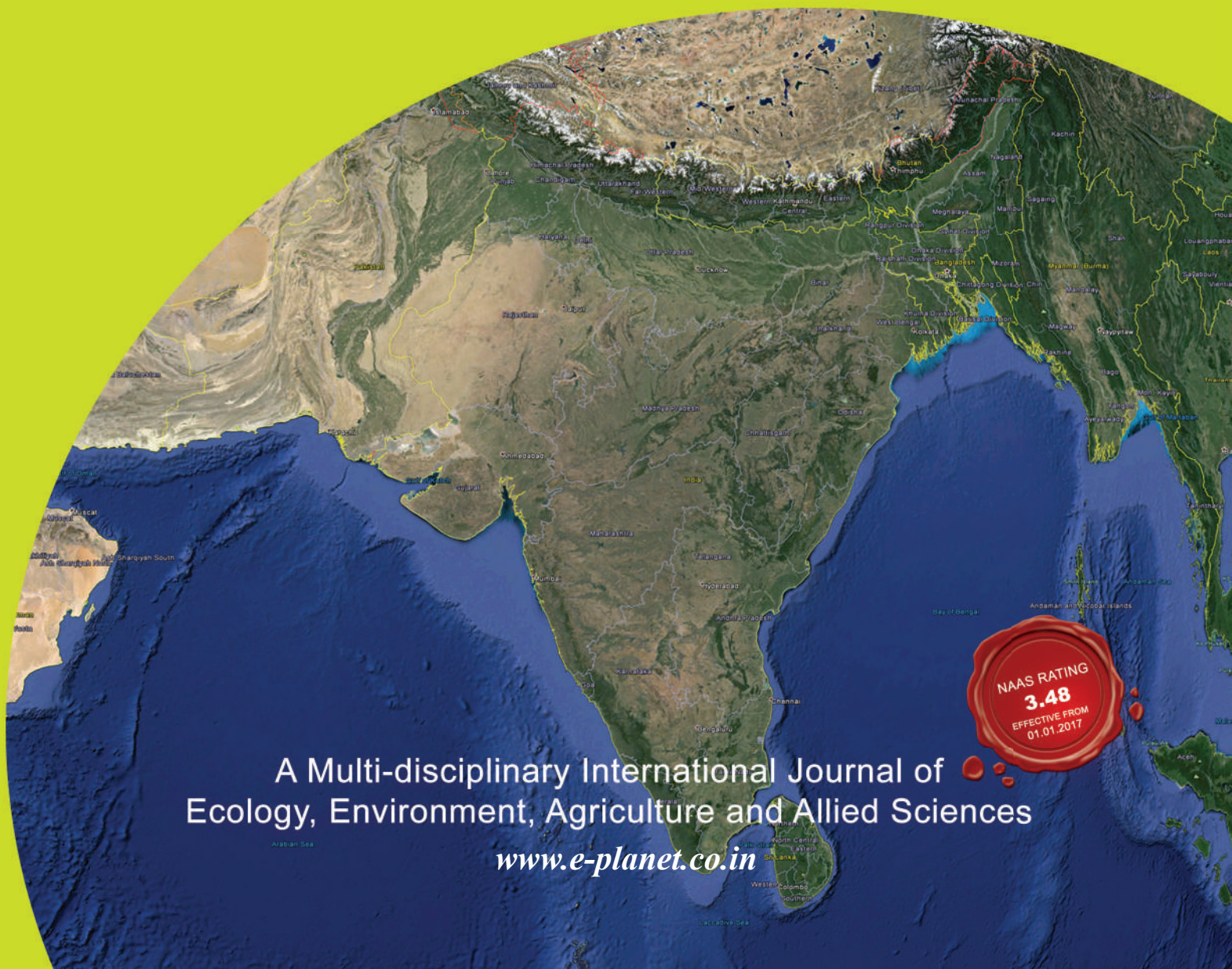
RNI No. ORI ENG / 2003 / 15643 / 22.11.2005

ISSN No. 0974 - 4398 / 2008

ORGANISATION FOR PROTECTION OF ECOSYSTEM ENVIRONMENT AND ENDANGERED SPECIES

# e-planet

Volume- 17 December - 2019 Issue No. - 2



NAAS RATING 3.48 EFFECTIVE FROM 01.01.2017

A Multi-disciplinary International Journal of
Ecology, Environment, Agriculture and Allied Sciences

*www.e-planet.co.in*

# Editorial Board




Financial assistance from Indian Council of Agricultural Research (ICAR), Krishi Bhavan, New Delhi for publication of this journal is gratefully acknowledged.

Printed, published & edited by Dr. R.K. Samantaray, 1(A), Nandankanan Zoo, P.O. Barang, Dist- Khurda, Odisha, India, Pin - 754005. Owned by the Organisation for Protection of Ecosystem, Environment and Endangered Species (OPES), Plot No. - A-47, Rameswarpatna, Maushima Square, Old Town, Bhubaneswar-751002, Odisha, India. Published and printed at Print-Tech Offset Pvt. Ltd., Bhubaneswar - 751024


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

**SUBSCRIPTION**

| | |
|---|---|
| Life Member (Individual) 15 yrs | – Rs. 5000/- |
| Life Member (Overseas)15 yrs | – USD 100/- |
| Life Member (Institutional) 15 yrs | – Rs. 30000/- |
| Patron (Individual) 15 yrs | – Rs. 20000/- |
| Patron (Institutional) 15 yrs | – Rs. 50000/- |

* Please send payment to : **OPES, Bhubaneswar** in shape of D.D. payable at Bhubaneswar


**ADDRESS FOR CORRESPONDENCE**
**Dr. R.K. Samantaray**
**Editor-in-Chief**
A - 47, Rameswarpatna, Maushima Square
Bhubaneswar - 751 002, Odisha
e-mail - eplanetjournal@gmail.com
Mob. : +91 9437090017 / 7008370017


**Please visit us at : *www.e-planet.co.in***

# e-planet

Volume - 17 December - 2019 Issue No. - 2


**A Multi-disciplinary International Journal**

**of**

**Ecology, Environment, Agriculture and Allied Sciences**

# CONTENTS

*e-planet* **17** (2): 89-97 (December 2019)

# Evolution of system of rice intensification (SRI) and economic security in Tripura state of North East hill region of India

**R. SINGH[1*] AND S.M. FEROZE[2]**

[1]*School of Social Sciences, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University, Umiam- 793103, Meghalaya, India*

[2]*College of Agriculture, Iroisemba, Imphal, Manipur, India*

**ramsingh.cau@gmail.com*

Date of receipt: 23.08.2019 Date of acceptance: 17.11.2019

**ABSTRACT**

India has developed a lot and production has taken momentum but parallel to this, the hunger index of India has not declined. Small-holder families constitute more than half of the national population. Many emerging site specific technologies have been initiated to enhance the production and nutritional status of the country. Among the technology, system of rice intensification (SRI) is one of them which has accelerated the livelihood of the farmers and also suitable for small operational holdings. A study to assess the impact of SRI on livelihood and nutritional food security in the state of Tripura, India has been conducted by collecting the primary data from 200 (100 SRI and 100 Non-SRI) smallholders household. Different indices were constructed to assess livelihood and food security. The SRI found highly economic beneficial method in production of rice in the state of Tripura with higher returns of 11.88 per cent difference between SRI and Non SRI farms. The method has impacted positively to enhance the food, nutrition, health and habitat. Moreover, adopted SRI households had 76 per cent better economic security than Non SRI household. Therefore, study recommend to realize its novelty through extension machinery of the state and also advocate developing a suitable package and practices with its economic benefits so that the SRI can get momentum to enhance area and production of the rice.

**Key words:** Economic security, evolution, food, SRI, Tripura

## INTRODUCTION

Agriculture employs about 60 per cent of the total workforce (FAO, 2013) of the world. The importance of this sector however, increases with diminishing resources for the ever-increasing global population (Brennan, 2012). The potential of agriculture for producing nutritious food is not appropriately tapped for reducing the malnourishment, but by adopting a multi-spectral approach (Das et al., 2014). Although the relationship between agriculture and human nutrition is intuitively direct, i.e. an increase in food production should lead to better availability, accessed and improved food intakes, the relationship however it is quite complex (World Bank, 2007). Hence the notion that malnutrition can be solved entirely by the supply of food grains or agricultural production is vain.

Like many other developing countries, agriculture plays a key role in the socio-economic development of India. The agricultural system in the country is a risk prone activity and a large number of farmers continue to operate under uncertain risk conditions (Akcaoz and Ozkan, 2005). Out of 119 countries, India ranks 103$^{rd}$ on the Global Hunger Index, 2018 with a score of 31.1,

designating a "*serious*" status of hunger (Grebmer et al., 2018). The gross production of food grains in the year 2017 was 2,71,980 metric tonnes while the per capita net availability of food grains in this specific year was 189.1 kg per year (GoI, 2018). The per capita availability depends on production while production is influenced by the profitability and producers share in consumers' rupee.

India still accounts for a quarter of the world's hungry people and home to over 190 million undernourished people (FAO, 2018). Small-holder farmers - defined as those marginal and sub-marginal farm households that own or/and cultivate less than 2.0 hectare of land - constitute 86.08% of the total holdings in 2015-16 against 85.01% in 2010-11 (Anon. 2019). In North East India, small size of operational holdings, ranging from 0.60 ha in Tripura to 1.33 ha in Meghalaya as compared to 1.42 ha at all-India level (Barah, 2006). Tripura state is the second highest densely state among the north-eastern region after Assam. Shortage of cultivable land is the main obstacle in the agriculture sector of the State with two-third of the total geographical area being hilly and a major part of it comprises of Reserved Forests (Anon. 2018). Only 24 per cent of the total area is cultivable, whereas the national average is 43. About 77.68 per cent of the agriculturists are small and marginal farmers in the state of Tripura, which is the highest in the north-eastern region (Anon. 2019).

Food security among the rural poor in India is tightly linked to poverty and production sustainability. Several studies, in the past have focused on leveraging or modifying agriculture to enhance the nutrition level (World Bank, 2007; Fanzo, 2015; Pandey et al., 2016; Halawar, 2019). Food grains mainly rice and wheat continues to be the main pillars of India's food security (Kumar et al., 2007). In India, rice is cultivated on about approximately 42.75 m. ha. area with production of 154.5 MT paddy and productivity of 2.41 t $ha^{-1}$ (USDA, 2016). It is estimated by 2025 that 15-20 million hectares of irrigated rice lowlands, which provide three quarters of the world's rice supply, are expected to suffer some degree of water scarcity (IWMI, 2007). To eliminate hunger and under nourishment for the world's population by 2025, it was estimated that the additional water requirements may be equivalent to all freshwater withdrawal used today for agriculture, industrial and domestic purposes (SIWI, 2005). Therefore, there needs to be a shift from conventional method of rice production to maintain sustainability and from a nutritional perspective. Among the non-conventional methods of farming for rice is the system of rice intensification which aims to improve nutritional outcomes through both the own-consumption, income pathways and environmentally friendly.

## MATERIALS AND METHODS

### Locale of the study

The study was conducted in north-eastern region of India, in Tripura state. Two districts of the state-South Tripura district and West Tripura district were selected which contributed more than 42.89 per cent and 36.04 per cent of the total area under SRI of the state, respectively. Agricultural situation of the West Tripura district differs to some extent from the other districts in regard to topography soil, extent of rainfall, variation in temperature and humidity which has resulted in difference in cropping pattern. The availability of cultivable land is limited in the district. Another constraint for better agriculture practice is the minimum size of the operational holdings. The paucity of plain land available for cultivation of cereal crops is also an imperative reason for attaching more stress on exploring possibility of horticultural development on hill land and introduction of plantation crops of economic value like black pepper, cocoa, coffee, cinnamon, high yielding early maturing varieties of cashew nut, dwarf varieties like rabi, wheat, groundnut, moong, maximum utilization of land by growing multiple crops in the district. The South Tripura district has been characterized by a humid *summer* and a dry cool *winter* with plenty of rains during July to October. Rain is brought by the South West monsoon, which normally comes in the month of May with maximum intensity of rainfall during June-July. *Autumn* and *Spring* are of very short duration. About 70 per cent of the catchments lie in hills and as such bed slopes are very steep and

the velocity of flood discharges is also high. South Tripura is known as the granary of the state because of its rich agricultural productivity manifested in cultivation and harvesting of high quality rice, potato, varied vegetables and fruits like mango, jackfruit, litchi, pineapple, black berry, etc.

**Sampling**

From each selected district, two blocks were selected on the basis of highest area under the SRI method at second stage of sampling. In South Tripura, Jolaibari block and Bokafa block were selected while in West Tripura district Lefunga and Bishalgarh blocks were selected. Two villages were further selected from each of the selected blocks. A total of 200 respondents were selected for the study, out of which 100 respondents practised Non-SRI method of rice cultivation. The detailed sampling plan is presented in Table 1.

**Data and analysis**

Primary household data of 200 rice growers (100 SRI and 100 Non-SRI) have been collected (Table 1) on evolution of SRI in the state since 2003 onwards. The data on cost of cultivation of rice under SRI and Non-SRI for both the seasons of *kharif* and *boro*, annual household income from different sources, expenditures, data on producer's surplus of rice were collected. The state has mono-cropping pattern of rice in three seasons *viz, aush, kharif* and *boro*. To work out the economic returns in SRI and Non-SRI following formulae were use:

Gross returns = Value of the main product + by product

Farm business income = Gross income – Cost $A_2$

Family labour income = Gross income – Cost $B_2$

Net income = Gross income – Cost $C_2$

Farm investment income = Farm business income – Wages of family labour.

To work out the livelihood security, the indicators used by CARE (1996) were used (Table 2).

Apart from above, indices health, habitat and economic security were worked out as follow:

$$\text{Economic Security Index} = \frac{(\%\text{ difference in possesion of economic goods by SRI and Non SRI farmers})}{(\text{Total number of items})}$$

**Table 1.** Selection of districts, block, village and respondents

| District | Block | Village | No. of households | | | Selection of respondents (No.) | | |
|---|---|---|---|---|---|---|---|---|
| | | | SRI | Non-SRI | Total | SRI | Non-SRI | Total |
| South Tripura | Jolaibari | North Jolaibari | 390 | 90 | 480 | 15 | 12 | 27 |
| | | Kalshi | 325 | 65 | 390 | 13 | 9 | 22 |
| | Bokafa | Betaga | 425 | 75 | 500 | 16 | 10 | 26 |
| | | Charakbai | 370 | 50 | 420 | 14 | 7 | 21 |
| West Tripura | Lefunga | Lembucherra | 252 | 108 | 360 | 10 | 14 | 24 |
| | | Kamalghat | 352 | 88 | 440 | 14 | 12 | 26 |
| | Bishalgarh | Tebaria | 225 | 145 | 370 | 9 | 19 | 28 |
| | | Noapara | 245 | 135 | 380 | 9 | 17 | 26 |
| Total | | | 2584 | 756 | 3340 | 100 | 100 | 200 |

**Table 2**. Selected indicators for livelihood security indices

| Livelihood security outcomes | Indicators | Measurement |
|---|---|---|
| Food Security | Calories Adequacy Ratio (CAR) | 24 hours recall method |
| | Diet diversity | 24 hours recall method |
| Economic Security | Women's income | ₹/annum |
| | Women's saving | ₹/annum |
| | Extent of land | ha |
| | Levels of productive assets | Per capita value of livestock |
| | Levels of unproductive assets | Availability of unproductive assets |

## RESULTS AND DISCUSSION

### Evolution of SRI method in India

System of Rice Intensification (SRI) is a package of practices developed by Father Henri de Loulanie at Madagascar during 1980's to overcome the problem of rice cultivation in acidic soil (Patel et al., 2008). SRI method is focus on improving the growing environment of rice plants, above and below ground, by improving the management of plants, soil, water and nutrients, to stimulate the growth of bigger and better root systems and the number and activity of beneficial soil organisms (Hidayati et al., 2016). The method is based on four components - quick and healthy plant establishment, improved soil conditions, weed control and water management. It has several benefits over traditional/conventional method of rice cultivation. The advantages of application of SRI method compared to the conventional method are less seed requirement, water savings up to 50%, reduction in the use of inorganic fertilizers by 50% if coupled with 50% organic fertilizer, or some combination of organic fertilizer and biological fertilizer, production costs reduced by 20%, and increasing yield (Hutabarat, 2011).

SRI was first experimented by the organic farmers of Pondicherry of India in the year 2000 (Prasad, 2007). The water saving potential of SRI was an important trigger that attracted farmers from many southern states to this new method (Basu and Leeuwis, 2012). In India, the adoption of SRI method was slow which started with about 1 million hectares of area under SRI cultivation, making it 2.42% of total area under rice cultivation in the country (Gujja and Thiyagarajan, 2009). This method is regarded as a key means of boosting national rice production under the Government of India's National Food Security Mission (NFSM).

SRI also gained popularity in North-eastern region of India due to its potential for high yields (Pathak et al., 2013). The first trial of SRI in North East was done in the Bokafa sub-division of South district of Tripura in the year 2001 (Anonymous, 2011). After two years of experiment conducted by state agricultural research station, Tripura, it was introduced at farmers' field. In Tripura on an average about 20 per cent higher yield was obtained from SRI as compared to conventional practice. Tripura state produces 176.13 thousand MT rice in 59.47 thousand ha of area with 2.81 t $ha^{-1}$ of yield under SRI method. As whole the state is producing 713.22 thousand MT rice in the area of 254.74 thousand ha, in which SRI contributing 23.35 per cent and 24.69 per cent of area and production in the state (Anon. 2013), respectively. Later on keeping in view its performance success at farmers' field SRI method came into momentum from the year 2003 onwards and it keeps on to increase its coverage in huge area of the state. Year wise adoption of SRI at micro level at the farmers' field termed as evolution of (Table 3) has been estimated. In the year 2003 the area under the method was accounted of 0.32 ha and it increased 52.88 ha during 2014 (Fig. 1). Similarly, the production of rice was estimated to be 7.2 quintal during the first year (2003) and it increased of 22.78 MT during 2014-15 (Fig. 2). Despite of the increasing trend in area and production of rice under the SRI in study area, the yield of rice was found to be in fluctuation trends.

Initially, the yield was estimated of 2.25 t ha$^{-1}$ which has been increased to 4.31 t ha$^{-1}$ (Fig. 3). Perhaps, the yield was the main reason behind attraction of SRI to extend it in the larger area of the state. The method has still potentiality to increase the level of yield as estimated and reported the yield to be 7-8 t ha$^{-1}$ (Anon. 2013). Rice is major crop in this region as well as in the state of Tripura. Therefore, SRI has played a vital role in enhancement of productivity and production of rice to fulfil the requirement of food as well as nutrition of human being in the state. The question of how SRI method can more effectively contribute to improved nutrition outcomes therefore requires an answer that encompasses factors other than food supply, and that takes into account other sectors in addition to agriculture that contribute to nutrition. Hence, the present study is an effort to provide an overview of system of rice intensification and its impact on the food, calories consumption and health security of the rice farmers in the state.

**Table 3.** Evolution of SRI in Tripura during 2003 to 2014

| Year | Area (ha) | Productivity (q ha$^{-1}$) |
|---|---|---|
| 2003 | 0.32 | 22.50 |
| 2004 | 0.96 | 22.60 |
| 2005 | 2.72 | 24.15 |
| 2006 | 5.68 | 18.66 |
| 2007 | 7.44 | 34.02 |
| 2008 | 13.24 | 34.75 |
| 2009 | 19.08 | 32.20 |
| 2010 | 28.92 | 34.23 |
| 2011 | 34.62 | 38.75 |
| 2012 | 43.02 | 40.05 |
| 2013 | 51.02 | 42.19 |
| 2014 | 52.88 | 43.08 |

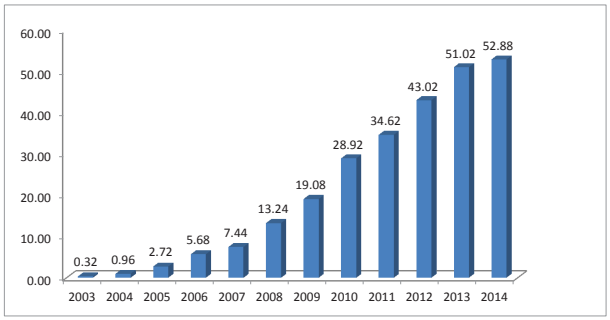



**Fig. 1.** Evolution of SRI area

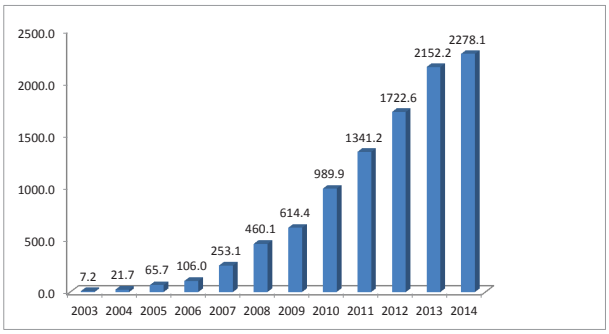



**Fig. 2.** Rice production under SRI since inception

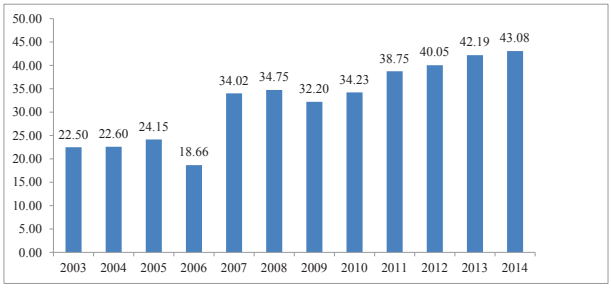



**Fig. 3.** Progress in yield of rice under SRI

## Growth trends in area and production of rice under SRI method

The compound average growth rate in area under SRI for last ten year (2003-2012) was estimated to be of 21.03 per cent with 0.47 per cent in production of rice under SRI. The method has been adopted very fast with increasing trends (Table 4). Consequently, the production of rice has increased from 7.20 q to 2278.10 q considering the increase in production area (Table 4), but the rate of

growth in production was not found an enthusiastic and has been estimated to be merely 0.47 per cent for last ten years. The probable reason may be due to fluctuations in yield (Fig. 4). Fewer yields may be due to climatic and technological factors as SRI is known have method of certain principles.

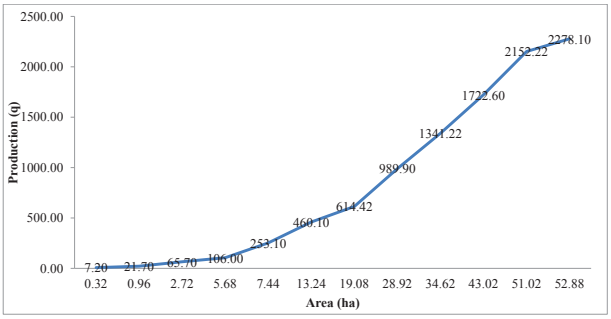



**Fig. 4.** Trends in area, production of rice in SRI method during the year 2003-14

**Table 4.** Growth rate of area and production in rice under SRI method of rice cultivation

| Year | Area (ha) | CAGR (%) | Production (q) | CAGR (%) |
|---|---|---|---|---|
| 2003 | 0.32 | | 7.20 | |
| 2004 | 0.96 | | 21.70 | |
| 2005 | 2.72 | | 65.70 | |
| 2006 | 5.68 | | 106.00 | |
| 2007 | 7.44 | | 253.10 | |
| 2008 | 13.24 | 21.03 | 460.10 | 0.47 |
| 2009 | 19.08 | | 614.42 | |
| 2010 | 28.92 | | 989.90 | |
| 2011 | 34.616 | | 1341.22 | |
| 2012 | 43.016 | | 1722.60 | |
| 2013 | 51.016 | | 2152.22 | |
| 2014 | 52.882 | | 2278.10 | |

## Annual income and expenditure

The income and expenditure directly affect the living standard of a household. The annual income of SRI household (₹136309 per annum) was higher than the Non-SRI farmers (₹120338 per annum) with the difference of ₹15970 per annum (11.72%). Similarly, the annual expenditure of SRI (₹ 90246 per annum) was more than Non-SRI (₹ 83135 per annum) with the difference of 7.88 per cent. Hence, SRI method has potential to enhance the income of the farmers (Table 5).

**Table 5.** Annual income and expenditure of rice grower

| | SRI | Non-SRI | Diff. | Diff. (%) |
|---|---|---|---|---|
| Income (₹/annum) | 136309 | 120338 | 15970 | +11.72 |
| Expenditure (₹/annum) | 90246 | 83139 | 13647 | +7.88 |

## Returns from rice crop

It was apparent from the analysis of returns in rice production under SRI and Non-SRI that the SRI method has realised more economic benefits than Non-SRI in both the seasons of *kharif* and *boro* (Table 6 and 7).

**Table 6.** Returns from rice cultivation under SRI and Non-SRI during *kharif* season

| Particulars | SRI Farm | Non-SRI Farm | Diff (%) |
|---|---|---|---|
| Total Gross return (₹ $ha^{-1}$) | 70209.37 | 61865.67 | +11.88 |
| Return Including Family labour (₹ $ha^{-1}$) | 13519.51 | 9735.38 | +27.99 |
| Return Excluding Family labour (₹ $ha^{-1}$) | 26881.48 | 20609.38 | +23.33 |
| Farm business income (GFI-Cost A2) (₹ $ha^{-1}$) | 36237.73 | 29028.13 | +19.90 |
| Farm investment income (Farm business income-wages of family labour) (₹ $ha^{-1}$) | 22875.76 | 18154.13 | +20.64 |

**Table 7.** Returns from rice cultivation under SRI and Non-SRI during *boro* season (₹ $ha^{-1}$)

| Particular | SRI Farm | Non-SRI Farm | Difference (%) |
|---|---|---|---|
| Total Gross return | 62680.33 | 61076.90 | +2.56 |
| Return Including Family labour (₹ $ha^{-1}$) | 9560.13 | 4177.83 | +56.30 |
| Return excluding Family labour (₹ $ha^{-1}$) | 22794.30 | 17750.52 | +22.13 |
| Farm business income (GFI-Cost A2) (₹ $ha^{-1}$) | 32150.55 | 26169.27 | +18.60 |
| Farm investment income (Farm business income-wages of family labour) (₹ $ha^{-1}$) | 18916.38 | 12596.58 | +33.41 |

**Producer surplus of rice at SRI and non-SRI household**

The study of producer surplus is always helpful to know the food security which directly linked to economic prosperity of a farmer. The more marketable surplus farmer is more is resourceful. The marketable surplus was estimated and found to be higher on SRI (63.64%) than Non-SRI (48.23%) even it is higher than the marketed surplus within SRI household. Hence, producer's surplus analysis shown SRI household has more retention power than the non-SRI farmer (Table 8).

**Food Security**

**Per capita food consumption in SRI and non-SRI household**

The consumption of food very much depends on the quantum of food production at household. Again the quantum of the food depends on the way of production of food. The diversified food consumed by the SRI and Non-SRI household was estimated on the basis of individual consumption. The quantity of rice consumption was found to be higher on SRI (0.51 kg per capita per day) than Non-SRI (0.45 kg per capita per day) household. The consumption of meat, fruit, milk, eggs, and nuts was found to be consumed more by the SRI than the Non-SRI household except vegetable intake. However, SRI households were observed to take more quantity of different food items than Non-SRI households. Therefore, SRI method has played its role to enhance income of the household and it made them to consume sufficient food item than the Non-SRI (Table 9).

**Table 8.** Producer surplus of rice in SRI and Non-SRI method (kg)

| Particulars | SRI | Non-SRI |
|---|---|---|
| Production (kg) | 2546.00 | 1938.43 |
| a) Home Consumption | 794.70 | 827.54 |
| b) Seed | 36.40 | 41.08 |
| c) Feeds | 79.39 | 73.56 |
| d) Wages in kind | 15.35 | 61.29 |
| Sub-total (a to d) | 925.84 | 1003.48 |
| Marketable surplus | 1620.16 (63.64) | 934.95 (48.23) |
| e) Losses during storage | 15.28 | 17.45 |
| Marketed Surplus | 1604.88 (63.00) | 917.50 (47.33) |

Note : figures in parentheses are to the total production

**Table 9.** Per capita food intake in SRI and Non-SRI farmers in kg per day per person

| Items | SRI | Non SRI | % change |
|---|---|---|---|
| Rice | 0.51 | 0.45 | 13.49 |
| Pulse (Dal) | 0.05 | 0.03 | 49.76 |
| Meat | 0.06 | 0.04 | 37.78 |
| Vegetable | 0.31 | 0.37 | -15.74 |
| Fruits | 0.14 | 0.11 | 25.51 |
| Milk | 0.09 | 0.07 | 24.93 |
| Eggs | 0.32 | 0.21 | 47.83 |
| Fish | 0.07 | 0.06 | 1.26 |
| Nuts | 0.03 | 0.02 | 63.85 |

## CONCLUSION

The study has revealed that SRI method has been accepted by the farmers of the Tripura state and area and number of farmers under SRI method have been increased over the year. Thus, SRI has left highly positive effect on every aspects of livelihood security. The method has enhanced the income of the SRI household. It has made capable and more secure to the household of Tripura state in nutritional food security. Producer's surplus, food, economic security all were found in better side than Non-SRI. Therefore, study advocate to prepare and initiate a comprehensive package of practices on SRI for its more adoption. Hence, it is suggested that SRI farming should be taken up as the alternative method of yield enhancement. The interface between agriculture and human development provides a far more complete picture of nutrition that relates supply to demand and production to consumption.

## ACKNOWLEDGEMENT

Authors are very grateful to the funding agency of Indian Council of Social Science Research, New Delhi for giving the grant for extra-mural research project from which this paper has been prepared. The authors are also thankful to esteemed Central Agricultural University for implementing this research project.

## REFERENCES

Akcaoz, H. and Ozkan, B. 2005. Determining risk sources and strategies among farmers of contrasting risk awareness: A case study for Cukurova region of Turkey. *J. Arid Environ.* **62**: 661-675.

Anonymous, 2019. *Agriculture Census* 2015-16 (Phase-I), Agriculture Census Division Department of Agriculture, Co-Operation and Farmers Welfare. Available at https://agcensus.nic.in/document/agcen1516/T1_ac_2015_16.pdf. Accessed on 10.07.2019.

Anonymous, 2018. *Economic Review of Tripura*, 2017-18. Directorate of Economics and Statistics Planning (Statistics), Department Government of Tripura, Agartala. Available at www.ecostat.tripura.gov.in. Accessed on 05 September 2018

Anonymous, 2013. *Economic review of Tripura* 2012-2013. Directorate of Economics and Statistics Planning (Statistics), Department Government of Tripura, Agartala

Anonymous. 2011. *Handbook of agriculture*. Indian Council of Agricultural Research, New Delhi.

Barah, B.C. 2006. *Agricultural development in North-East India challenges and opportunities*. Available at http://www.ncap.res.in/upload_files/policy_brief/pb25.pdf. Accessed on 05.September 2018.

Basu, S. and Leeuwis, C. 2012. Understanding the rapid spread of system of rice intensification (SRI) in Andhra Pradesh: Exploring the building of support networks and media representation. *Agric. Syst.* **111**: 34-44.

Brennan, B. 2012. *Nanobiotechnology in Agriculture.* Available at: http://www.strategicbusin essinsights.com/about/featured/2012/2012-10-nanobio-agriculture.shtml. Accessed November 30, 2019.

Das, P.K., Bhavani, R.V. and Swaminathan, M.S. 2014. A farming system model to leverage agriculture for nutritional outcomes. *Agric. Res.* **3 (3)**: 193–203.

FAO. 2013. *Synthesis of guiding principles on agriculture programming for nutrition.* Available at <www.fao.org/docrep/017/aq194e/aq194e00.htm>. Accessed on 10 July, 2019.

FAO. 2018. *FAO in India*. Available at http://www.fao.org/india/fao-in-india/india-at-a-glance/en/. Accessed on 10.07.2019.

Fanzo, J., Marshall, Q., Dobermann, D., Wong, J., Merchan, R.I., Jaber, M.I, Souza, A, Verjee, N and Davis, K. 2015. The integration of nutrition into extension and advisory services: a synthesis of experiences, lessons, and recommendations. Lindau, Switzerland: Global Forum for Rural Advisory Services. *Food Nutr. Bull.* **36**(2): 120-137.

GoI. 2018. *Per capita net availability of food grains*. Available at https://eands.dacnet.nic.in/PDF/PerCapita-FoodGrains.pdf. Accessed on 05. Sept. 2018

Grebmer, K.V., Bernstein, J., Patterson, F., Sonntag, A., Klaus, L.M., Fahlbusch, J., Towey, O., Folley, C., Gitter, S. Ekstrom, K. and Fritschel, H. 2018. *Global hunger index forced migration and hunger, 2018.* Available at https://www.globalhungerindex.org/pdf/en/2018.pdf. Accessed on 10 July, 2019.

Gujja, B., Loganandhan, N. and Goud, V.V. 2008. *System of rice intensification*: *Experiences of farmers in India*. ICRISAT-WWF Project. Andhra Pradesh, India.

Halawar, S.V. 2019. The trend analysis of major food grains in India. *Int. J. Curr. Microbiol. Appl. Sci.* **8**(3): 353-360.

Hidayati, N., Triadiati, P. and Anas, I. 2016. Photosynthesis and transpiration rates of rice cultivated under the system of rice intensification and the effects on growth and yield. *HAYATI J. Biosci.* **23**: 67-72.

IFPRI. 2011. Sustainable solution for ending hunger and poverty. *Agriculture for improving nutrition and health.* International Food Policy Research Institute Centre, New Delhi, India.

IWMI. 2007. *Rice: Feeding the Billions, Chapter14: Water for food, Water innovations.* International Water Management Institute, Stockholm, Sweden.

Kumar, P.H.M. and Kumar, H.S.V. 2013. Food security and nutritional scenario of India- an overview. *IOSR J. Agric. Vet. Sci.* **2**(5): 28-39.

Kumar, P., Mruthyunjaya, D. and Madan, M. 2007. Long-term changes in food basket and nutrition in India. *Economic and Political Weekly* pp. 3567-3572.

Pandey, V., Laxmi, S., Mahendra, D. and Jayachandran, U. 2016. Impact of agricultural interventions on the nutritional status in South Asia: A review. *Food Policy* **62**: 28–40.

Patel, D.P., Das, A., Munda, G.C., Ghosh, P.K., Ngachan, S.V., Kumar, R. and Saha, R. 2008. *SRI and ICM rice culture for water economy and higher productivity.* Report of ICAR, Research complex, Barapani.

Pathak, M., Shakywar, R.C. and Sah, D. 2013. Biodiversity of insect pests, natural enemies and diseases in SRI and traditional system of rice cultivation in Northeastern region of India. *Oryza* **50** (4): 370-374.

Prasad, C.S. 2007. Rethinking innovation and development: Insights from the System of Rice Intensification (SRI) in India. *Innovation J.* **12**(2): 1-25.

SIWI. 2005. *Stockholm International Water Institute (SIWI) policy institute for seeks sustainable solutions to the world's escalating water crisis.* Available at www.siwi.org/ documents/Resources/ Water. Accessed on 14. August.2018.

USDA. 2016. *Rice Productivity.* United States Department of Agriculture. Available at http://www.fas.usda.gov/data/India-grain-and-feed-animal. Accessed on 3 September, 2018.

World Bank. 2007. *From agriculture to nutrition: pathways, synergies, and outcomes.* Available at https://openknowledge.worldbank.org/handle/10986/9511. Accessed on 03 September, 2018

*e-planet* **17** (2): 98-105 (December 2019)

# Precision nitrogen management in maize cultivars under variable growing environments: Effects on plant growth, normalised difference vegetation index and leaf nitrogen

**A. P. GHOSH AND ANCHAL DASS***

*Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India*

**anchal_d@rediffmail.com*

Date of receipt: 09.10.2019 Date of acceptance: 18.12.2019

**ABSTRACT**

Fine tuning the nitrogen (N) recommendations, i.e. appropriate rate and time of N fertilizer application is an important factor for enhancing the growth and quality performance of maize cultivars and reducing N losses. Studies have shown that the normalised difference vegetation index (NDVI) and soil plant analysis development (SPAD) values were highly related with leaf N content of maize (*Zea mays*) and can sufficiently quantify the N requirements of maize plants. This study was conducted at New Delhi during rainy season of 2014-15 to determine the effects of two maize cultivars (PEEHM 5 and PC 3), three planting dates ( July 9, July 24 and August 7) and four N rates [Control (0 kg N $ha^{-1}$), 30 kg N $ha^{-1}$ basal + 30 kg N $ha^{-1}$ when SPAD ≤ 37.5 till silking Chlorophyll meter based (CMB), 30 kg N $ha^{-1}$ basal + 30 kg N $ha^{-1}$ when SPAD ≤ 37.5 at knee-high, pre-tasseling, silking Chlorophyll meter based stage-wise (CMBSW) and soil test crop response based (STCRB, 160 kg N $ha^{-1}$)] on different growth and quality characteristics of maize under north Indian conditions. Among plant characteristics, NDVI, SPAD value, leaf N content, total dry matter at maturity and leaf area index (LAI) were significantly higher in early planting dates, *i.e.* July 9 and CMB N treated crop than others at all the growth stages of maize. SPAD value recorded at tasseling stage were significantly correlated with estimated leaf N content and NDVI value at tasseling stage and total dry matter produced at maturity across the treatments.

**Key words :** Leaf N, maize cultivars, NDVI, N fertilizer, SPAD

## INTRODUCTION

Maize (*Zea mays* L.) is now the highest producing cereal crop of world, growing over a wide range of agro-climatic variations, and serving as staple food for millions of people throughout the world and an important animal feed (Sharma and Dass, 2012; Ghosh et al., 2017; Kumari et al., 2017). Moreover, it contributes to the ethanol production and forms raw material for several industrial products (Ghosh et al., 2016). In India, maize contributes nearly 9% to the national food grain production and constitutes a quality feed for poultry and animals (Dass et al., 2015a). Despite, its economic importance for food, feed and industrial products, concerns exist in maize cultivation, particularly related to nutrient management. Among various agricultural inputs, fertilizers contribute about 30–50% towards yield performance (Stewart, 2002; Dass et al., 2015b; Joshi et al., 2018). Of late, growing awareness about impaired soil health, declining or stagnating productivity growth and decreasing nutrient-use efficiency (NUE) are compelling the farmers to use higher levels of fertilizers, mostly N and P fertilizers, particularly during the last two decades leading to over mining

of other major, secondary and micro-nutrients (Dass et al., 2014a). Besides this, environmental pollution and global warming are the other serious issues related to existing nutrient management practices (Dass et al., 2014 b), especially so for N management with a low recovery efficiency.

N is a major yield determining factor required for maize (Shanti et al., 1997). Inefficient N fertilization in maize production system causes excessive nitrate levels in groundwater and leachate and N-induced hypoxia in estuarine areas from agricultural sources (McIsaac et al., 2002). N leaching losses increased and use efficiency decreased when fertilizer application rates exceeded crop N requirements (Van Es et al., 2002). N fertilizer application in 1-3 doses on the basis of soil test value is one of the widely followed approaches. However, the accuracy of this method is limited due to extensive sampling requirement in a short period of time (Ma and Dwyer, 1999) and high leaching losses in humid areas. Thus, precise application of optimum dose of N fertilizer according to crop demand is a compelling need to reduce losses and increasing efficiency (Ostergaard, 1997; Dass et al., 2014a, b). Two of such precision technologies, among many, namely, Normalized Difference Vegetation Index (NDVI) and chlorophyll (SPAD) measurement are widely used spectral indices involving optical sensing due to their ease of operation and effectiveness. NDVI measurements are related to reflectance by crop canopy in the visible (VIS) (400-700 nm) and near infrared (NIR) (700-1300 nm) spectral light bands. The NDVI value is calculated using the following equation:

$$NDVI = (NIR – VIS)/ (NIR + VIS)$$

The visible light reflectance by the crop canopy is primarily dependent on chlorophyll content of leaves (Campbell, 2002) and thus, greater leaf area and green plant biomass levels result in higher reflectance and higher subsequent NDVI values. Ercoli et al. (1993) reported a strong linear relationship between leaf chlorophyll concentration and leaf nitrogen (N) concentration. A good relationship has been documented between plant NDVI and plant N status (Rui et al., 2009; Rambo et al., 2010). Values from the chlorophyll soil plant analysis development (SPAD) meter (Minolta Camera Co., Osaka, Japan) are highly correlated with the N status of crops such as corn (*Zea mays* L.) (Blackmer and Schepers, 1995) because chlorophyll content depends on N supply (Pandey et al., 2000). Thus, a study involving comparative analysis of SPAD meter based N application with soil test value method and their effect on growth and relationship with spectral indices is imperative for making valid recommendations. Agronomic and physiological performances of maize vary greatly with different maize cultivars. Odeleye and Odeleye (2001) also reported that maize varieties differ in their growth characters, yield and its components. PEEHM 5 and PC 3 are two maize cultivars recently developed by IARI and recommended for cultivation in northern, north-east hill region, and southern India. Hence, an attempt has been made to evaluate the performances of these varieties under precise N management strategies. Planting dates also influence production and yield of maize due to alteration climatic elements (rainfall, temperature and relative humidity). Sárvári and Futó (2000) reported that each hybrid has an optimum sowing date, deviation from which (early or late sowing than optimum), can result in severe yield loss. These findings are enough reasonable to investigate the responses of different maize varieties to different growing environments to determine optimum planting conditions. Very few, if any, studies have characterized growth and yield of maize cultivars PEEHM 5 and PC 3 in response to changing environmental conditions resulting from a range of planting dates under Northern India conditions. Keeping all in view the present investigation was carried out evaluate the effect of planting dates and N application rates on growth and quality of maize cultivars using crop canopy sensors.

## MATERIALS AND METHODS

An irrigated field experiment was conducted at the research farm of Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi (28°38'23" N, 77°09'27"E and 228.6 m above MSL of Arabian sea) during *kharif* season 2014-15 on sandy loam soil. During the crop growth period in

*kharif* season of 2014-15, mean weekly maximum and minimum temperature, weekly maximum and minimum relative humidity, sun shine hours per day and evaporation were 34.23°C, 22.79°C, 84.81%, 53.24%, 5.6 hrs and 6 mm day$^{-1}$, respectively. Crop season received rainfall of 56.38 mm with a weekly average of 3.13 mm. The experimental design was split plot with three replications and 72 plots. Plots consisted of seven rows (60 cm inter-row spacing) and 4.8 m long with 3 m width.

Initial soil test indicated mean values of soil pH of 7.4, organic carbon of 0.58%, available phosphorus of 18.7 kg ha$^{-1}$, and available potassium of 262 kg ha$^{-1}$. Treatments consisted of 24 combinations with two varieties *viz.* hybrid variety PEEHM 5 and composite variety Pusa Composite 3 (PC 3) and three planting dates *i.e.* July 9, July 24 and August 7 in the main plot and four nitrogen application rates *i.e*. control (0 kg N ha$^{-1}$) (control), 30 kg N ha$^{-1}$ basal + 30 kg N ha$^{-1}$ when SPAD ≤ 37.5 till silking (CMB) , 30 kg N ha$^{-1}$ basal + 30 kg N ha$^{-1}$ when SPAD ≤ 37.5 at knee-high, pre-tasseling, silking (CMBSW) and soil test crop response based (STCRB, 160 kg N ha$^{-1}$) in sub plot.

Standard package and practices were followed to raise a healthy maize crop except treatments. Maize seeds (properly treated with insecticides) were dibbled on flat beds prepared manually by using 20 kg seed ha$^{-1}$. Nitrogen in the form of urea, phosphates as single super phosphate (SSP), potash as muriate of potash (MOP) were applied at the time of land preparation as basal. Subsequent N fertilizer after basal application was broadcasted based on SPAD meter reading taken according to treatment requirements. For zinc application, zinc sulphate ($ZnSO_4$) was used. To control weeds, atrazine @1.0 kg a.i. ha$^{-1}$ as pre-emergence herbicide was sprayed. Four post sowing irrigations and one extra irrigation for PC 3 were applied in maize to supply the adequate moisture at different stages for each planting date. Relative chlorophyll (SPAD values) content were measured in upper most fully expanded maize leaves with Minolta SPAD-520 meter (Konica Minolta Sensing, Inc., Japan) from at least ten plants from second row in maize crop at 10-day interval and also at knee-high, tasseling and maturity stages averaged out. The NDVI measurements were taken with the Green Seeker™ Handheld Optical Sensor Unit (N Tech Industries, Inc., USA) in the central rows of all plots and the instrument gives out digital values of NDVI. To determine total dry matter accumulation (DMA) in maturity, five plants from the sampling rows, *i.e.* second rows from boarder were uprooted, separated into different plant parts, air dried in shade for five days and finally oven dried at 70 ± 2°C till a constant weight was recorded. Total dry matter at maturity was calculated by using following formulae:

Total dry matter at maturity = [leaf dry weight + stem dry weight + cob (grain + rachis) weight + husk weight]

The leaf area was measured from the leaves of five sampled plants at knee-high and tasseling stages by using the leaf area meter (Model LI-COR-3100) and leaf area index was worked out as leaf area per unit land area.

N content in leaves of maize plants was estimated following standard procedure (Rana et al., 2014). The data relating to each parameter of maize were analyzed by technique of 'analyses of variance' for split-plot design (Rana et al., 2014). The standard error of mean (SEm±) and critical differences (CD) values at 5% level of significance were calculated for comparing the differences among treatment means.

## RESULTS AND DISCUSSION

In several past investigations, different maize genotypes have been reported to vary in ecological amplitude of adaptability and ability to intercept and use growth factors efficiently. Thus, they exhibit different growth, vigour and quality performances. Accordingly, in present experiment, an interpretation of facts indicated that hybrid variety PEEHM 5 recorded significantly higher amount of total DMA at maturity and 284 cm$^2$ per plant more leaf area at knee-high stage than composite PC 3. But at tasseling stage PC 3 recorded more leaf area (Tables 1, 2). Sharifi et al. (2009) also reported significant differences among different maize cultivars (including hybrids) in terms of

DMA, above-ground biomass and grain yields due to differences in maize cultivars to stomata conductance value and in partitioning of photosynthetic materials towards economic yield (Ghosh et al., 2017; Kumari et al., 2017). During initial growth stages (seedling and knee-high), PEEHM 5 exhibited faster growth rate and higher N uptake. This resulted in significantly higher leaf N content in PEEHM 5 than PC 3 at early growth stages. However, at tasseling and maturity stages, variety PEEHM 5 recorded significantly lower leaf N content because N was spent to produce carbohydrate in grain, and grain yield of the variety PEEHM 5 was significantly higher compared to PC 3. Thus, the difference in leaf N on an average between the varieties was nullified because composite PC 3 recorded poor above ground biomass (leaf + stem) and hence lower leaf N content during early stages of crop growth while at later stages it rapidly increased the same containing more leaf N than PEEHM 5. As a consequence, SPAD values did not vary significantly among the cultivars (Table 2). More amount of vegetation, or active photosynthetic tissue, will increase the amount of light absorbed in the red spectrum and light reflected in the near-infrared spectrum, and thus NDVI value (Federer et al., 1966). Correspondingly, PEEHM 5 showed significantly higher NDVI value at knee-high stage.

**Table 1.** Effect of varieties, planting dates and chlorophyll meter based N application on total dry matter at maturity, leaf N content, NDVI and SPAD meter readings of maize at knee-high and tasseling stages

| Treatment | Dry matter at maturity (g plant$^{-1}$) | Leaf N content (%) | | | NDVI | | SPAD values |
|---|---|---|---|---|---|---|---|
| | | Knee high | Tasseling | Maturity | Knee-high | Tasseling | Knee-high | Tasseling |
| Varieties | | | | | | | | |
| PEEHM 5 | 189.2 | 1.76 | 2.28 | 1.13 | 0.55 | 0.61 | 40.05 | 41.17 |
| Pusa Composite 3 | 180.9 | 1.66 | 2.38 | 1.18 | 0.46 | 0.64 | 38.52 | 42.21 |
| SEm (±) | 1.36 | 0.04 | 0.03 | 0.01 | 0.00 | 0.01 | 0.55 | 0.67 |
| CD (P=0.05) | 4.08 | 0.12 | 0.09 | 0.04 | 0.01 | 0.03 | 1.64 | 2.00 |
| Planting dates | | | | | | | | |
| July 9 | 192.9 | 1.86 | 2.40 | 1.19 | 0.59 | 0.68 | 41.44 | 43.46 |
| July 24 | 187.6 | 1.70 | 2.33 | 1.15 | 0.50 | 0.63 | 39.01 | 41.62 |
| August 7 | 174.5 | 1.58 | 2.27 | 1.13 | 0.43 | 0.56 | 37.40 | 39.99 |
| SEm (±) | 1.67 | 0.05 | 0.04 | 0.02 | 0.00 | 0.01 | 0.67 | 0.82 |
| CD (P=0.05) | 4.99 | 0.14 | 0.12 | 0.05 | 0.01 | 0.04 | 2.00 | 2.45 |
| Nitrogen | | | | | | | | |
| Control | 150.0 | 1.21 | 1.64 | 0.80 | 0.35 | 0.47 | 19.65 | 23.38 |
| CMB | 212.3 | 2.00 | 2.62 | 1.29 | 0.60 | 0.70 | 48.15 | 50.19 |
| CMBSW | 187.9 | 1.81 | 2.54 | 1.27 | 0.54 | 0.66 | 44.87 | 46.69 |
| STCRB | 189.9 | 1.84 | 2.52 | 1.26 | 0.54 | 0.67 | 44.46 | 46.50 |
| SEm (±) | 1.84 | 0.03 | 0.05 | 0.03 | 0.01 | 0.01 | 0.68 | 0.65 |
| CD (P=0.05) | 5.29 | 0.07 | 0.14 | 0.07 | 0.02 | 0.03 | 1.97 | 1.88 |

CMB: Chlorophyll meter based N application up to silking i.e. 30 kg ha$^{-1}$ N basal + 30 kg ha$^{-1}$ N top-dressed each time leaf SPAD value falls to ≤ 37.5; CMBSW: Chlorophyll meter based N application stage-wise i.e. 30 kg ha$^{-1}$ N basal + 30 kg N top-dressed each at knee high, pre-tasseling and silking stages when SPAD value falls to ≤ 37.5; STCRB: Soil test crop response based N application.

**Table 2.** Effect of varieties, planting dates and chlorophyll meter based N application on leaf area and LAI of maize at knee-high and tasseling stages

| Treatment | Leaf area ($cm^2$ $plant^{-1}$) | | LAI | |
|---|---|---|---|---|
| | Knee-high | Tasseling | Knee-high | Tasseling |
| Varieties | | | | |
| PEEHM 5 | 5088 | 5718 | 4.24 | 4.76 |
| Pusa Composite 3 | 4520 | 6000 | 3.76 | 5.00 |
| SEm (±) | 88.4 | 63.1 | 0.04 | 0.05 |
| CD (P=0.05) | 265.2 | 189.2 | 0.22 | 0.16 |
| Planting dates | | | | |
| July 9 | 4921 | 6299 | 4.10 | 5.25 |
| July 24 | 4909 | 5977 | 4.09 | 4.98 |
| August 7 | 4582 | 5300 | 3.81 | 4.42 |
| SEm (±) | 108.3 | 77.3 | 0.05 | 0.06 |
| CD (P=0.05) | 324.7 | 231.8 | 0.27 | 0.19 |
| Nitrogen | | | | |
| Control | 3450 | 4127 | 2.88 | 3.44 |
| CMB | 5869 | 6801 | 4.89 | 5.67 |
| CMBSW | 4919 | 6261 | 4.10 | 5.22 |
| STCRB | 4979 | 6246 | 4.15 | 5.21 |
| SEm (±) | 147.8 | 111.1 | 0.06 | 0.09 |
| CD (P=0.05) | 425.6 | 320.1 | 0.36 | 0.27 |

CMB: Chlorophyll meter based N application up to silking i.e. 30 kg $ha^{-1}$ N basal + 30 kg $ha^{-1}$ N top-dressed each time leaf SPAD value falls to ≤ 37.5; CMBSW: Chlorophyll meter based N application stage-wise i.e. 30 kg $ha^{-1}$ N basal + 30 kg N top-dressed each at knee-high, pre-tasseling and silking stages when SPAD value falls to ≤ 37.5; STCRB: Soil test crop response based N application

Early planting on July 9 resulted in vigorous growth and higher biomass yield (leaf area) due to favourable climatic conditions. Meteorological data revealed that August 7 planted crop experienced considerably low relative humidity in comparison to July 9 and July 24 (Mean average daily RH during the respective crop growth periods: 66.4, 69 and 70.3%) planted crop at the time of tasseling which may be a probable explanation for low grain yield, and hence total DMA at maturity. NDVI value was recorded significantly higher in July 9 sown plants at all growth stages than other planting dates due to higher canopy cover (Trout et al., 2008). N content in leaf was also significantly higher in crop sown on optimum time than delayed planting because of higher N uptake due to higher root length at knee-high stage (July 9: 225.4 cm, July 24: 219.3 cm and August 7: 195.3 cm) and conducive moisture regimes (Total rainfall during 16-23 July, 2014: 133 mm compared to 14–23 August, 2014: 0 mm) that enabled the plants to explore much greater volume of resource poor soil and capture nutrients and also favourable precipitation helped in mineralization of organic matter. Higher leaf N content resulted in significantly higher SPAD value in early planted crop (July 9 and July 24) at all the growth stages.

Chlorophyll meter based N (CMB) application significantly increased total dry matter production at maturity and LAI at vegetative growth phase than other N treatments due to split N

fertilization as per crop demand limiting the chances of N deficiencies. Continuous supply and uptake of N in CMB resulted in significantly higher leaf N content, SPAD and NDVI values due to greater canopy cover, chlorophyll content and vigorous plant growth compared to control and STCRB N. Dass et al. (2014), in line with our findings, also concluded that chlorophyll meter based N gives higher yield than STCR based N application, with considerable saving on N fertilizer.

Relationship among different parameters have been studied in an attempt to discuss and clarify the behavioural trend of corn genotypes under different environmental conditions finding cause and effect criteria. Higher nutrient uptake and concentration may attribute to higher leaf area and biomass production. Total DMA at maturity was significantly and positively correlated with LAI and leaf N content at tasseling, and both NDVI and SPAD value measured at tasseling stage were significantly (critical value of r at p=0.05 with d.f. 3 is 0.878) correlated with Leaf N content and LAI at tasseling stage and total DMA at maturity across the treatments. However, regression analyses revealed that total DMA at maturity had a linear relationship with LAI recorded at tasseling stage, while the relationship between NDVI and LAI at tasseling stage and SPAD value recorded and leaf N content at tasseling stage is quadratic (higher $r^2$ value than linear relationship) considering all treatments (Table 3; Figs. 1, 2 ,3).

**Table 3.** Correlation between total dry matter at maturity, NDVI, SPAD, leaf N content and LAI at tasseling stage across the treatments

| | Total dry matter at maturity | LAI at tasseling | Leaf N content at tasseling | NDVI at tasseling | SPAD value at tasseling |
|---|---|---|---|---|---|
| Total dry matter at maturity | 1 | | | | |
| LAI at tasseling | 0.952* | 1 | | | |
| Leaf N content at tasseling | 0.902* | 0.967* | 1 | | |
| NDVI at tasseling | 0.927* | 0.992* | 0.944* | 1 | |
| SPAD value at tasseling | 0.927* | 0.970* | 0.997* | 0.944* | 1 |

*p≤0.05 (two-tailed test)

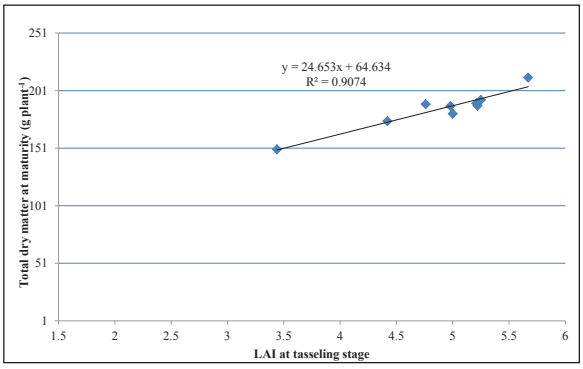



**Fig. 1.** Correlation between LAI at tasseling and total DMA at maturity

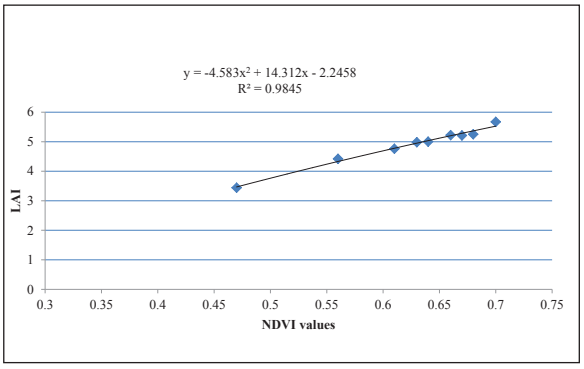



**Fig. 2.** Correlation between NDVI and LAI at tasseling stage

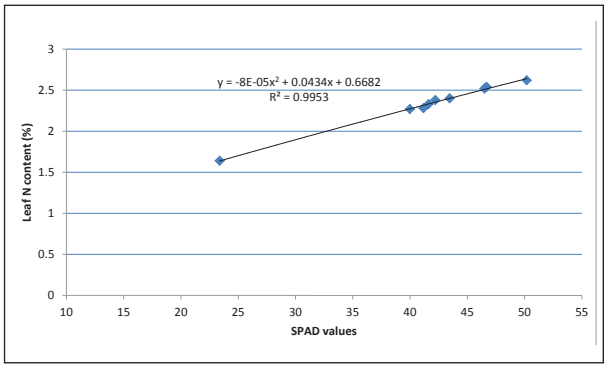



**Fig. 3.** Correlation between SPAD value and leaf N content at tasseling stage

Overall, it could be concluded that plant characteristics, NDVI, SPAD value, leaf N content, total dry matter at maturity and leaf area index were significantly higher in early planting dates (July 9) and CMB N [30 kg N $ha^{-1}$ basal + 30 kg N $ha^{-1}$at SPAD value ≤ 37.5 till silking] treated crop. SPAD values were significantly correlated with estimated leaf N content indicating that leaf N contents in maize leaf can be estimated non-destructively by using SPAD meter (Chlorophyll meter).

## ACKNOWLEDGEMENT

Authors are grateful to Head, Agronomy, Dean (PGS) and Director, ICAR-IARI, New Delhi-for allowing and supporting this research. The help extended by Sh. Sanjeev Kumar (Technical Officer) in conducting the field experiment successfully is appreciated and acknowledged.

## REFERENCES

Blackmer, T.M., and Schepers, J.S. 1995. Use of chlorophyll meter to monitor nitrogen status and schedule fertigation for corn. *J. Prod. Agric.* **8**: 56-60.

Campbell, J.B. 2002. *Introduction to remote sensing* (3rd ed.). The Guilford Press. New York, USA.

Dass, A., Vyas, A.K. and Kaur, R. 2014a. Nitrogen management in precision farming by soil plant analysis development meter. *Indian Farm.* **63**(12): 33–35.

Dass, A., Suri, V.K. and Choudhary, A.K. 2014b. Site-specific nutrient management approaches for enhanced nutrient-use efficiency in agricultural crops. *Res. Rev. J. Crop Sci. Technol.* **3**(3): 1-6.

Dass, A., Shivkumar, B.G., Dhar, S. and Kumar, K. 2015a. Soil and plant based precision N management in *rabi* maize (*Zea mays* L.) in north Indian alluvial plains. *Ann. Agric. Res., New Series* **36**: 358-363.

Dass, A., Jat, S.L. and Rana, K.S. 2015b. Resource conserving techniques for improving nitrogen-use efficiency. *Nutrient Use Efficiency: from Basics to Advances*. A. Rakshit, H.B. Singh, A. Sen (Eds.) Springer, p. 415.

Ercoli, L., Mariotti, M., Masom, A. and Massantini, F. 1993. Relationship between nitrogen and chlorophyll content and spatial properties in maize leaves. *Eur. J. Agron.* **2**(2): 113–117.

Federer, C.A. and Tanner, C.B. 1966. Spectral distribution of light in forest. *Ecology* **4**: 555-560.

Ghosh, A.P., Dass, A., Krishnan, P., Kaur, R. and Rana, K.S. 2017. Assessment of photosynthetically active radiation (PAR), photosynthetic rate (NPR), biomass and yield of two maize varieties under varied planting dates and nitrogen application. *J. Environ. Biol.* **38**(4): 683-688.

Joshi, E., Vyas, A. K., Dhar, S., Dass, A. and Prajapat, K. 2018. Nutrient omissions effect on growth, yield, water productivity and profitability of wheat in maize-wheat cropping system. *Indian J. Agric. Sci.* **88**(6): 924-30.

Kumari, K., Dass, A., Sudhishri, S., Kaur, R. and Kumar, R. 2017. Effect of irrigation regimes and nitrogen rates on photosynthetically active radiation interception, photosynthetic rate and dry matter partitioning in maize (*Zea mays* L.). *Indian J. Agric. Sci.* **87**(11): 1575-1578.

Ma, B.L. and Dwyer, L.M. 1999. Within plot soil mineral N in relation to leaf greenness and yield. *Commun. Soil Sci. Plant Anal.* **30**: 1919-1928.

McIsaac, G.F. and David, M.B. 2002. Relating net nitrogen input in the Mississippi river basin to nitrate flux in the lower Mississippi river: A comparison of approaches. *J. Environ. Quality* **31**: 1610-1622.

Odeleye, F.O. and Odeleye, M.O. 2001. Evaluation of morphological and agronomic characteristics of two exotic and two adapted varieties of tomato *(Lycopersicom esculentum)* in South West Nigeria. In: *Proc. 19th Ann. Conf. HORTSON* **1**: 140-145.

Ostergaard, H.S. 1997. Agronomic consequences of variable N fertilization. In: *Spatial variability in soil and crop. Precision Agriculture'97,* eds. J.V. Stafford, **I** : 315–320 . BIOS Scientific Publishers, Oxford, UK.

Pandey, R.K., Maranville, J.W. and Chetima, M.M. 2000. Deficit irrigation and nitrogen effects on maize in a Sahelian environment: II. Shoot growth, nitrogen uptake and water extraction. *Agric. Water Manage.* **46**: 15-27.

Rambo, L., Ma, B.L., Xiong, Y. and Silvia da, P.R.F. 2010. Leaf and canopy optical characteristics as crop-N-status indicators for field nitrogen management in corn. *J. Plant Nutr. Soil Sci.* **173**: 434–443.

Rana, K.S., Choudhary, A.K., Sepat, S., Bana, R.S. and Dass, A. 2014. *Methodological and Analytical Agronomy*. Indian Agricultural Research Institute, New Delhi, India. p. 276.

Rui, Y.K., Peng, Y.F., Wang, Z.R. and Shen, J.B. 2009. Stem perimeter, height and biomass of maize (*Zea mays* L.) grown under different N fertilization regimes in Beijing, China. *Int. J. Plant Prod.* **3**:85-90.

Sárvári, M. and Futó, Z.Z. 2000. Correlation between the sowing date, yield and grain moisture content of maize hybrids on chernozem soil. *Debreceni Egyetem Agrártudományi Közlemények* **1**: 32-41.

Shanti, K.V.P., Rao, M.R., Reddy, M.S. and Sarma, R.S. 1997. Response of maize *(Zea mays)* hybrid and composite to different levels of nitrogen. *Indian J. Agric. Sci.* **67**: 424-425.

Sharifi, R.S., Sedghi, M. and Gholipouri, A. 2009. Effect of population density on yield and yield attributes of maize hybrids. *Res. J. Biol. Sci.* **4**(4): 375–379.

Sharma, A.R. and Dass, A. 2012. Maize. (In) *Textbook of Field Crop Production*: *Food Grain Crops*, Vol. 1. Prasad, Rajendra (Ed.), Indian Council of Agricultural Research, New Delhi. pp. 98-136.

Stewart, W.M. 2002. *News and Views-A regional Newsletter*. 2p. Potash and Phosphate Institute, USA and the Potash and Phosphate Institute of Canada.

Trout, T.J., Johnson, L.F. and Gartung, J. 2008. Remote sensing of canopy cover in horticultural crops. *Hort. Sci.* **43**: 333–337.

Van Es, H.M., Czymmek, K.J. and Ketterings, Q.M. 2002. Management effects on N leaching and guidelines for an N leaching index in New York. *J. Soil Water Conserv.* **57**: 499–50

*e-planet* **17** (2): 106-110 (December 2019)

# Effect of integrated weed management in rainfed upland rice of Odisha

**S.M. PRASAD*, S. SAHA, M. CHOURASIA, D.R. SARANGI, T.R. SAHOO, S. SETHY AND R.K. MOHANTA**

*ICAR-National Rice Research Institute, Cuttack-753006, Odisha, India*

**smp_crri@yahoo.co.in*

Date of receipt: 04.08.2019 Date of acceptance: 25.11.2019

## ABSTRACT

A field experiment was conducted during wet seasons of three consecutive years, viz. 2013-15 under typical rainfed upland situation to evaluate the performance of different weed management techniques for improving the overall productivity and to work out the economics of different weed management practices in Vandana variety of rice. The highest grain yield (3.18 t $ha^{-1}$) was observed in weed free condition where three hand weeding at 15, 30 and 45 DAS has been done followed by two hand weedings (2.97 t $ha^{-1}$) at 15 and 35 DAS, which was at par with the stale seed bed + post emergence application of Azimsulfuron 35 g a.i. (2.86 t $ha^{-1}$) with weed control efficiency (WCE) of 90.8 per cent. Yield reduction due to weed competition in weedy plot was 58% over weed free check. Use of Azimsulfuron at 35 g a.i. per ha at 20 DAS proved to be more cost effective over the other treatments (BC ratio 1.21). Thus, use of Azimsulfuron at 35 g a.i. per ha 20 DAS was found to be the most cost-effective practice in upland conditions simulating the conditions prevalent in the present study.

**Key words:** Economics, upland rice, weed management, yield attributes

## INTRODUCTION

Direct seeded rice crop in upland situation face great weed competition in *kharif* season which limits its productivity. Weeds cause substantial yield losses (50-100%) and are considered the most important constraints in realizing the targeted high yields (Saha and Rao, 2007; Ogwuike et al., 2014; Rao et al., 2015). Aerobic soil condition, favourable temperatures and dry tillage practice encourage the germination and growth of diverse and highly competitive weed flora (Moorthy and Manna, 1993; Rao et al., 2007, 2015). The weeds compete with rice crop for nutrients, sun light and other necessary factors thereby causing the yield loss drastically and different rice varieties also respond differently to weed population (Garrity et al., 1992). Traditional method of weeding is very labour intensive, costly and time-consuming practice along with drudgery. Now-a-days, labour availability and that again at time of need is not very easy, which adds up the weed problem as weeding at critical times saves labour and improves yield both in quality and quantity (Prasad and Rafey, 1995; Juraimi et al., 2013; Chauhan et al., 2015).

To overcome this barrier various weed management practices (application of different herbicides and other management practices) are being followed, but most of the single practice are not fully effective and also economic (Tiwari and Singh, 1989; Chauhan, 2012; Juraimi et al., 2013). This strongly reiterates the demand for combining different weed management techniques to minimize the overall weed competition and reduce the total cost involved in weeding operation (Bhurer et al., 2013; Singh et al., 2016; Thakur et al., 2018). Thus, this experiment was conducted in a typical upland

situation to evaluate the efficiency of different weed management techniques and their economic viability.

## MATERIALS AND METHODS

A field experiment was conducted at Krishi Vigyan Kendra Cuttack, Santhapur during *kharif* of three consecutive years viz. 2013-2015 under typical rainfed upland having soil type of red lateritic, light in texture with acidic in reaction (pH 5.2 to 5.4) having organic carbon content (0.43 to 0.45%) total nitrogen (0.058 to 0.069 %), available phosphorous (10.8 to 15.1 kg $ha^{-1}$) and potassium (111.08 to 130.5 kg $ha^{-1}$).

The experiment was conducted in randomized block design with ten weed management practices (treatments) in four replications with upland rice variety "Vandana". The treatments consisted of $T_1$: Stale seed bed + post emergence application of Azimsulfuron (30 g a.i. $ha^{-1}$) at 20 day of sowing (DAS), $T_2$: Pretilachlor (750 g a.i. $ha^{-1}$) + 1 hand weeding (HW; 35 DAS), $T_3$: Pretilachlor (750 g a.i. $ha^{-1}$) + 1 mechanical weeding (MW; 30 DAS), $T_4$: PSE (Pyrazosulfuronethyl (PSE; 20 g a.i. $ha^{-1}$) + 1 HW 30 DAS, $T_5$: PSE (20 g a.i. $ha^{-1}$) +1 MW 30 DAS, $T_6$: MW twice (15 and 30 DAS), $T_7$: Azimsulfuron (35 g a.i. $ha^{-1}$) at 20 DAS, $T_8$: Hand weeding twice (15 and 35 DAS), $T_9$: Weed free (HW at 15, 30 and 45 DAS) and $T_{10}$: Weed infested plot. Mechanical weeding was done with finger weeder. Rice variety "Vandana" was sown in rows behind the country plough at spacing of 20 cm during third week of July using a seed rate of 80 kg $ha^{-1}$. A fertilizer dose of 40:20:20 kg N: $P_2O_5$ and $K_2O$ was applied as basal in the seed furrows in the form of single super phosphate and muirate of potash. Half of the N was applied to the crop at 20 DAS and rest two equal halves at 45 DAS and at panicle initiation (PI) stage. The weed density and dry wt. of weeds were recorded at 60 DAS with the help of 0.25 $m^2$ quadrants and converted per $m^2$ basis. Plant height (cm), number of panicles ($m^{-2}$), number of grains ($panicle^{-1}$), grain weight (n=1000), grain yield, straw yield, weed density (45 DAS), weed dry matter (60 DAS) and weed control efficiency (WCE; 60 DAS) were recorded for all the treatments. Weed control efficiency (WCE) denotes the magnitude of weed reduction due to weed control treatment. It was worked out by using the formula suggested by Mani et al. (1973) and expressed in percentage.

WCE (%) = 100 × (Dry weight of weeds in unweeded control-dry weight of treatment plot) / (Dry weight of weeds in unweeded control)

The cost of cultivation, gross return, net return were calculated in rupees per ha and the benefit: cost was also calculated.

## RESULTS AND DISCUSSION

In the experimental fields, grasses viz. *Cynadon dactylon*, *Eragrostis gangetium*, *Setaria glauca*, *Dactyloctenium aegyptium*, sedges viz. *Cyperus rotundus*, *Cyperus iria*, *Cyperus compressus*, *Fimbristylis miliacea* and broad leaf weeds viz. *Celocia argentea*, *Ludwigia perennis*, *Lindernia ciliata*, *Sida rhombifolia* were present as the major weeds. The broad-leaved weeds were the most predominant comprising 50-60% of total weed population in each year followed by sedges (30-40%) and grasses (10-15%).

The results revealed that the weed density ($m^{-2}$) in chemical weeding when integrated with cultural management practices, i.e. stale seed bed ($T_1$) resulted in similar weed density and also weed control efficiency (Table 1) as observed in triple and double hand weeding treatments ($T_8$, $T_9$). In these groups, the weed count and dry matter accumulation by weeds were significantly reduced over weedy check. The data on weed dry matter at 60 DAS when expressed as gram per square meter followed similar pattern. However, weeding with Pretilachlor and Pyrazosulfuron ethyl along with hand weeding or mechanical weeding had lower weed control efficiency in our field conditions. Similar to our findings, Behera et al. (1997) also got similar results while evaluating the efficiency of Butachlor + one HW or MW with finger weeder in controlling weed population in upland rice fields. Thus, timely weed control is considered to be the most critical for enhancing the productivity of rainfed upland rice (Saha et al.,1999). Among the various weed management techniques, the lowest

weed density and dry matter of weeds were recorded in weed free check having the highest WCE where three weedings were done. The treatment where two hand weedings were done recorded the second lowest weed density, dry matter of weeds and higher weed control efficiency closely followed by the treatment stale seed bed + post emergence application of Azimsulfuron. On application of different combinations of herbicides and cultural practices, Singh et al. (2016) recommended the use of good tillage practice along with herbicide chosen based on the dominant weeds in the system. This may be the reason Azimsulfuron acted as the best herbicide in the present study (Table 1).

**Table 1.** Performance of rice crop under different weed management techniques (pooled data)

| Treatment | Plant height (cm) | Panicles (no. $m^{-2)}$ | Grains $panicle^{-1}$ | 1000 grain weight (g) | Grain yield (t $ha^{-1}$) | Straw yield (t $ha^{-1}$) | Weed density (no. $m^{-2}$) | Weed dry matter at 60 DAS (g $m^{-2}$) | WCE (%) |
|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 109.1 | 220 | 72.4 | 24.08 | 2.86 | 5.44 | 74.5 | 8.2 | 90.8 |
| $T_2$ | 102.5 | 202 | 68.8 | 23.41 | 2.19 | 4.09 | 90.8 | 24.8 | 72.2 |
| $T_3$ | 101.2 | 198 | 68.0 | 23.32 | 2.06 | 3.84 | 94.2 | 27.7 | 68.8 |
| $T_4$ | 107.1 | 215 | 70.4 | 23.75 | 2.58 | 4.48 | 80.8 | 17.1 | 80.7 |
| $T_5$ | 103.4 | 210 | 70.0 | 23.48 | 2.36 | 4.43 | 86.7 | 21.4 | 75.9 |
| $T_6$ | 108.8 | 218 | 71.7 | 23.98 | 2.72 | 5.16 | 76.5 | 11.6 | 86.9 |
| $T_7$ | 107.6 | 216 | 70.8 | 23.93 | 2.70 | 5.10 | 78.2 | 12.4 | 86.0 |
| $T_8$ | 110.1 | 226 | 73.0 | 24.21 | 2.97 | 5.60 | 68.7 | 7.2 | 91.9 |
| $T_9$ | 110.5 | 228 | 73.4 | 25.37 | 3.18 | 5.38 | 65.5 | 0 | 100.0 |
| $T_{10}$ | 94.9 | 140 | 57.2 | 23.28 | 1.34 | 2.62 | 148.9 | 88.7 | - |
| CD (P= 0.05) | 8.0 | 7.2 | 5.4 | 0.46 | 0.17 | 0.21 | 10.2 | 7.08 | 5.64 |

The data on plant height differed significantly among treatments, where the weed population had a negative effect on plant height as $T_8$, $T_9$ and $T_1$ had higher plant height when compared to the weedy control or groups with less WCE (Table 1). Similar trend was also observed in case of other yield contributing parameters like panicle number, grains per panicle and grain weight, indicating weeds affect these parameters and the effect was significantly different than that of the control. Pooled data of three years revealed that the highest grain yield (3.18 t $ha^{-1}$) was observed in weed free condition where three hand weedings at 15, 30 and 45 DAS has been done followed by two hand weedings (2.97 t $ha^{-1}$) at 15 and 35 DAS, which was at par with the stale seed bed + post emergence application of Azimsulfuron 35 g a.i. (2.86 t $ha^{-1}$) with a weed control efficiency (WCE) of 90.8 per cent. The yields obtained in the treatments; $T_6$ Mechanical weeding twice and $T_7$ (Azimsulfuron @ 35 g a.i. $ha^{-1}$ at 20 DAS) were comparable to each other. Higher grain yields in these treatments was attributed to better control of weeds as observed from lower weed density and dry matter accumulation by weeds and increased yield attributing characters like higher number of panicle $m^{-2,}$ grains $panicle^{-1}$ and grain weight. Tiwari and Singh (1989) also recorded similar results in rainfed upland rice. Similar result was reported by Bhurer et al. (2013) who observed that weed free plot had the highest yield followed by pendimethalin 30 EC followed by two hand weeding and pendimethalin followed by 2, 4-D then one hand weeding. The maximum yield reduction due to weed competition was recorded 58% in weedy plots. Plant height and straw yield were also increased where weeds were controlled either by twice hand weeding or integrating chemicals or mechanical method (Table 1). Bhurer et al. (2013) also recorded similar

findings in direct seeded rice on grain yield and yield attributing characters.

The cost of cultivation varied among the treatments due to involvement of mechanical weeder, labour and chemicals as inputs in different weed management techniques (Table 2). Hand weeding thrice ($T_9$) or twice ($T_8$) were the costliest input wise, whereas $T_3$, $T_5$ and $T_7$ had lower input costs. The negative values in terms of net returns (₹5350 and ₹1320) were observed in case of $T_2$ and $T_3$ treatments due to lesser gross return and higher cost of cultivation due to labour requirement in hand weeding and mechanical weeding, respectively. Thus, it is imperative that weed management through chemical at right time will be most economical in rainfed upland rice production system (Table 2).

**Table 2.** Economics of different weed management techniques

| Treatment | Cost of cultivation (₹ ha$^{-1}$) | Gross return (₹ ha$^{-1}$) | Net return (₹ ha$^{-1}$) | B: C |
|---|---|---|---|---|
| $T_1$ | 27050 | 31180 | 5130 | 1.20 |
| $T_2$ | 30150 | 23800 | -5350 | 0.82 |
| $T_3$ | 24700 | 22380 | -1320 | 0.94 |
| $T_4$ | 28150 | 28060 | 910 | 1.03 |
| $T_5$ | 24550 | 25670 | 2120 | 1.09 |
| $T_6$ | 26200 | 29640 | 4440 | 1.18 |
| $T_7$ | 25350 | 29400 | 5050 | 1.21 |
| $T_8$ | 29650 | 32330 | 3680 | 1.13 |
| T9 | 32650 | 34450 | 2800 | 1.09 |
| T10 | 19250 | 14680 | -3570 | 0.80 |

In similar studies, weed free treatments resulted in the highest yield, but not economical due to high cost of cultivation (Bhurer et al., 2013). The highest benefit: cost (BC ratio: 1.21) was observed with $T_7$ (Azimsulfuron 35 g a.i. ha$^{-1}$ at 20 DAS) closely followed by $T_1$ (stale seed bed + post emergence application of Azimsulfuron 30 g a.i. ha$^{-1}$), whereas a negative BC ratio was obtained in $T_2$ and $T_3$ due to higher input cost ($T_2$), low weed control efficiency ($T_2$ , $T_3$) and lower rice yield ($T_2$ ,$T_3$) in these treatments. In terms of return, the highest net return (₹5130.00) was observed with $T_1$, but due to higher cost of cultivation than $T_7$, the BC ratio was reduced in the former treatment. Mechanical weeding with finger weeder at 15 and 30 DAS also had similar BC ratio as $T_1$ and $T_2$due to its effectiveness in weed control (Table 1).

## CONCLUSION

The present study indicated that weed free condition (three hand weedings at 15, 30 and 45 DAS) and two hand weedings (15 and 35 DAS) were superior in weed control, but the stale seed bed + post emergence application of Azimsulfuron 35 g a.i. and use of Azimsulfuron at 35 g a.i. per ha at 20 DAS were proved to be more cost effective over all the other treatments in upland conditions used in the study. However, the weed characteristic and their population should be targeted when selecting the herbicide.

## REFERENCES

Behera, U.K., Jha, K.P. and Mahapatra, I.C. 1997. On farm evaluation of different weed management practices in early rice (*Oryza sativa*) in the rainfed uplands in eastern India. *Indian. J. Agron*. **42**: 446-451.

Bhurer, K.P., Yadav, D.N., Ladha, J.K., Thapa, R.B. and Pandey, K.R. 2013. Influence of integrated weed management practices on dynamics and weed control efficiency in dry direct seeded rice. *Nepal J. Sci. Technol.* **14**(2): 33-42.

Chauhan, B.S. 2012. Weed ecology and weed management strategies for dry-seeded rice in Asia. *Weed Technol*. **26**:1-3.

Chauhan, B.S., Ahmed, S., Awan, T.H., Jabran, K. and Manalil, S. 2015. Integrated weed management approach to improve weed control efficiencies for sustainable rice production in dry-seeded systems. *Crop Protect.* **71**: 19-24.

Garrity, D.P., Movillon, M. and Moody, K. 1992. Differential weed suppression ability in upland rice cultivars. *Agron. J*. **84**: 586-591.

Juraimi, A.S., Uddin, M.K., Anwar, M.P., Mohamed, M.T.M., Ismail, M.R. and Man, A. 2013. Sustainable weed management in direct seeded rice culture: A review. *Austr. J. Crop Sci*. **7**: 989.

Mani, V.S., Malla, M.L., Gautam, K.C. and Bhagwndas. 1973. Weed killing chemicals in potato cultivation. *Indian Farm*. **VXXII**: 17-18.

Moorthy, B.T.S. and Manna, G.B. 1993. Studies on weed control in direct seeded rainfed upland rice. *Indian J. Agric. Res*. **27**: 175-180

Ogwuike, P., Rodenburg, J., Diagne, A., Agboh-Noameshie, A.R. and Amovin-Assagba, E. 2014. Weed management in upland rice in sub-Saharan Africa: impact on labor and crop productivity. *Food Secur.* **6**: 327-337.

Prasad, K. and Rafey, A. 1995. Effect of integrated weed management on weed growth, nutrient uptake, economics and energetics in rainfed upland rice (*Oryza sativa*). *Indian J. Agric. Sci*. **65**: 260-264.

Rao, A.N., Johnson, D.E., Sivaprasad, B., Ladha, J.K. and Mortimer, A.M. 2007. Weed management in direct-seeded rice. *Adv. Agron.* **93**: 153-255.

Rao, A.N., Wani, S.P., Ramesha, M. and Ladha, J.K. 2015. Weeds and weed management of rice in Karnataka State, India. *Weed Technol*. **29**: 1-7.

Saha, S., Moorthy, B. and Jha, K.P. 1999. Influence of different production factors on the performance of rainfed upland rice (*Oryza sativa*). *Indian J. Agric. Sci.* **69**: 449-450.

Saha, S. and Rao, K.S. 2007. *Weed management in rice*. CRRI Research Bulletin No. 2. Central Rice Research Institute, Cuttack, India.

Singh, V.P., Dhyani, V.C., Singh, S.P., Kumar, A., Manalil, S. and Chauhan, B.S. 2016. Effect of herbicides on weed management in dry-seeded rice sown under different tillage systems. *Crop Protect*. **80**: 118-126.

Tiwari, A.N. and Singh, K.K. 1989. Effect of removal of types of weed flora in upland direct seeded rainfed rice. *Indian J. Weed Sci*. **21**: 72-74.

Thakur, C.L., Shrivastava, G.K., Sreedevi, B. and Thakur, A.K. 2018. Realising aerobic rice potential in India-An integrated weed management perspective. *Int. J. Curr. Microbiol. Appl. Sci.* **7**(2): 575-589.

*e-planet* **17** (2): 111-116 (December 2019)

# Vegetative propagation of some selected horticultural crops

**HABIBULLAH HAMAYOUN[1*] AND GUL AHMAD ZAHIRYAN[2]**

*[1]Department of Agriculture, Faculty of Ghazni University, Ghazni, Afghanistan*
*[2]Department of Agriculture, Faculty of Kabul University, Kabul, Afghanistan*

**hamayoun.1383@gmail.com*

Date of receipt: 15.10.2019 Date of acceptance: 17.12.2019

**ABSTRACT**

Some of the horticultural crops are reproduced by asexual methods of plant propagation to regenerate clonal varieties although the sexual propagation method has also practiced for different plants. This can be done naturally for those plants which are propagating by vegetative means through specialized organs or by human intervention for targeted crops. The specialized plant organs are those plant parts which have used for storage of food reserves and propagation purposes. They reproduce by dividing and further separating the organs from their mother plants and are propagated to produce new clonal plants. Propagation by division is a form in which a group of plants or plant parts are cut which contains one or more of the underground or aerial roots or stem parts. This method is commonly used for different economically important horticultural crops viz. apple propagated by tongue grafting, grape propagated by hard wood cutting, strawberry by runner, potato by tuber, onion by bulb etc. In different field of horticultural crops propagation industry, identifying the appropriate plant parts that used for propagation and their methods of propagation are fundamental for plant propagators.

**Key words:** Bulb, hard wood cutting, propagation, runner, tongue grafting, tuber

## INTRODUCTION

Among the plant species found on the land surface, a higher form of plant species occupy a wide variety of habitats over the others (Bhende and Kurien, 2015). This wide adaptability determines the tendency to perpetuate in to particular environment by producing their offspring's to survive. This can happen by different reproduction methods viz. by sexual reproduction which is most important method for many plants and asexual reproduction method when reproduction by seed is limited (Bryant, 1995).

A vegetative reproduction is the process of multiplication in which a portion of fragment of the plant body functions as propagates and develops into a new individual plant which involves the production of new plants without the act of fertilization or sexual union. Further can be said that, vegetative propagation of plant is a form of plant propagation in which the new individual plant arises from any vegetative part of the parents (root, stem, leaf and other organs), and possesses exactly the same characteristics of their parent plant from which it was derived. According to Agrios (2005), clonally propagated plants are categorized as those cultivated for vegetative product and those cultivated for a fruit or reproductive product that mostly practiced in fruit trees propagation. In higher plants, any part of the structure may be capable of vegetative propagation. Many plants produce modified stems, roots, and leaves, especially for natural vegetative propagation. The most commonly known vegetative propagation of plants includes propagation by cuttings, which is obtained either from stem, leaf, root: by layering, by grafting, by modified specialized organ or by micro-propagation methods. But, In case of lower

plants, propagation occurs through binary fission, budding, fragmentation, formation of adventitious branches, gemmae, resting buds and sporadic (in lichens). All these methods of plant propagation by vegetative organ occur naturally but at the same time, man too has developed various methods of artificial vegetative propagation for many useful plants which are widely used in the horticultural industry. To do this, knowledge and skills of identification of plant organs which has to be used for plant propagation is paramount important for horticulturalists in order to multiply as per requirements. Therefore, the aim of this review paper is to discuss the propagation methods of selected horticultural crops by specialized organs.

**Propagation by specialized organs**

The plant is composed of four primary organs viz. roots, stems, leaves and flowers, which can be used as material for propagation. The most commonly utilized form of plant reproduction by people is seeds. But, a number of asexual methods including cutting, grafting, budding, layering, division, separation and micro-propagations are utilized when seed propagation is not feasible. Also an asexual methods of plant propagation are important to multiply cultivars with individual desirable characteristics that do not come to true from the seeds, to ensures the faster initial plant growth and higher survival rate of the plant, to produce higher yield with quality product, to reproduce plants which have a short life span and seed dormancy and to propagate a plants which are sterile to reproduce by seeds Hasan et al. (2011). Early (2008) clearly elaborated the role of vegetative propagated crops that almost all of the plants sold as perennials, bulbs, corms, trees and shrubs are vegetative propagated because most of them are hybrids which will not breed true to type from seeds. In many plant organs modifications exist to enable natural vegetative propagations. Of these, the stem is the most important one which produces a bud that completely grow to new plant with roots, stems and leaves. All daughter plants produced from these organs are identical called 'clones' of the mother plant and may serve as food stores. These stored foods enable to quickly burst growth of plants in the spring, e.g. iris rhizomes (Henry, 2005). According to McKey et al. (2010) and Stewart and Globig (2011), clonally propagated food crops encompass a huge range of phylogenetic, morphological and ecological diversity. Different parts of clonally propagated plants have been selected to provide food and clonal propagates such as stems, roots, leaves, fruits, under or sub-aerial specialized storage organs and even seeds. The specialized vegetative structures includes runners, suckers, crown, offsets, bulbs, corms, tubers, tuberous roots, rhizomes and pseudo-bulbs are used primarily for the storage of foods, nutrients and water during adverse environmental conditions and for germplasm propagules. Plants possessing these modified plant parts are generally herbaceous perennials, in which the shoots die down at the end of a growing season but the fleshy vegetative structure usually do not die and remains viable in the soil, which put forth new vegetative growth in the next season (McKey et al., 2010). Plants that survive as underground storage organs are called genotypes that can withstand period of adverse growing conditions in their regular growth cycles and used as propagules. For instance, potato tubers are modified stems that store starch in swollen underground structures known as tubers which serve as a seed for raising commercial potato crops. Different horticultural crops propagated by specialized organs either dividing them or separating from their mother plants in order to get smaller planting materials.

**Propagation by division**

Propagation by division is a form in which a group of plants or plant parts are cut or torn apart and each part of the divided plant contains one or more of the roots of the plant and a part of the stem of one or more stems. Division is probably the simplest form of plant propagation which is suitable for most clumps and rosette forming perennials (Henry, 2005).

Most of the perennial plants benefited from division as they get older and begin to lose their vigor. It involves little more than breaking up established clumps in to a number of smaller pieces. The only

complications come in knowing just when to divide and establishing a minimum size for the divisions. The success rate of plant rose from division is very high compared to the other propagation methods. Plants that have fibrous, rhizomatous roots, and form clumps or crowns, are typically split up for propagation in to new plants. The dividing line between fibrous rooted perennials, crown rhizome perennials and rhizomes are somewhat indistinct. Rhizomes are purely underground stems and separated from the crown of roots around the base of the plant (Henry, 2005). He also suggested that, plants suitable for division can be put in to three categories. Firstly, plants that form clumps of rosettes or of sets which can simply be cut up or broken apart in to rooted pieces and immediately regarded as new plants. This sort of division can in most cases be done any time of the year. Many of these types of plants will also produce runners or offsets which can be separated from the parent plants. Likewise any plants which produce suckers can be propagated by removing the rooted suckers and growing them on it. Secondly, there are plants that have distinct foliage clusters but fibrous crown, these plants will usually require careful cutting up and many in some cases have only a few roots per division. This can necessitate planting in some sort of nursery bed until establishment, although in most cases they will survive if planted out straight away. This division can undertake when the plant are not growing too actively and the weather is not too warm. Thirdly, those plants which fleshy crowns with foliage emerging at many points. Tese will require careful cutting and many in some case have distinct growth points. Each division will need at least one growth point if it is to strike. This sort of division is best done just as the plants are emerging from dormancy. The line between division and natural layering is overlapped. Many perennials and shrubs, particularly ground covers will strike roots wherever they come in contact with in the ground. If cut at the appropriate point these aerial roots will then develop as normal subterranean roots. Different horticultural crops can be propagated by different specialized organs i.e. 'propagation by division' (Henry, 2005).

**Propagation by tongue grafting**

Apple is king of temperate fruit, symbol of health and premier fruit of the world. Tongue grafting is the most successful method in apple propagation. In tongue grafting, a 5 mm slanting cut is made tapering into the bark on the lower end in the scion- wood, in the middle if this slanting cut, another cut is made upward to from a tongue. A similar slanting cut of identical length is made on the rootstock pointing upward. Then a similar tongue is also made in the rootstock, corresponding to the exact location if the tongue made in the scion wood. The scion tongue is inserted into rootstock tongue in a way that the two cuts fit each other firmly. If the thickness in the scion-wood is different to the rootstock, the tongue should be cut in a way that in inserting it in the rootstock, the cambium layer of both the rootstock and scion make as much contact as possible. After the scion wood is interlocked with rootstock, is tied with a thread and waxed or wrapped with an alkathene strip so as to make it airtight the height if the scion graft on stock should normally be 15 cm above the ground. The month of February to March is the best time for tongue grafting in apple (Sharma and Rana, 2015; Muthukumar and Selvakumar, 2013).

**Propagation by hard wood cutting**

Among the fruits, grapes occupy more than 10 million ha. area with annual global production of US $ 2 billion (Rao, 2005). It is propagated commercially by hard wood cutting (4 inches length and 8-10 mm diameter and 25-30 cm length) and can be prepared from the pruned wood. Growth regulators which are commercially used for cuttings is 1BA 2000 PPM in 10 second (Fig. 1 and 2)

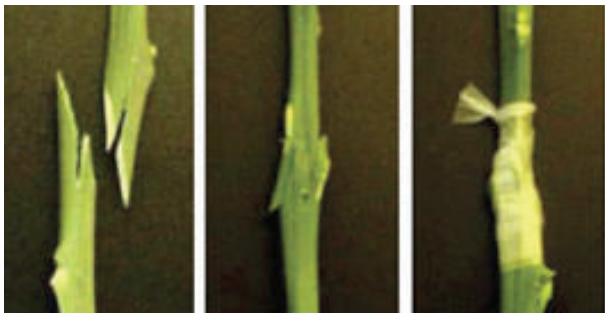


**Fig. 1.** Propagation by hard wood cutting

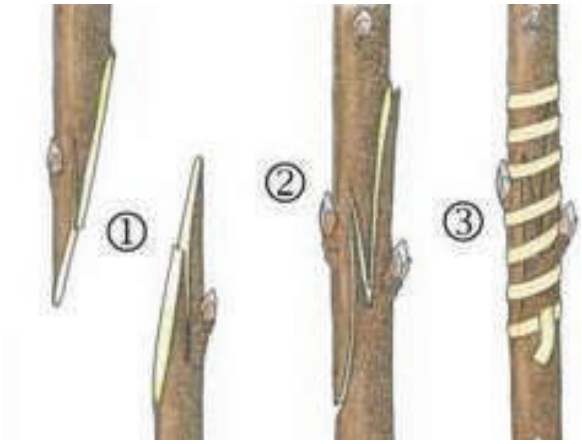



**Fig. 2.** Demo on propagation by hard wood cutting


**Fig. 4.** a, b Propagation by runner

## Propagation by runner

Strawberry is one of the most important fruit crops which is regenerated by specialized stems called runner which grows horizontally along the ground and forms a new plant at one of the nodes. One plant may have several runners and one runner may grow several nodes. The long and flexible runners facilitate to bend and positioned according to the desire of the person cloning them. When runner separated from the mother plant with intact roots, it serves as a propagule (Fig. 3 and 4). Growing strawberry plants from a runner is one of the easiest and quickest ways of propagating methods. According to Hasan et al., strawberry runners have been affected by photo period, as the day length has increased from 15 to 17 h, the number and length of strawberry runners also increased proportionately. So it is important to produce runners under a long period of light to get higher and vigor propagules (Ud-Deen, 2008).

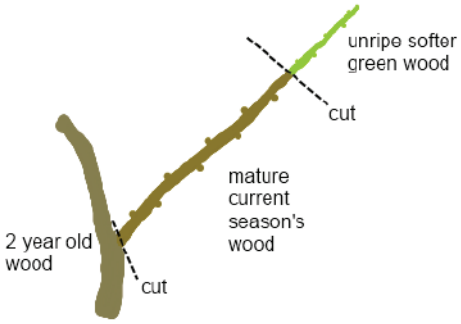



**Fig. 3.** a, b Propagation by runner

## Propagation by tuber

Potato is propagated vegetatively by 'division' of tubers. Tubers are divided into sections, each containing one or more eyes. Tubers are thickened underground stems that serve as storage organs. Tubers have no basal plate since

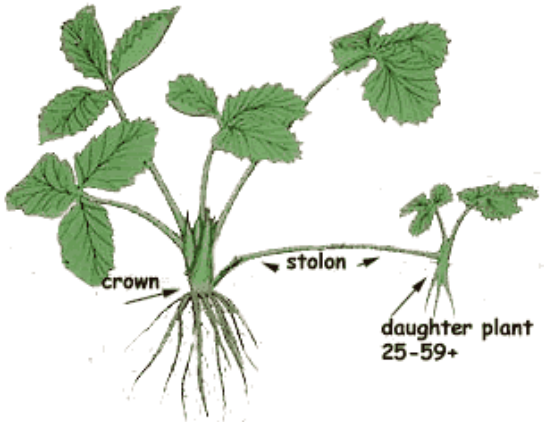



**Fig. 5.** Propagation by tuber

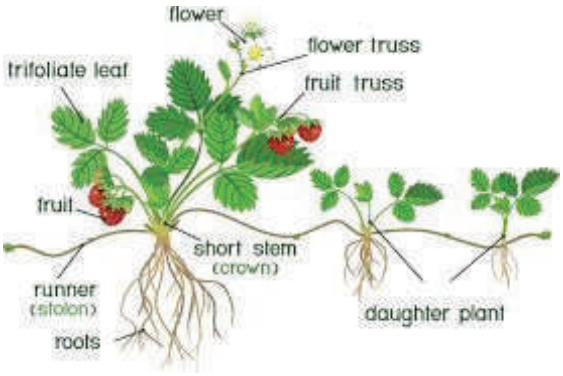



**Fig. 6.** Propagation by tuber having nodes

they do not originate from the base of a stem (Fig. 5). In potato (*Solanum tuberosum* L.) and many other tuberous plants, many tubers may raise from a single plant. Tubers are anatomically the same as stems having internodes and nodes from which eyes develop containing one or more shoot buds (Fig. 6). The tubers serve as an overwintering storage site producing new roots and shoots during the following season. The new shoots use the reserves from the tuber for initial growth and produce new tubers for the following season. Potato can be planted directly as whole or divided to smaller parts of tuber which have a bud at the node for shoot development. Planting different size of potato tubers has a direct effect on potato yields (Shrestha, 2007), the larger size and whole/half cut of potato tuber produces the higher tuber yields and are less susceptible to late blight potato disease as compared to the smaller size of the tubers.

### Propagation by bulbs

Onion (*Allium cepa* L.) is an important vegetable crop that is grown worldwide. It is propagated either by seed or bulb (Smith et al., 2001)

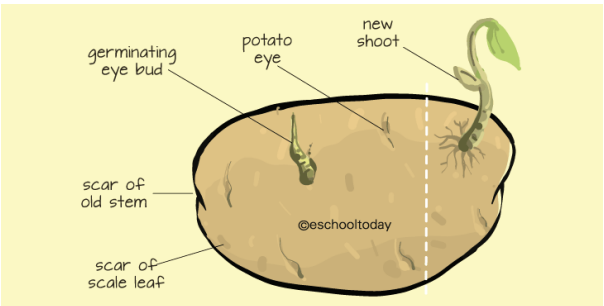



**Fig. 7.** Propagation by bulbs

Bulbs are a specialized modified underground organ consists of short, fleshy, usually vertical stem axis and enclosed by thick scales (Fig. 7). There are two kinds of bulbs; tunicate and non-tunicate,. the tunicate bulbs have outer modified leaves, which are dry and papery thin and non-tunicate or scaly bulbs lack this protective (papery) covering and are easily damaged. Meristems (lateral buds) develop between the scales and stem axis to form bulblets, known as offsets, when grown to mature size. The bulb size of onion has a direct effect on onion yield production. Some times when onion has propagated by bulb (Fig. 8), the upper portion of the bulb is removed in order to facilitate rapid initial growth of the bulb (Toogood and Anderson, 1999).

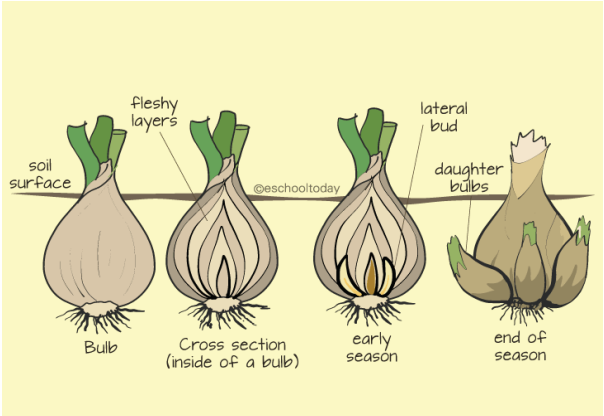



**Fig. 8.** Onion propagation by bulbs

## CONCLUSION

Almost all of the breathing creatures on this planet has directly or indirectly dependent on the plant products either for food or other purposes. Generally, plants can be reproducing sexually by seed and asexually by different plant organs which the propagules possesses an identical genetic feature of the original parent plants. Different horticultural plants propagated differently by their specialized organs either by separating or dividing of their organ to produce a copy of the parent plants. Crops like apple, grape and straw berry fruits and potato and onion vegetables are reproduced by these specialized organs. Knowing and applying of this propagation methods are of paramount importance for plant propagators in order to increase production and yield of respective crops.

## REFERENCES

Agrios, G.N. 2005. *Plant Pathology*. 3rd Edition, Elsevier, pp. 259-263.

Bhende, S.S. and Kurien, S. 2015. Sucker production in banana. *J. Trop. Agric*. **53**: 97-106.

Bryant, G. 1995. *Propagation handbook: basic techniques for gardeners*. Stack Pole Books, USA.

Early, M.P., Adams, C.R. and Bamford, K.M. 2008. *Principles of Horticulture.* Elsevier.

Hasan, S.M.Z., Al-Madhagi, I., Ahmad, A. Yusoff, W.A.B. 2011. Effect of photoperiod on propagation of Strawberry (Fragaria x ananassa Duch.). *J. Hort. Forestry*

Henry, R.J. 2005. Importance of plant diversity (in Henry, R.J. Ed.) *Plant Diversity and Evolution: genotypic and phenotypic variation in higher plants.* CAB International. pp. 1-6.

McKey, D., Elias, M., Pujol, B. and Duputié, A. 2010. The evolutionary ecology of clonally propagated domesticated plants. *New Phytol.* **186**: 318-332.

Muthukumar, P. and Selvakumar, R. 2013. *Glaustas Horticulture,* New Vishal Publications, New Delhi.

Rao, P.P., Joshi, P.K., Kumar, S. and Ganguly, K. 2008. *Agricultural Diversification in Andhra Pradesh, India: Patterns, determinants and implications*. Research Report no. 2. International Crops Research Institute, Patancheru, Andhra Pradesh, India.

Sharma, L.K. and Rana, R.K. 2015. Effect of top-working to improve the top-working in apple (Malus X Domestica Borkh) Orchards under mid-hill conditions of Kullu District. *Himachal J. Agric. Res.* **41**(1): 89-92.

Shrestha, H. 2007. *A Plant monograph of Onion* (*Allium cepa* L.). The School of Pharmaceutical and Biomedical Sciences, Pokhara University, Simalchaur, Pokara, Nepal pp: 7-8.

Smith, B.N, Harris, L.C, Mcarlie, V.W, Stradling, D.L, Thygerson, T. et al. 2001. Time, plant growth, respiration, and temperature. Hand book of plant and crop physiology. Marcel Dekker, Inc., NY, USA pp: 1-11.

Stewart, P. and Globig, S. 2011. *Reproductive physiology in plants*. CRC Press, USA.

Toogood, A.R. and Anderson, P. 1999. *Plant propagation*. American Horticultural Society.

Ud-Deen, M.M. 2008 . Effect of mother bulb size and planting time on growth, bulb and seed yield of onion. *Bangladesh J. Agric. Res.* **33**: 531-537.

*e-planet* **17** (2): 117-122 (December 2019)

# Performance of potato (*Solanum tuberosum* L.) with organic inputs in North-Eastern India

**J.M. MAWTHOH, LALA I.P. RAY*, A.K. SINGH, N.J. SINGH AND R.S. DHIVYA**

*School of Natural Resource Management, College of Postgraduate Studies in Agricultural Sciences, CAU-Imphal, Umiam-793103, Meghalaya, India*

**lalaipray@rediffmail.com*

Date of receipt: 15.10.2019 Date of acceptance: 17.12.2019

## ABSTRACT

A field experiment was conducted under organic regime on potato (*Solanum tuberosum* L.) in mid hills of Meghalaya during 2018-19 at experimental farm of College of Agriculture, Kyrdemkulai, Meghalaya. The treatments included irrigation scheduling and organic manure application, *viz.,* irrigation at sprouting ($S_1$); irrigation at sprouting + stolonization ($S_2$); irrigation at sprouting + stolonization + tuber initiation ($S_3$); irrigation at sprouting + stolonization + tuber initiation + tuber bulking ($S_4$) and organic treatments comprised of FYM (Farmyard manure) ($M_1$), poultry manure ($M_2$) and control ($M_0$). Tuber yield was found to be significantly higher under $S_2$ (17.52 t ha$^{-1}$) yielded the highest followed by $S_4$ (16.62 t ha$^{-1}$) and $S_3$ (14.87 t ha$^{-1}$), whereas, $S_1$ (6.61 t ha$^{-1}$) recorded the lowest yield. Organic manure treatments yielded significant results. $M_2$ (17.77 t ha$^{-1}$) showed the highest tuber yield closely followed by $M_1$ (13.94 t ha$^{-1}$) and lowest yield was reported by $M_0$ (10.22 t ha$^{-1}$). Maximum gross return, net return and BCR were reported in $S_2$ followed by $S_4$, $S_3$ and $S_1$. In case of organic manure, higher gross return, net return and BCR was recorded in $M_2$ followed by $M_1$ and $M_0$. Benefit Cost Ratio (BCR) also showed significant difference among the organic manure treatments, $M_2$ (2.82) produced the highest BCR over $M_1$ (2.13) and $M_0$ (1.79).

**Key words:** BCR, irrigation scheduling, organic manure, potato, strip plot design

## INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important foods in the world ranking fourth in production after rice, wheat and maize. It ranks second in India in terms of production after China (Scott and Suarez, 2011). In Meghalaya, the total area under potato cultivation is 18,473 ha and total production is 1,82,285 metric tonnes. One of the promising varieties of potato is Kufri Megha, grown mainly under irrigated conditions during the *rabi* or *post rabi* season. The north eastern states of India contribute about 10% of the total area under potato in the country and 4% of the total production in India (Gupta et al., 2004). But the potato productivity in this region is very low (8.64 t ha$^{-1}$) as scientific production technology has not been adopted (Burman et al., 2007).

Potato is highly sensitive to water stress and since it is being cultivated mostly during the *rabi* season, it is of utmost importance for water management through irrigation scheduling techniques for better potato production. Suitable irrigation scheduling during crop's critical stages (stolonization, tuber initiation and tuber bulking) can help farmers to conjunctively use water whilst also increasing the yield. Also, being an exhaustive crop, proper nutrient management needs to be addressed to ensure potential output. Manures improve crop growth by enhancing uptake of nutrients by plants to the soil and improve soil fertility by increasing available nutrients. Organic manure application enhances soil porosity, soil moisture content and water holding capacity (Mahmood et al., 2017).

## MATERIALS AND METHODS

A field experiment was conducted during November - March, 2018-19 at the College of Agriculture, Kyrdemkulai, Ri-bhoi district, Meghalaya with "Kufri Megha" potato variety. The experimental site is situated at 91° 18' to 92° 18' East longitude and 25° 40' to 26° 20' North latitude and at an altitude of 950 m above the mean sea level (MSL). The climate of Ri-bhoi is classified as subtropical humid type with high rainfall and cold winters. During the experimentation period, maximum weekly rainfall of 20.9 mm was received during 2nd standard week (January), the total amount of 81.73 mm was received during the crop-growing season. Mean weekly maximum temperature was highest during 11th standard week (27°C) and lowest in 1st standard week (18.20°C). Mean weekly minimum temperature was highest during 11th standard week (13.20°C) and lowest in 1st standard week (5.90°C). The average recorded weekly relative humidity was 90%.

The red clay loam soil has initial organic carbon and pH of 1.8%, 5.1 respectively. The available nitrogen (N), phosphorus (P) and potassium (K) at 0-30 cm were 242.8 kg $ha^{-1}$, 19.25 kg $ha^{-1}$ and 320 kg $ha^{-1}$, respectively. Organic manures were incorporated before sowing.

Potato crop is very sensitive to water deficit; hence, it requires frequent and shallow irrigations. Reduction in yield is often associated with water deficit during stolonization, tuber initiation and tuber bulking (FAO, 2008). Taking this into consideration, the criteria based on crop's critical growth stages were utilized for scheduling of irrigations *viz.* Irrigation at sprouting (10 DAS); Irrigation at sprouting (10 DAS) and stolonization (30 DAS); Irrigation at sprouting (10 DAS), stolonization (30 DAS) and tuber initiation (50-55 DAS); Irrigation at sprouting (10 DAS), stolonization (30 DAS), tuber initiation (50-55 DAS) and tuber bulking (65-70 DAS) on respective plots. FYM and poultry manure were applied at the rate of 24 t $ha^{-1}$ and 8 t $ha^{-1}$, respectively base on recommended nitrogen dose of potato. Seed rate and spacing adopted was 15 t $ha^{-1}$ and 50 cm × 20 cm respectively. First irrigation was given after sowing for inducing germination.

Total of 12 treatments consisted of four irrigation scheduling at critical stages and two organic manures and a control. The experiment was laid in strip plot experimental design. The treatments were given below.

### Vertical strips

i. Irrigation at sprouting (10 DAS) ($S_1$)
ii. Irrigation at sprouting(10 DAS) and stolonization (30 DAS) ($S_2$)
iii. Irrigation at sprouting(10 DAS), stolonization (30 DAS) and tuber initiation (50-55 DAS) ($S_3$)
iv. Irrigation at sprouting(10 DAS), stolonization (30 DAS), tuber initiation (50-55 DAS) and tuber bulking (65-70 DAS) ($S_4$)

### Horizontal strips

i. Control (no manure) ($M_0$)
ii. Farmyard manure ($M_1$)
iii. Poultry manure ($M_2$)

The crop calendar is presented in Table 1

**Table 1.** Calendar of operations

| Sl. | Cultural Operation | Date of Operation |
|---|---|---|
| 1. | Field preparation and incorporation of lime. | 14th November 2018 |
| 2. | Field layout | 17th November 2018 |
| 3. | Application of manures | 19th November 2018 |
| 4. | Sowing | 24th November 2018 |
| 5. | Gap filling | 27th December 2018 |
| 6. | Weeding | 29th December 2018 (as and when required) |
| 7. | Earthing up | 15th January 2019 |
| 8. | Harvesting | 23rd March 2019 |

Various plant growth parameters, *viz*., Plant height (cm), weight of tuber per plant, total tuber yield (t $ha^{-1}$) were estimated as per standard protocols. Cost of cultivation was calculated and accordingly benefit cost ratio (BCR) values were estimated for various treatment combinations.

The data obtained from various studies during investigation were statistically analysed by using the technique of analysis of variance for strip plot design over the computer. The difference between the treatment means was tested as for their statistical significance with appropriate critical difference (C.D.) value at 5% level of probability as explained by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

### Plant height

Plant height is an important parameter for determining the growth of plant. The maximum plant height was recorded at 105 DAS 29.98 cm. Plant heights of potato decreases with decrease of irrigation frequency (Kumar et al., 2007). It is readily influenced by the prevailing meteorological conditions during the growing season. At the time of maturity, the maximum plant height recorded was 29.98 cm under poultry manure treatment ($M_2$). Irrigation scheduling at crops' critical stages, *viz*., irrigation at sprouting ($S_1$); irrigation at sprouting + stolonization ($S_2$); irrigation at sprouting + stolonization + tuber initiation ($S_3$) and irrigation at sprouting + stolonization + tuber initiation + tuber bulking ($S_4$), did not show significant results on plant height and this may be due to the occurrence of light showers throughout the growing period. However, significant increase in plant height was observed with the application of organic amendments. The application of poultry manure showed the highest plant height (29.98 cm) and the shortest height was recorded under control treatment (23.73 cm) at 105 DAS as shown in Table 1. It might be due to the ability of poultry manure to decompose rapidly thereby, releasing the nutrients essential for plant growth Boateng et al. (2006). Other organic manures including FYM, has slow release of nutrients (Souza et al., 2008). The results reported a significant difference in plant height in plants derived in poultry manure and FYM compared with that of control. These results were in agreement to the findings of Karim et al. (2016). The increase in plant height from 90 DAS to 105 DAS is very small and this is due to the starting of senescence period where growth becomes stagnant.

### Yield attributes

Significant results were recorded in irrigation scheduling treatments on weight of tubers per plant. Even so, treatments with only one irrigation, *i.e.,* $S_1$ produced the lowest weight of tubers per plant. This indicates that water availability at the root zone of plant plays an important role on the final yield. And clearly, irrigation at stolonization proves to be the most critical stage for better crop performance (Table 1). This is in conformity with results reported by Saikia (2011) and Bora and Karmakar (2012). Hence, it can be concluded that the availability of water at root zone during potato growth helps in better yield and produce (Bisht et al., 2012). Among organic manure treatment $M_2$ (205.91 g) closely followed by $M_1$ (172.79 g) and $M_0$ (108.78 g). The findings are in accordance with Lemaga and Caesar (1990), Amara and Mourad (2013) and Karim et al. (2016).

Tuber yield was found to be significantly higher under $S_2$ (17.52 t $ha^{-1}$) yielded the highest followed by $S_4$ (16.62 t $ha^{-1}$) and $S_3$ (14.87 t $ha^{-1}$), whereas, $S_1$ (6.61 t $ha^{-1}$) recorded the lowest yield. Organic manure treatments yielded significant results. $M_2$ (17.77 t $ha^{-1}$) showed the highest tuber yield closely followed by $M_1$ (13.94 t $ha^{-1}$) and lowest yield was reported by $M_0$ (10.22 t $ha^{-1}$). Crop irrigated only at sprouting might have experienced water stress during the vegetative phase, reproduction phase and maturity phase causing a reduction in final tuber yield. The reduction in yield with treatment $S_1$ can also be attributed to the lesser number of tubers per plant and lower tuber weight per plant. High water requirement needs to be emphasized especially during potato critical stages of stolonization, tuber initiation and tuber bulking (Hassan et al., 2002; Saikia, 2011; Bora and Karmakar, 2012). Among organic manure treatment $M_2$ (17.77 t $ha^{-1}$) closely followed by $M_1$ (13.94 t

$ha^{-1}$) and $M_0$ (10.2 t $ha^{-1}$). Poultry manure has been reported to have a favourable effect on soil physical, chemical and biological properties (Demir et al., 2010; Oustani et al., 2015). The yield of potato is favourably higher under manure fertilisation and this may be attributed to the improvement of soil water retention and supplementation of required nutrient. Under control treatment, the yield is extremely low due to a smaller number of tubers, small tuber size and low weight of tubers per plant. These findings are in line with those reported by Chandrakar et al. (2017).

**Table 2.** Effect of irrigation scheduling and organic manures on performance of potato

| Treatments | Plant height (cm) | Weight of tuber per plant (g) | Tuber yield (t $ha^{-1}$) | Gross Return | Net Return | BCR |
|---|---|---|---|---|---|---|
| $S_1$ | 25.02 | 156.92 | 6.61 | 106777.78 | 12782.42 | 1.13 |
| $S_2$ | 28.05 | 169.01 | 17.52 | 271511.11 | 176483.25 | 2.83 |
| $S_3$ | 26.89 | 161.62 | 14.87 | 230888.89 | 134828.53 | 2.39 |
| $S_4$ | 26.85 | 162.45 | 16.62 | 257511.11 | 160418.25 | 2.63 |
| S.E. (m) ± | 0.58 | 3.11 | 0.37 | 5444.97 | 5444.97 | 0.06 |
| C.D (P=0.05) | NS | NS | 1.27 | 18839.24 | 18839.24 | 0.20 |
| $M_0$ | 23.73 | 108.81 | 10.02 | 156362.50 | 69353.73 | 1.79 |
| $M_1$ | 26.40 | 172.79 | 13.94 | 217945.83 | 116069.06 | 2.13 |
| $M_2$ | 29.98 | 205.91 | 17.77 | 275708.91 | 177961.56 | 2.82 |
| S.E. (m) ± | 0.38 | 2.25 | 0.24 | 3535.91 | 3535.91 | 0.04 |
| C.D (P=0.05) | 1.49 | 8.91 | 0.74 | 13881.61 | 13881.61 | 0.14 |

*NS= Non significant

## Economics

Gross return reported significant results under irrigation scheduling treatments, $S_2$ (₹ 2,71,511 $ha^{-1}$) recorded highest gross return over $S_4$ (₹ 2,57,511 $ha^{-1}$) followed by $S_3$ (₹ 2,30,889 $ha^{-1}$) and $S_1$ (₹ 1,06,778 $ha^{-1}$) being the lowest. For net return $S_2$ (₹ 1,76,483 $ha^{-1}$) recorded the highest net return closely followed by $S_4$ (₹ 1,60,418 $ha^{-1}$) followed by $S_3$ (₹ 1,34,829 $ha^{-1}$) and $S_1$ (₹ 12,782 $ha^{-1}$) being the lowest. BCR also showed significant difference among the irrigation scheduling treatments, $S_2$ (2.83) produced the highest BCR over $S_4$ (2.63) and $S_3$ (2.39) but the lowest is $S_1$ (1.13). Similar findings were reported by Bisht et al. (2012) and Chandrakar et al. (2017). For organic manure treatment, significant results were reported from gross return, net return and BCR. Gross return of $M_2$ (₹ 2,75,709 $ha^{-1}$) showed significantly higher results compared to $M_1$ (₹ 2,17,946 $ha^{-1}$) and $M_0$ (₹ 1,56,363 $ha^{-1}$). For net return, $M_2$ (₹ 1,77,962 $ha^{-1}$) showed significantly higher results compared to $M_1$ (₹ 1,16,069 $ha^{-1}$) and $M_0$ (₹ 69,354 $ha^{-1}$). BCR also showed significant difference among the organic manure treatments, $M_2$ (2.82) produced the highest BCR over $M_1$ (2.13) and $M_0$ (1.79). This can be attributed to the significantly larger amount of yield reported from poultry manure and FYM treatments over control treatment.

**Table 3.** Economics of potato cultivation under organic regime

| | Cost of cultivation (₹ ha$^{-1}$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Operation (s) | $S_1M_0$ | $S_1M_1$ | $S_1M_2$ | $S_2M_0$ | $S_2M_1$ | $S_2M_2$ | $S_3M_0$ | $S_3M_1$ | $S_3M_2$ | $S_4M_0$ | $S_4M_1$ | $S_4M_2$ |
| A. Fixed cost | | | | | | | | | | | | |
| Land rent | 8,330 | 8,330 | 8,330 | 8,330 | 8,330 | 8,330 | 8,330 | 8,330 | 8,330 | 8,330 | 8,330 | 8,330 |
| Pump hiring cost for irrigation | 1,000 | 1,000 | 1,000 | 2,000 | 2,000 | 2,000 | 3,000 | 3,000 | 3,000 | 4,000 | 4,000 | 4,000 |
| Miscellaneous | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| Total fixed cost (A) | 10,330 | 10,330 | 10,330 | 11,330 | 11,330 | 11,330 | 12,330 | 12,330 | 12,330 | 13,330 | 13,330 | 13,330 |
| B. Variable cost | | | | | | | | | | | | |
| Primary tillage | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 |
| Spading | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 |
| Lay out | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 |
| Seed cost | 40,500 | 40,500 | 40,500 | 40,500 | 40,500 | 40,500 | 40,500 | 40,500 | 40,500 | 40,500 | 40,500 | 40,500 |
| Sowing | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 | 2,760 |
| Gap filling | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 |
| Weeding | 3,450 | 3,450 | 3,450 | 3,450 | 3,450 | 3,450 | 3,450 | 3,450 | 3,450 | 3,450 | 3,450 | 3,450 |
| Earthing | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 |
| Dehaulming | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 |
| Harvesting | 2760 | 2760 | 2760 | 2760 | 2760 | 2760 | 2760 | 2760 | 2760 | 2760 | 2760 | 2760 |
| Manure cost | 0 | 14,400 | 10,400 | 0 | 14,400 | 10,400 | 0 | 14,400 | 10,400 | 0 | 14,400 | 14,400 |
| Lime | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 |
| Application labour charge | 920 | 920 | 920 | 920 | 920 | 920 | 920 | 920 | 920 | 920 | 920 | 920 |
| Plant protection measures using organic input | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 |
| Miscellaneous | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| Total variable cost (B) | 72,440 | 86,840 | 82,840 | 72,440 | 86,840 | 82,840 | 72,440 | 86,840 | 82,840 | 72,440 | 86,840 | 86,840 |
| Sub-Total (A+B) | 82,770 | 97,170 | 93,170 | 83,770 | 98,170 | 94,170 | 84,770 | 99,170 | 95,170 | 85,770 | 1,00,170 | 1,00,170 |
| C. Interest on working capital | 2690.025 | 3158.025 | 3028.025 | 2722.525 | 3190.525 | 3060.525 | 2755.025 | 3223.025 | 3093.025 | 2787.525 | 3255.525 | 3255.525 |
| Total cost of cultivation (A+B+C) | 85,460.03 | 1,00,328.03 | 96,198.03 | 86,492.53 | 1,01,360.53 | 97,230.53 | 87,525.03 | 1,02,393.03 | 98,263.03 | 88,557.53 | 1,03,425.53 | 1,03,425.53 |

## CONCLUSION

Irrigation scheduled at sprouting + stolonization ($S_2$) is the most suitable for better performance and better economics of potato. It may be concluded that among the organic amendments treatments there is significant differences in the yield and in BCR therefore, poultry manure may be preferred over the other manures.

## ACKNOWLEDGEMENT

The authors would like to thank Central Agricultural University, Imphal for the financial support for the study. Thanks are due to the Dean, College of Agriculture, Kyrdemkulai (CAU, Imphal) for providing all logistic support during the field trial. The authors would like to appreciate the Dean, College of Post Graduate Studies in Agricultural Sciences and all the research committee advisory members for their timely suggestions and help.

## REFERENCES

Bisht, P., Raghav, M. and Singh V.K. 2012. Effect of different irrigation schedules on the growth and yield of drip irrigated potato. *Potato J.* **39**(2): 202-204.

Boateng, S.A., Zickermann, J. and Kornahrens, M. 2006. Poultry manure effect on growth and yield of maize. *West Afr. J. Appl. Ecol.* **9**: 12-18.

Bora, P.K. and Karmakar, R.M. 2012. Productivity of potato under limited irrigation regime in relation to weather parameters. *Indian J. Dryland Agric. Res. Dev*. **27**(1): 52-57.

Burman, R.R., Kumar, M. and Nagaraj, K.M. 2007. Organic potato production- practices and extension strategy. In: *Advances in Organic Farming Technology in India*, (eds.) G.C. Munda, P.K. Ghosh, A. Das, S.V. Nagchan and K.M. Bujarbaruah, ICAR Research Complex for NEH Region. Umiam, India, pp. 271–279.

Chandrakar, C.K., Shrivastava, G.K., Dwivedi, S.K., Sharma, D., Pandey, K.K. and Singh, S.K. 2017. Advance Agro-techniques for yield efficiency and economics of potato (*Solanum tuberosum*) crop for Chhattisgarh Plains. *Int. J. Curr. Microbiol. App. Sci.* **6**(2): 766-777.

Demir, K., Sahin, O., Kadioglu, Y.K., Pilbeam, D.J. and Gunes, A. 2010. Essential and nonessential element composition of tomato plants fertilized with poultry manure. *Sci. Horti.* **127**: 16-22.

FAO. 2008. *Potato and water resources.* http://www.potato2008.org/ Accessed 2 June 2019.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical procedure for agriculture research*. 2nd Edn. International Rice Research Institute, Los Banos, Philipines. John Wily and Sons, New York. p. 324.

Gupta, V.K., Thakur, K.C., Kumar, S., Pandey, S.K. and Sah, U. 2004. *True Potato Seed- An alternative technology for potato production in North eastern hill region*. Technical bulletin no 64. Central Potato Research Institute, Shimla. p. 1.

Hassan, A.A., Sarkar, A.A., Ali, M.H. and Karim, N.N. 2002. Effect of deficit irrigation at different growth stages on yield of potato. *Pakistan J. Biol. Sci.* **5**(2): 128-134.

Karim, K.H., Maful, M.T. and Mahmut, F.M. 2016. Effect of different poultry and cattle manure rates on yield and yield components of potato (*Solanum tuberosum*) cv- Sante. *Egypt. J. Biol. (Bot.)*. **12** (2): 155-162.

Kumar, P., Pandey, S.K., Singh, S.V. and Kumar, D. 2007. Irrigation requirements of chipping potato cultivars under west-central Indian plains. *Potato J.* **34**(3-4): 193- 198.

Lemaga, B. and Caesar, K. 1990. Relationships between numbers of main stems and yield components of potato (*Solanum tuberosum* L. cv. Erntestolz) as influenced by different day lengths. *Potato Res.* **33**: 257-267.

Mahmood, F., Khan, I., Ashraf, U., Shahzad, T., Hussain, S., Shahid, M., Abid, M. and Ullah, S. 2017. Effects of organic and inorganic manures on maize and their residual impact on soil physico-chemical properties. *J. Soil Sci. Plant Nutr.* **17**(1): 22-32.

Oustani, M., Halilat, M.T. and Chenchouni, H. 2015. Effect of poultry manure on the yield and nutriments uptake of potato under saline conditions of arid regions. *Emir. J. Food Agric*. **27**(1): 106-120.

Saikia, M. 2011. Effect of irrigation and mulching on growth, yield and water use efficiency of potato in Assam. *Potato J.* **38**(1): 81-83.

Scott, G. and Suarez, V. 2011. Growth rates for potato in India 1961-2009 and their implications for industry. *Potato J.* **38**(2): 100-112.

Souza, P.A., Souza, G.L.F.M., Menezes, J.B. and Bezerra, N.F. 2008. Evaluations of cabbage cultivar grown under organic compost and mixed mineral fertilizers. *Hortic. Bras.* **26**: 143-145.

*e-planet* **17** (2): 123-126 (December 2019)

# Performance of *Kharif* hybrid tomato varieties in plateau agro-ecosystems of Odisha

**S. MUNA*, B. MALLICK AND B. TARIA**

*Krishi Vigyan Kendra (OUAT), Jashipur, Mayurbhanj, Odisha, India*

**munasagarika05@gmail.com*

Date of receipt: 15.10.2019 Date of acceptance: 17.12.2019

**ABSTRACT**

Tomato (*Solanum lycopersicum* L.) is the second most important vegetable of the world. Its demand in the market is throughout the year though it is regarded as a winter crop. In the well drained soils of plateau ecosystem, it can be cultivated in *kharif* season even in open field. Mayurbhanj district of Odisha is an extension of Chhotanagpur plateau representing North Central plateau agro climatic zone. Tomato is cultivated by the farmers of the district sporadically with the varieties available in local market. This experiment was under taken during 2015-16 to 2016-17 in the KVK, Mayurbhanj adopted village Badabil in the Farmers' field to evaluate the performance of best suitable tomato variety in *kharif* season. From the three F1 hybrids taken, Laxmi variety was found giving the highest yield of 178.4 q $ha^{-1}$ though it was more prone to wilting like diseases. Proper plant protection measures should be taken to reduce the yield loss due to incidence of insect pest and diseases. Arka Rakshak F1 hybrid was found less suitable in this plateau ecosystem for *kharif* season.

**Key words:** *Kharif*, plateau, tomato, wilt, yield

## INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the second most important vegetable in economic importance and consumption in the world after potatoes (Ibitoye et al., 2009). India is the second largest producer of tomatoes contributing 11.5% of global production after China (23%) (Shelke et al., 2016). Ripened tomatoes comprised of water (approximately 90%), soluble and insoluble solids (5-7%), citric and other organic acids and minerals. It is a rich source of vitamin A and C and also contains minerals like iron and phosphorous. Furthermore tomato is the richest source of dietary fibres, antioxidants like lycopene and beta-carotene (Singh et al., 2017). The antioxidant lycopene present in tomato plays an important role in prevention of cancer and other diseases in human beings (Agarwal and Rao, 2000). Its palatability and consumption in all forms has made it one of the most demanding vegetable globally. However, being a winter crop, in the peak production season, it faces distress sale but as an off season crop, it has a good market demand with much remunerative for the farmers (Pradhan et al., 2017). As Scherinemachers et al. (2016) opines cultivation of crops outside the regular cropping calendar when supply is low and prices are high, can give farmers better profits and consumers more choice. Tomato production during *kharif* and summer is generally less due to a number of biotic and abiotic factors. Atmospheric temperature and intensity of rainfall limits its production around the year. Now- a-days tomato is cultivated in open field condition or in green house conditions (Pandey et al., 2006). Though demand is high, it cannot be produced everywhere in all the times. Odisha state has ten agro climatic zone which creates lots of opportunities for production of different types of crops in each season. The plateau area of Northern Odisha is an extension of Chhotanagpur plateau region. Its well

drained soil and undulated topography with mild temperature creates a platform for production of off season vegetables like tomato. Keeping in view of the importance of *kharif* tomato production, this study was undertaken to find out the best suitable variety in plateau ecosystem of Odisha.

## MATERIALS AND METHODS

Mayurbhanj district, present in North Central plateau agro climatic zone of Odisha was selected purposively for the study. The land of the district is primarily undulated, well drained. About 50 acres of tomato was cultivated in Jashipur and its adjoining Karanjia and Raruan blocks during *kharif* season. This experiment was taken in farmer's field in KVK adopted village Badbil of Jashipur block with seven selected farmers with 0.25 acre of land each. Soil is sandy loam having soil pH 6.2. It was with high organic carbon, medium to high available N, Medium P and medium K. This trial was undertaken to ascertain the best suitable variety which was accessible and could be cultivated by the farmers of the zone. Three F1 hybrids Laxmi, Sakhyam and Arka Rakshak were taken for the study during *kharif* 2015-16 and 2016-17. The phenological development and different yield attributing characters were recorded in due time and were analysed with different appropriate statistical tools. The relation between different factors was enumerated using t-test.

## RESULTS AND DISCUSSION

As per the primary data available, off season tomato was cultivated in this area since more than a decade. Farmers were taking F1 hybrids available to them from the local market. However, no research was made to ascertain the suitable hybrid befitting to this agro climatic zone. The seeds of all three varieties were treated with Thiram 2 g $kg^{-1}$ and were sown in nursery during the last fortnight of July under low cost poly tunnel to avoid loss due to heavy rainfall. All seedlings were planted in a well drained pulverised soil at a distance of distance of 60 cm × 60 cm after seedling treatment in a solution of Carbendazim @ 2 g per litre and streptocyclin @ 1 g per 10 litre for 15 minutes. After 40 days of transplanting staking was given to plants with wooden sticks. Data recorded during various stages of crop growth on the phenological characters of different varieties in each plot during rabi 2015-16 and 2016-17 are mentioned as below.

**Table 1.** Phenological characters of different tomato hybrids (Average of the mentioned period)

| Varieties | Plant height (cm) | No of branches | Fruits per plant | Average fruit weight (g) | Yield (q $ha^{-1}$) |
|---|---|---|---|---|---|
| Laxmi | 64.6 | 6.4 | 52.5 | 58.4 | 178.4 |
| Sakhyam | 61.5 | 6.3 | 45.3 | 41.4 | 129.6 |
| Arka Rakshak | 83.2 | 7.0 | 33.8 | 38.4 | 110.0 |
| SEm(±) | 2.35 | 0.16 | 2.28 | 2.84 | 2.52 |
| CD(P=0.05) | 6.8 | 6.6 | 8.2 | 7.2 | 7.4 |

From Table 1 it was observed that out of the three hybrid varieties tested in this agro-climatic zone, Laxmi variety performed the best. Though all the three varieties were F1 semi-indeterminate hybrids, yet Arka Rakshak performed poorly in comparison to other two varieties. Arka Rakshak had the tallest physical growth with more number of branches but the fruits produced per plant were much less than the other two. Even it was observed that the average fruit size of the variety was only 38.4 g comparison to Laxmi variety which indicated

the variety was not fitted to this *kharif* season. The highest yield (178.4 q $ha^{-1}$) was recorded in Laxmi variety. All the yield attributing characters were found statistically significant at 5% level of significance (Table 2) which corroborates the findings of Sengupta et al. (2018).

**Table 2.** Paired t –test of hybrid tomato cultivation

| Parameters | t-calculated value |
|---|---|
| Height of plant | 5.95* |
| No. of branches per plant | 6.10* |
| No. of fruits per plant | 11.36* |
| Weight per fruit | 3.12* |
| Yield of tomato | 2.57* |

*Significant at 5% level of significance

Tomato cultivation in *kharif* season in open field requires much attention. Sufficient moisture and humidity in atmosphere and in soil make the crop prone to fungal infestations. *Fusarium* wilt, leaf blight and bacterial wilts are common problems in *kharif* tomato cultivation. To minimise the losses from such diseases, *kharif* tomato cultivation requires staking and support when the fruit is in contact with soil (Ranganamei, 2017). Such type of cultural practices reduces pest incidence and thereby increases the yield (Saunyama and Knapp, 2003). Table 3 below indicates the susceptibility of tested varieties to major insect pest and diseases.

**Table 3.** Susceptibility of major insect pest and diseases of different tested varieties

| Varieties | Bacterial wilt (%) | Fungal wilt (%) | Leaf blight (%) | Fruit borer infested (%) | Fruit rot (%) |
|---|---|---|---|---|---|
| Laxmi | 8.3 | 6.0 | 5.7 | 12.4 | 8.6 |
| Sakhyam | 14.1 | 6.5 | 4.6 | 11.6 | 8.8 |
| Arka Rakshyak | 1.6 | 3.4 | 7.2 | 9.6 | 7.6 |
| SEm(±) | 0.34 | 0.3 | 0. 19 | 0.26 | 0.18 |
| CD(P=0.05) | 3.6 | 4.6 | 4.2 | 4.6 | NS |

Wilt is a major disease of tomato crop causing huge loss and reduces the productivity. Above table indicated that from the three hybrids tested, Arka Rakshak was found less susceptible to bacterial and fungal wilt than the other two. Asha et al. (2011) reported that *Fusarium oxysporum* causes vascular wilt in tomato and reduces the yield upto the maximum level. Arka Rakshak was reported to be more infested to leaf blight than Laxmi and Sakhyam. The fruit borer infestation was less in Arka Rakshak. Fruit rot disease was found insignificant with the variation of varieties of tomato.

## ACKNOWLEDGEMENT

The authors are thankful to the assistance and guidance rendered by Dr Sujit Kumar Nath, Senior Scientist and Head, KVK, Mayurbhanj while successfully undertaking this farmer participatory experiment.

## REFERENCES

Agarwal, S. and Rao, A. 2000. Tomato lycopene and its role in human health and chronic diseases. *Can. Med. Assoc. J.* **163**(6):739-744.

Asha, B.B., Nayaka, S.C., Shankar, A.C.U., Srinivas, C. and Niranjana, S.R. 2011. Selection of effective

bio antagonistic bacteria for biological control of tomato wilt caused by *Fusarium oxysporum*. *J. Life Sci.* **6**: 239-244.

Ibitoye, D.O., Akin-Idowu, P.E. and Ademoyegun, O.T. 2009. Agronomic and lycopene evaluation in tomato (*Solanum lycopersicum*) as a function of genotype. *World J. Agric. Sci*. **5**: 892–895.

Pandey, Y.R., Pun, A.B. and Upadhyay, K.P. 2006 Participatory varietal evaluation of rainy season tomato under plastic house condition. *Nepal Agric. Res. J.* **7**: 11-17.

Pradhan, R., Nandi, A., Sahu, G.S. and Tripathy, P. 2019. Evaluation of tomato *(Solanum lycopersicum* L.) hybrids during rainy season in coastal plain of Odisha, India. *Int. J. Curr. Microbiol. Appl. Sci.* **8**(7): 2410-2417.

Rangnamei, K.L., Kumar, M., Meena, K.L. and Rajkhowa, D.J. 2017. Evaluation of tomato varieties for higher productivity in the NEH region of India. *Indian J. Hill Farm.* **30** (2): 256-258.

Saunyama, I.G.M. and Knapp, M. 2003. Effect of pruning and trelling of tomatoes on red spider mite incidence and crop yield in Zimbabwe. *Afr. Crop Sci. J.* **11**(4): 269-277.

Scherinemachers, P., Wu, M., Uddin, Md., Ahmad, S. and Hanson, P. 2016. Farmer training in off-season vegetables: Effects on income and pesticide use in Bangladesh. *Food Policy* **61**: 132–140.

Sengupta, A., Rajesh, K. and Prasanthi, S.J. 2018. Cultivation of organic tomato (*Solanum lycopersicum*) through adaptive trial. *Int. J. Curr. Microbiol. Appl. Sci.* **7**: 1308-1312.

Shelke, R.D., Katkade, J.L. and Jadhav, V.B. 2016. Comparative economics of *kharif*, rabi and summer cultivation of tomato in Latur district of Maharashtra. *Int. Res. J. Agric. Ecol. Stat*. **7** (2): 134-142.

Singh, P., Singh, R., Niwas, R., Kumar, A. and Khichar, M.L. 2017. Climatic suitability analysis for tomato cultivation in Haryana (India), *Int. J. Pure Appl. Biosci.* **5**(6): 1568-1573.

*e-planet* **17** (2): 127-133 (December 2019)

# Role of socio-economic variables and non-timber forest products on the livelihood dependency of forest fringe communities in Khordha forest division, Odisha

**M. SAHOO, H. NAYAK* AND T.L. MOHANTY**

*College of Forestry, Orissa University of Agriculture and Technology, Bhubaneswar, India*

**hiranmayee.nayak@gmail.com*

Date of receipt: 22.08.2019 Date of acceptance: 17.12.2019

## ABSTRACT

The objective of the paper was to analyze the socio economic status of forest fringe communities in Khordha Forest Division of Odisha. The study was based on primary data collected from villages in two Ranges namely, Balugaon and Ranpur range in Khordha Forest Division. Hundred respondents were randomly selected, data were collected through a structured survey questionnaire, analyzed with appropriate statistical methods and were interpreted in accordance with the objectives of the study. In the study area, it was found that the tribal males of age group 18-40 years were involved in non-timber forest products (NTFPs) collection. Generally, married persons were involved in the NTFPs collection to support their family with around family size of 4-8 members. We found that 80% of the respondents belonged to landless, marginal and small land holding, because of the small land holding category. The poor condition of the people also influenced the house type i.e. 73% of respondent's possessed kutcha house and semi-pucca house.

**Key words:** Forest, forest produce, livelihood, NTFPs, socioeconomic variables

## INTRODUCTION

Non-timber forest products (NTFPs) play an important role in the livelihood of the rural people living near the forest. Forest acts significantly in the life of landless and tribal people for income generation and food from forest (Singh et al., 2010; Ahenkan and Boon, 2011). NTFPs include wild edible fruit, mushroom, berry, root, tuber and green or vegetable etc. to meet the food requirements of the rural people. According to the World Resource Institute (1990), NTFPs provide livelihood to nearby 500 million people in India (MoEF, 1996).

India is a developing nation with a huge population living close to the forest with their livelihood critically linked to the forest ecosystem. The forest fringe communities do not just collect these forest products for their own consumption but also for commercial sale, which fetch them some income. Forest sector is the second largest land use system after the agriculture. Forests contribute 1.7% GDP of the country (FAO, 2016). People living in the forest fringe villages depend upon forest for a variety of goods and services. These include collection of edible fruits, flowers, tubers, roots and leaves for food and medicines, firewood for cooking, small woods for agricultural implements, house construction and fencing, fodder (grass and leave) for livestock and grazing of livestock in forest, collection and marketing of NTFPs (Parkash et al., 2006; Mukul et al., 2016). Similarly, sustainable use of sal leaves, twigs of different bushes for fodder, barks of medicinal plants, bamboo and cane may provide income to the rural people without affecting the forest.

## MATERIALS AND METHODS

The investigation was conducted during 2019 in Balugaon and Ranpur Forest Range of Khordha Forest Division, Odisha, selected randomly for

the purpose of study. Total 10 villages, five from each range, and four reserve forests were selected for the study of socio economic profile, utilization, dependency and marketing of forest products of the forest fringe villages. All the households have been randomly selected from the village. A total of 100 families from 10 villages belonging to four reserve forests of the division were taken. The data were collected through a structured survey questionnaire, analyzed with appropriate statistical methods and were interpreted in accordance with the objectives of the study. The data was collected personally through a semi-structured schedule pretested earlier. The statistical tools such as percentage, mean score, standard deviation, co-efficient of variation and co-efficient of correlation were employed for the analysis and interpretation of data.

## RESULTS AND DISCUSSION

Different socio-economic characteristics like family size, age, caste, gender, literacy, land holding size, marital status, ownership, employment status, livestock, occupation and income were analyzed. The study on age group revealed that all age group categories of people were involved in NTFP collection although the majority of respondents were in the age group of 18 to 40 (50%) out of which 67 % were male and 33% female in the study area. Out of the respondents, 77% belonged to scheduled tribe, 14% scheduled caste, 6% other backward caste and 3% general caste. Maximum numbers of respondents were married (65%), unmarried (23%), widow (11%) and divorcee (1%). The literacy level in the study area was in the order illiterate (28%), primary (62%), high school and above (10%). The overall high literacy rate might be due to government educational programs and mid-day meal facilities of the government for encouraging student attendance. Majority of the population are of nuclear family (58%) and rest in joint family (42%). Maximum number of family members constituting 4 to 8 in a group (51%) were involved in the NTFP collection, up to 4 numbers (40%), 8 to 12 numbers (9 %). Maximum number of respondents had marginal land holding, i.e. 1 to 2 ha (44%), landless (36%) and small (20%). 58% of the respondents were owner of land, 22% had leased in, 12% had leased out and 8% owner and leased out. 64% of respondents had non-irrigated land while 36% had irrigated land. We observed that maximum of 43% respondents had kaccha house, semi pucca (30%), thatched house (19%) and minimum number of pucca house (8%) in the study area. Maximum number of people were self-employed (39%), followed by part time employment (31%) and unemployed (30%) and majority were involved in agriculture, NTFPs and labour (72%). Multiple sources like family occupation, business, service and cattle rearing were diversified occupation. Maximum number of people's (69%) income lies between Rs 10000/- to 25000/-. Maximum people depends on agriculture, NTFPs and labour for income generation (Ahenkan and Boon, 2011). More than 31% of livestock was cow followed by hen (27%), goat (23%) and ox (19%) in the study site.

### Correlation among different socio-economic variables

Perusal of the Table 2 showed that age was significantly and positively correlated with literacy (0.214*), land holding (0.397**), type of ownership (0.381**) and negatively correlated with household type (-0.237*). Literacy had shown significant and positive correlation with family member (0.347**), land holding (0.493**), type of ownership (0.460**) and income (0.333**), but negatively correlated with type of land (-0.264**). Family type had significant and correlate positively correlation with family member (0.528**), land holding (0.531**), and income (0.538**). Family member was significantly and positively correlated with land holding (0.257**), type ownership (0.331**), household type (0.329**) and income (0.535**). Land holding was positively correlated with income (0.474**). Type of ownership was positively correlated with household type (0.225*) and negatively correlated with type of land (-0.227*). Type of land was significantly positively correlate with caste (0.206*) and negatively correlated with household type (-0.420**). Household type was significantly and negatively correlation with occupation (-0.220*). Employment status significantly and positively correlated with

**Table 1.** Socio-economic profile of the NTFPs collection: (n=100)

| Sl. no | Socio-economic characteristics | Number | Percentage |
|---|---|---|---|
| 1 | Age of the respondents | | |
| | 0-18 | 07 | 7.0 |
| | 18-40 | 50 | 50.0 |
| | 40-60 | 36 | 36.0 |
| | >60 | 08 | 8.0 |
| 2 | Gender of the respondents | | |
| | Male | 67 | 67.0 |
| | Female | 33 | 33.0 |
| 3 | Caste of the respondents | | |
| | General | 03 | 3.0 |
| | OBC | 06 | 6.0 |
| | SC | 14 | 14.0 |
| | ST | 77 | 77.0 |
| 4 | Marital status of the respondents | | |
| | Divorcee | 01 | 1.0 |
| | Widow | 11 | 11.0 |
| | Single | 23 | 23.0 |
| | Married | 65 | 65.0 |
| 5 | Literacy of the respondents | | |
| | Illiterate | 28 | 28.0 |
| | Primary | 62 | 62.0 |
| | High school and above | 10 | 10.0 |
| 6 | Family type | | |
| | Joint | 42 | 42.0 |
| | Nuclear | 58 | 58.0 |
| 7 | Family member of the respondents | | |
| | 4 to 8 members | 51 | 51.0 |
| | 8 to 12 members | 9 | 9.0 |
| | up to 4 members | 40 | 40.0 |
| 8 | Land holding of the respondents | | |
| | Landless | 36 | 36.0 |
| | Marginal | 44 | 44.0 |
| | Small | 20 | 20.0 |
| 9 | Ownership of the respondents | | |
| | Leased in | 22 | 22.0 |
| | Leased out | 12 | 12.0 |
| | Owner | 58 | 58.0 |
| | Owner and leased out | 08 | 8.0 |
| 10 | Types of land | | |
| | Irrigated | 36 | 36.0 |
| | Non-irrigated | 64 | 64.0 |
| 11 | Types of house | | |
| | Kutcha House | 43 | 43.0 |
| | Pucca | 8 | 8.0 |
| | Semi Pucca | 30 | 30.0 |
| | Thatched House | 19 | 19.0 |
| 12 | Employment status | | |
| | Part time employed | 31 | 31.0 |
| | Self employed | 39 | 39.0 |
| | Unemployed | 30 | 35.0 |
| 13 | Occupation | | |
| | Agriculture +NTFPs + Labour | 72 | 72.0 |
| | NTFPs+ Agriculture + Business | 09 | 9.0 |
| | NTFPs +Labour +Family Occupation | 09 | 9.0 |
| | Business + Agriculture +Cattle Rearing | 04 | 4.0 |
| | NTFPs +Agriculture + Government service | 06 | 6.0 |
| 14 | Income | | |
| | <10,000 | 16 | 16.0 |
| | 10,000-25,000 | 69 | 69.0 |
| | 25,000-50,000 | 15 | 15.0 |
| 15 | Livestock | Mean | |
| | Cow | 2.18 | 31.0 |
| | Ox | 1.32 | 19.0 |
| | Goat | 1.56 | 23.0 |
| | Hen | 1.88 | 27.0 |

**Table 2.** Correlation among different socio-economic variables

| | Age | Literacy | Family Type | Family Member | Land Holding | Types of Ownership | Types of Land | Household Type | Emp. Status | Income | Livestock | Gender | Cast | Marital Status | Occupation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 1 | | | | | | | | | | | | | | |
| Literacy | 0.214* | 1 | | | | | | | | | | | | | |
| Family type | 0.187 | 0.066 | 1 | | | | | | | | | | | | |
| Family member | -0.014 | 0.347** | 0.528** | 1 | | | | | | | | | | | |
| Land holding | 0.397** | 0.493** | 0.531** | 0.257** | 1 | | | | | | | | | | |
| Types of ownership | 0.381** | 0.460** | 0.163 | 0.331** | 0.188 | 1 | | | | | | | | | |
| Types of land | 0.141 | -0.264** | 0.016 | -0.117 | -0.070 | -0.227* | 1 | | | | | | | | |
| Household type | -0.237* | 0.092 | -0.029 | 0.329** | -0.115 | 0.225* | -0.420** | 1 | | | | | | | |
| Employment status | -0.085 | -0.156 | 0.077 | -0.003 | 0.017 | 0.018 | 0.192 | 0.118 | 1 | | | | | | |
| Income | 0.183 | 0.333** | 0.538** | 0.535** | 0.474** | 0.060 | 0.135 | 0.061 | 0.203* | 1 | | | | | |
| Livestock | -0.030 | 0.135 | 0.096 | -0.064 | 0.094 | 0.081 | -0.086 | 0.051 | -0.034 | -0.035 | 1 | | | | |
| Gender | -0.016 | 0.095 | 0.004 | 0.109 | -0.007 | 0.052 | -0.019 | -0.063 | -0.126 | -0.064 | -0.131 | 1 | | | |
| Caste | 0.195 | 0.050 | 0.018 | 0.039 | 0.024 | -0.093 | 0.206* | -0.136 | 0.019 | 0.222* | 0.040 | -0.088 | 1 | | |
| Marital status | -0.147 | 0.065 | -0.036 | -0.107 | -0.113 | 0.057 | -0.110 | 0.174 | -0.015 | -0.092 | -0.016 | 0.080 | -0.180 | 1 | |
| Occupation | 0.115 | 0.003 | 0.023 | -0.033 | 0.008 | 0.105 | 0.000 | -0.220* | -0.055 | 0.024 | 0.064 | -0.014 | 0.178 | -0.032 | 1 |

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).

income (0.203*). Income had significant and positive correlation with caste (0.222*). Livestock, gender and marital status had not shown significant, correlation with any other socio economic parameter.

Age was positively correlated with land holding and type of ownership which indicates the aged persons have more assets compared to young age people and was negatively correlated with household type which might be due to prevalence of the nuclear family in the study site. Literacy level was found to be positively correlate with land holding and income which indicated the educated mass have awareness about the different income generating activities. Family type had significant positive effect on family member, land holding and income of the family. Family member is positively correlated with land holding, household type and family income. Land holding was positively correlated with family income as majority of the respondent were depend upon agriculture as agriculture is the dominant livelihood.. Type of ownership was negatively correlated with type of land and household type. Household type was negatively correlated with occupation. Employment status was positively correlated with income. Income was positively correlated with caste. The status of employment determined the income of household.

Interpretation of Table 3 showed that NTFPs collection was significant and positively correlated with livestock rearing (0.275*) and negatively correlate with labour (-0.118*) and family occupation (-0.306**). Agriculture was significantly and positively correlated with other (services) (0.190*) and negatively correlated with labour (-0.236**). Labour was significantly and positively correlated with family occupation (0.204*), other (services) (0.367**) and negatively correlate with livestock rearing (-0.317**).

NTFPs collection was positively correlated with livestock rearing which might be due to rural people collect fodder for their livestock and also collect NTFPs while accompanying their livestock for grazing. NTFPs collection was negatively correlate with labour wages and family occupation which might be due to the people were more engaged in NTFPs collection due to lack of labour engagement . Agriculture was positively correlated with other (services) which might be due to the fact that those who were in service investing agriculture production from their land. Labour wages was negatively correlated with livestock rearing which indicates people who were engaged in labour activities gets less time for livestock rearing but prefers to go to forest for NTFPs collection.

Contribution of various sectors in employment generation is as follows- the maximum of 53.15 days per household (HH) per year (27.82 %) was in agriculture followed by NTFPs collection (24.79 %), labour (23.92 %), family occupation (9.73 %), livestock rearing (5.91 %) and services (7.80 %). It was inferred from the above data that agriculture, NTFPs collection and labour engagement and family occupation were the major livelihood and income generating activities in the study site as agreed by many earlier reports (Shaanker et al., 2004; Kar, 2012; Ahmed et al., 2016). Agriculture NTFPs collection and findings labour engagement were the major employment generation activities which was similar to the findings Kumar (2015) who reported an average employment of 115.56 and 77.81 man days per HH per year from wage sector and NTFP, respectively.

Perusal of data in Table 5 indicated that collection of sal leaves gave the major employment sources among the different NTFPs. It contributes to 5.67 days per HH per year of the total employment generated by NTFPs (47.35 days per HH per year). Siali leaves collection was the next important employment generating activity (5.62 days per HH per year) followed by collection of sal seed (5.28), cane berries (5.25), cane culm (4.37), tamarind (4.31), cherenga (4.28), honey (3.44), amla (2.58), mushroom (2.18), bahada (2.02), kochila seed (1.33), and harida (1.02). Sal leaves (11.97%), siali leaves (11.86%), cane berries (11.08%), cane culm (9.22%), tamarind (9.10%) and cherenga (9.03%) were the dominant NTFPs collected by the rural people among all NTFPs. Indigenous people depend on NTFPs and their livelihood sustainability depend

**Table 3.** Correlation of different income sources

| | NTFPs Collection | Agriculture | Labour | Family Occupation | Livestock Rearing | Others |
|---|---|---|---|---|---|---|
| NTFP Collection | 1 | | | | | |
| Agriculture | 0.075 | 1 | | | | |
| Labour | -0.118* | -0.236** | 1 | | | |
| Family occupation | -0.306** | 0.029 | 0.204* | 1 | | |
| Livestock rearing | 0.275* | 0.065 | -0.317** | -0.158 | 1 | |
| Others | -0.093 | 0.190* | 0.367** | 0.179 | -0.183 | 1 |

**Table 4.** Composition of employment in different sector

| Activities | Employment generated (days per household per year) | Percentage (%) |
|---|---|---|
| NTFP Collection | 47.35 | 24.79 |
| Agriculture | 53.15 | 27.82 |
| Labour | 45.70 | 23.92 |
| Family occupation | 18.60 | 9.73 |
| Livestock rearing | 11.30 | 5.91 |
| Others | 14.90 | 7.80 |
| Total | 191.00 | 100.00 |

**Table 5.** Seasonal contribution of employment from different NTFPs

| Sl. no | NTFPs | Season | Employment generated (days per household per year) | Percentage (%) |
|---|---|---|---|---|
| 1 | Siali leaf | October -May | 5.62 | 11.86 |
| 2 | Honey | November –June | 3.44 | 7.26 |
| 3 | Cane culm | March-April | 4.37 | 9.22 |
| 4 | Cane berries | February-March | 5.25 | 11.08 |
| 5 | Harida | November -January | 1.02 | 2.15 |
| 6 | Bahada | January -April | 2.02 | 4.26 |
| 7 | Amla | February –March | 2.58 | 5.44 |
| 8 | Sal leaf | All season | 5.67 | 11.97 |
| 9 | Sal seed | April-June | 5.28 | 11.15 |
| 10 | Mushroom | June-August | 2.18 | 4.60 |
| 11 | Kochila seed | December –January | 1.33 | 2.80 |
| 12 | Tamarind | March-April | 4.31 | 9.10 |
| 13 | Cherenga | December – May | 4.28 | 9.03 |
| | Total | | 47.35 | 100.00 |

upon forest and forest produce (Shahbuddin and Prasad, 2004; Shylajan and Mythili, 2007; Bharat Kumar et al., 2011; Mohanta et al., 2018).

## CONCLUSION

This study goals to highlight the significance of NTFPs in the livelihood of forest dependent communities and some strategies for their sustainable development and judicial utilization. NTFP contributes a lower proportion of total household income (about 24%) than agriculture (27%), it acted as safety nets in times of food scarcity and during off seasons where agricultural and wage income was nil. NTFP played a prominent role in both life and livelihood support for the villagers. Socio-personal, agro-economic and psychological attribution very often motivate the people for proper management and sustainable use of forest resources. The respondents depending on forest for livelihood support were mostly 18-40 years, primary to illiterate educated, within family size of 4-8 members, agriculture and collection of forest produce as the major occupation. After agriculture, NTFP collection was the most important activity among the respondents as all of them in the area were involved in this activity. The findings conclude that the respondents depend on forest for their livelihood. The forest department officials need to sensitize these people for proper management of the forest and collection of non- timber forest produce.

## ACKNOWLEDGEMENT

Authors extend their sincere thanks and gratitude to the DFO, Khordha Forest Division, Odisha and all the field staff for extending requisite help during the study. We are also thankful to the esteemed Dean and faculty members, College of Forestry, OUAT, Bhubaneswar for their unflinching support during the study.

## REFERENCES

Ahenkan, A and Boon, E. 2011. Non-Timber Forest Products (NTFPs): Clearing the confusion in semantics. *J. Human Ecol.* **33**(1): 1-9.

Ahmed, M.U, Jana, S.K and Roy, S.D. 2016. Marketing of non-timber forest products – a study in Paschim Medinpur district in West Bengal, India. *Intercontinental J. Marketing Res.* **4**(3).

Bharat Kumar, L.B., Patil, B.L., Basavraja, H., Mundinamani, S.M., Mahajanashetty, S.B. and Megeri, S.N. 2011. Participation behavior of indigenous people in NTFP extraction in Western Ghat Forests. *Karnataka J. Agric. Sci.* **24**(2): 170-172.

Kar, S.K. 2012. *Challenges in marketing of different commodities particularly the minor forest produces in the tribal sub plan areas in Odisha*. Orissa University of Agriculture and Technology, Bhubaneswar.

MoEF, 1996. *Annual Report 1996*. Ministry of Environment and Forest (MoEF), Government of India, New Delhi, India.

Mohanta, R., Panigrahi, R.S and Banerjee P.K. 2018. Socio economic attributes of Hill Khadia Tribe: A study on Mayurbhanj distict of Odisha. *Int. J. Sci. Environ. Technol.* **7**(10): 325 – 334.

Mukul, S.A, Rashid, A.M, Uddin, M.B and Khan, N.A. 2016. Role of non timber forest products in sustaining forest-based livelihoods and rural households' resilience capacity in and around protected area: Study in Bangladesh. *J. Environ. Plann. Manage.* **59**(4): 628-642.

Parkash, S, Prakash, S.S and Krishna, V.V. 2006. Participation behavior of indigenous people in extraction and marketing on Non Timber Forest Products in the dry deciduous forest of South India. *J. Trop. Forestry* **22**: 1-11.

Shaanker, R.U., Ganeshaiah, K.N., Krishnan, S., Ramya, R., Meera, C., Aravind, N.A., Kumar, A., Rao, d. Vanaraj, G., Ramachandra, J., Gautheir, R., Ghazoul, J., Poole, N. and Reddy, B.V.C. 2004. Livelihood gains and ecological costs of non-timber forest product dependence: Accessing the roles of dependence, ecological knowledge and market structure in three contrasting human and ecological settings in South India. *Environ. Conserv.* **3**: 242-253.

Shahbuddin, G. and Prasad, S. 2004. Assessing ecological sustainability of non-timber forest produce extraction. The Indian scenario. *Conserv. Soc.* **2**: 235-250.

Shylajan, C.S. and Mythili, G. 2007. *Community dependence on non-timber forest products: A Household analysis and its implication for forest conservation*. Working Papers 2007-005, Indira Gandhi Institute of Development Research, Mumbai, India.

Singh, A., Bhattacharya, P., Vyas, P. and Roy, S. 2010. Contribution of NTFPs in the livelihood of mangrove forest dwellers of Sundarban. *J. Human Ecol.* **29**(3): 191-200.

*e-planet* **17** (2): 134-138 (December 2019)

# Impact of cyclone Fani on tree damage in Bhubaneswar city, Odisha, India

**H.K. SAHOO[1], S. DEHURY[1] AND R.C. MISRA[2*]**

[1]*Vasundhara, Bhubaneswar- 751024, Odisha, India*

[2]*ICAR-National Bureau of Plant Genetic Resources, Exploration Base Centre, Cuttack-753006, Odisha, India*

**rcmisranbpgr@gmail.com*

Date of receipt: 12.08.2019 Date of acceptance: 25.11.2019

**ABSTRACT**

The frequency of cyclones has increased manifold in the recent years thus devastating the coastal and adjoining districts of Odisha. The cyclonic storm 'Fani' hit Odisha coast during May 2019 and devastated extensively in many coastal districts including the capital city of Bhubaneswar. It caused a great loss to the vegetation cover with uprooting of trees particularly along tree-lined avenues which necessitated assessing the damage of different tree species in the state capital. This destructive impact of cyclone Fani on the roadside vegetation in parts of the city was evaluated based on visual estimation and type of damages.

**Key words:** Bhubaneswar city, cyclone, damage, Fani, tree

## INTRODUCTION

Over the last two decades, the frequency of cyclones has increased and its effect has devastated coastal Odisha and its adjoining districts. Further, the climate change projections indicate that the average maximum wind speed will increase in the coming decades (Acharya and Panda, 2019). "FANI" was a very severe cyclonic storm that developed over the Bay of Bengal during the first week of May, 2019 (Abhilash, 2019). It crossed Puri coast within 8.30 – 11.30 hrs (IST) of 3rd May 2019 with a wind speed of 180-210 km $hr^{-1}$. It has left destruction in its wake, not sparing the trees in the coastal districts of Odisha. A provisional estimation reported by different agencieswas that more than 10 million trees have beenuprooted with an equal number of trees damaged in the very severe cyclone (Abhilash, 2019). Preliminary estimates revealed that the cyclone Fani damaged at least two million trees in the city of Bhubaneswar too. It has not only destroyed the green cover but also destroyed the home of many birds and animals (Debata, 2019). It has affected the livelihood of people, especially that of daily-wage labourers and farmers (Acharya and Panda, 2019). Therefore, there is an urgent need to assess ecological, cultural and economic loss faced due to Fani. The present study is to assess tree damage due to cyclone Fani in Bhubaneswar City, which may be used to further restore greenery and economically useful cyclone resistant trees.

## MATERIALS AND METHODS

The present study was carried out in and around Bhubaneswar city just after Fani. A rapid assessment was done in the village Kalarahanga, Patia station road, Jayadev Vihar - Nandan Kanan road, OMFED square to Acharya Vihar, Acharya vihar to AG office and to Gopabandhu square, Jayadev Vihar to CRP square and Regional Plant Resource Centre, Niladri Vihar and Sailashree Vihar areas (Fig. 1). Cyclone affected trees were counted and the type of damage estimated on visual estimation basis. The tree species of girth at breast height (GBH) were visually estimated and recorded.

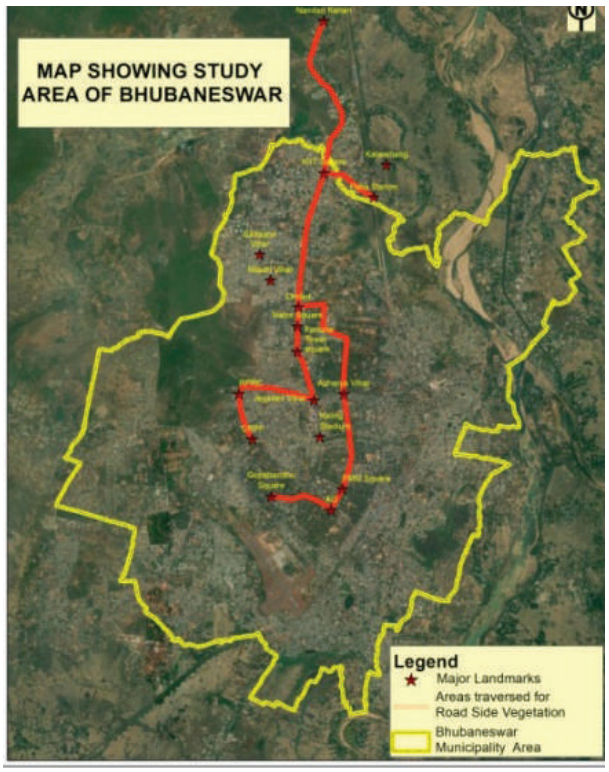



**Fig. 1.** Map showing study area of Bhubaneswar

## RESULTS AND DISCUSSION

The loss of vegetation affected by cyclonic storm Fani was observed and recorded at different locations of Bhubaneswar city (Fig. 2-8). It was observed that more than 99 per cent of trees experienced damage, out of which nearly 5 per cent trees were damaged completely, around 6 per cent trees uprooted, 31 per cent trees experienced severe damage and 57 per cent of trees were damaged partially (Table 1). The species like *Pongamia pinnata* (Karanja) and *Alstonia scholaris* (Chhatiana) were found to have experienced partial damage and were able to withstand the flow of wind. Although the fig plants like *Ficus benghalensis* (Bara) and *Ficus religiosa* (Ashwastha) faced minimum uprooting, they suffered loss from their branches. The species like *Azadirachta indica* (Nimba), *Mimusops elengi* (Baula), *Terminalia bellirica* (Bahada), *Syzygium cumini* (Jamu), *Mangifera indica* (Amba), *Terminalia arjuna* (Arjuna), *Pongamia pinnata* (Karanja), *Alstonia scholaris* (Chhatiana), *Ficus benghalensis* (Bara), *Ficus religiosa* (Ashwastha) and *Cassia fistula* (Sunari) were able to withstand the wind speed significantly with partial loss (< 50%) of branches. Trees like *Anthocephalus cadamba* (Kadamba), *Peltophorum pterocarpum* (Bishnuchuda), *Delonix regia* (Krushna chuda), *Albizzia lebbeck* (Sirisa), *Samanea saman* (Chakunda) were severely damaged due to loss of main and lateral branches which experienced maximum loss.

A study of cyclone Thane revealed that there was greater uprooting in introduced plantation species such as *Acacia auriculiformis* and *Tectona grandis*, whereas native species like *Azadirachta indica* and *Mangifera indica* underwent comparatively lesser damage (Sundarapandian et al., 2014). According to Bellingham et al. (1995) and Gleason et al. (2008), the plant species may vary in their capacity to resist wind (resistance), to offset the effects of injury (tolerance) and to recover from injury (resilience). It is unlikely that any one taxon will display all three of these characteristics, *viz.* resistance, resilience and tolerance. This is because of site and habitat-specific and resource limitations which will force a trade-off amongst them. Species which experienced more uprooting spread their roots on the surface soil and do not penetrate deeper into the soil (Bellingham et al., 1995; Gleason et al., 2008; Sundarapandian et al., 2014). Mickovski et al. (2007) noticed several factors that help in anchoring the plants and prevent uprooting. Further research is needed in order to identify species that are wind resistant, tolerant and resilient.

**Fig. 2.** Uprooted teak plants at Patia station road

**Fig. 3.** Damaged Kadamba plant at Niladri Vihar

**Fig. 6.** Village Kalarahanga affected by Fani

**Fig. 4.** Damage of house and vegetation including peepal tree at Kalarahnga square

**Fig. 7.** Devastated natural vegetation at Regional Plant Resource Centre

**Fig. 5.** Loss of natural vegetation at Nayapalli

**Fig. 8.** Damaged horticultural garden near Patia

**Table 1.** List of avenue species affected in part of Bhubaneswar city

| Scientific Name | Local name | Total Nos. | UPR | CD | HD | PD | UPR% | CD% | HD% | Total% |
|---|---|---|---|---|---|---|---|---|---|---|
| *Ailanthus excelsa* | Mahalaya | 23 | - | - | 6 | 17 | 0 | 0 | 26 | 26 |
| *Albizia lebbeck* | Sirisha | 118 | 4 | 5 | 79 | 30 | 8 | 4 | 67 | 79 |
| *Alstonia scholaris* | Chhatiana | 179 | - | - | 10 | 169 | 0 | 0 | 6 | 6 |
| *Anthocephalus cadamba* | Kadamba | 196 | 3 | 27 | 63 | 103 | 15 | 14 | 32 | 61 |
| *Artocarpus heterophyllus* | Panasa | 47 | 29 | 14 | 4 | - | 92 | 30 | 9 | 130 |
| *Azadirachta indica* | Limba | 77 | - | - | 19 | 58 | 0 | 0 | 25 | 25 |
| *Cassia fistula* | Sunari | 31 | - | - | 4 | 27 | 0 | 0 | 13 | 13 |
| *Cocos nucifera* | Nadia | 31 | - | - | - | 31 | 0 | 0 | 0 | 0 |
| *Delonix regia* | Krushana chuda | 119 | 20 | 15 | 54 | 30 | 29 | 13 | 45 | 87 |
| *Ficus benghalensis* | Bara | 68 | - | 1 | 46 | 21 | 2 | 1 | 68 | 71 |
| *Ficus religiosa* | Ashwastha | 18 | - | - | 8 | 10 | 0 | 0 | 44 | 44 |
| *Gmelina arborea* | Gambhari | 17 | - | - |  | 17 | 0 | 0 | 0 | 0 |
| *Lagestroemia flosreginae* | Patali | 26 | - | 2 |  | 24 | 8 | 8 | 0 | 15 |
| *Lannea coromondelica* | Mahi | 16 | - | - |  | 16 | 0 | 0 | 0 | 0 |
| *Mangifera indica* | Amba | 154 | 19 | 7 | 78 | 50 | 17 | 5 | 51 | 72 |
| *Mimusops elengi* | Baula | 25 | 2 | 5 | 7 | 11 | 28 | 20 | 28 | 76 |
| *Hyophorbe lagenicaulis* | Bottle palm | 34 |  |  |  | 34 | 0 | 0 | 0 | 0 |
| *Peltophorum pterocarpum* | Bishnuchuda | 92 |  |  | 66 | 26 | 0 | 0 | 72 | 72 |
| *Pongamia pinnata* | Karanja | 201 |  |  | 8 | 193 | 0 | 0 | 4 | 4 |
| *Simarouba glauca* | Mahatila | 11 |  |  | 1 | 10 | 0 | 0 | 9 | 9 |
| *Sygygium cuminii* | Jamu | 21 |  | 4 | 12 | 5 | 19 | 19 | 57 | 95 |
| *Tectona grandis* | Saguan | 153 | 24 | 19 | 54 | 56 | 28 | 12 | 35 | 76 |
| *Terminalia bellirica* | Bahada | 11 |  |  |  | 11 | 0 | 0 | 0 | 0 |
| *Terminalia catappa* | Pestabadam | 9 |  |  |  | 9 | 0 | 0 | 0 | 0 |
| TOTAL |  | 1,677 | 101 | 99 | 519 | 958 | 12 | 6 | 31 | 49 |

UPR: Uprooted, CD: Completely damaged, HD: Heavily damaged, PD: Partially damaged

**Recommended tree species for avenue plantation**

From the above study, it is revealed that the avenue plantation should consist of *Pongamia pinnata, Alstonia scholaris, Azadirachta indica, Terminalia arjuna, Putranjiva roxburghii, Ficus benghalensis, Ficus religiosa* and *Casia fistula.* These plants have experienced less damage during the cyclone Fani.

**ACKNOWLEDGEMENT**

We thank Bibhore Deo for assisting in collection of information from secondary sources. Special thanks are due to Mr Manas Ranjan Mishra, Executive Director, Vasundhara for encouraging to perform this study.

**REFERENCES**

Abhilash, P.C. 2019. Flood to Fani: climate-related disasters taking a toll on sustainable development. *Clim. Change Env. Sust.* **7**(1): 1-2.

Acharya, D. and Panda, G.K. 2019. Evaluation of impacts of cyclones on the livelihood status of the people of coastal Odisha and its remedial measures. *e-planet* **17**(1): 83-88.

Bellingham, P.J., Tanner, E.V.J. and Healey, J.R.1995. Damage and responsiveness of Jamaican montane tree species after disturbance by a hurricane. *Ecology* **76**: 2562–2580.

Debata, S. 2019. Impact of cyclone Fani on the breeding success of sandbar-nesting birds along the Mahanadi River in Odisha, India. *J. Threatened Taxa* **11**(14): 14895-14898.

Gleason, S.M., Williams, L.J., Read, J., Metcalfe. D.J. and Baker, P.J. 2008. Cyclone effects on the structure and production of a tropical upland rainforest: Implications for life-history trade-offs. *Ecosystems* **11**: 1277–1290.

Mickovski, S.B., Bengough, A.G., Bransby, M.F., Davies, M.C.R., Hallett, P.D. and Sonnenberg, R. 2007. Material stiffness, branching pattern and soil matric potential affect the pullout resistance of model root systems. *Eur. J. Soil Sci.* **58**(6): 1471-1481.

Saxena, H.O. and Brahmam, M. 1994-96. *Flora of Orissa*. vol. 1-4. OFDC, Bhubaneswar.

Sundarapandian, S.M., Mageswaran, K., Gandhi, D.S. and Dar, J.A. 2014. Impact of Thane cyclone on tree damage in Pondicherry University campus, Puducherry, India. *Curr. World Environ.* **9**(2): 287-300.

*e-planet* **17** (2): 139-145 (December 2019)

# Therapeutic uses of mangrove plants of Kansaridia forest block in Mahanadi delta of Odisha, India

**M.R. PATTNAIK[1*] AND S.K. SEN[2]**

*[1]Khariar Forest Dvision , Raj Khariar, Nuapada, 766107, Odisha, India*
*[2]Department of Botany, Panchayat College, Bargarh, 768 028, Odisha, India*

**dr.mihirpattnaik@gmail.com*

Date of receipt: 14.07.2019 Date of acceptance: 18.11.2019

## ABSTRACT

An attempt has been made to highlight some of the plants growing in mangrove areas of Kansaridia forest block of Mahanadi Delta in Odisha, located along the east coast of India. A field survey was undertaken in this forest block to record the ethno-medicinal utility of certain mangrove plants. The present paper deals with 20 plant species of 14 genera belonging to 11 families. The collected plant specimens were identified using regional flora and herbarium deposited in the Mangrove Forest Division (Wildlife), Rajnagar.

**Key words:** Ethno-medicine, Kansaridia block, Mahanadi delta, mangrove plants

## INTRODUCTION

Mangroves are the coastal intertidal halophytic plants which play very important role in the estuaries and land-sea interface areas of deltaic ecosystem of both tropical and subtropical zones. Generally, mangroves survive in saline condition of coastal areas and most of them are evergreen vegetation. It has been recognized and realized that all over the world mangroves are threatened and endangered, though mangrove ecosystems are considered as most productive ecosystem of the world. Mangrove forest provides all the tangible benefits to the coastal communities by supporting the variety and variability of plants. The major forest produce from mangroves are fuel wood, fodder, timber, tannin, oil, industrial raw materials, medicinal plant etc., which are variously used by the coastal inhabitants for their livelihood.

India has a very rich heritage of traditional health care system through Ayurvedic, Unani and Homeopathy system of medicines (Pandit, 2010). Knowledge of ethno-medicine is available through Vedic texts and commentaries. Also there is in use another less exploited source of information in use which comes from folklore and passed through generations in certain restricted and remote habitations (Jain, 1996). Ethno-medicinal practices are the holistic health care management methodologies adopted in non-literate cultures as the word 'ethno' means traditions or indigenous to local people. These practices have been percolating down from one generation to another by oral transmission. Hence the ethno-medicinal practices distinguish itself from well documented systems of other medicines (Sahoo and Misra, 2019). Due to over exploitation by local inhabitants and lack of proper records, these plant resources along with related indigenous knowledge are depleting to a great extent day by day.

Keeping this in view, the present study was undertaken in Kansaridia PRF of Mahanadi Delta to deal with the traditional indigenous knowledge used by the local people.

## STUDY AREA

Present study was undertaken during 2008-2010 in the Kansaridia Proposed Reserved Forest (PRF) of Mahanadi delta located in the Kendrapara

district of Odisha along the east coast of India. It is situated between 20° 20' 58.3" to 20° 22' 11.7" North latitude and 86° 45' 30" to 86° 46' 00" East longitudes near Hukitola lake (Chataka) to the north of Light house at the False point. It is bounded by Bay of Bengal at the north, Khola nala and Hetamundia PRF at the east, Batighar PRF at the south and Sanatubi PRF and Kansari nala in the west (Fig. 1). It spreads over an area of 1394.744 ha having periphery 19.12 km out of which 610 ha is under encroachment for prawn culture and the rest 784.744 ha of area harbours luxuriant mangrove vegetation. The area receives maximum rainfall during the month from June to October with average annual rainfall about 1641 mm. The climate is tropical, warm and humid having maximum temperature 42°C and the minimum is 9°C in the month of May and January respectively. Throughout the year the mean relative humidity ranges from 70-85%. Soil of the area is mostly alluvial with deposits of silt. Approximately 64 mangrove species and their associates are recorded from Mahanadi delta among which many plants have certain medicinal properties (Pattnaik, 2007).


**Fig. 1.** Map showing Kansaridia forest block

A total of 6 villages namely Kajalpatia, Kochilabelari, Batighar, Sanatubi, Badatubi and Barakolikhola are adjacent to this mangrove forest with more than 4500 inhabitants. They depend mostly on fishing and agriculture. These villages are lacking modern facilities because of their remoteness. The inhabitants are utilizing mangrove forest resources to meet their various needs like construction of houses, food, fodder, fuel, medicine etc.

With a view to protect the mangroves in general and medicinal plant species in particular, 200 ha area of this forest block has been constituted as Medicinal Plant Conservation Area (MPCA) by the Forest Department, Government of Odisha.. The protection of the area is vested with Maa Ramachandi V.S.S which has been constituted on 8 November 2008 by the active cooperation of the villagers of Kochilabelari having 121 numbers of households.

## MATERIALS AND METHODS

The traditional knowledge of plant based remedies for the treatment of diseases is confined with the medicine man, all of which belong to indigenous practitioners. The practices of traditional knowledge have been passed on orally from one generation to other generation. The main objective of the study is to document the history, method of preparation and application of plant part(s) used by the local ethnic community.

### Collection of ethno-medicinal data

After a thorough reconnaissance, the area was surveyed and demarcated with boundary pillars. Field tours were undertaken in different villages to collect information about traditional knowledge regarding the medicinal use of mangrove plants and their products. Before collection of information, a friendly base was established with them, because they were very much reluctant to share their traditional knowledge on plants to any outsiders. The respondents were mainly village headman, traditional healers, local herbalist and women folk who were selected on the basis of their recognition as knowledgeable members concerning folk medicine. Repeated queries were made to confirm the information.

### Identification of plants

Identification of collected plants was done using relevant flora (Haines, 1921-25; Benerjee and

Rao, 1990; Saxena and Brahmam, 1994-96) and the specimens collected during the investigation were preserved as herbarium materials.

## RESULTS AND DISCUSSION

During present investigation, 20 medicinal mangrove plant species belonging to 11 families and 14 genera were studied. The plants are enumerated alphabetically by their botanical names along with their respective families within parenthesis, vernacular names, collection number, parts used and their medicinal uses (Table 1). The form of herbal preparations have also been presented against different kind of diseases.

**Table 1.** List of medicinal mangrove species of Kansaridia forest block in Mahanadi delta

| Sl. No. | Botanical Name and Family Name | Local Name | Parts used | Form of herbal preparation | Diseases/ailments |
|---|---|---|---|---|---|
| 1 | *Acanthus ilicifolius* Linn. (Acanthaceae) | Harakancha - 68 | Leaf<br>Leaf<br>Fruit | Decoction<br>Extract<br>Pulp | Rheumatism<br>Body pain<br>Blood purifier |
| 2 | *Aegiceras corniculatum* Linn. (Myrsinaceae) | Khalsi -72 | Hypocotyle | Paste | Hyperacidity |
| 3 | *Avicennia alba* Blume. (Avicenniaceae) | Kala Bani -33 | Bark<br><br>Root | Paste<br><br>Paste | Wounds and skin diseases<br>Boils,<br>Insects bite, stomach disorder |
| 4 | *Avicennia officinalis* Linn. (Avicenniaceae) | Dhala Bani -29 | Leaf<br>Bark | Paste<br>Paste | Sprain<br>Wounds & skin diseases |
| 5 | *Brownlowia tersa* Linn. (Tiliaceae ) | Lati Sundari - 45 | Leaf | Paste | Boils |
| 6 | *Bruguiera cylindrica* Linn. (Rhizophoraceae) | Kaliachua -76 | Leaf<br>Fruit<br>Bark | Decoction<br>Pulp<br>Decoction | Conjunctivitis, eye irritation,<br>Wild ant bite<br>Diarrhoea & jaundice |
| 7 | *Bruguiera gymnorhiza* Linn. (Rhizophoraceae) | Bandari - 66 | Leaf<br>Fruit<br>Bark | Decoction<br>Pulp<br>Decoction | Conjunctivitis, eye swelling,<br>Wild ant bite<br>Diarrhoea |
| 8 | *Bruguiera parviflora* Roxb. (Rhizophoraceae) | Dot -12 | Leaf<br>Fruit | Decoction<br>Pulp | Eye irritation,<br>eye swelling,<br>conjunctivitis Wild ant bite |
| 9 | *Caesalpinia crista* Linn. (Caesalpiniaceae) | Nentei - 52 | Leaf<br>Seed | Paste<br>Paste | Scabies<br>Rheumatism |
| 10 | *Ceriops decandra* Griff. (Rhizophoraceae) | Garani -30 | Bark | Paste | Fish diseases |
| 11 | *Clerodendrum inerme* Linn. (Verbenaceae ) | Chiani -46 | Root | Powder | Jaundice |
| 12 | *Excoeacaria agallocha* Linn. (Euphorbiaceae ) | Guan -17 | Latex | Raw | Cut wound, paralysis |

| Sl. No. | Botanical Name and Family Name | Local Name | Parts used | Form of herbal preparation | Diseases/ailments |
|---|---|---|---|---|---|
| 13 | *Kandelia candel* Linn. (Rhizophoraceae) | Sindhuka -28 | Stilt root | Powder | Hypertension |
| 14 | *Rhizophora apiculata* Blume. (Rhizophoraceae) | Rai- 59 | Bark | Decoction | Hematuria, diarrhoea, dysentery |
| | | | Bark | Decoction | Bleeding |
| 15 | *Rhizophora mucronata* Linn. (Rhizophoraceae) | Rai - 60 | Bark | Decoction | Hematuria, diarrhoea, dysentery |
| | | | Bark | Decoction | Bleeding, neck inflammation. |
| 16 | *Sonneratia apetala* Buch-Ham. (Sonneratiaceae) | Keruan -47 | Fruit | Juice | Hemorrhage |
| | | | Fruit | Raw | Poor eye sight |
| 17 | *Sonneratia caseolaris* Linn. (Sonneratiaceae) | Orua 32 | Fruit | Juice | Hemorrhage |
| | | | Fruit | Raw | Poor eye sight |
| 18 | *Tamarix troupii* Linn. (Tamaricaceae) | Jagula -61 | Leaf | Raw | Stomach pain |
| 19 | *Xylocarpus mekongensis* Pierre. (Meliaceae) | Pitamari -44 | Seed | Oil | Hair illuminant |
| 20 | *Xylocarpus granatum* Koen. (Meliaceae) | Sisumara -65 | Seed | Paste | Breast tumor |
| | | | Bark | Paste | Cholera |
| | | | Fruit | Paste | Elephantiasis |

It is evident from the present observation that the inhabitants living in and around the mangrove forests of Mahanadi delta have good knowledge about traditional use of plants. The ethno-medicinal study revealed therapeutic potential of 36 applications from 20 plants species for treating 51 different diseases and ailments. There is variation in frequencies of different plant parts used to treat the diseases (Table 2). There were 6 plant parts used by the traditional healers for treatment of diseases, out of which bark was most frequently used for 10 species (28.59%), followed by leaf and fruit for 9 species (25.71%) in each and root for 3 species (8.57%).

**Table 2.** Parts of medicinal plant used

| Plant part | Frequency | Percentage (%) |
|---|---|---|
| Root | 03 | 8.57 |
| Leaf | 09 | 25.71 |
| Bark | 10 | 28.59 |
| Fruit | 09 | 25.71 |
| Seed | 03 | 8.57 |
| Hypocotyle | 01 | 2.85 |

There were 8 herbal preparations observed from this study (Table 1). The most frequently used preparation was paste for 12 prescriptions (33.0 %), followed by decoction for 10 prescriptions (28.0 %), pulp for 4 preparations (11.0 %), extract and raw for 3 preparations (8.0 %) each, powder for 2 (6.0 %) and oil and latex for 1 prescription ( 3.0 ) each (Fig. 2).

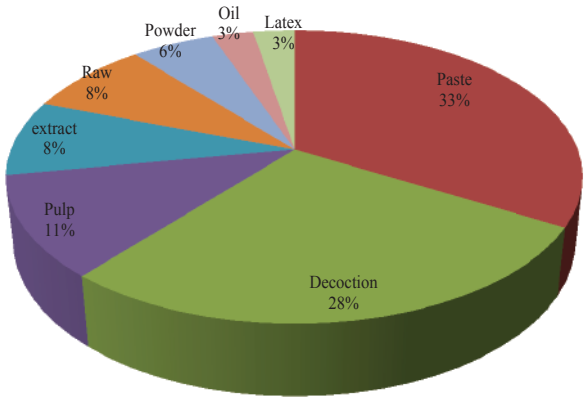



**Fig. 2.** Percentage of herbal preparation

**Table 3.** Comparison of mangrove plants with other similar researches

| Sl. . | Name of the Plant | Ravindran et al. (2005) | Onrizal and Mansor (2010) | Oratal et al. (2012) | Present study |
|---|---|---|---|---|---|
| 1. | *Acanthus ilicifolius* L. | √ | √ | | √ |
| 2. | *Aegiceras corniculatum* Linn. | | | | √ |
| 3. | *Avicennia alba Blume* | √ | √ | √ | √ |
| 4. | *Avicennia officinalis* L. | √ | | | √ |
| 5. | *Brownlowia tersa* Linn. | | | | √ |
| 6. | *Bruguiera cylindrica* Linn. | | | √ | √ |
| 7. | *Bruguiera gymnorrhiza* Lamar. | √ | √ | | √ |
| 8. | *Bruguiera parviflora* Roxb. | | | | √ |
| 9. | *Caesalpinia crista* Linn. | | | | √ |
| 10. | *Calophyllum inophyllum* L. | | | √ | |
| 11. | *Capparis sepiaria* L. | | | √ | |
| 12. | *Cayratia trifolia* (L.) Domin | | | √ | |
| 13. | *Ceriops decandra* Griff. | | | | √ |
| 14. | *Clerodendrum inermis* (L.) Gaertn. | √ | | √ | √ |
| 15. | *Colubrina asiatica* (L.) Brongn. | | | √ | |
| 16. | *Derris scandens* (Aubl.) Pittler | | | √ | |
| 17. | *Derris trifoliata* Lour. | | | √ | |
| 18. | *Excoeacaria agallocha* L. | √ | √ | √ | √ |
| 19. | *Heritiera littoralis* Aiton | | | √ | |
| 20. | *Hibiscus tiliaceus* L. | | | √ | |
| 21. | *Ipomoea pescarprae* (L.) Sweet | √ | | | |
| 22. | *Kandelia candel* Linn. | | | | √ |
| 23. | *Lumnitzera racemosa* Willd. | | | √ | |
| 24. | *Rhizoprora mucronata* Lam. | √ | | √ | √ |
| 25. | *Rhizophora apiculata* Blume | √ | √ | √ | √ |
| 26. | *Salicornia brachiata* Roxb**.** | √ | | | |
| 27 | *Solanum trilobatum* L. | | | √ | |
| 28 | *Sonneratia alba* Smith | | √ | | |
| 29. | *Sonneratia apetala* Buch-Ham. | | | | √ |
| 30. | *Sonneratia caseolaris* (L.) Engl. | | | √ | √ |
| 31. | *Tamarix troupii* Linn. | | | | √ |
| 32. | *Xylocarpus granatum* Koen | √ | √ | | √ |
| 33 | *Xylopyrus mekongennsis* Pierre | | | | √ |
| | Total | 11 | 09 | 35 | 20 |

**Comparative analysis with similar study**

Rabindran et al. (2005) have reported 11 mangrove medicinal species from Pichavaram mangroves of East coast, Tamil Nadu whereas Ornizol and Mansor, 2010 have reported 9 species form North Sumatra, Indonesia and Oratal et al. (2012) have reported 35 mangrove plants from Phra Peninsula of Sonkhla province as against 20 species reported during the present day. As reported three plant species such as *Avicennia alba, Excoeacaria agallocha* and *Rhizophora apiculata* have some medicinal properties which is in agreement with the present observation. Contrary to the previous findings *Aegiceras corniculatum, Brownlowia tersa*, *Bruguiera parviflora, Caesalpinia crista*, *Ceriops decendra, Kandelia candel, Sonneratia apetala, Tamarix troupii* and *Xylocarpus mekongensis* are the plants found only from the present study area (Table 3).

Twenty medicinal plant species identified from Kansaridia forest block are being utilized to cure 29 diseases and ailments. Family Rhizophoraceae represents highest number of species (7) as regards to their medicinal properties is concerned followed by Avicenniaceae and Sonneratiaceae represented by 2 species each. The genus *Bruguiera* is represented 3 species followed by *Rhizophora*, *Sonneratia* and *Xylocarpus* are representing 2 species. *Acanthus illicifolius* and *Caesalpinia crista* have the potentiality to cure rheumatism. At the same time *xylocarpus granatum* is not only very popular in the locality to be used against breast tumor, but also have miraculous effect against elephantiasis. *Bruguiera cylindrica* is used long since as a curative measure against jaundice and latex of *Excoeacaria agallocha* against paralysis in such a remote part of the country.

Since time immemorial, plants are indispensable source of natural products for the health of human beings and they have a great potential for producing new drugs (Nascimento et al., 2000; Litteton et al., 2005) as they contain compounds of therapeutic value (Panda et al., 2009). Even today the people who live adjacent to the forest areas, use plant products to cure chronic diseases. According to WHO, plants are a source of compounds having ability to combat diseases, antimicrobial, antiviral and antifungal activities (Nascimento et al., 2000; Gazim et al., 2008). Plant products are less toxic and environmentally friendly and less pollutant are produced in course of their production and have minimum health hazards (Opra and Wakocha, 2008).

At present context, new diseases are arising day by day and infectious diseases are the second most serious cause of death worldwide (Abeysinghe et al., 2010). In the present health care system of the world, the rise of antibiotic resistant micro-organisms is one of the severe problems. Thus, WHO is trying to promote traditional medical system (Bizimina, 1997) in order to combat diseases. In such a scenario mangroves of Mahanadi delta will act as an epitome of phytomedicines for benefit of the society. Therefore, long term conservation measures by way of creating awareness on the rural folk should be undertaken on a priority basis.

**CONCLUSION**

The present investigation has included the therapeutic values employed to cure certain important diseases and ailments like breast tumor, cholera, elephantiasis, eye-sight problems, hemorrhage, hyperacidity, hypertension, jaundice, paralysis, rheumatism, skin diseases, stomach disorders, etc. These ethno-medicinal plants are subjected to intensive phyto-chemical screening in view of their immense potential to cure certain vital diseases and ailments.

The inhabitants of fringe villages around mangrove forests live in remote rural areas where modern health care facilities are not available. Besides the plant species studied, many plants are also used for the preparation of various medicines. But the secretiveness of the medicinal practitioners and fear of overexploitation of the plant resources by the outside people, their communities pose reluctance to disclose all the information which is still with them.

This research work was conducted in remote areas to record and document the utilization of mangrove plants which have been helpful to them in the treatment of various diseases. Apart from

that awareness campaign should be conducted by the NGO's and governmental organizations about the utility, preservation and conservation of the mangrove plant species along with their associates on priority basis. With the development of modern medicines which are very effective, traditional medicinal practices have been overlooked. Though modern medicines are believed to cure most of the ailments, such facilities could not be available in each and every corner in proper form. Furthermore, such medicines are very costly and not readily available in remote pockets. The main loopholes that prevailing in the localities are improper diagnosis of the diseases, delay in treatment and age-old superstitions that cause casualties among the people. At present there is urgent need for exploration and documentation of medicinal plant wealth of mangroves of Mahanadi delta. It will not only help in conservation of mangroves but also lead to the integrated development of the local community.

## ACKNOWLEDGEMENT

The authors are thankful to the DFO, Mangrove Forest Division, Rajnagar to support the work. The authors are also thankful to Mr. Kalipada Baroi, Botanist and Mr. Srimanta Mandal, President, Maa Ramachandi VSS for providing information over medicinal uses of the plants.

## REFERENCES

Abeysinghe, P.D. 2010. Antibacterial activity of some medicinal mangroves against antibiotic resistant. pathogenic bacteria. *Indian J. Pharm. Sci*. **72**(2): 167–172.

Bizimina, N. 1997. Scientific evidence of efficacy of medicinal plants for animal treatment, Ethnoveterinary medicine: Alternative for livestock development, Proceedings of an International Conference, Pune , 4-6 November, Abstr., pp 11-12.

Benerjee, L.K. and Rao, T.A. 1990. *Mangroves of Orissa coast and their ecology.* Bishen singh Mahendra Pal Singh, Dehra Dun.

Gazim, Z.C., Rezende, C.M., Fraga, S.R., Svidzinski, T.I. and Cortez, D.A. 2008. Antibacterial activity of the essential oil from *Calendula officinalis* L. (Asteraceae) growing in Brazil. *Braz. J. Microbiol*. **39**: 61–63.

Haines, H.H. 1921-25. *The Botany of Bihar and Orissa*. Arnold and Sons, London.

Jain, S.K. 1996. *Ethnobotany in Human welfare.* Deep Publications, New Delhi.

Litteton, J., Rogers, T. and Falcone, D. 2005. Novel approaches to plant drug discovery based on high throughput pharmacological screening and genetic manipulation. *Life Sci.* **78**: 467–475.

Nascimento, G.G.F, Locatelli, J., Freitas, P.C. and Silva, G.L. 2000. Antibacterial activity of plant extracts and phytochemicals on antibiotic resistant bacteria. *Braz. J. Microbiol*. **31**: 247–256.

Onrizal and Mashhor Mansor, 2010. *Ethnobotanical study of medicinal plants from mangrove forests in North Sumatra, Indonesia.* Paper presented at the 1st Pharmaceutical Sciences Conference and Exhibition (PSCE) 2010 on 27-28 September 2010 at Vistana Hotel, Penang, Malaysia.

Opra, E.U. and Wokocha, R.C. 2008. Efficacy of some plant extracts on the in vitro and in vivo control of *Xanthomonas campestris* Pv. Vesicatoria. *Agric. J.* **3**: 163–170.

Oratal, N., Patcharin, S., Kornkanok, Y. and Narumon, S. 2012. A survey of medicinal plants in mangrove and beach forests from sating Phra Peninsula, Songkhla Province. *J. Med. Plant Res.* **6**(2): 2421-2437.

Panda, S.K., Thatoi, H.N. and Dutta, S.K. 2009. Antibacterial activity and phytochemical screening of leaf and bark extracts of *Vitex negundo* from Similipal, Orissa. *J. Med. Plant Res.* **3**: 294–300.

Pandit, P.K. 2010. Inventory of ethno veterinary medicinal plants of Jhargram Division, West Bengal, India. *Indian Forester* **136**(9): 1183-1194

Pattnaik, M.R. 2007. *Integrated Mangrove Ecosystem of Bhitarkanika: Evaluation, Utilization and Conservation*. D.Sc. Thesis submitted to Utkal University, Orissa.

Ravindran, K.C., Venkatesan, K., Balakrishnan, V., Chekkapan, K.P. and Balasubramanian, 2005. Ethnomedicianl studies of Pichavaram mangroves of East coast, Tamil Nadu. *Indian J. Tradit. Know.* **4**(4): 409-411.

Sahoo, H.K. and Misra, R.C. 2019. Indigenous phyto-therapy of Kandha tribe for primary healthcare in Kandhamal district, Odisha. *e-planet* **17** (1): 1-8

Saxena, H.O. and Brahmam, M. 1994-96. *The Flora of Orissa.* Orissa Forest Development Corporation, Bhubaneswar and Regional Research laboratory, Bhubaneswar, Orissa.

*e-planet* **17** (2): 146-151 (December 2019)

# Molecular detection of *Theileria* spp. in apparently healthy cervids of Nandankanan Zoological Park, Odisha

**S.K. SAHU[1], S.R. HOTA[2], B.K. BEHERA[2], M. DASH[2] AND N. SAHOO[1*]**

[1]*Nandankanan Zoological Park, Forest and Environment Department, Government of Odisha, India*

[2]*Centre for Wildlife Health, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar-751003, Odisha, India*

**niranjanasahoo@hotmail.com*

Date of receipt: 10.09.2019 Date of acceptance: 17.12.2019

**ABSTRACT**

*Theileria* spp., predominantly a tick-borne haemoprotozoan parasites of cattle, do infect wild animals especially in endemic areas. Identification of infectious agents provides valuable information on epidemiology. Molecular study was conducted in two species of wild cervids, i.e., brow-antlered deer and sambar deer of Nandankanan Zoological Park (NZP), Bhubaneswar, Odisha to assess the occurrence of blood pathogen. Following DNA extraction from the whole blood samples, the product was subjected to PCR with 989/990 primers specific for *Theileria* genus where a product size of 1098bp upon gel electrophoresis were recorded in positive cases. Out of 9 brow-antlered deer and 12 sambar deer samples processed, 8 samples (4 from each species) showed presence of *Theileria* spp. indicating a prevalence rate of 38 per cent. The study uncovered the carrier stage of *Theileria* spp. among wild cervidae population in NZP and thereby laid down stepping stone towards control measures.

**Key words:** Carrier stage, Nandankanan Zoological Park, PCR, theileriosis, wild cervid

## INTRODUCTION

The genus *Theileria*, comprising of obligate intracellular haemoprotozoan parasites, have the ability to infect both domestic as well as wild ruminant throughout the world (Garcia-Sanmartin et al., 2007). Apart from its economic effect on domestic bovines in the form of low productivity or mortality, this tick-borne disease has also been reported to infect wild ruminants like white-tail deer (Schaeffler, 1961), elk (Chae et al., 1998), sika-deer (Inokuma et al., 2004), mule deer (Kjemtrup et al., 2000), fallow deer (Galupppi et al., 2010) and water deer (Han et al., 2009). Some species of the genus *Theileria* such as *T. annulata* and *T. parva* are highly pathogenic and cause significant mortality among susceptible animals (Tait and Hall, 1990; Gitau et al., 1999). However, other *Theileria* spp. like those of *T. orientalis/buffeli* group are considered to be benign or less pathogenic probably because of a long evolutionary relationship between the parasite and the host (Zanet et al., 2014). Nevertheless, clinical disease may occur in stressful situations related to translocation, concurrent diseases or malnutrition (Kocan and Kocan, 1991; Hofle et al., 2004; Sawczuk et al., 2008).

*Theileria* spp. are cosmopolitan parasites (Chae et al., 1999) that have been detected in wild ruminants in many countries including Japan (Ikawa et al., 2011), South Korea (Han et al., 2009), Brazil (Silveira et al., 2013), the United States (Garner et al., 2012), Italy (Galupppi et al., 2010), Austria (Fuehrer et al., 2013) and Spain (Garcia-Sanmartin et al., 2007). Though India has long been established as a victim of bovine theileriosis,

reports of theileriosis among wild animals are scant. Literature search on the incidence of theileriosis among domesticated bovines in India over the last four decades has revealed the existence of theileriosis in clinical as well as carrier stages (Anonymous, 2015; Kakati et al., 2015). The occult infection may remain as a potential source of infection for other susceptible hosts. But there is lack of information on prevalence of such infection among wild animals in India that is essentially required to chalk out effective location specific control programme.

Keeping the above facts in forefront, the present study was conducted to unveil status of *Theileria* spp. infection, if any, by blood smear examination and polymerase chain reaction (PCR) in two different species of wild cervids viz. brow-antlered deer (*Rucervus eldii*) and sambar deer (*Rusa unicolor*) maintained separately under captivity in Nandankanan Zoological Park (NZP), Bhubaneswar, Odisha, one of the largest zoos of India.

## MATERIALS AND METHODS

Odisha is privileged to own NZP, one of the premier zoological parks across India, which is geographically located between 20° 23' 08" to 20° 24' 10" N latitude and 85° 48' 09" to 85° 48' 13" E longitude. Of huge repertoire, wild ruminants constitute a major chunk. The state experiences moderately hot and very humid climate favouring rapid multiplication of vectors and propagation of vector-borne diseases of which theileriosis is one with economic repercussions (Ogre, 1999). Five species of theileria (*T. annulata, T. parva, T. taurotragi, T. velifera* and members of *T. sergentii/ orientalis/buffeli* group) have been found to infect animals throughout the world. The state of Odisha has also witnessed reports of theileriosis among domesticated bovines in its coastal districts. But the report of this disease among wild animals of Odisha is silent. Therefore, the need to unveil the picture of theileriosis in the wild mammals is of paramount importance.

During the process of therapeutic management, there was a need of collecting whole blood samples from two different species of wild *Cervidae* i.e., Brow-antlered deer and Sambar deer for hemato-biochemical analysis. Such blood samples were screened for presence of *Theileria* spp. using conventional blood smear examination and PCR.

Approximately one millilitre of blood sample was collected properly from jugular vein of nine Brow-antlered deer and 12 Sambar deer each belonging to both sexes in EDTA coated vacutainers, during restraint for therapeutic management and surgical interventions. Such samples were brought to the Centre for Wildlife Heath, OUAT for laboratory investigation.

### Microscopic examination (ME)

Thin blood smears prepared from whole blood samples were fixed with methanol for 5 minutes and subjected to staining with 10% Giemsa's solution for 40 minutes. Blood smears were carefully examined for presence of *Theileria* spp. parasites under the oil immersion lens (100 X magnifications).

### Molecular diagnosis through PCR

Genomic DNA was extracted from each blood sample using commercially available DNA mini kit (QIAGEN, GERMANY). According to the manufacturer's instructions, 200 µl of whole blood was used for each sample. The integrity of extracted DNA was checked by agarose gel electrophoresis. Purified DNA was used as template for the PCR. In PCR, 989/990 set of primers were used specific for *Theileria* genus (Table 1). PCR was performed in a final reaction volume of 25 µl reaction mixtures containing 2 µl DNA sample (using 30 ng $\mu l^{-1}$ template in case of DNA reference samples), 50 mM KCl, 10 mM Tris–HCl (pH 8.3), 1.5 mM $MgCl_2$, 200 µM of dNTP mix, 20 pmol of each primer, 0.5U Taq polymerase enzyme and sterile distilled water up to 25 µl. The reaction mixture was placed on a heating block of a Proflex PCR system (Thermofischer scientific). After a denaturation step of 5 min at 94°C, each of 30 cycle consisted of 1 min at 94°C, 1 min at 55°C, 1 min at 72°C followed by 10 min at 72°C. Positive control and negative control were run along with

the test samples. The amplification products were subjected to electrophoresis on 1.5 per cent agarose gel with ladder and the amplified products were visualized using Gel Documentation system. A product size of 1098 bp by primers 989/990 were considered positive for *Theileria* genus

**Table 1.** Primer set used for PCR to detect *Theileria* spp.

| Oligo name | Sequence (5'----> 3') | Product size | Target genome |
|---|---|---|---|
| 989 | GTAACCTTTAAAAACGT | 1098 bp | *Theileria* genus specific |
| 990 | GTTACGAACATGGGTTT | | |

Source: Vet. World, Prevalence of theileriosis in cross-bred cattle authored by Kohli et al. (2014)

## RESULTS AND DISCUSSION

On microscopic examination, all 21 blood smears examined were found negative for the presence of both the stages of *Theileria* parasite i.e., piroplasm and/or schizonts under 100X resolution by oil immersion. However, molecular detection through PCR revealed a more elaborate picture where 8 (38 %) cases found positive for *Theileria* spp. (Fig. 1). Out of these, 4 positive samples belonged to Brow-antlered deer and the rest four were from Sambar deer.

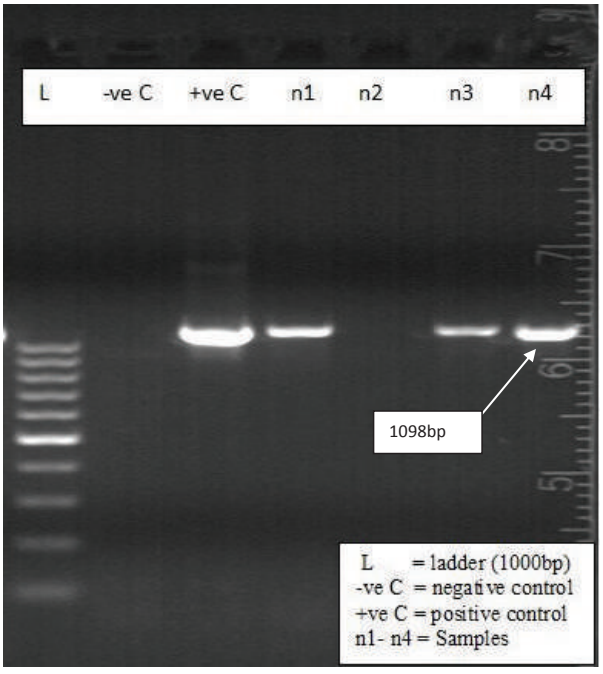



**Fig. 1.** Gel image showing positive amplification of *Theileria* spp. in wild cervids (Brow-antlered deer and Sambar deer) and amplicon size in base pairs.

*Theileria* sp. is an obligatory intracellular parasite that exhibit indirect lifecycles. *Ixodid* spp. (hard ticks) belonging to the genus *Rhipicephalus*, *Hyalomma*, *Haemaphysalis* and *Amblyomma* have been reported to be the vectors for different species of *Theileria* parasites across the globe. *Theileria* sporozoites are transmitted to susceptible animals in the saliva of the feeding tick. In cattle the disease is characterized clinically by pyrexia, inappetance, swollen peripheral lymph nodes, anaemia and icterus. Other clinical signs include lacrimation, corneal opacity, nasal discharge, terminal dyspnoea and diarrhoea. In wild animals, though carrier stages are seen in a number of bovids and cervids, clinical infection has been reported in a gaur calf (*Bos gaurus*) in India with clinical signs of opacity of both eyes, reduced appetite, clay coloured stool loose in consistency, champing of jaws and pyrexia. Outside India, clinical infections have been documented in Sika deer in China with symptoms of pale mucous membrane, weight loss and swollen prescapular lymph nodes (Liu et al., 2016). Fatal infections have also been recorded in African antelopes where clinical signs observed were depression, drooping of the ears, prolonged intermittent recumbency, anorexia, and lagging behind the herd. On inspection after immobilization, the animals were found to be anemic, icteric, and pyrexic, with generalized lymph node enlargement and prolonged bleeding times. Nijhof et al. (2005) recorded icterus and widespread petechiae (especially in the renal cortex), splenomegaly, red pulp hyperplasia, pulmonary edema, and a generalized lymphoid hyperplasia in antelopes during postmortem examination. Punched ulcers in the abomasums, a characteristic pathognomonic lesion in cattle, was not noticed.

Though the conventional Giemsa stained thin blood smear examination continues to be the gold standard method for identification of intra-erythrocytic piroplasm and schizont stage of *Theileria* spp., this method is rarely successful in case of carrier animals (Durrani and Kamal, 2008). Such statement substantiates the findings in the present study where none of the thin blood smears were positive for *Theileria* parasites under microscopy. Moreover, by microscopic examination, it is generally not possible to discriminate different species of *Theileria* spp. that may occur as single or mixed with other species simultaneously within the same host (Parthiban et al., 2010). The serological tests like IFA and ELISA are also not suitable due to cross reactivity with other *Theileria* spp. (Anonymous, 2014) and inability to distinguish between active carriers and animals with antibodies due to prior infections (Dolan, 1986).

In the present investigation, PCR could identify *Theileria* spp. in 38 % (8/21) of the apparently healthy wild cervids of NZP that established the carrier status of this parasite. To the best of our knowledge, this study is probably the first of its kind to report *Theileria* infection in cervids in India. Appearance of carrier animals is a cause of concern as it poses as a risk and focus of infection to other susceptible healthy animals in the zoo viz., Four horned antelopes, Blackbuck, Mouse deer, Swamp deer, Barking deer, Hog deer, Sambar deer, Spotted deer, Brow-antlered deer and Nilgai. In addition to that, there is a herbivore safari in the park that inhabits four of these species that are Barking deer, Spotted deer, Sambar deer and Four horned antelopes which creates a greater risk of transmission of this parasite among the wild herbivores.

Carrier animals are usually the chronic form of piroplasms (Kohli et al., 2014). It could be inferred that the carrier animals along with the tick feeding on them may act as the source of infection for the healthy population. They usually remain undetected by conventional microscopic and serological methods due to low level of infection (Roy et al., 2000). To overcome these constraints, PCR was preferred for its high sensitivity and the ability to amplify even a minute concentration of parasitic DNA in the blood enabling the detection of carrier animals especially in endemic conditions (Mans et al., 2015).

Livestock could also be a possible source of this parasite to wildlife population in the buffer areas (Daniels, 2007). It is a fact that some species of *Theileria* have also been found capable of being mechanically transmitted to healthy cattle by minute volumes of blood through intravenous inoculation by hypodermic needle as well as through biting arthropods (Hammer et al., 2016) which further escalates the risk factor associated with the carriers of this disease. An inverse relationship exists between age and resistance to infection, where fawns gradually acquire immunity without showing clinical symptoms, and immunity is maintained by repeated challenges with the parasites. Consequently, a persistent parasite reservoir is established in the wild ruminants (Garcia-Sanmartin et al., 2007). It has already been established that stressors like high parasitemia, poor nutrition, high population density, harsh weather conditions, or handling (e.g. translocation) can lead to symptomatic piroplasmosis which is a cause of severe disease and death among wild animals (Hofle et al., 2004).

Buparvaquone with/without oxytetracycline is considered effective against theileriosis. However, treatment with these agents does not completely eradicate theileria infections, rather leads to the development of carrier state in that hosts. Reliable live vaccines of known efficacy are available only against species *T. annulata.* But its use in carrier animals is still under scrutiny.

More sustainable and reliable methods for the control of theileriosis include deployment of a combination of strategic tick control and specific attention towards tick or parasite screening in imported animals (Radostitis et al., 2009). Hence, findings of the study will stimulate implementation of preventive practices in the Nandankanan Zoological Park to restrict hemoparasite transmission.

## CONCLUSION

Present study indicated asymptomatic carrier state of *Theileria* spp. in wild cervids i.e., like brow-antlered deer and Sambar deer in Nandankanan Zoological Park, Odisha. Though conventional blood smear examination could not detect presence of piroplasm/schizont in blood smear, PCR could detect *Theileria* spp. in 38 % (8/21) of the apparently healthy wild cervids.

## ACKNOWLEDGEMENT

Authors express their deep sence of thanks and gratitude to the Director, Nandankanan Zoological Park, Forest and Environment Deptt., Govt. of Odisha and Dean, College of Veterinary Science and Animal Husbandry, OUAT, Bhubaneswar-751003, Odisha for their kind support to undertake the study.

## REFERENCES

Anonymous. 2015. NDDB - Animal Health Updates, *Quaterly Newsletter* **3**(4).

Anonymous. 2014. *Office International Epizootics (OIE) Terrestrial Manual*. Chapter 2.4.16.

Chae, J.S., Lee, J., Kwon, O., Holman, P.J., Waghela, S.D. and Wagner, G.G. 1998. Nucleotide sequence heterogeneity in the small subunit ribosomal RNA gene variable (V4) region among and within geographic isolates of *Theileria* from cattle, elk and white-tailed deer. *Vet. Parasitol.* **75**: 41–52.

Chae, J.S., Allsopp, B.A., Waghela, S.D., Park, J.H., Kakuda, T., Sugimoto, C., Allsopp, M.T., Wagner, G.G. and Holman, P.J. 1999. A study of the systematics of *Theileria* spp. based upon small-subunit ribosomal RNA gene sequences. *Parasitol. Res*. **85**: 877–883.

Daniels, P.W., Halpin, K., Hyatt, A. and Middleton, D. 2007. Infection and disease in reservoir and spill over hosts: determinants of pathogen emergence. *Curr. Top. Microbiol. Immunol.* **315**: 113–131.

Dolan, T.T. 1986. Chemotherapy of East Coast fever: The long term weight changes, carrier state and disease manifestations of parvaquone treated cattle. *J. Comp. Pathol.* **96**: 137.

Durrani, A.Z. and Kamal, N. 2008. Identification of ticks and detection of blood protozoa in friesian cattle by polmerase chain reacton test and estimation of blood parameters in district Kasur, Pakistan. *Trop. Anim. Health Prod.* **40**(6): 441-447.

Fuehrer, H.P., Biro, N., Harl, J., Worliczek, H.L., Beiglböck, C., Farkas, R., Joachim, A. and Duscher, G.G. 2013. Molecular detection of *Theileria* sp. ZS TO4 in red deer (*Cervus elaphus*) and questing *Haemaphysalis concinna* ticks in Eastern Austria. *Vet. Parasitol.* **197**(3-4): 653–657.

Galupppi, R., Aureli, S., Bonoli, C., Caffara, M. and Tampieri, M. P. 2010. Detection and molecular characterization of *Theileria* sp. in fallow deer (*Dama dama*) and ticks from an Italian natural preserve. *Res. Vet. Sci*. **24**: 61-69.

Garcia-Sanmartin, J., Aurtenetxe, O., Barral, M., Marco, I., Lavin, S., Garcia-Perez, A.L. and Hurtado, A. 2007. Molecular detection and characterization of piroplasms infecting cervids and chamois in Northern Spain. *Parasitology* **134**: 391–398.

Garner, B.C., Holman, P. and Berent, L.M. 2012. Theileriosis in a reindeer (*Rangifer tarandus tarandus*) associated with a potentially novel *Theileria* sp. *Vet Clin Pathol.* **41**(4): 497–501.

Gitau, G.K., Perry, B.D. and McDermott, J.J. 1999. The incidence, calf morbidity and mortality due to *Theileria parva* infections in small holder dairy farms in Murang'a District, Kenya. *Prev. Vet. Med*. **39**(1): 65-79.

Han, J.I., Jang, H.J. and Na, K.J. 2009. Molecular detection of *Theileria* sp. in wild Chinese water deer (*Hydropotes inermis argyropus*). *J. Wildl. Dis.* **45**: 1213–1216.

Hammer, J.F., Jenkins, C., Bogema, D. and Emery, D. 2016. Mechanical transfer of *Theileria orientalis*: possible roles of biting arthropods, colostrum and husbandry practices in disease transmission. *Parasites Vectors* **9**: 34.

Höfle, U., Vicente, J., Nagore, D., Hurtado, A., Pena, A., de la Fuente, J. and Gortazar, C. 2004. The risks of translocating wildlife. Pathogenic infection with *Theileria* sp. and *Elaeophora elaphi* in an imported red deer. *Vet. Parasitol*. **126**: 387–395.

Ikawa, K., Aoki, M., Ichikawa, M. and Itagaki, T. 2011. Occurrence of two distinct *Theileria* lineages in sika deer (*Cervus nippon*) of Iwate Prefecture. *Japan J. Vet. Med. Sci.* **73**(10): 1371–1373.

Inokuma, H., Tsuji, M., Kim, S.J., Fujimoto, T., Nagata, M., Hosoi, E., Arai, S., Ishihara, C. and Okuda, M. 2004. Phylogenetic analysis of *Theileria* sp. from sika deer, *Cervus nippon,* in Japan. *Vet. Parasitol.* **120**: 339–345.

Kakati, P., Sarmah, P.C., Bhattacharjee, K., Bhuyan, D. and Baishya, B.C. 2015. Molecular detection and associated pathogenesis in a fatal case of *Theileria orientalis* infection in India: Probable circulation of a virulent strain and stress associated factors. *Int. J. Recent Sci. Res*. **6**: 4235-4239.

Khan, M.G.A. 1981. Theileriosis in a gaur calf (*Bos gaurus*). *Indian Vet. J*. **58**:72-73.

Kjemtrup, A.M., Thomford, J., Robinson, T. and Conrad, P.A. 2000. Phylogenetic relationships of human and wildlife piroplasmisolates in the western United States inferred from the 18S nuclear small subunit RNA gene. *Parasitology* **120**: 193-487.

Kocan, A.A. and Kocan, K.M. 1991. Tick-transmitted protozoan diseases of wildlife in North America. *Bull. Soc. Vector Ecol.* **16**: 94–108.

Kohli, S., Atheya, U.K. and Thapliyal, A. 2014. Prevalence of theileriosis in cross-bred cattle: its detection through blood smear examination and polymerase chain reaction in Dehradun district, Uttarakhand, India. *Vet. World* **7**(3): 168-171.

Liu, J., Yang, J., Guan, G., Liu, A., Wang, B., Luo, J. and Yin, H. 2016. Molecular detection and identification of piroplasms in sika deer (*Cervus nippon*) from Jilin Province, China. *Parasites Vectors* **9**: 156.

Mans, B.J., Pienaar, R. and Latif, A.A. 2015. A review of Theileria diagnostics and epidemiology. *Int. J. Parasitol. Parasites Wildlife.* **4**: 104-118.

Nijhof, A.M., Pillay, V., Steyl, J., Prozesky, L., Stoltsz, W.H., Lawrence, J.A., Penzhorn, B.L. and Jongejan, F. 2005. Molecular characterization of Theileria species associated with mortality in four species of African Antelopes. *J. Clin. Microbiol*. **43**(12): 5907–5911.

Ogre, P.B. 1999. Assessment of natural Ixodid tick infestation. *J. Vet. Med.* **46**: 405-419.

Parthiban, M., Saranya, R., Magesh, M. and Raman, M. 2010. Detection of Theileria parasite in cattle of Tamilnadu using nested PCR. *Tamilnadu J. Vet. Anim. Sci.* **6**: 162-165.

Radostitis, O.M, Gay, C.C, Hinchcliff, K.W and Constable, P.D. 2009. *Veterinary Medicine: A text book of the diseases of cattle, sheep, goat, pigs and horses*, 10th edn. Saunders Ltd., London. pp. 1526-1531.

Roy, K.C., Ray, D., Bansal, G.C. and Singh, R.K. 2000. Detection of *Theileria annulata* carrier cattle by PCR. *Indian J. Exp. Biol*. **28**: 283-284.

Sawczuk, M., Maciejewska, A. and Skotarczak, B. 2008. Identification and molecular characterization of *Theileria* sp. infecting red deer (*Cervus elaphus*) in north western Poland. *Eur. J. Wildl. Res*. **54**: 225–230.

Schaeffler, W.F. 1961. *Theileria* in white-tailed deer in the United States. *J. Protozool.* **8**: 10.

Silveira, J.A., Rabelo, E.M., Lacerda, A.C., Borges, P.A., Tomás, W.M., Pellegrin, A.O., Tomich, R.G. and Ribeiro, M.F. 2013. Molecular detection and identification of hemoparasites in pampas deer (*Ozotoceros bezoarticus* L. 1758) from the Pantanal Brazil. *Ticks Tick Borne Dis.* **4**(4):341–345.

Tait, A. and Hall, F.R. 1990. *Theileria annulata*: control measures, diagnosis and the potential use of subunit vaccines. *Rev. Sci. Technol*. **9**(2): 387–403.

Zanet, S., Trisciuoglio, A., Bottero, E., Fernández de Mera, I.G., Gortazar, C., Carpignano, M.G. and Ferroglio, E. 2014. Piroplasmosis in wildlife: Babesia and Theileria affecting free-ranging ungulates and carnivores in the Italian Alps. *Parasites Vectors* **7**: 70.

*e-planet* **17** (2): 152-156 (December 2019)

# Photographic evidences of Indian grey wolf (*Canis lupus pallipes*) in Sundargarh forest division, Odisha, India

**N.C. PALEI[1*], B.P. RATH[1], H.S. PALEI[2] AND A.K. MISHRA[3]**

[1]*O/o Principal Chief Conservator of Forests (Wildlife) and Chief Wildlife Warden, Odisha, India*

[2]*Aranya Foundation, Bhubaneswar, Odisha, India*

[3]*Sundargarh Forest Division, Odisha, India*

**wildpalei@gmail.com*

Date of receipt: 26.07.2019 Date of acceptance: 17.12.2019

**ABSTRACT**

The Indian grey wolf (*Canis lupus pallipes*) is a rare and lesser-known top predator in India. A rapid camera trapping survey was conducted to assess the large carnivores and their preys in the Sundargarh forest division, Odisha, India. Two individuals of Indian grey wolf were recorded during the survey offering the first photographic evidence of the Indian grey wolf outside protected areas of Odisha. This record increases knowledge on the distribution of the species. More extensive surveys are needed to understand the distribution and population dynamics of Indian grey wolf in the area. We provide photographic evidence of Indian grey wolves and highlight the importance of Odisha forest for species conservation.

**Key words:** Camera trapping, *Canis lupus*, Indian grey wolf, Odisha, photographic evidence

## INTRODUCTION

Wolves are placed in the family Canidae and the genera *Canis* includes species of wolves, jackals, and the domestic dog. The taxonomy and phylogeny of the wolves has been variously explained as including a single species *C. lupus* (Nowak, 2009) or at most as two species with the second being *C. rufus* as suggested by Goldman (1937). Two of these subspecies, the Tibetan wolf (*Canis lupus chanco*) whose range extends from the trans-Himalaya into Tibet and China, and the Indian wolf (*Canis lupus pallipes*) ranging over much of Peninsular India inhabit the Indian subcontinent. Traditional taxonomy considers them as distinct relatives of other Gray wolves; however, recent molecular genetics studies contest this and suggest that (WII, 2017) the wolves from the Himalayas (Tibetan wolf, *Canis lupus chanco*) are the basal form that gave rise to the Indian wolf (*Canis lupus pallipes*).

Further, the two are distinct enough to be treated as full species (Aggarwal et al., 2003). Sharma et al. (2004) suggested that wolf populations of Indian subcontinent have three divergent, ancient and parapatric mtDNA lineages; namely the *Canis lupus pallipes* clade (peninsular India, Iran, Iraq and parts of Arabia), Himalayan clade of *Canis lupus chanco* (Ladakh, Spiti, Tibet and Nepal) and the wolf-dog clade of *Canis lupus chanco* (northwest Jammu and Kashmir, i.e. Gilgit and Baltistan). Based on a combined analysis of nuclear and mitochondrial DNA, Bardeleben et al. (2005) suggested that the relationships among the wolf-like canids remains poorly understood due to their recent divergence. Aggarwal et al. (2007) proposed the revision of the taxonomy of the wolves in India and proposed a new species *Canis indica*. Conclusive evidence that fully elucidates the taxonomy and phylogeny of the wolves remains to be fully explained and the studbook uses the

taxonomy suggested by Nowak (2009).

The Indian grey wolf *Canis lupus pallipes* is considered as the top carnivore species of the Indian open plains, semi-arid grasslands, scrublands and grazing lands (Singh and Kumara, 2006). It is considered as endangered species in India, features on Schedule-I of the Indian Wildlife (Protection) Act, 1972 and listed as Appendix-I under the Convention on International Trade in Endangered Species (CITES). The species can grow up to a height of 65 to 75 cm with a body length of 90 to 105 cm excluding 35-40 cm tail. They attain a body weight upto 40 to 60 kg. The dentition and large skull distinguish the wolves from rest of the family. The skin colour of the species varies from grey and blacking coat (Prater, 2005). Jhala (2000) estimated that the wolf population was between 2000-3000 in entire Indian peninsula. The Indian grey wolf had once one of the largest natural range of any land mammal (Sheldon, 1992). The Indian grey wolf is widely occurring, but at low density throughout its range in the Indian sub-continent. The core habitat of this species is the western, central and peninsular India in open grassland, scrubland and rocky hills (Sahi, 1982). The eastern population of Indian grey wolf found in Odisha, Jharkhand, Bihar and parts of West Bengal, is an exception and occurs in moist forested habitats (Sahi, 1982). They prefer open forest on the periphery of protected forest areas where forest reduced to scrub forest due to heavy biotic pressure (Jhala, 2003). Only a few reports on the occurrence of wolf are available from Odisha (Palei et al., 2013; Nair and Panda, 2013). Camera traps is increasingly used as survey tool to study wildlife (Das et al., 2019). Here we report the photographic evidence of Indian grey wolf from Sundargarh Forest division, Odisha, India.

## MATERIALS AND METHODS

The Indian grey wolf was recorded during the survey of carnivores and their prey species in Sundargarh Forest division, western Odisha. The study area lies between 21º 47' 7" N to 22º 32' 2" N and 83º 32' 19" E to 84º 34' 18" E (Fig. 1). The forest division shares its boundaries with Chhattisgarh and Jharkhand. It covers 3576.39 km$^2$ and is dominated by tropical dry-deciduous, northern tropical dry-deciduous and northern dry-mixed deciduous forest (Champion and Seth, 1968). The major species, viz. *Anogeissus latifolia, Terminalia tomentosa* and *Ougeinia dalbergioides* etc., which are more akin to the dry deciduous forest, whereas the low level Sal forest are characterized by dense undergrowth because of its comparatively cooler climate and species like *Syzygium cumini, Albizzia* species, *Emblica officinalis* etc. are the common associates. The main species present in the top storey are *Shorea robusta, Terminalia tomentosa, Anogeissus latifolia, Pterocarpus marsupium, Adina cordifolia, Syzygium cumini, Mytragyna parvifolia and Albizzia procera*. The middle storey contains *Dalbergia latifolia, Ougeinia oojinensis, Gmelina arboria, Bridelia retusa and Cleistanthus collinus*. The ground flora comprises *Holarrhena antidysentrica, Nyctanthes arbortristis*etc and the important climbers are *Bauhinia vahlii, Combretum decandrum* etc.

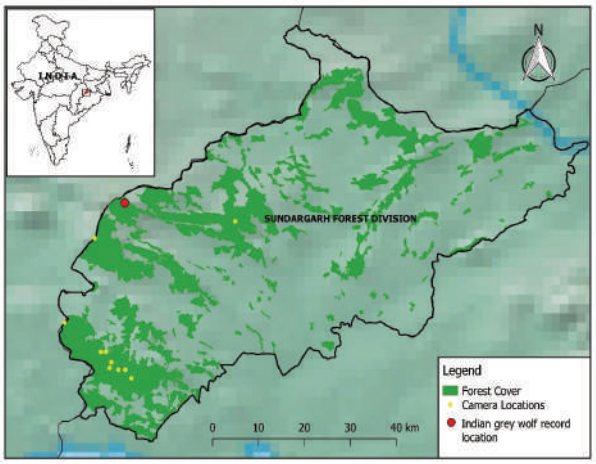



**Fig. 1.** Indian grey wolf captured location in Sundargarh Forest Division, Odisha, India

The mean minimum and maximum temperature varied from 6-20 °C in January and 35-45 °C in May. The mean annual rainfall is 1,100-1,500 mm during the monsoon between June and September. We used 45 motion sensor camera traps (Cuddeback Model C1) to carry out a mammal survey from 25$^{th}$ October to 20$^{th}$ November 2018. We set up 30 camera trap stations in Dangakhol,

Garjanpahad Reserve Forest of Hemgiri forest range, 15 in Jamkani Reserve Forest of Lepripara forest range and one in Dhanubauns Reserve Forest of Gopalpur forest range (Fig. 1). We selected most suitable sites likely to trap all species based on preliminary sign surveys of their tracks and scats. Moreover, we interviewed local forest staff. Camera traps were predominantly set along forest roads, game trails and footpaths. At each location one camera trap was installed for 25 days, yielding a total of 1125 trap nights.

## RESULTS AND DISCUSSION

During the survey we recorded a total of five localities in 12 photograph captured Indian grey wolf in Sundargarh Forest Division. A total 45 camera trap stations with a total sampling effort of 1125 trap days from 25$^{th}$ October to 20$^{th}$ November 2018. Out of 45 locations five locations were recorded in Indian grey wolf. The first photograph of a male Indian grey wolf was obtained once on 12$^{th}$ May 2018 at 07:12 (Fig. 2). After that, a female Indian grey wolf was photographed on 19$^{th}$ May 2018 at 09:04 (Fig. 3). The Indian grey wolf photos and different camera trap stations (Fig. 2 and 6; Table 1).

**Fig. 2.** Camera trap photo of a male Indian grey wolf was captured on 12th May 2018 in Ushakothi, Lepripara Range, Sundargarh Forest Division, Odisha, India.

The population of Indian grey wolves were sporadic and rare in Odisha. Several camera trap studies in different parts of Odisha did not reveal their presence (Palei et al., 2016; Debata and Swain, 2018). But it may be possible that due to its elusive behaviour, naturally low population density (Jhala, 2003). However, Palei et al. (2013) reported the livestock depredation by Indian grey wolf in Hadagarh Wildlife Sanctuary, Odisha. Therefore, survey of population trend, ecology and threats of Indian grey wolf in Odisha is needed to understand its status.

**Fig. 3.** Camera trap photo of a female Indian grey wolf was captured on 17th May 2018 in Jamkani, Sundargarh Forest Division, Odisha, India.

**Fig. 4.** Camera trap photo of a male Indian grey wolf was captured on 11$^{th}$ April 2018 in Singharibahal, Hemgiri, Sundargarh Forest Division, Odisha, India

In addition to the Indian grey wolf, threatened species such as tiger (*Panthera tigris)*, leopard (*Panthera pardus)*, elephant (*Elephas maximus)*,

**Fig. 5.** Camera trap photo of a male Indian grey wolf was captured on 10th April 2018 in Telianala of Chengapahad, Hemgiri, Sundargarh Forest Division, Odisha, India.

**Fig. 6.** Camera trap photo of a male Indian grey wolf was captured on 11th April 2018 in Kodbahal, Hemgiri Range, Sundargarh Forest Division, Odisha, India.

sloth bear (*Melursus ursinus)* and four-horned antelope (*Tetracerus quadricornis)* were also recorded from this study area, highlighting the importance for threatened species conservation. Thus, extensive surveys of these areas are warranted, as they may be a stronghold for threatened species.

**Table 1.** Records on the occurrence of the Indian grey wolf in Sundargarh Forest Division, Odisha

| Sl. | Year | Locations | Forest type | Type of records | Photo captured |
|---|---|---|---|---|---|
| 1 | 2018 | Ushakothi , Lepripara Range, Sundargarh Forest Division, Sundargarh | Dry deciduous forest | Camera trap | 02 |
| 2 | 2018 | Jamkani, Lepripara Range, Sundargarh Forest Division, Sundargarh | Dry deciduous forest | Camera trap | 02 |
| 3 | 2018 | Singharibahal, Hemgiri Range, Sundargarh Forest Division | Dry deciduous forest | Camera trap | 02 |
| 4 | 2018 | Telianala of Chengapahad, Kanika, Sundargarh, Forest Division. | Dry deciduous forest | Camera trap | 03 |
| 5 | 2018 | Kodbahal, Hemgiri Range Sundargarh, Forest Division,Sundargarh | Dry deciduous forest | Camera trap | 03 |

## ACKNOWLEDGEMENT

Authors extend their sincere thanks to Dr. Sandeep Tripathi, Principal Chief Conservator of Forests (Wildlife) and Chief Wildlife Warden, Odisha Forest Department and Divisional Forest Officer, Sundargarh Forest Division for supporting the study. Thanks to the Sri Habiram Choudhury, Range Officer, for his valuable support in field level and Prasanta Kumar Patel, Forester, Dolagobinda Panigrahi, Forest Guard and other field staff of Hemgiri Range who accompanied us in various field trips and provided other valuable field information.

## REFERENCES

Aggarwal, R.K., Kivisild, T., Ramadevi, J. and Singh, L. 2007. Mitochondrial DNA coding region sequences support the phylogenetic distinction of two Indian wolf species. *J. Zool. Syst. Evol. Res.* **45**: 163–172.

Aggarwal, R.K., Ramadevi, J. and Singh, L. 2003. Ancient origin and evolution of the Indian wolf: evidence from mitochondrial DNA typing of wolves from Trans-Himalayan region and Pennisular India. *Genome Biol.* **4**(6): 1.

Bardeleben, C., Moore, R.L. and Wayne, R.K. 2005. A molecular phylogeny of the Canidae based on six nuclear loci. *Mol. Phylogenetics Evol.* **37**: 815–831.

Champion, H.G. and Seth, S.K. 1968. *A Revised Study of the Forest Types of India.* Government of India. New Delhi, India, p. 404.

Das, U.K., Setty, J. and Srivastava, V. 2019. Population study of tiger (*Panthera tigris tigris*) by trap camera photo capture in Katarniaghat Wildlife Sanctuary, Uttar Pradesh, India. *e-planet* **17**(1): 70-75.

Debata, S. and Swain, K.K. 2018. Estimating mammalian diversity and relative abundance using camera traps in a tropical deciduous forest of Kuldiha Wildlife Sanctuary, eastern India. *Mammal Study* **43**: 45 –53.

Goldman, E. 1937. The wolves of North America. *J. Mammal.* **18**: 37–45.

Jhala, Y.V. 2003. Status, ecology and conservation of the Indian wolf *Canis lupus pallipes*sykes. *J. Bombay Nat. Hist. Soc*. **100**: 293–307.

Nair, M.V. and Panda, S.K. 2013. *Just Friends*. **XXXIII** (3)

Nowak, R.M. 2009. Taxonomy, morphology, and genetics of wolves in the Great Lakes region. In: *Recovery of Gray Wolves in the Great Lakes Region of the United States*, A.P. Wydeven, T.R. van Deelen, E. Heske (Eds.), Springer-Verlag, New York, pp. 233-250

Palei, H.S., Debata, S., Mohapatra, P.P. and Sahu, H.K. 2013. Livestock predation by endangered Indian Wolf (*Canis lupus*) in Hadagarh Wildlife Sanctuary, Eastern India. *Indian Forester* **139**(10): 895-898.

Palei, H.S., Pradhan, T., Sahu, H.K. and Nayak, A.K. 2016. Estimating mammalian abundance using camera traps in the tropical forest of Similipal Tiger Reserve, Odisha, India. *Proc. Zool. Soc.* **69**: 181–188.

Prater, S.H. 2005. *The book of Indian animals*. Oxford University Press, Oxford, New York, pp. 125-126.

Sahi, S.P. 1982. Status of gray wolf (*Canis lupus pallipes*) in India: a preliminary survey. *J. Bombay Nat. Hist. Soc.* **79**: 493–502.

Sharma, D.K., Maldonado, J.E., Jhala, Y.V., and Fleischer, R.C. 2004. Ancient wolf lineages in India. *Proc. Royal Soc. London B: Biol. Sci.* **271**(Suppl 3): S1-S4.

Sheldon, J.W. 1992. *Wild dogs: The natural history of non-domestic Canidae*. Academic Press Inc., New York, p. 248.

Singh, M. and Kumara, H.N. 2006. Distribution, status and conservation of Indian grey wolf in Karnataka. *India. J. Zool*. **270**: 164-169.

Wildlife Institute of India. 2017. *National Studbook of Indian Wolf* (*Canis lupus pallipes*), Wildlife Institute of India, Dehradun and Central Zoo Authority, New Delhi, p. 76.

*e-planet* **17** (2): 157-159 (December 2019)

# Unusual nesting site of red-wattled lapwing (*Vanellus indicus)* in Dehradun, Uttarakhand, India

**A. SINGH[1], R. JOSHI[2] AND K. PURI[3*]**

[1]*Endangered Flora and Fauna on Earth Conservation Team, Dehradun, Uttarakhand, India*

[2]*Conservation and Survey Division,* [3]*Environment Education Division, Ministry of Environment, Forest and Climate Change, Government of India, New Delhi 11 00 03, India*

**genetics_1407@yahoo.co.in*

Date of receipt: 03.12.2019 Date of acceptance: 18.12.2019

**ABSTRACT**

Red wattled lapwing (*Vanellus indicus*) is a ground bird, residing in the open countryside, ploughed fields, grazing patches, and dry beds of water bodies in parts of Asia. Literature reveals that typical nesting habitat of this bird includes open country, grazing land, fallow fields, dry beds of village tanks, and islets in rivers. In natural conditions, 3-4 eggs are laid in a 'ground scrape' or a depression, sometimes fringed with pebbles and goat or hare droppings. Here, we report observations of the nesting of Red-Wattled Lapwing on a cemented rooftop of house in Dehradun (30° 19' 31.00" N, 78° 0' 6.00" E), Uttarakhand State, India. This ground-nesting bird species have adapted to the rapid urbanisation including urban environments and have developed change in their breeding sites depending upon the needs of their young. Our observations provide incentive to gather more data in connection with changing nesting pattern of ground-nesting bird species. Further, there has been limited study on the range of threats being faced by the lapwings in the state of Uttarakhand. More studies have to be conducted to ascertain the reasons causing such a shift in the nesting habitat of the species .

**Key words:** Nesting pattern, Red wattled lapwing, threats, urbanisation, Uttarakhand

## INTRODUCTION

Red wattled lapwing (*Vanellus indicus)* belongs to the family Charadriidae of the avian order Charadriiformes (Jerdon, 1984). It is a ground bird, residing in the open countryside, ploughed fields, grazing patches, and dry beds of waterbodies in parts of Asia (Ali, 1996; Vyas and Rakesh, 1997; Kaur and Khera, 2017). It feeds on insects and acts as biological pest control. It has characteristic loud alarm calls sounding like 'did he do it'. It is currently classified as Least Concern according to the IUCN Red List (Birdlife International, 2016) and is a common and widespread wading bird of the Indian subcontinent.

Typical nesting habitat includes open country, grazing land, fallow fields, dry beds of village tanks, and islets in rivers (Ali and Ripley, 1998). In natural conditions, 3-4 eggs are laid in a 'ground scrape' or a depression, sometimes fringed with pebbles and goat or hare droppings (Sharma, 1992). The incubation period ranges from 28 to 30 days and both sexes perform incubation duties (Desai and Malhotra, 1976; Ali and Ripley, 1998).

There are reports of its nest on flat pebbled roofs in urban environments (Gole and Mundkur, 1980; Patnaik, 1980; Tehsin and Lokhandwala, 1982; Mundkur, 1985; Grimmett et al., 1998). Muralidhar and Barve (2013) have recorded nests of this species on the corrugated asbestos roof of a bungalow in urban area of Mumbai, Maharashtra which sufficed that species has been adapting to urban settings and choosing a nest location

with minimize human and livestock interference. Sangha (2011) reported its nesting in stone boundary wall near his residence. The nest was in irregular depression and filled with pebbles, grit, and limestone to create flat surface in depression.

## MATERIALS AND METHODS

Observations of the nesting of Red-Wattled Lapwing was reported on a cemented rooftop of house in Dehradun (30° 19' 31.00" N, 78° 0' 6.00" E), Uttarakhand State, India. The house is surrounded by barren land, roads and human habitation. It was observed on the rooftop of the house in the month of March 2019 (Fig. 1).

**Fig. 1.** Red Wattled Lapwing on the rooftop of AS author's residence

**Fig. 2.** Four eggs of Red Wattled Lapwing on the rooftop

**Fig. 3.** Three chicks of red wattled lapwing

The nest was built on the rooftop stuffed by pebbles and small stones (Fig. 2). Breeding season in the present study was similar to the study of Vyas and Rakesh (1977), i.e. during the month of March. Four eggs were layed on 29.3.2019 and out of which, three eggs hatched on 26.4.2019 (Fig. 3) and one egg hatched on 27.4.2019 with 29-30 days of incubation.

## RESULTS AND DISCUSSION

Chicks of lapwings are nidifugous and precocial, i.e. they leave the nest and follow the parents soon after hatching (Walter, 1982). It was interesting to note how the chicks safely descend on the ground from house rooftop without injuring themselves. In the present study, it was observed that all the four chicks descended to ground through jumping technique after 5-6 days.

Sethi et al. (2011) reported that nest survival and hatching has been higher in roof nests of Red-wattled lapwing than in the ground-nests found in district Haridwar. Desai and Malhotra (1976) studied the nesting success and observed 52.70 % hatched successfully, and overall nesting success of 40.54%. According to Gupta and Kaushik (2011) hatching success was found to be around 60.92% in Kurukshetra, Haryana, while Muralidhar and Barve (2013) reported 75% hatching success in Mumbai, Maharashtra.

Literature reveals that ground-nesting bird species have adapted to the rapid urbanisation and urban environments (Palei et al., 2017) and have

developed change in their breeding sites depending upon the needs of their young. Use of flat roofs for nesting has been suggested as an adaptive response of ground-nesting birds (Baumann, 2006).

Loss of natural habitat, increasing local population pressure, to minimise predation pressure are possible reasons for roof-nesting by Red-wattled Lapwing (Mundkur, 1985). Our observations provide incentive to gather more data in connection with changing nesting pattern of ground-nesting bird species. Further till date there has been no study on the range of threats being faced by the lapwings in the state of Uttarakhand. More studies have to be conducted to ascertain the reasons causing such a shift in the nesting habitat of the species.

## REFERENCES


Ali, S. and Ripley, D. 1998. *Handbook of the birds of India and Pakistan*. Oxford University Press, Delhi.

Ali, S. 1996. *The book of Indian birds*. 12th, revised and enlarged, Reprint ed. J. C. Daniel (ed.) Pp. 1-354. Bombay Natural History Society and Oxford Univeristy Press, Mumbai, India.

Baumann, N. 2006. Ground-nesting birds on green roofs in Switzerland: preliminary observations. *Urban Habitats* **4**: 37–50.

Bird Life International. 2016. *Vanellus indicus*. *The IUCN Red List of Threatened Species* 2016.

Desai, J.H. and Malhotra, A.K. 1976. A note on incubation period and reproductive success of the Red-wattled Lapwing *Vanellus indicus* at Delhi Zoological Park. *J. Bombay Nat. Hist. Soc.* **73**: 392–394.

Gole, P. and Mundkur, T. 1980. An unusual nest of a pair of Red-wattled Lapwing. *Newsletter for Birdwatchers* **20**:15.

Grimmett, R., Inskipp, C. and Inskipp, T. 1998. *Birds of the Indian Subcontinent.* Oxford University Press, Delhi.

Jerdon, T.C. 1984. *The Birds of India*. George Wyman and Company, pp. 648-649.

Kaur, M. and Khera, K.S. 2017. On the fundamentals of breeding biology and present threats to red wattled lapwing (*Vanellus indicus)* in agricultural landscape of Punjab. *J. Entomol. Zool. Stud.* **5**(4): 1501-1506.

Mundkur, T. 1985. Observations on the roof-nesting habit of the Red-wattled Lapwing (*Vanllus indicus*) in Poona, Maharashtra. *J. Bombay Nat. Hist. Soc*. **82**: 194–196.

Muralidhar, A. and Barve, S. 2013. Peculiar choice of nesting of Red-wattled. *Indian Birds* **8**(1): 6-9.

Palei, H.S., S. Debata, Mohapatra, P.P. and Mishra, A.K. 2017. Diversity and status of birds in Bonai Forest Division, Odisha, India. *e-planet* **15** (2): 166-177

Patnaik, H.P. 1980. Unusual nesting site of Red-wattled Lapwing. *Newsletter for Birdwatchers* **20**: 9.

Sangha, H.S. 2011. Unusual nesting site of the Red wattled lapwing *Vanellus indicus* in human habitation in Jaipur, Rajasthan. *Indian Birds* **7**(2):49.

Sethi, V.K., Bhatt, D., Kumar, A. and Naithani, A.B. 2011. The hatching success of ground- and roof-nesting Red-wattled Lapwing *Vanellus indicus* in Haridwar, India. *FORKTAIL* **27**: 7–10.

Sharma, S.K. 1992. Use of droppings of Indian Hare for nest making by Redwattled Lapwing. *Newsletter for Birdwatchers* **32** (7-8): 19.

Tehsin, H.R. and Lokhandwala, J. 1982. Unusual nesting site of Red-wattled Lapwing. *J. Bombay Nat. Hist. Soc.* **79** (2): 414

Walter, J.R. 1982. Parental Behavior in Lapwings (Charadriidae) and its relationships with clutch sizes and mating Systems. *Evolution* **36**(5): 1030-1040.

*e-planet* **17** (2): 160-164 (December 2019)

# Clinico-pathological investigation of theileriosis in buffaloes in coastal Odisha

**M.K. MISHRA, A.P. ACHARYA*, S.K. PANDA, B.K. PATRA AND K. BEHERA**

*College of Veterinary Science and Animal Husbandry, OUAT, Bhubanewar, Odisha, India*

**acharya@gmail.com*

Date of receipt: 27.08.2019 Date of acceptance: 17.12.2019

**ABSTRACT**

The present study was conducted in buffaloes over a period of five years from 1st July 2012 to 30th June 2017. The blood samples received in the Department of Veterinary Pathology, College of Veterinary Science and Animal Husbandry, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha from buffaloes suspected to be affected with theileriosis on basis of clinical signs were included in the study. The cases were screened by examination of stained blood smear. Out of 180 numbers of blood samples from buffaloes, 168 (93%) cases were found positive and 12 (7%) cases were found negative. Season wise distribution of cases showed that the disease was highly prevalent in summer (44.04%) followed by rainy (35.11%) and least in winter season (20.83%). The disease was more seen in middle aged (6-9 yrs) animals followed by young to adult animals of <6 yrs of age. The clinical signs recorded in affected buffaloes were non-remittent pyrexia, enlargement of prescapular and prefemoral lymphnodes, anorexia, drop in milk yield, tachycardia, dyspnoea, pale mucous membrane, haemoglobinuria, corneal opacity, icterus, brisket edema etc. The average Hb%, PCV and TEC were 10.25±2.51 g %, 31.02±7.61 and 6.20±1.28 million per cmm respectively indicating anaemia due to erythrolysis. TLC was 8159.23±2324 and the percentage of N, L, E, B and M in DLC were 42.43±14.77, 52.77±14.91, 3.58±3.91, and 1.35±0.75 respectively. The average MCV, MCH, MCHC values were 42.99±7.48, 14.20±2.46 and 33.06±1.18 respectively.

**Key words:** Buffalo, theileriosis, clinical signs, hematology, Piroplasms

## INTRODUCTION

Buffaloes contribute more than 55% of total milk production of the country. Dairy cattle and buffaloes suffer from tick borne diseases and theileriosis is the biggest obstacle to livestock production (Dhar et al., 1987). The disease is caused by *Theileria annulata* of Genus *Theileriae* under Family *Theileridae* and being transmitted by ticks of *Hyaloma* spp. Theileria are obligate intracellular protozoan parasites that infect both wild and domestic bovines throughout the world along with some species of small ruminants causing clinical and subclinical infections. The disease is also known as 'Mediterranean coast fever' or 'Bovine tropical theileriosis' or simply 'Tropical theileriosis' and production losses and death in dairy animals in Africa, Asia and Middle East countries.

The pathological progression of the disease in a typical acute, often fatal, infection is manifested by clinical signs including enlarged superficial lymph nodes, persistent fever, anorexia, congested mucous membranes, corneal opacity, emaciation, unthriftiness, infertility, tachycardia and tachypnoea (Radostits et al., 2010). During the advanced stage there is lymphoid depletion and disorganization associated with massive lymphocytolysis and depressed leucopoiesis causing severe leukopenia. Due to widespread

destruction of the immune system, the animal shows dyspnoea, recumbency and finally death. Additionally, *T. annulata* infection is associated with profound changes in haematological profile and investigations of peripheral blood may reveal severe anaemia, leukopenia, and lymphocytopenia. Diagnosis of the clinical theileriosis can be made based on combined clinical signs and pathological findings.

Theileriosis very much occurs in buffaloes as like as cattle. Buffaloes not only suffer from clinical form of theileriosis but also act as carrier and source of infection for healthy cattle. But, there has been very little work undertaken globally to study this particular disease in buffaloes. This may be due to that buffaloes are reared in groups at the outskirt of human habitation nearby river, pond or swampy areas. They are hardy animals and are considered more resistant to diseases than indigenous cattle. The clinical signs and symptoms are less noticed as individual care is not taken up in buffaloes as seen in cattle (particularly crossbred and exotic cattle). It is also difficult to access these animals and handle them for treatment or collection of clinical samples for their robust size and hardy nature. There is no systematic study on the occurrence and pathology of theileriosis in buffaloes in India except few sporadic reports. The current investigation was aimed to study the clinico-pathological and hematological changes in affected dairy buffaloes.

## MATERIALS AND METHODS

The blood samples were received time to time at Teaching Veterinary Clinical Complex, CVScAH, OUAT from buffaloes with suspected signs of theileriosis. They were then screened for theileriosis by examination of Giemsa stained blood smears. A total of 180 samples were screened and put for further investigation. The haematological values in the affected buffaloes which were found positive by examination of blood smears were recorded. Screening of affected animals was mostly based on clinical signs and presence of piroplasms in blood smear. The important clinical signs shown by theileria affected buffaloes were non-remittent pyrexia, enlargement of prescapular lymph node (Fig. 1) and prefemoral lymph nodes including other signs as described earlier.

**Fig. 1.** Swollen pre-scapular lymphnode

## RESULTS AND DISCUSSION

### Screening of theileriosis

Examination of stained blood smears revealed piroplasms inside erythrocytes. The number of erythrocytes having piroplasms in their cytolplasm per high power microscopic field varied from case to case. The piroplasms were having different shapes like ring , oval, spherical, umbrella, comma, dot etc. (Fig. 2). Most of the blood smears

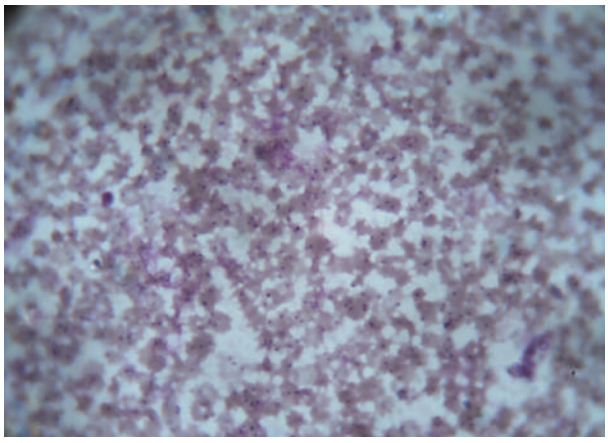


**Fig.2.** Microscopic examination of blood smear

from buffaloes showed rolex or chain formation of RBCs. Most of the workers (Hasanpour et al., 2008; Sridevi et al., 2011; Vahora et al., 2012; Kaushal et al., 2013; Ariyaratne et al., 2014; Sudan et al.,

2014; Waskel et al., 2015) have reported use of this method as a primary screening practice.

**Incidence of disease**

Positive cases were detected after screening of suspected blood smear to find out the incidence in coastal districts of Odisha. The cases were from districts adjoining Bhubaneswar namely Khurda, Puri and Cuttack. Only two cases were from Nayagarh district. Out of 180 numbers of blood samples from dairy buffaloes, 168 (93%) cases were found positive and 12 (7%) cases were found negative. Season wise distribution of cases showed that the disease was highly prevalent in summer (44.04%) followed by rainy (35.11%) and least in winter season (20.83%). The age of affected buffaloes varied from 1.5 yrs to 15 yrs with an average age of 6.3 yrs. Distribution of positive cases of theileriosis among different age groups revealed that the disease was more seen in middle aged (6-9 yrs) animals followed by young to adult animals of <6 yrs of age and seen least in older animals of age> 9 yrs. The number of positive cases in the above three age groups were 71 (62.88%), 81 (26.43%) and 16 (10.68%) in <6 yrs, 6-9 yrs and > 9 yrs of age respectively. Out of 168 cases found positive for theileriosis, 154 cases were of females and 14 cases in males.

Many previous workers (Khan et al., 2004; Oura et al., 2011; Vahora et al., 2012; Kaushal et al., 2013; Mohamed et al., 2013; Kundave et al., 2014; Pienaar et al., 2014; Waskel et al., 2015; Memon et al., 2016) have reported occurrence of the disease in buffaloes from various parts of the world. But systematic epidemiological investigation on the disease in India has not been performed. This may be due to the fact that the buffaloes are kept in large herds in riverbeds and barren lands and they cover large areas daily in search of food.

**Haematological alterations**

Blood is of crucial importance for the maintenance of physiological equilibrium in the body. However, this equilibrium may be disturbed due to certain physiological and pathological conditions. The knowledge of haematological constituents is useful in diagnosing various pathological and metabolic disorders, which can adversely affect the productive and reproductive performance of buffaloes, resulting in great economic losses to farmers.

There were 168 numbers of positive cases and 12 negative cases found by examination of blood smear. All the 168 cases were subjected to haematological study. The parameters studied were Hb%, PCV, TLC, TEC, DC, MCV, MCH and MCHC. The values were compared with normal values. The average haemoglobin percentage of theileriosis in affected buffaloes was 10.25±2.51 g% which was lower than normal value. The haemoglobin percentage in the affected buffaloes varied from 3.8 to 17.4 g%. Packed cell volume (31.02±7.61) was also lower than normal. The PCV values in the affected buffaloes ranged from 12 to 55. Total leucocyte count of individual cases showed great variation ranging from 2600 per cmm upto 15600 per cmm and the average value was 8159.23±2324. Total erythrocyte count was lower than normal and the average was 6.20±1.28 million per cmm indicating anaemia due to erythrolysis. In differential leucocyte count the percentage of neutrophil, lymphocyte, eosinophil, basophil and monocyte were 42.43±14.77, 52.77±14.91, 3.58±3.91, and 1.35±0.75, respectively. Although the average figures seem to be within the normal range there was great variation in individual data for the different cell types. Neutrophill, lymphocyte, eosinophil, basophil and monocyte percentage varied from 8-82, 17-90, 0-20, 0-1 and 0-7 respectively. The average mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) values were 42.99±7.48, 14.20±2.46 and 33.06±1.18 respectively (Table 1).

The erythrocyte indices have been reflected in chart 1. Many workers (Osman et al., 2007; Hasanpour et al., 2008; Mohamed et al., 2013; Ariyaratne et al., 2014; Memon et al., 2016) have reported fall in erythocytic indices indicating anaemia caused due to erythrolysis due to theileriosis.

**Table 1.** Minimum, maximum and mean haematological values

| Parameters | Min | Max | Affected Buffaloes | Apparently Healthy |
|---|---|---|---|---|
| Hb (g%) | 3.8 | 17.4 | 10.25±2.51 | 13.24±1.97 |
| TLC ('000 per cmm) | 2600 | 15600 | 8159.23±2324 | 6800±1036 |
| TEC (million per cmm) | 4 | 10.3 | 6.20±1.28 | 7.4±1.34 |
| PCV (%) | 12 | 55 | 31.02±7.61 | 38.08±3.92 |
| N (%) | 8 | 82 | 42.43±14.77 | 35.22±4.63 |
| L (%) | 17 | 90 | 52.77±14.91 | 62.31±5.78 |
| E (%) | 0 | 20 | 3.58±0.91 | 3.54±.033 |
| B (%) | 0 | 1 | 0.07 ± 0.02 | 0.02±.001 |
| M (%) | 0 | 7 | 1.35±0.75 | 1.22±0.42 |
| MCV (fl) | 25.92 | 74.63 | 42.99±7.48 | 40.41±6.79 |
| MCH (pg) | 8.33 | 24.18 | 14.20±2.46 | 13.64±2.06 |
| MCHC (g per dl) | 30.28 | 36.67 | 33.06±1.18 | 38.45±2.06 |

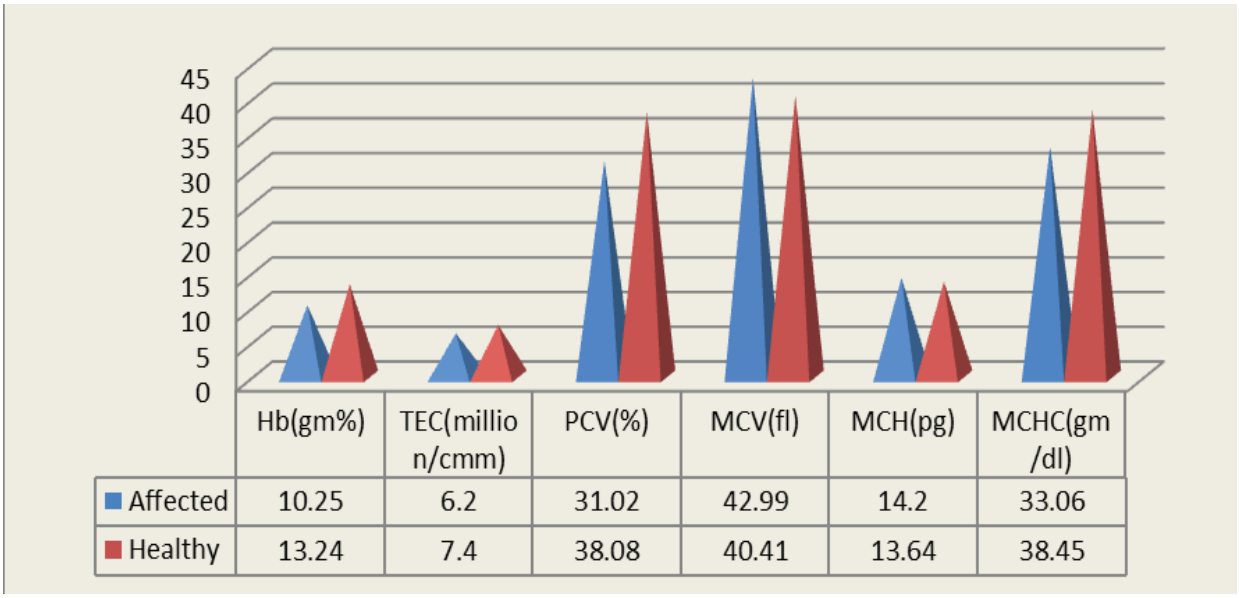



**Fig. 3.** Comparison of erythrocytic indices of affected ones with healthy buffaloes

## CONCLUSION

From the above study it can be concluded that clinicopathological examination of suspected cases of Theileriosis is instrumental in diagnosis of the disease. Microscopic examination of thin blood smears of suspected blood sample is an age old golden method for diagnosis of theileriosis. Haematological estimation of suspected blood sample is usually practiced as an aid to diagnosis by clinician.

## REFERENCES

Ariyaratne, M.D., Gothami, W.S. and Rajapakse, R. 2014. Application of PCR Technique on Confirming Theileria infection in cattle and buffaloes with determining the relationship between Animals PCV and WBC count with the infection. *Int. J. Sci. Res. Pub.* **4**(7): 317-326

Dhar, S., Malhotra, D. V., Bhusan, C. and Gautam, O. P. 1987. Treatment of clinical cases of bovine tropical theileriosis with buparvaquone, (BW 720C). *Indian Vet. J.* **64**: 331-34.

Hasanpour, A., Moghaddam, G.A., and Nematollahi, A. 2008. Biochemical, haematological and electrocardiographic changes in buffaloes naturally infected with *Theileria annulata, Korean J. Parasitol*. **46**(4): 223-227.

Kaushal, G.D., Tiwari, S.K., Pal, S., Sinha, B., Choudhary, Y. and Singh, H. 2013. Cerebral theileriosis in a buffalo calf. *Indian Vet. J*. **90**(3): 104-105.

Khan, M.Q., Zahoor, A., Jahangir, M. and Ashraf Mirza, M. 2004. Prevalence of Blood parasites in Cattle and Buffaloes, *Pakistan Vet. J.* **24**(4): 193-195.

Kundave, V.R., Patel, A.K., Patel, P.V., Hasnani, J.J. and Joshi, C.G. 2014. Qualitative and Quantitative assessment of *Theileria annulata* in Cattle and buffaloes Polymerase chain reaction. *J. Trop. Biol. Med.* **31**(4): 728-735.

Mahmmod, Y.S., Elbalkemy, F.A., Klaas, I.C., Elmekkawy, M.F. and Monazie, A.M. 2013. Clinical and haematological study on water buffaloes (*Bubalus bubalis*) and crossbred cattle naturally infected with *Theileria annulata* in Sharkia province, Egypt. *Ticks Tick-borne Dis.* **2**: 168–171.

Memon, M.I., Memon, N., Kachiwal, A.B., Memon, M.R. and Bhutto, B. 2016. Prevalence of Theileriosis and its impact on Hematological values in Naturally infected Buffaloes at Hyderabad. *Pakisthan J. Agric. Agril. Engg. Vet. Sci.* **32**(1): 85-94.

Osman, S.A. and Al-Gaabary, M.H. 2007. Short communication-Clinical, haematological and therapeutic studies on tropical theileriosis in water buffaloes (*Bubalus bubalis*) in Egypt. *Vet.Parasitol.* **146**(3-4): 337-340.

Oura, C.A.L., Tait, A., Asiimwe, B., Lubega, G.W. and Weir, W. 2011. Haemoparasite prevalence and *Theileria parva* strain diversity in cape buffalo (*Syncerus caffer*) in Uganda. *Vet. Parasitol.* **175**: 212-219.

Pienaar, R., Latif, A.A., Thekisoe, O.M.M. and Mans, B.J. 2014. Geographic distribution of Theileria sp. (buffalo) and Theileria sp. (bougasvlei) in Cape buffalo (*Syncerus caffer*) in southern Africa. *J. Parasitol.* **141**: 411-424.

Radostits, O.M., Gay, C. C., Hinchcliff, K.W., Constable, P.D. 2010. *Veterinary Medicine*, 9th Edn, Saunders Publishers Ltd, London, pp. 1530-31.

Sridevi, C., Lakshmirani, N. and Rayulu, C.V. 2011. Concurrent infection of theileriosis and ehrlichiosis in a buffalo, *J. Vet. Parasitol.* **25**(1): 84-85.

Sudan, V., Sharma, R.L., Yadav, R. and Borah, M.K. 2014. Turning sickness in a riverine buffalo naturally infected with *T. Annulata. Clin. Pathol.* **23** (1): 39-42.

Vahora, S.P., Patel, J.V., Patel, B.B., Patel, S.B. and Umale, R.H. 2012. Seasonal Incidence of haemoprotozoan diseases in crossbred cattle and buffalo in Kaira and Anand district of Gujurat. *Vet. World* **5**(4): 223-225.

Waskel, S. and Gaur, U. 2015. Incidence of theileriosis in cattles and buffaloes during rainy season. *Eur. J. Exp. Biol*. **5**(8): 71-73.

## BRIEF INSTRUCTIONS TO AUTHORS

***e-planet*** publishes peer reviewed original research articles and review articles in English on multifarious aspects of ecology, environment, agriculture and allied sciences etc. in the form of full-length papers having a bent towards environmental issues.

1. **Submission of manuscript.** The manuscript developed in WORD, along with tables and figures in EXCEL and photographs in high resolution .jpg or .png should be sent to the Editor-in-Chief, *e-planet* (OPES) by e-mail – eplanetjournal@gmail.com including Article Certificate (Give details of telephone/ e-mail id of all authors).
2. **Preparation of manuscript.** Papers should be written in simple and clear language, strictly following the latest *e-planet* journal style. Avoid footnotes in the text. The complete scientific name (genus, species and authority for the binomial) of all the experimental organisms should be given at the first mention both in the Abstract and Materials and Methods. International System of Units in abbreviated form should be used for all the measurements. Spell out the acronyms in the first instance. Manuscript should be typed in double-spacing on one side of Bond Paper (A-4). Tables must not exceed 12 vertical columns. Leave liberal margins on both the sides. Arrange the manuscript in the order of short title, title, author(s), address of each author/ institution of each author, abstract (approx. 300 words), key words (approx.- 5), introduction, materials and methods, results and discussion, acknowledgement and references.
   - **2.1. Short Title/ Title.** A short title of the paper should appear on the top of the article, followed by the long title in small letters. The short title appears on alternate printed pages of each article in capital letters.
   - **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.

RNI - Regd. No. ORI ENG/2003/15643 Dated -22.11.2005