Anhinga melanogaster*	C	WV
38	Phalacrocoracidae	Little cormorant	*Microcarbo niger*	C	*Re*
39		Indian Shag	*Phalacrocorax fuscicollis*	UC	*WV*
40		Great Cormorant	*Phalacrocorax carbo*	UC	Re
Order: Falconiformes					
41	Falconidae	Common Kestrel	*Falco tinnunculus*	O	Re
42		Peregrine falcon	*Falco peregrinus*	O	Re
Order: Accipitriformes					
43	Accipitridae	Black Winged Kite	*Elanus caeruleus*	*O*	WV
44		Black kite	*Milvus migrans*	C	Re
45		Black eared kite	*Milvus lineatus*	R	Re
46		Jerdon's Baza	*Aviceda jerdoni*	O	Re
47		Crested honey buzzard	*Pernis ptilorhynchus*	C	Re
48		White bellied Sea eagle	*Haliaeetus leucogaster*	R	PV
49		Palla's fish eagle	*Haliaeetus leucoryphus*	R	PV
50		Brahminy kite	*Haliastur indus*	O	PV
51		Osprey	*Pandion haliaetus*	UC	PV
52		Short toed snake eagle	*Circaetus gallicus*	O	PV
53		Crested Serpent eagle	*Spilornis cheela*	UC	PV
54		Booted eagle	*Hieraaetus pennatus*	O	PV
55		White eyed buzzard	*Butastur teesa*	UC	WV
56		Crested Goshawk	*Accipiter trivirgatus*	R	WV
57		Shikra	*Accipiter badius*	C	Re
Order: Gruiformes					
58	Rallidae	Common Moorhen	*Gallinula chloropus*	*C*	Re
59		White-breasted Waterhen	*Amaurornis phoenicurus*	C	Re
60		Grey headed swamphen	*Porphyrio porphyrio*	C	WV
61		Common Coot	*Fulica atra*	UC	WV
62		Ruddy breasted crake	*Zapornia fusca*	UC	WV
63		Water cock	*Gallicrex cinerea*	C	Re

Sl no.	Family	Common name	Scientific name	Abundance	Migratory status
Order: Charadriiformes					
64	Turnicidae	Yellow legged buttonquail	*Turnix tanki*	UC	Re
65		Barred buttonquail	*Turnix suscitator*	UC	Re
66	Burhinidae	Indian Thick Knee	*Burhinus oedicnemus*	UC	Re
67		Great Thick knee	*Esacus recurvirostris*	R	Re
68	Jacanidae	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	*UC*	WV
69		Bronze-winged Jacana	*Metopidius indicus*	C	Re
70	Recurvirostridae	Black winged stilt	*Himantopus himantopus*	C	WV
71	Charadriidae	River Lapwing	*Vanellus duvaucelii*	*C*	Re
72		Grey headed Lapwing	*Vanellus cinereus*	UC	WV
73		Yellow wattled Lapwing	*Vanellus malabaricus*	C	Re
74		Red wattled Lapwing	*Vanellus indicus*	C	Re
75		Little ringed plover	*Charadrius dubius*	C	Re
76		Kentish plover	*Charadrius alexandrinus*	C	WV
77		Lesser sand plover	*Charadrius mongolus*	C	WV
78		Greater sand plover	*Charadrius leschenaultii*	UC	WV
79	Scolopacidae	Common Snipe	*Gallinago gallinago*	*C*	WV
80		Common Redshank	*Tringa totanus*	UC	WV
81		Common Greenshank	*Tringa nebularia*	C	WV
82		Green Sandpiper	*Tringa ochropus*	C	Re
83		Wood Sandpiper	*Tringa glareola*	C	Re
84		Marsh Sandpiper	*Tringa stagnatilis*	UC	WV
85		Common Sandpiper	*Actitis hypoleucos*	C	Re
86		Curlew sandpiper	*Calidris ferruginea*	R	WV
87		Eurasian curlew	*Numenius arquata*	R	WV
88		Little Stint	*Calidris minuta*	UC	WV
89		Ruff	*Calidris pugnax*	UC	WV
90		Temminck's Stint	*Calidris temminckii*	C	WV
91		Ruddy turnstone	*Arenaria interpres*	UC	WV
92		Whimbrel	*Numenius phaeopus*	C	WV
93	Glareolidae	Small Pratincole	*Glareola lactea*	*C*	WV
94		Collared pratincole	*Glareola pratincola*	C	WV
95		Oriental pratincole	*Glareola maldivarum*	UC	WV

Sl no.	Family	Common name	Scientific name	Abundance	Migratory status
96	Laridae	River Tern	*Sterna aurantia*	*C*	Re
97		Pallas's gull	*Larus ichthyaetus*	C	WV
98		Brown headed gull	*Larus brunnicephalus*	C	WV
99		Caspian tern	*Hydroprogne caspia*	UC	WV
100		Little Tern	*Sternula albifrons*	R	WV
101		Whiskered Tern	*Chlidonias hybrida*	UC	WV
Order: Columbiformes					
102	Columbidae	Eurasian Collared Dove	*Streptopelia decaocto*	*C*	WV
103		Spotted Dove	*Streptopelia chinensis*	C	Re
104		Laughing Dove	*Streptopelia senegalensis*	C	Re
105		Common Pigeon	*Columba livia*	C	Re
106		Orange breasted green pigeon	*Treron bicinctus*	UC	PV
107		Yellow footed green pigeon	*Treron phoenicoptera*	UC	PV
108		Oriental Turtle Dove	*Streptopelia orientalis*	O	WV
Order: Psittaciformes					
109	Psittacidae	Alexandrine Parakeet	*Psittacula eupatria*	*C*	Re
110		Rose-ringed Parakeet	*Psittacula krameri*	C	Re
111		Plum-headed Parakeet	*Psittacula cyanocephala*	R	WV
Order: Cuculiformes					
112	Cuculidae	Jacobin Cuckoo	*Clamator jacobinus*	*O*	WV
113		Common Hawk Cuckoo	*Hierococcyx varius*	C	Re
114		Chestnut winged cuckoo	*Clamator coromandus*	O	Re
115		Common cuckoo	*Cuculus canorus*	O	R
116		Plaintive cuckoo	*Cacomantis merulinus*	O	R
117		Grey bellied Cuckoo	*Cacomantis passerinus*	UC	WV
118		Asian koel	*Eudynamys scolopacea*	C	Re
119		Southern Coucal	*Centropus sinensis*	C	Re
Order: Strigiformes					
120	Tytonidae	Barn Owl	*Tyto alba*	R	Re
121	Strigidae	Indian Scops Owl	*Otus bakkamoena*	*R*	Re
122		Spotted Owlet	*Athene brama*	C	Re
123		Mottled wood owl	*Strix ocellata*	R	Re
124		Brown fish owl	*Bubo zeylonensis*	R	PV
125		Dusky eagle Owl	*Bubo coromandus*	UC	Re
126		Brown boobook	*Ninox scutulata*	R	PV
127		Jungle Owlet	*Glaucidium radiatum*	R	Re

Sl no.	Family	Common name	Scientific name	Abundance	Migratory status
Order: Bucerotiformes					
128	Upupidae	Common Hoopoe	*Upupa epops*	O	WV
Order: Caprimulgiformes					
129	Caprimulgidae	Jerdon's Nightjar	*Caprimulgus atripennis*	C	Re
130		Indian Nightjar	*Caprimulgus asiaticus*	C	Re
Order: Apodiformes					
131	Apodidae	Asian palm swift	*Cypsiurus balasiensis*	UC	Re
132		Little swift	*Apus affinis*	C	Re
Order: Coraciiformes					
133	Coraciidae	Indian roller	*Coracias benghalensis*	C	Re
134	Halcyonidae	Stork billed kingfisher	*Halcyon capensis*	*R*	Re
135		Black capped kingfisher	*Halcyon pileata*	C	Re
136		White throated kingfisher	*Halcyon smyrnensis*	C	Re
137	Alcedinidae	Common kingfisher	*Alcedo atthis*	UC	Re
138	Cerylidae	Pied Kingfisher	*Ceryle rudis*	C	Re
139	Meropidae	Blue-tailed Bee-eater	*Merops philippinus*	*C*	Re
140		Small Bee-eater	*Merops orientalis*	C	Re
Order: Piciformes					
141	Megalaimidae	Brown headed Barbet	*Psilopogon zeylanicus*	*C*	Re
142		Coppersmith Barbet	*Psilopogon haemacephalus*	C	Re
143	Picidae	Rufous woodpecker	*Micropternus brachyurus*	*UC*	Re
144		Grey headed Woodpecker	*Picus canus*	UC	Re
145		Black rumped Flameback	*Dinopium benghalense*	C	Re
Order: Passeriformes					
146	Aegithinidae	Common Iora	*Aegithina tiphia*	C	Re
147	Artamidae	Ashy woodshallow	*Artamus fuscus*	UC	WV
148	Campephagidae	Large cuckooshrike	*Coracina macei*	*UC*	WV
149		Black winged cuckooshrike	*Coracina melaschistos*	R	WV
150		Rosy minivet	*Pericrocotus roseus*	O	PV
151		Black headed cuckooshrike	*Lalage melanoptera*	R	WV
152	Lanidae	Long tailed Shrike	*Lanius schach*	*C*	WV
153		Brown Shrike	*Lanius cristatus*	C	Re
154		Bay backed Shrike	*Lanius vittatus*	R	WV

Sl no.	Family	Common name	Scientific name	Abundance	Migratory status
155	Dicruridae	Black Drongo	*Dicrurus macrocercus*	*C*	Re
156		Spangled drongo	*Dicrurus bracteatus*	C	Re
157		White bellied drongo	*Dicrurus caerulescens*	C	Re
158		Ashy drongo	*Dicrurus leucophaeus*	UC	Re
159	Oriolidae	Indian golden Oriole	*Oriolus oriolus*	*C*	WV
160		Black napped oriole	*Oriolus chinensis*	UC	Re
161		Black hooded Oriole	*Oriolus xanthornus*	C	Re
162	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	*C*	Re
163		House Crow	*Corvus splendens*	C	Re
164		Jungle Crow	*Corvus macrorhynchos*	C	Re
165	Hirundinidae	Streak throated Swallow	*Petrochelidon fluvicola*	*O*	WV
166		Barn Swallow	*Hirundo rustica*	C	Re
167		Wire tailed swallow	*Hirundo smithii*	UC	Re
168		Red rumped Swallow	*Cecropis daurica*	UC	WV
169	Alaudidae	Jerdon's bushlark	*Mirafra affinis*	*C*	Re
170		Indian bushlark	*Mirafra erythroptera*	UC	Re
171		Bengal bushlark	*Mirafra assamica*	O	WV
172		Ashy crowned sparrow Lark	*Eremopterix griseus*	O	WV
173		Oriental Skylark	*Alauda gulgula*	C	Re
174	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	*C*	Re
175		Red-whiskered Bulbul	*Pycnonotus jocosus*	C	Re
176		White browed Bulbul	*Pycnonotus luteolus*	UC	WV
177	Cisticolidae	Ashy prinia	*Prinia socialis*	*UC*	SV
178		Plain Prinia	*Prinia inornata*	C	Re
179		Zitting Cisticola	*Cisticola juncidis*	UC	WV
180	Sylvidae	Greenish Leaf warbler	*Phylloscopus trochiloides*	*C*	WV
181		Yellow eyed Babbler	*Chrysomma sinense*	C	Re
182		Common Tailor Bird	*Orthotomus sutorius*	C	Re
183		Clamorous Reed Warbler	*Acrocephalus stentoreus*	UC	WV
184		Blyth's Reed Warbler	*Acrocephalus dumetorum*	UC	WV
185	Sylvidae	Booted Warbler	*Iduna caligata*	UC	Re
186		Western crowned warbler	*Phylloscopus occipitalis*	R	Re
187		Common Chiffchaff	*Phylloscopus collybita*	C	Re
188	Locustellidae	Striated grassbird	*Megalurus palustris*	C	Re
189	Pellorneidae	Puff throated Babbler	*Pellorneum ruficeps*	O	WV
190	Leiothrichidae	Jungle Babbler	*Turdoides striata*	C	Re
191	Sturnidae	Jungle myna	*Acridotheres fuscus*	*C*	Re
192		Common myna	*Acridotheres tristis*	C	Re

Sl no.	Family	Common name	Scientific name	Abundance	Migratory status
193	Sturnidae	Asian pied starling	*Gracupica contra*	C	Re
194		Chestnut tailed starling	*Sturnia malabarica*	C	WV
195		Brahminy starling	*Strurnia pagodarum*	C	WV
196		Rosy starling	*Pastor roseus*	C	WV
197	Monarchidae	Indian paradise flycatcher	*Terpsiphone paradisi*	*O*	WV
198		Black naped monarch	*Hypothymis azurea*	R	WV
199	Muscicapidae	Orange headed Thrush	*Geokichla citrina*	*O*	WV
200		Oriental Magpie Robin	*Copsychus saularis*	C	Re
201		Indian Robin	*Saxicoloides fulicata*	C	Re
202		Pied bushchat	*Saxicola caprata*	C	Re
203		Blue rock Thrush	*Monticola solitarius*	R	WV
204		Blue capped rock thrush	*Monticola cinclorhyncha*		
205		Asian brown flycatcher	*Muscicapa dauurica*	UC	WV
206		Blue throated blue flycatcher	*Cyornis rubeculoides*	UC	WV
207		Tickell's blue flycatcher	*Cyornis tickelliae*	R	WV
208		Verditer flycatcher	*Eumyias thalassinus*	UC	SV
209		Taiga flycatcher	*Ficedula albicilla*	UC	WV
210	Irenidae	Jerdon's Leafbird	*Chloropsis cochinchinensis*	C	Re
211	Dicacidae	Pale bellied Flowerpecker	*Dicaeum erythrorhynchos*	UC	WV
212	Nectariniidae	Purple rumped sunbird	*Leptocoma zeylonica*	*C*	Re
213		Purple sunbird	*Cinnyris asiaticus*	C	WV
214	Passeridae	House sparrow	*Passer domesticus*	*UC*	Re
215		Black breasted weaver	*Ploceus benghalensis*	C	Re
216		Baya Weaver	*Ploceus philippinus*	R	WV
217	Estrildidae	Red avadavat	*Amandava amandava*	*R*	WV
218		White-throated Munia	*Euodice malabarica*	O	WV
219		White-rumped Munia	*Lonchura striata*	O	WV
220		Scaly breasted munia	*Lonchura punctulata*	C	WV
221		Black-headed Munia	*Lonchura malacca*	UC	WV
222	Motacillidae	Yellow wagtail	*Motacilla flava*	*C*	WV
223		Citrine wagtail	*Motacilla citreola*	C	WV
224		Forest Wagtail	*Dendronanthus indicus*	R	SV
225		Grey wagtail	*Motacilla cinerea*	UC	WV
226		White wagtail	*Motacilla alba*	C	WV
227		White browed wagtail	*Motacilla maderaspatensis*	UC	WV
228		Blyth's pipit	*Anthus godlewskii*	C	Re
229		Paddyfield pipit	*Anthus rufulus*	C	Re
230		Olive backed pipit	*Anthus hodgsoni*	O	WV

WV- Winter visitor, SV- Summer visitor, PV- Partial visitor, Re- Resident R- Rare, UC- Uncommon, C- Common, O- Occasionally

During the study period, family wise bird species were recorded, i.e. Accipitridae (15) sp., Scolopacidae (14), Anatidae (13), Muscicapidae (11), Ardeidae (12), Motacillidae (9), Charadriidae (8), Cuculidae (8), Sylvidae (8), Columbidae (7), Strigidae (7), Rallidae (6), Laridae (6), Turnidae (6), Estrildidae (5), Phasianidae (5), Campephagidae (4), Alaudidae (5), Hirundinidae (4), Halcyonidae (3), Phalacrocoracidae (3), Glareolidae (3), Psittacidae (3), Picidae (3), Lanidae (3), Dicruridae (4), Oriolidae (3), Passeridae (3), Pycnonotidae (3), Cisticolidae (3), Corvidae (3), Falconidae (2), Threskiornithidae (2), Ciconiidae (2), Caprimulgidae (2), Apodidae (2), Turnicidae (2), Burhinidae (2), Jacanidae(2), Meropidae (2), Megalaimidae (2), Monarchidae (2), Nectariniidae (2), Recurvirostridae (1), Tytonidae (1), Pellorneidae (1), Leiothrichidae (1), Irenidae (1), Dicacidae (1), Cerylidae (1), Aegithinidae (1), Artamidae (1), Upupidae (1), Dendrocygnidae (1), Podicipedidae (1), Anhingidae (1), Coraciidae (1), Alcedinidae (1) sp. and Locustellidae (1) sp.

Some nocturnal birds were recorded in the study area i.e. Barn owl (*Tyto alba*), Indian scops Owl (*Otus bakkamoena*), Spotted owlet (*Athene brama*), Mottled wood owl (*Strix ocellata*), Brown fish owl (*Bubo zeylonensis*), Dusky eagle owl (*Bubo coromandus*), Brown hawk owl (*Ninox scutulata*) and Jungle owlet (*Glaucidium radiatum*) were recorded in Balukhanda, Beldal and riverbed of Nuanai river in the sanctuary (Fig. 4). Birds of prey sp. were recorded during the study area i.e. Black Winged Kite (*Elanus caeruleus*), Black kite (*Milvus migrans*), Black eared kite (*Milvus lineatus*), White bellied Sea eagle (*Haliaeetus leucogaster*), Greater Spotted eagle (*Clanga clanga*), Brahminy kite (*Haliastur indus*), Osprey (*Pandion haliaetus*), Short toed snake eagle (*Circaetus gallicus*), Crested Hawk eagle (*Nisaetus cirrhatus*), Crested Serpent eagle (*Spilornis cheela*), Booted eagle (*Hieraaetus pennatus*), White eyed buzzard (*Butastur teesa*), Crested Goshawk (*Accipiter trivirgatus*) and Shikra (*Accipiter badius*) recorded in Konark, Chandrabhaga and Ramachandi area of the sanctuary (Fig. 5). Some migratory birds were recorded in the study area namely Ruddy shelduck (*Tadorna ferruginea*), Cotton pigmy goose (*Nettapus coromandelianus*), Gadwall (*Mareca strepera*), Bar headed goose (*Anser indicus*), Eurasian Wigeon (*Mareca penelope*), Spot bellied duck (*Anas poecilorhyncha*), Northern Shoveler (*Spatula clypeata*), Northern Pintail (*Anas acuta*), Common Teal (*Anas crecca*), Red crested pochard (*Netta rufina*) and Tufted Duck (*Aythya fuligula*) recorded the marshy area of Beldal, Nuanai river mouth, Chandrabhaga, Balukhand, Kadua and Prachi river (Fig. 6) and some water dependant bird recorded during the Konark, Chandrabhaga, Ramachandi Nuanai river mouth and Balukhand area (Fig. 7-9) and also some terrestrial bird also recorded in Nadiamatha, Bankimuhan near Puri in the west and Keluni Muhan (Prachi river mouth) near Daluakani in the East, Baliguali, Balipatana, Beldal, Beleswarpatana Kadua and Prachi River with multiple coloured photographs (Fig. 10-13).

The total sanctuary is hardly 87 Sq. Km which include private land, habitations etc. Heavy anthropogenic pressure in the sanctuary is surrounded by 45 well populated villages with more than 20,000 populations. The sanctuary is a hot spot of tourist activity. Besides the marine drive road either passes through or adjoins the sanctuary boundary. This has resulted in high traffic flow. Pressure not only on the sanctuary forests, but also on the private land included in the sanctuary and land bordering the sanctuary along the marine drive road due to its proximity to two tourist centers, i.e. Puri and Konark temple are the famous tourist spots located outside the sanctuary. Increase tourist activity round the year as a serious threat to the birds and other wildlife of this sanctuary. About 22,000 domestic cattle of the adjoining villages used to graze in the sanctuary as there is hardly any pasture available to divert the cattle population out of the sanctuary. All the domestic cattle of encroached villagers are also dependent on the sanctuary for grazing and browsing, thereby causing great damage to forest regeneration. Dependency of the local villages on the forest for their daily household fuel requirement and lucrative cashew nuts of the plantation in the sanctuary also creating adverse conditions for these

a. Athene brama

b. Bubo coromandus

c. Otus bakkamoena

d. Strix ocellata

e. Tyto alba

f. Bubo zeylonensis

Fig. 4 (a-f). Some nocturnal birds in Balukhanda-Konark Wildlife Sanctuary, Puri

g. Haliaeetus leucogaster

h. Accipiter badius

i. Pandion haliaetus

j. Oriental honey buzzard

k. Milvus migrans

l. Haliastur indus

Fig. 5 (g-l). Some birds of prey in Balukhanda-Konark Wildlife Sanctuary, Puri

m. Anser indicus

n. Nettapus coromandelianus

o. Anas acuta

p. Anas poecilorhyncha

q. Sarkidiornis melanotes

r. Tadorna ferruginea

Fig. 6 (m-r). Some migratory birds in Balukhanda-Konark Wildlife Sanctuary, Puri

s. Charadrius leschenaultii

t. Esacus recurvirostris

u. Actitis hypoleucos

v. Chlidonias hybrida

w. Gallinago gallinago

x. Calidris temminckii

Fig. 7 (s-x). Some water dependent birds in Balukhanda-Konark Wildlife Sanctuary, Puri

y. Nycticorax nycticorax

z. Ixobrychus flavicollis

aa. Plegadis falcinellus

ab. Anastomus oscitans

ac. Mycteria leucocephala

ad. Ardeola grayii

Fig. 8 (y-ad). Some water dependent birds in Balukhanda-Konark Wildlife Sanctuary, Puri

ae. Halcyon smyrnensis

af. Alcedo atthis

ag. Halcyon capensis

ah. Ceryle rudis

ai. Motacilla citreola

aj. Motacilla alba

Fig. 9 (ae - aj). Some water dependent birds in Balukhanda-Konark Wildlife Sanctuary, Puri

ak. Caprimulgus asiaticus

al. Nectarinia zeylonica

am. Terpsiphone paradisi

an. Amandava amandava

ao. Megalaima haemacephala

ap. Pastor roseus

Fig. 10 (ak-ap). Some terrestrial birds in Balukhanda-Konark Wildlife Sanctuary, Puri

aq. Oriolus oriolus

ar. Motacilla maderaspatensis

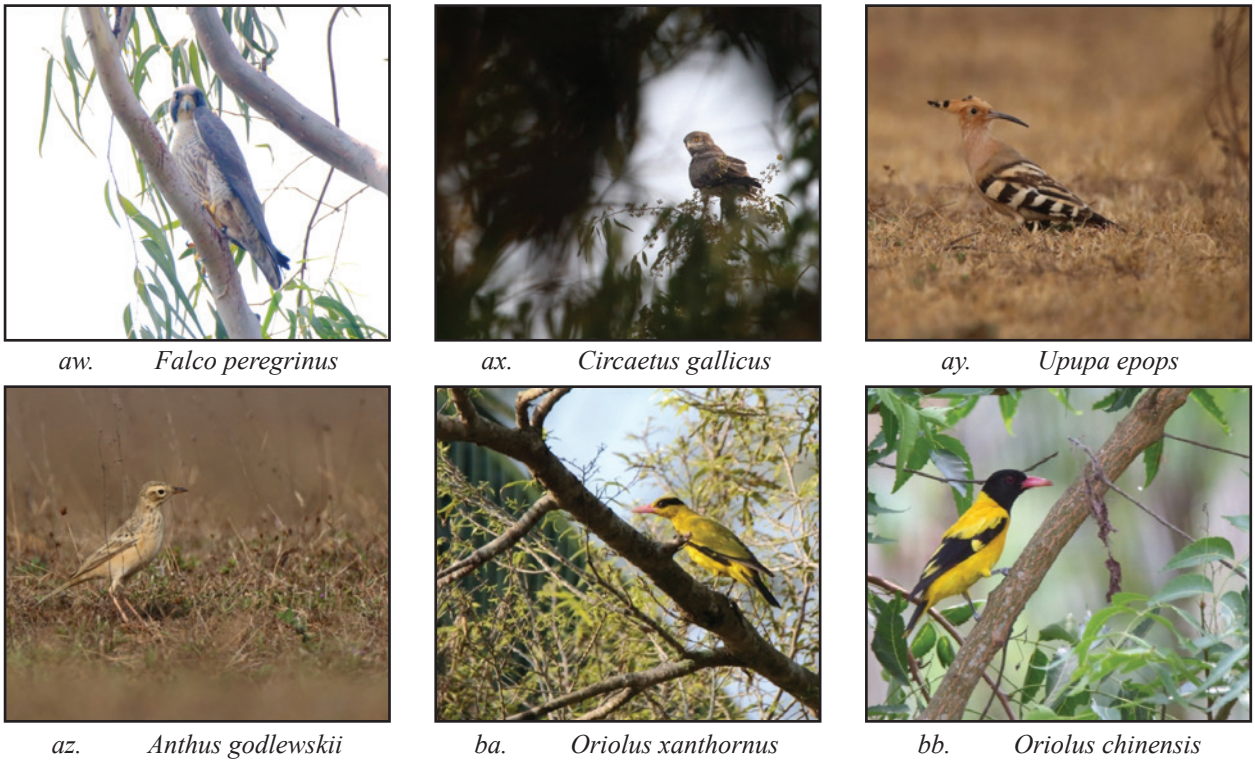
as. Lonchura malacca

at. Lonchura malacca

au. Glareola lactea

av. Anthus rufulus

Fig. 11 (aq-av). Some terrestrial birds in Balukhanda-Konark Wildlife Sanctuary, Puri



aw. Falco peregrinus *ax. Circaetus gallicus* *ay. Upupa epops*

az. Anthus godlewskii *ba. Oriolus xanthornus* *bb. Oriolus chinensis*

Fig. 12 (aw-bb). Some terrestrial birds in Balukhanda-Konark Wildlife Sanctuary, Puri

bc. Eremopterix griseus *bd. Mirafra assamica* *be. Merops philippinus*

bf. Sturnia pagodarum *bg. Celeus brachyurus* *bh. Clamator jacobinus*

Fig. 13 (bc-bh). Some terrestrial bird in Balukhanda-Konark Wildlife Sanctuary, Puri

birds of this region. Whatever barren land including gochar available in these villages have been planted with cashew which is an attractive cash crop, inter planted with casuarina to supplement the firewood requirements. This has resulted in reduction of fodder availability to the wild animals. It is therefore necessary to create grazing pastures in the village gochar land as eco development activity to reduce pressure on the sanctuary. Fishing in sea and in river mouth endangering to the wildlife in river mouth areas i.e white bellied sea eagle, fish eagle etc. Heavily populated habitations nearby and heavy and increased biotic pressure on the sanctuary. Forest fire is one of the most widespread and important factor of habitat destruction and it occur annually, predominantly during summer. These can be detrimental to breeding ground birds. Due to fire many of birds are killed and eggs are destroyed. Awareness programmes among to the general public or Vana Sarakhyana Samiti (VSS) and Eco Development Committee members, school students are being raised to join with department to conserve it for future generation. The present study shows that the loss of suitable habitat due to the forest fire strongly affected the numerical strength as well as divesting of the species. In addition, the species is protected by low and we are lucky so for that contamination by pollution is generally low. However, there are local threats of shooting and poisoning, tree felling, accident at fish farm and excessive disturbance of breeding from residential development and recreational activities.

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Carbon sequestration potential of *Eucalyptus* spp.: A review

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ABSTRACT

Climate change has become an important and sensitive environmental issue that has captured the global attention of many intellectuals during the recent past. The increasing concentration of carbon dioxide in the atmosphere is believed to have contributed significantly to the climate change. Among all the available options, the use of perennial woody vegetation is an efficient, cost-effective and environmental friendly strategy for storing and sequestering the atmospheric carbon. According to the Kyoto Protocol, an international agreement, carbon sequestration through afforestation and reforestation by long-term rotational tree crops are potentially mitigation strategies as carbon credit for many countries to meet their commitments of green house gas emissions reduction. Besides, the wood production from agro-forestry plantations will reduce pressure from timber extraction in natural forests. Therefore, the tree like *Eucalyptus* spp. has been selected for the study to provide both the benefits not only for harvesting the year round and for mitigating the climate change to compensate green house gas emission but also for sequestering the atmospheric carbon. The study concluded that the *Eucalyptus* plantations have significant contribution in carbon sequestration potential.

Key words: Carbon sequestration, climate change, *Eucalyptus*, fast growing, short rotation

INTRODUCTION

Carbon sequestration (CS) through sink enhancement by way of integration of trees into landscapes is one of the cost effective mitigation strategies. Land-use, Land-use Change and Forestry (LULUCF), an approach that became popular in the context of the Kyoto protocol, allows afforestation and reforestation as greenhouse gas (GHG) offset activities (Nair et al., 2011). Climate change evident linked to human induced increase in GHGs concentrations is well documented (IPCC, 2001, 2007). The total global potential for afforestation and reforestation activities for the period 1995-2050 is estimated to be between 1.1 and 1.6 Pg C per year, of which 70% could occur in the tropics (IPCC, 2000). Afforestation and reforestation are seen as potentially attractive mitigation strategies, as wood production and carbon (C) storage can be combined. United Nations Framework Convention on Climate Change (UNFCCC) has recognized the importance of plantation forestry as a greenhouse gas mitigation option as well as the need to monitor, preserve and enhance terrestrial carbon stocks (Updegraff et al., 2004). However, there is a large variation in the carbon sequestration potential of different plantation species and there are varying estimates of the carbon sequestration rates of

common plantation species (FAO, 2003; Negi and Chauhan, 2002). Short rotation tree crops, either as farm forestry or agroforestry systems, are considered an effective means to mitigate the greenhouse effect, due to their ability to accumulate substantial quantities of carbon in vegetation in a limited period. In addition, production from plantation forests may relieve pressure on timber extraction from natural forests, and thus contribute to forest conservation (Prasad et al., 2012). Significant carbon stocks are stored in plantations in the tropical and temperate regions (Malhi et al., 2008). Short rotation tree plantations grow rapidly, give high yields and are a significant source of raw material for the industry. Fast growing species yield at least 10 m^3 ha^{-1}, usually a mean annual increment is between 20 and 30 m^3 ha^{-1} or even more. Plantations make good financial sense and the returns of investments on *Eucalyptus* plantations are generous (Bauhus et al., 2010). Carbon sequestration mitigates CO_2 emissions in the long term and in this way contributes to reducing the effects of climate change. Intensively managed forest plantations grow faster and simultaneously produce more biomass than many natural forests. Due to this fast growth rate a plantation have better potential for carbon sequestration than a native forest. Plantations also alleviate the pressure on harvesting of natural forests (Evans and Turnbull, 2004; IPCC, 2007; Kaul et al., 2010). High carbon sequestration potential is an important consideration in all tropical tree planting programmes. This is particularly significant in view of the rising CO_2 levels and the growing need to sequester it. The carbon storage is intricately linked with site quality, nature of land use, choice of species, silvicultural and other crop management practices adopted (Swamy et al., 2003; Mandal et al., 2013). Mandal et al. (2013) estimated current annual carbon increment (CACI) to be highest under a study undertaken at Shreepur public plantation in Mahottari district of Nepal with recommended sites following package of silviculture adopting right agronomical practices. The most recent Intergovernmental Panel on Climate Change (IPCC) assessment reports a net carbon sink of 1.4 + 0.7 Pg C per yr in the terrestrial ecosystems in the 1990s, offsetting about 20% of the global carbon emissions from fossil fuel combustion and cement production. Wood products have a potential role in the mitigation of greenhouse gas emissions, either acting as carbon pools and sinks or by substituting more energy intensive construction materials and fossil fuels (Burschel et al., 1993; Schlamadinger and Marland, 1996).

With an increasing concern for global climate changes resulting from more and more anthropogenic greenhouse gas, protecting carbon stocks in the existing forests and getting the new carbon stocks through afforestation and reforestation have become the important measures to enhance the carbon sequestration capacity in the terrestrial ecosystems and mitigate the increasing carbon dioxide concentration in the atmosphere (Lal, 2005). Pattnayak et al. had a comprehensive study on different forest types of world and their vegetation pattern which acts like a major carbon pool of terrestrial ecosystem. The growing or regenerated forest lands store and sequester more carbon through rapid growth of canopy cover and above ground biomasses. Global forest plantation cover was 187 million ha in 2005, about 1.4% of the total world available land area, of this planted area, 36% forest was located in the tropics and 64% in the non tropical regions. The tropical forest plantation area was more than doubled from 1995 to 2005 and on average, the growth rate of tropical forest plantations was 8.6% per year (FAO, 2006; Arias et al., 2011). Plantation forests are important sources of timber that alleviate the pressure on native forests for commercial forest products and are viewed as an effective means of short term carbon sequestration (Turner et al., 1999; Curlevski et al., 2010). Global warming risks from emissions of green house gases by anthropogenic activities have increased the need for the identification of ecosystems with high carbon sink capacity as an alternative mitigation strategy of terrestrial carbon sequestration. The plantation technology sector has received recent attention for its enormous potential carbon pools that reduce carbon emissions to the atmosphere. Global warming is among the most dreaded problems of the new millennium. The carbon emission is

supposedly the strongest casual factor for global warming. Trees are important sinks for atmospheric carbon i.e. CO_2, since 50% of their standing biomass is carbon itself (Ravindranath et al., 1997). Trees like *Eucalyptus* can be harvested year round and provide a living inventory of available biomass. The main goal of this paper is to assess the carbon sequestration potential of *Eucalyptus* under different land use systems.

EUCALYPTUS

Eucalyptus spp. belongs to Myrtaceae family is one of the most widely planted exotics in the tropics and an important fast growing and short rotation tree species of India. There are more than seven hundred species of *Eucalyptus* which are mostly native to Australia (Holidy, 2002) and some 170 species, varieties and provenance of *Eucalyptus* were tried in India (Bhatia, 1984). It is estimated that about 80 lakh hectares of land is under cultivation of *Eucalyptus* in the country (Surya Prakash, 2008). *Eucalyptus* is the most favored plantation trees in Indian subcontinent due to its fast growth, suitability to all types of soils, adoptability to varying climatic conditions and tolerance to water logging, salinity and sodicity (Singh et al., 2014) and for their economic, ecological values and high survival traits (Joshi et al., 2013). *Eucalyptus* can grow up to the soil pH of 11.0, 9.2 and 8.8 in sandy soil, clay and loamy soils respectively (Gupta et al., 1990).

Several pulp and paper mills and forest development corporations have embarked on raising *Eucalyptus* plantations on a large scale. Farmers are also taking up planting of *Eucalyptus* in farm lands in view of its short rotation period and high economic returns. At present, the total planted area in India is around 8 M ha and these plantations were mostly of seed origin (Aregowda et al., 2010). The new clonal *Eucalyptus* plantations started appearing on the horizon since 1992 covering nearly 2,50,000 ha of land so far (ICFRE, 2011). There is a high demand for the *Eucalyptus* wood in India for various purposes like timber, pulp wood, fire wood and poles (Saxena, 1991). Commercial *Eucalyptus* plantations are important global assets providing wood and wood fiber products to modern societies and offer a wide range of social, environmental and economic benefits to millions of people. Wood is mainly used as an excellent source of pulpwood. It is also used as poles, scaffolding, transmission lines and in construction industry. Again, wood has been tried as timber in construction and furniture industry. *Eucalyptus* plantations raised on a shorter rotation for production of pulpwood provide maximum return. Due to its multiple uses, demand of *Eucalyptus* wood is increasing day by day. The clonal *Eucalyptus* trees yield more, clear, straight and knot free timber in comparison to normal seed rooted *Eucalyptus* and fetches better market price of the wood.

CARBON SEQUESTRATION POTENTIAL IN *EUCALYPTUS* PLANTATION

Eucalyptus, an important short rotation tree species fixes the atmospheric CO_2 into biomass and sequester carbon at a faster rate as compared to other short rotation forestry species. Various authors worked on the carbon sequestration aspect of *Eucalyptus* which is summarized for the better understanding. The contribution of trees outside forests toward wood production and environmental amelioration by *Eucalyptus* in the Punjab state was studied by Dogra (2011) which sequester carbon at the rate of 236.8 kg per tree at DBH and height of 30 cm and 24 m, respectively. Further, biomass production and carbon sequestration potential of fast growing multipurpose tree species, viz., *Albizia procera, Casuarina equisetifolia, E. tereticornis* and *Gmelina arborea* at 20 years stand age was reported by Madhusudanan et al. (2011). Among the four species, *E. tereticornis* fixes carbon of 114.36 Mg ha^{-1}. Likewise, Chauhan et al. (2009) explained that tree stem C storage (4.20 t ha^{-1}) and total C storage (9.36 t ha^{-1}) were recorded in *E. tereticornis* plantation. The estimated rate of C flux in selected planted forests in India, further planted forests of short rotation tree species with regular leaf shedding patterns have more capacity for C sequestering in litter which decomposes more rapidly than species with annual or bimodal leaf shedding patterns, mixed planted forests of exotic and native species could be more efficient in sequestering C than

monocultures and fast growing hardy species like *Eucalyptus* could be ideal choice for wastelands afforestation or reforestation. *Eucalyptus* with the highest capacity of total C flux in the planted area of 27.5 Mt C per yr (Raizada et al., 2003). According to Joshi et al. (2013) studied that the rate of carbon sequestration by *Eucalyptus* hybrid of 8 years plantation was 7.88 t C ha^{-1}per yr of the Terai region of central Himalaya. Due to fast growth rate and adaptability to a range of environments, short rotation plantations, in addition to carbon storage rapidly produce biomass for energy and contribute to reduced greenhouse gas emissions. The net annual carbon sequestration rates were achieved for fast growing short rotation poplar (8 Mg C ha^{-1} per year) and *Eucalyptus* (6 Mg C ha^{-1} per year) plantations followed by moderate growing teak forests (2 Mg C ha^{-1} per year) and slow growing long rotation sal forests (1 Mg C ha^{-1} per year) revealed by Kaul et al. (2010). The carbon content of *E. tereticornis* plantations was found to be 38.10 t ha^{-1} (one year plantation) and 115.88 t ha^{-1} (four year plantation) when estimated by biomass and carbon content per cent formula method by Ulman and Avudainayagam (2014). Chavan and Rasal (2011) worked on carbon sequestration potential of *Eucalyptus* spp. in the Aurangabad city, found sequestered carbon stocks in above ground biomass is of 254.50 t ha^{-1}. Study also revealed clonal plantation of *Eucalyptus*, have got more potentiality to sequester carbon. Ram et al. (2011) found *E. tereticornis* clones planted in strip manner in water logging site of Haryana sequestered carbon total of 15.5 t ha^{-1} after the age of 5 years 4 months.

CARBON SEQUESTRATION POTENTIAL OF EUCALYPTUS IN DIFFERENT AGRO-FORESTRY SYSTEMS

Eucalyptus is adopted as a multipurpose tree species (MPTs) in different agroforestry systems particularly in the agrisilvicultural and silvipastoral system. *Eucalyptus* is raised for pulpwood, plywood and as an api-silviculture purpose in agroforestry. Furthermore, various authors carried out for the CS potential of *Eucalyptus* in agroforestry condition to estimate the environmental service. Carbon sequestration potential of *Eucalyptus* based agroforestry systems sequester C to the tune of 34 Mg C ha^{-1}. Carbon sequestration estimates of all the systems were made in line with their biomass production potential. CO_2 mitigation by plant is directly related to biomass production of the different plant components. Higher carbon stock value of system can be attributed to more biomass in any system (Prasad et al., 2012). Further, the carbon sequestration (t ha^{-1}) by different agroforestry systems was studied in Navsari, Gujarat. Among seven agroforestry systems maximum above ground (34.05 t ha^{-1} per year), below ground (8.85 t ha^{-1} per year) and total (42.90 t ha^{-1} per year) C was sequestered in spider lily + *Eucalyptus* system (Panchal, 2013). Similarly, the total carbon sequestered by agroforestry systems was highest (47.87 t ha^{-1} per year) in the *Eucalyptus* + Spider lily system. Average sequestration potential in agroforestry systems has been estimated to be 25 t C ha^{-1} (Sathaye and Ravindernath, 1998). Total carbon sequestration occurred in *Eucalyptus hybrid* + wheat boundary plantation based agroforestry system of 8.53 t C ha^{-1} and carbon sequestration rate of 0.88 53 t C ha^{-1} per year was reported by Yadava (2010). *Eucalyptus* clones in the tree plantation land use system has the maximum carbon sequestration potential of 106.27 t ha^{-1} per yr as compared to tree species like *Manilkara zapota, Mangifera indica, Tectona grandis, Albizia procera, Casuarina equisetifolia, Dalbergia latifolia, Jatropha curcas, Terminalia arjuna* and minimum of 7.55 t ha^{-1} per yr in *Manilkara zapota* in tree plantation land use system. Likewise, Singh and Pandey (2011) estimated net annual carbon sequestration in agroforestry crops indicate that components with the highest rates in India are poplar, *Eucalyptus* and bamboo (species in the Bambusae tribe). They also established that tropical home gardens have a particularly high carbon sequestration potential of 16-36 Mg t ha^{-1} per yr.

CONCLUSION

Under the present scenario of climate change, short rotation, fast growing tree species are mostly recommended in the different land use systems. *Eucalyptus* meets these requirements and

a cost effective measures to mitigate the problem of climate change by environmental services along with other primary produces. It covers an area of 2.5 lakh hectare at national level with an average carbon sequestration of 9.62 - 11.4 t ha^{-1}. Along with that *Eucalyptus* serves wide range of environmental services.

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Factors influencing establishment of teak (*Tectona grandis* Linn. f) plantation: A review

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ABSTRACT

Teak, the most valuable timber species of tropics, covers about 4.346 million ha of forest and represents 75% of high tropical hardwood plantations. Considering its importance, the species is now introduced in large areas outside its natural ranges such as Indian subcontinent and south eastern Asia. Due to large natural range, the local factors vary significantly. Teak is a light adoring species and found in areas with rainfall varying from 500 mm to 5000 mm and in temperature ranges of 2°C to 48°C. Well drained alluvial soil with acidic pH (6.5), made of volcanic origin and with high limestone content is good for better growth of the species. The productivity of a plantation can be largely improved through the selection of a correct site for the plantation programme. Presence of different macro and micronutrients affect the anatomical properties of wood of this species. According to its growth performance in different countries different sites qualities are present like poor, moderate and good. Teak is a species of tropical summer rain climate is generally absent in dipterocarp forest. Due to huge profitability of the timber species sometimes the agriculture lands are converted into plantation area. It is found that factors like climate (rainfall, temperature, light etc.) and edaphic (soil physical and chemical properties, topography etc.) should be taken in to consider before selection of site, as its rotation period is too long.

Key words: Climate, ecological significance, geology, site condition, soil, *Tectona grandis*

INTRODUCTION

Teak (*Tectona grandis* Linn. f) is an important plantation species and is one of the most valuable timber species in the tropics where it is grown in over 2.25 million ha. The reputation of teak timber is due to its matchless combination of qualities such as durability, strength, attractiveness, workability and superior seasoning capacity. It has been widely planted both within its home range and in other tropical regions. Global forest area covers 3,999 million ha (30.6%) of land and about 299 million ha (7%) of this is planted forest. It had been increased by 105 million ha since 1990 (FAO, 2016). Teak forest constitutes about 4.346 million ha and represents 75% of high tropical hardwood plantation, 83% of which is in tropical Asia (IUFRO, 2018). It is one of the most important, widely planted members of Verbenaceae family (Robertson and Reilly, 2006). However, successful teak plantations are only found in discontinuous regions within the tropical climate zones (Kyaw et al., 2020). This is also the main cause that site selection is given priority for a successful teak plantation.

In order to clarify the site conditions suitable for teak plantations, it is important to determine the main factors controlling the growth of teak. Kaosa-ard (1981) considered that climatic factors like rainfall, temperature, light and edaphic factors like parent material, soil moisture, soil physical and chemical properties were important controlling factors for the natural distribution of teak (Deb et al., 2017). It is most important to analyze the

interrelationships between the distribution, growth and site conditions to determine these controlling site factors. Using information from the literature, this study gives idea of the site conditions of teak forests to define suitable and limiting conditions of climate and soil as site requirements of teak.

NATURAL DISTRIBUTION OF TEAK AND CLIMATE

Naturally, teak is distributed in limited regions of south and Southeast Asia discontinuously, covering the Indian Peninsula, Myanmar, northern and western Thailand and northwestern Laos along the northern Thai border, as well as central and eastern Java where teak was introduced about 400-600 years ago. Teak is found in area from 73° E longitude in India to 104°30' E in Thailand, and from about 25°30' N latitude in Myanmar to its southern boundary from 9° N latitude in India. Natural distribution areas of teak are presented in Fig. 1 and Fig. 2. The teak distribution areas are included in zones of the tropical climate with summer rain (Walter, 1979). Zonal vegetation of this climate type is generally tropical deciduous forests which are underlain by zonal red clay or red earth soils. Teak is a characteristic species of tropical monsoon forests, which become partly or completely leafless in the dry season. It is important to note that the distribution of teak is not accurately found in all the area of this climate type. This suggests that rather than climatic factors, edaphic factors also control the distribution of teak significantly in the tropics (Deb et al., 2017).

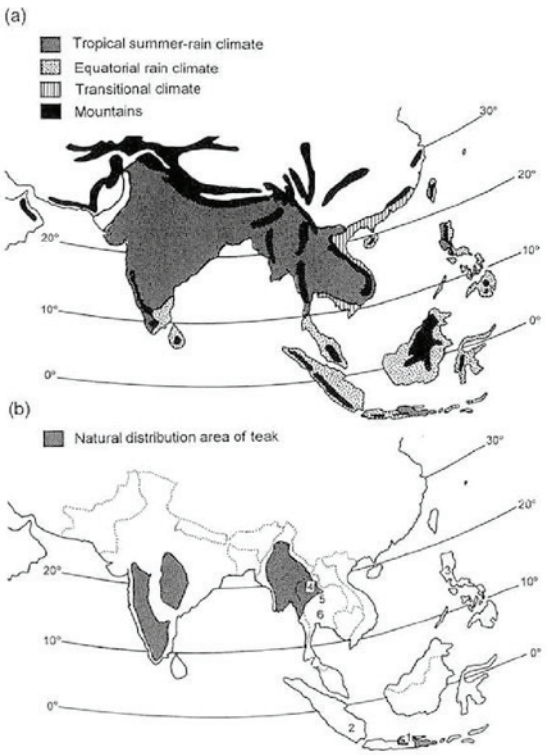

Fig. 1. Maps of (a) climate types (b) Natural distribution of teak. The numbers in the map (b) indicate the locations of teak plantations as: 1. Cepu, 2. Benakat, 3. Carranglan, 4. Lam pang, 5. Dong Lam, 6. Klang Dong, 7. Khao Chong

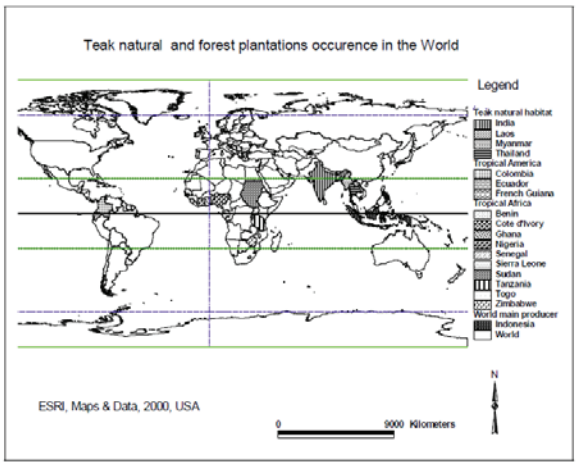

Fig. 2. Teak natural and forest plantation occurrence in the world

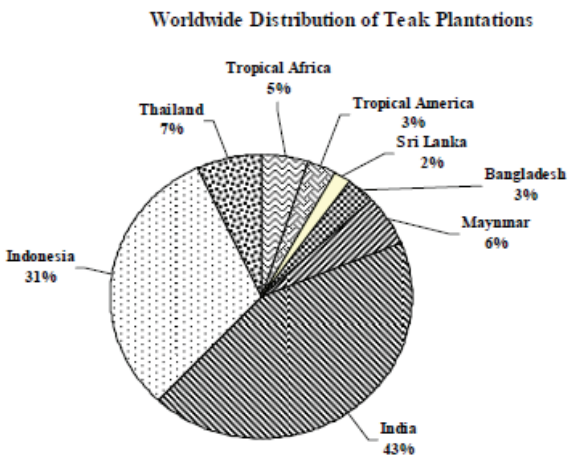

Fig. 3. Worldwide distribution of teak plantations indicating it's maximum distribution in India, Indonesia and Thailand

FACTORS CONTROLLING DISTRIBUTION AND GROWTH OF TEAK

There were many factors controlling the distribution and growth of teak viz. rainfall or soil moisture, temperature, light, geological formation and soil conditions (Troup, 1921; Deb et al., 2017; Rizanti et al., 2018).

CLIMATIC REQUIREMENTS

Rainfall

Teak occurs naturally over a wide range of climatic conditions, from very dry localities with annual rainfall as low as 500 mm (e.g. in Khandesh, Nimar and West Kurnool in India) to very moist localities with annual rainfall as high as 5,000 mm, e.g. on the west coast of India (Seth and Khan, 1958). Its growth is best and reaches large dimensions in a warm-moist tropical climate with rainfall ranging from 1,270-3,800 mm per annum (Kaosa-ard, 1981). However, for the production of good timber qualities, the species requires a periodic marked dry period of 3-5 months.

Studies on ecology of the teak forests in India, Seth and Khan (1958), and Champion and Seth (1968) classified the teak forests in India by correlating the amount of annual rainfall, stand composition and the qualities of teak into five types.

1. Very moist teak forest: Rainfall over 2,500 mm per annum; deep alluvial or sedimentary loams often clay soils; low (<10) percentage of teak; very dense evergreen undergrowth; little natural regeneration; no fires.

2. Moist teak forest: Rainfall 1,600- 2,500 mm per annum; deep loamy soils; fair to medium (10-25) percentage of Teak; dense undergrowth; air but patchy -natural regeneration; no fires.

3. Semi-moist teak forest: Rainfall 1,300-1,600 mm per annum; moderately deep and loamy soils; medium to high (20-60) percentage of teak; moderate undergrowth; fairly adequate natural regeneration; occasional fires.

4. Dry teak forest: Rainfall 900-1,300 mm per annum; shallow or sandy or stiff clayey top-soil soils; high (50) percentage to almost pure stand of teak; light and patchy undergrowth; group or patchy natural regeneration; frequent fires.

5. Very dry teak forest: Rainfall less than 900 mm per annum; poor shallow and rapid run-off or drainage soils; medium percentage of Teak; scanty ground cover; practically absent natural regeneration; annual fires.

Temperature

Temperature is one of the most important factors controlling distribution, growth and development of teak in natural condition. Teak occurs in locality where the maximum temperature may be as high as 48°C for the hottest month to minimum temperature may be as low as 2°C for the coldest month (Seth and Khan, 1958; Haig et al., 1958; Champion and Seth, 1968). Teak growth appears to be best in the localities with the mean monthly maximum temperature of about 4°C and mean monthly minimum temperature of about 13°C (Haig et al., 1958).

Light

Several studies indicated that teak is a light demanding tree species; in other word this species is intolerant of shade (Troup, 1921; Kermode, 1957; Qureshi, 1964; Bhatnagar, 1966; Kadambi, 1972; Nwoboshj, 1972). Studies on natural regeneration of Teak, Troup (1921) and Kermode (1957) reported that the major causes for the failure in natural regeneration was inadequate light at the ground level of the moist teak forests. Day-length or photoperiod seems to have little effects on growth and development of teak seedling (KoKo, 1972; Kanchanaburangura, 1976).

EDAPHIC FACTORS: TOPOGRAPHY, GEOLOGY AND SOIL

Teak is capable of growing over a wide range of edaphic conditions. The quality and distribution of natural teak is related to the nature of edaphic conditions of its growing area (Tewari, 1995; Rizanti et al., 2018). According to Mahaphol (1954), the majority of teak forests are located on hilly or undulating grounds with well-drained soil. Teak forests are also found in well-drained alluvial

plains along the river banks. Teak does not tolerate stiff clay soil and waterlogged areas, and does not thrive on excessively dry sandy soils as well. Teak does not occur on lateritic soil (Troup, 1921) and its growth is stunted in shallow soils and on ridge tops (White, 1991).

A quantitative study on relationship between geological formation and natural occurrence of teak on the northern slope of Satpuras in India had done by Kulkarni (1951). It is found that teak is definitely associated with rocks of volcanic origin and it grows better on basic rocks than acidic rocks. Limestone areas are usually suitable for teak growth because of high pH, high base content and adequate drainage of soil. However, hard, slowly disintegrating limestone with shallow soil leads to poor growth (White, 1991). On alkaline soils with pH values ranging from 7.5-8.5, teak deteriorates in qualities, and above a pH level of 8.5 the presence of excess alkalis in soils seemed to be definitely toxic toward teak growth. Several studies conducted in Thailand have shown that the soil which is suitable for teak is generally acidic. The pH values of the top-soils (at the A-horizon) throughout the natural teak forests in Thailand are ranging between 6.2 to7.0, with an average value of about 6.5 (Bloch, 1958). This average pH value is still in the range of teak soil pH requirement as proposed by Kulkarni (1951).

The most suitable soil conditions consists good drainage, deep subsoil, slightly acid to alkali and high base content, especially calcium. These soil conditions can be found in soils derived from limestone, base-rich igneous rocks and alluvial materials.

Table 1. Soil characteristics data of different countries under teak plantation areas

Country	Soil texture	Soil type	Parent rock	pH	Reference
Myanmar	Sandy loam	-	-	6.5-7.5	Pandey and Brown (2002)
India [central (failed)]	Clay	Vertisol	Basalt	-	Chandrashekhar (1996), Shah (2001), Pande (2004), Bhat and Hwan (2007)
India [South (Chhindwara)]	Sandy loam	-	Alluvium	7.9	
India [South (Nilambur)]	Sandy loam	-	Laterite	-	
NW Costa Rica	Clay loam	-	-	5.2	Perez (2005), Perez and Kanninen (2005), Alvardo (2006)
Benin	Clay	Calcic	Clay, Marls	5.5-8	Drechsel et al. (1991)
Liberia	-	Cleysols	Granite	3.8-5.9	
Cote d' Ivoire	Clay Loam	-	Gneiss	-	Poorter et al. (1994)

The worldwide suitability of growing teak in tropical country can be seen in Table 1. Teak grows well on sandy loam soil implying good water drainage with a depth > 90 cm. and near neutral status of pH between 6.5-7.5 (Alvarado, 2006).

SOIL PROPERTIES AFFECTING ANATOMICAL PROPERTIES OF WOOD

The physical and chemical soil properties are associated to the cell division and differentiation of cambial cells, and this interaction is influenced as well by environmental or ecological conditions (Dünisch and Bauch, 1994, Aguilar-Rodriguez et al., 2006). Wood properties were influenced by few physical and chemical soil properties. The phosphorus in the soil up to 30% of the normal tangential shrinkage, complemented by the limo content representing 9.5% of the total variation, while variations in Normal Radial Shrinkage were explained by iron content (40%) and by limo content (15.1%). Green density was explained only in 8.5% by the zinc content, while the heartwood content was related to DBH (30.6%) and Plantation density (6.5%) but not to any soil characteristic. Pith percentage, a considerably important wood property (or wood defect) was slightly correlated to tree age (16.7%) and calcium content (14.9%) (Dünisch and Bauch, 1994).

Fig. 4. Nilambur teak plantation, Kerala, India

Fig. 5. Barbara teak plantation, Odisha, India

Fig. 6. Teak plantation in Thailand
Source: https://www.123rf.com/photo_19112517_teak-trees-in-an-agricultural-forest-thailand.html

Fig. 7. Teak forest at Java Island
Source: heru017.blogspot.com

TEAK PLANTATIONS IN VARIOUS SITE CONDITIONS

The site for teak plantation should be carefully selected, e.g. through species, site matching. Within a planting zone, the effect of site quality on plantation growth may be demonstrated through the construction of Site Index curves. Difference in diameter growth of teak grown in different site qualities, both within and outside the natural distribution range of teak studied by Koasa-ard (1998). He reported that in poor site condition the DBH of teak is 11.7 cm, 19.8 cm, 27.4 cm, 34.0 cm, 39.9 cm and 45.0 cm in 10, 20, 30, 40, 50 and 60 years of age while in good site qualities the diameter at breast height is generally higher than poor site qualities i.e. 14.7 cm, 27.2 cm, 38.4 cm, 47.8 cm, 55.4 cm and 60.7 cm. Similarly, in Thailand, the reported DBH of teak in 10, 20, 30, 40, 50 and 60 years varies in poor and good site qualities. In poor site areas it is 7.2 cm, 12.7 cm, 16.2 cm, 19.2 cm, 21.5 cm and 23.8 cm respectively where as in good site quality area it is 15.0 cm, 22.9 cm, 27.7 cm, 31.4 cm, 33.9 cm and 36.7 cm respectively. In Cote d' Ivoire reported DBH growth in poor qualities areas are 15.0 cm , 22.0cm, 26.7 cm in 10, 20 and 30 years of age respectively while in good site qualities it is 30.2 cm, 44.0 cm and 52.5 cm. The DBH growth of teak in Sri Lanka varies in poor and good site qualities areas. In 10, 20 and 30 years of age the DBH of teak is 13.4 cm, 19.2 cm, and 25.5cm in poor site quality while in good site quality these are recorded slightly higher i.e. 17.0 cm, 26.0 cm and 34.0 cm.

In the above findings of Koasa-ard, the increment in DBH of teak in India in poor site was about 33.3 cm while in good site it was achieved about 46 cm in 60 years of time period. In Thailand the 60 year time period DBH increment is about 16.6 cm and 21.7 cm in poor and good site qualities respectively. Similar results have also seen in Cote d' Ivoire and Sri Lanka in poor and good site quality areas. So, taking this into consideration, we can conclude that in the increment in DBH is higher in good site quality areas than poor site qualities. The poor and good site qualities might be because of different site factors and as well as quality of planting materials which had direct impact on DBH in the different studied areas.

The growth of teak plantations in Bago and Paukkaung township, Myanmar

Hlaing and Teplyakov (2013) studied the teak plantation at the age of 10, 15 and 20 years old in Bago and Paukkaung Township, Myanmar. After soil analysis, it is found that in both plantations pH is acidic (i.e. about 6.1). In Bago, total nitrogen percentage of 0.063 %, phosphorus percentage of 0.0003%, potassium percentage of 0.005%, calcium percentage of 0.15%, organic matter of 3.11% was recorded. In Paukkaung, the recorded total nitrogen percentage, phosphorous percentage, potassium percentage, calcium percentage and organic matter percentage are 0.047%, 0.0001%, 0.005%, 0.27% and 3.23% respectively.

They also studied different growth performance of both plantations. In both growth study at three different ages are recorded i.e. 10 years, 15 years and 20 years. In Bago, current stocking are 496, 523 and 280 trees ha^{-1} in 10,15 and 20 years while in Paukkaung the current stocking are 571, 505 and 307 trees ha^{-1} in 10, 20 and 30 years respectively. Recorded average DBH in 10,20 and 30 years are 10.0 cm, 14.1 cm and 20.6 cm in Bago and 13.7 cm, 15.2 cm and 21.5 cm. in Paukkaung. Similarly, recorded average height in 10, 15 and 20 years are 9.5m, 13.7m and 15.2m in Bago while in Paukkaung this is 12.0m, 14.3m and 14.7m. In Bago recorded total basal area are 5.31m2, 7.84 m2 and 12.0 m2 in 10,20 and 30 years of age while in same age range it was 11.16 m^2, 9.54m^2 and 11.83m^2 in Paukkaung plantation sites. Recorded total volume in Bago was 25.02m^3, 53.12m^3 and 82.08 m^3 in 10, 15 and 20 years respectively. In Paukkaung total recorded volume in 10, 15 and 20 years are 67.30m^3, 62.46m^3 and 79.12m^3 respectively. MAI and CAI of both sites are also recorded. In Bago, in 10,15 and 20 years the MAI are 2.78m^3 ha^{-1} per yr, 3.54m^3 ha^{-1} per yr and 4.77m^3 ha^{-1} per yr and CAI are 6.34 m^3 ha^{-1} per yr, 1.35 m^3 ha^{-1} per yr and 1.14 m^3 ha^{-1} per yr respectively. In Paukkaung, in

10,15 and 20 years the MAI are 6.73 m^3 ha^{-1} per yr, 5.21 m^3 ha^{-1} per yr and 3.84m^3 ha^{-1} per yr and CAI are 10.98 m^3 ha^{-1} per yr, 0.23 m^3 ha^{-1} per yr and 1.31 m^3 ha^{-1} per yr respectively.

From above analysis we can see that the site Paukkaung has more average DBH and average Height within same age period. So the soil properties for Paukkaung can be taken into consideration as these resulted good diameter and height increment than Bago. As the CAI, MAI, basal area and total volume depend on height and diameter these values are higher in site Paukkaung than Bago. The important growth parameters like average DBH, average height, total volume, MAI and CAI mainly more in the plantation site Bago which was directly influenced by different soil and its physical chemical properties of that particular site.

Growth and productivity of teak plantations and farmlands in coastal zone of Karnataka (India)

Shahapurmath et al., (2016) studied the growth performance and productivity potential of teak grown in pure plantation (G1) as well as in the farmlands (G2) at coastal zone of Karnataka in different age class (5-10 yrs, 11-15 yrs, 16-20 yrs and 21 to 25 yrs). Recorded height in G1 is 8.34m, 10.38m, 13.39m and 11.60m and in G2 is 8.24m, 14.05m, 13.39m and 11.95m in different age class i.e. 5-10 yrs, 11-15 yrs, 16-20 yrs and 21-25 yrs respectively. Similarly, recorded DBH in G1 is 15.34cm, 18.09cm, 20.15cm and 27.73m and in G2 is 18.94cm, 18.36cm, 24.14cm and 33.30cm in different age class i.e. 5-10 yrs, 11-15 yrs, 16-20 yrs and 21-25 yrs respectively. Recorded tree volume of G1 are 0.0154 m3, 0.267 m3, 0.428 m3,0.865 m3 in 5-10 yr, 11-15yr, 16-20 yr and 21-25 yrs respectively. Similarly, tree volume of G2 are 0.232 m^3, 0.275 m^3, and 0.643 m^3, 1.321 m^3 in 5-10 yr, 11-15yr, 16-20 yr and 21-25 yrs respectively. For timber volume in 5-10 yr, 11-15 yr, 16-20 yr and 21-25 yrs different values are recorded for G1 and G2. For G1 it was 0.055 m^3, 0.096 m^3, 0.228 m^3 and 0.363 m^3 and for G2 it was0.108 m^3, 0.111 m^3, 0.380 m^3 and 0.742 m^3.

These growth parameters have shown that teak grown in farmland was significantly higher than tree grown in pure plantation. This is due to good edaphic condition in farmland and less competition than pure plantation. So climatic and edaphic conditions have more impact on growth performance of teak.

Evaluation of plantation of teak grown in Sri Lanka

Wijenayakeet al. 2019 used the height-diameter and relative taper curves for estimation of planted Teak stands in dry and intermediate zones of Sri Lanka. Three sites are selected.

Site I: Punewa, a 44-year-old teak plantation which is in the Northernpart of Sri Lanka, with an average annual temperature of approximately 27°C. Poor silvicultural management due to inaccessibility to the field. Total number of trees was 3037 and density was recorded 152. Average DBH 32.0cm, average total height 17.5m, average bole 6.3m, normal form factor 0.391, average basal area at 1/10 height 0.0729 m^2 average total cubic volume 0.5m^3, Stand cubic 75.9 m^3 ha^{-1}, average merchantable volume 0.253m^3 and stand merchantable volume 38.5m^3 ha^{-1}.

Site II: Inamaluwa, a 51-year-old teak plantation which is located inthe middle part of Sri Lanka, with an average annual temperatureof approximately 26°C. Less silvicultural practices due to the threat of wild elephants. Total number of trees was 5830 and density was recorded 199. Average DBH 31.8cm, average total height 15.3m, average bole 6.1m, normal form factor 0.440, average basal area at 1/10 height 0.0721 m^2 average total cubic volume 0.486m^3, Stand cubic 96.6 m^3 ha^{-1}, average merchantable volume 0.253m^3 and stand merchantable volume 50.3m^3 ha^{-1}.

Site III: Monaragala, 48-year-old teak plantation where located in the intermediate zone with an average annual temperature of approximately 27°C. Silvicultural practices were followed according to standards of the Forest Department. Total number of trees was 2752 and density was recorded 205. Average DBH 27.7cm, average total height 19.7m,

average bole 11.2m, normal form factor 0.433, average basal area at 1/10 height 0.0526 m^2 average total cubic volume 0.449m^3, Stand cubic 91.9 m^3 ha^{-1}, average merchantable volume 0.301 m^3 and stand merchantable volume 61.6m^3ha^{-1}.

The analysis of different stand properties in different site qualities shows average DBH, average basal area are highest in site I. Total number of trees, normal form factors and stand cubic are better in site II than other site qualities. Density, average total height, average bole, average merchantable volume, and stand merchantable volume is highest in site III than other site conditions. So the change in edaphic and climatic condition shows variation in growth parameters.

Productivity comparison of *Tectona grandis* in different countries of tropics in different age

Raymond (1996) studied accumulated volume production of Teak in different countries of Tropics. In India accumulated volume production in 10, 20, 30, 40, 50, 60, 70 and 80 years are 123 m^3 ha^{-1}, 226 m^3 ha^{-1}, 318 m^3 ha^{-1}, 416 m^3 ha^{-1}, 500 m^3 ha^{-1}, 564 m^3 ha^{-1}, 616 m^3 ha^{-1} and 648 m^3 ha^{-1} respectively. In Indonesia accumulated Volume Production recorded in 10-80 years and he found that it increases gradually i.e. 207 m^3 ha^{-1}, 412 m^3 ha^{-1}, 591 m^3 ha^{-1}, 784 m^3 ha^{-1}, 880 m^3 ha^{-1}, 1002 m^3 ha^{-1}, 1106 m^3 ha^{-1} and 1200 m^3 ha^{-1} respectively. In Cote d' Ivoire accumulated volume production are 170 m^3 ha^{-1}, 295 m^3 ha^{-1}, 393 m^3 ha^{-1}, 489 m^3 ha^{-1} and 579 m^3 ha^{-1} in 10, 20, 30, 40 and 50 years. In Sudan, 97 m^3 ha^{-1} recorded in 20 years, 166 m^3 ha^{-1}, 182 m^3 ha^{-1}, 192 m^3 ha^{-1} recorded in 60, 70 and 80 years of age.

From the findings of Raymond we can see that, accumulated volume production of teak is highest in Indonesia followed by India in 80 years while Cote d' Ivoire is in 2nd place in 50 years after Indonesia and followed by India. Sudan shows lowest accumulated volume production after 80 years.

ECOLOGICAL SIGNIFICANCE

Teak is normally absent in dipterocarp forests regardless of whether the trees are evergreen or deciduous. Teak is naturally distributed within the tropical summer-rain climate. Under the equatorial rain climates of Southeast Asia, various evergreen *Dipterocarpus* spp. dominate, and teak and most other deciduous non-dipterocarp trees appear to be excluded under humid climates due to the competition with members of evergreen forests (Kyaw et al., 2020).

The discontinuous distribution of teak is attributed to the discontinuous occurrence of suitable intrazonal and azonal soils. On the other hand, deciduous *Dipterocarpus* spp. such as *Dipterocarpus obtusifolius*, *D. tuberculatus* and *Shorea siamensis* predominate in poor soils which are characteristically shallow, gravelly to sandy, or lateritic although they occur under the same climate type in the lndo-China region. Teak is distributed in the western and central parts of Peninsular India, where extensive areas of Vertisols and Chromic Luvisols developed mainly from Cretaceous-Eocene basalts or alluvium derived from them. The Vertisols are slight to moderately calcareous.

NATURAL AND ECONOMIC CONDITIONS FOR TEAK PLANTATIONS

Teak requires fertile soils for adequate growth. Suitable areas for teak plantations usually overlap with farmlands. Therefore, there are usually conflicts of land use between teak silviculture and agriculture because of the similar soil requirements of teak and the crops. For rational and productive land use, it is important to identify slight differences in soil requirements between teak and agricultural crops and to allocate every plot of land to the most suitable plant species.

The teak plantation area in Cepu, eastern Java, provides a good example, where teak plantations cover mainly hilly and drier areas whereas farmlands occupy alluvial plains and gentle slopes. Although teak also grows well in the agricultural areas, the cultivation of agricultural crops there is more profitable than teak plantations. In hilly areas, teak plantations may be more profitable because agricultural productivity decreases there to a greater degree than teak productivity due to less fertile soil conditions and differences in soil requirements

of teak and agricultural crops. In addition, it is important to establish forests on steep hills for soil conservation because the forested lands generally prevent soil erosion more than agricultural lands.

CONCLUSION

The productivity of a plantation can be largely improved through the selection of a correct site for the plantation programme. For the success of teak plantations, especially in areas outside of its natural distribution, it is most important to identify suitable sites for teak growth. The rotation period is also too high (minimum 40 years). Once a site is converted to plantation the complete output will be achieved after a long time period. So, these sites must be determined, based on factors of locality that includes, climatic factors (temperature, rainfall, etc.), edaphic factors (soil and geology). Climatic humidiy factors must be thoroughly analyzed as minute variation in each of the climatic factors can affect the establishment and success rate of the plantation. Apart from this, analysis of soil physical properties (drainage, texture, etc.) and chemical ones (pH, exchangeable cations, etc.) must be taken into consideration as they help to estimate the fertility of each site. In many instances, with constant climatic factors, variation in edaphic factors affect the species distribution significantly. Therefore, these factors of locality of plantation sites must be taken into consideration while introducing this species outside its natural area.

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   - **2.2. Author(s).** Author(s) name(s) should be typed in bold letters, first initials and then surname. Corresponding author's name should be specified by an asterisk mark . Serial numbers of authors to be superscripted on top right e.g. 1,2,3 representing the group of authors from the particular institution. Corresponding name of the of the institutions / place of work be given serially below the authors name. E-mail id be indicated below the detailed address.
   - **2.3. Abstract.** Maximum 200-300 words convening the objectives, methodology and the most important results.
   - **2.4. Key words.** Maximum of 5-6 key words should be provided for subject indexing.
   - **2.5. Introduction.** It should be concise and include the scope of the work in relation to the state of art in the same field along with specific objectives.
   - **2.6. Materials and Methods.** A full technical description of the methods followed for the experiment(s) should be given, providing enough information. Detailed methodology should be given when the methods are new while for standard methods, only references may be cited.
   - **2.7. Results and Discussion.** In this section, only significant results of the experiment(s) should be reported. Along with the tables and figures, the discussion should deal with interpretation of results and relate the author's findings with the past work on the same subject. The conclusions drawn should be explicitly listed at the end of this section.
3. **References.** Please refer "Misra, R.C., Pani, D.R., Kumar, P. and Das, P. 2018. Vegetation mapping and management strategy of mangroves of Bhitarkanika wildlife sanctuary, Odisha: A remote sensing approach. *e-planet* **16**(2): 89-101. Distinction for the same author and same year be done as 2017a, 2017b etc. Unpublished data, thesis and personal communication are not acceptable as references.
4. **Table.** Number the tables consecutively in Arabic numerals. Tables should have comprehensible legends. Conditions specific to a particular experiment should be stated. Zero results must be represented by 0 and not determined by n.d. The dash sign is ambiguous. For values <1, insert a zero before the decimal point.
5. **Illustrations.** All graphs, diagrams and half-tones should be referred to as Figure and should be numbered consecutively in Arabic numerals. The figures should either match with the column width (8.5 cm) or the printing area (17.8 x 22 cm). The legends should be brief and self-explanatory. All graphs, figures should be drawn by EXCEL and submitted in editable format. Define in the footnote or legend any non-standard abbreviations or symbols used in a table or figure.
6. **Reviews.** Full length review articles are also invited.

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