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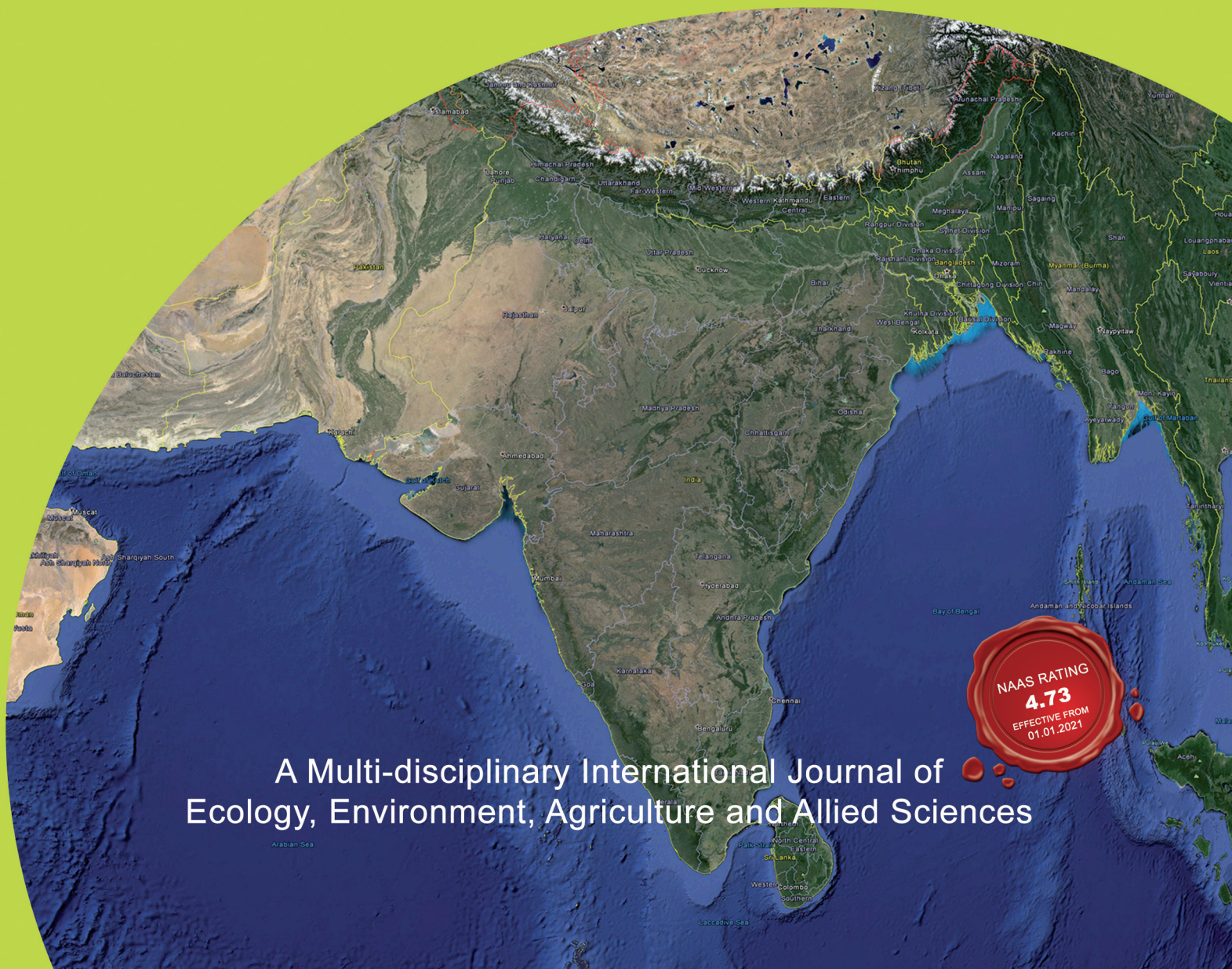

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Review on navgraha vatika: An eco-friendly pathway to landscape gardening

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ABSTRACT

The word "navgraha" refers to the nine celestial bodies or planets of our solar system and "vatika" represents the garden and greenery. So, the "navgraha vatika" symbolizes the gardening techniques, done by planting nine special plants (which represent the nine planets), in appropriate directions. The navgraha vatika is closely related to rashi or nakshatra vatika established close to sacred places i.e., astrologically planned gardens. The history of gardening in Ancient India shows that it follows a formal garden pattern having sacred geometry. So, by taking that in consideration, navgraha vatika follows formalism having geometrical and symmetrical patterns. According to Indian Astrology, the presence of planets (grahas) maintains the overall balance of energy in the universe/cosmos. This is also a reason to establish navgraha vatika in order to bring the entire universe on the earth. It would be noteworthy to mention that more oxygen is being released by navgraha plant species as compared to any other plant species. The twigs as well as branches of the nine planetary plants are used in yagnas or holy rituals. In this review paper, the importance of navagraha on both humans and the environment has been discussed. Brief description about all the nine planets and plants associated with them, along with a layout, has also been thoroughly discussed.

Key words: : Indian custom and traditions, landscape gardening, navgraha vatika, rashi vatika

INTRODUCTION

Homo sapiens and their habitat get highly affected by the effects of herbs and horoscopes surrounding them (Maneesha et al., 2021). In conformity with Vedic astrology, planets (grahas) are stated as celestial bodies that have influence on human life on earth. Navgraha vatika is basically dedicated to the trees associated with these nine planets; and their arrangement in a formal manner following geometrical and symmetrical patterns. Navgraha vatika, is nothing more than a garden consisting of nine important plants. These plants represent the celestial bodies of our solar system. The concept of navgraha vatika is not new to India. Our ancestors established navgraha "vatika" or "vana" near hallowed or dedicated places with indicative plants in order to display reverence and ensure strength and vigor. It also has a vast effect on life on earth and so affects the longevity of human beings too. Research has shown that navagraha plants are best known for their effect on human health and wellness, attracting divine energies and power, protecting the environment and also adding aesthetic beauty to the surrounding. Out of these indicative plants, majorities are infrequent medicinal tree species of pharmaceutical importance, which draws attention towards the forethought of our forebears which was to preserve these natural resources off-site, in order to make

its pharmaceutical benefits available for upcoming generations. In Ancient medicine, extensively used secondary metabolites like Antioxidants, alkaloids, saponins, terpenes, flavonoids and tannins are in abundance and well provided with these navgraha tree species. It has been demonstrated that (Vidula et al., 2021). This is how they freshen up and allow the flow of good vibrations to every living entity surrounding it.

The twigs as well as branches of the nine planetary plants are used in yagnas or holy rituals also, because of the medicinal values of the plants as well as the smoke from the "yagna kundas" when gets released in the atmosphere, destroyed many harmful disease-causing organisms and purifies the air. The prime objective of demonstrating navagraha vatikas is to set up optimistic ways of promoting prosperity and tenacity on various levels: domain, discrete and community (Parihar and Sharma, 2021). All the navgrahas and the trees associated with them along with their specific directions of planting and their family is being summarized in the Table 1 below:

Table 1. Nine planets and the colour, direction, and plants associated with them

Sl. No.	Planet name	Colour	Direction of planting	Name of plant associated	Family
1.	Surya (Sun)	Light pink	Centre	*Calotropis gigantea* (Madar)	Asclepiadaceae
2.	Chandra (Moon)	White	S-E	*Butea monosperma* (Palash)	Fabaceae
3.	Budha (Mercury)	Green	North	*Achyranthes aspera* (Apamarg)	Amaranthaceae
4.	Shukra (Venus)	White	East	*Ficus racemosa* (Gular)	Moraceae
5.	Mangal (Mars)	Deep red	South	*Acacia catechu* (Khair)	Fabaceae
6.	Guru (Jupiter)	Yellow	N-E	*Ficus religiosa* (Peepal)	Moraceae
7.	Shani (Saturn)	Black	West	*Prosopis cineraria* (Shami)	Mimosaceae
8.	Rahu (Dragon's head)	Brown	S-W	*Cynodon dactylon* (Doob grass)	Poaceae
9.	Ketu (Dragon's tail)	Brown	N-W	*Desmostachya bipinnata* (Kush/Halfa grass)	Poaceae

TREES ASSOCIATED WITH THE PLANETS

Surya (Sun)

Plant associated - *Calotropis gigantea*

The Sun is the king of all planets. Heart, head, brain, right eye, bones etc. are all conquered by the mighty planet sun. The plant associated with it is *Calotropis gigantea* which is commonly known as "Madar" or "Wasteland weed". One of the dominant latex yielding plants with ethnopharmacological implementation and abundant in proteolytic enzymes, is *Calotropis gigantea* (Bhatia et al., 2022). The flowers and leaves of *calotropis* are of religious importance used to offer God in temples. Fresh foliage of madar heated with ghee is used to prepare ear drops to cure ear infection. There have been various documented mechanisms for the anticancer activity of *C. gigantea.* The extract from the bark of stem from *C. gigantea*, including the dichloromethane component, has been shown to suppress antioxidant expression and promote the formation of reactive oxygen species (ROS) in anticipation of colon cancer cells (Suknoppakit et al., 2023).

Chandra (Moon)

Plant associated - *Butea monosperma*

The plant associated with this graha is *Butea monosperma* which is commonly known as "Palash". This planet rules the heart, blood, brain, lungs of the human body. Leaves, twigs, stem, bark, roots, and gums etc. are traditionally used for medical purposes. Palash flowers possess large medicinal values as they are used in treating enlarged spleen disorders, menstrual disorders and are also used as brain stimulants (Mazumder et al., 2011). It possesses

blood cleaning, anti-leprotic, anti-microbial as well as anti-ulcers properties (Das et al., 2011). For curing various ailments, plant-based natural products have been used for time immemorial. In the Indian traditional system, Palash tree holds an important place. Experiments and research have found that Bark of Palash tree has inhibitory actions on pro-carcinogenic proteins (Hassan et al., 2019). Sore throat can be treated by using boiled Palash leaves in water as well as by brushing teeth with twigs of palash, one can get rid of halitosis or bad breath.

Budha (Mercury)

Plant associated- *Acharyanthes aspera*

"Apamarg" plant commonly known as "chirchiri" belongs to the family Amaranthaceae. These are widely grown throughout the tropical world. The planet Budha favours- hair, face, nose, chest and tongue, and its effects can be controlled by the Apamarga tree. Leaf juice of apamarg can be extracted by squeezing it in between the palms. The leaf extract is mostly used as ear drops to heal contamination. Traditionally, this plant is used in asthma and cough treatment. It is pungent, anti-phlegmatic, antiperiodic, diuretic and laxative and hence useful in treating oedema, dropsy, piles and eruption of skin etc. (Pandey et al., 2013).

The roots, foliage and the other plant parts are used for medicinal purposes. These ingredients are highly recommended and useful in Ayurveda (Rehman et al., 2018). This medicinal plant starts germinating at the onset of monsoon and matures in the winter season and attains senescence in the summer season. Achyranthes aspera also known as "chaff flower" is an extravagantly aromatic plant used as an herb. It contains low fat content and less caloric content. This plant also has ample number of vitamins and minerals. From dietary to devotion, this plant has got many importance and uses (Srivastav et al., 2011).

Shukra (Venus)

Plant associated - *Ficus racemosa*

Ficus racemosa, commonly known as "Gular" represents this planet. It belongs to the family "Moraceae" and is by and large found in the tropical part of India. Fruits of gular are used in making vegetables, pickles, curries and are also used to make traditional liquor of South Africa. The bark of gular trees is highly effective for mosquito or any other insect bites and helps in curing mouth ulcers. Tender leaf juice consumption can be helpful in reducing dysentery. Flavonoids, triterpenoids, alkaloids etc. are highly present in the foliage parts of this plant (Yadav et al., 2015). Leaf latex, when soaked in cotton and applied in the affected areas, is found to be helpful in curing piles. Gluanol acetate is the vital constituent of fruits of gular. From the leaves of Ficus racemosa tree, a novel biosorbent was derived using NaOH treatment, which was found helpful in removing lignin content from biomass and to promote development of significant pores. It is also proven beneficial in wound healing and hepatoprotective actions (Ahmed and Urooj, 2010). This tree absorbs and decreases the level of carbon dioxide, as well as enhance the aesthetic appeal and value of the property. The *Ficus racemosa* tree species does more organic carbon sequestration i.e. 65.367 tons per year (Dubal et al., 2013).

Mangal (Mars)

Plant associated - *Acacia catechu*

The neck, marrow and anal region of the human body are controlled by the planet Mangal. *Acacia catechu,* a deciduous tree, commonly known as "khair", well represents this planet. The heartwood of the khair tree, has multipurpose uses such as in furniture making and when boiled and processed, it is called "kattha" (catechin), which is used in "paan".

"Kattha" is an important ingredient in chewing Betel leaf, and regionally for pickling of leather and dye, "Cuth" is used which is a byproduct obtained while producing kattha (Bhattarai et al., 2020). The Duramen part of this tree is costly and fetch higher price in market than other species. In accordance with Hindu culture, the khair tree is also treated to be sacred or holy. From funerals to various functions, wood of this tree is useful in many ways. Roots of *A. catechu* hold up the soil tight and also helps in its nutrient enrichment and reducing erosion (Zhao et al., 2023). The size of acacia rhizobia colonies that exist spontaneously varies greatly in the field. When

acacia populations are tiny (<50 per g), rhizobial inoculation of the plant often leads to increased N fixation (Brockwell et al., 2005).

Bruhaspati / Guru (Jupiter)

Plant associated - *Ficus religiosa*

Ficus religiosa (peepal) is the state tree of Bihar and is one of the oldest trees known so far. Among all the herbal plants, this tree owns a significant place, as each bit and segment of peepal tree is proven to be helpful in traditional medicine treatment (Kumar et al., 2018). The major organs of human body viz., liver, kidney, and pancreas, are governed by the planet Guru. From its leaves, barks, seeds, and fruits every part is used in naturopathy or ayurveda. The juice extracted from the leaves helps in treating kidney disorders. Whooping cough and asthma can be treated by decocting the bark. In case of abdominal pain, powdered tender leaves with milk bring relief when taken. Fresh twigs of peepal can be the best substitute for a toothbrush. In the various sacred books viz., Puranas, Ramayana, Mahabharata, etc. *F. religiosa* is believed to find its authentication and declaration (Verma and Gupta, 2015). The fruits of the peepal tree are found to be reserved in proteins, minerals, and phytochemicals (Makhija et al., 2010).

Shani (Saturn)

Plant associated - *Prosopis cineraria*

Prosopis cineraria, commonly known as "Shami " is a significant medicinal, traditional and religious plant of India. This plant also rules the knees, legs, muscles, and teeth of the human body. This plant has been identified as both cultural heritage as well as immensely rich in raw materials for agri-food and pharmaceutical (Giustra et al., 2022). It can grow well not only in hot arid but also in semi-arid regions of the world (Garg and Mittal, 2013). For the treatment of dyspepsia, consumption of extract of fresh leaves when mixed with the lemon is found to be beneficial. *P. cineraria* (Khejri) is believed to have a significant role in the rural economy. Being a good source of fuel and timber, this tree holds higher importance in Hindu rituals. Researchers have proven that, under the canopy of this plant, there is higher biomass and soil moisture content (Shankar et al., 1976; Gupta and Saxena, 1978). This plant also helps in adding microbial fertilizers in the soil by the process of nodulation (Basak and Goyal, 1975).

Rahu (Dragon's head)

Plant associated- *Cynodon dactylon*

Rahu is often referred as shadow body as it causes an eclipse dedicated to the ascending (or north) lunar node. *Cynodon dactylon* commonly known as "Durva", is the plant associated with planet Rahu. This plant is generally kept in the category of weed, throughout the country, but is also believed to be used for worshiping Lord Ganesha and offering doob grass to complete the Puja. This plant is also referred to as doob or dhuv in Hindi, Shataparva in Sanskrit and Bermuda grass/Bahama grass in English. *C. dactylon* offers antidiabetic properties and is used in treating heavy bleeding and other menstrual problems. Research have shown that *C. dactylon* is used as hemostatic and acts as wound healing agent (Biswas et al., 2017). In landscape design planning, this doob grass is also known in the name of turf grass and has a wide range of medical and health benefits. Various issues related to health and well-being like ulcers, arthritis, bacterial infection can be solved by implementation of the essence of this herbal plant (Ashokkumar et al., 2013).

Ketu (Dragon's tail)

Plant associated - *Desmostachya bipinnata*

Ketu is also referred as shadow body as it causes an eclipse dedicated to the descending (or south) lunar node. The plant associated with ketu graha is the darbha grass, which is also known as "Halfa grass". The darbha grass is highly rich in antioxidants properties and is a strong tonic (Khyade et al., 2018). "Kusha is the other name of this grass in Sanskrit language. It is also referred to as an extremely victorious monocotyledon herb on earth, because of the presence of important phytochemical contents in it. In defiance of several ecological changes, this grass is said to exist long on the earth (Fakhireh et al., 2012). Because of its herbal and phytochemical effects, these grasses have huge importance in traditional medicine and ayurveda

and hence their taxonomic family is examined to be sacred. This perennial grass holds various economic purposes both as medicine and cattle fodder. *D. bipinnata* is believed to be grown well in arid, semi-arid and hyper-arid regions, and there they show the autecological characteristics. In recent research, a unique phenomenon about this plant has been identified, which shows its resistance towards salinity (Adnan et al., 2016).

ESTABLISHMENT AND MANAGEMENT OF NAVGRAHA VATIKAS

It is a skillful task, designing any type of garden, and it requires proper planning for successfully designing a new garden. Consideration and analysis of several things is required like type of garden, purposes, theme etc. The next phase would be examining all necessary physical inputs and judging feasibility of developing the particular type of garden decided. Every type of garden has a set of requirements, and one has to evaluate all those things in detail, once the conceptualization is over.

SELECTION AND SURVEY OF AREA

Navgraha vatika are more likely to be established in tropical or subtropical areas either manually or with the help of instruments. This helps to know natural grades, topography, level difference etc. for best use of the area retaining its natural characters.

SOIL AND CLIMATE

Area should be best equipped with fertile soil with required macro and micro nutrients in it, better source of water supply and good drainage facilities. Analysis of soil with respect to type (clay/ loam/sandy), pH (acidic or alkaline) and availability of plant nutrients is a primary requirement. For growing major associated tree species, Loamy soil with pH 5.0-6.0 is highly recommended. Type of soil and climate are the two important factors which influence selection of plants and, therefore, should be considered carefully.

BASIC FACILITIES

Requirements of basic facilities like, electricity, light, water sources, drainage, expenditure estimates are needed for garden development. Current and correct market rates are the basic requirement for preparation of proper estimates of expenditure (Roy, 2020).

DESIGN AND LAYOUT

While preparing the layout of the garden, good decision for directions and angle of every tree is a prerequisite. The size and canopy of each tree must be given special attention and accordingly spacing between the tree species should be maintained. Here, I have designed a layout of navgraha vatika, keeping in mind, to follow geometry and symmetrical pattern.

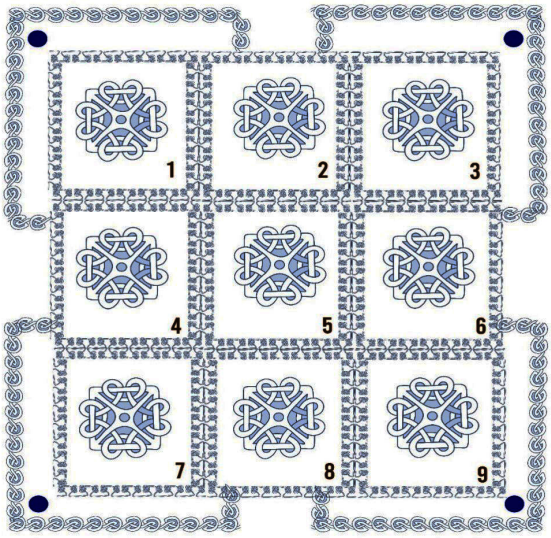

Fig. 1. A formal layout and landscaping of navgraha vatika

INDEX (Fig. 1)

i. Buddha (*Achyranthes aspera*)
ii. Shukra (*Ficus racemosa)*
iii. Chandra (*Butea monosperma)*
iv. Guru (*Ficus religiosa)*
v. Surya (*Calotropis gigantea)*
vi. Mangal (*Acacia catechu)*
vii. Ketu (*Desmostachya bipinnata)*
viii. Shani (*Prosopis cineraria)*
ix. Rahu (*Cyanodon dactylon)*
x. Concrete walkways
xi. Hedges
xii. Fountains/water bodies

This layout illustrates not only navgraha garden but also, our Indian custom and traditions. Above design depicts formal gardening style having a concrete walkway that surrounds the garden. The center piece is divided into nine equal square having nine navagraha associated plants. The four corners of the centerpiece is surrounded by L-shapes structure which can be decorated by using hedges viz., Alternanthera, Bougainville, duranta, Jatropha etc. In the above layout, the corners of these L-shapes structures are beautified by establishing fountains.

SELECTION OF PLANTING MATERIAL

Selection of healthy plants, free from pests and disease should be the primary task. Besides the nine navagraha trees, other varieties of ornamental and flowering plants are also needed to exhibit different forms of growth, texture, colour, to add on the beauty of the garden (Roy, 2013). Therefore, trees, shrubs, climbers, annuals, etc. usually find a place in the garden along with other primary plants.

PLANTING OF THE NAVGRAHA TREES

The plants which are linked with the navgraha vatika, are mainly vigorous and durable in nature and are accessible to cultivate. The area where vatika is to be established, should be first levelled, and ploughed well. All kind of plant debris, pebbles, and unwanted materials if present in the soil, should be removed. Required amount of vermicompost, green manure or farmyard manure should be applied over the top layer of soil to increase its fertility and nutrient availability. After that, it is advisable to start the planting of the plant on the onset of monsoon i.e. in the month of May-June (Maneesha et al., 2021). This can be done by making required size of pits which should be stuffed with FYM and manures. When the planting is completed, labelling of each plant should be done in order to make the visitors aware about their botanical name, family, as well as their medicinal importance. Proper plant to plant and row to row distance should be maintained so that the visitors could walk around easily and could enjoy the vista of the vatika (Roy, 2020).

MANAGEMENT PRACTICES

The garden layout should be fenced well to protect it from grazing animals and other disturbance during initial years. Various Horticultural practices viz., weeding, irrigation, pruning, mulching, manuring, pest management etc. is required to establish the garden successfully. Monsoon is the right time for pruning to keep the shrubs in shape as well as to encourage new growth and flowering; and to enhance the elegance of the garden in manifold. The ultimate purpose of care and maintenance of navgraha vatika is to keep the garden well maintained and presentable round the year.

CONCLUSION

Research has shown that these trees that are associated with planetary movements, have strong effects on surroundings. They help in air purification for better survival of flora and fauna. In addition, when the twigs of these are burnt out, the smoke that evolves helps in destroying all kinds of disease producing microorganisms. This navgraha vatika can be established around or in temples or any public places, because of its countless benefits. It has also been believed that the place where these trees are being planted, holds the high frequency of energy, and hence brings joy and prosperity in the surroundings. In this dynamic era of advanced technologies, the longevity of human beings is in threat and there is a great need to rediscover and re-establish our lost tradition of worshiping and valuing navgraha, and their plants. So, together let's take an initiative to make people aware about this natural heritage of ours and grow these trees and live a prosperous life.

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Contribution of Orissa to origin and nomenclature of cultivated rice (*Oryza sativa*): A review

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ABSTRACT

Rice is the highest producing grain crop in the world having wider adaptations not only to diverse agro-ecosystems, but also to various thermal regimes making it suitable to be grown in three different seasons i.e. *Kharif* (Rainy), *Rabi* (Winter) and *Zaid* (Summer). Hence, it is important to know the origin of this wonder crop. Many workers have made their efforts to identify the center of origin of this crop with credible information. Based on the findings of various workers, it can be concluded that the center of origin of cultivated rice (*Oryza sativa*) is Orissa or Odisha and the genus Oryza has been derived from the word Orissa or Orysa or Oryza.

Key words: Centre of origin, cultivated rice, nomenclature, Odisha, Orissa, *Oryza sativa*

INTRODUCTION

Rice crop having scientific name *Oryza sativa* is the highest producing cereal crop in the world with a total production of 769.23 million tons annually. Globally with a cultivated area of 163.09 million hectares, it comes next to wheat in terms of acreage. The average productivity of this crop is 4717 kg ha^{-1}. The main producing countries are China, India, Indonesia, Bangladesh, Vietnam, Thailand, Myanmar, Philippines, Cambodia, and Japan (Agricultural Statistics at a Glance, 2022). In India, it is cultivated almost in all the states in an area of 46.38 million hectares with production of 130.29 million tons. It is known as Dhanyam in Sanskrit, Dhan in Hindi, Dhana in Odia, Nel in Tamil, Nell in Malayalam, Dhan in Bengali, Vari in Telugu, Bhata in Karnataka, Jhona in Punjabi, Bhata in Marathi, Dangara in Gujarati, Dhan in Nepali, Dhan in Assamese and Phou in Manipuri. Similarly rice (de husked uncooked) is known as Tandula in Sanskrit, Arici in Tamil, Chawal in Hindi, Biyyam in Telugu, Ari in Malayalam, Akki in Kannada, Chaula in Odia, Chal in Bengali, Caula in Punjabi, Tandula in Marathi, Bhata in Gujarati, Chamal in Nepali, Chal in Assamese and Chak hao in Manipuri.

HISTORY OF RICE CULTIVATION

Rice is an ancient crop and is expected to be domesticated about 10000 years back (ICAR, 2012). Archeological excavations in India revealed that presence of rice in India could be dated back to 4530 B.C. However, some historians opine that it is recorded from China in around 2800 B.C. But it is certain that rice is a crop of Asia, more particularly South-East Asia and is used as staple food of people from ancient times. The rice plant belongs to grass family known as *Poaceae* and genus *Oryza*. Altogether 23 species are found under the genus *Oryza*. Out of which 21 spices are wild and two species are cultivated. Between the two cultivated species, *Oryza sativa* is cultivated in Asian countries and other rice growing areas where as *Oryza glaberrima* is cultivated in West African countries (Singh, 1993). Various workers of the

world have tried to identify the centers of origin of this crop. De Candolle worked extensively on the origin of crop plants of the world and concluded that India is the center of origin of rice due to prevalence of huge diversity of rice genotypes (De Candolle,1886). Watt also worked on origin of crops and reported that South India is the center of origin of rice (Watt, 1892). However, Vavilov studied the origin of cultivated plants and reported that India and Burma should be regarded as center of origin of rice (Vavilov, 1926). Dr. K. Ramaiah, a noted rice breeder and first director of Central Rice Research Institute, Cuttack (Established in the year 1945) has worked extensively on rice origin in the world. He has reported that more than 1750 traditional land races existed at Jeypore tract of Odisha during 1955-1960. He suggested that Jeypore tract is the real center of origin of cultivated rice, which was subsequently seconded by many renowned rice workers. Oka and Chary (1962) based on their independent investigations, reported that Jeypore rice are forms of intermediate between cultivated and wild types "still staying in the midst of differentiation". Sharma et al. (2000) working on origin of rice opined that Jeypore tract is the center of origin of Aus (early maturing rice varieties) ecotypes. A UNDP (United Nations Development Programme) publication Equator Initiative on "Tribal Communities of the Jeypore tracts of Orissa, India" reported that the Jeypore tract in the Indian state of Orissa (now Odisha) is considered as center of origin and diversity of Asian cultivated rice (*Oryza sativa*). The report also mentions that "Once Orissa was the traditional home to the largest number of rice varieties with more than 1750 varieties" (UNDP, 2012). Koraput is also recognized as one of the important agro-biodiversity hot spots of India (National Biodiversity Authority, 2023). Orissa (now Odisha) is the only state in the world where rice is grown thrice a year. In other words, it is grown in three different seasons. The *Aus* or autumn rice is locally known as *Beali* and is shown in May-June and harvested in September-October. The second rice called *Aman* or winter rice is locally called *Sarada* and is grown in June-July and harvested in November-December. The summer rice or *Boro* rice is locally known as *Dalua* and is sown in December-January and harvested in April-May. Both autumn and winter rice together come under kharif rice. Regional Center of M.S. Swaminathan Foundation, Chennai at Jeypore, Odisha working for conservation of native germplasms of rice and millets has reported that the center of origin of cultivated rice (*Oryza sativa*) is Jeypore tract of Odisha (Arunachalam et al., 2006). Considering the rich germplasm diversity of rice, government of India during British rule, decided to establish a Central Rice Research Institute at Cuttack, Orissa in the year 1945 to hasten rice breeding and yield improvement work (Ramiah and Ghose, 1951; Ramiah, 1953). Dr. K. Ramiah, world's renowned rice breeder made its founder director which was brought to the administrative control of Indian Council of Agricultural Research, New Delhi in the year 1966. International Rice Research Institute (IRRI), Manila, Philippines, was established much later in the year 1960 to speed up rice research work in the world. Orissa not only provided a large number of rice germplasm to the rest of the world for rice research but also has provided numerous food items prepared from rice compared to any other parts of the world. The processed rice products include parboiled rice *(Usunachaula), Aruachaula, Mudhi* (Popped rice), *Chuda* (Flaked rice), *Khai* (Lia), *Mudhi muan, Khai muan, Mudhi ukhuda, Khai ukhuda, Kora khai, Hudumba, Chuda muan, Mudhi chattua, Chuda chhatua etc*. Similarly, *Aruabhat, Usunabhat, Kanica, Khiri, Pakhala, Torani*, various *Pitha* items such as *Chakulipitha, Podapitha, Manda pitha, Chhunchipatra pitha, Enduri pitha, Chitau pitha* and *Gaintha pitha* etc. are the best rice gifts of Odisha to the rest of the world. Due to presence of highest number of native germplasms with three distinct growing seasons and evolution of large number of rice based products in Odisha compared to any other regions of the world, it can be scientifically confirmed that centre of origin of cultivated rice is Jeypore track of Orissa (now Odisha).The practice of conserving germplasms from years to year is an inherited habit of the inhabitants in general and tribal population in particular. Even some persons like Mrs. Kamala Pujari a tribal farmer from Koraput district has

received *Padmashree award* from government of India for her work on conservation of hundreds of traditional rice germplasms.

CULTURAL LINKAGES OF ORISSA TO RICE

It can be rightly said that the culture of Odisha is rice culture. Here, rice panicle is considered as Goddess *Laxmi* (goddess of wealth) and worshipped. In every Thursday in the month of *Margasira* (November-December), a bunch of fresh ripened rice panicles are collected and worshipped as goddess *Laxmi* (Das, 2005; Anonymous, 2007). *Nuakhai* is another important festival, where newly harvested rice grain products are offered as *Prasad* to Goddess *Samaleswari*, the principal deity of Western Odisha. Similarly, in *Akhaya Trutiya* festival, rice seeds are worshipped and broadcasted in the field as a symbol of inviting Goddess *Laxmi* for a bumper harvest and after that auspicious beginning, the paddy sowing starts in the state (Mohanty and Mohanty, 1979). Orissa or Odisha is a religious state of India where hundreds of festivals are celebrated annually and in Oriya culture, without paddy and rice grains worship of any God or Goddess is impossible (Pattanayak, 2002).

CONTRIBUTION OF ORISSA TO IT'S NOMENCLATURE

The scientific name of cultivated rice is *Oryza sativa* and belongs to the family Poaceae. As per Wikipedia, it has been derived from two Latin words '*Oryza*' and '*Sativa*'. '*Oryza*' means rice and '*Sativa*' means cultivated. Latin word means the language of ancient Roman Empire. In Rome, the cultivated crops are mainly wheat, barley, and millets not rice. The staple food of people is wheat. Moreover, in nineteen century, photo insensitive varieties were not developed, and the climate of ancient Rome was not suitable for its cultivation. There was no reporting of prevalence of rice germplasm from Rome. The rice crop has not been originated from Rome also. In nomenclature, some indication is always kept regarding the identity of the product. Hence, it is unlike that its nomenclature will take Roman words or say Latin words. In contrast, the then Orissa was having rice cultivation from ancient times with huge germplasm diversity and is the center of origin of cultivated rice. During East India company's rule in India, rice was exported from Orissa to European nations. Even during the great Orissa famine called "*Na Anka Durbhikhya*" in the year 1866, in which more than one million people died due to starvation because of low rice production, it was exported to the tune of 33000 tonnes from Orissa to outside. As Dadabhai Naroji's statement in BBC during great Orissa famine, a whooping 200 million pounds of rice was exported from India to Europe (BBC.com). This proves that there was rice export from Orissa during medieval times too. Let us discuss the nomenclature issue of *Oryza*. The center of origin of cultivated rice belongs to Jeypore tract of *Orissa*. Earlier the name of the state of Odisha was *Orissa* and the language of the people was *Oriya or Orya*. These two words Orissa and Oriya / Orya are spelled and written differently by different people during those days due to pronunciation difference. For example: Orissa is written as *Oryssa or Orysa*. As the letter 'S' and 'Z' are interchangeably used, some people might have spelled it as *Orysa or Oryza*. The people of Orissa are called *Oriyas* and the word *Oriyas* is written as *Oryas* or *Oryaz* etc. Some of the historians are in the opinion of that the word *Oryza* has been derived from the word *Arisa*, or *Ariza* which is a famous *pitha* (rice cake) prepared from rice in Orissa. They believe that the word *Oryza* has come from combination of two words such as "*Orysa*" and *Arisa* or *ariza* (Ory + Za = Oryza).This Arisa or Ariza is a tasty rice cake and the first food given to Lord Buddha by the Oriya trader *Tapassu* and *Bhallika* soon after his enlightenment (Mohanty et. al, 2007). Later on, the genus name *Oryza* might have been used in *Latin* language as alien terms are directly used. As tomato an alien crop to India, and when it is incorporated in Hindi, it has taken the name tomato.

CONCLUSION

Based on the review of various rice scientists of the world, it is found that more than 1750 different land races of cultivated rice (*Oryza sativa*) were recorded in Jeypore tract of Odisha, which is highest diversity in the world with respect

to rice germplasm inventory. The historical and evolutionary perspectives strongly indicate the origin of rice to the state of Orissa, India. National Biodiversity Authority and UNDP (United Nations Development Programme) publicized the same origin giving the authenticity. If we analyze the nomenclature issue, it strongly indicates that rice is originated from Orissa. The seasonal, export evidence, availability of largest products, many other socio-cultural and religious facts also lead the same. More so, the world-famous scientists like K. Ramaiah substantiated with more research results and facts to authentify the origin to Jeypore tract of Orissa. Hence, it can be concluded that the center of origin of cultivated rice is Jeypore tract of Odisha. Similarly, it can be concluded that the genus *Oryza* has been derived from the name *Orissa/ Orisa/ Orysa/ Oryza* of the then Orissa state (now Odisha) from where cultivated rice has been originated. The word sativa generally refers to cultivated and has been given to many plants as species name in the binomial nomenclature. Such as oat (*Avena sativa*), cannabis (*Cannabis sativa*), taramira or rocket (*Eruca sativa*), lettuce (*Lactuca sativa*), Alfalfa (*Medicago sativa*), black cumin (*Nigella sativa*), parsnip (*Pastinaca sativa*) and many others.

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Phytohormone regulation on apple fruit maturation

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ABSTRACT

Apple (*Malus domestica* Borkh.), one of the largest fruit crops in terms of cultivated area and yield. The fruit is generally marketed after storage, which is of great significance for regulating the market supply in the off-season. Apple-fruit ripening culminates in desirable changes in structural and textural properties are governed by a complex regulatory network. Much is known about ethylene as one of the most important factors promoting apple-fruit ripening. However, the dynamic interplay between phytohormones also plays an important part in apple-fruit ripening. Here, the complex regulatory network concerning the action of phytohormones during apple-fruit ripening has been evaluated and reviewed. Future research prospects have also been discussed.

Key words: Apple, fruit ripening, phytohormone, regulation

INTRODUCTION

Plant hormones are endogenous organic combinations active at very little concentration, produced in one tissue, and translocated to another point in the plant where their effects on growth and development are manifested. A single plant cell can respond to more than one hormone, while a single hormone can affect different tissues in different ways. PGRs also do have effect on apple fruit ripening and maturation (Li et al., 2017). Climatic conditions of Afghanistan are highly adjustable for numerous temperate fruits crops. There are a large number of prevalent horticultural species. Wide range of Agro-ecological zones provides a long season of consistent supply. Afghanistan is an unique center of genetic diversity and significantly contributes to the international horticulture community. Cherry, plum, apricot, peach, pear, apple, walnut, pistachio, fig, grape, pomegranate, almond, are among the species present across the country. Horticultural crops are relatively water effective, contribute to significant production diversification and are a source of much needed nutrients for the human population. Horticulture is land and labor intensive which is an advantage for poor farmers. Considering the regional reputation for high-quality produce, horticulture becomes a prime source of export enhancing country's economy. Horticulture occupies 2.7% of the total cultivated area; 55% of fruit crops, 40% of vegetables and 5% of other products. The main fruit crop regarding area is grape with 51%, followed by almond with 11%, apricot 5.7% and apple 5.1%. Grape (fresh grape and raisin) is the most spread species in the country (14 provinces out of 34) and is by large by value and volume, the highest perennial fruit crop by value and volume. The apple is the pomaceous fruit of the apple tree, species *Malus x domestica* Borkh. in the rose family (Rosaceae). It is one of the most widely cultivated tree fruits in Afghanistan and the most widely known of the many members of genus *Malus* that are used by humans. Apple trees have different ripening rates which may be supplied

year-round from time of harvest (Watkins, 2003). As a typical climacteric fruit, apples have a peak in respiration and a burst of ethylene to unleash the ripening process in an autocatalytic response just prior to the initiation of ripening. Apple-fruit ripening is mainly regulated by the phytohormone ethylene (Sunako et al., 1999). Therefore, it appears to be possible to control the storage life of apple fruit by regulating ethylene biosynthesis. For example, treatment with the compound ethephon, which is converted into ethylene in plants, promotes ethylene production and apple-fruit ripening (Li et al., 2016). A better understanding of the hormone regulatory mechanisms in the ripening of apple-fruit is both biologically meaningful and economically significant for generating strategies to improve apple-fruit qualities and fruit nutrition, and reduce postharvest economic losses. Watkins (2003) summarized research advances in the phytohormone regulation of apple-fruit ripening and discussed future perspectives.

USE OF DIFFERENT HORMONES

Ethylene

Gaseous hormone produced in many plant tissues, autocatalytic (stimulates its own production) volatile gas production stimulated during ripening, flooding, stress, senescence, mechanical damage, infection product of combustion of petrochemicals ethylene, a gaseous phytohormone, plays a central role in climacteric fruit ripening. In the apple ripening process, ethylene production gradually increases to a peak, and then gradually decreases, the fruit then moves into the aging stage (Fig. 1). The ethylene produced in climacteric fruit is divided into two systems i.e. System 1 and 2. System 1 is mainly responsible for ethylene biosynthesis in young fruits. System 1 ethylene is also auto inhibited. System 2 is mainly responsible for ethylene biosynthesis in ripe fruits (Fig. 2-3) and active when climacteric ethylene should be produced (Watkins, 2003).

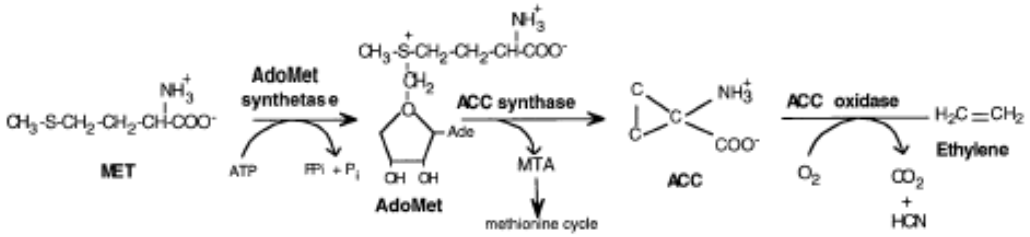

Fig. 1. Stages of production of ethylene

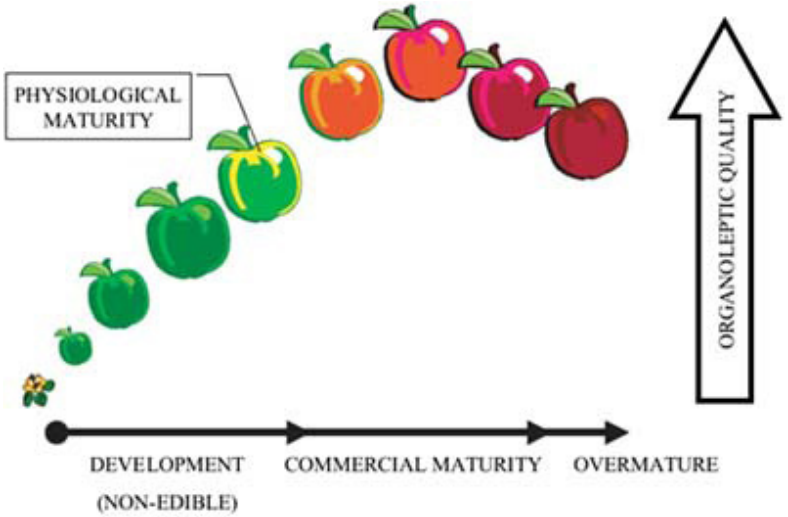

Fig. 2. Stages of maturation in apple fruits

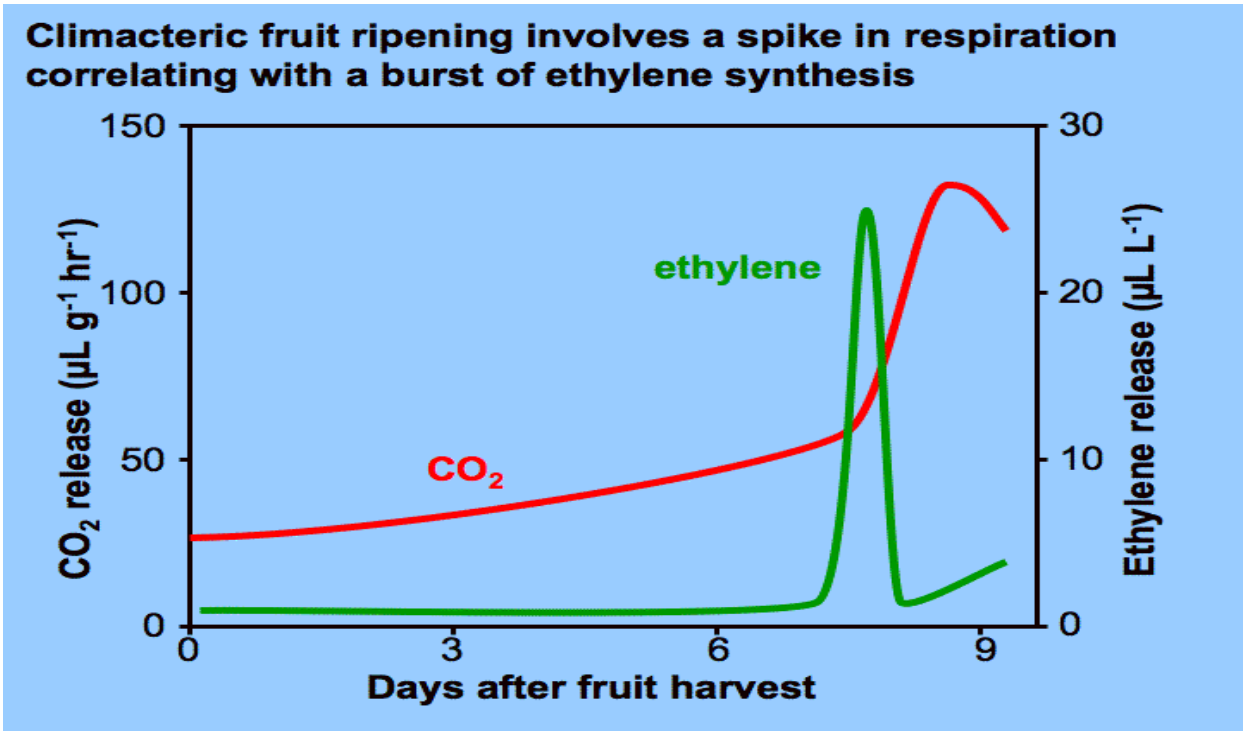

Fig. 3. Rate of CO_2 and ethylene released in ethylene synthesis

Role of Ethylene

1. Most importantly, Ethylene breaks the dormancy of seeds and buds.
2. It enhances respiration rate during ripening of fruits.
3. It facilitates senescence and abscission of both flowers and leaves.

Auxins (Indole acetic acid)

Auxins have been widely studied as growth and development regulators in fruit (Kumar et al., 2014). An increasing number of studies show that auxins also act as a fruit-ripening regulator (Fig. 4). In general, the most abundant free auxin, indole-3-acetic acid (IAA), is seen as the main regulator in fruit. In apple fruit, endogenous IAA contents are extremely high during the initial growth developmental stages, after which IAA contents tend to decline to low levels at the onset of fruit ripening (Yue et al., 2020). Signal transduction by auxin is also well understood. In the absence of auxin, auxin/ indoleacetic acid proteins (Aux/ IAAs) interact with auxin response factor (ARF) and suppress their activity, which prevents the downstream progression of signaling.

Role of Auxin

1. Involved in the initiation of roots in stem cuttings.
2. Reduction of dropping of leaves and fruits at early stages.
3. Regulate xylem differentiation and assists in cell division.
4. Apical dominance may occur in which the growth of lateral buds is inhibited by the growth of apical buds. In such cases, the shoot caps may be removed.

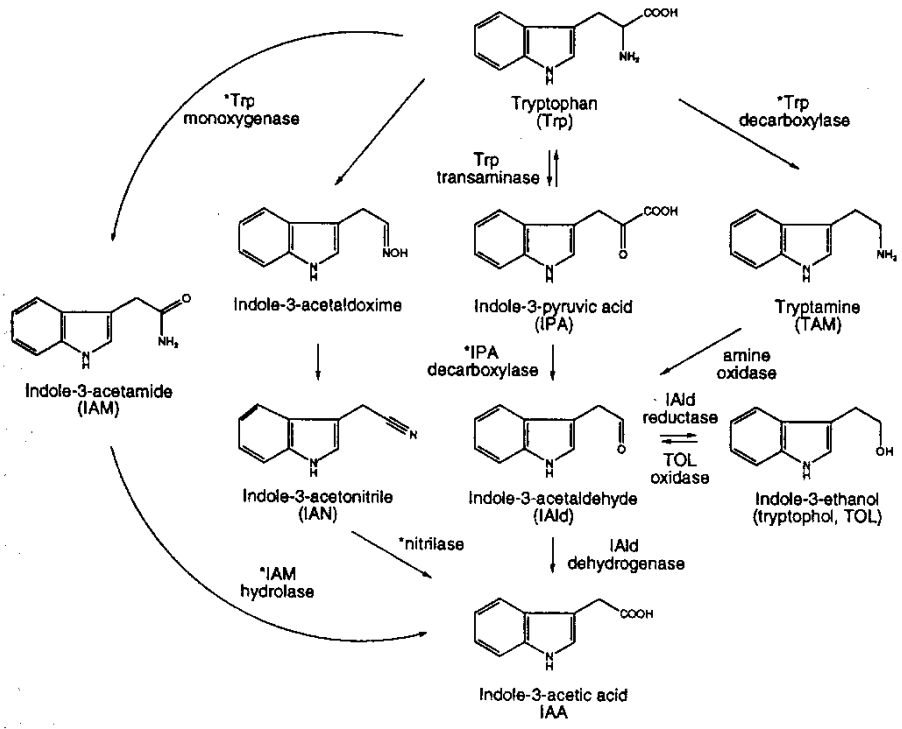

Fig. 4. The action of auxin in plant

Abscisic Acid (ABA)

Abscisic acid (Fig. 5) has long been described to be primarily involved in the ripening process of non-climacteric fruit (Watkins, 2003). In recent years, an increasing number of studies discovered that ABA also regulates the ripening of climacteric fruit. The endogenous ABA concentration is low in green fruit but increases during apple-fruit ripening (Onik, et al., 2018). Studies showed that the maximal endogenous ABA precedes a burst of ethylene in apple fruit. These results indicated ABA may be the other regulatory factor upstream of ethylene for apple-fruit ripening. So far, there is not much information about the mechanisms through which ABA regulates apple-fruit ripening (Onik et al., 2018).

Role of Abscisic acid

1. Helps in the maturation and development of seeds.
2. Inhibits plant metabolism and seed germination.
3. It is involved in regulating abscission and dormancy.
4. It is widely used as a spraying agent on trees to regulate dropping of fruits.

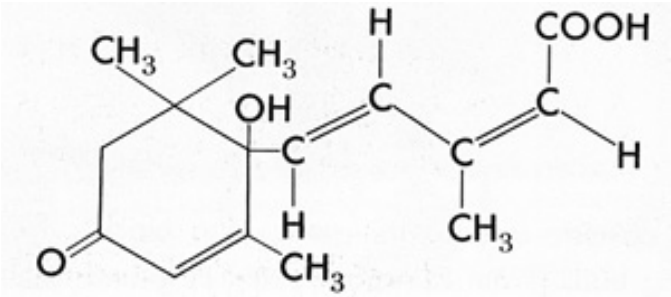

Fig. 5. Chemical formulae of ABA

Gibberellins

Gibberellins (GAs) are a category of tetracyclic triterpenoid hormones (Fig. 6) in higher plants regulating a wide range of developmental processes; reported by Onik et al. (2018). Recent studies on GAs mainly focused on seed development, flowering, and fruit set and development because of the high concentration of GAs found in flowers and immature fruit. Among several hundred plant GAs, only a limited number are bioactive in higher plants, such as GA1, GA3, GA4, and GA7. GA1 and GA4 are highly abundant, whereas GA3 and GA7 are less abundant as reported by Li et al. (2017). In fruit, GAs accumulates during early fruit development but decrease to a low concentration during fruit ripening. Injecting the GA biosynthesis inhibitor prohexadione Ca into mature green tomatoes accelerated the fruit ripening (Li et al., 2017). Additionally, exogenous GA3 treatment can reduce ethylene production and depress the ripening of various climacteric fruit, such as bananas, persimmon (*Diospyros kaki*), mangos (*Mangifera indica*), and tomatoes. These results demonstrate that GAs is an inhibitor of fruit ripening. However, the regulation of GAs in apple-fruit maturation (Fig. 7) and ripening has rarely been studied. In apples, the inactivation of GAs was controlled by a gene encoding gibberellin 2-beta-dioxygenase 1 (GA2OX1) observed to be high in post ripening apples that were harvested at 120 DAFB followed by five days of storage at 20°C. However, knowledge on the mechanisms regarding how GAs regulate apple-fruit ripening remains limited (Li et al., 2017).

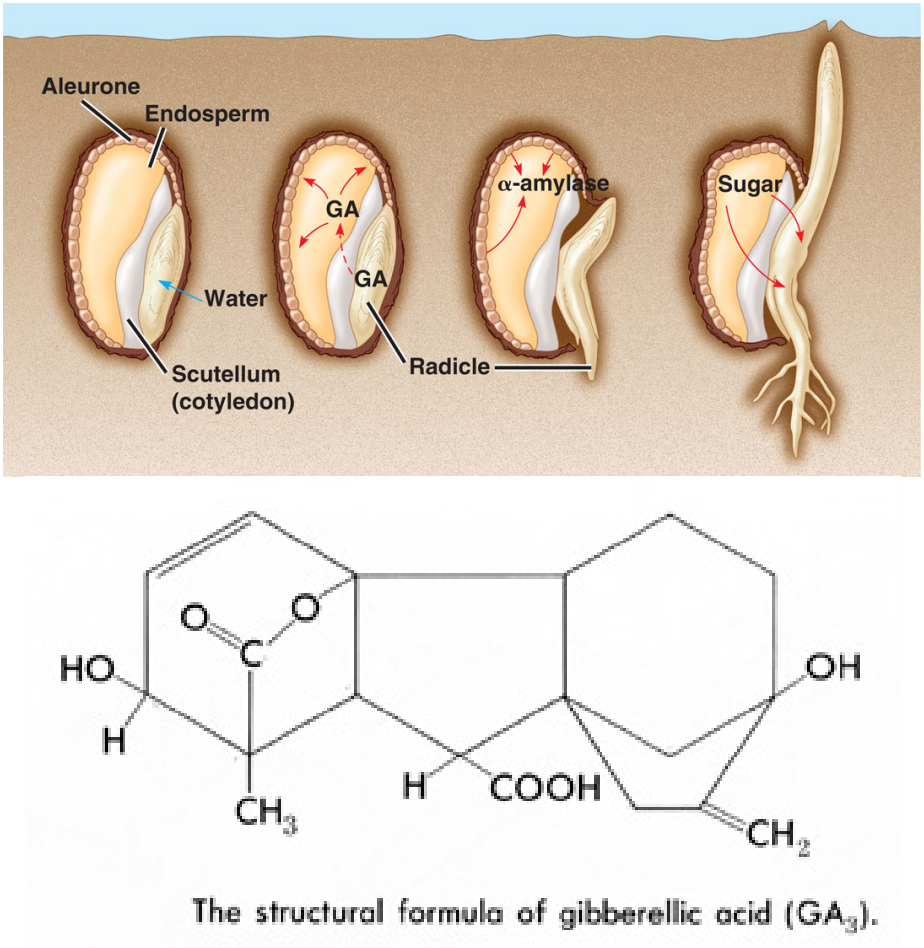

Fig. 6. Structural formula of GA

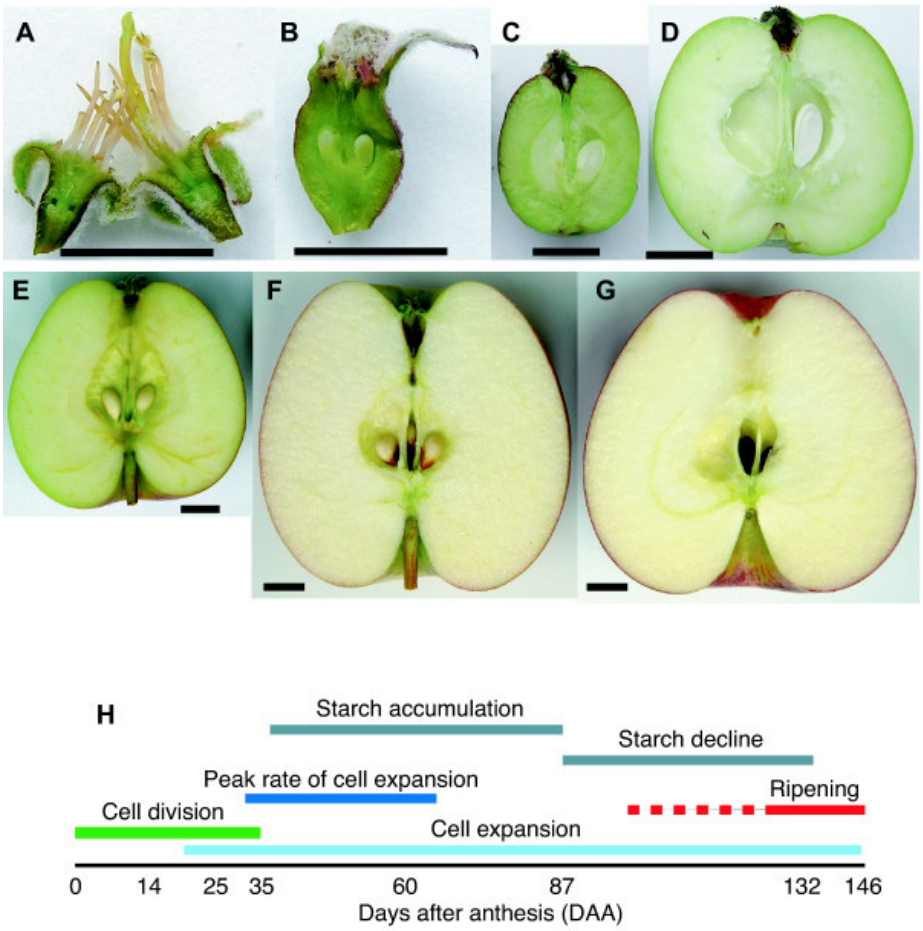

Fig. 7. The maturation stages of apple (A to G)

Role of Gibberellin

1. Delay senescence in fruits.
2. Break bud and seed dormancy.
3. Facilitate elongation of fruits such as apples and enhance their shape.
4. Helps in increasing the crop yield by increasing the height in plants such as sugarcane and increase the axis length in plants such as grape stalks.

RESULTS AND DISCUSSION

Plant growth regulators play an important role in the production of high-quality trees and fruit. Read the product. Plant growth substances also help to bring rapid changes in the phenotypes of the plants and also improves the growth, translocation of nutrients to economic parts and ultimately improve the maturation and productivity of fruit crops. Due to the shorter ripening period, apples are harvested at the commercial maturity stage for a longer shelf life and proper marketing supply. The transition from growth to maturation of fruit is characterized by alterations in the phytohormones profiles to drastically terminate fruit expansion and promote fruit ripening. A clear understanding of these phytohormonal shifts in apples is meaningful and crucial for regulating the period from commercial to physiological ripening. Moreover, phytohormonal regulation in apple ripening is of great significance for regulating the market supply in the off-season of fruit production (Li et al., 2017). Fruit ripening is a complicated physiology and biochemistry reaction involving well-organized regulation by multiple

hormones, and accompanied by subtle changes of metabolic and physiological traits. Ethylene is specifically required for the ripening of climacteric fruit. The biosynthesis of ethylene in climacteric fruit is divided into systems 1 and 2. However, the mechanism for system 1 ethylene shifting to system 2 ethylene is not clear (Fig. 7). Understanding this mechanism is a major focus of research on fruit ripening. Current information indicates that ethylene could be the destination of hormonal crosstalk during apple-fruit ripening. Ethylene signaling in apple-fruit ripening is tightly coordinated under the influence of multiple phytohormones. Cytokines (CKs) have crucial functions in various phases of plant growth and development as a major phenomenon (Li et al., 2017), but studies on the effects of CKs on apple fruit ripening are limited. Other plant hormones primarily act through minor adjustments to ethylene's action during apple fruit ripening. However, available information is limited about the crosstalk of multi hormones during apple-fruit ripening. Given the complexity of apple-fruit ripening processes, exploring the basic molecular mechanisms of their regulation by crosstalk among hormones is more difficult. More work is required to elucidate the molecular basis of multi-hormonal cross talk, and this is becoming a major focus of research on fruit ripening.

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Gamma rays and maleic hydrazide induced cytogenetic effects and pollen sterility in greengram (*Vigna radiata* L. Wilczek)

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ABSTRACT

Cytogenetic studies for induced chromosomal variations and effects are considered as an accurate index in mutation breeding for determination of the potency of different doses of gamma rays and maleic hydrazide (MH) and deducing an optimum dose. Therefore, the present investigation was carried out to estimate the relative frequency and spectrum of meiotic chromosomal abnormalities at various stages of cell division using Gamma rays, Maleic hydrazide, and their combination treatments in the M1 generation of greengram (*Vigna radiata* L. Wilczek) varieties Sujata and OBGG-52. The analysis revealed a wide range of induced meiotic chromosomal abnormalities like univalents, multivalents, chromosome stickiness, laggards, bridges, and micronuclei by different mutagen doses. In general, the meiotic chromosomal abnormalities increased along with the increase in concentration of mutagens in both varieties. However, the induction of meiotic aberrations was higher in MH treatments, suggesting that MH could be more effective in inducing additional variability than gamma rays in greengram. It was observed that the combined treatments induced meiotic abnormalities at a higher frequency as compared to individual treatments of gamma rays and MH. The comparative study of induced chromosomal abnormalities in different varieties suggested that the variety Sujata expressed higher mutagenic sensitivity than the *var*. OBGG-52 towards the single mutagenic treatments used whereas in combined treatment of moderate doses, OBGG-52 expressed higher mutagenic sensitivity than Sujata. The pollen sterility observed in mutagenic treatments may be due to the induced mutations in chromosomes. A positive and significant correlation between the induced chromosomal abnormality and the pollen sterility was observed in both varieties.

Key words: Chromosomes, gamma rays, induced mutation, maleic hydrazide, pollen sterility

INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] also known as golden gram, mungbean, mashbean, moong, etc is one of the most important pulses crops and belongs to the family *Fabaceae (Leguminosae)*. It is widely grown in the subtropical countries of South and Southeast Asia, Australia, West Indies, South and North America, and Tropical and Subtropical Africa. It is an excellent source of dietary fiber, high-quality protein, minerals, vitamins, and significant amounts of bioactive compounds, including polysaccharides, polyphenols, and peptides thus becoming a popular functional food in promoting good health. Mutation breeding is now a pillar of modern plant breeding, along with recombinant breeding and transgenic breeding. Induced mutations provide a powerful means of creating new and useful variability in crop plants both in qualitative and quantitative traits (Das and Misra, 2005). Physical and chemical mutagens induce genes to mutate at rates above

spontaneous baselines, thus producing a range of novel traits and broadening of genetic diversity of plants (Das and Baisakh, 2013). Physical or chemical mutagen-induced quantitative variation not only serves as an alternative source of germplasms for natural variation but is also useful in generating appropriately linked gene complexes that are responsible for the improvement in yield and other characteristics of economic interest (Das and Prusti, 2020). Selection of efficient mutagens and their treatment doses is a prerequisite for successful mutagenesis in crop plants as mutagens are potential tools for direct improvement of qualitative and quantitative characters.

Gamma rays, one of the most used physical mutagens in mutation breeding are known to influence plant growth and development by inducing cytological, genetic, biochemical, physiological, and morphological changes in cells and tissues. Gamma rays are highly energetic ionizing radiation with a higher penetration power and thus can induce various changes at the chromosomal and molecular level and prove to be an effective physical mutagen in creating variation and effective mutation. Chemical mutagens also play a key role in inducing chromosomal aberrations and mutations that are useful for crop improvement (Das and Baisakh, 2022). Among the chemical mutagens used for induction of mutations in various crops, Maleic hydrazide ($C_4H_4N_2O_2$) is one of the most effective, efficient, and frequently used mutagens. It is a structural isomer of uracil, a pyrimidine compound of RNA. The mode of action of Maleic hydrazide (MH) is through its interference with the synthesis of uracil or by incorporating into RNA molecule replacing the uracil or it reacts with sulfhydryl groups of nucleic acids. Darlington and Mcleish (1951) were the first to report that it induces chromosome breaks. Many of these breaks induced by MH were in the heterochromatic region of the chromosome. Mcleish (1952) observed that breakage occurs during interphase leading to chromosomal break. Since heterochromatin is the site of the majority of the polygenes, MH can be effectively utilized for the induction of micromutation in quantitative traits. More recently, numerous experiments performed with various plant species have shown that MH acts as an inhibitor of the synthesis of nucleic acids and proteins (Swietlińska and Zuk, 1978).

The cytogenetic investigation is an important source of information regarding the genetic changes due to mutagens as they deal with the genetic material, the chromosomes, and more appropriately the DNA which controls the phenotype. The cytogenetic abnormalities due to any mutagen have been regarded as one dependable parameter for estimating the mutagenic potential of a mutagen which can be judged by the percentage of abnormalities it induces. The induced genetic changes occurred by the mutagens provide good scope for further improvement of greengram crop. It also provides considerable information to assess the sensitivity of plants for different mutagens and to ascertain the most effective mutagens and their treatment doses for a given crop to realize maximum results. Mutation of any of the genes disrupts meiosis, gametes sterility, and other abnormalities. Chromosomal rearrangements are one of the most frequently produced cases of mutation that result from the action of both physical and chemical mutagenic agents. Analysis of chromosomal behavior at various meiotic stages is one of the most dependable indices for the estimation of the potency of any mutagen. Thus, the investigation of meiotic aberrations and their genetic consequences forms an integral part of most mutation studies. To induce genetic variability and utilize useful mutants in plant breeding programs, the identification of the appropriate mutagen and its appropriate dose/ concentration is essential (Das and Baisakh, 2011). Hence a study was undertaken to assess the effect of different doses of gamma-rays and MH on meiotic behavior and pollen sterility in the M_1 generation of greengram.

MATERIALS AND METHODS

Dry and well-filled seeds of two greengram varieties, namely Sujata and OBGG-52 were administered mutagenic treatments with three doses each of gamma rays (20, 40 and 60 kR), Maleic Hydrazide (0.01, 0.02 and 0.03 %), and combine mutagens of 40 kR gamma rays with 0.02% MH

and were coded as G1, G2, G3, M1, M2, M3 and G2M2, respectively. Dry seeds were irradiated with gamma ray treatment at Bhaba Atomic Research Centre, Trombay. For treatment with MH, the seeds were pre-soaked in distilled water for six hours, blotted dry and then treated with a freshly prepared aqueous solution of the above chemical mutagen for 6 hours, with intermittent shaking. For combination treatment, seeds were first irradiated with forty kR gamma rays and then treated with 0.02% MH solution in the same manner as described above. After treatment, the seeds were thoroughly washed with running water to bleach out the residual chemicals and then dried on blotting paper after treatment. To grow the M_1 generation, the treated seeds were sown in two replications with spacing of 25×10 cm^2. Young flower buds from fifty randomly selected plants from each treatment were fixed in Carnoy's fluid (1-part glacial acetic acid: three parts chloroform: six parts ethyl alcohol), separately for 24 hours. Then these flower buds were transferred to vials containing 70% alcohol and preserved at 5°C. Chromosomal abnormalities were scored by Sqush Technique. Mean pollen sterility was determined based on acetocarmine stainability.

RESULTS AND DISCUSSION

In the present study, a broad spectrum of chromosomal aberrations was induced at various stages of meiotic division in M_1 generation using Gamma-rays, MH alone as well as in combination in both varieties of greengram (Table 1 and 2). The spectrum of meiotic chromosomal abnormalities (CA) observed in various mutagenic treatments in both varieties included univalents, multivalents, chromosome stickiness, laggards, bridges, and micronuclei.

Table 1. Frequency and spectrum of chromosomal abnormalities induced by gamma rays, MH, and their combination in greengram var. Sujata

Treatments	Univalent (%)	Multivalent (%)	Stickiness (%)	Bridge (%)	Laggard (%)	Micro-nuclei (%)	Total chromosomal abnormality (%)	Pollen sterility (%)
G1	0.37	1.12	0.75	0.37	-	-	2.61	2.11
G2	1.22	0.81	1.63	1.22	1.63	0.81	7.32	4.56
G3	1.81	0.90	3.17	1.81	2.71	1.81	12.21	7.81
M1	1.21	1.61	1.21	0.81	2.02	0.40	7.26	4.27
M2	1.69	2.12	3.39	1.27	3.81	0.85	13.13	9.03
M3	2.71	2.26	3.62	1.36	4.07	1.36	15.38	12.19
G2M2	2.06	2.06	3.29	1.65	3.29	1.23	13.58	9.70
C	-	-	-	-	-	-	-	

Table 2. Frequency and spectrum of chromosomal abnormalities induced by gamma rays, MH, and their combination in greengram var. OBGG-52

Treatments	Univalent (%)	Multivalent (%)	Stickiness (%)	Bridge (%)	Laggard (%)	Micro-nuclei (%)	Total chromosomal abnormality (%)	Pollen sterility (%)
G1	-	0.72	0.72	1.08	-	-	2.52	2.14
G2	1.14	0.76	1.52	1.14	1.52	0.76	6.84	3.78
G3	1.15	0.77	2.69	1.54	1.92	1.15	9.22	5.47
M1	1.09	0.73	1.46	-	1.82	-	5.10	2.68
M2	1.15	1.15	2.69	0.38	3.08	0.77	9.22	7.45
M3	2.37	1.58	3.56	1.19	3.95	1.19	13.84	10.23
G2M2	1.61	1.21	2.82	0.81	3.22	0.81	10.48	8.60
C	-	-	-	-	-	-	-	-

The univalents were found in almost all treated populations (except G1 in OBGG-52) and their frequency was maximum at the higher dose of mutagen (Table 1 and 2). The occurrence of univalents indicates non-homology between certain chromosomes in the complement (Goyal et al., 2019). The mutagenic treatments induce structural changes in chromosomes and induced gene mutations might be responsible for the failure of pairing among homologous chromosomes and hence the presence of univalents (Das and Baisakh, 2022). Kumar and Tripathi (2004) reported that the chemical mutagens induce univalent formation through cryptic structural changes in chromosomes, which restrict the pairing and in turn reduce the chiasma frequency. The multivalent were observed in all treated populations and followed dose dependency in MH treatments. The moderate dose combination treatment G2M2 produced higher multivalent in comparison to single moderate dose mutagenic treatments (G2 or E2) in the variety OBGG-52 but in Sujata, the pattern observed was M2 > G2M2 > G2. Multivalents can be attributed to irregular pairing and breakage followed by translocation and inversions (Dixit and Dubey, 1986). The occurrence of multivalent association is a common feature in treated plants with the presence of more than two homologous chromosomes.

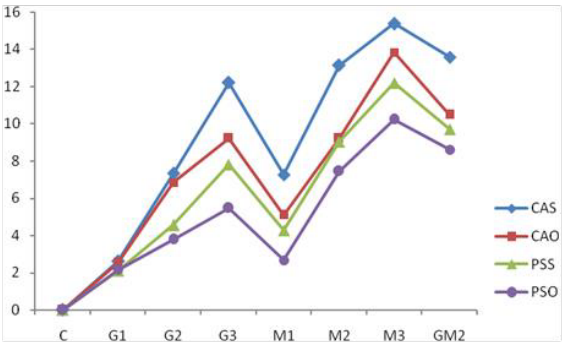
All the mutagenic treatments in both varieties induced stickiness of chromosomes and their frequencies were increased with increasing the dose of the mutagens in both varieties (Table 1 and 2). It was also observed that the moderate dose combination treatment (G2M2) produced higher stickiness of chromosomes in comparison to single moderate dose mutagenic treatments (G2 or M2). This stickiness of chromosomes resulted due to depolymerization of DNA (Darlington, 1942), partial dissolution of nucleoprotein (Kaufmann, 1956), and alteration in the pattern of organization of chromosomes (Evans, 1962). McGill et al. (1974) and Klasterska et al. (1976) suggested that stickiness arises due to improper folding of chromosome fibers, while Jayabalan and Rao (1987) reported that it is due to the disturbances of cytochemical balanced reactions in the nucleic acids by the mutagens. Gaulden (1987) postulated that stickiness may result from the defective functioning of one or two types of specific non-histone proteins involved in chromosome organization which is necessary for chromatid separation and segregation. The altered functioning of these proteins leads to stickiness which is caused by the mutations in the structural genes coding for them (hereditary stickiness) or by the action of mutagens (induced stickiness). Gulfishan et al. (2010) explained that some kinds of gene mutations lead to incorrect coding of some non-histone proteins involved in chromosome organization and lead to chromosome clumping. It may also be possible that the mutagen itself reacts with the histone proteins and brings about a change in the surface property of chromosomes due to improper folding of DNA which causes them to clump or stick. The stickiness of chromosomes at metaphase-I adversely affected the normal disjunctions of chromosomes at anaphase-I, which resulted in the formation of laggards and unequal separation of chromosomes at the anaphase stage (Das and Baisakh, 2022).

The chromosomal bridges were observed in almost all the treatments in both varieties (Except M1 in OBGG-52) and their frequencies were increased with increasing the dose of both mutagens in both varieties of greengram. The chromosomal bridge formation may be attributed to the general stickiness of chromosomes at the metaphase stage or the breakage and reunion of chromosomes. The chromosome bridge was useful for obtaining information on clastogenic activity (Das and Baisakh, 2022). Chromosomal bridges occur due to sister chromatid exchange followed by delayed or failure of their separation during later stages of anaphase and telophase chromosome. Saylor and Smith (1966) reported that the bridge formation could be due to the failure of chiasmata in a bivalent to terminalize, and the chromosomes get stretched between the poles. Sinha and Godward (1972) suggested that paracentric inversion may lead to the formation of chromatin bridges at anaphase I/II and telophase I/II. The bridges may be due to the stickiness of chromosomes. This stickiness interfered with the normal arrangement of chromosomes at metaphase and further led to their

inability to separate, thus leading to sticky bridges. When the spindle fibers pulled the chromosomes towards the poles these bridges were broken into fragments, which either moved towards the poles or formed the laggards and micronuclei (Rees, 1955). The presence of single and multiple bridges may be due to the occurrence of dicentric chromosomes formed because of breakage fusion bridge cycles (McClintock, 1941; Das and Baisakh, 2022).

In the present study, the laggards observed may be the result of delayed terminalization, the stickiness of chromosomes or the failure of chromosomal movement due to abnormal spindle formation, and as a result spindle fibers failed to carry the respective chromosomes to the polar region and resultantly lagging chromosome appeared (Tarar and Dnyansagar, 1980; Jayabalan and Rao, 1987; Das and Baisakh, 2022). The formation of laggards may also be due to chromosomal breakage by binding to DNA in GC-rich regions (Bhat et al., 2007). In the present study, lower doses rarely induced laggards in gamma rays and the frequencies of laggards were increased with increasing the dose of gamma-rays and MH in both the varieties. The moderate dose combination treatment G2M2 produced higher lagging chromosomes in comparison to single moderate dose mutagenic treatments (G2 or E2) in the variety OBGG-52 but in Sujata, it found different i.e., M2 > G2M2 > G2. Dose dependency result observed for the frequency of micronuclei in the present study. During telophase, a high frequency of micronuclei was observed at high-dose treatments of gamma rays as well as MH in both varieties. It was also found that the moderate dose combination treatment (G2M2) produced a higher frequency of micronuclei in comparison to single moderate dose mutagenic treatments (G2 or M2) in both varieties. Micronuclei might have arisen from the fragments and lagging chromosomes which failed to reach the poles and get included in the daughter nuclei (Kumar and Dubey, 1998; Das and Baisakh, 2022). The cytological study of the control plants had normal meiosis activities in comparison to mutagen-treated populations.

Cytological studies of these treatments revealed that there was an increase in the frequency of the total meiotic chromosomal abnormality as increased the mutagen dose of gamma rays and MH (Fig. 1) confirmed the observations of earlier workers (Dhamyanthi and Reddy, 2000; Bhat et al., 2007). Although the types of chromosomal abnormalities were common in both the varieties, the frequency of such aberrations was comparatively more in var. Sujata than the OBGG-52 indicates that it is more sensitive towards the mutagens (Table 1 and 2). Among the different doses or concentrations of mutagens, MH shows more chromosomal abnormalities than gamma-rays. Such chromosomal abnormalities may lead to the formation of nonfunctional spores. A dose dependent increase in meiotic abnormalities has also been reported by Ignacimuthu and Babu (1989) in urdbean (*V. mungo*) and mung beans (*V. radiata*).



(CAS: Chromosomal abnormality in Sujata, CAO: Chromosomal abnormality in OBGG-52, PSS: Pollen sterility in Sujata, PSO: Pollen Sterility in OBGG52)

Fig 1. Effect of gamma-rays and MH treatments on chromosomal aberrations and pollen sterility in greengram var. Sujata and OBGG-52

Pollen sterility is an index of the meiotic behavior. The reasons for pollen sterility in mutagenic treatments may be due to induced gene mutation or invisible deficiencies. In the present investigation, the pollen sterility (PS) was increased with the increases in the dose/concentration of both mutagens, i.e., gamma rays and MH treatments (Fig. 1). An exceedingly high percentage of sterility was observed at high-dose treatments of gamma rays and MH in both varieties (Tables 1, 2). Gamma-ray treatments recorded the maximum pollen sterility (7.81% in Sujata and 5.47% in OBGG-52) at the higher dose (60kR) whereas the minimum pollen sterility (2.11% in Sujata and 2.14% in OBGG-52) at a lower dose (20kR). In the case of MH treatments, the maximum pollen sterility (12.19% in Sujata and 10.23% in OBGG-52) was observed at 0.03%, and the minimum (4.27% in Sujata and 2.68% in OBGG-52) at 0.01%. In Combination treatment, the pollen sterility was observed at 9.70% in Sujata and 8.60% in OBGG-52. The negative effect of mutagens on pollen fertility may be due to the cumulative effects of various meiotic aberrations that occurred due to the induction of mutations. The increased pollen sterility with increasing doses of mutagens was also reported by several investigators in greengram (Das et al., 2006; Das and Baisakh, 2020; Das and Baisakh, 2022). The probable reason for increased pollen sterility might be due to more meiotic irregularities such as translocations (Das and Baisakh, 2020). Ramanna (1974) reported that any deviation in karyokinesis or cytokinesis could produce non-viable microspores. It may therefore be assumed that cytological disturbances due to any physical or chemical mutagenesis were responsible for pollen sterility. Moreover, due to the mutations caused by gamma rays and MH, the changed protein product because of changes in amino acid sequences might have affected the fertility of pollens. The relationship between chromosomal aberration and pollen sterility in different mutagenic treatments of both varieties are presented in Fig. 2 and 3 which suggest that induced pollen sterility may be the result of chromosomal aberrations and increases with increasing the frequency of the total chromosomal abnormalities in both varieties of greengram. Correlation coefficient values between chromosomal abnormality and pollen sterility due to mutagenic treatments (0.985 in Sujata and 0.969 in OBGG-52) were positive and highly significant. This agrees with many workers (Bhamburker and Bhalla, 1985; Das and Baisakh, 2022) who have also reported dose-dependent decrease in pollen fertility. Reduction in pollen fertility observed in mutagen treated population is attributed to the vast array of meiotic aberrations that were induced by mutagens leading to the formation of aberrant pollen grains (Rana and Swaminathan, 1964; Sinha and Godward, 1972). The relationship between diverse types of induced chromosomal abnormalities and pollen sterility in both varieties are presented in Fig. 4 and 5. The correlation coefficient values between diverse types of chromosomal abnormalities and pollen sterility were positive and significant in both varieties of greengram (Table 3).

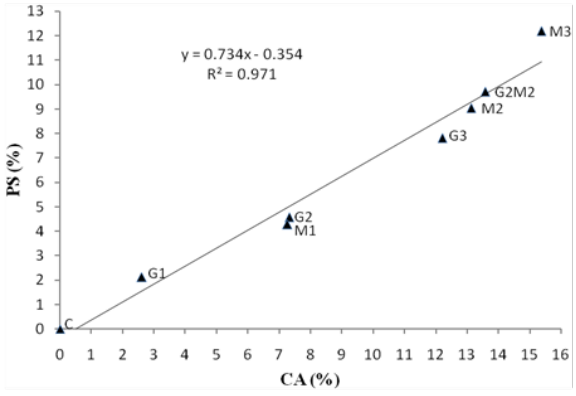


Fig. 2. Relationship between chromosomal aberrations and pollen sterility in different mutagenic treatments in greengram var. Sujata

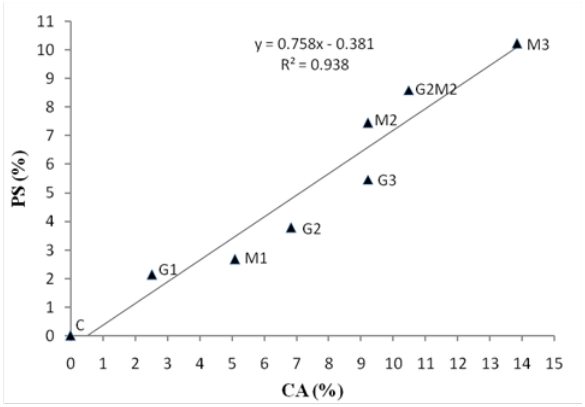
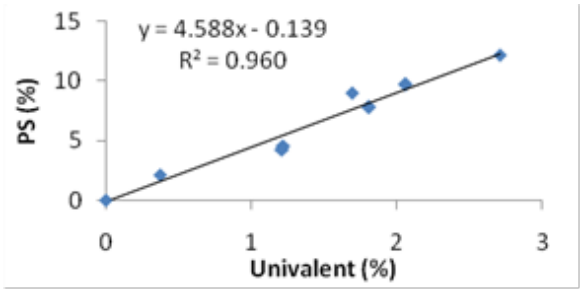
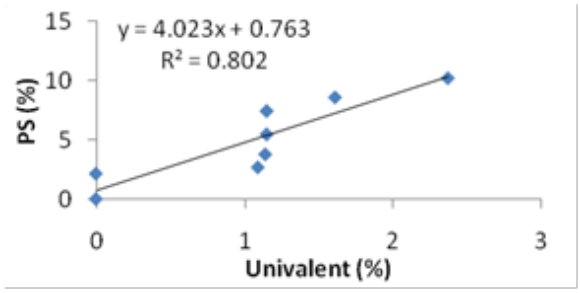
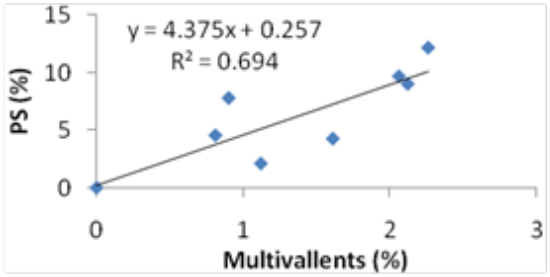
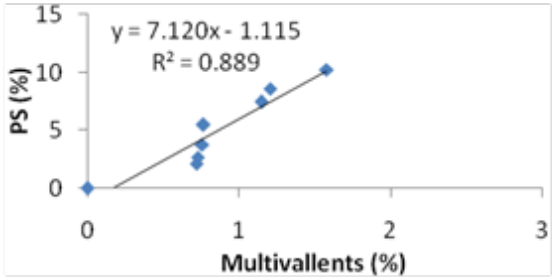


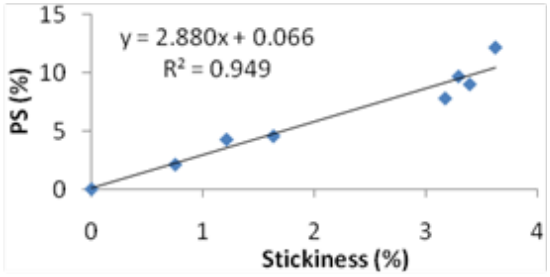
Fig. 3. Relationship between chromosomal aberrations and pollen sterility in different mutagenic treatments in greengram var. OBGG 52

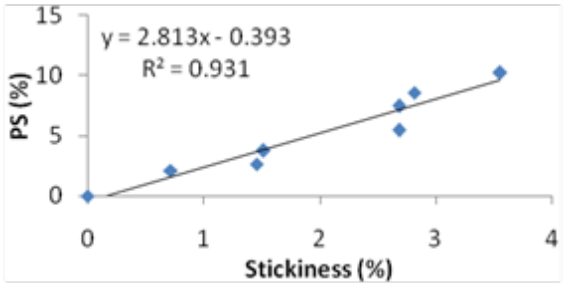

y = 4.588x - 0.139
R² = 0.960
PS (%)
Univalent (%)

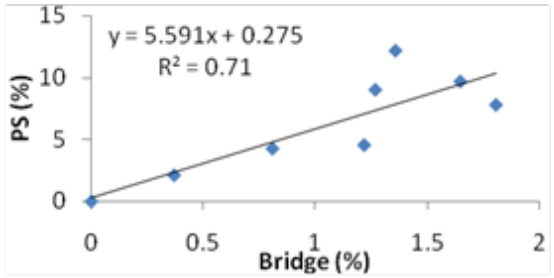

y = 4.023x + 0.763
R² = 0.802
PS (%)
Univalent (%)

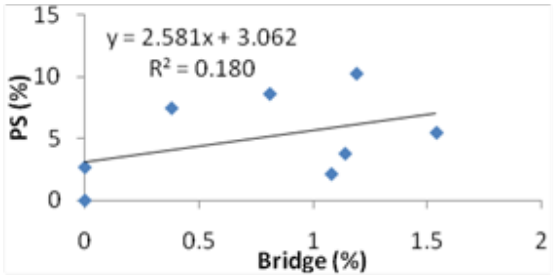

y = 4.375x + 0.257
R² = 0.694
PS (%)
Multivallents (%)

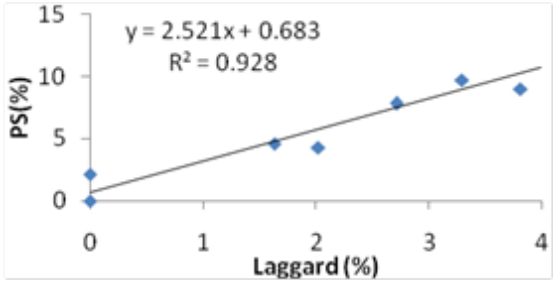

y = 7.120x - 1.115
R² = 0.889
PS (%)
Multivallents (%)

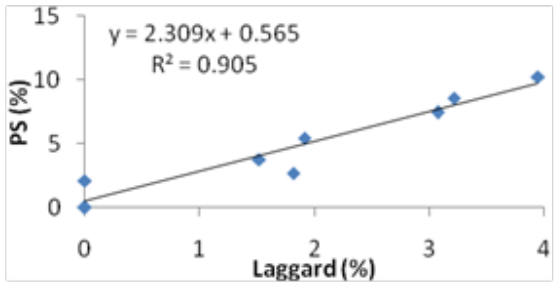

y = 2.880x + 0.066
R² = 0.949
PS (%)
Stickiness (%)


y = 2.813x - 0.393
R² = 0.931
PS (%)
Stickiness (%)


y = 5.591x + 0.275
R² = 0.71
PS (%)
Bridge (%)


y = 2.581x + 3.062
R² = 0.180
PS (%)
Bridge (%)


y = 2.521x + 0.683
R² = 0.928
PS(%)
Laggard (%)


y = 2.309x + 0.565
R² = 0.905
PS (%)
Laggard (%)

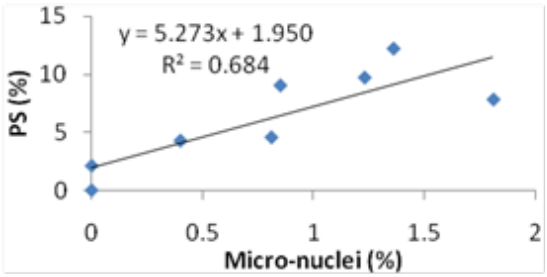


Fig. 4. Relationship between different chromosomal abnormality and pollen sterility in Sujata

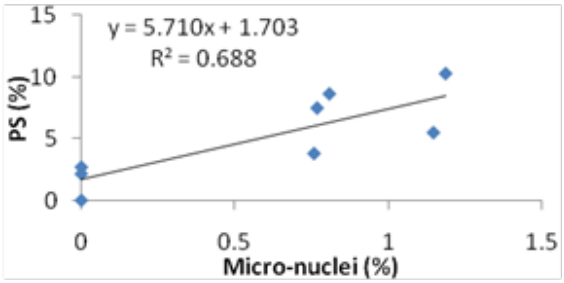


Fig. 5. Relationship between different chromosomal abnormality and pollen sterility in OBGG-52

Table 3. Correlation coefficient between different induced chromosomal abnormalities and pollen sterility.

Sl. No.	Chromosomal abnormalities	Correlation coefficient with pollen sterility	
		Sujata	OBGG-52
1	Univalent	0.980	0.896
2	Multivalent	0.833	0.943
3	Stickiness	0.974	0.965
4	Bridge	0.843	0.424
5	Laggard	0.964	0.951
6	Micro-nuclei	0.827	0.829

CONCLUSION

In the present investigation, various meiotic chromosomal variations i.e., univalent, multivalent, chromosome stickiness, laggards, bridges, and micronuclei were noticed in the gamma rays and MH-treated populations of both varieties of greengram whereas, the meiosis was normal in the control populations of both varieties. The percentage of chromosomal abnormalities as well as pollen sterility percentage increased with an increase in dose/concentration of gamma rays and MH. Based on the cytogenetic effect of different doses or concentrations of mutagens, MH shows more chromosomal abnormalities than gamma rays. A positive and significant correlation between chromosomal abnormality and pollen sterility was observed in this study. The relationship between chromosomal variations and pollen sterility suggested that induced pollen sterility may be due to the induced mutation in chromosomes and chromosomal aberrations which induce for production of a changed protein product as a result of changes in amino acid sequences and this changed protein product might have affected the morphology and fertility of pollen grains thus pollen sterility observed. It is concluded that both the mutagens are effective in inducing genetic variability for the improvement of greengram. Even though all mutations are not beneficial, it is the skill of a researcher to select the appropriate dose, mutagen, plant characters, purposes, and methods for breeding programmes to improve yield and other desirable characters in greengram.

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Conserving crop wild relatives of North-East India for sustainable agriculture

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ABSTRACT

Crop wild relatives (CWRs) offer valuable genetic resources for breeding better crop varieties, making agriculture more sustainable and resilient to meet global challenges like climate change. India occupies a significant position in the global conservation landscape due to its exceptional biodiversity. The Northeast region, located within the Indo-Burma Hotspot, contributes significantly to this diversity. CWRs in this region hold untapped potential for improving crop diversity, yet there remains a huge number of CWRs that are poorly documented and conserved. Consequently, the identification, documentation, and conservation of these wild resources are vital for agriculture. The Northeast region's tribal communities, constituting around 12% of India's tribal population, possess traditional knowledge about plant utilization and conservation. Their involvement is pivotal in preserving CWRs and their habitats. Effective CWR conservation calls for collaboration among research institutions, non-governmental organizations and local communities to preserve the genetic diversity inherent in Northeast India. Notable CWRs in Northeast India include wild rice, citrus relatives, wild bananas, brassicas, legumes, turmeric-ginger species and many more. The conservation of CWRs is not only crucial for biodiversity preservation but also for the future of agriculture. Raising awareness among the public, policymakers and agricultural communities is essential to ensure the conservation and utilization of CWRs.

Key words: Conservation, crop wild relatives, North-East India, traditional knowledge

INTRODUCTION

Crop wild relatives (CWRs), also known as wild progenitors or wild relatives of crops, are plant species that are closely related to cultivated crops. These are found in their natural habitats as wild plants. They often share common ancestors with cultivated crops and, therefore, these wild plants may be genetically similar to the domesticated crops. Maxted et al. (2006) defined CWR as “a wild plant taxon that has an indirect use derived from its relatively close genetic relationship to a crop”. Conservation and utilization of crop wild relatives are essential for sustainable food production as they provide valuable genetic resources to the breeders to develop novel crop varieties with improved crop yield, quality etc. to face global challenges of climate change. In other words, CWRs are the hidden treasures of valuable genes in the world of plants.

McNeely (1990) designated India as one of the twelve mega-diversity countries in the world and that research findings played a major role in placing India prominently on the global conservation landscape. Earlier, Myers (1988, 2000) delineated 'hotspots' of global biodiversity, identifying regions with both exceptional biological diversity and high endemism, yet facing significant anthropogenic threats. Northeast India, which lies between 21°

50′ and 29° 34′ N latitude and 85° 34′ and 97° 50′ E longitude, is considered as one of the most biologically diverse places in India. The Northeast India forms a distinctive part of the Indo-Burma Hotspot which ranks 6th among the 25 biodiversity hotspots of the world (Tandon et al., 2009). The diverse landscape and bio-geographical features of this region contribute to creating an ecologically rich environment. Pradheep et al. (2017) stated that the richness in biodiversity is commonly attributed to the diverse topography and extensive forest coverage present in this region. Approximately 45% of the country's total plant species are found in this region, showcasing a remarkable biodiversity of both flora and fauna. Moreover, this area serves as a vital genetic treasure trove for a wide range of agricultural and horticultural crops. It is home to several important CWRs that are closely related to cultivated crops many of which are yet to be properly documented and studied. Wild relatives of crops provide a vast resource of genetic diversity for breeding new, higher yielding, climate resilient crop varieties, but unfortunately there are a lot of species that are still under-conserved in NE India. Therefore, identification, documentation and conservation of the plants, particularly crop wild relatives in North East India, is of great importance in agriculture.

KEY ASPECTS OF CWR CONSERVATION IN NORTH-EAST INDIA

India is known for its indigenous plants that are used to cure various diseases (Gogoi and Bhoutekar, 2017). However, the decline in biodiversity has become a worldwide concern these days. Crop wild relatives are also confronting threats in their natural habitats due to various human activities. Pradhan and Nayak (2017) stated that many of the species are in the verge of extinction due to habitat loss. In the North Eastern region of India, which encompasses a significant portion of the country's forest cover, is losing its forest cover consistently to the extent of 765 square km (0.45%) in all the states except Assam and Tripura (Anonymous, 2019).

The wild relatives of crop plants of NE India can be conserved using two broader strategies, viz., *in situ* and *ex situ* conservation.

In situ conservation of CWR populations in their natural habitats allows these plants to evolve and adapt naturally while maintaining ecological balance. Conservation efforts may include the protection of natural habitats of CWRs by designating protected areas, national parks, or community reserves to safeguard the ecosystems in which these wild relatives thrive. For this, the identification of hot spots as well as critical habitats of CWRs for *in situ* conservation is an important thrust area for this NE region. A site or population that has been identified as having rare, threatened, or high levels of genetic diversity is worthy of joining the national, regional, or global networks. Maxted et al. (2015) showed the actual process of a site/population joining the network (Fig. 1).

One of the crucial cornerstones for conserving the CWRs in Northeast India lies in the active involvement and participation of indigenous communities. The Northeast region is primarily inhabited by tribal communities who hold a wealth of traditional knowledge. This area is home to over 200 distinct tribal groups, comprising approximately 12 per cent of India's total tribal population (Ali and Das, 2003; Ganguly, 2016). These tribal communities, residing in biodiverse environments, possess a profound knowledge on conservation and utilization of plants viz., endemic food plants, medicinal plants, CWRs and their habitats. The deep-rooted traditional knowledge of these people about the local ecosystems is invaluable for the preservation of these vital plant resources. Recently, emphasis has been given on greater use of local and traditional or indigenous knowledge alongside conventional scientific knowledge in making decisions about biodiversity and natural resources (Fazey et al., 2006; Raymond et al., 2010). In 2010, parties to the UN Framework Convention on Climate Change adopted a decision on ‘enhanced action on adaptation’ that identified the need to draw attention on traditional and indigenous knowledge as the best available science.

The United Nations Development Agenda (UN, 2012) also acknowledges their importance, stating "traditional and indigenous knowledge, adaptation and coping strategies can be major assets for local response strategies". Therefore, *in situ* conservation of wild relatives can be achieved by creating awareness among the local people. Public awareness and community-based programmes should be encouraged for conservation (Sahoo et al., 2016). Further, providing special incentives to local people for growing and maintaining these precious wild resources may also aid in conservation.

Moreover, the fundamental step in CWR conservation is the collection of seeds, plant material, or genetic resources from unique wild relatives, which are endemic to NE India, to be stored in seed banks, gene banks, or living collections to ensure their long-term preservation. It ensures the preservation of genetic diversity for future breeding programmes.

CWRs are valuable genetic resources for crop improvement. Therefore, comprehensive documentation of CWRs is of utmost importance as it helps the breeders to incorporate desirable traits from wild relatives into cultivated crops. Generation of passport data and preparation of inventory on endemic CWRs should be prioritized.

An effective approach to conserve CWRs necessitates collaboration among research institutions, non-governmental organizations (NGOs), and local communities to collectively work towards preserving the invaluable genetic diversity present in Northeast India. For that raising awareness among the local people about the importance of CWRs and their role in sustaining agriculture is of paramount significance to protect the region's CWRs.

Most of the *ex-situ* conservation of germplasm have been done in the National Gene Bank, New Delhi. The Regional Gene Bank Module with medium-term storage at Barapani, Meghalaya, is also associated with *ex situ* conservation in the region. AAU-ARRI, Titabor, Jorhat, Assam has also been maintaining 7000 accessions of different rice cultivars.

MAJOR IMPLICATIONS OF CROP WILD RELATIVES IN CROP IMPROVEMENT PROGRAMMES

CWRs may play a significant role in crop improvement programmes by offering a wealth of wide genetic diversity. The genetic diversity of CWRs can be used to develop novel crop varieties. By conserving and utilizing CWRs, we ensure the preservation of genetic resources that may be critical for future crop improvement efforts. CWRs often thrive in diverse and challenging environments. These are rich sources of valuable traits like resistance to biotic and abiotic stresses. Further, they are the potential sources of genes for developing climate-resilient crops that can thrive in challenging conditions, such as flood, drought, extreme temperatures, cold etc. CWRs possess natural resistance to pests and diseases and these traits can be transferred to cultivated crops through breeding to reduce the reliance on chemical pesticides.

NOTABLE CROP WILD RELATIVES FOUND IN NORTH-EAST INDIA

The Northeastern part of India region is a hotspot for wild rice species. Hore (2005) stated about occurrence of wild relatives of cultivated rice in the NE region. Intermediate forms between cultivated and wild species, viz., *Tulsibaon, Bogibaon* and *Kenkuabaon* were also observed. The major wild species found in the region are *Oryza rufipogon, O. granulata, O. officinalis, O. nivara* and *O. meyeriana*. Further, some closely related taxa were also reported namely *Hygrorhiza aristata, Leersia hexandra* and *Zizenia latifolia* (Hore and Sharma, 1993). Recently, in 2022, Borjuli, Sonitpur District, Assam was notified as a Wild Rice Biodiversity Heritage Site considering the significant populations of *O. rufipogon* in this area. This was done under the initiatives of ICAR-NBPGR.

The region is also recognized as a centre of origin for Citrus (L.) species and is home to several wild and endangered Citrus species, including *Citrus indica, Citrus macroptera, Citrus latipes,*

Citrus ichagensis and *Citrus assamensis,* which thrive in their native and undisturbed habitats (Hynniewta et al., 2013).

Table 1. Some of the endemic crop wild relatives of NE region

Name of the plant species	Area
Neoluffa sikkimensis	Sikkim, North-eastern region
Trichosanthes khasiana; T. ovata, T. bracteata var. tomentosa	Khasi Hills, North-eastern region, southern Western Ghats
Amorphophallus bulbifera, A. campanulatus	Khasi Hills (Meghalaya) and eastern Himalaya (Sikkim) and Deccan Plateau
Dioscorea alata	Western and North-eastern Himalaya
Docynia hookeriana	North-eastern Himalayan region
Mangifera khasiana; M. sylvatica	Assam, West Bengal and Tripura, Arunachal Pradesh
Musa cheesmanii; M. flaviflora (Musa thompsonii)	Assam, Manipur and Meghalaya
Prunus acuminata; P. jenkinsii	Central and eastern Himalaya, Upper Assam and Arunachal Pradesh
Rubus burkillii; R. lanatus, R. lineatus	Namdapha Biosphere Reserve (NEH Region), Kumaon to Sikkim Himalaya
Camelia caudata; C. kissi, C. drupifera, C. lutescens	Namdapha Biosphere Reserve (NEH region), North-eastern India
Eurya runachalensis, Gordonia excelsa, Schima wallichi	North-eastern India
Saccharum sikkimensis, S. benghalensis, S. ravennae	Sikkim Himalaya, NEH region

Source: Pandey et al. (2005)

Further, wild Musa spp. are largely distributed in North-Eastern States, Western Ghats, Eastern Ghats and Andaman and Nicobar Islands (Joe and Sabu, 2016). In Northeastern India in Khasi, Jaintia, Naga, Patkai and Garo hills, wild Musa species may occur also at both lower and higher altitudes. The region hosts wild banana species, like *Musa balbisiana*, which are important for breeding programs. This is one of the hotspots of biodiversity for crop genetic resources and neighbouring to the centre of origin for Brassica, i.e. Indo- Chinese region. The region also houses wild legume species related to cultivated crops like mung beans and kidney beans, which can provide traits for better yields and resistance to pests and diseases.

Further, primitive type of maize had been reported from this region. Ginger, turmeric, chilli, cinnamon and large cardamom have wild relatives in this region. The variability is very high in turmeric, chilli and ginger (Upadhyay and Sundriyal, 1998). Some of the CWRs endemic to the NE region are presented in Table 1. Since the endemic species are region specific, therefore, endemism signifies uniqueness of this region (Chatterjee et al., 2006).

CONCLUSION

Crop wild relatives and traditional landrace varieties contain a vast array of beneficial traits that are essential to improve the resilience of crops in harsh climates and to sustain global food supplies. Therefore, to sconserve crop wild relatives in Northeast India there is the need to raise awareness among the public, policymakers and agricultural communities about the importance of Crop wild relatives and their conservation in the days to come.

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Identification of physiological traits governing drought tolerance through principal component analysis in greengram [*Vigna radiata* (L.)Wilczek] germplasm accessions

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ABSTRACT

An experiment was conducted to identify most important physiological trait governing drought tolerance in greengram [*Vigna radiata* (L.) Wilczek] through principal component analysis (PCA). Two hundred germplasm accessions along with five check entries were evaluated in an augmented design during summer 2015 by imposing drought stress condition. Observations were recorded on six physiological traits viz; harvest index, spad chlorophyll meter reading, leaf water potential,proline content, relative water content and specific leaf area. Mean squares of attributes to 'genotypes vs check entries' were significant for all the physiological traits except relative water content. Principal component analysis was carried out for 6variables showing positive correlation with yield to identify most important physiological trait governing drought tolerance.The first two factors explained 88.03 % of the total variability controlled by physiological traits. Highest factor loadings / component coefficients were recorded by proline content (0.98) followed by spad chlorophyll meter reading, leaf water potential (0.92), relative water content (0.87), harvest index (0.78) and specific leaf area (0.72).Among the six variables studied, proline content (21.03) had highest per cent contribution to the total variabilityfollowed by leaf water potential (18.63), spad chlorophyll meter reading (18.61), relative water content (16.82), harvest index (13.30) and specific leaf area (11.58). Thus, the study identified proline content as the most important physiological trait governing drought tolerance in greengram.

Key words: Drought tolerance, greengram, PCA, physiological trait, proline

INTRODUCTION

Greengram is leguminous plant species belongs to the family Fabaceae with the chromosome number of 2n=22. It is the self-fertilized species, originated from south Asia with the possible progenitor of *Vigna radiata* var. sublobata. Greengram is an important edible bean in the human diet worldwide (Goud et al., 2022).

It is an important short-duration grain legume having wider adaptability and low input requirements (Das and Baisakh, 2022). The crop fits very well in Rice-pulse cropping system of major Rice growing areas (Mahunta et al., 2018). Greengram is one of the principal legumes and is a very nutritive crop grown for its high protein seeds (Singh et al., 2017). India is the major producer of greengram in the world and grown in almost all the States. It is grown in about 36 lakh hectares with the total production of about 17 lakh tonnes of grain with a productivity of about 500 kg ha^{-1}. Since it is rich in protein, it can be considered as the meat for vegetarians (Sumi et al., 2021). Essential amino acids especially lysine and tryptophan are mainly found in greengram along with other proteins (Chakraborty et al., 2021). It is highly consumed legume and has the ability to withstand wide environmental conditions (Patil et al., 2021). The crop is considered to be potential crop because of its tolerance to drought and high temperature (Brijal et al., 2020 ; Batzer et al., 2022). It is quite versatile crop which can be grown for seeds, green manure and forage (Singh et al., 2023) besides, the crop can restore soil fertility by biological nitrogen fixation and so adds value in the rice-wheat rotation (Kaur et al., 2021 ; Alipour et al., 2023). Average productivity of mung bean in India is one of the lowest compared to world average. The reasons attributable to lower productivity of greengram in India are; 1) Greengram is mainly grown as a fallow crop in rabi or late rabi season utilizing available residual soil moisture after harvesting main kharif crop. Hence crop is expected to experience several kinds of droughts during its cropping period. 2) It is cultivated on marginal and poor fertile soils under rainfed condition. 3) Crop is likely to experience severe droughts in days to come because of climate change and global warming which are adding to the woes of reduced soil moisture availability to crop production. Despite holding such a great promise, mung bean is often grown in mostly rain-fed lands with limited inputs making it prone to a number of abiotic stresses. One of the most sensitive sectors to climate change is agriculture (Akbari et al., 2023). Among these stresses, drought is the major stress leading to heavy crop loss. Soil moisture deficit is a multidimensional stress affecting plants at various levels of their growth (Yordanov et al., 2000). Greater emphasis is now laid on increasing the productivity and thereby the total production of pulses under stress conditions (Sathyamoorthi et al., 2023).

Contemporary climate change is exposing plants to drought stress and other abiotic stress conditions (Elena et al., 2021). Pulses are more sensitive to high temperature stress at reproductive stage (Partheeban et al., 2017). During the reproductive stage, high temperature causes flower drop, induce male sterility, impair anthesis and shortens the grain-filling period (Partha et al., 2019). Yield is dependent on various factors, like morpho-physiological traits and response to various environmental factors (Daizi et al., 2023). Presence of the genetic variability and suitable selection criteria is imperative for screening of genotypes for heat tolerance (Bhatti et al., 2023). New improved crop varieties developed through breeding programmes can help up-lift farmers economic status (Bert et al., 2019). The major constraints in achieving higher productivity are; lack of exploitable genetic variability and absence of suitable ideotype for different cropping systems (Chippy et al., 2021). The molecular mechanisms driving capacity of plants to memorize a stress and generate stress resistant progenies are still unclear (Anna et al., 2020).

Studying water stress through quantification of physiological responses of plants under water stress is a viable, reliable and accurate approach. Selection efficiency in breeding for water stresscould be enhanced if particular physiological or morphological attributes related to yield under stress environment could be identified and employed as selection criteria for complementing traditional plant breeding. While designing a breeding program to improve drought tolerance of a crop plant, it is necessary to gain knowledge concerning both the genetics and physiological mechanisms. Therefore, physiological traits with strong correlation with response of plants to drought are crucial in understanding and exploring water stressmechanisms

Multivariate analysis such as principal component analysis (PCA), usually starts out with data involving a substantial number of correlated

variables. Principal Component Analysis (PCA) is a very powerful dimension-reduction tool that can be used to reduce a large set of variables to a small set that still explains most of the information of the large data set thus,reducing the dimensionality of large data sets which are often difficult to interpret. The first principal component with highest PCA coefficients / eigenvalue accounts for as much of the variability in the data as possible and each succeeding component accounts for as much of the remaining variability as possible with corresponding eigen values /PCA coefficients. The present study was taken up with an objective to identify most important physiological trait governing drought tolerance in greengram, so that this trait acts as an important selection criteria for breeding crop varieties for drought tolerance.

MATERIALS AND METHODS

The experiment was conducted at Research Farm of College of Agriculture, Hassan, University of Agricultural Sciences, Bengaluru, India. The experimental site is geographically located at Southern Transitional Zone (Zone-7) of Karnataka with an altitude of 827 m above Mean Sea Level (MSL) and at 12.97° N latitude and 75° 33′ to 76° 38′ E longitude. The study material consisted of 205 germplasm accessions of greengram [*Vigna radiata* (L.) Wilczek] collected from different research institutions / organizations representing different agro-climatic zones. List of germplasm accessions possessing minimum and maximum values for the traits under study is given in Table 1.

Table 1. List of germplasm accessions possessing minimum and maximum values for the traits under study

Sl. No	Traits	Genotypes with minimum value for the trait		Genotypes with maximum value for the trait	
1	HI	CNS-9	20.51	LGG-582	48.50
2	SCMR	IC-39605	36.58	LGG-579	72.91
3	LWP	AKL-39	-8.14	AKL-216	-2.15
4	PC	COGG-954	62.70	VGG10-010	201.33
5	RWC	PLM-92	33.62	AKL-79	99.11
6	SLA	CGG-973	31.96	KM13-9	265.30

Layout of the experiment

The experiment was conducted in an Augmented Randomized Complete Block Design with 205 germplasm accessions. As per the augmented RCBD, the check entries were replicated twice randomly in each block. There were 5 blocks, each block had 5 plots of size 3x3 m^2 thus each block size was 15 m^2. The gross area of experimental plot was 75 m^2. The row spacing was 30 cm and inter plant distance was 10 cm. The experiment was conducted during summer 2015. Recommended practices were followed to raise healthy crop.

Imposing drought condition

Drought condition was imposed by withholding irrigation 25 days after sowing (Baroowa and Gogoi, 2015; Pooja et al., 2019). Since the experiment was conducted during summer season, there were no unpredicted rains during the entire cropping period hence the drought condition was effectively imposed. The rainfall data of experimental site during the cropping period is given in Table 2.

Plant sampling and data collection

Observations were recorded on five randomly chosen competitive plants from each germplasm accession for all the characters except days to 50% flowering and days to maturity, which were recorded on plot basis. The values of five competitive plants were averaged and expressed as mean of the respective characters. The observations were taken on the traits like; Harvest index (%), SCMR (SPAD Chlorophyll meter reading), Leaf water potential (Mpa), Proline content ($\mu g\, g^{-1}$), Relative water content, Specific leaf area and Seed yield per plant.

Statistical analysis

Analysis of variance (ANOVA)

The trait mean value of five randomly selected plants in each of the genotype and check entries were used for statistical analysis. ANOVA was performed to partition the total variation among genotypes and check entries into sources attributable to 'Genotypes+Check entries', Genotypes', Check entries' and Genotypes vs check entries', following the augmented design as suggested by Federer (1956) using statistical package for augmented design SAS version 9.3 and IndoStat. The adjusted trait mean of each of the genotype was estimated (Federer, 1956) and the same was used for all subsequent statistical analysis.

Table 2. Meteorological data of experimental site for the year 2015

Months	Temperature (°C)			Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum	Average		
January	28.25	15.00	21.32	61.03	0.59
February	30.35	15.25	23.10	50.72	Nil
March	31.70	19.50	25.34	58.70	2mm
April	32.50	21.25	25.87	66.55	Nil

Correlation co-efficient analysis

To determine the degree of association of physiological characters with yield under drought stress, the correlation coefficients were calculated.

Phenotypic coefficient of correlation between two variables was determined by using variance and covariance components as suggested by Al-Jibouriet al. (1958).

Where, rp (xy) is the phenotypic correlation coefficient and Covp(xy) is phenotypic co-variances

The calculated value of 'r' was compared

$$r_p(xy) = \frac{Cov_p\,(xy)}{\sqrt{\sigma 2_p(x)\ X\ \sigma 2_p(y)}}$$

with 't' table value with n-2 degree of freedom at 5 per cent level of significance.

Principal component analysis

Factor analysis, using the Principal Component Analysis (PCA) as extraction method and Varimax rotation, was performed to verify if the assay data variation and obtained factors to explain genotype performance and identify drought tolerance controlling physiological factors. Biplot analysis was presented by first two principal component analysis (PCA) which were computed based on rank correlation matrix using data from 6 physiological traits by Microsoft Excel (2007) and XLSTAT 2014, Copyright Addinsoft 1995-2014 (http://www.xlstat.com) as described by Iqbal et al. (2014)

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance revealed highly significant mean squares attributed to germplasm accessions for all the traits. Significant mean squares were recorded for all the traits (Table 3). Mean squares attributed to 'Genotypes vs check entries' were found significant for all the traits except relative water content. These results suggest significant differences among the germplasm accessions. The germplasm accessions as group, differed significantly for all of the traits under investigation, similarly, check entries as group, differed significantly for most of the traits under study.

Table 3. Summary of Augmented ANOVA for physiological traits of germplasm accessions under drought condition

Sources of Variations	DF	HI	SCMR	LWP	PC	RWC	SLA
Blocks (b)	4	247.54 **	396.55 **	1.17 **	470.90 **	423.68 *	4067.34 *
Entries (e)							
(Genotypes + Checks)	204	54.41 *	98.71 **	2.45 **	1707.90 **	425.40 **	4283.10 **
Checks	4	64.39 *	24.49	0.82 **	942.07 **	63.06	1924.20
Genotypes	199	53.01 *	79.58 *	2.33 **	1712.67 **	433.68 **	4294.15**
Checks vs Genotypes	1	293.20 **	4203.25 **	32.57 **	3822.09 **	227.32	11518.68**
Error	16	19.57	31.14	0.03	1.48	130.64	1339.95

*Significant at P =0.05, ** Significant at P=0.01

Multivariate Analysis

PCA is a mathematical procedure that transforms a greater number of correlated variables into a smaller number of uncorrelated variables called principal components. Principal component analysis has to be performed only for those traits (independent variables) having positive correlation with dependent variable yield. Hence, correlation studies were first carried out to identify traits to be considered for principal component analysis

Correlation coefficient analysis

Correlation coefficients are used to measure the strength of the relationship between two variables (dependent and independent). Pearson correlation is one of the most commonly used statistic hence, Pearson correlation was performed and is presented in Table 4.

Table 4. Correlation matrix (Pearson (n))

Variables	HI	SCMR	LWP	PC	RWC	SLA	SYPP
HI	1	0.70*	0.70*	0.74*	0.61*	0.34*	0.60*
SCMR	0.70*	1	0.80*	0.91*	0.79*	0.60*	0.62*
LWP	0.70*	0.80*	1	0.93*	0.77*	0.60*	0.61*
PC	0.74*	0.91*	0.93*	1	0.86*	0.67*	0.63*
RWC	0.61*	0.79*	0.77*	0.86*	1	0.66*	0.51*
SLA	0.34*	0.60*	0.60*	0.67*	0.66*	1	0.41*
SYPP	0.60*	0.62*	0.61*	0.63*	0.51*	0.41*	1

Values in bold* are significantly different at alpha=0.05

Principal component analysis

Principal component analysis of physiological traits governing drought tolerance was performed and eigenvalues are presented in Table 5. The first two factors explain 88.03 per cent of the total variability controlled by physiological traits. Highest factor loadings / component coefficients were recorded by proline content (0.98) followed by Spad chlorophyll meter reading, leaf water potential (0.92), relative water content (0.87), harvest index (0.78) and specific leaf area (0.72).

Table 5. Eigen values of PCA for physiological traits

Descriptives	F1	F2	F3	F4	F5	F6
Eigen value	4.59	0.68	0.28	0.22	0.18	0.02
Variability (%)	76.60	11.43	4.69	3.78	3.10	0.38
Cumulative %	76.60	88.03	92.73	96.51	99.61	100.00

Factor loadings / component coefficient values of PCA of 6 different traits have been presented in Table 6.

Table 6. Factor loadings / component coefficient values of PCA

Traits	F1	F2	F3	F4	F5	F6
Harvest index	0.78	-0.51	-0.25	-0.22	-0.04	-0.006
Spad chlorophyll meter reading	0.92	-0.07	0.05	0.07	0.35	-0.04
Leaf water potential	0.92	-0.09	0.01	0.28	-0.21	-0.06
Proline content	0.98	-0.03	0.04	0.11	-0.004	0.12
Relative water content	0.87	0.16	0.34	-0.26	-0.08	-0.01
Specific leaf area	0.72	0.61	-0.30	-0.06	-0.007	-0.008

Among the six variables studied, proline content (21.03) had highest per cent contribution to the total variability possessed by physiological traits followed by leaf water potential (18.63), spad chlorophyll meter reading (18.61), relative water content (16.82), harvest index (13.30) and specific leaf area (11.58) (Table 7 and Fig. 1).

Table 7. Per cent contribution of the physiological traits to the total variability in PCA

Traits	F1	F2	F3	F4	F5	F6
Harvest index	13.30	39.20	22.89	23.06	1.33	0.18
Spad chlorophyll meter reading	18.61	0.81	1.13	2.75	68.46	8.22
Leaf water potential	18.63	1.24	0.09	36.43	25.82	17.77
Proline content	21.03	0.17	0.70	6.01	0.008	72.07
Relative water content	16.82	4.13	43.23	30.01	4.32	1.45
Specific leaf area	11.58	54.42	31.94	1.71	0.02	0.29

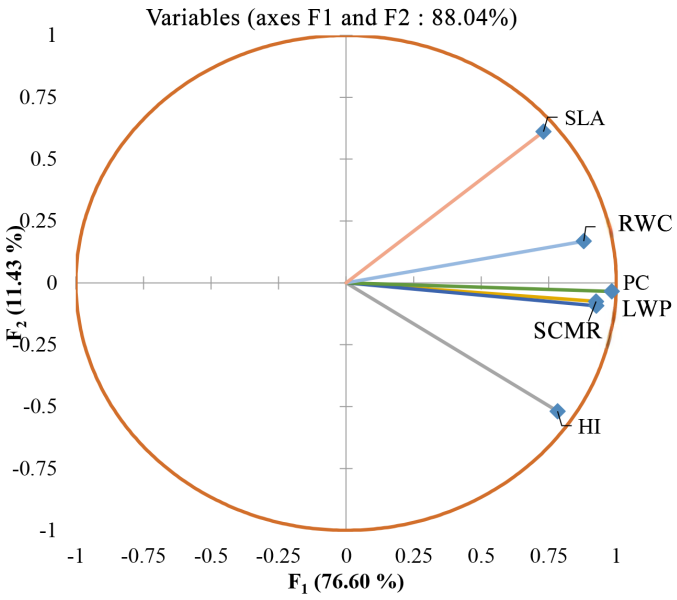

Fig. 1. Loading plot of principal component analysis for six drought tolerant physiological variables

CONCLUSION

The study identified proline content as the most prominent physiological trait governing drought tolerance in greengram. Hence, proline can be used as one of the potential physiological trait to identify drought tolerant genotypes.

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Ocimum basilicum var. *pilosum* (Willd.) Benth.: A new distributional record of wild sweet basil from Odisha

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ABSTRACT

The genus *Ocimum* Linn. (Lamiaceae), commonly called as basil, is highly valued for its medicinal properties in indigenous as well as modern pharmacological system. It is also used in perfumes, cosmetics and food industries and associated with diverse Indian cultural traditions. The members are widely distributed in tropical and subtropical regions of Asia, Africa and South America. During the investigation for germplasm collection in parts of Odisha, the natural occurrence of *Ocimum basilicum* var. *pilosum*, a wild sweet basil, was explored first time from undomesticated habitats of the state. On elucidative review, its natural occurrence in Odisha is found to be a new taxonomic record for the flora of Central and Eastern India. The present communication deals with information on its taxonomic description, phenology, germplasm collection and photographs to facilitate easy identification and rational use.

Key words: Eastern and central India, new record, Odisha, sweet basil

INTRODUCTION

Ocimum Linn. belonging to the tribe *Ocimeae* of family *Lamiaceae*, is a large and diversified genus of annual, biennial, or perennial herbs and sub-shrubs of high economic importance due to the presence of essential oils. It is used in traditional medicines including antiseptics, perfumes, cosmetics, cleaning products, food industries and associated with several Indian cultural traditions. The plant is highly valued for its therapeutic properties in traditional as well as modern pharmacological system. The genus *Ocimum* has complex taxonomy attributed to the occurrence of large number of subspecies, varieties, and cultivars on account of high degree of polymorphism and biochemical variability in essential oils which offer diverse medicinal potential (Paton et al., 1992; Pandey et al., 2014; Misra and Das, 2016). *Ocimum* oil exhibited several biological properties like insecticidal, nematocidal, fungistatic, anti-bacterial including antioxidant, anti-aging, anti-inflammatory, anti-carcinogenic and cardio-vascular agents (Zhang et al., 2009). The genus comprises approximately 30 to 160 species (Charles and Simon, 1990; Pushpagandan and Bradu, 1995; Mabberley, 1997; Gill et al., 2012), mainly distributed in the tropical and warm temperate regions of the world such as Africa, Asia, South America (Sobti and Pushpagandan, 1982; Vieira and Simon, 2000). However, out of 327 scientific plant names of species rank, *Ocimum* has 66 accepted species names and the rest were placed as synonyms and unassessed (Anonymous, 2014). India is represented by 9 species (including three exotics) mainly confined to tropical and peninsular regions (Anonymous, 1966).

Ocimum basilicum L., the common basil or sweet basil, an annual aromatic culinary herb, native to Southeast Asia, is cultivated throughout the greater part of India and has significant economic value

(Anonymous, 1966). The morphology of the species is very variable and its botanical nomenclature is complicated. It shows high polymorphism and classified into 2 to 6 varieties based on growth habit, stem or leaf colour, leaf shape, degree of hairiness on branch, petiole, leaves, and peduncle etc. (Drury, 1866; Gamble, 1925; Matthew, 1982; Rawat et al., 2016). O. *basilicum* var. *pilosum*, one of such varieties, a potential medicinal herb with sharp pungent aromatic odour, mainly distributed in tropical and subtropical regions of Asia: China and India (Drury, 1866; Hooker, 1885; Wu and Li, 1977; Zhang et al., 2009) was reported in wild condition from peninsular region of India (Gamble, 1925; Matthew, 1982; Mohanan and Henry, 1994; Pullaiah et al., 2011). In the present report, the natural occurrence of O. *basilicum* var. *pilosum*, a high valued medicinal and aromatic species, from Odisha forms new plant record for Eastern and Central India.

MATERIALS AND METHODS

During exploration for germplasm collection of medicinal and aromatic plants in parts of Odisha, the first author noticed the occurrence of one peculiar wild species of *Ocimum* at different locations in Sundargarh and Dhenkanal districts of Odisha (Fig. 1. A-C). A total number of nine germplasm accessions of this species were collected from northern plateau and central table land phyto-geographical zones of Odisha. The seed germplasm was collected on-spot from exploration sites bearing respective accession number and conserved in the National Gene Bank, NBPGR, New Delhi for long term storage (Table 1). Further, the seeds were multiplied, and live plants were maintained and characterized in experimental plots of NBPGR Base Centre, Cuttack (Fig. 1.D). The plant voucher specimens bearing both vegetative and flowering parts were deposited in the herbarium of NBPGR base centre, Cuttack, Odisha along with one set at the National Herbarium of Cultivated Plants, NBPGR, New Delhi. The live plants and herbarium specimens were meticulously studied and cross-checked with the plant descriptions and references cited in the Indian literature and abroad. Further, the morphological features of the plant were examined using the trinocular lens and dissection microscope and the distinctive characters were described. The photographs of the vegetative, flowering or fruiting and the seeds along with the associated species in the natural habitat were taken for reference and future use.

RESULTS AND DISCUSSION

After thorough examination of the vegetative and floral characters of live plants coupled with study on herbarium specimens and perusal of literature (Drury, 1866; Gamble, 1925; Matthew, 1982), the species was identified as *Ocimum basilicum* var. *pilosum* (Willd.) Benth., a species reported in wild state so far only from Kerala, Tamil Nadu, and Andhra Pradesh (Matthew, 1982; Henry et al., 1987; Mohanan and Henry, 1994; Pullaiah et al., 2011; Sasidharan, 2011). It was observed that the plants were found growing luxuriantly in wild habitats and its occurrence has been recorded at nine locations of Sundargarh and Dhenkanal districts, part of central table land and northern plateau zones of Odisha. On verification of major published Indian literature, it was found that it has not been reported till date in wild condition from Central and Eastern India including Odisha (Haines, 1922; Mooney, 1950; Saxena and Brahman, 1995; Mudgal et al., 1997; Singh and Karthikeyan, 2000; Singh et al., 2001). Therefore, the present collection counts an addition of species to the flora of Odisha and forms a new distributional record for Eastern and central India. A detailed taxonomic description on morphology of different parts of the plant species along with field photographs (Fig. 1. E-H), ecology and ethno-botanical uses are provided for easy identification and sustainable utilization.

Taxonomic description

***Ocimum basilicum* L. var. *pilosum* (Willd.) Benth.**

Ocimum basilicum Linn. var. *pilosum* (Willd.) Benth., Labiat. Gen. Spec. 5.1832; *Ocimum basilicum* var. *pilosum* (Willdenow) Bentham, Prodromus Systematis Naturalis Regni Vegetabilis 12:33. 1848. Drury, Handb. Ind. Fl. II: 516. 1866; Fl. Brit. Ind. 4: 608.1885; Gamble, Fl. Pres. Madras 777 (1111).1924; Matthew, Fl. Tamil Nadu Carnatic 2: 1269. 1982; Pullaiah, Fl. Eastern Ghats 4:569.2011.

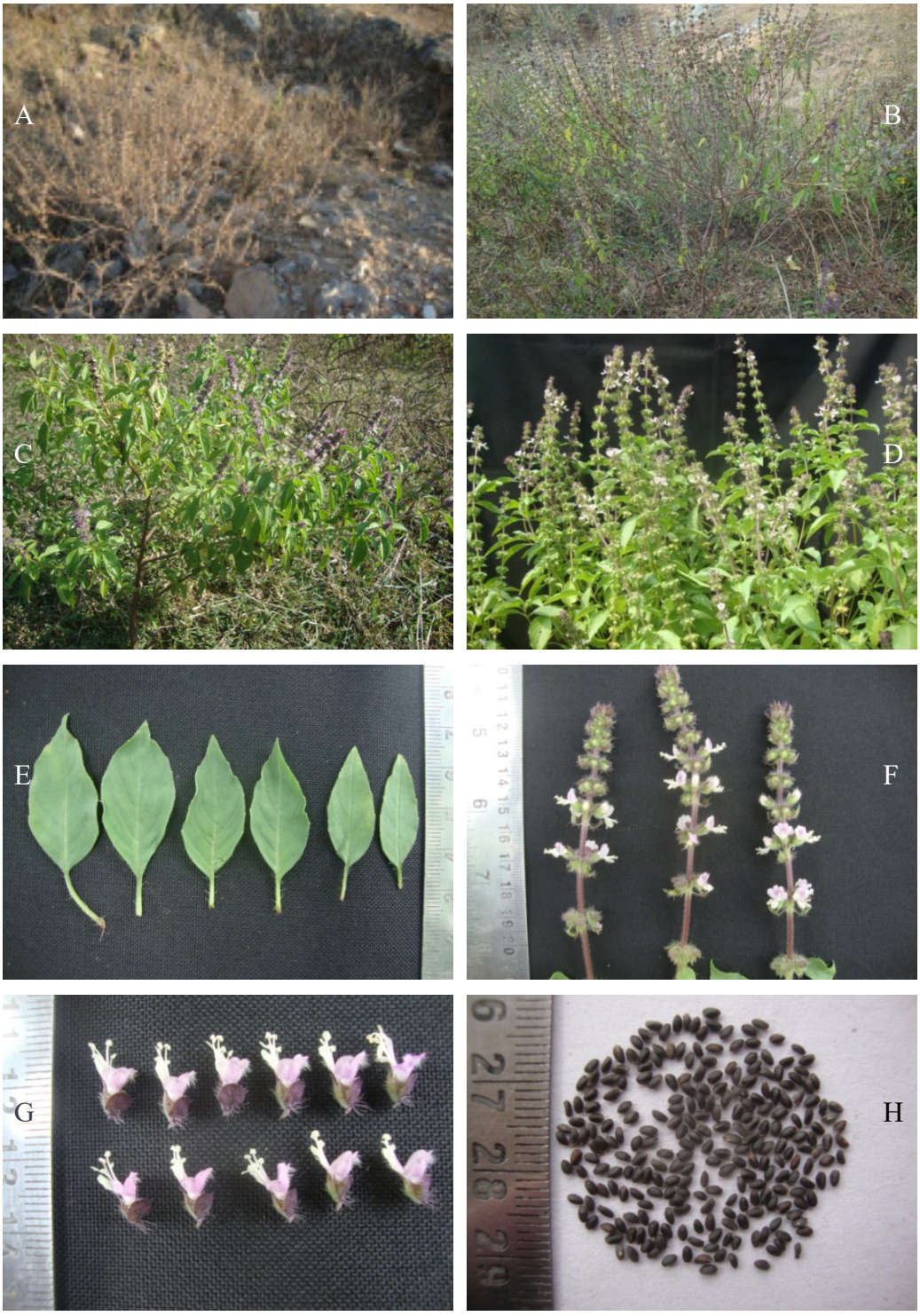

Fig. 1. *Ocimum basilicum* var. *pilosum*. A - C. Wild occurrence on foot hill at Kudpani village, Kuarmunda; Dengurpani village, Gurundia; Gilkuda village, Subdega block; Sundargarh, Odisha. D. Maintained in experimental plot, NBPGR Regional Station, Cuttack. E. Leaves. F. Inflorescence. G. Flowers. H. Seeds

Table 1. Specimen examined and seed germplasm collected and conserved (*Ocimum basilicum* var. *pilosum*)

Site	Collection No.	IC No.	Date of collection	Source	Site of collection					
					Village	Block	District	State	Latitude	Longitude
1	RCM/ GD/144	599357	20.03.13	Wasteland	Gaudakateni	Hindol	Dhenkanal	Odisha	20° 47'	85° 22'
2	RCM/ SS/41	641756	05.03.2021	Disturbed wild	Badasahi	Gurundia	Sundargarh	Odisha	21° 52'	84° 47'
3	RCM/ SS/56	641765	06.03.2021	Disturbed wild	Kudpani	Kuarmunda	Sundargarh	Odisha	22° 24'	84° 41'
4	RCM/BV/ PK/07	649107	08.12.2022	Natural wild	Ramaeuda	Lahunipada	Sundargarh	Odisha	21° 50'	85° 00'
5	RCM/BV/ PK/10	649109	08.12.2022	Natural wild	Basubahal	Lahunipada	Sundargarh	Odisha	21° 52'	85° 00'
6	RCM/BV/ PK/41	649120	09.12.2022	Natural wild	Dhengurpani	Gurundia	Sundargarh	Odisha	21° 57'	84° 34'
7	RCM/BV/ PK/62	649131	11.12.2022	Natural wild	Kustuna	Kutra	Sundargarh	Odisha	22° 09'	84° 12'
8	RCM/BV/ PK/114	649152	15.12.2022	Natural wild	Gilkuda	Subdega	Sundargarh	Odisha	22° 10'	84° 07'
9	RCM/BV/ PK/117	-	15.12.2022	Natural wild	Katangidihi	Subdega	Sundargarh	Odisha	22° 12'	84° 07'

Annual erect under-shrub up to 1.2 m high; stem much branched, base globous; branches 4-angled, woody, purplish-green, hairy, tender parts pilose, apex purple, nodes with a tuft of hairs around. Leaves oblong to elliptic-lanceolate, lamina glabrascent above, glandular, sparsely hairy on midrib and sometimes on veins below, 3.5-5.0 × 1.5-2.0 cm; petiole densely pilose, ca 1 cm; base acute to decurrent, attenuate; margin sparingly serrate, apex gradually acute. Racemes elongated, 15-25 cm long, 3-chotomous, purple, slender, densely hairy; verticillasters densely pilose, many flowered; bracts 2, petiolulate, oblanceolate, 5-10 mm, green, base attenuate, margin ciliate, apex acute; pedicel ca 3 mm in flower. Calyx campanulate, 2-lipped, ca 4 × 3 mm, densely pubescent outside, pilose at throat; tube 3-4 mm long in flower, lobes 5 (4+1), imbricate, densely ciliate; middle tooth of upper lip widest, spreading, ca 3 mm, sub-orbicular, deep purple, concave, mucronate, pilose, often with a tuft of long hairs at the base; lower lip 4-toothed with central pair of teeth longer than upper lip, up to 5 mm long; lateral lobes lanceolate, ca 4 mm long, tooth apex spinescent, ciliate; fruiting calyx persistent, not markedly enlarged in fruit, brown when dry. Corolla tubular, purplish, limb 2-lipped, up to 7 mm long; lobes 5 (4+1), unequal, obliquely campanulate at throat; upper lip spreading, 5 mm long, sub-equally 4-lobed; lower lip longer, ca 7 mm long, declinate, margin entire; limb puberulent outside; tube ca 3 mm, throat dilated. Stamens 4, free, in 2-pairs, white, declinate, with lower lip of corolla; posterior filaments hairyw at base. Nutlets ovoid-lanceolate, dark grey to black, ca 2 × 2 mm, glandular, with a white basal areola, mucilaginous when wet.

Flowering and fruiting: October - December

Distribution

The species grows in tropical and subtropical regions of Africa and southern Asia including India and China (Wu and Li, 1977). In India, it was recorded earlier in southern peninsula: Kerala, Tamil Nadu, and Andhra Pradesh (Drury, 1866; Gamble, 1925; Matthew, 1982; Henry et al., 1987; Mohanan and Henry, 1994; Pullaiah et al., 2011; Sasidharan, 2011).

Habitat

The plants were found growing rare in wild state in dryer areas in disturbed habitats adjoining to foothills in scrublands in association with herbs, shrubs and grasses. The dominant associates are *Cassia occidentalis, Triumfetta pentandra, Corchorus aestuans, Xanthium strumarium, Urena sinuata* and *Fioria vitifolia* etc. A total of 9 germplasm accessions were recorded from different locations of northern plateau and central tableland zones of Odisha. The species is hardy, prefers direct sunlight and propagated well through seeds.

Specimens examined and germplasm collected and conserved

Nine germplasm accessions of *Ocimum basilicum* var. *pilosum*, locally called as *Jungli Tulsi* or *Bana Dahana*, were assembled from partly disturbed wild habitats of Lahunipada, Gurundia, Kutra, Kuarmunda and Subdega blocks of Sundargarh and Hindol block Dhenkanal district of Odisha and brief passport information on respective accession numbers and their germplasm conservation in National Gene Bank, ICAR-NBPGR, New Delhi were provided in Table 1.

Taxonomic notes

The taxon resembles *Ocimum africanum* Lour. (syn. *O. citriodorum* Vis.), reported from parts of Odisha state, in many respects having young shoots or apical nodes, petioles and verticillasters pilose with spreading hairs, oblong to elliptic-lanceolate leaves and acute to decurrent leaf base (Misra et al., 2022). However, this taxon is different from *Ocimum africanum* and can be distinguished from it in possessing taller habit (up to 1.2 m), purplish-green branches, non-lemon scented, very aromatic and fragrant shoot and leaves and purplish corolla.

Ethno-botanical uses

Munda and Oraon tribes of Gurundia and Subdega blocks of Sundargarh district, Odisha use the juice of fresh leaves along with ginger for treatment of common cold, cough and malaria and intermittent fever. The leaves along with honey are given to children to boost immunity. The leaves either crushed or cut into pieces and put in a glass of hot water and its steam is inhaled for curing migraine, headache and sore throat. The leaves are also consumed in morning to prevent stress in old age patient.

Biochemical analysis of essential oil

The essential oil extracted from leaves of *O. basilicum* var. *pilosum* (IC- 641756 and IC-641765) exhibited several active compounds out of which the predominant chemotypes (%) were represented by methyl chavicol-rich (78.06 and 71.75) and linalool-rich (17.86 and 24.65) types. Earlier study on chemotypic characterisation of this taxonomic variety also reported methyl chavicol-rich chemotypes (79.66-90.71%) germplasm (Raina and Gupta, 2018). Methyl chavicol commonly known as estragol, a phenyl propanoid compound, is widely used in perfumes and flavour industry. However, the essential oil analysis of this taxon collected from Tengzhou country, Shandong Province (East China), by Zhang et al. (2009), reported linalool (29.68%), as the major active compound, which may be due to their distribution in divergent eco-climatic zones and edaphic condition.

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Identification key and check list of taxa of family Asteraceae of Jharkhand, India

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ABSTRACT

A checklist of flora of Asteraceae of Jharkhand state was prepared with the help of relevant literature and voucher specimens found in Central National Herbarium, Howrah, Herbarium of Ranchi University, Ranchi and National Botanical Research Institute, Lucknow. All the genera, species and varieties were enumerated with identification keys. The generic distributions at the global, national and state level and species on district-wise have been provided. The valid names of the species along with author citation(s), flowering and fruiting time and occurrence at district level were provided. Our study revealed that the family Asteraceae in Jharkhand is represented by 123 species and 05 varieties under 62 genera. The purpose of compilation of the checklist is to document the diversity and distribution of the members of family Asteraceae in Jharkhand state and the taxonomic key is to help students and botanist for ease of identification.

Key words: Asteraceae, checklist, flora, Jharkhand

INTRODUCTION

Jharkhand is literally known as land of bushes compassing an area of 79,710 sq. km with geo-coordinates 21° 95' to 25° 45' N, 83° 35' to 87° 95' E (https://himset.com/states/statewise-latitude-longitude.php). The state is bounded in north to Bihar, north-west to Uttar Pradesh, west to Chhattisgarh, south to Odisha as well as east to West Bengal. About 29.61% of the geographical area (23,605 sq. km) of the state is covered by natural forest and after addition with tree plantation, it increased to 32.48% which higher than the national average of 23.81% (http://forest.jharkhand.gov.in/). According to Champion and Seth (1968), there are three types of forests are found in the state: (a) Moist tropical forests, (b) Dry tropical forests, and (c) Montane subtropical forests.

Moist tropical forests type is dominated by Sal (*Shorea robusta*), the principal associates of *Shorea robusta* are *Pterocarpus marsupium, Terminalia alata, T. arjuna, T. bellirica, Madhuca longifolia, Mitragyna parvifolia, Protium serratum, Haldinia cordifolia, Dillenia pentagyna, Garuga pinnata, Diospyros melanoxylon, Syzygium cumini, Alstonia scholaris, Artocarpus lakoocha, Schleichera oleosa,* etc. Some common shrubs are *Colebrookea oppositifolia, Petalidium barlerioides, Urena lobata, Uraria rufescens, Croton roxburghii, Desmodium gyroides,* etc. and prominent climbers are *Ampelocissus latifolia, A. tomentosa, Abrus precatorius, Naravelia zeylanica, Bauhinia vahlii, Tiliacora acuminata, etc*.

Dry tropical forests covers about 75% of the total forest area and dominated by *Boswellia, Acacia, Butea*, bamboos, etc. in different localities. The *Shorea robusta* are smaller in size with compare to moist tropical forests. Dominant trees are *Shorea robusta, Anogeissus latifolia, Buchanania lanzan, Terminalia alata, T. bellirica, Sterculia urens, Boswellia serrata, Mitragyna parvifolia,*

Butea monosperma, Lannea coromandelica, Lagerstroemia parviflora, Acacia catechu, Soymida febrifuga, Ailanthus excelsa, etc. and common shrubs are *Murraya paniculata, Nyctanthes arbor-tristis, Helicteres isora, Ziziphus mauritiana, Flemingia chappar, F. macrophylla, F. strobilifera, Flacourtia indica, Petalidium barlerioides, Indigofera cassioides, Woodfordia fruticosa, etc*. Parasitic angiosperms like, parasitic angiosperms are *Cuscuta* spp., *Dendrophthoe falcata, Viscum* spp., *etc* are commonly visible in this type of forests.

Montane subtropical forests are restricted to small patches in Parasnath hilly areas above 1,220 m. Common species are *Pittosporum wightii, Meyna spinosa, Grewia spp., Berberis asiatica, Reinwardtia indica, Thalictrum foliolosum* and in between 650 to 1,220 m *Litsea monopetala, Ficus microcarpa, F. mollis, Symplocos racemosa, Alangium salvifolium, Indigofera pulchella*, are frequently found.

There are three well defined seasons in Jharkhand viz. summer, rainy and winter. The summer season is in between March to June, it is hot and dry and temperature varies from 40 to 46°C. The rainy season is starts from middle of June to middle of October and the annual average rainfall is c. 1200 mm. The winter sets in the month of November and continues up to February (https://www.accuweather.com/). Ranchi, Hazaribagh, Santal Pargana and Singhbhum districts has red soil due high percentage of acid soluble Ferric oxide and lower pH ranging. However, in the higher plateaus and valleys, lateritic soil is found. In addition, in some pockets alkali and saline soils are also found. Tribal population of the state is about 26%, Santhal is the major tribe and some other major tribes are Oraon, Parhaiya, Ho, Lohra, etc.

Diversity of flora is important indicator of the health of ecosystem (Bhujel et al., 2017; Misra et al., 2018; Shukla et al., 2022). The rich diversity of flora had attracted many taxonomists in the state. Anderson (1863) was the first sporadic plant explorer in Parashnath hills to study the flora of Bihar based on the collection of Hooker, Edgeworth and Thomson and after few years Clarke (1884) also studied on the flora of Parasnath. Haines (1910) did extensive work in Chotanagpur plateau and published a comprehensive account entitled “A Forest Flora of Chotanagpur" with 275 species recorded from Singhbhum. However, his most notable work was "Botany of Bihar and Orissa" which was appeared in six parts including 813 species from Singhbhum were reported (Haines, 1921-1925). Later, other botanists like Mooney (1941,1944,1950), Mukerjee (1947,1956), Bressers (1951), Sanyal (1957), Ara (1960,1966), Kanodia and Malick (1966), Panigrahi (1966), Meher-Homji (1971), Paul (1976,1978,1984,1990), Paul and Prasad (1978), Raizada (1978), Majumdar and Biswas (1979), Biswas and Maheshwari (1980), Mishra (1985), Paria and Chattopadhyay (2000, 2005), Singh et al. (2001), Sarma and Sarkar (2002) and Ranjan (2014) have significantly contributed to the flora of Bihar and Jharkhand states. The past publications revealed that the family Asteraceae of Jharkhand was not studies so far therefore the present work was taken up to evaluate the diversity of the family in the state.

MATERIALS AND METHODS

The present work on checklist of the family Asteraceae was initiated in June, 2016 and completed in March, 2017. The relevant literatures like, the Botany of Bihar and Orissa (1921-1925), Flora of Bihar analysis (2001), Flora of Palamau (2002), Flora of Parasnath (2014) and some additions to the Botany of Bihar and Odisha (1941) and Supplement to the Botany of Bihar and Odisha (1950) were referred. In addition, the specimens deposited in Central National Herbarium (CAL), Howrah, Herbarium of Ranchi University, Ranchi and National Botanical Research Institute (LWG), Lucknow were consulted. Worldwide distribution of species was verified through Mabberley (2008, 2017) and POWO (https://powo.science.kew.org/). IPNI (https://www.ipni.org/) and POWO (https://powo.science.kew.org/) was consulted for updated information. The National level and state level distribution was verified from endemic

vascular plants of India (2009) and Flora of Bihar analysis (2001), respectively. The nomenclature was updated through authentic online databases: the plant list (http://www.theplantlist.org) and International Plant Name Index (http://www.ipni.org). The Bentham and Hooker's system of classification was followed and a dichotomous key for diagnostic features for genera and species was provided for easy identification of taxa.

RESULTS AND DISCUSSION

A total of 128 taxa under 62 genera, 123 species and 5 varities were recorded from published literatures (Singh et al., 2001) , specimens deposited at CAL, herbarium of Ranchi University and National Botanical Research Institute, Lucknow. The species/ varieties are arranged alphabetically along with notes on phenology and distribution at district label. The identification keys to the genera are as follows:

Key to the genera

1a	Achenes covered in burr	*Xanthium (LXI)*
1b	Achenes not covered in burr	2
2a	Capitula homogamous	3
2b	Capitula heterogamou	.22
3a	Plants produces milky juice; flowers all ligulate	4
3b	Plants produces watery juice, if present; flowers all tubular	8
4a	Achenes distinctly beaked; beak slender	5
4b	Achenes not beaked, if beaked, beak very short and stout in Youngia	6
5a	Radical leaves long petioled	*Ixeris (XXXIX)*
5b	Radical leaves sessile	*Lactuc a (XL)*
6a	Achenes compressed	*Sonchus (LIII)*
6b	Achenes narrow, truncate at both the ends	7
7a	Achenes 4-5-ribbed; inner involucral bracts scarious margined	*Launaea (XLIII)*
7b	Achenes 10-20-ribbed; inner involucral bracts not scarious margined	*Youngia(LXII)*
8a	Anthers tailed at base	9
8b	Anthers not tailed at base	13
9a	Leaves not spinous margined; achenes winged	*Caesulia(XIII)*
9b	Leaves mostly spinous margined; achenes not winged	10
10a	Heads one flowered, crowded into globose involucres	*Echinops(XXIV)*
10b	Heads many flowered, separate	11
11a	Plants armed; achenes of outer florets without pappus	*Carthamus(XV)*
11b	Plants unarmed; achenes of outer florets with pappus	12
12a	Heads solitary, terminal; basal areole oblique or lateral	*Tricholepis(LVI)*
12b	Heads in fascicles, corymbs or panicles; basal areole horizontal	*Saussurea(XLVIII)*
13a	Anthers sub-entire or cleft at base	14
13b	Anthers entire at base	19
14a	Leaves opposite	15
14b	Leaves alternate	18
15a	Plants usually twining herbs; heads 4-flowered; involucral bracts 3-5	*Mikania(XLIV)*
15b	Plants usually erect herbs; heads more than 4-flowered; involucral bracts more than	16
16a	Pappus of capillary bristles	*Eupatorium(XXX)*

16b	Pappus of scales or clavate hairs	17
17a	Pappus of scales	*Ageratum(IV)*
17b	Pappus of clavate hairs	*Adenostemma(III)*
18a	Heads distinct; florets 1-many	*Vernonia(LIX)*
18b	Heads in glomerules; florets 1-5	*Elephantopus(XXVI)*
19a	Leaves usually opposite; heads in terminal glomerules, 1-flowered; pappus a toothed or fimbriate cup	*Lagascea(XLI)*
19b	Leaves usually alternate; heads not in glomerules, many flowered; pappus a fine capillary hairs or bristles	20
20a	Involucre ecalyculate	*Emilia(XXVII)*
20b	Involucre calyculate	21
21a	Inflorescences solitary or corymbose; capitula yellow to purple; involucral bracts not connivent; receptacles flat, pitted or shortly fimbriate; achenes fusiform	*Gynura(XXXVII)*
21b	Inflorescences lax terminal racemes; capitula pink to brick red; involucral bracts connivent; receptacles convex, naked, shallowly alveolate; achenes cylindrical	*Crassocephalum(XXI)*
22a	Anthers tailed at base (except Laggera and Blumeopsis)	23
22b	Anthers not tailed at base (rarely tailed in Senecio)	34
23a	Leaves mostly spinous margined; involucral bracts with long spreading or recurved spinescent awns; receptacles shortly bristly; achenes punctate between angles	*Amberboa(V)*
23b	Leaves not spinous margined; involucral bracts not with long spreading or recurved spinescent awns; receptacles glabrous; achenes not punctate between angles	24
24a	Receptacles paleaceous	*Athroisma(VIII)*
24b	Receptacles epaleaceous	25
25a	Heads usually radiate (except Carpesium)	26
25b	Heads discoid or disciform	29
26a	Achenes beaked; pappus absent	*Carpesium(XIV)*
26b	Achenes not beaked; pappus present	27
27a	Achenes obscurely ribbed; pappus 1-seriate, few or absent in ray florets	*Pentanema(XLVI)*
27b	Achenes prominently ribbed; pappus 1-2-seriate, many in ray florets	28
28a	Heads solitary; outer row of pappus of short jagged teeth or forming a setulose-laciniate cup	*Pulicaria(XLVII)*
28b	Heads solitary, corymbose or panicled; outer row of pappus of hairs, not forming cu	*Inula(XXXVIII)*
29a	Involucral bracts all scarious; style arms of bisexual florets filiform, obtuse, capitate, truncate or 2-cleft; achenes scaly or papillose	30
29b	Outer involucral bracts herbaceous or dry and inner scarious; style arms of bisexual florets filiform; achenes variously hairy or glandular	31
30a	Bisexual florets all sterile; styles undivided or notched	*Anaphalis(VI)*
30b	Bisexual florets all or mostly fertile; styles divided	*Gnaphalium(XXXIV)*
31a	Heads compound, few flowered aggregated into globose glomerules	*Sphaeranthus(LIV)*
31b	Heads solitary, many flowered, arranged in lax panicles or corymbs	32
32a	Leaves decurrent	*Laggera(XLII)*
32b	Leaves not decurrent	33

33a	Anthers tailed	*Blumea(XI)*
33b	Anthers not tailed	*Blumeopsis(XII)*
34a	Leaves usually alternate	35
34b	Leaves usually opposite	45
35a	Style arms truncate or appendiculate	36
35b	Style arms flattened or plano-convex	41
36a	Pappus of fine capillary hairs or bristles	*Senecio(L)*
36b	Pappus absent (sometimes short auriculate in Cotula).	37
37a	Heads many	*Artemisia(VII)*
37b	Heads solitary	38
38a	Involucral bracts many seriate, incurved in fruits	*Sphaeromorphaea(LV)*
38b	Involucral bracts sub 2-seriate, not incurved in fruits	39
39a	Stoloniferous; heads sessile; corolla of outer florets wanting	*Soliva(LII)*
39b	Non stoloniferous; heads sessile or peduncled; corolla of outer florets usually present	40
40a	Leaves toothed or lobed; heads sessile or sub-sessile; involucral bracts 2-seriate; achenes angled, not stipitate	*Centipeda(XVI)*
40b	Leaves pinnatifid or pinnatisect; heads peduncled; involucral bracts sub-2-seriate; achenes compressed, stipitate	*Cotula(XX)*
41a	Ray florets absent	42
41b	Ray florets present	44
42a	Pappus a short tube with fimbriate mouth	*Grangea(XXXV)*
42b	Pappus absent	43
43a	Receptacles flat; achenes with thickened margins	*Dichrocephala(XXIII)*
43b	Receptacles conical or convex; achenes without thickened margins	*Cyathocline(XXII)*
44a	Heads in corymbose or panicles; involucral bracts many seriate; ligules indistinct	*Conyza(XVIII)*
44b	Heads solitary or few in lax racemes; involucral bracts 2-3-seriate; ligules distinct	*Erigeron(XXIX)*
45a	Filaments papillose or pubescent	*Cosmos(XIX)*
45a	Filaments glabrous	46
46a	Heads in terminal glomerules, one flowered	*Flaveria(XXXI)*
46b	Heads non-glomerulate, more than one flowered	47
47a	Leaves divided to the base or deeply pinnatifid	48
47b	Leaves simple or pinnately compound	49
48a	Achenes linear, with retrorsely barbed pappus awns	*Bidens(IX)*
48b	Achenes somewhat rounded, without retrorsely barbed pappus awns	*Parthenium(XLV)*
49a	Ray florets only fertile; achenes trigonous, covered with hooked bristles	*Acanthospermum(I)*
49b	Ray florets sterile or fertile; achenes not trigonous (except Spilanthes), not covered with hooked bristles	50
50a	Disc achenes rounded or laterally compressed; pappus absent or of 2 short, weak awns	51
50b	Disc achenes dorsally compressed or angular; pappus present or absent	57
51a	Outer involucral bracts clavate, spreading; inner ones enclosing the achenes	52
51b	Outer involucral bracts not clavate, erect; inner ones not enclosing the achenes	53

52a	Terrestrial herbs; outer involucral bracts prominently glandular	*Sigesbeckia(LI)*
52b	Marshy herbs; outer involucral bracts eglandular	*Enydra(XXVIII)*
53a	Receptacles flat, never conical	54
53b	Receptacle convex or conical	56
54a	Paleas bristle or awn like	*Eclipta(XXV)*
54b	Paleas linear or oblanceolate, concave or folded	55
55a	Flowers white; paleas obtuse, lacerate; pappus of 2-5 unequal bristles	*Blainvillea(X)*
55b	Flowers yellow; paleas acute, entire; pappus cup like or of 1-2 weak awns or absent	*Wedelia(LX)*
56a	Receptacles convex; achenes enclosed in hardened, pointed palea	*Sclerocarpus(XLIX)*
56b	Receptacles conical; achenes not enclosed	*Acmella(II)*
57a	Pappus of 2-3 bristles or awns (lacking in ChrysanthellumandGuizotia).	58
57b	Pappus consisting of 5 or more bristles or scales	61
58a	Achenes compressed	59
58b	Achenes fusiform, angular	60
59a	Margins of achenes laciniate winged; pappus of 2 unbarbed awns	*Synedrella(LVI)*
59b	Margins of achenes not laciniate winged; pappus awns absent	*Guizotia(XXXVI)*
60a	Achenes often dimorphic; pappus absent	*Chrysanthellum(XVII)*
60b	Achenes not dimorphic; pappus present	*Glossocardia(XXXIII)*
61a	Erect, annual herbs; pappus of short fimbriate scales, c. 1 mm long	*Galinsoga(XXII)*
61b	Prostrate, ascending, perennial herbs; pappus of fine plumose bristles, c. 5 mm long	*Tridax(LVIII)*

I. ACANTHOSPERMUM Schrank

Eight species distributed in tropical America (Mabberly, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

1. *A. hispidum* DC. *Fl. and Fr.*: Aug-Feb. *Distrib.*: Chota Nagpur, Hazaribagh, Koderma, Ranchi.

II. ACMELLA Rich. exPers.

About 30 species, distributed in tropical regions (Mabberley, 2008); 4 species in India (Karthikeyan et al., 2009); 3 species in Jharkhand.

Key to the species

1a	Achenes eciliate; pappus absent	*A. calva*
1b	Achenes ciliate; pappus present	2
2a	Heads radiate	*A. uliginosa*
2b	Heads discoid	*A. oleracea*

2. *A. calva* (DC.) R.K. Jansen *Fl. and Fr.*: February - August. *Distrib.*: Palamau, Santal Pargana.

3. *A. oleracea* (L.) R.K. Jansen *Fl. and Fr.*: Throughout the year.

Distrib.: Almost throughout the state.

4. *A. uliginosa* (Sw.) Cass. *Fl. and Fr.*: Mar - Sept.

Distrib.: Ranchi.

III. ADENOSTEMMA J.R. Forst. and G. Forst.

About 20 species, distributed in America, Asia (Mabberley, 2008); 2 species and 8w vareties in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

5. *A. lavenia* (L.) Kuntze *Fl. and Fr.*: Oct-Jan.

Distrib.: Hazaribagh.

IV. AGERATUM L.

About 40 species, mainly distributed in Tropical America, now widespread Pantropical (Mabberley, 2008); 2 species in India (Karthikeyan et al., 2009); 2 species in Jharkhand.

Key to the species

1a	Involucral bracts narrowly lanceolate, apex long acuminate, pilose; corolla equal to or longer than pappus scale	*A. houstonianum*
1b	Involucral bracts broad, oblong or lanceolate-oblong, apex acute, glabrous; corolla shorter than pappus scale	*A. conyzoides*

6. *A. houstonianum* Mill. Fl. and Fr.: November - December.

Distrib.: Chota Nagpur.

7. *A. conyzoides* L. *Fl. and Fr*.: Almost throughout the year.

Distrib.: Throughout the state.

V. AMBERBOA (Pers.) Less.

About 20 species, distributed in Mediterranean to C. Asia (Mabberley, 2008); 2 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

8. *A. ramosa* (Roxb.) Jafri Fl. and Fr.: Aug - Jan.

Distrib.: Ranchi.

VI. ANAPHALIS DC.

About 40 species, distributed in Asia, America and Europe (Mabberley, 2008); 37 species and 5 varieties in India (Karthikeyan et al., 2009); 2 species in Jharkhand.

Key to the species

1a	Leaves 1-nerved; bracts clawed	*A. adnata*
1b	Leaves 3-nerved; bracts not clawed	*A. contorta*

9. *A. adnata* DC. Fl. and Fr.: August - March.

Distrib.: Chota Nagpur

10. *A. contorta* (D. Don) Hook.f. *Fl. and Fr.*: July - March.

Distrib.: Giridih, Hazaribagh.

VII. ARTEMISIAL.

About 400 species, distributed in north temperate regions, W. S. America and south Africa (Mabberley, 2008); 46 species, 19 varieties and 3 forma in India (Karthikeyan et al., 2009); 4 species in Jharkhand.

Key to the species

1a	Undershrubs, up to 2 m tall	*A. japonica*
1b	Herbs, up to 1.5m tall	2
2a	Involucre hemispheric	*A. caruifolia*
2b	Involucre ovoid or campanulate or subglobose	3
3a	Disc florets 8-12, bisexual	*A. indica*
3b	Disc florets 5-7, unisexual (male)	*A. capillaris*

11. *A. capillaris* Thunb.

Fl. and Fr.: August - December. *Distrib.*: Palamau.

12. *A. caruifolia* Buch.-Ham.

Fl. and Fr.: March - April. *Distrib.*: Hazaribagh, Santal Pargana, Sahibganj.

13. *A. indica* Willd.

Fl. and Fr.: August - December. *Distrib.*: Palamau.

14. *A. japonica* Thumb.

Fl. and Fr.: April - December. *Distrib.*: Hazaribagh, Palamau, Ranchi, Giridih.

VIII. ATHROISMA DC.

About 8 species, distributed in tropical Africa, Asia, Indonesia and Malaya (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

15. *A. laciniatum* DC.

Fl. and Fr.: April - June. *Distrib.*: Sahibganj.

IX. BIDENS L.

About 230 species, distributed throughout the world (Mabberley, 2008); 12 species and 2 varieties in India (Karthikeyan et al., 2009); 2 species in Jharkhand.

Key to the species

1a	Leaves 3-5 partite or undivided; phyllaries spathulate	*B. pilosa*
1b	Leaves pinnate or bipinnate; phyllaries linear	*B. biternata*

16. *B. biternata* (Lour.) Merr. and Sherff

Fl. and Fr.: April - October.

Distrib.: Hazaribagh, Palamau, Giridih.

17. *B. pilosa* L.

Fl. and Fr.: March - December.

Distrib.: Hazaribagh, Palamau, Santal Pargana.

X. BLAINVILLEA Cass.

Pantropical; c. 10 species (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

18. *B. acmella* (L.) Philipson

Fl. and Fr.: August - January. *Distrib.*:Hazaribagh, Palamau, Ranchi.

XI. BLUMEA DC.

About 100 species distributed in Old World Tropics and S. Africa (Mabberly, 2008); 32 species in India (Karthikeyan et al., 2009); 14 species and 3 varieties in Jharkhand.

Key to the species

1a	Plants densely white woolly all over	2
1b	Plants glabrate or variously pubescent but never woolly all over	3
2a	Leaves spiny toothed; corolla of bisexual florets hairy on tube and lobes	*B. malcolmii*
2b	Leaves not spiny toothed; corolla of bisexual florets hairy only on lobes	*B. hieracifolia*
3a	Corolla lobes of bisexual florets with multicellular hairs in addition to colleters	*B. obliqua*
3b	Corolla lobes of bisexual florets glabrous or with unicellular hairs in addition to colleters	4
4a	Outer involucral bracts oblong-ovate to oblong-lanceolate	*B. procera*
4b	All involucral bracts linear or lanceolate	5
5a	Receptacles fimbrillate	*B. aromatica*
5b	Receptacles glabrous or pilose	6
6a	Heads glomerulate, clusters interruptly spicate	*B. fistulosa*
6b	Heads paniculate	7
7a	Leaves spiny toothed; corolla hairy	.8
7b	Leaves not spiny toothed; corolla of female florets glabrous	9
8a	Prostrate herbs with branches radiating from the rootstock; leaves irregularly dentate; corolla hairy on lobes	*B. oxyodonta*
8b	Erect herbs; leaves alternately long and short toothed; corolla hairy all over	*B. eriantha*
9a	Receptacles minutely pilose	*B. laciniata*
9b	Receptacles glabrous	10
10a	Achenes ribbed	11

10b	Achenes not ribbed	13
11a	Outer bracts with purple margins; pappus exceeding the coroll	*B. atropurpurea*
11b	Outer bracts without purple margins; pappus shorter or equal to corolla	12
12a	Plants glabrous	*B. virens*
12b	Plants pubescent or glandular	*B. membranacea*
13a	Leaves not lyrately lobed; heads purple	*B. mollis*
13b	Leaves lyrately lobed; heads yellow	*B. lacera*

19. *B. aromatica* DC.

Fl. and Fr.: November - April.

Distrib.: Chota Nagpur.

20. *B. atropurpurea* Haines

Fl. and Fr.: December - March. *Distrib.*: Giridih.

21. *B. eriantha* DC.

Fl. and Fr.: December - April. *Distrib.*: Hazaribagh, Palamau, Singhbhum.

22. *B. fistulosa* (Roxb.) Kurz

Fl. and Fr.: December - April. *Distrib.*: Hazaribagh, Palamau, Ranchi, Sahibganj, Singhbhum.

Key to the varieties

la	Plants white woolly; leaves usually radical, obscurely dentate; involucral bracts usually straw coloured	*var. hamililtoni*
1b	Plants silky-sericeous; leaves mostly cauline, distinctly irregularly serrate-dentate; involucral bracts usually purple-tipped	*var. hieracifolia*

B. hieracifolia (D. Don) DC.

23. *B. hieracifolia* var. *hamiltoni* (DC.) C.B. Clarke

Fl. and Fr.: March - June. *Distrib.*: Palamau.

24. *B. hieracifolia var. hieracifolia*

Fl. and Fr.: February - June. *Distrib.*: Hazaribagh.

25. *B. l*acera (Burm.f.) DC.

Fl. and Fr.: January - April. *Distrib.*: Hazaribagh, Koderma, Palamau and Singhbhum

26. *B. laciniata* (Roxb.) DC.

Fl. and Fr.: March - April.

Distrib.: Hazaribagh and Palamau.

27. *B. malcolmii* (C.B. Clarke) Hook.f.

Fl. and Fr.: December - March.

Distrib.: Chota nagpur.

B. membranacea DC.

Key to the varieties

la	Plants glandular pubescent; leaves elliptic-ovate or lanceolate	*var. muralis*
1b	Plants simple pubescent; leaves obovate or obovate to lanceolate	*2*
2a	Plants slender, pubescent; leaves obovate; involucral bracts herbaceous; heads 5-6 mm across	*var. membranacea*
2b	Plants robust, strigose; leaves obovate to lanceolate; involucral bracts rigid; heads 7-8 mm across	*var. jacquemontii*

28. *B. membranacea var. jacquemontii* (Hook.f.) Randeria

Fl. and Fr.: December - April.

Distrib.: Hazaribagh, Palamau.

29. *B. membranacea var. membranacea*

Fl. and Fr.: November - April.

Distrib.: Hazaribagh, Singhbhum.

30. *B. membranacea var. muralis* (DC.) Hook.f.

Fl. and Fr.: January - April.

Distrib.: Hazaribagh, Palamau.

31. *B. mollis* (D. Don) Merr.

Fl. and Fr.: December - April.

Distrib.: Hazaribagh, Palamau.

32. *B. obliqua* (L.) Druce

Fl. and Fr.: February - March. *Distrib.*: Palamau.

33. *B. oxyodonta* DC.

Fl. and Fr.: January - April.

Distrib.: Hazaribagh, Palamau and Singhbhum.

34. *B. procera* DC.

Fl. and Fr.: December - April. *Distrib.*: Sahibganj.

35. *B. virens* DC.

Fl. and Fr.: December - March. *Distrib.*: Hazaribagh.

XII. BLUMEOPSIS Gagnep.

One species in India to Western Malesia (Mabberly, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

36. *B. flava* (DC.) Gagnep.

Fl. and Fr.: November - January. *Distrib.*: Chota Nagpur and Santal Pargana.

XIII. CAESULIA Roxb.

One species in NE India (Mabberly, 2008); a monotypic genus of the Indian subcontinent (Pant, 1995; Karthikeyan et al., 2009).

37. *C. axillaris Roxb*.

Fl. and Fr.: August - February. *Distrib.*: Throughout the state.

XIV. CARPESIUM L.

Twenty five species distributed in Eurasia, Indo-malaysia to Australia (Mabberly, 2008); 6 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

38. *C. cernuum L*.

Fl. and Fr.: December - February.

Distrib.: Santal Pargana.

XV. CARTHAMUS L.

About 13 species, distributed in Mediterranean regions, Africa and Asia (Mabberley, 2008); 3 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

39. *C. tinctorius L*.

Fl. and Fr.: February - April.

Distrib.: Hazaribagh, Palamau.

XVI. CENTIPEDA Lour.

About fivespecies, distributed in Madagascar, Afghanistan, Indomalesia, Australia, New Zealand, Polynesia and Chile (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

40. *C. minima* (L.) A. Br. and Aschers.

Fl. and Fr.: March - January.

Distrib.: Hazaribagh, Koderma, Lohardaga, Ranchi, Sahibganj, Singhbhum.

XVII. CHRYSANTHELLUM Rich.

About 6 species, distributed throughout the world (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

41. *C. americanum* (L.) Vatke

Fl. and Fr.: August - December. *Distrib.*: Hazaribagh, Koderma, Palamau, Singhbhum.

XVIII. CONYZA Less.

About 60 species, distributed in temperate and subtropical regions, temperate and warm Africa (Mabberley, 2008); 9 species and 1 variety in India (Karthikeyan et al., 2009); 6 species in Jharkhand.

Key to the species

1a	Leaf base amplexicaul	2
1b	Leaf base not amplexicaul	3
2a	Radical leaves withered at anthesis; leaves pinnately cleft; heads more than 1 cm across	*C. aegyptiaca*
2b	Radical leaves persistent at anthesis; leaves dentate; heads less than 1 cm across	*C. japonica*
3a	Corolla of outer florets less than half to style and pappus	*C. leucantha*

3b	Corolla of outer florets nearly equalling to style and pappus	*4*
4a	Pappus white	*C. canadensis*
4b	Pappus yellow or reddish	*5*
5a	Pappus reddish, c. 1 mm long	*C. stricta*
5b	Pappus yellow,3-3.5 mm long	*C. bonariensis*

42. *C. aegyptiaca* (L.) Aiton

Fl. and Fr.: August - May.

Distrib.: Palamau, Giridih.

43. *C. bonariensis* (L.) Cronquist

Fl. and Fr.: August - February.

Distrib.: Palamau, Sahibganj, Giridih, Hazaribagh.

44. *C. canadensis* (L.) Cronquist

Fl. and Fr.: June - August. *Distrib.*: Palamau.

45. *C. japonica* (Thunb.) Less. ex DC.

Fl. and Fr.: May - Oct. *Distrib.*: Hazaribagh, Palamau.

46. *C. leucantha* (D. Don) Ludlow and Raven

Fl. and Fr.: December - March.

Distrib.: Hazaribagh, Palamau, Singhbhum, Giridih.

47. *C. stricta* Willd.

Fl. and Fr.: August - October. *Distrib.*:Giridih.

XIX. COSMOS Cavanilles

About 25 species, distributed in tropical America, West Indies, Asia (Mabberley, 2008); 3 species in India (Karthikeyan et al., 2009); 2 species in Jharkhand.

Key to the species

1a	Ray laminae yellow to red-orange;peduncles with one or more leafy bracts	*C. sulphureus*
1b	Ray laminae pink, purple, purplish, rose-pink, violet or white;peduncles without leafy bracts	*C. caudatus*

48. *C. caudatus Kunth*

Fl. and Fr.: December - February. *Distrib.*: Santal Pargana.

49. C. sulphureus Cav.

Fl. and Fr.: December - February. *Distrib.*: Hazaribag.

XX. COTULA L.

About 50 species, distributed in Southern hemisphere to N. Africa and Mexico (Mabberley, 2008); 6 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

50. *C. anthemoides* L.

Fl. and Fr.: December - March. *Distrib.*: Koderma, Giridih.

XXI. CRASSOCEPHALUM Moench

About 30 species distributed in Africa, Madagascar and in warm Africa to Yemen and Mascarenes (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

51. *C. crepidioides* (Benth.) S. Moore

Fl. and Fr.: December - January. *Distrib.*: Singhbhum, Gumla.

XXII. CYATHOCLINE Cass.

About 3 species, distributed in tropical Asia (Mabberley, 2008); 2 species and 2 varieties in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

52. *C. purpurea* (Buch.-Ham. ex D. Don) Kuntze

Fl. and Fr.: December - March. *Distrib.*: Giridih, Hazaribagh, Lohardaga, Palamau, Santal Pargana, Singhbhum.

XXIII. DICHROCEPHALA L'Herit ex DC.

About 10 species, distributed in Africa, Madagascar, China, India (Mabberley, 2008); 4 species and 1 subspecies in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

53. *D. chrysanthemifolia* (Blume) DC.

Fl. and Fr.: December. *Distrib.*: Hazaribagh.

XXIV. ECHINOPS L.

About 100 species, distributed in Mediterranean regions, Europe, Africa and Asia (Mabberley, 2008); 4 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

54. *E. echinatus* Roxb.

Fl. and Fr.: March - July.

Distrib.: Hazaribagh, Koderma.

XXV. ECLIPTA L.

About 4 species, distributed in warmer regions of America, Africa, Australia and Asia (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

55. *E. prostrata* (L.) L.

Fl. and Fr.: Throughout the year.

Distrib.: Throughout the state.

XXVI. ELEPHANTOPUS L.

About 25 species, distributed in tropics and warmer temperate regions of both hemispheres (Mabberley, 2008); 1 species in India including Jharkhand (Karthikeyan et al., 2009); 1 species in Jharkhand.

56. *E. scaber* L.

Fl. and Fr.: August - December.

Distrib.: Koderma, Dalma, Gumla.

XXVII. EMILIA Cass.

About 30 species, distributed in S. Africa. S. China, Japan, Phillipines and Sri Lanka and in Old world tropical countries (Mabberley, 2008); 8 species and 2 varieties in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

57. *E. sonchifolia* (L.)DC.

Fl. and Fr.: March - January.

Distrib: Hazaribagh, Koderma, Gumla.

XXVIII. ENYDRA DC.

About 10 species, distributed in warmer parts of the world (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

58. *E. fluctuans Lour.*

Fl. and Fr.: December -January.

Distrib.: Ranchi.

XXIX. ERIGERON L.

About 390 species, distributed throughout the world, especially N. America and C. America (Mabberley, 2008); 21 species and 2 varieties in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

59. *E. sublyratus* DC.

Fl. and Fr.: October - April. *Distrib.*: Singhbhum.

XXX. EUPATORIUM L.

About 1200 species (before segregation), distributed in Europe, Asia, Africa, chiefly in Mexico, West Indies and Tropical S. America (Mabberley, 2008); 11 species and1 variety in India (Karthikeyan et al., 2009); 2 species and1 variety in Jharkhand.

Key to the species

1a	Leaves 3-5-fid	*E. mairei var. heterophyllum*
1b	Leaves entire or undivided	*2*
2a	Achenes with shining glands	*E. nodiflorum*
2b	Achenes without glands	*E. odoratum*

60. *E. mairei* H. Lev. var. *heterophyllum* (DC.) Karthik and Moorthy

Fl. and Fr.: July-September. *Distrib.*: Palamau.

61. *E. nodiflorum* Wall. ex DC.

Fl. and Fr.: December - February. *Distrib.*: Palamau.

62. *E. odoratum* L.

Fl. and Fr.: February - May. *Distrib.*:Chota Nagpur.

XXXI. FLAVERIA Juss.

About 21 species, distributed in America, Australia (Mabberley, 2008); 2 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

63. *F. trinervia* (Spreng.) C. Mohr

Fl. and Fr.: March - October. *Distrib.*: Chota Nagpur.

XXXII. GALINSOGA Ruiz and Pavon

Thirteen species distributed in temperate and subtropical Central and South America (Mabberly, 2008); 2 species in India (Karthikeyan et al., 2009); 1 species in Jharkahnd.

64. *G. parviflora* Cav.

Fl. and Fr.: August - February. *Distrib.*: Palamau, Ranchi.

XXXIII. GLOSSOCARDIA Cass.

About 12 species, distributed in S.E. Asia. Africa (Mabberley, 2008); 2 species in India (Karthikeyan et al., 2009); 2 species in Jharkhand.

Key to the species

1a	Plants woody at base; achenes not compressed, linear-oblong, 5-ribbed on both faces	*G. bidens*
1b	Plants herbaceous at base;achenes dorsally compressed, narrowly oblong, not ribbed	*G. bosvallea*

65. *G. bidens* (Retz.) Veldkamp

Fl. and Fr.: March - December. *Distrib.*: Gumla, Hazaribagh, Koderma, Palamau, Ranchi.

66. *G. bosvallea* (L.f.) DC.

Fl. and Fr.: September - October.

Distrib.: Lohardaga, Palamau, Ranchi, Hazaribagh, Singhbhum.

XXXIV. GNAPHALIUM L.

About 300 species, cosmopolitan in distribution (Mabberley, 2008); 4 species in India (Karthikeyan et al., 2009); 7 species in Jharkhand.

Key to species

1a	Heads in leafless corymbs,clustered	*G. luteo-album*
1b	Heads in spikes or panicles, lax	2
2a	Stout herbs; leaf base semi-amplexicaul, more or less decurrent	*G. hypoleucum*
2b	Slender herbs; leaf base attenuate or narrowed to the stem	3
3a	Lower surface of leaves white pannose, the sub-appresed hairs tightly emeshed	*G. purpureum*
3b	Lower surface of leaves loosely villose, lanate to appressed white tomentose	4
4a	Pappus hairs free at base	*G. polycaulon*
4b	Pappus hairs coherent at base	5
5a	Leaves flaccid	*G. flaccidum*
5b	Leaves not flaccid	6
6a	Stems erect or decumbent, branching from base; disc florets 2-3, c. 2.25 mm long	*G. pensylvanicum*
6b	Stems prostrate; disc florets 4-5, c. 1 mm long	*G. pulvinatum*

67. *G. flaccidum* Kurz

Fl. and Fr.: February - March. *Distrib.*:Giridih.

68. *G. hypoleucum* DC. *Fl. and Fr.*: May - October.

Distrib.: Throughout the state.

69. *G. luteo-album* L.

Fl. and Fr.: January - April.

Distrib.: Giridih, Hazaribagh.

70. *G. pensylvanicum* Willd.

Fl. and Fr.: January - November. *Distrib.*: Hazaribagh.

71. *G. polycaulon* Pers.

Fl. and Fr.: Throughout the year.

Distrib.: Hazaribagh, Palamau, Singhbhum.

72. *G. pulvinatum* Del.

Fl. and Fr.: December - March. *Distrib.*:Palamau.

73. *G. purpureum* L.

Fl. and Fr.: August - May. *Distrib.*: Hazaribagh, Palamau, Singhbhum, Giridih.

XXXV. GRANGEA Adans.

About 6 species, distributed in tropical Asia and Africa (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

74. *G. maderaspatana* (L.) Poir.

Fl. and Fr.: November - April. *Distrib.*:Santal Pargana, Singhbhum, Palamau, Hazaribagh.

XXXVI. GUIZOTIA Cass.

Six species distributed in Africa (Mabberly, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

75. *G. abyssinica* (L.f.) Cass.

Fl. and Fr.: October - February. *Distrib.*: Chota Nagpur, Giridih, Gumla, Palamau, Ranchi, Singhbhum.

XXXVII. GYNURA Cass.

About 100 species distributed in Asia, Africa, Australia, Malaysia, China, Nepal and Sri Lanka (Mabberley, 2008); 8 species in India (Karthikeyan et al., 2009); 2 species in Jharkhand.

Key to the species

1a	Herbs; achenes blackish, oblong, 2-3 mm long, faintly ribbed	*G. bicolor*
1b	Shrubs; achenes dark brown, cylindrical, 4-6 mm long, prominently ribbed	*G. nepalensis*

76. *G. bicolor* (Roxb. ex Willd.) DC.

Fl. and Fr.: August - January. *Distrib.*: Singhbhum

77. *G. nepalensis* DC.

Fl. and Fr.: December - March. *Distrib.*: Chota Nagpur.

XXXVIII. INULA L.

About 50 species distributed in temperate and subalpine regions of Europe, Africa and Asia; 17 species in India (Karthikeyan et al., 2009); 4 species in Jharkhand.

Key to the species

1a	Herbs	2
1b	Shrubs or undershrubs	3
2a	Stem branched from a woody root stock; ligules yellow; ray florets up to 8 mm long; pappus pale red	*I. obtusifolia*
2b	Stem simple; ligules white; ray florets 11-12 mm long; pappus white	*I. nervosa*
3a	Leaves silky villous or woolly below; heads discoid; pappus white	*I. cappa*
3b	Leaves glabrous or pubescent on both surfaces but not white woolly; heads radiate; pappus pale brown	*I. eupatorioides*

78. *I. cappa* DC.

Fl. and Fr.: October - December. *Distrib.*: Palamau.

79. *I. eupatorioides* DC.

Fl. and Fr.: November - December.

Distrib.: Chota Nagpur.

80. *I. nervosa* Wall. ex DC.

Fl. and Fr.: August - October.

Distrib.: Palamau.

81. *I. obtusifolia* Kemer

Fl. and Fr.: August - October. *Distrib.*: Koderma.

XXXIX. IXERIS (Cass.) Cass.

About 20 species, distributed in Himalayan region to Japan (Mabberley, 2008); 1 species in India (Mamgain and Rao, 1995; Karthikeyan et al., 2009); 1 species in Jharkhand.

82. *I. polycephala* Cass.

Fl. and Fr.: December - March. *Distrib.*: Palkot

XL. LACTUCA L.

About 50 species, distributed throughout the world (Mabberley, 2008); 5 species, 1 subspecies and 1 variety in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

83. *L. serriola* Tourner

Fl. and Fr.: April - October. *Distrib.*:Giridih.

XLI. LAGASCEA Cav.

About15 species, distributed in Mexico, tropical S. America to West Indies (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

84. *L. mollis* Cav.

Fl. and Fr.: August - December.

Distrib.: Palamau, Ranchi.

XLII. LAGGERA Sch.-Bip. ex Koch

Seventeen species distributed in Old Word tropical countries (Mabberly, 2008); 2 species in India (Karthikeyan et al., 2009); 3 species in Jharkhand.

Key to the species

la	Stem not winged; corolla of bisexual florets pi006Ek; achenes sub-compressed	*L. aurita*
1b	Stem winged; corolla of bisexual florets bluish purple; achenes faintly ribbed	*2*
2a	Wings of stem broad, entire and continuous; pappus 6-7 mm lo	*L. alata*
2b	Wings of stem narrow, toothed and interrupted; pappus 4-5 mm long	*L. crispata*

85. *L. alata* (D. Don) Sch.-Bip. ex Oliver

Fl. and Fr.: November - January.

Distrib.: Giridih, Palamau.

86. *L. aurita* L.f.

Fl. and Fr.: December - March.

Distrib.: Koderma, Singhbhum.

87. *L. crispata* (Vahl) Hepper and Wood

Fl. and Fr.: December - April. *Distrib.*: Palamau, Ranchi, Singhbhum.

XLIII. LAUNAEA Cass.

About 45 species, distributed in S.E. Asia, C. Asia, Europe and Africa (Mabberley, 2008); 9 species in India (Karthikeyan et al., 2009); 5 species in Jharkhand.

Key to the species

1a	Achenes prominent lyribbed	*2*
1b	Achenes rugose/rugulose	*4*
2a	Ligules pink	*L. intybacea*
2b	Ligules yellowish	*3*
3a	Achenes sub-compressed	*L. acaulis*
3b	Achenes columnar	*L. sarmentosa*
4a	Herbs with procumbent to erect stems or acaulescent	*L. procumbens*
4b	Herbs with thick root stock	*L. asplenifolia*

88. *L. acaulis* (Roxb.) Babe ex Kerr

Fl. and Fr.: March - June.

Distrib.: Hazaribagh, Singhbhum.

89. *L. aspleniifolia* (Willd.) Hook.f.

Fl. and Fr.: January - April.

Distrib.: Hazaribagh

90. *L. intybacea* (Jacq.) Beauverd

Fl. and Fr.: September - December.

Distrib.: Palkot, Koderma, Dalma.

91. *L. procumbens* (Roxb.) Ramayya and Rajagopal

Fl and Fr.: March - September. *Distrib.*: Palamau, Singhbhum, Hazaribagh, Koderma.

92. *L. sarmentosa* (Willd.) Sch.-Bip. ex Kuntze

Fl. and Fr.: June - September.

Distrib.: Singhbhum, Palamau.

XLIV. MIKANIA Willd.

About 300 species, distributed in United States through Mexico, central America and W. Indies to S. America, few species in E. Hemisphere (Mabberley, 2008); 2 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

93. *M. micrantha* Kunth

Fl. and Fr.: December - March. *Distrib.*: Palamau.

XLV. PARTHENIUM L.

About 16 species, distributed in N. America and West Indies (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

94. *P. hysterophorus* L. *Fl. and Fr.*: July - March. *Distrib.*: Hazaribagh, Palamau.

XLVI. PENTANEMA Cass.

Eighteen species distributed in Turkey and Central Asia to Sri Lanka (Mabberly, 2008); 3 species in India (Karthikeyan et al., 2009); 3 species in Jharkhand.

Key to the species

la	Involucral bracts acute with erect tip,glabrous,; ligules lanceolate; ray florets epappose	*P. indicum*
1b	Involucral bracts acuminate with recurved tip, hairy; ray florets pappose	*2*
2a	Plants sparsely pubescent; lower leaves sub-sessile; leaf apex acuminate	*P. cernuum*
2b	Plants softly woolly; all leaves sessile; leaf apex obtuse to sub-acute	*P. vestitum*

95. *P. cernuum* (Dalzell) Ling

Fl. and Fr.: November - February. *Distrib.*: Giridih.

96. *P. indicum* (L.) Ling

Fl. and Fr.: October - February. *Distrib.*: Hazaribagh, Koderma, Palamau, Ranchi, Singhbhum.

97. *P. vestitum* (Wall. ex DC.) Ling

Fl. and Fr.: February - May.

Distrib.: Santal Pargana.

XLVII. PULICARIA Gaertn.

Seventy seven species distributed in temperate region and warm Eurasia (Mabberly, 2008); 12 species in India (Karthikeyan et al., 2009); 2 species in Jharkhand.

Key to the species

1a	Ray florets ligulate	*P. angustifolia*
1b	Ray florets tubular	*P. foliolosa*

98. *P. angustifolia* DC.

Fl. and Fr.: May - October. *Distrib.*: Lohardaga, Palamau, Ranchi.

99. *P. foliolosa* DC.

Fl. and Fr.: April - June. *Distrib.*: Hazaribagh.

XLVIII. SAUSSUREA DC.

About 403 species, distributed in temperate Asia, Australia, Europe and N. America (Mabberley, 2008); 69 species and 7 varieties in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

100. *S. heteromalla* (D. Don) Hand.-Mazz.

Fl. and Fr.: March - May. *Distrib.*: Palamau.

XLIX. SCLEROCARPUS Jacq.

About 8 species, distributed in tropical and warm America, Africa (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

101. *S. africanus* Jacq. ex Murray

Fl. and Fr.: March - July. *Distrib.*: Ranchi.

L. SENECIO L.

About 1000 species (Mabberley, 2008); 43 species in India (Mathur, 1995); 48 species, 1 subspecies and 6 varieties in India (Karthikeyan et al., 2009); 3 species in Jharkhand.

Key to the species

1a	Stems glabrous or sparsely arachnoid tomentose; leaves cuneate or amplexicaul at base; involucral bracts 12-14	*S. nudicaulis*
1b	Stems sparsely pubescent when young; leaves truncate or slightly cordate or attenuateat base; involucral bracts 8-10	*S. wightianus*

102. *S. nudicaulis Buch*.-Ham. ex D. Don

Fl. and Fr.: March - June.

Distrib.: Hazaribagh, Palamau.

103. *S. wightianus* DC. ex Wight

Fl. and Fr.: September - December.

Distrib.: Singhbhum.

LI. SIGESBECKIA L.

About 12 species distributed in tropical countries (Mabberly, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

104. *S. orientalis* L.

Fl. and Fr.: April - December.

Distrib.: Throughout the state.

LII. SOLIVA Ruiz and Pavon

About 8 species, distributed in S. America (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

105. *S. anthemifolia* (Juss.) Sweet

Fl. and Fr.: December - February

Distrib.:Hazaribagh.

LIII. SONCHUS L.

About 50 species, distributed throughout the world (Mabberley, 2008); 5 species, 1 subspecies and1 variety in India (Karthikeyan et al., 2009); 3 species in Jharkhand.

Key to the species

1a	Perennial herbs, rhizomatous	*S. brachyotus*
1b	Annual herbs, non-rhizomatous	*2*
2a	Stem slightly angular and finely grooved	*S. oleraceus*
2b	Stem cylindrical and not grooved	*S. asper*

106. *S. asper* (L.)Hill

Fl. and Fr.: April - September. *Distrib.*: Hazaribagh, Koderma.

107. *S. brachyotus* DC.

Fl. and Fr.: March - November.

Distrib.: Palamau, Gumla.

108. *S. oleraceus* L.

Fl. and Fr.: March - November.

Distrib.: Palamau.

LIV. SPHAERANTHUS L.

Forty species distributed to old World tropics to Iran and Egypt (Mabberly, 2008); 4 species in India (Karthikeyan et al., 2009); 2 species in Jharkhand.

Key to the species

1a	Leaves double-dentate with stalked glands	*S. indicus*
1b	Leaves single-dentate with sessile glands	*S. senegalensis*

109. *S. indicus* L.

Fl.andFr.: January - April. Distrib.: Throughout the state.

110. *S. senegalensis* DC.

Fl. and Fr.: January - April. *Distrib.*: Bihar

LV. SPHAEROMORPHAEA DC.

One species in Australia (Mabberly, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

111. *S. australis* (Less.) Kitam.

Fl. and Fr.: April - May.

Distrib.: Giridih, Hazaribagh.

LVI. SYNEDRELLA Gaertn.

One species, native of tropical America (Mabberley, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

112. *S. nodiflora* (L.) Gaertn.

Fl. and Fr.: September - December.

Distrib.: Throughout the state.

LVII. TRICHOLEPISDC.

Eighteen species, Central Asia to India (Mabberley, 2008); 13 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

113. *T. stictophyllum* C.B.Clarke

Fl. and Fr.: April - July. *Distrib.*: Palamau.

LVIII. TRIDAX L.

About 26 species distributed in America (Mabberly, 2008); 1 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

114. *T. procumbens* L.

Fl. and Fr.: July - February.

Distrib.: Throughout the state.

LIX. VERNONIA Schreb.

About 1000 species, distributed in tropical and mostly American (Mabberley, 2008); 54 species, 1 subspecies and 7 varieties in India (Karthikeyan et al., 2009); 8 species in Jharkhand.

Key to the species

1a	Achenes 3-5 angled and 3-5-ribbed	*V. patula*
1b	Achenes terete or rarely 3-5 angled but always 6-10-ribbed	*2*
2a	Outer phyllaries foliose	*V. anthelmintica*
2b	Outer phyllaries not foliose	*3*
3a	Leaves white-tomentose or densely villous beneath	*V. albicans*
3b	Leaves glabrous, glabrescent or sparsely pubescent beneath	*4*
4a	Stem basally glabrescent	*V. aspera*
4b	Stem basally pubescent	*5*
5a	Pappus uniseriate	*V. saligna*
5b	Pappus biseriate	*6*
6a	Capitula sessile or subsessile	*V. squarrosa*
6b	Capitula distinctly peduncled	*7*
7a	Capitulum with 5-12 florets	*V. divergens*
7b	Capitulum with 18-30 florets	*V. cinerea*

115. *V. patula* (Aiton) Merr.

Fl. and Fr.: December - March.

Distrib.: Chota Nagpur.

116. *V. anthelmintica* (L.) Willd.

Fl. and Fr.: September - January. *Distrib.*: Hazaribagh, Lohardaga, Palamau, Singhbhum.

117. *V. albicans* DC.

Fl. and Fr. March - August. *Distrib.*: Gumla.

118. *V. aspera* Buch.-Ham.

Fl. and Fr.: September - January. *Distrib.*: Hazaribagh, Palamau, Ranchi, Santal Pargana.

119. *V. saligna* DC.

Fl. and Fr.: October - December.

Distrib.: Santal Pargana.

120. *V. squarrosa* (D. Don) Less.

Fl. and Fr.: October - January.

Distrib.: Hazaribagh, Lohardaga, Singhbhum.

121. *V. divergens* (DC.) Edgew.

Fl. and Fr.: December - May.

Distrib.: Hazaribagh, Palamau, Ranchi, Gumla.

122. *V. cinerea* (L.) Less.

Fl. and Fr.: Almost throughout the year.

Distrib.: Singhbhum, Chaibasa, Daltonganj, Palamau, Koderma, Gumla.

LX. WEDELIA Jacq.

About 70 species, distributed in tropical and warm temperate regions of the world (Mabberley, 2008); 6 species and 2 varieties in India (Karthikeyan et al., 2009); 3 species and 1 variety in Jharkhand.

Key to the species

1a	Involucral bracts nearly equaling to the disc florets	*2*
1b	Involucral bracts much longer than the disc florets	*3*
2a	Climbing shrubs, 1-3 m high	*W. biflora*
2b	Erect or suberect herbs, 15-60 cm high	*W. montana var. wallichii*
3a	Leaves subsessile, spathulate-lanceolate, margins entire or faintlyserrate	*W. chinensis*
3b	Leaves distinctly petioled, ovate, margins serrate	*W. urticaefolia*

123. *W. biflora* (L.) DC.

Fl. and Fr.: October - December.

Distrib.: Hazaribagh.

124. *W. chinensis* (L.) Merr.

Fl. and Fr.: March - September.

Distrib.: Hazaribagh.

125. *W. montana* (Blume) Boerl. var. *wallichii* (Less.) H. Koyama

Fl. and Fr.: October-December.

Distrib.: Hazaribagh.

126. *W. urticaefolia* DC.

Fl. and Fr.: Throughout the year.

Distrib.: Throughout the state.

LXI. XANTHIUM L.

Three species in world, cosmopolitan (Mabberly, 2008); 3 species in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

127. *X. strumarium* L.

Fl. and Fr.: March - December.

Distrib.: Throughout the state.

LXII. YOUNGIA Cass.

About 35 species, distributed in Himalayan region eastwards to Japan from tropical to alpine regions (Mabberley, 2008); 12 species and 2 subspecies in India (Karthikeyan et al., 2009); 1 species in Jharkhand.

128. *Y. japonica* (L.)DC.

Fl. and Fr.: October - April. *Distrib.*: Giridih, Hazaribagh, Palamau, Singhbhum.

At global level the family Asteraceae is represented by c. 1590 genera and 23,600 species, distributed in temperate and subtropical zones

(Mabberley, 2008). It is the fourth largest family of India with 950 species under 167 genera (Arisdason and Lakshminarasimhan, 2017). In present communication, 128 taxa (123 species and 05 varieties) under 62 genera for the state Jharkhand have been enumerated. Members of Asteraceae are very common in neighboring states e.g. West Bengal has 239 species, 02 subspecies and 10 varieties are under 108 genera (Ranjan et al., 2016), Uttar Pradesh has 152 species and 05 varieties are under 88 genera (Khanna, 2017), Odisha has 102 species and 53 genera (Saxsena and Brahmam, 1995) and Bihar has 84 species and 4 varieties are under 54 genera (Kumar et al., 2019).

The study indicates that the Asteraceae are much diversified in the state, out of 62 genera, a total of 37 are represented by only one species and 5 are represented by 5 or more species. The most diversified genus is *Blumea* with 14 species, followed by *Vernonia* (09 species), *Gnaphalium* (07 species), *Conyza* (06 species) and *Launaea* (05 species). A total of ten species are occurs throughout the state, i.e. *Acmella oleracea, Ageratum conyzoides, Caesulia axillaris, Eclipta prostrata, Sigesbeckia orientalis, Sphaeranthus indicus, Synedrella nodiflora,Tridax procumbens, Wedelia urticaefoliaand Xanthium strumarium*. On the other hand, distributions of 43 species are restricted to only one district of Jharkhand state.

Out of 128 taxa, c. 82 species flowered in winter season and c. 35 species in summer (Fig. 1). Most of the Asteraceae species follows similar flowering phenology. It may due to the optimization of pollination and seed dispersal (Torres and Galetto, 2011). It has been observed that in Jharkhand all members of family Asteraceae are herbaceous except three shrubby taxa *i.e. Artemisia japonica* Thumb., *Eupatorium mairei* H. Lev. var. *heterophyllum* (DC.) Karthik. and Moorthy and *Vernonia divergens* (DC.) Edgew.

Mabberley (2008, 2017) reported the distribution of Genus *Caesulia* Roxb. with the species *Caesulia axillaris* Roxb. innorth-eastern India only but this species is widely distributed in Indian subcontinent, like Pakistan, Nepal, Bangladesh and Myanmar (Pant, 1995). Hence,

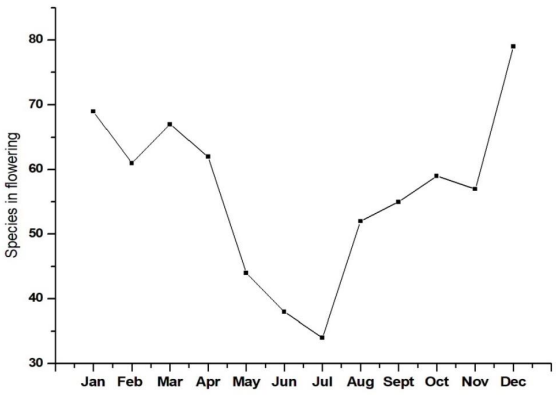

Fig. 1. Flowering phenology of the taxa

there is a conflict on distribution of the genus and need an extensive assessment. However, we have noticed that this genus is distributed almost throughout in plains, paddy fields, shallow ditches and moist low lying areas of India.

Blumeopsis, Caesulia and *Sphaeromorphaea* are monotypic genera documented in present study. The representative species of respective genus is distributed in the state, e.g. *Blumeopsis flava* has been recorded in Chota Nagpur, Santal Pargana, *Caesulia axillaris* is occurs throughout in the state and *Sphaeromorphaea australis* wasreported from Giridih and Hazaribagh districts.

The distribution of genera of family Asteraceae of Jharkhand at global and national level were studied and compiled. It will help us to known the status of the associated genera in the world and India. On the basis of species diversity, genus *Eupatorium* has the maximum number of species at global level, comprises c. 1200 species in World, 12 taxa in India and 03 taxa in Jharkhand, it was followed by Senecio (c. 1000 species in World, 43 in India and 03 in Jharkhand), Vernonia (c. 1000 species in World, 62 taxon in India and 09 species in Jharkhand), Saussurea (c. 403 species in World, 76 taxon in India and 01 species in Jharkhand), Artemisia (c. 400 species in World, 68 taxa in India and 04 species in Jharkhand) etc. Eight genera (Bidens, Chrysanthellum, Erigeron, Gnaphalium, Lactuca, Senecio, Sonchus and Xanthium) are distributed throughout the world/cosmopolitan while other genera have restricted distribution.

The cultivated species like, *Calendula officinalis* L., *Chrysanthemum coronarium* L., *Chrysanthemum indicum* L., *Cichorium endivia* L., *Cosmos bipinnatus* Cav., *Cynara scolymus* L., *Eupatorium foeniculaceum* Willd., *Glebionis coronari*a (L.) Cass. ex Spach, *Gynura aurantiaca* (Blume) DC., *Helianthus annuu*s L., *H. argophyllus* Torr. and Gray, *Lactuca sativa* L., *Tegetes erecta* L., *Tithonia diversifolia* (Hemsl.) A. Gray, *Vernonia elaeagnifoiia* DC. and *Zinnia violacea* Cav. are not included in the present communication.

CONCLUSION

A total of 130 taxa belongs to the family Asteraceae are documented. Furthermore, distributions at global and national level of associated genera have been provided. This data will be ready references to assess the Asteraceae diversity in the state of Jharkhand. The study will facilitate strategies for management of wild plants and habitat conservation aspects in terms of plant diversity and resource management.

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Orchid diversity of Jamtara Forest Division, Jamtara, Jharkhand, India

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ABSTRACT

The present survey was conducted in the year 2023 to study the orchid diversity in Jamtara Forest Division, Jamtara, Jharkhand, India. The study was made during the flowering period of orchid species for proper identification. The survey outcome revealed a total of 19 species belonging to 11 genera, out of which four species are terrestrial and 15 species are epiphytes.

Key words: Jamtara, Jharkhand, orchidaceae, orchid diversity

INTRODUCTION

Orchids are the most advanced, diverse and widespread family of monocots on the earth. The origin of these plants dates back millions of years. However, exactly how old is the family, has long been disputed, as there are no fossil remains to work with (Schiff, 2018). The family Orchidaceae is the most diverse group of plants, with an estimate of about 28,000 currently accepted species and 800 sub-species (Pal and Nagrare, 2006; Bazzicalupo et al., 2023). They are divided into five sub-families: Apostasioideae, Vanilloideae, Cypripedioideae, Epidendroideae, and Orchidoideae (Chase et al., 2018). As orchid seeds are very small and mild, they are dispersed through wind when they fall into some new environmental condition. They either die, attempt to tolerate, or even bring approximately a few genotypic trades to adapt to the new surroundings. This is one of the reasons why orchids are such a big group of plants (Gupta and Kumar, 2007; Kumar et al., 2007). They grow in diverse ecosystems except the polar regions and hot-dry deserts (Benzing and Atwood, 1984). In many countries, some orchids have also been used as traditional natural drugs (Bal et al., 2007; Misra et al., 2013; Kumar et al., 2021). In India, they are represented by about 1256 species (Misra, 2019; Singh et al., 2019; Kumar and Kumar, 2020). In the state of Jharkhand, India, however, no comprehensive study on orchids has been carried out so far. The population of many orchids in the state is declining due to anthropogenic factors and climatic changes. Therefore, their documentation and conservation are necessary. The present study highlights the diversity of orchids in Jamtara Forest Division, Jharkhand, India, for future in-situ conservation plans.

MATERIALS AND METHODS

Study area

Jamtara Forest Division (JFD) is situated in the Eastern part of Jharkhand state in Jamtara district (Fig. 1). It is located at 23.95°N 86.8°E and has an average elevation of 155 m. JFD has four ranges, namely: Jamtara, Nala, Kundhit, and Narayanpur. It experiences extremes of climate, with the mean temperature varying from 17°C to 32°C. In winter, the minimum temperature is 2°C,

and the maximum temperature rises up to 45°C in the months during April to May. The monsoon starts in July and lasts till October. The average annual rainfall in the Jamtara and Kundahit Ranges of the Division is slightly greater than that of the rest of the areas (Ajinkya et al., 2023).

Data collection

Extensive field surveys were conducted in 2023 across the division, and the study was made during their flowering period for proper identification of species (Fig. 2).

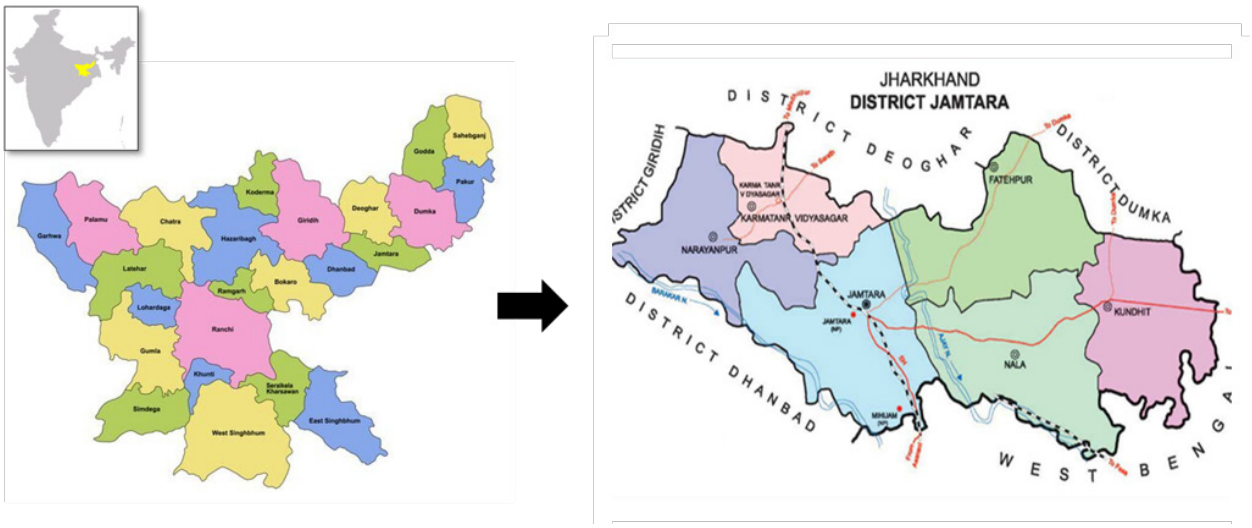

Fig. 1. Geographical location of study area

Information on the phenology, habit, habitat, color of flower, local name, relative abundance, associated plants, etc. for many species were recorded. (Kumar et al., 2021).

RESULTS AND DISCUSSION

The study revealed that the study area harbours about 19 species of orchids belonging to 11 genera. Among them, four species are terrestrial, 15 species are epiphytic. The genus *Luisia* represents four species viz. *L. inconspicua, L. trichorhiza, L. tristis, L. zeylanica* followed by the genus *Acampe* with three species namely *A. carinata, A. praemorsa and A. rigida*. The genus *Eulophia, Oberonia* and Vanda represents two species each those are *E. diffusiflora, E. picta, O. ensiformis, O. falconeri, V. tessellata* and *V. testacea,* respectively. It was noticed that the flowering period for the terrestrial orchids in study areas is mainly during June to August and the *Habenaria plantaginea* is one of the late flowering orchids, blooms between August to October. The epiphytic orchids bloom during February to June. Some epiphytic orchids also show late flowering that is in the month of September to November, like *O. ensiformis, O. falconeri* and *Bulbophyllum careyanum* (Table 1, Fig. 3).

During the literature survey, it was observed that very little documentation is available on the orchid diversity of Jharkhand state. Gupta and Kumar (2007) recorded 20 species of orchids from Saranda Forest Division, West Singhbhum District of Jharkhand. Kumar et al. (2007) recorded a total of 63 species, of which 33 are terrestrial, and one semi-aquatic species, whereas 29 are epiphytic, of which five were found to be lithophytes. Kumar and Kumar (2020) documented a total of 31 orchid species with their medicinal uses, of which 17 are epiphytic, 10 are terrestrial, three are lithophytic, and one belongs to semi-aquatic habitat in Jharkhand state.

Table 1. Orchid diversity of Jamtara Forest Division, Jamtara, Jharkhand, India

Sl. No.	Botanical Name	Habitat	Flowering periods
1.	*Acampe carinata* (Griff.) Panigrahi	Epiphyte	Oct – Jan
2.	*A. praemorsa* (Roxb.) Blatt. & McCann	Epiphyte	May – Oct
3.	*A. rigida* (Buch.-Ham. ex Sm.) P.F.Hunt	Epiphyte	Aug – Sep
4.	*Aerides multiflora* Roxb.	Epiphyte	Jun – July
5.	*Bulbophyllum careyanum*(Hook.) Spreng.	Epiphyte	Sep- Dec
6.	*Eulophia diffusiflora* M.W. Chase, Kumar & Schuit.	Terrestrial	Jun – July
7.	*E. picta* (R.Br.) Ormerod	Terrestrial	Jun – July
8.	*Habenaria plantaginea* Lindl.	Terrestrial	Aug – Oct
9.	*Liparis odorat*a (Willd.) Lindl.	Terrestrial	July – Aug
10.	*Luisia inconspicua* (Hook.f.) King & Pantl.	Epiphyte	Mar – May
11.	*L. trichorhiza* (Hook.) Blume	Epiphyte	Mar – May
12.	*L. tristis* (G.Forst.) Hook.f.	Epiphyte	Feb – Mar
13.	*L. zeylanica* Lindl.	Epiphyte	Mar – May
14.	*Oberonia ensiformis* (Sm.) Lindl.	Epiphyte	Oct – Nov
15.	*O. falconeri* Hook.f.	Epiphyte	Sep – Oct
16.	*Rhynchostylis retusa* (L.) Blume	Epiphyte	Mar – Jun
17.	*Smitinandia micrantha* (Lindl.) Holttum	Epiphyte	Apr – Jun
18.	*Vanda tessellata* (Roxb.) Hook. ex G.Don	Epiphyte	Mar – Oct
19.	*V. testacea* (Lindl.) Rchb.f.	Epiphyte	Apr – May

Fig. 2. Survey works in study areas, a) documentation of *H. plantaginea*, b) A local inhabitant shows *Vanda tessellata*

Fig. 3. Some common orchids of Jamtara Forest Division, Jharkhand, India A) *V. tessellata*, B) *H. plantaginea*, C) *A. praemorsa*

CONCLUSION

The study concludes that Jharkhand state has less documentation on orchid diversity. In this regard, the present investigation offers baseline data for upcoming exploration projects in the state that aim to document the diversity of orchids. In addition, the present study highlights the orchid species found in Jamtara Forest Division, Jamtara, Jharkhand, and suggests to build a long-term conservation plan for the state.

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Occurrence and activity pattern of leopard cat (*Prionailurus bengalensis*) in Bhitarkanika Wildlife Sanctuary, Odisha, India

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ABSTRACT

The leopard cat (*Prionailurus bengalensis*) is a medium-sized cat endemic to South and Southeast Asia. It is an IUCN Red list of 'Least Concern' species because of habitat loss and poaching. The presence and activity pattern of leopard cats in Bhitarkanika Wildlife Sanctuary, Odisha, India is reported through camera trap surveys from 10th July 2021 to 30th June 2022 in five blocks. From a total of 13350 camera-trapping nights at 160 sampling sites, 73 independent detections of leopard cats at 22 sites in the sanctuary were detected. Leopard cats were nocturnal, with peak activity at 03.00 AM to 06.00 AM and 07.00 PM to 09.00 PM. Present study suggests that it is the need of the hour to conserve the leopard cats in the identified potential habitats including its major prey species. Further, extensive research and monitoring are required for these cats in the protected areas of the state of Odisha.

Key words: Activity pattern, Bhitarkanika Wildlife Sanctuary, camera trapping, leopard cat

INTRODUCTION

The leopard cat (*Prionailurus bengalensis*) is a small wild cat native to continental South, Southeast and East Asia. Since 2002, it has been listed as Least Concern (LC) on the IUCN Red List as it is widely distributed although threatened by habitat loss and hunting in parts of its range (Ghimirey et al., 2022). The leopard cat has got the broadest geographic distribution among all small Asian cats. It is found in most part of the Southeast Asia. It's distribution range includes countries such as: Afghanistan, northern Pakistan, India, Korea (Nowell and Jackson 1996), Bhutan, Myanmar, Bangladesh, Laos, Cambodia, Vietnam, Thailand (Sunquist & Sunquist 2002), extant wild felids in Asia with a range extending from northern Pakistan, through most of India and China, south through Malaysia, Indonesia and Borneo (Ross et al., 2015). The leopard cat, *Prionailurus bengalensis*, is approximately the size of a domestic cat, but with longer legs. The tail is about 40-50% of the length of head and body. The body color can be pale to reddish or grayish yellow. Individuals from the northern part are pale silver grey, whereas those from the south are yellow, ochre or brownish. The spots can form stripes on the neck and back. The underbelly and neck are white. The tail is spotted, with a few indistinct rings near the black tip (Yu and Wozencraft, 1991; Sunquist and Sunquist, 2002). Leopard cat's daily activity patterns have been documented as arrhythmic (Rabinowitz, 1990), arrhythmic with crepuscular and nocturnal peaks (Grassman 2000, 2004; Austin, 2002), and crepuscular and nocturnal (Rajaratnam, 2000; Mohd Azlan and Sharma, 2006; Schmidt et al., 2009; Oh et al., 2010). Despite most felids exhibiting crepuscular and nocturnal behaviour (Kitchener, 1991), they are capable to adapt to a wide range of light conditions (Sunquist and Sunquist, 2002).

In Odisha, leopard cats are distributed sporadically and confined to the coastal area and reportedly Similipal Tiger Reserve (Palei et al., 2016; Palei et al., 2018, 2021; Mishra and Mohan, 2022). In this paper, the occurrence, relative abundance, activity pattern and photographic evidence of leopard cats have been reported in Bhitarkanika Wildlife Sanctuary, Odisha, India.

MATERIALS AND METHODS

Study Area

The study is undertaken in the Bhitarkanika Wildlife Sanctuary (BWS; 86° 46 to 87° 03' E and 20° 30' to 20° 48' N), a mangrove forest area of Odisha, India occupying an area of 672 sq km (Fig. 1). It is established by rich alluvial deposits of the Brahmani, Baitarani and Dhamra rivers. The area receives an annual rainfall of 1680 mm, with the minimum and the maximum monthly temperatures of 15°C and 40°C, respectively. The land elevation ranges from 3.66 m to 8.23 m. The BWS has a wide network of rivers and creeks, which are mainly fed by tidal water. It is the unique habitat of mangrove forests, numeric creeks and mud flats located in Kendrapara District of Odisha. The deltaic region is a unique habitat with mangrove vegetation on either side of the creeks and tidal mudflat. The mangrove ecosystem is one of the largest in the Indian sub-continent and the floral diversity is the second highest in world after Papua New Guinea. Bhitarkanika is home to diverse flora and fauna out of which some are endemic. It is an ideal habitat for reptiles like estuarine crocodile, water monitor lizard, king cobra and python. Important avifauna includes the kingfishers, storks, ibises, waders, and a variety of migratory ducks like bar-headed goose, brahminy duck, gadwall, pintail, etc. The major vegetation associations along the creeks consist of tree species, such as *Heritiera fomes, Sonneratia apetala, Avicennia officinalis* and *Excoecaria agallocha* (Misra et al., 2018). Apart from the leopard cat, other carnivores found in Bhitarkanika Wildlife Sanctuary are fishing cat (*Prionailurus viverrinus*), jungle cat (*Felis chaus*), jackal (*Canis aureus*), hyeana (*Hyaena hyaena*), Indian fox (*Vulpes bengalensis*), small Indian civet (*Viverricula indica*), common palm civet (*Paradoxurus hermaphroditus*) and smooth coated otter (*Lutra lutra*). Major herbivore species recorded in the study area are sambar (*Rusa unicolor*), spotted deer (*Axix axis*), wild pig (*Sus scrofa*), porcupine (*Hytrix indica*) and hanuman langur (*Semnopithecus entellus*).

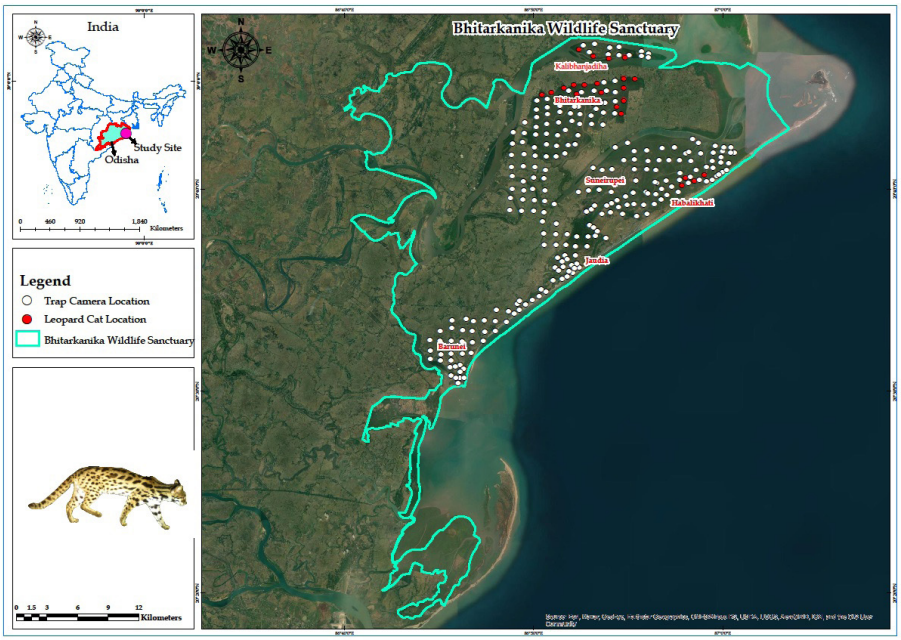

Fig. 1. Study area showing locations of camera traps and leopard cat (*Prionailurus bengalensis*) in Bhitarkanika Wildlife Sanctuary, Odisha.

Camera trap survey

Camera trap survey was carried out from 10th July 2021 to 30thJanuary 2022 (Table 1) as a part of a broader study of mammalian diversity. The survey was conducted within the "intensive study area" (ISA) of 10 km^2, representing all major habitat found in the BWS (Fig. 1). Camera trap surveys were conducted in five blocks of the sanctuary from 10th July 2021 to 17th June 2022. (Table 1). Most suitable camera trap locations were selected (along animal trails, forest roads & near creeks) which are likely trap animals based on preliminary sign surveys. At each camera trap station, a pair of automated motion-triggered digital camera-traps (Cuddeback Model C1; Non-Typical, Inc., Green Bay, WI) was placed on both sides of roads, facing each other, placed around 30-40 cm above the ground without using lure or bait. In this survey, all cameras were operational 24 hours per day. Cameras were checked every week to replace the batteries and memory cards and to ensure their proper functioning. Total sampling effort was calculated as the sum of the effective days across all stations that each camera was functioning (Boitani and Powell, 2012). We considered photos separated by at least 30 minutes as independent events (Ohashi et al., 2013; Guo et al., 2017). All camera traps were strapped to trees approximately 50 cm above ground. Camera traps were set to operate 24 h per day and programmed to delay sequential photographs by 30 s recording time. Each camera trap was checked at least once a week for battery level, positioning and to replace memory (SD) cards. Each photograph was manually checked to identify the species. Date, time and temperature were noted for each identified species.

To estimate the abundance of leopard cat, RAI (relative abundance index) was calculated based on following formula (O'Brien et al., 2003; Palei et al., 2016):

RAI = (Number of independent picture events/Total sampling effort) × 100

The authors used independent detections to evaluate the temporal activity pattern of the leopard cat and calculated the proportion of time active on day and night to describe the temporal activity pattern of leopard cat as per the methodology undertaken by Karanth et al. (2017). Under the study, the authors used the 'radar plot' in window excel, which fits a circular distribution to the 24-h cycle time.

Table 1. Survey efforts and detection of leopard cat with the number of trap-nights in Bhitarkanika Wildlife Sanctuary

Blocks	Sampling Period	No. of Camera stations	Trap nights (effort)	Leopard cat photo captured
Barunei	10th July 21 to 17th June 22	30 (Five phases)	2250	No photo captured
Suneirupei	16th Oct 21 to 17th June 22	30 (Five phases)	2250	No photo captured
Jaudia	2th May 22 to 17th June 22	20	750	No photo captured
Habalikhati	16th Oct 21 to 1 Dec 21	10	450	15
Bhitarkanika	7th Jan 2022 to 10th Apr 22	40 (Two phases)	3600	46
Kalibhanjadiha	14th Feb 22 to 30th June 22	30 (Three phases)	4050	12
Total		160	13350	73

RESULTS AND DISCUSSION

The data from the installation of camera traps in the survey area from 10th July 2021 to 30th June 2022, covering 160 locations with an area of 672 sq km in Bhitarkanika Wildlife Sanctuary (BWLS), a total effort of 13350 trap nights from 160 camera trap locations with five blocks were interpreted (Table 1). A total of 73 photos of leopard cats were recorded in different blocks of BWLS (Table 1). The highest leopard cats were recorded in Bhitarkanika block n=46, 63%, followed by Habalikhati block n=16, 08%, Kalibhanjadiha block n=12, 22% (Fig. 3, 4 & 5). There were no records of presence of leopard cats from Barunei Block, Suneirupei block and Jaudia block of Bhitarkanika Wildlife

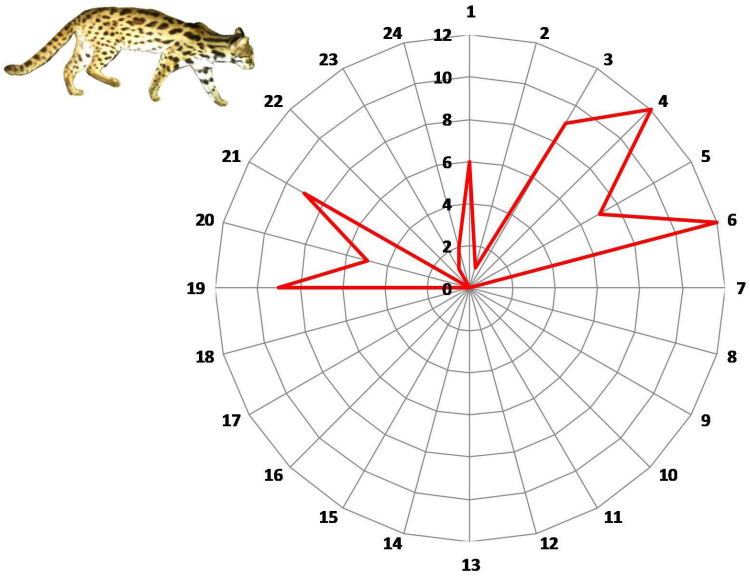

Fig. 2. Daily activity pattern of leopard cat (*Prionailurus bengalensis*) in Bhitarkanika Wildlife Sanctuary, Odisha. Circular plot is divided in 24 intervals of 1 h, and filled diamond points represent the number of independent detections of leopard cat in each interval.

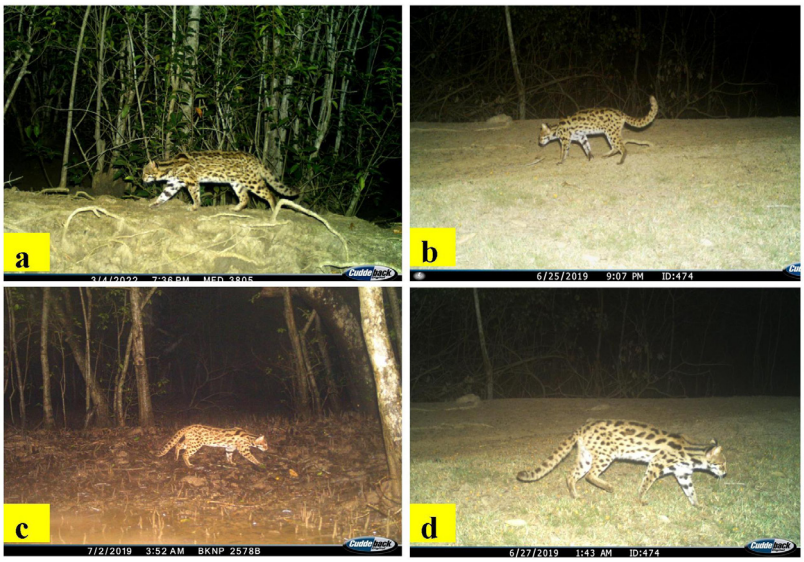

Fig. 3. Leopard cat (*Prionailurus bengalensis*) in Kalibhanjadiha, Bhitarkanika Wildlife Sanctuary, Odisha. (Photo: Odisha Forest Department)

Sanctuary. The RAI of Leopard cat was equal to 0.54 events per 100 camera trap days. Leopard cats were mostly nocturnal, with the maximum photo captured during the night hours (58 independent detections, 89.39%) more actively between 08:00-10:00 PM (62.0%) of the independent movement) with a peak around 04.00 AM to 6.00 AM (Fig. 2). Leopard cats showed bimodal peaks in their activity; the first peak was observed from late evening to midnight and the next in the late night with 3.00 AM to 6.00 AM (Fig. 3). Though leopard cats were active throughout the night, they exhibited reduced activity during the daytime (Fig. 2).

This is the first comprehensive study on occurrence and activity pattern of leopard cat in Bhitarkanika Wildlife Sanctuary. From the present study, it can be inferred that leopard cats are distributed in Bhitarkanika block, Habalikhati block and Kalibhajadiha block of Bhitarkanika Wildlife Sanctuary (Fig. 1). The other areas like Jaudia, Suneirupei and Barunei are highly vulnerable to various anthropogenic activities such as agriculture, intensive fishing and aquaculture practices. Leopard cats can be flexible in their activity patterns; in areas with higher human disturbance, they are more active at nighttime, whereas in National Parks or Wildlife Sanctuaries, their activities are more evenly throughout the day (Chen et al., 2016).

Conservation of small cat (Leopard cat, fishing cat and jungle cat) is a major focus in Bhitarkanika Wildlife Sanctuary, Odisha. The current study establishes baseline information on leopard cats in the above sanctuary. Similar studies have shown a low abundance, suggesting that good tree cover and small prey greatly influences the presence of the leopard cat in tropical regions (Bashir et al., 2013). In the present study area, a diverse assemblage sympatric species, such as leopard cat, jungle cat, and fishing cat (Lyngdoh et al., 2011; Gopi et al., 2012) have been reported to occur. Such habitats, thus, need to be protected from conservation point of view. Therefore, further detailed study needs to be undertaken to focus on leopard cats in the Bhitarkanika Sanctuary and other vulnerable coastal parts of Odisha to have better understanding of the ecology of the species. The present study can be useful for preparing future management plan and conservation strategies of leopard cats in Bhitarkanika Wildlife Sanctuary, Odisha, India.

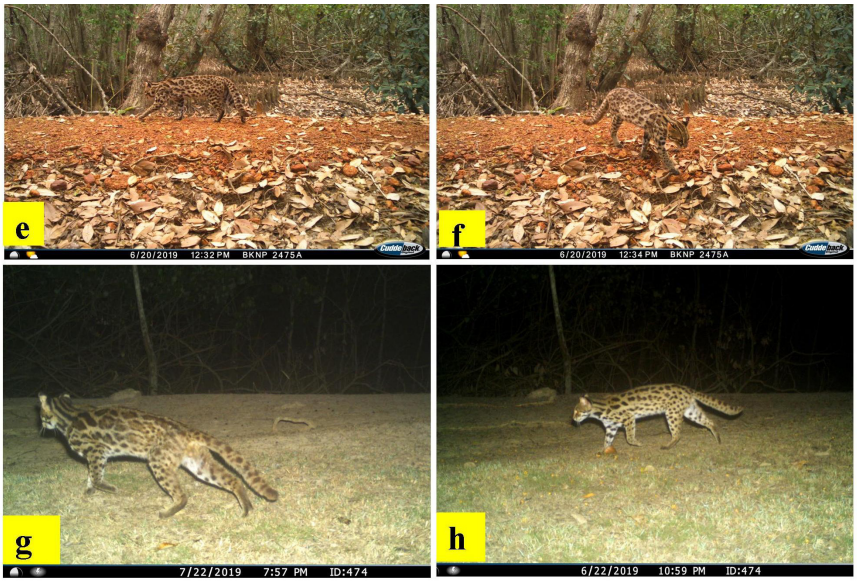

Fig. 4. Leopard cat (*Prionailurus bengalensis*) in Bhitarkanika block, Bhitarkanika Wildlife Sanctuary, Odisha. (Photo: Odisha Forest Department)

Fig. 5. Leopard cat (*Prionailurus bengalensis*) in Habalikhati, Bhitarkanika Wildlife Sanctuary, Odisha. (Photo: Odisha Forest Department)

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Modified technique for surgical implantation of transmitter device for radio telemetry in levantine vipers (*Macrovipera lebetinus*) in Kashmir region, India

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ABSTRACT

India harbours 23 species of viper among which Levantine viper (*Macrovipera lebetinus*) inhabits the regions of Jammu and Kashmir. In and around the vicinity of Srinagar, Jammu and Kashmir, human-snake conflict has been observed majorly involving *M. lebetinus*. With the capability of hemotoxic venom, the envenomation adversely impacts the victim's cardiovascular system. Wildlife SOS team frequently receives calls from locals to rescue Levantine vipers. With requisite equipment and protective gear, the rescuers are deputed to rescue these snakes and to release them back into safer habitat as a part of human-snake conflict mitigation. In order to understand the habitat ecology, and activity pattern of the species in the released natural habitat telemetry study was planned. The authors successfully accomplished the implantation of SI-2 transmitter device in *M. lebetinus* for radio telemetry studies. After a post operative observation of 14 days, the vipers were released back into suitable natural habitat. The detailed surgical interventions and anaesthetic procedures are discussed in this article.

Key words: Conflict mitigation, human-snake conflict, levantine viper, radio telemetry, surgical implantation

INTRODUCTION

Reptiles are ubiquitous but cryptic. It's always challenging to understand their behavioural pattern and ecology in natural habitats as well as the adaptation of those snakes rehabilitated in the suitable habitat as a part of conflict mitigation. Thus, the need of developing some special devices arises and herpetology scientists started to design suitable device based on their study need by considering the peculiar anatomy and physiology of the various reptiles including snake species. Radiotelemetry has been used for locating snakes by numerous previous researchers (Fitch and Shirer, 1971; Parker and Brown, 1972; Landreth, 1973; Brown and Parker, 1976; Nickerson et al., 1978; Henderson et al., 1980; Jacob and Painter, 1980; Reinert and Cundall, 1982). In most cases, a miniature transmitter was force-fed to the snakes. This method is unsatisfactory for long-term tracking of free-ranging snakes because, the effective range of the transmitter is small due to the necessary absence of an appreciable antenna; and the presence of the transmitter in the stomach may cause changes in foraging behavior (Fitch and Shirer, 1971). The transmitter may be regurgitated after a few days to

several months, making planned long-term studies difficult. Brown and Parker (1976), Henderson et al. (1980), and Jacob and Painter (1980) used surgical implantation of transmitters, but the methods were not described in detail and one of the most valuable benefits of surgical implantation, i.e., increased range, was not obtained as no antenna was used.

Passive integrated transponder (PIT) tags have been established as an effective method of uniquely marking animals across a wide range of taxa (Elbin and Burger, 1994; Gibbons and Andrews, 2004). In the year 2016, the PIT tag telemetry in studying a population of Queen snakes (*Regina septemvittata*) was done by Oldham et al., 2016 in Jessamine County, Kentucky (USA). Furthermore, newer tracking technology (i.e., satellite or global positioning trackers) often cannot be used for snakes due to size or shape constraints. In 1982, an improved surgical implantation method for radio-tracking snakes was developed by Reinert & Cundall, 1982 with commercial SM 1 and SB 2-IV transmitters (AVM Instrument Co., 6575 Trinity Ct., Dublin, CA 94566 with 1.4-volt Hg batteries (Eveready E675, E625, or E640) and 30-40 cm whip antennas of 32 AWG 7 x 40 Teflon insulated hook-up wire in venomous snakes (Crotalus horridus and Agkistrodon contortrix). Under the study, the authors used SI-2, VHF (138-235 MHZ) transmitters with VIP ANTENA in nine Levantine vipers which were rescued from conflict situation in and around Srinagar, Kashmir, India as a part of conflict mitigation. In this article, the authors discussed the adopted technique for induction of anaesthesia, transmitter implantation, and post-operative care in detail.

MATERIALS AND METHODS

Wildlife SOS is an NGO working successfully in many parts of India and is actively involved with the rescue and rehabilitation of wild animals including various kinds of conflict mitigation projects. With the collaboration of the Jammu & Kashmir wildlife protection department, Wildlife SOS is running rescue and rehabilitation centres for black and brown bears at Dachigam and Pahalgam. Those centres also perform reptiles rescue and rehabilitation in and around the Srinagar region of Kashmir. Levantine viper (*Macrovipera lebetinus*) is one of the major conflict species and receives frequent rescue calls from Srinagar city. So, it needs to be rescued and rehabilitated in a suitable habitat. To understand the ecology and activity pattern of these snakes, it was planned to have a radio telemetry study. The rescued snakes were selected as per the size and body weight (Table 2). Then a radiographic examination was performed to evaluate the skeletal damage if any and to eliminate the gravid females.

Radio transmitter specifications

For the above study, the authors used SI-2 transmitters from Holohil Systems Ltd., Canada (Table 1).

Anaesthetic approach

Immobilization of snakes is mandatory to implant transmitter beneath the skin and it needs versatile expertise as snakes have peculiar breathing physiology. The freely movable trachea of snakes is narrow and long, making up to one-fifth of the length of the body and the opening remains at the front portion of the mouth (Lillywhite et al., 1976). In snakes, the right lobe of the lung is developed to the two-fifth of the total body length whereas, the left lobe is either missing, vestigial, or well developed but is smaller than right lung (van Soldt et al., 2015). The cerebral regulation is weak as snakes don't have a diaphragm. Metabolism in snakes is generally low and it may vary according to environmental temperature. As the metabolism is low, the influence of the anaesthetics also builds slowly and so as the awakening. To achieve complete immobilization, the spinal reflex must be inhibited especially in the case of largely vegetatively neuroregulated animals. The respiration of a snake may also stop completely due to anesthesia as it doesn't have a diaphragm and the anesthesia blocks the

Table 1. Detailed specification of transmitter

Frequency range	138 – 235 MHz
Transmitter	Crystal-controlled two-stage design pulsed by a CMOS multivibrator
Pulse Width (standard)	24 milliseconds
Pulse Rate (standard)	35 pulses per minute (ppm), Available from 20-120ppm
Power Output	Set to use available battery power over the required transmitter life
Activation	Removing an external magnet starts the transmitter. Replacing the magnet stops the transmitter
Housing	The battery and transmitter are hermetically sealed in a brass case. A small groove is added to the unit to allow for suturing during implantation. To prevent tissue reactions, the case is coated with multiple layers of a biologically inert butyl rubber compound. For subcutaneous placement, asymmetrically tapered ends can be added, increasing the length by 5mm at each end
Antenna	Finely stranded stainless-steel cable, covered with a clear Teflon coating. Clear silicone tubing reinforces the base
Total weight of the transmitter with the VIP antenna	 7.8 g

muscle between the ribs (Betz, 1962). General anaesthesia is paramount to ensure minimal invasive surgical procedure as the transmitter needs to be implanted inside the celomic/peritoneal cavity. Earlier reports on the anaesthesia of snakes were published during 1930s and were all connected to venom glands and venom production of snakes (Tait, 1928; Clark, 1937; Kellaway, 1937). In all these studies, as an inhalation anesthetic agent, majorly chloroform and later a mixture of ether and air was used which made the snakes motionless during venom gland operation. After a decade, a new volatile fluid called Fluothane or Halothane came to the limelight which is neither inflammable nor irritates the respiratory tract (Hackenbrock and Finster, 1963). This procedure of snake anaesthesia was followed in several studies such as in Rattlesnake (Reinert and Cundall, 1982), in Meadow viper (Ujvari and Krosos, 1997; Ujvari and Kosos, 1999) and also in Common Grass snake (Nagy and Korsos, 1999). However, particularly in venomous snake species chamber induction is

Table 2. List of levantine viper (*Macrovipera lebetinus*) undergone the telemetry procedure

Sl. No.	Snake ID	Gender	Weight (in kg)	Total length (cm)
1	LV-1	Male	0.505	100
2	LV-3	Male	0.680	100
3	LV-4	Male	0.455	100.3
4	LV-5	Male	0.480	91.4
5	LV-6	Male	0.930	102
6	LV-2	Female	0.460	96.5
7	LV-7	Female	0.415	91.4
8	LV-8	Female	0.425	83.8
9	LV-9	Female	0.370	80

found to be effective and widely used (Mader and Divers, 2014). The authors adopted a modified method in Levantine vipers i.e., instead of using a separate inhalation mask/chamber, the anesthetic delivery system was made within the snake restraining tube itself. Isoflurane with oxygen was used to induce general anesthesia after restraining the snake inside the transparent restraining tube, and provision was made to fix the oxygen supply directly into the restraining tube and the measured volume of isoflurane-soaked cotton ball was kept separately in a glass chamber which was fixed to the cranial end of the restraining tube (Fig. 1). A Doppler probe was attached to the ventral surface at the cardiac location of the snake's body to monitor the heartbeat throughout the procedure.

Surgical procedure

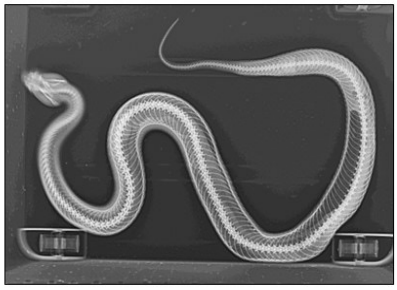
The surgical plane of anaesthesia was assessed by the symptoms of nil tongue flicking motion, and disappearance of righting reflex. After the surgical plane of anesthesia was attained, the morphometry, and sexing were performed. The exact body weight measured with a digital weighing balance. The snake was kept to mediolateral position, and the surgical site; six to seven inches above the cloaca was sterilized with antiseptic lotion. The position for implantation for radio transmitter varies with the size of the snakes. A scalpel blade (number 11) was used to make the dermal incision (less than an inch) where the dorsal and ventral scales adjoining to expose the abdominal muscle. A small nick was made on the abdominal muscle, then that was extended a little bit gently with scissor and forceps. The pre-sterilized transmitter was inserted inside the coelomic cavity with gentle pressure by holding the same at the antenna side. Tiny nick was made on the dorsal aspect of the snake 2 inches below the heart or, towards the head; to insert the endoscopic forceps subcutaneously for pulling and fixing the VIP antenna under the skin. The muscle layer was opposed separately with 3-0 / 4-0 absorbable needled suture material by a simple interrupted suturing technique. The dermal incision was opposed separately with simple interrupted suture materials, and tissue adhesive glue was also applied in the dermal incision to ensure the complete apposition (Fig. 2).

Recovery monitoring -postoperative care

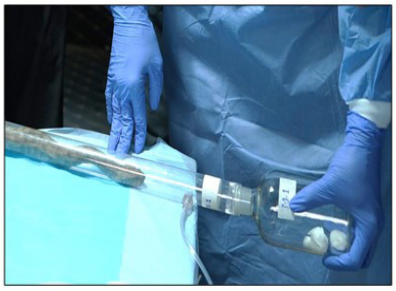
Wound dressing was done and Dressol bandage spray (Vamso Biotec. Pvt. Ltd.) was applied on the incision sites. Maintaining the snake's body temperature is essential for quick recovery and improving their metabolic rate. In order to prevent hypothermia it is paramount to maintain the patient within the POTZ of the species throughout the preanesthetic, perianesthetic and postanesthetic (Mader and Divers, 2014). The snake was kept inside the observation box with warm water bags. The infrared lamp was also used as a heat source till the animal starts recovering and frequent tongue flipping. The snakes were kept under observation for a period of 14 days prior to release (Fig. 2).

RESULTS AND DISCUSSION

The authors made slight modifications in the surgical procedure as described earlier by (Reinert and Cundall, 1982). Instead of using a needle for fixing the antenna by multiple pricking the skin, endoscopic forceps were used through a tiny incision to make tunnel under the skin to pull and fix the flexible VIP antenna subcutaneously. Most of the investigators recommend a transmitter that does not affect the normal mobility of the snake. A limit value of about 4-5% of the body mass is generally given (Weatherhead and Anderka, 1984; Reinert, 1992), but in the case of smaller species length and width of the transmitter can also be important. For a small, slender snake the transmitter should be accordingly to the slender (Weatherhead and Anderka, 1984). Even if the transmitter is less than 4% of the body mass of snake, having a large diameter object under the skin can cause intolerable inconvenience to the snake. Thus, it is important to select slender sized transmitter and snake with prescribed body mass and length (approximately the length of snake should be four times the length of the transmitter with antenna) for convenience. The transmitter here used in the procedure was slender and fit. No complications were found during and after the implantation of SI2 transmitter in *M. lebetinus* and the diameter and length of transmitter was found fit for the species.



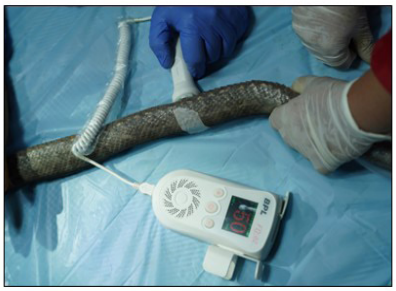
Step 1: Radiogarphic examination of Levantine viper (*Macrovipera lebetinus*) prior to surgery



Step 2: Induction of L. viper in a snake tube followed by anaesthetic chamber to attain general anaesthesia

Step 3: Measurement of body weight through digital weighing balance

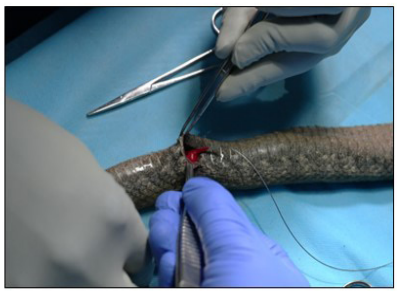
Step 4: Determination of gender through probing



Step 5: Monitoring of cardiovascular performance

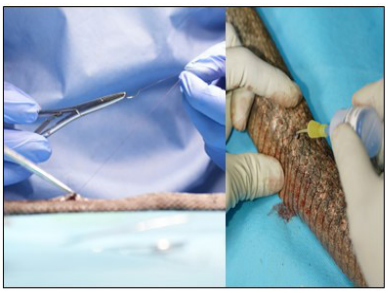
Step 6: Morphometric analysis and markings at mediolateral aspect for implantation of transmitter

Fig. 1 (Step 1-6). Step wise illustration of attaining general anaesthesia, morphometry and monitoring



Step 7: Dermal incision at mediolateral aspect and insertion of transmitter in coelomic cavity

Step 8: Endoscopic forceps inserted subcutaneously to pull and fix the VIP antenna under the skin



Step 9: Simple interrupted suture at dermal incision and application of tissue adhesive glue

Step 10: Radiographic examination showing implanted transmitter

Step 11: Recovery monitoring with maintaining POTZ of the species

Step 12: Completion of post operative care and found fit to release back in suitable natural habitat

Fig. 2 (Step 7-12). Surgical procedure and recovery monitoring

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BRIEF INSTRUCTIONS TO AUTHORS

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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.
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5. **Illustrations.** All graphs, diagrams and half-tones should be referred to as Figure and should be numbered consecutively in Arabic numerals. The figures should either match with the column width (8.5 cm) or the printing area (17.8 x 22 cm). The legends should be brief and self-explanatory. All graphs, figures should be drawn by EXCEL and submitted in editable format. Define in the footnote or legend any non-standard abbreviations or symbols used in a table or figure.
6. **Reviews.** Full length review articles are also invited.

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