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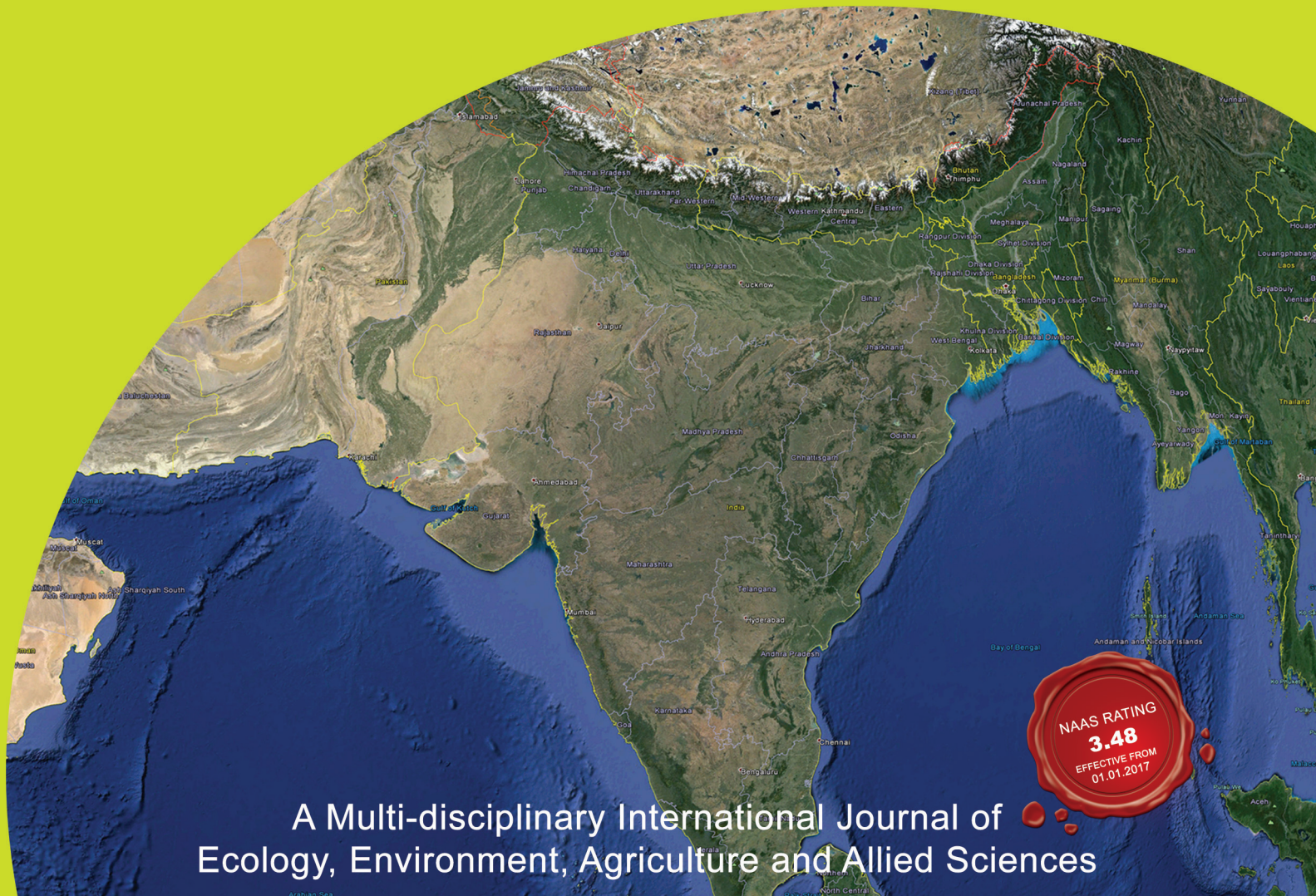

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Rauvolfia serpentina (Sarpagandha): An overview

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ABSTRACT

Rauvolfia serpentina or the Serpentina plant is a climbing or twining herb or shrub, belonging to the natural order Apocynaceae, very well known for its immense therapeutic use in the pharmaceutical world. *Rauvolfia serpentina* is found to be the most consistently successful and effective drug in curing violent maniacal disorders associated with psychosis, schizophrenia, insanity, insomnia and epilepsy. The pharmacologic actions of *Rauvolfia serpentina* is due to the presence of alkaloids, carbohydrates, flavonoids, glycosides, phlobatannins, phenols, resins, saponins, sterols, tannins and terpenes. The root extracts are mostly used for its various medicinal properties. It also helps in the treatment of intestinal disorders, particularly diarrhea and dysentery and also as anthelmintic. The present review focuses mainly on chemical composition and importance of *Rauvolfia* alkaloids.

Keywords: Therapeutic uses, *Rauvolfia serpentina*, alkaloids, ethnobotany, chemical composition

INTRODUCTION

India is one of the richest sources of traditional herbs and medicinal plants. From time immemorial our people are using these herbs to cure all kinds of diseases and illness. Now a days, millions of people are suffering from various types of diseases worldwide, therefore, there is a need to get new formulations of medicine which can cure these diseases. Though there are availability of different pharmaceutical formulations, these seem to be more costly and less affordable. Therefore, there is need to shift from these pharmaceutical formulations to traditional medicines. But over exploitation of these medicinal herbs has resulted in loss of genetic biodiversity. Therefore, we have to be concerned about bringing these medicinal plants into proper cultivation system so that our natural resources stay safe. Ahmed and Barua (2013) have discussed about the good agronomic practices (GAPs) for different medicinal and aromatic plants so that these plants can be brought under cultivation and production system. The therapeutic uses of medicinal plants are safe, economical and effective and are easily available to medium and small farmers. India has been considered as one of the major store house of various indigenous plants that are used to cure diseases of various kind. The local availability of all herbs in our surrounding helps us to use these herbs as home remedies.

Rauvolfia serpentina (L.) Benth. ExKurz. (family: Apocynaceae) is commonly known by different names; Sarpagandha or Chandrika; Sarpagandha in Sanskrit means snakes smell or repellent, refers to the use of the said plant as an antidote for snake bite. This is also known as Arachortita in Assamese, Barachandrika in Hindi, Harki in Marathi, Chevanamalpodi in Tamil, etc. It is an evergreen, woody, glabrous and perennial shrub with maximum height up to 60 cm. The plant possess tuberous root with pale brown cork and elliptic to lanceolate or obovate leaves in whorls of three (Deshmukh et al., 2012).

DISTRIBUTION

Sarpagandha is an important medicinal plant distributed in the foot-hills of Himalayan range, up to the elevation of 1300-1400 m. and almost all over the country. It is used in preparation of traditional medicine in India, China, Africa and many other countries. It is found in India, Pakistan, Sri Lanka, Burma and Thailand. In India, it is widely distributed in the sub-Himalayan tract from Punjab to Nepal, Sikkim and Bhutan. It is also found in the lower hills of Gangetic plains, eastern and Western Ghats and Andaman and Nicobar island. It is mostly found in moist deciduous forests at altitudes ranging from sea level to an altitude of 1200 m high. In the Deccan, it is associated with bamboo forests (Vakil, 1955).

ETHNOBOTANY

During collection of commercial non-timber and other forest products in Odisha, the tribal people mostly collect the traditional herbs from forests (Rout et al. 2010). In Virudhunagar district of Tamil Nadu, Rajendran and Agarwal (2007) have reported medicinal use of fruits and seeds of this species by the ethnic tribals of India. Chakma community residing in the north-western periphery of Namdapha National Park in Arunachal Pradesh has mentioned the name of *Rauvolfia serpentina* in a report on traditional medicobotany of India (Sarmah et al. 2008; Mao et al. 2009) have reported this plant as a part of the ethnobotanical wealth of Northeast India. Ethnomedicinal importance of this plant was reported by Dey and De (2010). This plant was described from the wetlands of Terai region of Nepal by Siwakoti (2006). In 2009, Bhattarai has referred to the traditional use of this plant in dysentery, fever, cut wounds, boils, stomach-ache, menstrual problems etc. Rijal (2008) has also mentioned this plant's utility while quantitatively assessing the indigenous plant uses among two Chepang communities in the central mid-hills of Nepal. The tribes of Chhatarpur district, Madhya Pradesh, India use this plant against snake bite (Arjariya and Chaurasia, 2009). This plant has been used by local people of Himalayan mountains for snake bite (Ghorbani et al., 2006). Fresh root of *Aristolochia indica* is grounded along with the roots of *Rauvolfia serpentina* (vernacular name: Amalpori) and mixed in water and taken twice daily for three days against snake bite by the Kurichayas of Kannur district, Western Ghats, Kerala, India. A decoction of powdered rhizome and leaves is also given in snake bite (Rajith and Ramachandran, 2010). About 10 ml of root paste is taken orally for treatment of snake bite by the forest dwellers of the Daitari range of hills of Odisha, India (Mohapatra et al., 2008).

THERAPEUTIC USES

The roots of this shrub have been used for centuries in ayurvedic medicines. According to Ayurveda, it is the best among all anti-hypertensive drugs. The root is bitter, acrid, pungent and anthelmintic. The drug preparation consists of air-dried roots that are used as antihypertensive and sedative. It is also used for the treatment of various central nervous system disorders associated with psychosis, schizophrenia, insanity, insomnia and epilepsy. This shrub is highly effective in the treatment of high blood pressure. It is also very useful in mental disorders like insanity, mental illness and traumas. But due to indiscriminate collection and over exploitation of natural resources for commercial purposes to meet the requirements of pharmaceutical industry, coupled with limited cultivation and increasing population, it is now an endangered species in India (Mallick et al., 2012). The plant is reported to contain a large number of therapeutically useful indole alkaloids and these alkaloids are largely located in the roots (Kumaria et al., 2013). Mixed with other plant extracts, they have been used in the treatment of cholera, colic and fever. The root was believed to stimulate uterine contraction and recommended for the use in childbirth. A study by Azmi and Qureshi in 2012 showed therapeutic effects of *Rauvolfia* with incomplete hypoglycemic action in diabetic hypertensive patients. The juice of the leaves has been used as a remedy for the opacity of the cornea (Sukumaran, 2008). *Rauvolfia's* juice and extract obtained from the root can be used for treating gastro-intestinal, hepatic and circulatory diseases. The juice of tender leaves and root extract is used to treat liver pain, stomach pain and dysentery to expel intestinal worms (Anisuzzaman, 2007).

PHYTOCHEMICAL CONSTITUENTS

Rauvolfia serpentina carries aesthetic value due to its phytochemical properties. The contributions towards the study of its phytochemical composition vary upon the geographical location and species. In 2013, Kumarin et al*.,* reported that the roots of the sarpagandha contains 0.7-3.0 % of total alkaloids and about 0.1 % of the active principle resperine which is an indole alkaloid, present in the root. Hence, root biomass production of this plant could be of economic importance. The thin layer chromatography resulted in extraction of crude alkaloids (Verma and Verma, 2010) was found to be 0.416 mg g^{-1} and 0.217 mg g^{-1} on dry weight basis in roots and leaves of *Rauvolfia serpentina*. Similarly, Hussain et al*.,* (2015) quantified the phytochemical constituents using GC-MS. This indicated the presence of fats (2%), alkaloid (12.4%) and saponins(7.35%). A total of 147 molecules, reported to be extracted from various plant parts (Fig. 1) and broadly classified into different chemical classes (Fig. 2). The percentage of alkaloid depends on geographical place from where the plant is collected and also the season of collection. Generally samples from Assam have a higher percentage of alkaloid (2.57%) and December is the best month for the collection for getting more percentage of alkaloid (Herbal Monograph). The major phytochemical components are described below in Table 1 followed with a brief discussion about the constituents.

Table 1. Phytochemical composition of *Rauvolfia serpentina* in plant sample and expressed as mg 100 g^{-1} dry weight (Harisaranraj et al., 2009)

Phytochemicals	*Rauvolfia serpentina mg 100 g^{-1}*
Alkaloids	1.48±0.02
Flavonoids	1.72±0.11
Phenols	1.86±0.11
Tannins	0.51±0.20

Results are mean of triplicate determinations on a dry weight basis ± Standard Deviation

Alkaloids

Alkaloids are large group of organic molecules occurring naturally and contain basic low molecular weight nitrogen atoms. Alkaloids are produced by bacteria, fungi, plants and animals. Basically these alkaloids are produced by more than 20% of the plant species and they use it as defense mechanism against plant pathogens and herbivorous animals. Since ages, alkaloids from different plant extract of *Rauvolfia serpentina* have been found to be used as potions as well as poisons.

Three types of alkaloids are present in *Rauvolfia serpentina (*Tyler et al., 1988)

i. Weakly basic indole alkaloids: the principal alkaloids are reserpine, rescinnamine, despiridine and these are tertiary indole alkaloids.

ii. Indoline alkaloids of intermediate bases: reserpiline, ajmaline, iso-ajmaline, rauwolfinine are tertiary indoline alkaloids.

iii. Strong anhydronium bases: serpentine, serpentinine and also tonine are strongly basic anhydronium alkaloids

While ajmalinine, ajmalicine, chandrine, renoxidine, reserpinine, sarpagine, tetraphyllicine, yohimbine, 3-epi-ayohimbine are the other alkaloids present in *Rauvolfia serpentina* (Herbal Monograph).

Flavonoids

Flavonoids have the general structure of a 15-carbon skeleton, which consists of two phenyl rings (A and B) and heterocyclic ring of carbon. Flavonoids are widely distributed in plants. An important role of flavonoids is to serve as visual signals by acting as pigments in fruits and flowers, firstly to attract animals as pollinators in flowers and later to attract animals to eat the fruits and thereby help in seed dispersal. These are potent water-soluble antioxidants and free radical scavengers, which prevent oxidative cell damage and have strong anticancerous activity. Flavonoids in intestinal tract also lower the risk of heart disease. As antioxidants, flavonoids provide anti-inflammatory activity used for the treatment of diseases in herbal medicine. (Mittal et al*.,* 2012).

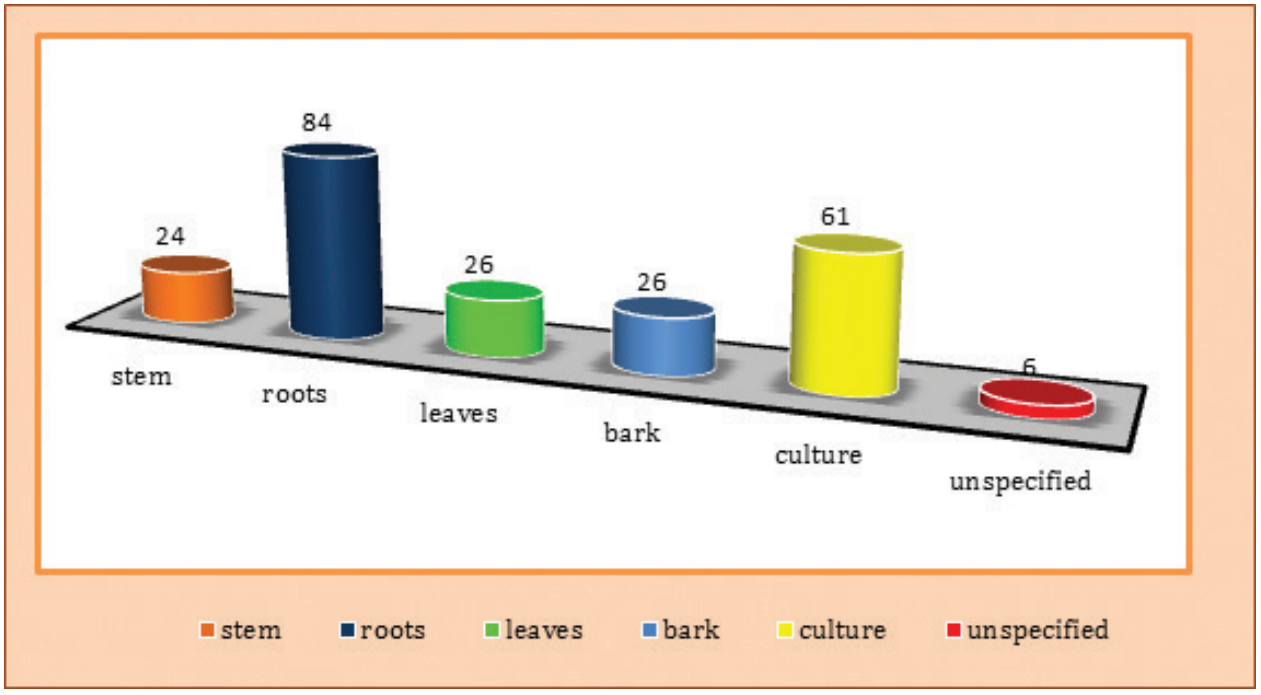

Fig. 1. Distribution of *Rauvolfia serpentina* plant-derived molecules across various plant parts (Pathania et al., 2015)

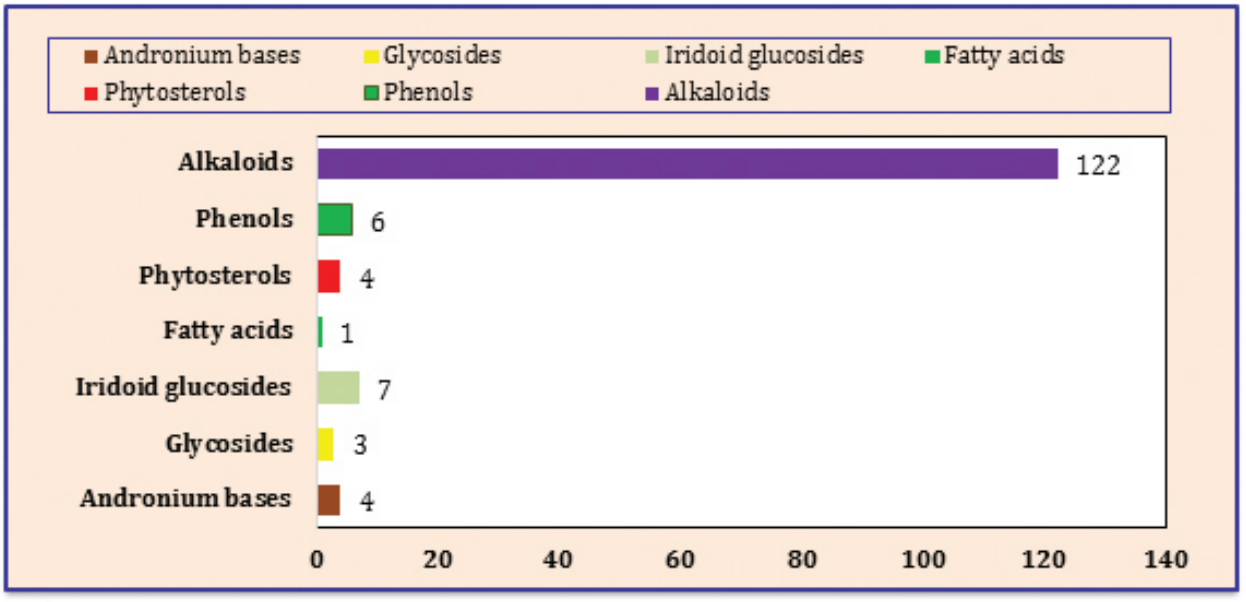

Fig. 2. Number of plant derived molecules of *Rauvolfia serpentina* (Pathania et al., 2015)

Phenols

A phenol is any of a family of organic compounds characterized by a hydroxyl (-OH) group attached to a carbon atom that is part of an aromatic ring. These phenolic compounds are biosynthesised through shikimate pathway. Phenols are considered as secondary plant metabolites mostly found in herbs, shrubs, vegetables and trees (Naira et al., 2013). Phenolic compounds also produce allelopathic effect. Presence of high quantity of total polyphenolic compounds in *Rauvolfia serpentina* shows significant antidiabetic and hypolipidemic properties (Qureshi et al., 2009). It is used as an expectorant and emulsifying agent and antimicrobial compound.

Tannins

The tannins are the secondary compounds that are widely distributed in many plant species, where they play a role in protection from predation sometimes as pesticides and in plant growth regulation. The oxidation inhibiting activity of tannin is due to the presence of gallic acid and diagallic acid. Healing of wounds and inflamed mucous membranes are hastened up due to presence of tannins. Thus, *Rauvolfia serpentina* helps in treating many disorders by traditional medicine healers in south eastern India (Agoha, 1974).

OTHER IMPORTANT BIOCHEMICAL CONSTITUENTS PRESENT IN ROOTS

Reserpine

Reserpine was isolated in 1952 from the dried root of *Rauvolfia serpentina*. It is a relatively weak tertiary base occurring in the oleoresin fraction of the roots and is useful in the treatment of hypertension, cardiovascular and neurological diseases (Weiss et al., 2000). The antihypertensive properties of *Rauvolfia* roots are attributed to reserpine (3, 4, 5-trimethyl benzoic acid ester of reserpic acid, an indole derivative of 18 hydroxyyohimbine type). It is the most prominent of all alkaloids and used mainly as a natural tranquillizer. (Banerjee and Modi, 2010). Reserpine is now being utilized as a tool in physiological studies of body functions and in pharmacological studies. Resperine can bind the catecholamine storage vesicles of the nerve cell because of its antihypertensive actions on central nervous system (CNS) and peripheral nervous system. This interferes with the function of autonomic nervous system by depleting the transmitter substance from the adrenergic neurons and possibly by activating the central parasympathetic system (Nammi et al., 2005). Resperine can control heart rate, cardiac contraction, peripheral resistance, sedation and lowering of blood pressure, especially in cases of hypertension exacerbated by stress and sympathetic nervous system activity.

Ajmaline

In 1931, Salimuzzaman Siddiqui first isolated this compound from the roots of *Rauvolfia serpentina*. He named it ajmaline, after Hakim Ajmal Khan, one of the most illustrious practitioners of Unani medicines in South Asia (Siddiqui, 2013). Ajmaline has been used as a treatment for Wolff-Parkinson-White syndrome which is characterized by arrhythmias with the ventricles contracting prematurely resulting in tachycardia and a shortened refractory period. This compound is considered as a class I anti-arrhythmic agent, which is highly useful in diagnosing hereditary cardiac disorder (Brugada Syndrome) and differentiating between subtypes of patients with this disease (Rolf et al., 2003). The action of ajmaline on systemic and pulmonary blood pressure is similar as of serpentine (Gawade and Fegade, 2012).

Ajmalicine

Ajmalicine or raubasine (alkaloid) is an antihypertensive drug used in the treatment of high blood pressure and also having large number of applications in the treatment of circulatory diseases, especially in providing relief to normal cerebral blood flow. It helps in prevention of strokes and helps in lowering blood pressure (Srivastava et al., 2006). About 3500 kg of ajmalicine is isolated from either *Rauvolfia* or *Catharanthus spp*. annually by pharmaceutical industries for the treatment of circulatory diseases. The ajmalicine is derived from tryptophan which is converted to tryptamine via secologanin, strictosidine and cathenamine. Reduction of cathenamine to ajmalicine is facilitated by enzyme NADPH and tryptophan decarboxylase (TDC). Decarboxylase might be the key enzyme involved in the synthesis of ajmalicine in *Rauvolfia* (Liu et al., 2012).

Serpentine

Serpentine, a type II topoisomerase inhibitor, exhibits antipsychotic properties (Costa-Campos et al., 2004). The enzyme peroxidase (PER) is responsible for oxidation of ajmalicine to serpentine by catalyzing bisindole alkaloid localized in the vacuole (O'Connor and Maresh, 2006).

Saponins

Saponins are a class of chemical compounds found in particular abundance in various plant species and derive their name from the soapwort plant (genus *Saponaria*, family Caryophyllaceae), the root of which was used historically as a soap. Saponins are being promoted commercially to be used as dietary supplement and nutraceuticals. Some of the characteristics of saponins include formation of foams in aqueous solutions, hemolytic activity, cholesterol binding properties and bitterness. (Sodipo et al., 2000). Saponin has the property of coagulating red blood cells. The high saponin content of *Rauvolfia serpentina* substantiates the use of this extracts to stop bleeding and in treating wounds (Harisaranraj et al., 2009).

Deserpidine

Deserpidine is an ester alkaloid isolated from *Rauvolfia* with antipsychotic and antihypertensive properties that has been used for the control of high blood pressure and for the relief of psychotic behavior (Varchi et al., 2005). It differs from reserpine only by means of absence of a methoxy group at C-11, which is synthesized from reserpine. It is capable of reducing high blood pressure by controlling nerve impulses along various nerve pathways. As a result, they act on the heart and blood vessels to lower blood pressure and also for the relief of psychotic behaviour. Deserpidine also binds and inhibits the angiotensin converting enzyme and competes with angiotensin I for binding at the angiotensin-converting enzyme. It also blocks the conversion of angiotensin I to angiotensin II (Varchi et al., 2005).

Rescinnamine

Rescinnamine, a purified ester alkaloid of alseroxylon fraction in species of *Rauvolfia*; related chemically and pharmacologically to reserpine with similar uses. It is clinically a less potent alkaloid than reserpine and not so effective in lowering blood pressure (Klohs et al., 1954). Rescinnamine inhibits angiotensin converting enzyme, peptidyldipeptidase that catalyzes the conversion of angiotensin I to the vasoconstrictor substance, angiotensin II which stimulates aldosterone secretion by the adrenal cortex. Firstly, it inhibits the Angiotensin Converting Enzyme (ACE) and then blocks the conversion of angiotensin I to angiotensin II. Inhibition of ACE results in decreased plasma angiotensin II. Angiotensin II is a vasoconstrictor and a negative-feedback mediator for renin activity, its lower concentration results in a decreasing in blood pressure and stimulation of baroreceptor reflex mechanisms, which ultimately results in decreased vasopressor activity and aldosterone secretion.

Yohimbine

A pharmacologically well characterized alkaloid Yohimbine, is used as a selective alpha-adrenergic antagonist or alpha-blocker in the blood vessels for the treatment of erectile dysfunction. It dilates blood vessels and increases blood flow in the penis, which helps in improving erectile function (Andersson, 2001).Yohimbine was also explored as a remedy for diabetes in animal and human models carrying polymorphisms of the α2A-adrenergic receptor gene. Antagonism at these receptors relaxes smooth muscle and lowers blood pressure. It works by increasing certain chemicals in the body, which dilates the pupils of the eye (Rosenren et al., 2009).Yohimbine indicated to reverse the effects of xylazine in animals. The combination of yohimbine and 4-aminopyridine may be used for rapid reversal of xylazine-induced sedation in goats (Ndeereha, et al., 2001).

MINERAL AND VITAMIN COMPOSITION

Rauvolfia contains a large number of macro and micro-nutrients and the most abundant macro nutrient is calcium. The presence of calcium helps in treating wounds and coagulation of blood at a faster rate. The sodium content is low (Table 2) that can be an added advantage due to the direct relationship of sodium intake with hypertension in human. The presence of zinc shows that plant can

play valuable roles in the management of diabetes, which result from insulin malfunction. The plant *Rauvolfia serpentina* is also an excellent source of ascorbic acids, riboflavin, thiamin and niacin (Okwu, 2003). Ascorbic acid is vital for body performance as it plays an important role in normal wound healing (Okwu, 2004) and lack of it impairs the normal formation of intercellular substances throughout the body (including collagen, bone matrix and tooth dentine). The *Rauvolfia serpentina* is used in herbal medicine as a potential source of useful drugs for the treatment of many diseases as it is a rich source of phytochemicals, minerals and vitamins (Mittal, et al., 2012; Harisaranraj, et al., 2009).

Table 2. Mineral composition of *Rauvolfia serpentina* and expressed as mg 100 g^{-1} dry weight (Harisaranraj, et al., 2009)

Minerals	*Rauvolfia serpentina* *mg 100 g^{-1}*
Macroelements	
Magnesium	0.10±200
Calcium	0.32±0.10
Potassium	0.04±0.11
Phosphorus	0.18±0.22
Sodium	0.02±0.10
Microelements	
Iron	1.85±0.20
Zinc	5.38±0.11

Results are mean of triplicate determinations on a dry weight basis± Standard Deviation.

Rauvolfia serpentina are rich source of vitamins (Table 2). Ascorbic acid (vitamin C) was found to be 44.03 mg 100 $g^{-1}$and along with that, Riboflavin, thiamine and niacin were also detected. The presence of phenolic compounds in the plant indicates that this plant may be anti-microbial agent (Harisaranraj et al., 2009).

CONCLUSION

Sarpagandha has promising potential in India especially north east India. The chemical constituents are highly useful and can be utilized for various medicinal purposes. Apart from being used popularly in the treatment of hypertension, mental disorder and schizophrenia, its use in traditional system of medicine in the treatment of gastrointestinal problems, snake bites, skin diseases, malaria, AIDS, asthma etc. must be critically evaluated. So far little work has been done to abridge the vast gap between ethnomedicinal utilization of this plant species and its active principles related to the treatment of various ailments. It is to be noted that the tribal use of the plant species must be verified by further scientific experimentation and this rich folklore can be utilized in herbal therapy and drug discovery. But for the efficient utilization and sustainability of this plant, few strategies have to be followed like; conserving the plant species in small area like herbal gardens or seed banks or gene banks and cultivation of the plant species which are rare and have high medicinal importance.

From the above discussion, it is evident that *Rauvolfia serpentina* is a major plant species of ethnic use. Over exploitation, loss of habitat, poor seed germination rate etc. are the major factors of decline of this important plant species of south-east Asian countries. Although the roots are the major source of active principles, leaves, stem, fruits, seeds and flowers are also being utilized by the aboriginals to treat different diseases. Several attempts have been made to conserve this threatened and endangered plant either by *in situ*, *ex-situ* or *in-vitro* conservation strategies.

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Canned foods: Their preservation methods and public health implications

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ABSTRACT

Food spoilage is a complex process and excessive amounts of food are lost due to spoilage even with modern day preservation techniques. Canning is a method where food can be prevented from spoilage by storing it in a container that are hermetically sealed and then sterilize by heat which destroys most, if not all the microorganisms. However, heated canned foods may undergo spoilage either due to chemical or biological spoilage. Most common types of spoilage encountered in canned foods are flat sour, Thermophilic Anaerobes (T.A.) spoilage, stinker spoilage and hydrogen swells. Food spoilage bacteria are classified according to their oxygen requirement as obligate aerobe, facultative anaerobe and obligate anaerobe, non spore forming bacteria, yeast, mold etc. In addition to this canned food can be source of deadly bisophenol poisoning and histamine poisoning. Canned foods can be prevented from spoilage as long as they are remain intact and preserved in best possible way in cool and dry environment.

Key words: Canned food, food spoilage, thermophilic anaerobes

INTRODUCTION

Food preservation is pre requisite for protecting the food from spoilage thus prolonging its shelf life. One method of preserving food is by canning. Canning is the process of applying heat to food that's sealed in a jar in order to destroy any microorganisms that can cause food spoilage. Proper canning techniques stop this spoilage by heating the food for a specific period of time and killing these unwanted microorganisms. During the canning process, air is driven from the jar and a vacuum is formed as the jar cools and sealed. In other word, it is a method where food can be prevented from spoilage by storing it in a container that are hermetically sealed and then sterilized by heat which destroys most, if not all the microorganisms (FDA, 2001). The type of heat treat¬ment will however, depend on the nature of the food material and varies from pasteurization for milk, juices and other liquids to sterilization by steam under pressure for canned vegetables or soups (Fellows, 1999). At milder heat treatment a number of heat resistant organisms survive and these may subsequently grow and cause spoilage if conditions are favorable. Following heating, the canned food is then stored at a low temperature. Some foods which are processed at high temperatures can be stored at room temperature.

BENEFITS OF CANNED FOODS

Impact on the environment

Canned foods in general are very environment friendly because the metal cans are endlessly recyclable (Fig.1). In fact, food cans are the most recycled package today. Their recycling rate is more than two-and-a-half times higher than that of most other packaging

options. Additionally, cans are made with more recycled content than most package types, which reduce the demand for new natural resources (SRIS, 2010).

Impact on reduction of waste and costs

Because fruits and vegetables are picked fresh and immediately processed to seal in freshness and flavor, canned fruits and vegetables are a product one can feel good about using at any time. According to a recent study, Americans waste approximately 15 % to 20 % of fresh fruits and vegetables every year (Buzby et al., 2011). Canned meats and fish, such as chicken and tuna, are available in portion-controlled containers and can be enjoyed anytime, anywhere without requiring prior refrigeration. Consumers can cut costs two ways by eating canned foods: eliminating the waste of unconsumed fresh produce or spoiled meat and paying less for canned products at the grocery store.

Impact on convenience

Can foods are loved by many individuals and their family members as these are nutritious, convenient and help in easy preparation of a meal. For the people doing job in food industry, canned foods are easy to demo as few materials are required for the purpose and no cooktop are needed. Moreover, it is great for supermarket tours as it brings people to the middle of the stores, makes them feel good about shopping the aisles.

METHODS OF FOOD PRESERVATION BY CANNING AND FOOD SAFETY

Canned foods must be heated, for safety purpose, to a high enough temperature for a long enough time to destroy enzymes, yeasts, moulds and bacteria that cause food spoilage. Moreover, the canned food must be tightly sealed thereby organisms in the air cannot enter and cause spoilage. The time and temperature needed to destroy organisms in different foods varies. The temperature of boiling water, 212°F, is effective in killing organisms in acid foods. In low-acid foods a much higher temperature, 240°F, is needed to make the food safe to eat and to maintain good quality. To obtain a temperature of 240°F, a pressure canner must be used. The exact times given in a circular for processing fruits and vegetables are based on work by the Consumer and Food Economics Research Institute, Agricultural Research Service, U.S. Department of Agriculture (University of Illinois Circular 1112). As per the circular, failure to use the proper temperature for the length of time required for the food being canned can result in disaster.

Pressure canning

The equipment used in this method is called pressure canner and usually used for processing all common vegetables except tomatoes and pickles. Moreover, it is used for other low-acid foods, such as meat, poultry and fish. For safe use of the pressure canner, the safety valve must be checked properly. The pet-cock opening can be cleaned by drawing a string or narrow strip of cloth through it. The dial pressure gauge should be checked each year before the canning season. One can see a county extension adviser, dealer, or manufacturer about checking it. The weighted gauge needs only to be thoroughly cleaned. The canner kettle must be washed well before using it. The cover can be wiped with a damp, clean cloth; however, it shouldn't be put in water. When using the canner, the manufacturer's directions should be strictly followed (University of Illinois Circular 1112).

Another equipment known as 'Pressure saucepan' having an accurate indicator or gauge for controlling pressure at 10 pounds (240° F.) may be used for processing vegetables in pint jars.

Water-bath canning

In this method, high acid foods can be processed safely in equipment called 'Boiling-water-bath canner'. This type of canners are used for fruits, tomatoes and pickled vegetables. This method sometimes referred to as hot water canning. Any large vessel will do for a boiling-water-bath canner if it meets these requirements: It should be deep enough to have at least 1 inch of water over the top of the jars. The canner should not be overloaded. Jars should not touch one another or touch the sides of the canner. If the pressure canner is deep enough, one can use it as a water bath. The cover can be set in place without fastening it. One must ensure to have the pet cock wide open so that steam escapes and no pressure is built up (University of Illinois Circular 1112).

Home canning with glass jars and closures

Only jars manufactured especially for home canning are used in this method. Processing times are given for half-pint, pint, or quart jars, so one should not use jars larger than those recommended for whatever is being canned. Only jars and lids that are perfect should be used. One cannot have an airtight seal with a defective jar or lid. Jars do not need to be sterilized when food is to be processed in the boiling water bath or in the pressure canner. However, they do need to be clean and hot. If one has a dishwasher, it can be used for this job. Two types of closures for glass jars are used i.e. the two-piece cap and the porcelain-lined zinc cap (University of Illinois Circular 1112). One should make sure to follow the sealing directions for each type of closure.

Porcelain-lined zinc cap

If the porcelain lining is cracked, broken, or loose, or if there is even a slight dent at the seal edge, the cover must be discarded. Opening these jars by thrusting a knife blade into the rubber and prying ruins many good covers. Each time one uses a jar; he should have a new rubber ring of the right size. The rings can be washed in hot sudsy water and then be rinsed well. The wet rubber ring should be fitted on the shoulder of the jar. The jar can be filled leaving the necessary headspace. Any food which might have spilled on the ring or rim should be carefully wiped off. The cap can be screwed on firmly and then it should be turned back 14 inch. As soon as the food has been processed, the seal should be completed by screwing the cap tight (University of Illinois Circular 1112).

Two-piece cap

The metal lid with sealing compound can be used only once. The lids should be pre treated according to the manufacturer's directions. The jar can be filled, then the rim may be wiped clean. The lid can be put on the jar with the sealing compound next to the glass. The metal band must be screwed down tight. The lid has enough give to let air escape while the food is being processed. It should not be screwed farther after taking the jar from canner. The band may be removed after the contents of the jar are cold, usually after 24 hours (University of Illinois Circular 1112).

Important preliminary steps in canning

i. All the canning equipment needed must be assembled before the canning season begins. It is ensured that all equipment is clean and in good operating condition.

ii. Foods suitable for canning must be selected. It is to be remembered that canning does not improve the quality of a food. For best quality results quality food items such as sound, firm and ripe fruits and young, tender vegetables must be chosen. Care should be taken to sort the food items, so that they will be cooked evenly. In case of fruits, they can be canned quickly while they are fresh, if possible within 2 to 3 hours after they are gathered.

iii. Foods such as fruits and vegetables should be washed thoroughly. When dirts are removed, some of the bacteria that are hardest to kill are removed. Washing should be done in small batches with several changes of water (University of Illinois Circular 1112).

SPOILAGE OF CANNED FOODS

Heated canned foods may undergo spoilage either due to chemical or biological reasons. The most important chemical spoilage of canned foods is the "hydrogen swell" produced as a result of the action of the food acid with the metal can. Such spoilage occurs mostly due to imperfect tinning and lacquering of the interior of the can used for canning acidic foods (Jay et al., 2005). Biological spoilage of canned foods by microorganisms may result either from the survival of organisms after the heat treatment or leakage of the container permitting entrance of microorganisms (Anon., 2013), may be vegetative cells or spore formers depending on the heat treatment. Acid foods are processed at temperatures around 100°C which results in the killing of all vegetative cells of bacteria, yeasts and molds. Only bacterial spores may survive but these do not grow in acid foods. On the other hand, meat, vegetables and milk are processed at lower temperatures. This may eliminate vegetative cells but not the spores, which germinate later and cause spoilage. Here are the terms used in the food industry to describe canned foods with signs of spoilage (Hayes , 1985):

Soft Swell

A can that is bulged on both ends, but not so tightly that the ends can't be pushed in somewhat with a thumb press (Fig. 2).

Hard Swell

A can that is so tightly bulged on both ends that the ends can't be pressed in. A can with a hard swell will generally "buckle" before it bursts (Fig. 3).

Flipper

A can whose end normally looks flat, but "flips out" when struck sharply on one end.

Springer

A can with one end bulged out. With sufficient pressure, this end will flip in, but the other end will flip out.

Leaker

A can with a crack or hole in the container that has caused leakage. Flipper and Springer cans do not always indicate microbial spoilage, but are often an indication of contamination. Soft swells, hard swells and leakers usually do represent microbial spoilage but can sometimes be caused by chemical reactions. Microbial spoilage of canned food occurs when heat processing fails to meet standard requirements. This can occur because of home canning of foods or carelessness in handling the raw materials before canning which results in a high level of contamination that ordinary heat processing may not control. Spoilage can also occur when defective containers permit the entrance of microorganisms after the heat process. Bacteria can cause heat resistant endospores which results in the spoilage of commercially canned foods. The processing of low-acid foods is over particular concern because *Clostridium botulinum* thrives in this environment and causes botulism food poisoning (Sobel, 2005). The risk of botulism is greater with home-canned foods than it is with commercially-canned.

The fact that spoilage in canned vegetables is due to bacteria, has been definitely known since Russel (1895) isolated the causative organisms responsible for an outbreak of spoilage in canned peas in Wisconsin (Wilson and Tanner, 1948). The thermophilic bacteria were factors in spoilage of canned vegetables was not recognized until Barlow investigated spoilage in corn in a canning plant at Gibson city and reported the presence of living thermophilic bacteria which developed only when the cans were improperly cooled and/stored in hot warehouses. He described two types of spoilage due to thermophilic bacteria i.e. Flat sour and T.A. spoilage.

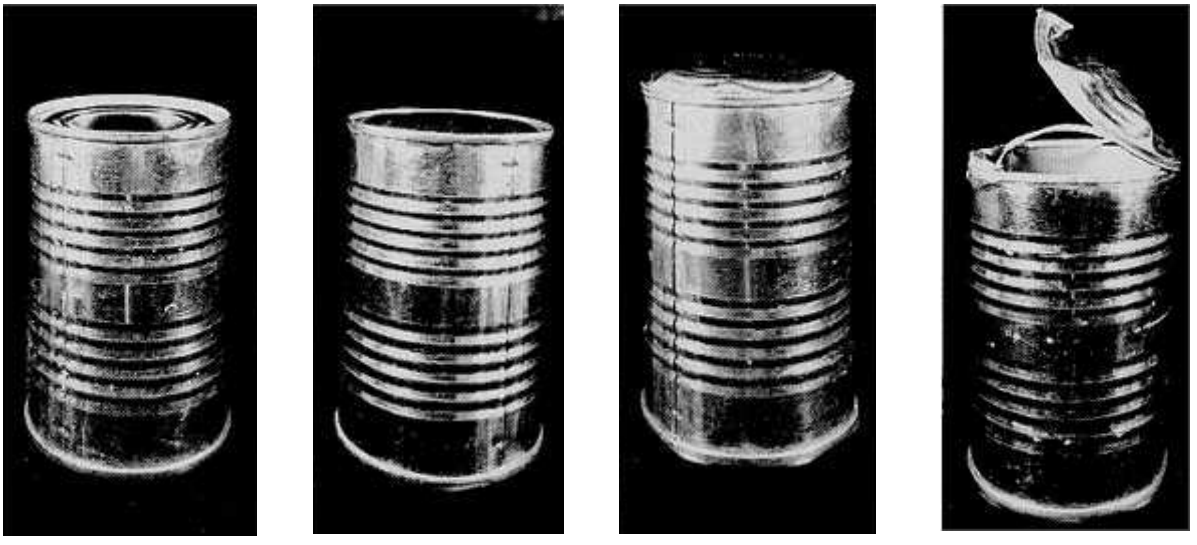

Fig 1-4: Changes in cans as a result of microbial spoilage (Fig.1 Normal Can: the top of the can is indented due to negative pressure (vaccum) inside ; Fig.2 Slightly swollen lid resulting from minimal gas production ; Fig.3 Severe swell due to extensive gas production ; Fig.4 The Can shown in above was dropped and the gas pressure resulted in a violent explosion) * Source: AFDO, A pocket puide to pan perfect.

There are three types of microbial spoilage: Flat sour, thermophilic anaerobes (T.A.) spoilage and stinker spoilage (Frazier and Westhoff, 2008) which are described below.

Flat sour

It pertains to spoilage in which acids are formed with no gas production. The ends of the can, therefore, remain flat.

T.A. spoilage

It is caused by Thermophilic anaerobes that produce acid and gases in low-acid foods. Cans swell and sometimes burst (Fig. 4).

Another spoilage is due to spore former known as Stinker spoilage.

Stinker spoilage

Here, spore formers cause the spoilage that produce hydrogen sulfide and blackening of the can. The great deformation of the can (Fig. 3) is potentially dangerous and could explode if dropped or hit! Development of spoilage control in canning has necessarily been slow. Conscious, tangible effort in this direction dates back to the first realization by scientifically trained technologists that certain types of bacteria are associated with spoilage of canned foods and that, in the case of nonacid foods, the significant organisms form spores of such high resistance to heat that temperature higher than boiling are necessary for their destruction (Cameron, 1938).

CLASSIFICATION OF FOOD WITH RESPECT TO ACIDITY

Canned foods can be grouped as low acid foods, medium acid foods, acid foods and high acid foods as mentioned in the following table on the basis of acidity (Cameron and Esty, 1940).

Table 1. Grouping of canned foods on the basis of acidity

Group	Type of Acid Food	pH	Examples of Food
Group I	Low acid foods	>5.3	Vegetables such as peas, corn, beans etc. and meat, fish and poultry.
Group II	Medium acid foods	3.0-5.5	Beets, pumpkin, spinach etc.
Group III	Acid foods	4.5-5.7	Tomatoes, pears etc
Group IV	High acid foods	<3.7	Berries, etc.

* Source: Cameron and Esty, 1940

Except for the dividing line between acid and high-acid foods, this classification serves as well perhaps as any. In practice, it has been found that pH 4.00 is a more realistic dividing line between acid and high-acid foods. Seldom will spore-bearing bacteria grow in heat-processed foods with pH values of 4.0 or lower. Some of the butyric anaerobes and *Bacillus coagulans (B.thermoacidurans)* will grow in laboratory culture or even in foods at pH values as low as 3.7; however, this generally occurs only with very heavy inoculate.

The dividing line between low-acid and acid foods is taken as 4.5 because some strains of *Clostridium botulinum* will grow and produce toxin at pH values as low as about 4.6. Some of the highly heat-resistant saccharolytic anaerobes for example, Clostridium thermosaccharolyticum grow in and cause spoilage of foods in this semi-acid range. Therefore, until more is known of bacterial heat resistance and bacterial growth in the 'semi-acid foods, they perhaps should remain in the low-acid grouping.

CLASSIFICATION OF SPOILAGE BACTERIA

In low-acid and acid foods, the spore-bearing bacteria are of greatest concern from the standpoint of sterilization. With respect to oxygen requirements they may be classified as follows: (1) Obligate aerobes-Bacillus spp., (2) Facultative anaerobes-Bacillus spp., (3) Obligate anaerobes-Clostridium spp.

Obligate aerobes

This group includes those species that require molecular oxygen for growth. From the standpoint of food sterilization, it is the least important of the

three groups. Under present-day methods of canning, most foods contain very low levels of molecular oxygen, insufficient to support appreciable growth. Beyond this, spores of most obligate aerobes are low in heat resistance compared with spores of a number of organisms in the other two groups. However, as with most things, there are exceptions; in canned cured meat products containing nitrate, the *Bacillus subtilis* and *Bacillus mycoides* group of organisms may at times be of greater economic importance than some other groups of bacteria (FDA, 2001).

Facultative anaerobes

Spore-bearing bacteria of the facultative anaerobic group carry importance from the standpoint of food sterilization. Of particular importance in low-acid and acid foods are thermophilic spore-bearing bacilli. Of greatest importance in low-acid foods are *Bacillus stearothermophilus* and related species causing flat-sour spoilage (Frazier and Westhoff, 2008) where as in acid foods there are three species of facultative anaerobes-namely, *Bacillus coagulans (B. thermoacidurans)*, *Bacillus macerans* and *Bacillus polymyxa*. Of these, Bacillus coagulans is the more important, particularly in spoilage of tomatoes and tomato products. *Bacillus macerans* and *Bacillus polymyxa* have been isolated as causative organisms in spoilage of some fruits and fruit products.

Obligate anaerobes

Some species of spore-bearing anaerobes produce spores those are relatively quite heat-resistant. With reference to canned food spoilage these may be classified in two groups, mesophilic and thermophilic. Of the thermophiles, the most important are the saccharolytic organisms, which do not produce hydrogen sulfide. *Clostridium thermosaccharoliticum* is generally considered the type species of this group (Hayes, 1985). These organisms are very saccharolytic, producing large quantities of gas, chiefly carbon dioxide and hydrogen, from a wide variety of carbohydrates. Consequently, they cause spoilage of the "swell" or gaseous type. They often produce a butyric or "cheesy" odor on foods. They generally are of greater importance in the spoilage of semi-acid products (pH 4.5 to 5.0) than are flat-sour types (Yousef and Carolyn, 2000).

Thermophilic spore-bearing anaerobes that produce hydrogen sulfide are responsible for the so-called "sulfur stinker" spoilage of canned foods. *Clostridium nigrificans* is considered the type species of this group (Hayes, 1985). These organisms are proteolytic and hydrogen sulfide is the only gas they produce in great quantity. They are only weak, if at all saccharolytic, because the hydrogen sulfide is soluble in the product, spoiled cans usually remain flat. Many products spoiled by these organisms become black, owing to the interaction of the hydrogen sulfide and iron. Spoilage by these organisms is comparatively rare for two reasons: Incident of their spores in most products is generally low and the spores of most strains are relatively low in heat resistance compared with spores of the saccharolytic thermophilic anaerobes and the flat-sour thermophilic facultative anaerobes. Neither of the above groups is of importance in foods having pH values below about 4.5 (Anon., 2001).

Next in importance, in low acid foods, to the groups discussed above are spore-bearing mesophilic anaerobes. Because of its public health significance, the toxin producing organism, C*lostridium botulinum*, should perhaps be considered of greatest importance among organisms of this group (Sobel, 2005). Of the different botulinum types, A, B and E are of greatest significance. Spores of Types A and B are considerably more heat-resistant than spores of Type E and therefore of greatest concern in the sterilization of canned foods. Fortunately, the incidence of the more-resistant strains of P.A.3679 is very low in most foods. For this reason, canning processes designed to assure a high degree of safety with regard to *C. botulinum* are often adequate to prevent economically important spoilage by even the most resistant of these nontoxic putrefactive anaerobes.

In summary, of the mesophilic obligate anaerobes, in spoilage of low-acid and semi-acid foods (pH 4.5 and above) the putrefactive anaerobes, *C. sporogenes* and related species, are of greatest importance. In spoilage of acid foods (pH 4.0 to 4.5) the butyric anaerobes, *C. pasteurianum* and related species, are of greatest importance (Frazier et al., 1987). The temperature range of optimum growth of these organisms is 25^0 to 35^0C [77^0 to 95^0F] (Yousef and Carolyn, 2003).

NON-SPORE-BEARING BACTERIA, YEASTS AND MOLDS

Except when they gain entrance through container leakage, these organisms are of greatest importance in spoilage of high-acid canned foods (pH below 4.0) given relatively mild heat processes-pickles, grapefruit, citric juices, rhubarb, cranberries also in spoilage of concentrated and sweetened products, etc.

Of the non-spore-bearing bacteria, Lactobacillus and Leuconostoc spp. are most important (Potter and Hotchkiss, 1999). A wide variety of yeasts have been found as spoilage agents of number of high-acid foods given mild heat processes. Molds are generally considered significant as spoilage agents in canned foods.

The temperature range of optimum growth for most of these non-spore-bearing bacteria, yeasts and molds is from 20^0 to 35^0C. (68^0 to 95^0F).

ORGANISMS ENTERING VIA CONTAINER LEAKAGE

Microorganisms that enter through leaks during cooling need not necessarily be heat resistant. Because of varied types of bacteria in contaminated cooling water and on can-handling equipment, many different species of bacteria have been associated with leakage spoilage. Usually, though not always, a mixed flora causes leakage spoilage of a container. Commonly found are micrococci, gram-negative rods of the *Pseudomonas*-Achromobacter group and yeasts. It should be recognized that very minute amounts of heavily contaminated water could cause spoilage.

BISPHENOLS IN CANNED FOODS

Bisphenol A (BPA) and Bisphenol F (BPF) are chemical components of resins used to coat some cans (Kawamura et al., 1999). BPA is used to create linings for cans that maintain the integrity of the can, prevent contamination and maintain the safety of the food. More specifically, can linings play an important functional role, safeguarding foods from microbial contamination. And, can coatings prevent perforation defects in the can that would allow bacteria and microorganisms to enter, thereby maintaining the integrity of the can and protecting against food poisoning and food borne illness. In a study by Kawamura et al., 1999 BPF did not leach into food but BPA did. BPA was found in some canned foods like some vegetables but not infant formulae (Kawamura et al., 1999). In fact, the U.S. Food and Drug Administration; World Health Organization; European Food Safety Authority; Health Canada;16 and other global agencies responsible for food products confirmed that BPA in the marketplace today poses no risk to consumers (U.S. Food and Drug Administration, 2012; WHO, 2010; European Food Safety Authority, 2012 and Health Canada, 2012). BPA-lined cans have been effectively safeguarding the global food supply since they were first introduced in the 1960s, without a single incident of food borne illness associated with canned foods since inception.

SCOMBROID POISONING IN CANNED FISH PRODUCTS

Fish such as tuna, mackerel, bonito and saury that contain high levels of free histidine in their muscle are often implicated in scombroid poisoning incidents (Taylor, 1986). Histamine is the causative agent of scombroid poisoning, a food borne chemical hazard mostly seen in canned fish products. Scombroid poisoning is usually a mild illness with a variety of symptoms including rash, urticaria, nausea, vomiting and diarrhea, flushing , tingling and itching of the skin (Russsell and Maretic, 1986).

STORAGE LIFE OF CANNED FOODS

Generally, as long as the container remains intact, canned foods have a long shelf life even at room temperature. If more stringent storage conditions are required for health and safety reasons, then the label must state these storage conditions. As a general rule, the best shelf life will be obtained when canned foods are kept in a cool, dry place. The label of the product for any storage instructions must be checked. If the label has storage instructions, then the food must be stored accordingly at the point-of-purchase. If instructions are not provided on the label, then it should be stored in a cool dry place. Containers should be handled carefully to avoid denting or other damage. Much work has been done on microbiology of spoiled foods but less on the normal sound products which appear on the market (Wilson and Tanner, 1948).

Canned fruits, vegetables and meats are recommended in a variety of food and nutrition policies and initiatives including the 2010 Dietary Guidelines for Americans, Let's Move, the U.S. Thrifty Food Plan, American Heart Association, Academy of Nutrition and Dietetics and the National Heart, Lung and Blood Institute's DASH diet. (Department of Agriculture and U.S. Department of Health and Human Services, 2010; Let's Move, 2010; U.S. Department of Agriculture. 2006; American Heart Association, 2010; Academy of Nutrition and Dietetics, 2010 and U.S. Department of Health and Human Services National Heart, Lung and Blood Institute, 2006). Canned fruits and vegetables are nutritionally similar to fresh and frozen ones, in some cases even better (Miller and Knudson, 2012; Kapica and Weiss, 2012; and Durst and Weaver, 2013).

CONCLUSION

Food spoilage is the deterioration of quality in canned or preserved food that makes the food unsafe for eating. Mold, yeast, bacteria and enzymes are the spoilers. Ingesting spoiled food can cause a wide range of ailments, depending on the type of spoilage and the amount of food consumed. Symptoms vary from mild, flu like aches and pains to more-serious illnesses or even death.

A "hermetically sealed" container for canned food is considered as one that is appropriately constructedand intended to assure no entry of microorganism and thus maintains the commercial sterility of its contents after thermal processing.

Spoilage can be prevented in home canned products by adequately heat processing of food for particular time. The method used for processing depends on whether the food is high acid or low acid. Any practice that does not involve adequate processing is potentially dangerous and should be avoided.

Clostridium botulinum organism which forms spore, in the absence of air, as in a sealed jar and in the presence of low-acid food, germinate and produce gas and a toxin. It is this toxin that causes botulism, a very serious food poisoning. Though the spores formed by the bacterium are very resistant to heat, the toxin they form is easily destroyed by heat. Therefore, as per the Circular 1112 of University of Illinois, in home canning of low-acid foods there are three rules to follow:

i. Always process low-acid foods in a pressure canner at 10 pounds or more pressure for the recommended time.

ii. Boil low-acid home canned foods for at least 10 to 20 minutes before tasting. Corn and spinach should be boiled for 20 minutes.

iii. Destroy all bulging, swollen, or leaking cans of food as well as food from glass jars with bulging lids. Do not taste (University of Illinois Circular 1112).

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Effect of climatic variables on fire incidence and burnt area in tropical forests in Nepal

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ABSTRACT

This research was objectively done to correlate the climatic variables with the number of wildfire incidence and burnt area in Nawalparasi, Nepal. MODIS satellite data was used to detect the fire incidence and burnt areas. Climatic (temperature and humidity) data for 2000-2014 periods were obtained from Government of Nepal. The burnt areas of each year were clipped using Arc GIS to calculate the fire affected areas and number of incidences. Meanwhile, the correlation was evaluated to determine the relationship of climatic variables with the fire incidence and burnt area. The analysis showed that temperature and humidity of the study area varied throughout the active fire season (March to May). R^2 values were 0.0123 and 0.0260 of temperature with number of fire occurrence and brunt area respectively. R^2 was same nearly 0.0288 of the correlation of humidity with fire incidence and burnt area. The regression models were tested applying t-test ($p \leq 0.05$) for humidity with fire incidence and burnt area. The results showed that there was a clear relationship between wildfire and climatic factors, especially the humidity. The findings can be useful to establish baseline information for forest fire management in Nepal and other developing countries with similar ecological contexts.

Key words: Burnt area, climatic variables, fire occurrence, MODIS

INTRODUCTION

Wildfires are integral component of the earth system, which play key role in regulating vegetation structure and ecosystem functions (Balling, Meyer and Wells 1992). An increase in the number of wildfires and burnt area has been reported during the last decades in many parts of the world (Stocks et al., 1998) and (Flannigan, Stocks and Weber 2003; Brown JT 2004) . Fuel load inside forest governs the occurrence of fire along with the dryness of the fuel which indirectly determines the availability of fuel moisture (Chuvieco et al., 2004). Fire regimes are controlled by a very wide array of factors (Krebs et al., 2010). There is relation between patterns of fire and the climatic variables (Debnath et al., 2012)

Climate variables like temperature and humidity are two crucial drivers of fire activities. High temperatures and low humidity can cause fuel drying and hence an increase in fire occurrence. Climatic conditions affect the fuel accumulation and moisture, thus having an effect on the probability of a fire to occur as well as on its spread over the landscape (Syphard et al., 2008 and Vilar et al., 2010). The climatic factors have been emerged as evidence for wildfires, especially large wildfires (Piñol, Terradas and Lloret, 1998; Gillett, 2004 and Swetnam, 2006).

Global temperature has increased by ~0.2^0C per decade over the last three decades (IPCC, 2007). Nepal also experiences increase in mean annual

temperature by 0.04°C and 0.01°C in maximum and minimum respectively during 1971-2012. The highest temperature was recorded in the Terai and Siwalik regions and the lowest in the High Himalaya region (Government of Nepal 2015). Nepal has experienced anomalous wildfire events in recent years including some transboundary fires (Government of Nepal 2010). Despite the fact that wildfire has been a major environmental problem, there is no systematic and complete record of the wildfire occurrence and their effects in Nepal (Bajracharya, 2001). In this context, the paper attempts to answer a key question: does the fire incidence and burnt area respond to climatic factors? Hence the study was carried out to identify correlation of climatic variables with the number of wildfire incidences and burnt area in Nawalparasi district of Nepal during period of 2000-2014.

MATERIALS AND METHODS

Study area

The study district is located in the Lumbini Zone in the Western Development Region of Nepal and lies within latitude 27°21' to 27°47' and longitude 83°36' to 84°25' covering an area of 2162 sq.km, The elevation ranges from 91m to 1936m above the mean sea level. About 55 % (122, 365 ha.) of district land is under forest. *Shorea robusta* and Terai hard wood, Terai Hardwood forest, Riverine forest *Dalbergia sissoo* and *Acacia catechu* are the main forest types found in the district. *Shorea robusta* is the dominant species in 94% of the forest areas. Approximately 16% of the total area comprises mountain region and the remaining land include Siwalik (fragile small hills), Terai (flat lands) and Inner Terai (valleys in the Siwalik- foothills of the mountain) regions. The latter two regions have a gentle slope up to 15^0, while the Mahabharata (lower elevation hill) and Siwalik range bear steep slope $15\text{-}50^0$. Most (61.7%) of the forests are located in the Siwalik. The Terai and hill regions have 22.45% and 15.98% forest covers, respectively. About, 6% of the forests have been handed over to local communities as community forest. The east-west national high way passes through the central part of the district. The study area has divided into three physiographical region such as Terai, Siwalik and hill where covers.

The study area is vulnerable to forest fire particularly during the summer months from March to April due to high temperature and very dry condition. According to District Forest Office (DFO), the occurrence of forest fire and its adverse effects on the forest services have increased in recent years; resulting in loss of forest products and adverse effect on the local economy.

Data sources and collection methods

Two types of data were collected and used in the research, including the Moderate Resolution Imaging Specto-radiometer (MODIS) of Terra and Aqua satellites observation data and the climatic data. The satellite data was downloaded free of cost from MODIS satellite image while climatic data for the period of 2000-2014 were acquired from the Department of Hydrology and Meteorology (DHM) Nepal. The active fire points are the past actual fire occurrences that have occurred in the area as recorded by MODIS of Terra and Aqua satellites. The past fire occurrences data, which provides the location and date of fire ignitions, were obtained from MODIS active fire products (version 5.1). Those point data in the form of shape files were then further analyzed in Arc Map 10.1. Point count by polygon method was used to identify the number of fire occurrences within the study area.

The burnt area related data was obtained from MODIS in the form of TIFF format containing burnt area pixels along with the burnt date information. The monthly level 3 gridded burnt area product (MCD45A1) of Terra and Aqua satellites were downloaded from the ftp server (ftp: //bal.geog.umd.edu/Collections5/TIFF/Win18/) for 15 years (2000 – 2014). Burnt area pixels within study district of Nepal were then extracted from the TIFF format using clip function processed in Arc Map 10.1. Again clip function was applied to extract district boundary shape file of study area. Meanwhile, the climate data (temperature and relative humidity) of the study area were collected as daily basis annual data from the Department of Hydrology and Meteorology for the period of 2000-2014. It was used to identify the climatic characteristics of study area in the spring season (March, April and May).

Data analysis

The data on fire incidences, burnt area and climatic variables over the 15 years (2000-2014) was analyzed using Microsoft Excel and SPSS 20 to find out trends, condition and its correlation between the wildfire occurrence, burnt area and climatic factors (temperature and humidity).The method adopted in data analysis is described in detail in the following sections.

Analysis of historical pattern of wildfire and climatic condition

The collected daily basis data of temperature and relative humidity was converted in to annual form by using the Microsoft Excel program. The mean, standard error, standard deviation, maximum and minimum of months of May, April and March over the 15 years period were analyzed by using the SPSS (version 20). The temporal data of climatic factors was graphically plotted by using Microsoft Excel tool. It helped explore the information of behavior of the climatic factors within the given period. The clip function was applied to extract district boundary shape file of study district. The number of wildfire occurrence and burnt area were extracted from the attribute tables of shape files. The extracted data was graphically analyzed by using the Microsoft Excel and SPSS (version 20).

Analysis of correlation between fire occurrence, burnt area and climatic variable

The relationship between the number of fires, burnt area against the climatic variable (temperature and relative humidity) of spring season (March, April and May months) was analyzed in SPSS 20 version. The linear regression was carried out to find the relationship between wildfire occurrence, burnt area and climatic variables. The mean, standard error, standard deviation, maximum and minimum range of temperature, humidity, number of fire occurrence and burnt area were analyzed by using the descriptive statistical tool. The value of Pearson correlation (r) and R^2 values were calculated by using liner regression and t-test at 5% level of significance to find out the relationship between mean temperature and relative humidity against the no. of fire incidence, burnt area of the study area.

RESULTS AND DISCUSSION

Climatic condition (Mean temperature and humidity)

The March, April and May months comprise an active season in the study area. The mean temperature of March, April and May were 23.13°C, 28.80°C and 30.73°C, respectively. The (Fig.1a) showed the highest mean temperature in May, while it was lowest in March. Meanwhile, relative humidity were recorded

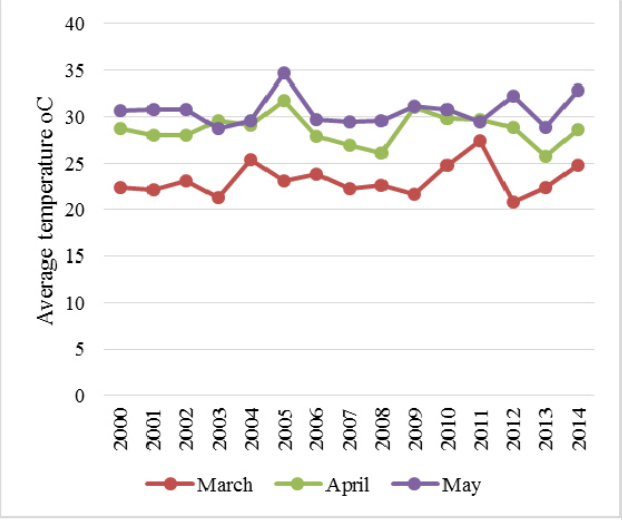

Fig.1a. Mean temperature condition

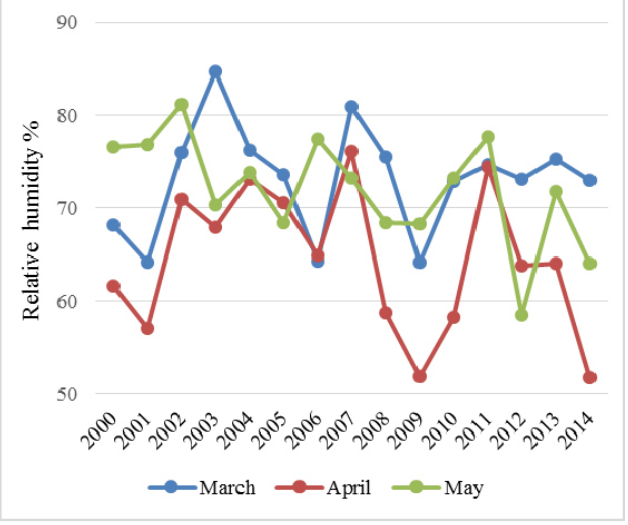

Fig. 1b. Average relative humidity in %

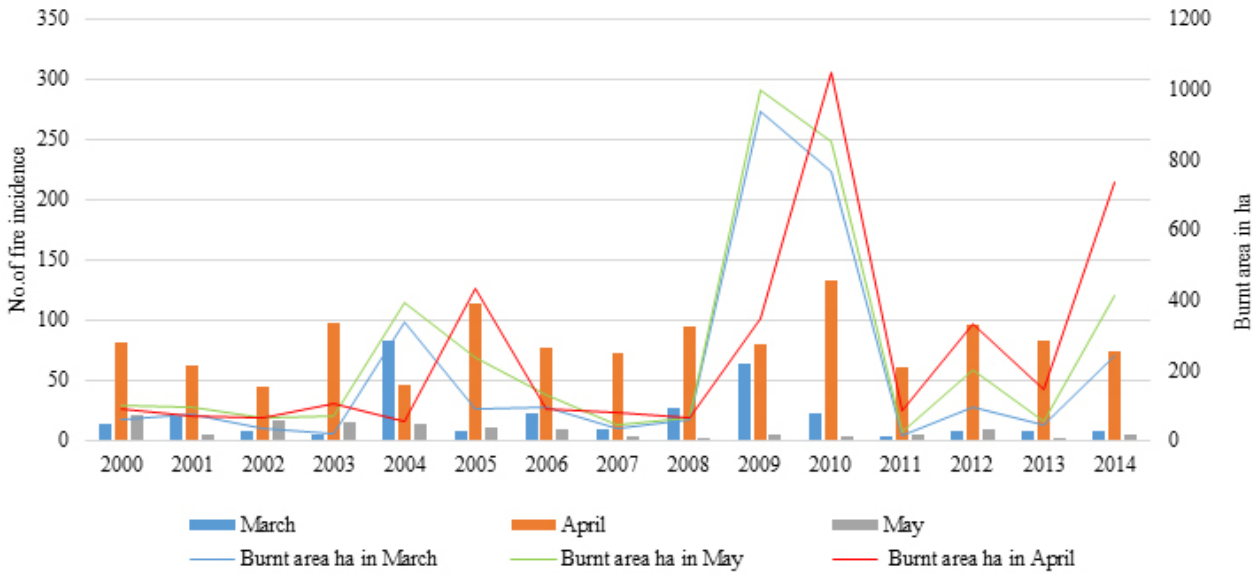

Fig. 2. Spatial and temporal no. fire incidence, burnt area

73.13, 64.40 and 71.93% in of March, April and May respectively (Fig.1b). The lowest relative humidity was recorded 52 % in 2009 and 2014 years, which was followed by 2001 in April with 57%. The relative humidity was the highest in March and lowest in April. The overall condition of both climatic variables was found varying over the 15 years period in the study area.

Spatial and temporal status of fire incidence and burnt area

Trends of spatial and temporal fire incidence and burnt area of March, April and May months of 15 years showed that the number of fire incidence was the highest in April in comparison to March and May and same result was recorded for burnt area as well (Fig. 2).

The highest number of wildfire incidences noticed in April of 2003, 2005, 2009, 2010 and 2012 where other March and May months indicated lowest. The highest record of burnt areas were found in year 2005, 2009, 2010, 2012 and 2014. The 1, 472 wildfire incidences and 4615.28 hectares forest burnt were recorded in the active fire season over the 15 years which constitutes 82.5% of total annual wildfire incidence and burnt area. The anomalous wildfire incidences were found during the active fire season (Fig. 2).

Statistics of temperature, humidity, number of fire occurrence and burnt area

The statistical result showed variation on the temperature, humidity, wildfire occurrence and burnt area of forest, resulting in instability of these variables. The maximum temperature (30.7^{o}C) and humidity (73.1%) were recorded in May and March months while the highest mean number of fire occurrence (i.e. 81) and largest burnt area (248.5 hectares) occurred in April. It was indicated that April was higher affected month than other during the active fire season (Table 1).

Relationship of climatic variables with wildfire events

The regression fit line between temperature and forest fire incidence is presented in the (Fig.3a). This showed that the model $y = 1.1684x + 4.134$ whereas y denotes number of fire occurrence as dependent variable and x stands as independent variable for temperature. The $R^2 = 0.0123$ value showed positive relation between temperature and numbers of wildfire

Table 1. Variation in temperature, humdity, fire incidence and burnt area

Variables	Months	Mean	Standard Error	Standard Deviation	Maximum	Minimum
Temperature (Degree Celsius)	March	23.1	0.44	1.72	27.00	21.00
	April	28.8	0.43	1.69	32.00	26.00
	May	30.7	0.43	1.66	35.00	29.00
Humidity (%)	March	73.1	1.56	6.04	85.00	64.00
	April	64.4	1.99	7.74	76.00	52.00
	May	71.9	1.51	5.87	81.00	59.00
No. of fire	March	20	5.92	22.94	83.00	3.00
	April	81	6.18	23.94	133.00	44.00
	May	8	1.51	5.87	21.00	2.00
Burnt area ha	March	56.5	21.36	82.74	274.00	4.00
	April	248.5	75.68	293.13	1045.00	55.00
	May	16.3	3.79	14.68	50.00	1.00

occurrence. The p values ($p \geq 0.05$) showed the temperature was insignificantly correlated with the incidences of wildfires.

The result of relationship between temperature and burnt area is presented in the (Fig. 3b). It showed the equation y = 8.5231 x - 122.81 whereas y denotes burnt area as dependent variable and x stands as independent variable for temperature.

The R^2 value of regression fit line between temperature and burnt area was 0.022 which showed positive relationship between temperature and numbers of fire occurrence. The value ($p > 0.05$) showed insignificant relationship between temperature and forest burnt area.

The Fig. 4a showed equation y= -2.5423x + 214.03 whereas y denotes number of fire occurrence as dependent variable and x stands as independent variable for humidity. The regression fit line with humidity and number of fire occurrence indicated negative relationship with R^2= 0.2621.The value ($P<0.05$) showed the correlation exists significantly between humidity and fire incidences.

The Fig. 4b showed equation y= -14.84x + 1149.3 whereas y denotes burnt area as dependent

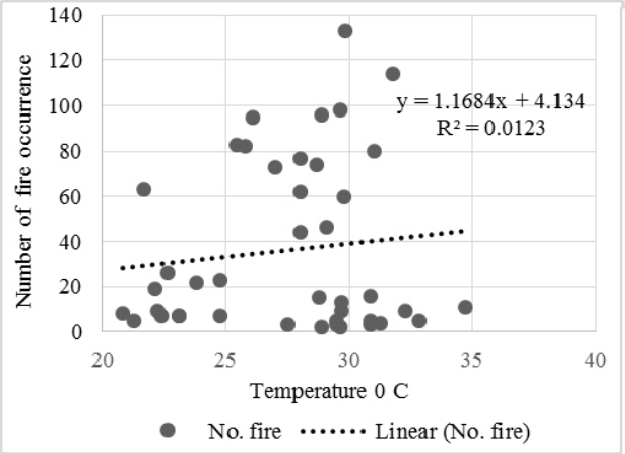

Fig. 3a. Relationship between temperature and number of fire occurrence

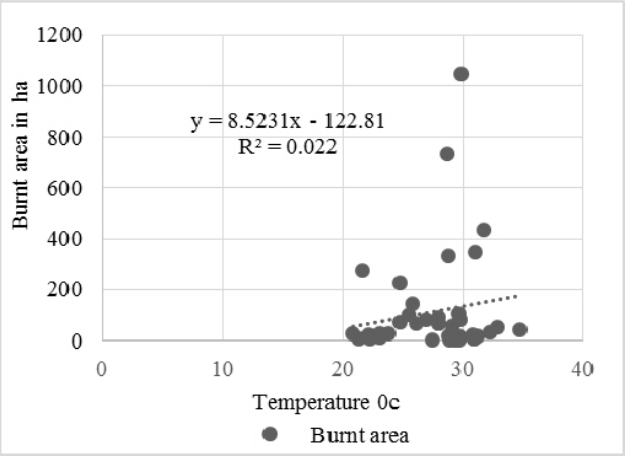

Fig.3b. Relationship between temperature and forest burnt area

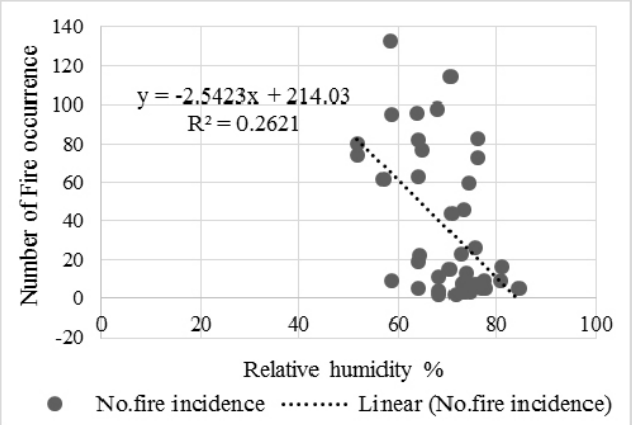

Fig. 4a. Relationship between humidity and numbers of wildfire occurrence

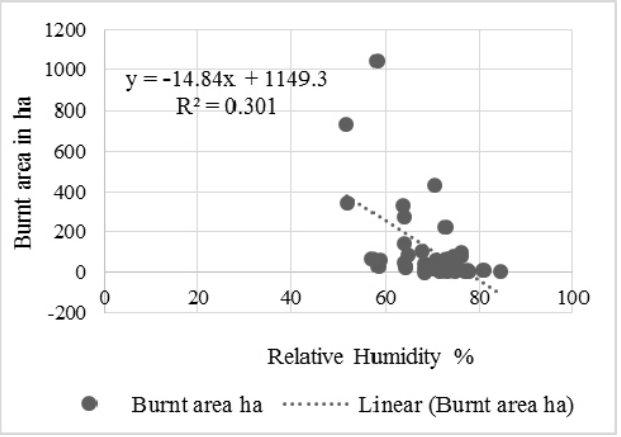

Fig. 4b. Relationship between humidity and burnt area

variable and x stands as independent variable for humidity. The regression fit line between humidity and burnt area was negative relationship having R^2 (0.301). Likewise, the value $p<0.05$ indicated the significant relationship.

DISCUSSION

These results showed the variation in the mean temperature which indicate a slight but definite warming trend in the mean temperature in the active fire season (pre-monsoon season). The study report of climate and climatic variation over Nepal (Government of Nepal, 2015) also showed the increasing trends of mean temperature between the periods of 1971-2012 in the entire country which was similar to this research findings. The (IPCC 2007) report also showed that future global temperature will be warmer than current levels, resulting an increase in the drought areas creating favorable environment to wildfire activity which statement supported to this research. Similarly temperature change is also found in most parts of the China (Tang et al., 2010). Spatial and temporal analysis of rainfall and temperature trend of India study report showed the temperature fluctuations and increase significantly (Mondal, Khare and Kundu, 2015). Both results corroborate with our research findings.

The relative humidity also found to vary during March, April and May months. The lowest humidity (64.40%) was found in April month. The research finding was consistent with Alexandrose Dimitrakopoulos 2011, whose result showed the large fire incidents occurred during the heat waves (higher air temperature and lowest humidity). It was supported by Urbieta et al., 2015 result which indicated low humidity in April was the indication of favorable fuel as well as the hot temperature being suitable for ignition and expansion of the fire.

The number of fire incidences and burnt areas increased annually. The April month was found with highest number of fire incidence and burnt area during the fire active season. The finding was consistent with study of Kiran Chand et al. (2006) which showed higher numbers of forest fires incidence occurred in the mixed deciduous forests in central Indian range during the March– April. The result of the study undertaken by Bowman et al. (2017) indicated that the extreme wildfire events were globally distributed across all flammable biomes which supported this result.

The present research showed the positive relationship between number of fire occurrence and burnt area with the mean temperature. Meanwhile, it depicted negative relationship between humidity and number of fire occurrence as well as burnt area. The relationship coexists between wildfire and climatic factors, especially with the humidity. A research done by Khanal, S., (2015), showed that there was strong relationship of climatic variables with fire activity in Nepal. Another research by Srivastava (2013) showed that the positive correlation exist between incidences

of fire with temperature in tropical dry deciduous forest of India. Similarly, other research done by authors Swetnam (2006) and Kodandapani (2004), emphasized that the number of wildfires and burnt areas were increased in different terrestrial ecosystems across the globe. It can be said that three months like March, April and May are active fire season.

CONCLUSION

The climatic variables particularly temperature and humidity are the key factors affecting forest fire incidence and burnt area. The higher mean temperature and the lowest humidity cause increased long spell of dryness leading to low moisture in the combustible material which favor increase in fire incidents. The month of April showed the highest numbers of fire incidence and burnt area, which was followed by March. The relationship coexists between wildfire and climatic factors, especially with the humidity. The findings are expected to be useful for managing forest fires, with similar ecological contexts. Further research in this context is necessary to establish baseline information for wildfire management planners, early fire warning system and sustainable forest management.

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Use of the Mitscherlich equation for estimating maintenance requirement for amino acids and their efficiency of utilization for accretion in growing swine

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ABSTRACT

Darmani Kuhi et al. (2001) developed a Mitscherlich equation to estimate energy and amino acid (AA) requirements by growing broilers for maintenance, gain and protein (or AA) accretion. In the study presented herein, the scope of the model was extended to growing swine to provide an estimate of their AA requirements for maintenance and growth using the results of four studies taken from literature. The equation was fitted by non-linear regression procedures to estimate parameters, from which other biological indicators were calculated. A number of criteria were used to evaluate general goodness of fit of the model, including model behaviour, biologically meaningful parameter estimates and statistical performance. The model estimated the maintenance requirements for lysine, sulphur amino acids and threonine to be in the range 37-74, 11-40 and 17-63 mg kg^{-1} of LW/d, respectively, depending on the data source and the live-weights (LW) of pigs (age). The values determined for average lysine requirement for body protein accretion varied from 6.5-7.3 g $100g^{-1}$ of protein accretion. For sulphur amino acids and threonine, the determined values were 3.95 and 4.35 g $100g^{-1}$ of protein accretion, respectively. The estimated maintenance requirements and the determined values of AA requirements for protein accretion were in good agreement with values reported previously by other researchers. Average efficiency of recovering AA in body weight and body protein was greatest at low intakes of AA and decreased as intakes increased.

Key words: Amino acids, law of diminishing returns, Mitscherlich equation, swine, maintenance and growth requirements

INTRODUCTION

Hendricks et al. (1931) first applied the law of diminishing returns to describe the relationship between feed consumption and live-weight in growing animals. Parks (1982) showed that a diminishing returns equation such as the Mitscherlich equation or monomolecular growth function (Mitscherlich, 1909; Thornley and France, 2007; Darmani Kuhi et al., 2010) can be used to describe change in size with age. Blaxter and

Boyne (1978) proposed the Mitscherlich equation for describing the relationship between energy retention and feed intake, based on a detailed analysis of over 80 calorimetric experiments with sheep and cattle. The response of energy retention rate to increments in rate of feed intake obeys the law of diminishing returns over all levels of intake. The Mitscherlich equation forms an integral part of the metabolizable energy (ME) system used in feeding dairy cows in the United Kingdom (Agnew et al., 2004). However, in swine nutrition studies, a limited effort has been made to use of the law of diminishing returns. There are numerous studies suggesting that a limiting amino acid is utilized with constant efficiency over the range of intakes from maintenance to that required for maximal protein accretion (Batterham et al., 1990; Chung and Baker, 1992; Adeola, 1995). In contrast, Heger and Frydrych (1985) and Gahl et al. (1994) demonstrated that the utilization of amino acids declined as their intake apprached that required for maximum protein retention. Similarly, Fuller and Garthwaite (1993), studying the response of body protein accretion to ideal protein intake in individual pigs, found that the response could be described better by a curvilinear rather than a rectilinear model. The potential and validity of a specially re-parameterized Mitscherlich equation (Darmani Kuhi et al., 2001) to partition AA intakes between requirements for maintenance and growth has been demonstrated recently in relation to broilers using results from two types of studies, namely bioassay and nitrogen balance experiments (Kebreab et al., 2008; Darmani Kuhi et al., 2009; 2011; 2012). The present study aims to apply this model in order to provide estimates for AA requirements for maintenance and growth in growing swine.

MATERIALS AND METHODS

The Model

The re-parameterized Mitscherlich or monomolecular equation (Darmani Kuhi et al., 2001) takes the form:

$$y = y_{\max} \text{üüü}^{-k(x-x_m)} \qquad x \geq$$

where y is live-weight (LW) or protein accretion [g of LW or protein/kg of LW/d], $y_{\max}$ is the maximum attainable value for y, k is a fractional rate parameter [mg of AA/kg of LW/d]$^{-1}$, x is AA intake [mg of AA/kg of LW/d] and x_m is AA intake at maintenance. The average efficiency of AA utilization, $\bar{k}_g$, between Δ_1 times maintenance and Δ_2 times maintenance ($\Delta_2 \geq \Delta_1 \geq 1$) is determined by:

$$\bar{k}_g\left(\Delta_1,\ \Delta_2\right) = \frac{y(\Delta_2 x_m) - y(\Delta_1 x_m)}{(\Delta_2 - \Delta_1)x_m}.$$

Experimental Data

Results of four studies taken from the literature were used in this study (Batterham et al., 1990; Yang et al., 1997 a, b, c). Details of experimental characteristics of the data including sources, types of treatment and growth phases are shown in Table 1.

Table 1. Data sources used in the study

Source[a]	Growth phase (kg)	Consideration
Batterham et al. (1990) (M and F)	20-45	Effect of dietary lysine concentration on efficiency of lysine retention
Yang et al. (1997a) (M) Exp.1 Exp.2	 11-15 39-46	Development of model equation to subdivide lysine requirements
Yang et al. (1997b) (M) Exp. 1 Exp. 2 Exp. 3	 10.5-15 39-46 67-76	Development of model equation to subdivide Met. + Cys. requirements
Yang et al. (1997c) (M) Exp. 1 Exp. 2 Exp. 3	 11-14 39-46 67-76	Development of model equation to subdivide Threonine requirements

[a]M=male, F=female.

Statistical Procedures

Due to absence of a single robust criterion for model evaluation, three criteria were used to evaluate model adequacy: 1) model behaviour when fitting the curves using non-linear regression, 2) statistical performance and 3) comparison of biologically meaningful indicators obtained using the monomolecular. All statistical analyses were performed using the non-linear procedure of the statistical package SAS (SAS Institute Inc., Cary, NC, USA). The proportion of variation accounted for $(\bar{r}^2)$, the amount of total variation about the mean value of y explained by the fitted curves, was used as a measure of adequacy of the model.

RESULTS AND DISCUSSION

Fig. 1 shows the fit of the model to the data on LWG (or protein accretion) versus AA intake. The resultant curves (Fig. 1) and general goodness of fit, based on variation accounted for $(\bar{r}^2)$ and standard error (SE) estimated for the growth parameters, indicated that fits of the model to the data sets were acceptable (Table 2). Extrapolation of the curves shown in Fig. 1 gives the point at which LWG and protein accretion becomes zero. Therefore, intersection of the curves with the *x*-axis representing the maintenance level of AA requirements (Table 2). The maintenance requirements estimated using the model were in the range 37-74, 11-40 and 17-63 mg kg^{-1} of LW/d for lysine, sulphur amino acids and threonine, respectively, depending on the data source and the weights of pigs (age).

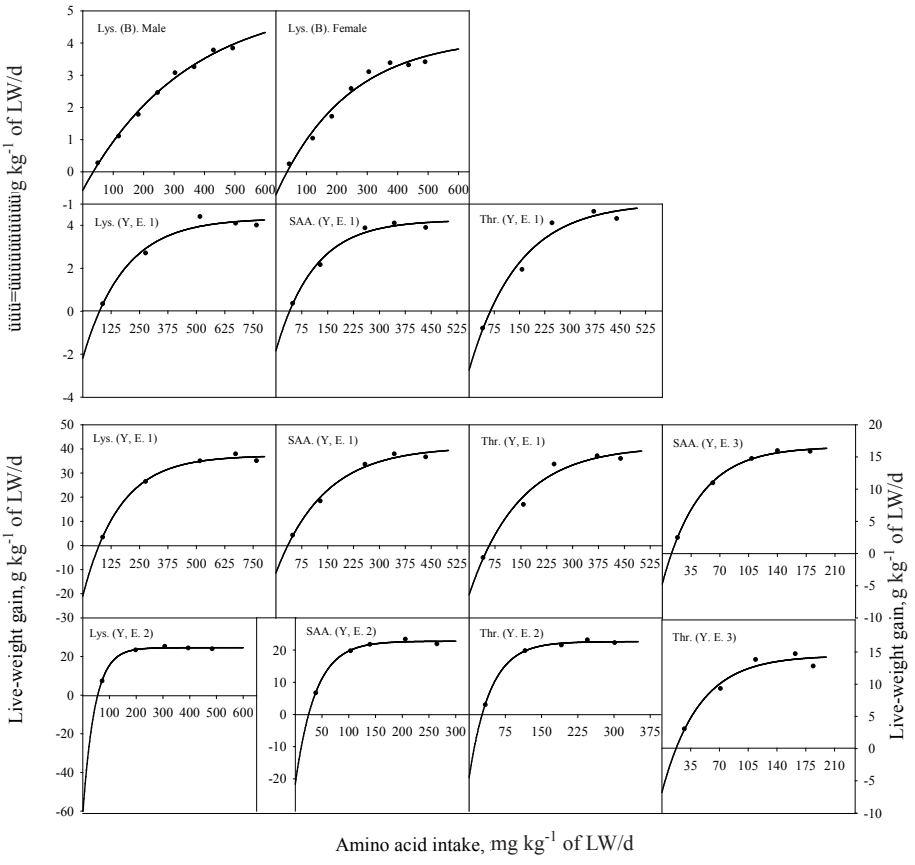

Fig. 1. Plots of live-weight gain (LWG) and protein accretion (g of LW (or protein) accretion/kg of LW/d) against AA intake (mg kg^{-1} of LW/d), showing fit of monomolecular equation to data. The AAs were: Lysine (Lys), Sulpher Amino Acids (SAA) and Threonine (Thr). The letters (B) and (Y) indicate fit of equation to data from Batterham et al. (1990) and Yang et al. (1997a, b, c). E1, E2 and E3 indicate Experiments 1, 2 and 3 in Yang et al. (1997a, b, c).

Indicators calculated from the Mitscherlich equation together with reported values of growth indicators are shown in Table 2. From Table 2 it is clear that the values determined for average lysine requirement for body protein accretion, with an average value of 6.9 g 100g^{-1} of protein accretion and those determined for sulphur amino acids (3.95 g 100g^{-1} of protein accretion) and threonine (4.53 g 100g^{-1} of protein accretion) are in good agreement with values reported by other researchers (*e.g.* ARC, 1981; Fuller et al., 1989; Heger et al., 2002). Average efficiency of recovering AA in body weight and body protein was greatest at low intakes of AA and decreased as intakes increased (Fig. 1).

Table 2. Growth indicators calculated from the Mitscherlich equation together with their reported values

Amino acid	Response variable	x_m mg kg^{-1} of LW/d	$\bar{r}^{2a}$	$[0.1*(1/k_g)]^b$ Model	(References)^c values	
					Maintenance mg kg^{-1} of LW$^{0.75}$/d	g 100g^{-1} protein
Lysine, Exp 1 Yang et al. (1997a)	Protein retention	73.8 (19.1)	94.63	6.5	36 (F), 39 (H)	7 (A), 6.8 (F), 7.8(H)
Lysine, Exp 1 Yang et al. (1997a)	Live-weight gain	71.8 (8.7)	98.67	-	-	-
Lysine, Exp 2 Yang et al. (1997a)	Live-weight gain	56 (5)	99.14	-	-	-
Lysine, Batterham et al. (1990)	Protein retention	34.6 (8.1)	99.17	7.3	-	-
Lysine, Batterham et al. (1990)	Protein retention	36.8 (13.2)	96.45	6.9	-	-
Met. + Cys., Exp 1 Yang et al. (1997b)	Protein retention	39.5 (8.6)	97.06	3.95	49 (F), 46 (H)	3.5 (A), 3.6 (F), 3.5 (H)
Met. + Cys., Exp 1 Yang et al. (1997b)	Live-weight gain	34.4 (9.6)	97.74	-	-	-
Met. + Cys., Exp 2 Yang et al. (1997b)	Live-weight gain	25 (3.3)	98.59	-	-	-
Met. + Cys., Exp 3 Yang et al. (1997b)	Live-weight gain	11.2 (1.4)	99.62	-	-	-
Threonine, Exp 1 Yang et al. (1997c)	Protein retention	63 (12.7)	93.99	4.53	53 (F), 49 (H)	4.2 (A), 4.7 (F), 4.5 (H)
Threonine, Exp 1 Yang et al. (1997c)	Live-weight gain	58.5 (11.2)	95.21	-	-	-
Threonine, Exp 2 Yang et al. (1997c)	Live-weight gain	26.9 (1.8)	99.38	-	-	-
Threonine, Exp 3 Yang et al. (1997c)	Live-weight gain	17.2 (7.7)	90.96	-	-	-

[a]Adjusted r^2.
[b]Average AA requirement for protein accretion between 1-4 times maintenance (g of AA/100 g of protein accretion).
[c]Reported values of amino acid requirements for maintenance and carcass amino acid composition of pigs. (A) ARC (1981); (F) Fuller et al. (1989) and (H) Heger et al. (2002).

[d]For details on different experiments (Exp 1, Exp 2 and Exp 3) see Table 1.

The response of nitrogen retention to nitrogen inputs is usually represented rectilinearly with an abrupt cut. The data, however, may support this or be more suggestive of a diminishing returns curve. Since, under controlled conditions, the slope of the curve describing the relationship between nitrogen retention and nitrogen input represents the quality of the protein fed (biological value, net protein utilization and nitrogen balance index), the assumption that the relationship is linear has tended to be adopted. Most data are linear to a good approximation, but a curvilinear response is probably a more precise interpretation (Boorman, 1980). Models based on the premise that growth rate determines requirements based on some fixed rate of nutrient utilization do not adequately represent the biological phenomena involved. Since responses of animals to dietary energy, protein and AAs are diminishing returns phenomena, they should be evaluated as such to estimate optimum economic levels, rather than as biological maxima (Pesti and Miller, 1997). Darmani Kuhi et al. (2001, 2009) developed a Mitscherlich equation to estimate energy and AA needed by growing broilers for maintenance, gain and protein accretion. In the study presented herein, the aim was to assess the applicability of this model in estimating AA requirements for maintenance, gain and protein accretion in growing swine. With regard to the estimates of AA requirements for maintenance and average AA requirement for protein accretion between 1 and 4 times maintenance (Table 2), the estimates lie in the range reported by other researchers (ARC, 1981; Fuller et al., 1989; Heger et al., 2002). Considering the values of average efficiency of recovering AA at different multiples of maintenance, the efficiency of utilization of AA is greatest at low intake levels and decreases as intakes increase.

CONCLUSION

Results presented here and those previously reported for poultry (Darmani Kuhi et al., 2001; 2009; 2011; 2012; Kebreab et al., 2008) can be considered as a basis for accepting the general validity of the Mitscherlich or monomolecular equation to predict the magnitude and direction of responses of growing animals to dietary energy and protein (or AA) intake without making any initial assumptions.

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Clinico-pathological and haemato-biochemical alterations in Canine Ehrlichiosis

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ABSTRACT

Ehrlichiosis, a vector-borne disease of dogs, has gained importance worldwide because of its growing prevalence and zoonotic importance. An investigation was conducted in the Department of Veterinary Epidemiology and Preventive Medicine, College of Veterinary Science and Animal Husbandry, Orissa University of Agriculture and Technology, Bhubaneswar to record the clinical, haematological, biochemical and ultrasonographic alterations in 35 dogs with canine ehrlichiosis that was confirmed through polymerase chain reaction (PCR) producing amplicon at 843 bp. The predominant clinical signs were pyrexia, weight loss, epistaxis, conjunctivitis, vomition and pale mucous membrane. Other clinical signs were weakness, limping and lymphadenomegaly. Majority of the affected dogs (32/35) had tick infestation. Anaemia and thrombocytopenia were two important pathognomonic haematological alterations noticed. Ultrasonography revealed hepatomegaly, gall bladder distention, splenomegaly and ascites, in descending order of intensity. Elevated level of alkaline phosphatase (ALP), blood urea and creatinine were considered specific biochemical alterations in ehrlichiosis.

Key words: Ehrlichia, vector-borne, clinical signs, haematological, biochemical, ultrasonography

INTRODUCTION

Ehrlichiosis, a hemoparasitic disease, is caused by a special type of rickettsia that belongs to the genus *Ehrlichia* of family Anaplasmataceae. Among canine vector-borne diseases, ehrlichiosis is most prevalent across the globe especially in tropical and subtropical countries including India with risk to both canine and human population (Perez et al., 1996). Canine monocytic ehrlichiosis was first described in 1935 in Algeria (Pyle, 1980) and subsequently found in different parts of the world i.e., India (Lakshmanan et al., 2007), USA (Bowman et al., 2009), Brazil (Bulla et al., 2004), Turkey (Tuna et al., 2009), Thailand (Laummaunwai et al., 2014) etc. There are at least 9 *Ehrlichia* species that may infect dogs (Kelly, 2000) among which *Ehrlichia canis* is mostly seen in India (Bhatacharjee et al., 2014 and Singh et al., 2014). The prevalence rate varied from 3.1 to 88.0% (Murphy et al., 1998; Bulla et al. 2004; Alexandre et al., 2009; Silva et al., 2012). As regards the Indian scenario, the prevalence of *E. canis* was reported to be 50% (49/98) in Chennai (Lakshmanan et al., 2007) and 20.6% from four different regions of India (Abd Rani et al., 2011). *E. canis* is transmitted transstadially but not transovarially in *Rhipicephalus sanguineus* ticks (Groves et al., 1975). Affected dogs suffer from pyrexia, pale mucus membrane, loss of body weight, epistaxis, lymphadenomegaly, conjunctivitis etc. (Harrus et al., 1997; Waner et al., 1999; Behera et al., 2015). In human, *Ehrlichia* infection causes fever, skin rashes, renal failure, neurologic syndrome and sometimes death in immunosuppressed people. Hence, the zoonotic importance of this vector-borne disease has drawn a great significance in this geographic region of the sub-continent.

MATERIALS AND METHODS

The study was undertaken in pet dogs presented in the College of Veterinary Science, Orissa University of Agriculture and Technology, Bhubaneswar from nine districts of Odisha viz. Khurda, Puri, Cuttack, Jagatsinghpur, Mayurbhanj, Ganjam, Malkangiri, Sambalpur and Dhenkanal during June 2015 to May 2016.

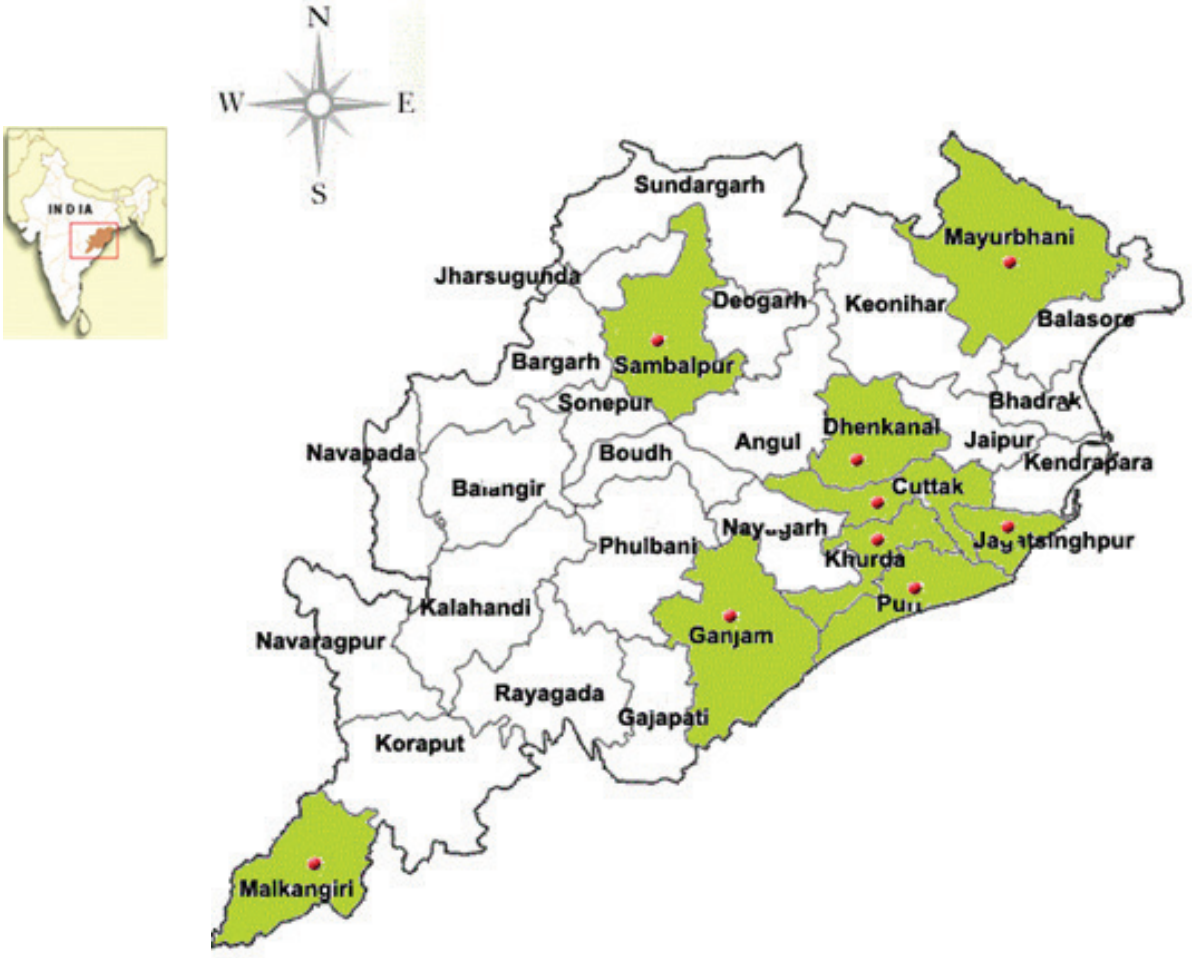

Fig. 1. Shaded area show the districts covered under the study

A data sheet was prepared to take into account the important clinical signs those were earlier documented by various workers in canine ehrlichiosis that include pyrexia, loss of body weight, pale mucus membrane, limping, epistaxis, conjunctivitis, lymphadenomegaly, vomition, diarrhoea, seizure, convulsion and duration of illness. Clinical signs persisting beyond seven days were considered as chronic illness. The data sheet was prepared gathering information from pet owners and the suspected cases were subjected to further laboratory investigation for confirmation. Two milliliter of blood samples were collected in EDTA vial (0.5ml) and clot activator vial (1.5 ml) from each suspected dog by vein puncture for hematological tests and PCR whereas the serum samples collected in clot activator vial was used for biochemical analysis. The genomic DNA was extracted from a blood sample by using QIA amp^{R} DNA blood mini kit according to the recommended procedure and stored at -20^{0}C for subsequent use. These DNA samples were subjected to polymerase chain reaction (PCR).

Haematological tests were conducted as per the procedures described by Benjamin (1978). Serum concentrations for alkaline phosphatase (ALP), urea and creatinine were performed in Auto-analyser (TURBO CHEM100 © 2013 CPC Diagnostics, model 4611) using commercially available kits (Fig 2).

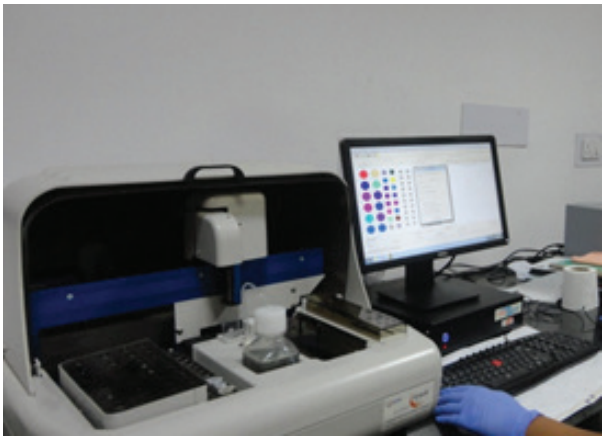

Fig. 2. Biochemical estimation through auto analyzer

The dogs found positive for *Ehrlichia* infection by PCR were subjected to ultrasonography using 5.0 MHz transducer (Hitachi Aloka Medical, Ltd. Model-UST9137) with focused attention to the abdomen.

RESULTS AND DISCUSSION

A total of 35 dogs were found positive for *Ehrlichia* infection during the PCR assay. Weakness/ anorexia, weight loss, pyrexia, vomiting, pallor mucus membrane, limping, conjunctivitis, epistaxis, lymphadenomegaly, coughing, seizure/paresis, polymyositis/ peripheral edema were recorded in 31(88.57%), 29(82.86%), 27(77.14%), 20(57.14%), 17(48.57%), 12(34.29%), 8(22.85%), 7(20.0%), 5 (14.28%), 2(5.71%) and 1(2.85%) dogs with *Ehrlchiosia* infection, respectively (Table 1). Such observation is in accordance with the findings of Glaus et al., 1992; Nakaghi et al., 2008 and Dhankar et al., 2011. All the dogs were either infested or had the history of tick infestation which potentiated its mode of transmission i.e., through ticks. Based on the duration of illness, the clinical signs are divided into three phases i.e., acute, subclinical and chronic (Waner et al., 1999; Unver et al., 2001b). Dogs can harbor *E. canis* for years without developing the clinical form of illness and these dogs can eliminate the parasite and recover from canine monocytic ehrlichiosis (CME) without medical treatment (Harrus et al., 1998b). Herein, under the study both the acute (14/32) and chronic (18/32) forms of the disease were recorded.

Table 1. Clinical manifestations observed in dogs suffering from ehrlichiosis (N=35)

Clinical signs	Number of dogs (%)
Tick infestation	32(91.43)
Weakness	31(88.57)
Anorexia	31(88.57)
Weight loss	29(82.86)
Pyrexia	27(77.14)
Vomition	20(57.14)
Pallor mucus membrane	17(48.57)
Limping	12(34.29)
Conjuctivitis	8(22.85)
Epistaxis	7(20.00)
Lymphadenomegaly	7(20.00)
Coughing	5(14.28)
Seizure	2(5.71)
Paresis	2(5.71)
Polymyostis	1(2.85)
Peripheral edema(hind limbs and scrotum)	1(2.85)

Fig. 3. Conjunctivitis, a marked symptom

Fig. 5. Epistaxis recorded in ehrlichiosis

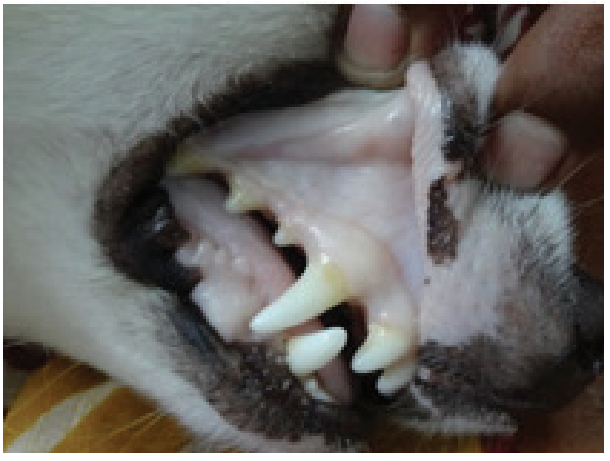

Fig. 4. Pale mucous membrane in ehrlichiosis

Fig. 6. Clinical signs of Lymhadenomegaly

The ultrasonographic imaging of the dogs with Ehrlichiosis revealed hepatomegaly, gallbladder distention, splenomegaly and ascites. Pathological alterations were found in either single or multiple organs. Hepatomegaly with gallbladder distention was found in majority dogs i.e., 11(31%) followed by hepatomegaly with ascites in 7(20%), hepatomegaly alone in 6(17%), ascites in 4(11%), gallbladder distention in 3(9%), splenomegaly in 2(6%) and hepatomegaly, gall bladder distention and ascites in 2(6%) dogs (Fig. 7). Such observations were in agreement with Kumar (2004) and Sarma et al. (2013). The main target organs of tick-borne intracellular diseases were bone marrow, spleen and lymph node including other internal organs such as liver, kidney and lungs (Jackobson and Clark, 1994). Multi-organ dysfunction with liver and spleen involvement is common in clinical cases of canine monocytic ehrlichiosis (Ganguly and Mukhopadhayay, 2008). The study by Harrus et al. (1998b) suggested that the spleen is the organ most likely to harbor *E. canis* parasites during the subclinical phase and the last organ to accommodate the parasite before elimination. Hence, splenomegaly is one of the ultrasonographic alterations of dogs with ehrlichiosis.

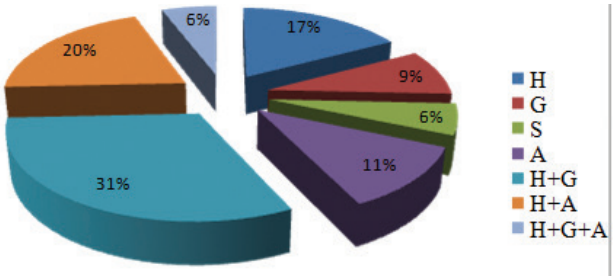

Fig. 7. Intensity of ultrasonographic alterations in *Ehrlichia* infected dogs (N=35)

H: Hepatomegaly
G: Gall bladder distention
S: Splenomegaly
A: Ascites
H+G: Hepatomegaly + Gall bladder distention
H+A: Hepatomegaly + Ascites
H+G+A: Hepatomegaly+ Gall bladder distention+ Ascites

Haemato-biochemical tests were performed in 35 dogs, positive for *Ehrlichia* infection where haemoglobin concentration was found in the range from 4.2 to 13.5 g % with a mean of 8.26±0.42 g %. The minimum and maximum platelet count were 0.02 × 10^6/cu mm and 0.195 × 10^6/cu mm with a mean of 0.077±0.007 × 10^6 /cu mm. The mean value of alkaline phosphatase(ALP) concentration was 175.76±16.43 IU L^{-1} which was within the range of 57.9 to 398.5 IU L^{-1}. Blood urea concentration was found to be 42.67±2.13 mg dl^{-1} with a range from 22.9 to 69.7 mg dl^{-1}. Creatinine concentration was found to be in a range from 0.48 to 15.38 mg dl^{-1} with a mean of 2.9±0.53 mg dl^{-1}. The *Ehrlichia* infected dogs presented with Hb < 3.0 g % and creatinine concentration > 10.0 mg dl^{-1} were succumbed during our investigation. Anaemia and thrombocytopenia were two significant haematological alterations which were also recorded in the present study. This is in agreement of the findings of Bhadesiya and Raval (2015), Singh et al. (2014) and Harrus et al. (1999). Anemia might be due to bone marrow hypoplasia by the parasites leading to impaired production of cellular components of blood (Neer et al., 2002). The variation in the type of anemia can be attributed to several influential factors such as nutritional status, iron reserves in the body, concurrent infection and age of the infected dogs. The development of thrombocytopenia may be due to large-scale destruction of the cells in the spleen that begins a few days after the infection (Smith et al., 1975) or due to bone marrow hypoplasia leading to impairment of normal functions (Waner, 2008). The development of thrombocytopenia has also been attributed to an immune-pathological mechanism described by Waner et al., 1999, who demonstrated significant levels of serum anti-platelet IgG, 17 days after experimental *E. canis* infection that resulted in the removal of antibody adsorbed thrombocytes by the mononuclear phagocyte system in the liver and spleen. Elevated level of alkaline phosphatase (ALP), blood urea and creatinine recorded in the study were in accordance with the reports by Behera et al. (2015) and Morar et al. (2015). *E. canis* resides and replicates in the cytoplasm of circulating monocytes and macrophages affecting other internal organs like liver and kidney, hence elevating the ALP, blood urea and creatinine level. Harrus et al.(1996) documented biochemical alterations like hypoalbuminemia, hyperglobulinemia, increased serum enzyme activities of AST and ALT. Hypoalbuminemia is seen in all stages of canine ehrlichiosis and may be a consequence of anorexia and associated with decrease in protein uptake, blood loss and peripheral loss to oedematous inflammatory fluids as a consequence of vasculitis (Woody and Hoskin, 1991), decreased protein production due to concurrent liver disease (Reardon and Pierce, 1981) or due to proteinuria. Studies have indicated that proteinuria might occur independently or concurrently with glomerulonephritis (Frank and Breitschwerdt, 1999; Codner and Maslin, 1992; Waddle and Littman, 1988).

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Variation, correlation and path-coefficient study on morphometric traits and yield attributes of some groundnut breeding lines

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ABSTRACT

Thirty two F6 progenies along with 4 released varieties of groundnut as parents were evaluated in R.B.D for yield and its component traits grown in *rabi* (dry) season showed a wide range of variation in all the 10 morphometric traits including yield. The P.C.V. and G.C.V. estimates were high for haulm yield per plant and low for harvest index and shelling percent. The rest of the characters exhibited medium PCV and GCV. However, low values of G.C.V. were observed in shelling percentage and harvest index indicated that they are controlled largely by non-additive gene action and selection would be less effective, so there is need to create variability either by hybridization or mutation followed by selection. No of branches per plant and 100 kernel weight showed high heritability and high genetic advance, indicated that these traits are mainly governed by additive gene action. Hence, improvement of these traits would be more effective through the phenotypic selection. Moderate heritability and genetic advance (GAM) as percent of mean for plant height, pod number per plant, kernel number per plant, kernel yield and pod yield indicated the additive and non additive gene actions for these traits and phenotypic selection would be effective to some extent. Direct or indirect effect of various characters on pod yield were studied and that study indicated that kernel yield per plant, number of kernels per plant, hundred kernel weight followed by plant height and number of branches per plant were identified as the most important yield components and due emphasis should be placed on these characters while selecting for high yielding genotypes in Spanish bunch groundnut. Out of 36 genotypes evaluated the genotypes like OGZ5, OGZ2, R 2001-3A, OGZ6 and OGX4 were sorted out to be promising in respect of high yield. OGZ5 and OGZ6 recorded highest pod and kernel yield per plant with haulm yield although exhibited moderate chlorophyll and protein values is due to the balance in the physiological parameters contributing towards yield. OGZ5 and OGZ6 may be identified as promising line for high protein content (25%) and (31%) with moderate chlorophyll and higher yield. The higher productivity in these promising lines is due to a combination of various morpho- physiological traits and which could be ascribed as the basis of potential productivity in groundnut. High yield of different promising entries could be attributed to taller plant height, moderate to high number of branches /plant and number of pods per plant and moderately high 100 kernel weight , may serve as the basis of yield vigour which could be utilized as important selection criteria for prediction and realization of high yield in groundnut.

Keywords: Groundnut, genetic variability, heritability, correlation, morphometric traits

INTRODUCTION

Groundnut is an important oil, food and feed legume crop grown in over 100 countries. It covered 24 million ha area worldwide with a total production of 41 million tons in 2012 (FAOSTAT, 2012). In India, groundnut is cultivated in an area of 4.9 m ha, with production and productivity levels of 5.8 m tons and 1179 kg ha^{-1} respectively during 2012. Groundnut is valued as a rich source of energy contributed by oil (48–50%) and protein (25–28%) in the kernels. They provide 564 kcal of energy from 100 g of kernels (Jambunathan, 1991). Breeding for high yield and superior quality parameters such as food (protein) is an important targeted trait in advanced breeding programmes which help in enhancing the economic returns to the farmers and other stakeholders along the value chain. The pod yield is a function of crop growth rate, duration of reproductive growth and the fraction of crop growth rate partitioned toward pod yield. Therefore, understanding the physiological basis of yield and manipulation of physiological trait such as harvest index is as important as yield contributing parameters i.e. Pod yield per plant, number of pods per plant , shelling outturn and 100-seed weight for improvement of production and productivity in groundnut. Haulm yield becomes an important consideration in addition to pod yield for the development of dual purpose varieties in groundnut. Adequate amount of genetic variability and the genetic nature of the traits of interest are prerequisites for judicious selection of parents as well as choice of appropriate breeding methods for the development of improved varieties in groundnut. However, much of the variability is still underexploited in groundnut improvement. Therefore, it becomes a serious and challenging problem for the breeders to make rapid improvement for development of varieties with high yield, better resistance and superior quality in groundnut. Selection for yield per se has been the basis for improving groundnut productivity in semi-arid environments (Nigram et al., 1991) but gain from such selection is slow due to large environmental effects. Further, inter genotypic competition and a large experimental error associated with yield measurements often bias the outcome of selection for higher yield. Therefore, several workers in different crop plants have emphasized the importance of indirect selection for yield through component traits governed by genes with additive effect and strong correlation with yield. Therefore, it would be rewarding and the efficiency of single plant selection for yield would be improved via selection of other additional component traits rather than yield alone. Use of physiological models offer means of identifying traits linked with yield and the selection of such traits for improvement of yield may enhance the efficiency of breeding (Williams, 1992). Wallace et al.,(1993) suggested that indirect selection for yield will be most effective when applied to traits that already integrate most of the genetic and environmental effects that lead to yield. Bandyopadhyay et al.,(1985) evaluated the genetic potential of F2 progeny from single and three-way crosses using and they found that a selection index based on physiological and yield components to be more effective than an index based on yield components alone. The effectiveness of early generation selection in peanut appears to be enhanced by limiting its use to traits of high heritability or to indirect selection for yield, based on selection for correlated traits. This is contrary to the results of Halward et al., (1990) who reported no relationship between yield of F3 and F4 and concluded that pod yields in early generations were ineffective in predicting the yield potential of crosses grown in bulk in later generations. Realizing the importance of developing groundnut varieties with high yield, better resistance and superior quality and in the light of the above discussions, efforts were made to evaluate 32 breeding lines along with 4 parental lines during the course of present investigation for the assessment of (i) Availability and extent of genetic variability in yield and yield attributing characters and other traits like chlorophyll and protein level, (ii) Nature and magnitude of character association in relation to yield and its components and various other traits, (iii) Identification of promising breeding lines for prediction of higher yield and (iv) Direct and indirect effects of different component traits on yield through path analysis.

MATERIALS AND METHODS

The present study was undertaken in the department of Plant Breeding and Genetics, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar. The thirty six genotypes were evaluated comprised of 4 parents and their 32 progenies. Plant materials, their source and characters are mentioned in Table 1. Observations on ten quantitative characters like plant height (cm), number of branches per plant, haulm yield per plant (g), harvest index (%), number of pods per plant , shelling percentage, number of kernels per plant, 100 kernel weight (g), kernel yield per plant (g) and pod yield per plant (g) were recorded from the field trial. The data were analyzed to get information on genetic variation of yield and its components for selection of promising lines. Correlations among traits, direct and indirect effects of component traits on yield were estimated for selecting characters contributing to yield. Besides these, chlorophyll (a+b) and seed protein were estimated to study their relationship with yield. Each entry was represented by three rows of 3m length with 3 replications. Observations were recorded for 5 plants by random sampling per genotype in each replication.

Analysis of variance of 4 parents and their 32 progenies for each character was carried out in RBD with plot means for partitioning of total variance into components. The test weight of significance of difference among lines was done by F test.

Genetic variance and heritability

The phenotypic, genotypic and environmental variance components for different characters were estimated from the mean squares in ANOVA according to Al-Jibouri et al. (1958).

Correlation coefficient

Utilizing the various components of variance, co-variance, the genotypic, phenotypic correlation were computed according to Al-jibouri et al.(1958).

Path coefficient

In present study pod yield is taken as 'effect' and 9 growth component characters related to yield as 'causal factors'. Path coefficients are obtained by solving simultaneous equations, which gives the basic relationship between correlations (Wright, 1921; Dewey and Lu, 1959).

Estimation of chlorophyll content by SPAD meter

Soil plant analytical development (SPAD) chlorophyll meter reading (SCMR) was taken in 3 random sample leaf from tip of the main stem at 60 days after sowing.

Procedure and estimation over extraction of chlorophyll sample by chemical method

Pre-chilled 80% acetone was added during grinding of 0.5g sample to dissolve the pigment. Leaves were grind to a fine powder. Extraction was decanted to 2ml eppendorf tubes. Then those chlorophyll samples were centrifuged at 5000 rpm for 5mins at 4^0c in the dark. Then the entire extract decanted into the 10ml measuring cylinder and volume made to 10ml in each sample. OD value of each sample was read in sprectrophotometer. Samples are taken in cuvette (1ml capacity) of sprectrophotometer. OD value recorded at 646nm and 663nm against the solvent 80 per cent acetone as blank. chl a and chl b content calculated according to procedure of Porra et al.(1989).

Protein content estimation

Protein can be estimated by method (Lowry et al. 1959) by estimating total nitrogen content. Hydrolysing the protein and estimating the aminoacid alone will give the exact quantification. This method is sensitive enough to give a moderately constant value and hence largely followed.

RESULTS AND DISCUSSION

Mean performance of the genotypes

Mean performance of 36 genotypes for all the ten morphometric traits is presented in (Table 2) The genotype TG 26 was the tallest plant with 22.73 cm in plant height. OGZ7 was observed to be shortest in plant height of 12.13cm. The highest number of branches per plant (8.07) was observed in OGY14. OGY7 exhibited the lowest haulm yield per plant (5.0 g) with highest harvest index (70.29). The haulm yield per plant was highest (15.67 g) in OGZ6. The parent R 2001-3 exhibited highest number of pods per plant (23.87) and

Table 1. Plant materials, their sources and characters

Variety no	Genotype	Source	Character
1	AK 12-24	Local variety	Well adopted var.
2	TG-26	Local variety	Better grain filling capacity
3	OGX1	AK-12-24 × TG-26	-
4	OGX2	AK-12-24 × TG-26	-
5	OGX3	AK-12-24 × TG-26	-
6	OGX4	AK-12-24 × TG-26	-
7	OGX5	AK-12-24 × TG-26	-
8	R-2001-3	Local variety	Higher number of pod/plant
9	AK-159	Local variety	Large seed and leaf size
10	OGZ1	AK-159 × TG-26	-
11	OGZ2	AK-159 × TG-26	-
12	0GZ3	AK-149 × TG-26	-
13	0GZ4	AK-159 × TG-26	-
14	OGY1	R-2001-3 × TG26	-
15	OGY2	R-2001-3 × TG-26	-
16	OGY3	R-2001-3 × TG-26	-
17	OGY4	R-2001-3× TG-26	-
18	OGY5	R-2001-3 × TG-26	-
19	OGY6	R-2001-3 × TG-26	-
20	OGY7	R-2001-3 × TG-26	-
21	OGY8	R-2001-3 × TG-26	-
22	OGY9	R-2001-3 × TG-26	-
23	OGY10	R-2001-3 × TG-26	-
24	OGY11	R-2001-3 × TG-26	-
25	OGY12	R-2001-3 × TG-26	-
26	OGY13	R-2001-3 × TG-26	-
27	OGY14	R-2001-3 × TG-26	-
28	OGY15	R-2001-3 × TG-26	-
29	OGY16	R-2001-3 × TG-26	-
30	OGY17	R-2001-3 × TG-26	-
31	OGY18	R-2001-3 × TG-26	-
32	OGY19	R-2001-3 × TG-26	-
33	OGY20	R-2001-3 × TG-26	-
34	OGZ5	AK-159 × TG26	-
35	OGZ6	AK-159 × TG26	-
36	OGZ7	AK-159 ×TG26	-

Table 2. Mean performance of the groundnut genotypes

Sl No	Character/ Genotype	Plant height (cm)	No. of branches per plant	Haulm yield per plant	Harvest index (%)	No. of pods per plant	Shelling (%)	No. of kernels per plant	100 kernel weight(g)	Kernel yield per plant(g)	Pod yield per plant(g)	Protein (%)	SCMR	Chlorophyll a+b(µg g^{-1})
1	AK 12-24	15.57	4.07	6.33	69.39	12.73	52.75	21.27	35.41	7.53	14.53	30.58	9.00	286.83
2	TG 26	22.73	4.63	10.33	57.92	15.87	79.84	29.73	38.22	11.34	14.20	19.61	7.00	460.19
3	OG X1	16.83	3.50	9.33	45.51	9.43	62.70	13.67	35.85	4.88	7.80	13.68	7.96	391.71
4	OG X2	18.33	4.50	10.00	52.92	11.93	75.73	22.33	38.36	8.61	11.47	10.41	7.36	686.25
5	OG X3	19.10	4.00	10.00	52.05	13.67	73.65	23.47	35.00	8.15	11.10	17.85	8.84	352.59
6	OG X4	18.33	5.00	12.33	56.00	20.13	76.79	24.53	38.92	12.18	15.73	15.75	9.51	196.10
7	OG X5	12.53	4.20	7.00	57.06	9.93	78.34	17.00	43.20	7.30	9.30	10.21	7.83	154.10
8	R 2001-3	19.87	7.73	12.33	58.66	23.87	71.65	33.13	37.54	12.44	17.33	14.66	8.58	125.76
9	AK 159	16.23	5.23	9.00	60.18	16.80	75.64	29.67	35.26	10.33	13.67	13.04	6.58	391.56
10	OG Z1	16.73	6.80	14.33	48.03	13.20	61.28	17.93	43.27	7.79	12.67	9.01	7.53	208.71
11	OG Z2	20.00	6.40	11.33	62.43	14.13	74.09	20.93	65.36	13.69	18.47	18.41	10.78	221.29
12	OG Z3	14.13	5.00	11.00	52.74	17.87	72.70	19.53	43.63	8.48	11.73	23.32	12.32	166.36
13	OG Z4	12.80	4.93	10.33	50.26	11.40	75.42	18.07	43.29	7.81	10.40	26.25	12.50	288.55
14	OG Y1	16.73	7.60	9.33	58.38	18.33	73.11	29.47	33.27	9.89	13.53	13.32	9.81	192.79
15	OG Y2	17.13	7.00	7.33	63.69	18.27	73.58	22.87	40.56	9.25	12.73	14.09	9.30	203.84
16	OG Y3	21.33	6.73	8.00	62.30	16.13	72.71	23.40	38.49	8.90	12.27	8.43	10.91	216.77
17	OG Y4	16.73	7.60	7.80	63.36	16.47	71.85	24.53	39.23	9.65	13.40	15.59	8.01	198.75
18	OG Y5	14.07	6.73	5.80	67.64	16.80	72.21	23.47	37.10	8.72	12.13	12.55	7.30	242.71
19	OG Y6	17.20	6.67	6.67	62.71	15.53	73.21	22.40	36.65	8.10	11.07	19.79	7.50	174.51
20	OG Y7	12.33	6.80	5.00	70.29	15.47	74.89	23.07	38.26	8.82	11.80	20.51	8.55	292.90
21	OG Y8	14.53	6.57	7.67	56.31	16.87	76.24	20.27	37.66	7.58	9.93	16.95	7.60	88.33
22	OG Y9	18.13	6.20	7.67	61.90	14.33	75.73	19.27	46.81	9.15	12.00	21.13	7.30	201.60
23	OG Y10	16.47	7.00	8.33	62.43	19.33	72.72	24.07	40.96	9.93	13.80	12.45	7.10	135.81
24	OG Y11	13.47	6.33	6.67	64.92	15.53	77.61	23.00	40.22	9.21	11.93	18.45	7.40	87.73
25	OG Y12	16.47	7.40	8.33	62.33	18.13	75.02	27.20	37.20	10.22	13.60	19.95	8.50	113.05
26	OG Y13	15.13	7.13	6.33	68.09	13.87	71.63	27.80	35.00	9.72	13.53	13.88	8.60	297.86
27	OG Y14	16.73	8.07	9.13	58.32	15.27	71.17	24.60	35.56	8.82	12.47	16.99	8.10	217.69
28	OG Y15	17.53	7.20	9.13	60.31	17.33	73.51	27.93	36.45	10.33	13.87	24.41	9.20	220.59
29	OG Y16	17.60	6.87	8.13	63.22	14.80	76.70	26.40	40.13	10.63	13.87	23.17	7.10	214.00
30	OG Y17	16.07	7.07	6.33	70.09	13.93	76.63	28.73	39.03	11.25	14.73	30.64	9.15	240.06
31	OG Y18	18.33	7.67	9.00	61.60	16.87	76.53	29.00	36.82	10.78	14.13	27.95	8.18	143.60
32	OG Y19	19.07	7.47	9.00	62.37	20.00	76.04	32.27	35.18	11.24	14.80	17.80	9.01	159.95
33	OG Y20	18.60	7.33	11.53	48.11	15.17	60.57	15.53	40.59	6.42	10.47	20.26	8.64	109.37
34	OG Z5	22.20	7.73	17.67	54.94	18.73	75.06	23.47	67.65	15.86	21.27	25.43	8.65	281.05
35	OG Z6	21.93	6.27	15.67	52.18	18.27	71.67	24.20	50.37	12.25	17.07	31.39	11.50	282.79
36	OG Z7	12.13	5.13	6.00	67.41	14.60	75.98	23.33	39.52	9.18	12.07	32.72	12.80	130.97

kernels per plant (33.13). Among the genotypes, parent AK 12-24 exhibited lowest shelling per cent and the other parent TG 26 exhibited highest shelling per cent (79.84). The hundred kernel weight of test entries ranged from 33.27 g (OGY1) to 67.65 g (OGZ5). Besides 100 kernel weight, OGZ5 exhibited highest value in both kernel yield (15.86 g) and pod yield (21.27g) per plant. A perusal of the relative magnitude of variation from the analysis of variance and range of variations in respect of all the characters under study, revealed the presence of ample genetic variability in the material, thus providing enormous scope for selection of genotypes and which could be used in the future breeding programmes for realization of high and stable yield in groundnut. Similar results were also reported by Jatti et al. (2008); Savalya et al. (2009); Singh et al. (2010) and Upadhyaya et al. (2011).

The mean chlorophyll, protein and pod yield with SCMR are presented in Table 2. OGX2 recorded the highest total chlorophyll but not higher yield. OGY8 recorded lowest chlorophyll. OGZ7 exhibited highest protein percentage with highest SCMR. Some lines show higher range of SCMR reading (10.78-12.80) from which OGZ4 and OGZ6 shows moderate range of chlorophyll. High yielding line as OGZ6 showed high SCMR reading, with moderate chlorophyll value, with high protein content. OGZ5 recorded highest pod and kernel yield per plant with haulm yield although exhibited moderate chlorophyll value with higher protein content. The highest yield obtained in OGZ5 with moderate chlorophyll content is due to the balance in the physiological parameters contributing towards yield. Babitha et al. (2006) reported low, medium and high for SPAD chlorophyll meter reading (SCMR) in moisture stress and high tolerance stress. So OGZ5 and OGZ6 may be identified as promising line.

The protein content of 36 genotypes, presented in Table 2 indicated that entries like AK 12-24, OGZ4, OGY17, OGY18, OGZ5, OGZ6 and OGZ7 contain higher level of protein content ranging from 25.43 % -32.72 %. The variability in protein content in groundnut has been reported by Asibuo (2008) and Cholin et al. (2010). It was interesting to note that majority of high yielding lines except OGZ5 and OGZ6 were lower in protein content and on the contrary, high protein lines are inferior in yield performance. There is a general observation that high yielding lines are inferior in protein content. However, it is an important significant finding that two promising lines like OGZ5 and OGZ6 combine high yield with high protein content, which could be identified as promising and prospective lines, on the contrary some of the genotypes like AK 12-24, OGZ4, OGY17, OGY18 and OGZ7, despite lower yield have high protein content could be utilized as parental sources for transferring protein content in groundnut. Upadhyaya et al. (2012) reported eighteen accessions with higher nutritional traits such as protein content, oil content, with superior agronomic trait.

Variability, heritability and genetic advance

The 4 parents and their 32 progenies showed wide variation in all the 10 traits including yield. The genotypic source of variations were highly significant (at 1% level) for all the traits (Table 3).

The genetic parameters of morphological characters in groundnut during *rabi* (dry) seasons are presented in Table 4. Wide range of variation was recorded for all the characters. The P.C.V. and G.C.V. estimates were high for haulm yield per plant and low for harvest index and shelling per cent. The rest of the characters exhibited medium PCV and GCV. Among F2 population of six single crosses and their parents, John et al. (2008) and Jatti et al. (2008) observed high estimates of GCV and PCV, for haulm yield per plant. However, low values of G.C.V. were observed in shelling percentage and harvest index indicated the need to create variability either by hybridization or mutation followed by

Table 3. Analysis of variance of 10 characters of groundnut

Sl. No.	Character	Source	MSS	F	Prob>F
1	Plant height (cm)	Replication	77.036	7.509**	0.001
		Genotype	22.722	2.215*	0.002
2	No of branches per plant	Replication	7.763	14.999**	0.000
		Genotype	4.877	9.424**	0.000
3	Haulm yield per plant (g)	Replication	1.111	0.148	0.863
		Genotype	23.375	3.110**	0.000
4	Harvest index (%)	Replication	27.975	0.968	0.385
		Genotype	125.385	4.337**	0.000
5	No. of pods per plant	Replication	23.373	2.129	0.127
		Genotype	26.009	2.369**	0.001
6	Shelling (%)	Replication	32.216	1.009	0.370
		Genotype	89.110	2.791**	0.000
7	No. of kernels per plant	Replication	1.082	0.072	0.931
		Genotype	61.932	4.090**	0.000
8	100 kernel weight(g)	Replication	5.302	0.265	0.768
		Genotype	160.773	8.022**	0.000
9	Kernel yield per plant (g)	Replication	0.230	0.053	0.949
		Genotype	13.062	2.987**	0.000
10	Pod yield per plant (g)	Replication	2.037	0.265	0.768
		Genotype	20.187	2.625**	0.000

* Significant at 5 % level, **Significant at 1 % level

Table 4. Genetic parameters of the morphological characters in groundnut

Character	Mean	Range	PCV (%)	GCV(%)	h^2(%)	GA (% of mean)
Plant height (cm)	17.03	12.13-22.73	22.291	11.967	28.82	13.23
No of branches per plant	6.29	3.5-8.07	22.307	19.155	73.74	33.89
Haulm yield per plant (g)	9.17	5.00-17.67	39.010	25.066	41.29	33.18
Harvest index (%)	59.61	45.51-70.29	13.109	9.513	52.66	14.22
No. of pods per plant	15.86	9.43-23.87	25.210	14.112	31.33	16.27
Shelling (%)	72.92	52.75-79.84	9.793	5.987	37.38	7.54
No. of kernels per plant	23.82	13.67-33.13	23.275	16.579	50.74	24.33
100 kernel weight(g)	40.45	33.27-67.65	20.231	16.934	70.07	29.20
Kernel yield per plant(g)	9.62	4.88-15.86	28.016	17.685	39.85	23.00
Pod yield per plant(g)	13.19	7.80-21.27	26.105	15.472	35.13	18.89

selection. Low G.C.V. estimates for shelling per cent was also reported by Pradhan and Patra (2011) in a study taking 460 genotypes of groundnut germplasm in four different seasons for pod yield and yield component characters. High heritability estimates were observed for number of branches per plant and 100 kernel weight indicating less influence of environment on these characters. Jogloy et al. (2011) recorded low to moderate heritability estimates for 100-seed weight. Johnson et al. (1955) reported that heritability estimates along with genetic gain would be more useful than the former alone in predicting the effectiveness of selecting the best individual. Therefore it is essential to consider the predicted genetic advance along with heritability estimate as a tool in the selection programme for better efficiency. Along with high heritability, high genetic advance as percentage of mean has been noticed for number of branches per plant and hundred kernel weight. Therefore it was clear that these two traits were less influenced by the environmental changes due to the presence of additive gene action in their expressions. For number of branches per plant, John et al.,(2008) reported low heritability and moderate genetic advance as per cent of mean where as Hiremath et al. (2011) observed high GCV accompanied by high heritability and high genetic advance as per cent of mean. Savaliya et al. (2009) and John et al.(2008) observed high heritability combined with high genetic advance (GAM) as per cent of mean for 100-seed weight, in contrast to which Jogloy et al. (2011) recorded low to moderate heritability estimates for 100-seed weight. Heritability and genetic advance as per cent of mean were moderate for harvest index and low for shelling per cent. Similar result was also reported by Vishnuwardhan et al. (2013) for shelling percentage and harvest index.

Thus harvest index and shelling per cent were controlled largely by non-additive gene action and selection would be less effective. Moderate heritability and genetic advance (GAM) as per cent of mean for plant height, pod number per plant, kernel number per plant, kernel yield and pod yield indicated the additive and non additive gene actions for these traits and phenotypic selection would be effective to some extent. High heritability along with, high genetic advance as percentage of mean for number of branches per plant and hundred kernel weight indicated that these traits are mainly governed by additive gene action and responsive to selection. Hence improvement of these traits would be more effective through the phenotypic selection. Low genetic advance along with low heritability estimate for shelling per cent and harvest index is released varieties during 1905 to 2002 were reported by Rathnakumar et al. (2010) revealed no significant improvement in these two traits. Rather the enhanced pod yield of 9.4 kg ha^{-1} per annum has resulted mainly from improvements in number of pods per plant, pod and seed weight.

Table 5. Phenotypic correlation coefficients (rp) among the characters in groundnut

Character	1	2	3	4	5	6	7	8	9	10
1	1.000	0.122	0.485**	-0.281*	0.267	-0.159	0.146	0.268	0.316*	0.378*
2		1.000	0.170	0.180	0.488**	0.007	0.414**	0.081	0.372*	0.388**
3			1.000	0.684**	0.392**	-0.233	0.042	0.518**	0.474**	0.576**
4				1.000	0.065	0.294	0.418**	-0.112	0.234	0.170
5					1.000	0.104	0.552**	0.116	0.600**	0.607**
6						1.000	0.353*	0.084	0.357*	0.028
7							1.000	-0.192	0.645**	0.576**
8								1.000	0.564**	0.568**
9									1.000	0.939**
10										1.000

Table 6. Genotypic correlation coefficients (rg) among the characters in groundnut

Character	1	2	3	4	5	6	7	8	9	10
1	1.000	0.250	0.847**	-0.293*	0.493**	0.247	0.499**	0.422**	0.882**	0.884**
2		1.000	-0.041	0.417**	0.687**	0.197	0.474**	0.089	0.451**	0.438**
3			1.000	-0.713	0.120	0.033	-0.152	0.644**	0.461**	0.481**
4				1.000	0.292*	0.131	0.507**	-0.212	0.231	0.263
5					1.000	0.416**	0.750**	-0.101	0.597**	0.526**
6						1.000	0.487**	0.120	0.547**	0.237
7							1.000	-0.356*	0.581**	0.490**
8								1.000	0.554**	0.583**
9									1.000	0.943**
10										1.000

1. Plant height (cm), 2. No of branches per plant, 3. Haulm yield per plant (g), 4. Harvest index (%), 5. No. of pods per plant, 6. Shelling (%), 7. No. of kernels per plant, 8. 100 kernel weight(g), 9. Kernel yield per plant (g), 10. Pod yield per plant (g) * and ** [Significance at 5 % level and 1 % level of probability respectively at n-2 degrees of freedom]

Phenotypic and genotypic correlations among traits

Out of the 45 correlation coefficients among the 10 traits 22 correlation coefficients were significant at phenotypic level (Table 5), whereas 28 correlation coefficients were significant at genotypic level (Table 6). In general, the values of genotypic correlation (rg) were higher than their corresponding phenotypic correlation (rp) indicating that there was high degree of association between two variables at genotypic level. Its phenotypic expression was deflated by the influence of environment, pointing out the possibilities of effective phenotypic selection. Pod yield per plant and kernel yield per plant exhibited highly significant positive correlations and both these traits also exhibited significant positive correlations with number of branches per plant, haulm yield per plant, number of pods and kernels per plant and hundred kernel weights at both phenotypic and genotypic level. The plant height was significantly associated with pod yield per plant. Haulm yield exhibited highly positive correlation with plant height.

Besides correlation with pod and kernel yield, haulm yield also exhibited significant positive correlation with hundred kernel weight and number of pods per plant. Thus it can be inferred that haulm yield is one important selection criteria for increasing pod and kernel yield per plant. Number of pods per plant and number of kernels per plant were positively associated and both were positively correlated with number of branches per plant. Number of kernels per plant exhibited positive correlation with harvest index and shelling percentage.

Hiremath et al.(2011), Giri and Hudge (2010), Shoba et al.(2012) and Korat et al.(2010) reported significant positive association for pod yield per plant with kernel yield and 100 seed weight both at genotypic and phenotypic level. Gomes and Lopes (2005) also reported that pod yield was positively associated with 100 seed mass, primary secondary branches per plant and harvest index.According to Vaithiyalingan et al.(2010), pod yield exhibited significant positive association with pods per plant, dry matter production, kernel weight and harvest index that supports the present finding.

Table 7. Direct and indirect effects of component traits on pod yield

Characters	Plant height (cm)	No. of branches per plant	Haulm yield per Plant	Harvest index (%)	No. of pods per plant	Shelling (%)	No. of kernels per plant	100 kernel weight (g)	Kernel yield per plant(g)	Pod yield per plant (g)
Plant height (cm)	-0.076	-0.028	-0.023	0.004	0.042	-0.109	0.269	0.223	0.583	0.884
No of branches per plant	-0.019	-0.111	0.001	-0.005	0.059	-0.087	0.255	0.047	0.298	0.438
Haulm yield per plant (g)	-0.065	0.005	-0.027	0.009	0.010	-0.015	-0.082	0.340	0.304	0.481
Harvest index (%)	0.022	-0.046	0.020	-0.013	0.025	-0.058	0.273	-0.112	0.152	0.263
No. of pods per plant	-0.038	-0.076	-0.003	-0.004	0.086	-0.184	0.404	-0.054	0.395	0.526
Shelling (%)	-0.019	-0.022	-0.001	-0.002	0.036	-0.442	0.262	0.063	0.361	0.237
No. of kernels per plant	-0.038	-0.053	0.004	-0.007	0.064	-0.215	0.539	-0.188	0.383	0.490
100 kernel weight(g)	-0.032	-0.010	-0.018	0.003	-0.009	-0.053	-0.192	0.528	0.366	0.583
Kernel yield per plant (g)	-0.067	-0.050	-0.013	-0.003	0.051	-0.241	0.313	0.292	0.660	0.943

Path co-efficient analysis

The correlation of pod yield per plant was further analyzed by the method of path coefficient analysis based on genotypic correlation. Correlation of yield with other characters were partitioned into components of direct and indirect effects to know the nature and relative importance of the components in determining pod yield (Table 7). The present path coefficient analysis showed low residual effect (0.0476) indicating that most of the major yield components were included in the study. (Wallace et al.1993) also reported indirect selection for yield will be most effective when applied to traits that already integrate most of the genetic and environmental effects. Kernel yield per plant had the highest direct positive effects on pod yield per plant followed by number of kernels per plant and 100 kernel weight. All other characters through these three characters made major indirect contribution towards pod yield. Plant height, number of branches per plant and number of pods per plant exhibited greater influence on pod yield per plant via kernel number per plant and kernel yield per plant. Haulm yield and harvest index influenced indirectly on pod yield through kernel weight and kernel number respectively. Present study thus indicated that for selection prime emphasis should be given on kernel yield per plant, number of kernels per plant, hundred kernel weight followed by plant height and number of branches per plant. Dhaliwal et al. (2010) and Babariya and Dobariya (2012) also observed high positive direct contribution of kernel yield per plant to the pod yield. Thus, kernel yield per plant, number of kernels per plant, hundred kernel weight followed by plant height and number of branches per plant were identified as the most important yield components and due emphasis should be placed on these characters while selecting for high yielding genotypes in Spanish bunch groundnut.

Identification of promising breeding lines and the basis of higher productivity in groundnut

Out of 36 genotypes evaluated for yield and yield contributing parameters the genotypes like OGZ5, OGZ2, R 2001-3A, OGZ6 and OGX4 were found promising in respect of pod yield per plant. A perusal of data from the mean performance in Table -6, it is observed that superior performance of all traits was

not expressed in a promising genotypes and different genotypes were found to be superior for various characters. The higher productivity in the promising varieties was due to a combination of various morpho-physiological traits and which could be ascribed as the basis of potential productivity in groundnut. For instance, the higher yield in OGZ5 could be attributed to taller height, higher no. of branches, high shelling percentage, higher 100 kernel weight and higher kernel yield per plant and higher harvest index. High yield level of P3 was due to tall plant height and higher magnitude of number of branches, number of pods, shelling percentage, number of kernels per plant and kernel yield per plant. High yield level in OGZ6 was due to tall height, higher shelling percentage and higher kernel yield per plant. The higher yield level of OGX4 could be attributed to higher no. of pods per plant and higher shelling percentage.

From the foregoing observations on superior yield performance of selected genotypes and their association with various yield related traits it is revealed that superior performance of all the traits was not expressed in any promising genotype and different genotypes were found to be superior for various characters and so no definite trend of relationship is suggested, still it is clearly demonstrated that high yield of different promising entries could be attributed to taller plant height , moderate to high number of branches per plant and number of pods per plant and moderately high 100 kernel weight , may serve as the basis of yield vigor which could be utilized as important selection criteria for prediction and realization of high yield in groundnut.

The result of present study indicated that the pattern of high yield in relation to different component traits differ greatly from genotype to genotype and any generalization regarding yield potentially of a genotype for all the traits is quite difficult. Gomes and Lopes (2005), Korat et al. (2010), Dhaliwal et al. (2010), Shoba et al. (2012) and Babarya and Dabariya (2012) reported similar findings, indicating that higher yield level was due to higher number of branches/plant, higher number of pods per plant, 100 kernel weight, kernel yield per plant and shelling percentage and which are most important and key traits for stability of pod yield and these traits could be successfully employed for realization of higher productivity and ensures the possibility of predicting the performance of genotypes for higher productivity in groundnut.

CONCLUSION

The P.C.V. and G.C.V. estimates were high for haulm yield per plant. However, low values of G.C.V. were observed in shelling percentage and harvest index indicated the need to create variability either by hybridization or mutation followed by selection. Along with high heritability, high genetic advance as percentage of mean has been noticed for number of branches per plant and hundred kernel weight. These traits are mainly governed by additive gene action and thus less influenced by the environmental changes. Hence improvement of these traits would be more effective through the phenotypic selection. Thus, harvest index and shelling per cent were controlled largely by non-additive gene action and selection would be less effective. Moderate heritability and genetic advance (GAM) as per cent of mean for plant height, pod number per plant, kernel number per plant, kernel yield and pod yield indicated the additive and non additive gene actions for these traits and phenotypic selection would be effective to some extent.

Kernel yield per plant had the highest direct positive effects on pod yield per plant followed by number of kernels per plant and 100 kernel weight. All other characters through these three characters made major indirect contribution towards pod yield. Plant height, number of branches per plant and number of pods per plant exhibited greater influence on pod yield per plant via kernel nuber per plant and kernel yield per plant. Haulm yield and harvest index influenced indirectly on pod yield through kernel weight and kernel number respectively. Present study thus indicated that for selection prime emphasis should be given on kernel yield per plant, number of kernels per plant, hundred kernel weight followed by plant height and number of branches per plant were identified as the most important yield components and due emphasis should be placed on these characters while selecting for high yielding genotypes in Spanish bunch groundnut.

Highest yield obtained in OGZ5 with moderate chlorophyll content is due to the balance in the physiological parameters contributing towards yield. However it is an important significant finding that two promising lines like OGZ5 AND OGZ6 combine high yield with high protein content, which could

be identified as promising and prospective lines, on the contrary some of the genotypes like AK 12-24, OGZ4, OGY17, OGY18 AND OGZ7, despite lower yield have high protein content could be utilized as parental sources for transferring protein content in groundnut.

Out of 36 genotypes evaluated for yield and yield contributing parameters the genotypes like OG Z5, OGZ2, R 2001-3A, OGZ6 and OGX4 were found promising in respect of pod yield per plant. Superior performance of all traits was not expressed in promising genotypes and different genotypes were found to be superior for various characters. The higher productivity in the promising varieties is due to a combination of various morpho- physiological traits and which could be ascribed as the basis of potential productivity in groundnut.

The result of present study indicated that the pattern of high yield in relation to different component traits differ greatly from genotype to genotype and any generalization regarding yield potentially of a genotype for all the traits is quite difficult., However the higher yield level was due to higher number of branches/plant, higher number of pods per plant, 100 kernel weight , kernel yield per plant and shelling per cent and which are most important and key traits for stability of pod yield and these traits could be successfully employed for realization of higher productivity and ensures the possibility of predicting the performance of genotypes for higher productivity in groundnut.

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Influence of mulch on depletion pattern of *in situ* soil moisture in rajma crop system of Meghalaya

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ABSTRACT

In situ soil moisture is one of the constraints in crops production during the winter season when there is hardly any source of irrigation under a hilly terrain. A field trial was taken up to assess the *in situ* soil moisture depletion under two organic mulching materials, viz. maize stover and weed mulch. The performance of Rajma crop was studied under the influence of the organic mulch in the mid hill of Meghalaya. The percentage of emergence (79.75%) was found higher for weed mulch followed by maize stover mulch and un-mulch treatment. The soil moisture content and soil moisture stress were found to be within the acceptable range for weed mulch plot at two different monitored soil depths viz., 0-15 cm, 16-30 cm. The depletion pattern of soil moisture was found rapid under un-mulch treatment (control) over organic mulch treatments. Within the organic mulch treatment, rapid depletion pattern was recorded for weed mulch over maize stover mulch. The economic yield and benefit cost ratio (BCR) recorded for Rajma cultivar "selection-9" was 2.52 and 1.45 t ha^{-1}, respectively under weed mulching.

Key words: Organic mulch, Rajma, moisture depletion pattern, soil depth

INTRODUCTION

The increase in agricultural productivity demands optimum utilization of natural resources like land and water. Mulching is one of the important practices in restoring moisture; among various mechanical and agronomic measures, to reduce soil erosion, increase *in situ* soil moisture storage and improve the productivity of crops (Bhatt and Rao, 2004). The practice of mulching has been widely used as a management tool in many parts of the world. However, the effect varies with soils, climate and kind of mulch materials used and the rate of application. The surface mulch favourably influences the soil moisture regime by controlling evaporation (Ramakrishna et al., 2006; Montenegro et al., 2013). To increase water availability to crops, it is necessary to adopt *in situ* moisture conservation techniques in addition to large scale soil and water conservation practices and various water harvesting measures (Lannotti, 2007; Chavan et al., 2010). Mulching can help to improve crop yield and optimize water use (Lamont, 1999; Parmar et al., 2013; Prasad et al., 2014 and Saikia et al., 2014). Mulches which are derived from plant material are called organic mulch, viz. grass, straws, leaves *etc* (Lannotti, 2007) and can be fruitfully utilized to retain moisture. A field trial was taken up to assess the *in situ* soil moisture depletion under two organic mulching materials, viz. maize stover and weed mulch with Rajma as a test crop at the mid hill of Meghalaya.

MATERIALS AND METHODS

A field trial was carried out during winter season (2015-16) at the experimental farm of the College of Postgraduate Studies, Umiam, which is located at Ri-Bhoi district, Meghalaya to study the soil moisture depletion pattern under organic mulch. The performance of a legume crop, Rajma cultivar

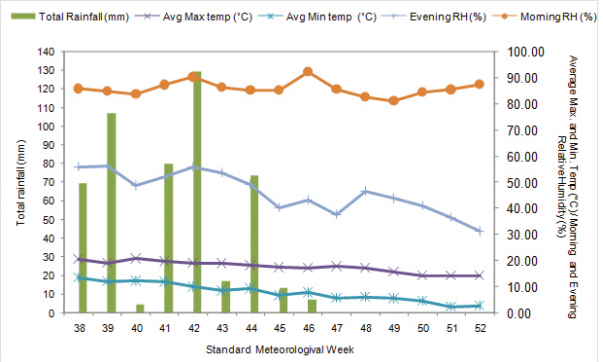


Fig. 1. Weekly variation of rainfall, temperature and humidity

"selection-9" was studied under the mulching practices. The experimental soil was sandy clay loam with PH of 4.83 and organic carbon (1.96%). The weekly rainfall (mm), average maximum and minimum temperature (^{0}C) and relative humidity (%) is shown in Fig. 1 and the weekly rainy day (day), pan evaporation (mm) and wind speed (km hr^{-1}) is shown in Fig. 2. During the experimentation period, maximum weekly rainfall of 129.2 mm was received during the 42nd standard week (October), the total amount of 325.2 mm was received during the crop-growing season. The total number of rainy days recorded was 14; the highest number of rainy day occurred during the 39th standard meteorological week (5 days).

To record the moisture stress developed at the 0-15 and 16-30 cm soil depth, tensiometers were also installed at the respective mulch and un-mulch plots.

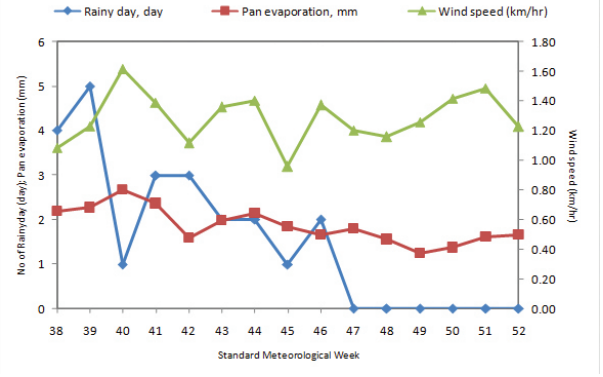


Fig. 2. Weekly variation of rainy days, pan evaporation and wind speed

A calibration curve was prepared for the tensiometer prior to the installation and shown in Fig. 3.

A soil moisture characteristics curve was also prepared to know the moisture holding capacity of

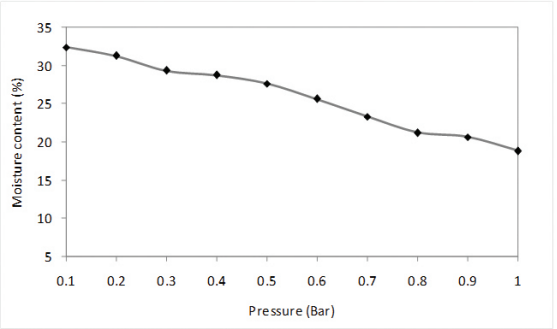


Fig. 3. Calibration curve of a tensiometer

the soil. According to the prepared soil moisture characteristic curve soil moisture contents in Field capacity (FC) and Permanent wilting point (PWP) are 29.34% and 8.66%, respectively. The prepared curve is shown in Fig. 4.

Mulching was applied @ 5 t ha^{-1} one day after sowing of the seed. The maize stover was chopped

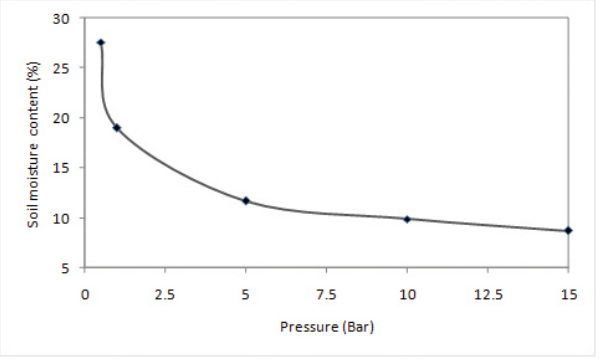


Fig. 4. Soil moisture characteristics curve

first and then spread over the plot. Standard agronomic practices were followed during crop growing period and the crop was harvested at maturity.

RESULTS AND DISCUSSION

Seed emergence

The emergence percentage for the Rajma varieties under different organic mulching is presented in Table 1. Weed mulch (79.75%) gave higher germination as compared to un-mulched (75.60%) indicating a better *in situ* soil moisture holding capacity by mulching practices. The results were well in agreements with the findings of Bonanno and Lamont, 1987; Sharma and Acharya, 2000; Roy et al., 2010; Sharma et al., 2010; Nwokwu, 2014.

Table 1. Effect of mulching on emergence of Rajma

Treatments	Emergence percentage (%)
Un-mulch	75.60
Maize stover mulch	77.50
Weed mulch	79.75

Soil moisture depletion

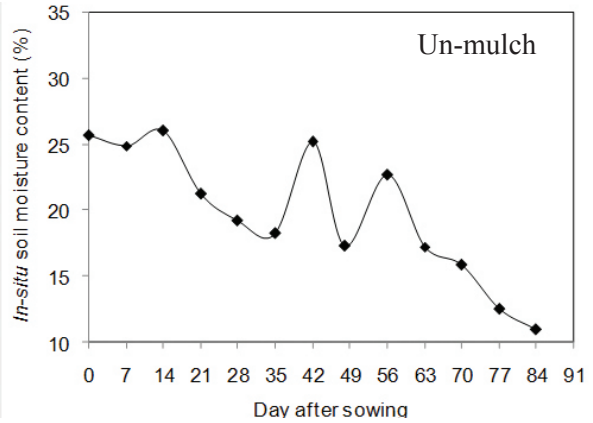
The soil moisture values were recorded to determine the depletion pattern of soil moisture at two different depths, *i.e*., 0-15 cm and 16-30 cm for un-mulched and organic mulch treatment plots. The depletion status figures of un-mulching treatment at two depths are shown in Fig. 5 and 6, respectively. The weekly recorded data of *in situ* soil moisture is shown in the figure and the depletion status was found steady, however, the value of *in situ* moisture content recorded was found more at lower depth than at the upper layer. The same trend was observed for maize stover mulch and un-mulch treatment. Weed mulch showed better soil moisture retention as compared to maize stover mulch.

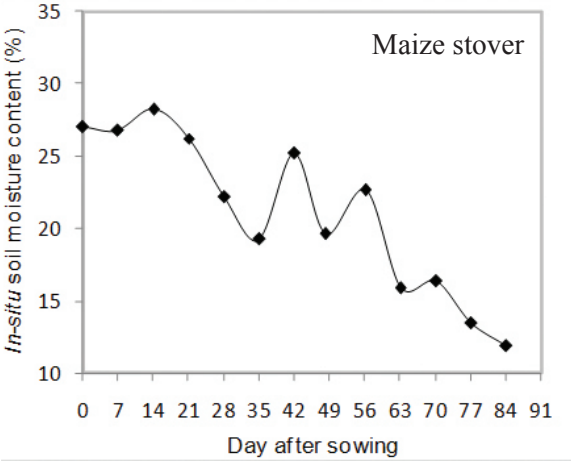
At the 15 cm depth the soil moisture fluctuation was recorded, where, the lowest was 10.98% at 84 days after sowing (DAS) and the highest value was 26% at 14 DAS. While at the 30 cm depth, the soil moisture status showed the highest value at 14 DAS as 32.15% and the lowest at 84 DAS as 15.64%. The weekly *in situ* soil moisture status for the maize stover mulch at 0-15 cm depth was found highest at 14 DAS (28.23%) and latter decreased; the lowest recorded value was at 84 DAS (11.91%); during the final stage of the crop. During a later stage of vegetative and pod formation, the *in situ* moisture was found higher and again it starts decreasing. While at 15- 30 cm depth the *in situ* soil moisture status of the maize stover mulch was found to be ranged between the lowest at 84 DAS (16.89%) and the highest at 14 DAS (31.23%). It may be noted that the *in situ* soil moisture depletion pattern was not steady as compared to un-mulch condition and the value of soil moisture was found higher at lower depth. It may be noted that the *in situ* soil moisture content was found more as compared to the other mulch treatments. The recorded soil moisture status for weed mulch at 15 cm depth was found to be lowest at 84 DAS (14.25%) and the highest value was observed at 14 DAS (29.87%). Whereas, at the 30 cm depth of weed mulching the soil moisture status were found to be ranged between the lowest of 19.24% at 84 DAS and the highest of 34.14% at 14 DAS. Similar findings were reported by Ahmed et al., 2007; Chavan et al., 2010; Parmer et al., 2013; Saikia et al., 2014.

Soil moisture observations

The tensiometer readings of the pressure gauge were recorded by the tensiometer installed in the un-mulched and organic mulched treatment field at two different depths, i.e., 15 and 30 cm are shown in the Fig. 7. The variation of tensiometer reading from 0 to 87 day of culture shows a steady increasing of soil moisture tension value as compared to the other two organic mulch treatments condition. The minimum value of soil moisture tension at 15 cm and 30 cm depth was recorded as 2.6 and 1.8 k pa, respectively.

For maize stover mulch treatment the soil moisture tension at 15 cm and 30 cm depth was 2.2 and 2 k pa, respectively. However, for weed mulch treatment the soil moisture tension at 15 cm and 30 cm depth was 1.9 and 1 kpa, respectively. The soil moisture tension values were found higher for the upper layer of soil depth as compared to the bottom layer, which indicates the availability of relatively more soil moisture at the bottom layer of soil for all organic mulch and un-mulch treatment plots. Similar trend in organic mulching treatments was also reported by Sinkevičienė et al., 2009; Chavan et al., 2010. The different between the high tension and lower tension is more at the top 15 cm depth (8 k Pa) at the end of the growing season, while (5 k Pa) was recorded at the 30 cm depth. Mulches reduce soil deterioration by preventing runoff and soil loss, minimize the weed infestation, increase the *in situ* soil moisture availability and reduce water evaporation (Sarangi et al., 2010). The *in situ* soil moisture depletion pattern was not found steady as compared to un-mulching condition and the value of soil moisture was found higher at lower depth, under organic mulching and un-mulch condition. Similar findings were reported by Ahmed et al., 2007; Chavan





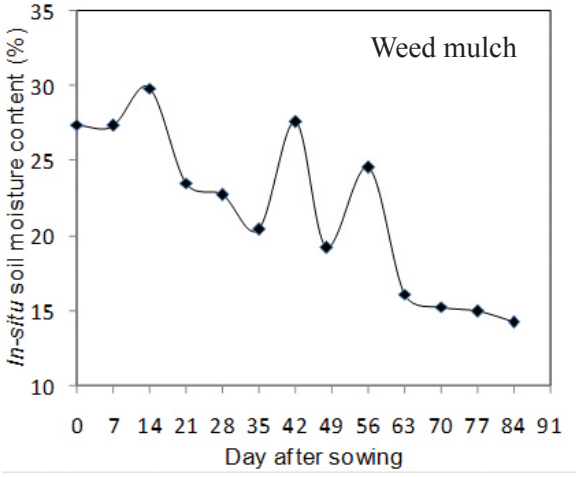
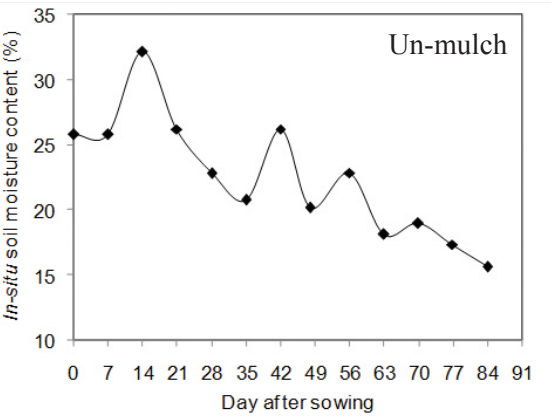
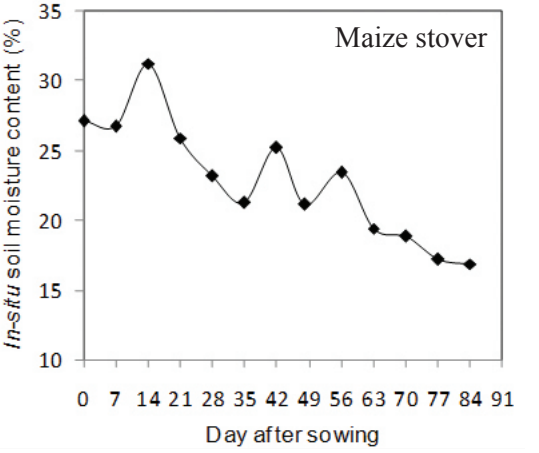


Fig. 5. Soil moisture content at 15 cm depth





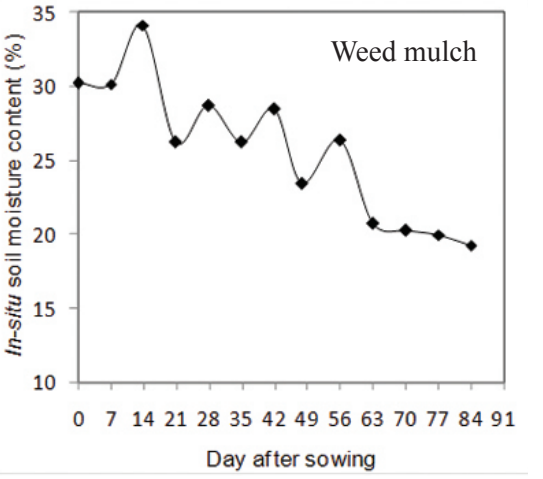
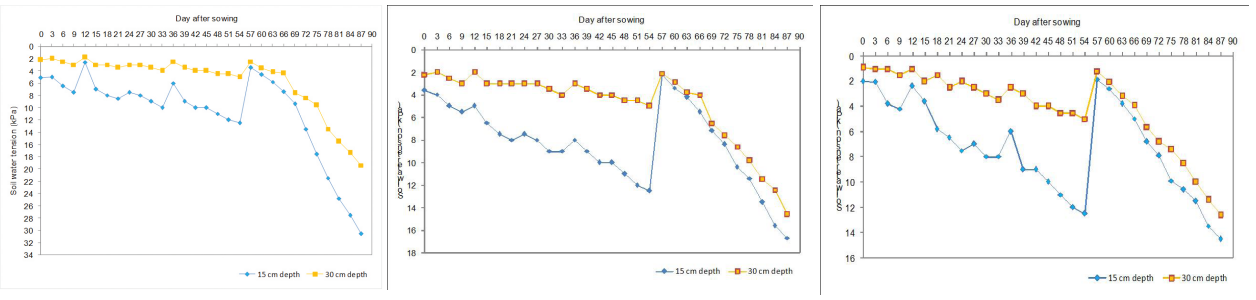


Fig. 6. Soil moisture content at 30 cm depth



a. un-mulch b. maize stover mulch c. weed mulch

Fig. 7. Variation of soil tension under condition

et al., 2010; Parmar et al., 2013; Saikia et al., 2014. Weed mulch showed better soil moisture retention as compared to maize stover mulch.

Crop yield parameters

The organic mulching and the varieties selected for the field trial gave positive results on the yield parameters. The reductions in number of pods per plant may also be attributed due to abscission of flowers and pods (Malik et al., 2006) and or by the failure of fertilization due to the production of unviable pollens under moisture stress conditions under un-mulched plots (Ahmed and Suliman, 2010). Increasing the length of pod may be related with the age of the plant and its genetic characters as reported by Singh et al., 1994; Rashid and Hossain, 2014. Weed mulching treatment registered an increase in seed yield of Rajma. This was mainly due to availability of optimum soil moisture content at the seeds development stage, which enabled higher nutrient uptake, greater dry matter accumulation, more grains per pod and increased hundred seed weight. Better control of weeds under mulch which could have also favoured to increase the yield as reported by Barman et al., 2005; Chawla, 2006; Chinnathurai et al., 2012.

CONCLUSION

Weed mulch is more effective in maintaining optimum soil moisture content at the seeds development stage, which enabled higher nutrient uptake, greater dry matter accumulation, more grains per pod and increased hundred seed weight. Better control of weeds under mulch which could have also favoured to increase the yield per plant. The soil moisture depletion was found rapid under un-mulch as compared to organic mulching. Hence, organic mulch can play a major role in maintaining *in situ* soil moisture and can be used by the farmers of the hilly regions to cultivate winter crop.

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Ergonomic evaluation of old manual wire mesh bench threshing of sunflower on farm women of Subarnapur and Mayurbhanj district of Odisha

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ABSTRACT

Sunflower threshing is one of the tedious job and done by female workers. Manual method of sunflower threshing by hand is fatigue, consumes time and its output is also very low. Different manual sunflower threshers have been developed by different research centres as pedal operated, hand operated wire mesh type and perforated GI sheet type thresher. Keeping this in view KVK, Sonepur and Mayurbhanj-1 have undertaken FLD on sunflower threshing for threshing sunflower for drudgery reduction of farm women and compared its performance with traditional method of threshing by hand. Ten female subjects were selected from each district in the age group 25-45years. The mean value of working heart rate was observed to be 110 and 109 beats/min in wire mesh type threshing bench, whereas 112 and 115 beats/min was in traditional method of threshing in Subarnapur and Mayurbhanj district respectively. The output was observed to be maximum 7.71 and 11kg hr^{-1} in wire mesh type threshing bench whereas 1.37 and 2.8 kg hr^{-1} in traditional method of sunflower threshing for both the districts of Subarnapur and Mayurbhanj district. The energy expenditure in threshing by wire mesh type threshing bench and traditional method was 8.77, 8.61 kJ min^{-1} and 9.08, 9.56 kJ min^{-1} respectively in two districts. Cardiac cost of work was low in wire mesh type threshing bench than that of traditional method of threshing. Hence from drudgery aspect and output point of view wire mesh type sunflower threshing bench is better than that of traditional method of threshing of sunflower.

Keywords: Sunflower thresher, energy expenditure, output, cardiac cost, threshing efficiency

INTRODUCTION

Agriculture, the single largest production endeavour in India, contributing 25% of GDP, is increasingly becoming a female activity. Agriculture sector employs 4/5th of all economically active women in the country. It is estimated that women are responsible for 70 per cent of actual farm work and constitute upto 60 per cent of the farming population (Basu and Singh, 2004). Women play a significant and crucial role in agricultural development and allied fields, including in the main crop production, livestock production, horticulture, post harvest operations, agro/social forestry, fisheries, etc. Cent per cent population of farm women observed to be involved in sowing, transplanting, weeding, winnowing, drying, cleaning and dehusking (Badigar et al., 2006). The nature and extent of women's involvement in agriculture, no doubt, varies greatly from region to region (Roshan and Ashok, 2011). In some of the farm activities like processing and storage, women predominate so strongly that, men workers are numerically insignificant (Aggarwal, 2003). Studies on women in agriculture conducted in India and other developing and under developed countries all point to the conclusion that women contribute far more to the agricultural production than has generally been

acknowledged. Generally the available agricultural technologies are not women friendly as they are not designed taking into consideration the women's ergonomic aspects. There exists a gap between design engineers and farm planners and also the lack of women's access to articulate their needs. The result is that the women farmers have to carry out various field operations with the age old hand tools or with their hands. The farm women are employed in the operations which are either not mechanized or least mechanized and involve a lot of drudgery (Singh et al., 2010). The posture adopted during these operations are not proper and lead to occupational health problems if not given due attention. The modern technology thus, if not given due consideration to upgrade the skill of women, it may harm them in long run rather than benefiting them (Singh et al., 2007). Sunflower crop (*Helianthus annuus L.*) was introduced to Indian agriculture during 1969 to bridge the demand-supply gap of edible oil in the nation within these 40 years it is designated as one of the most popular oilseed crop of the farming community (Nath et al., 2013). Oilseed crops occupy an important position in the agricultural economy of any country. Sunflower is one of the most important emerging oil seed crop grown in our state next to that of groundnut and mustard (Goel et al., 2010). The area of this crop in our state is 29, 690 ha (Anonymous, 2013). It is also one of the important cash crops adopted by the farmers hence the area under this crop is increasing day by day. Threshing is one of the crop processing operation to separate the grains from the ear heads and prepare the grains for selling (Kakhandaki et al., 2012). The harvesting of the seeds of this crop is also done by the farm women. Due to non availability of suitable machinery for its harvest and post harvest operations, farm women are following the traditional methods. Previously due to unavailability of the suitable harvesting implements for sunflower thresher to the farm women, they do it by rubbing the cub with hand or with each other to thresh the seeds. The output of the traditional method of threshing is very low and also it depends upon the efficiency of the worker along with this it also increase the drudgery farm women also. Goel et al. (2009) worked on wire mesh type thresher and reported that highest threshing capacity was observed with this as against traditional practices (7.71 kg hr^{-1} and 1.37 kg hr^{-1}). and recommended for small and marginal farmers of the state. Hence in this research paper an attempt has been made by Krishi Vigyan Kendra, Sonepur and Mayurbhanj-1 to study the suitability of sunflower threshing bench (wire mesh type sunflower threshing) for the farm women of Subarnapur and Mayurbhanj district and to compare it with manual method of threshing by hand with a view to get them involved in the mechanical method of threshing.

MATERIALS AND METHODS

Selection of subject and field

This FLD was conducted at the farmer's field in village Bidurpalli of Ullunda block of Subarnapur district and in village Badsole and Badjode in Baripada block of Mayurbhanj district of the state Odisha by Krishi Vigyan Kendra, Sonepur and Mayurbhanj respectively in *Rabi* (dry), 2016-17 during the month of March and April. The moisture content of sunflower during threshing varied from 11% to 12% in Subarnapur district and 9 to 10.5% in Mayurbhanj district. The study was carried out on 10 farm women each from both the districts involved in sunflower threshing activity aged between 25-45 years with normal health. Traditional methods of threshing of sunflower in Subarnapur district was hand rubbing and in Mayurbhanj district it was done by rubbing two flowers with each other by hand.

Wire mesh type thresher

It consists of a square frame having each side of 600 mm and a height of 200 mm and is made up of 30 x 30 x 3 mm MS angle. Wire mesh with mesh size of 10 x 10 mm was welded with the main frame and served as the threshing surface (Fig.1). The workers rub the cubs over the wire mesh and the seeds are dropped at the ground, which is collected later and cleaned manually.

Threshing of sunflower by wire mesh type sunflower threshing bench was compared with traditional method by hand. During the experiment various parameters such as output, threshing efficiency, working heart rate, resting heart rate, cardiac cost at work and average energy expenditure were studied. Stopwatch was used to record the time and Digital Heart rate monitor was used for measuring heart rate. Following parameters were recorded during experiment for hand threshing and by sunflower threshing bench.

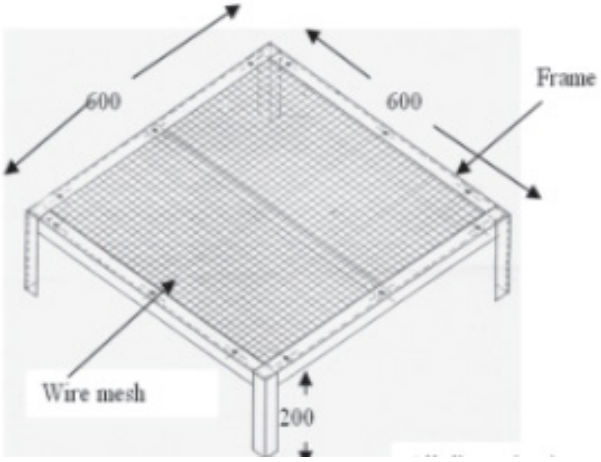

Fig. 1. Wire mesh type Sunflower thresher

Heart rate

Heart rate was recorded using a digital heart rate monitor. In the morning resting heart rate (RHR) of the respondent was recorded and after completion of the activity working heart rate (WHR) was recorded.

Energy expenditure rate

From the average values of heart rate energy expenditure was calculated with the help of formulae given by Varghese et al. (1994) which is as follows EER (kJ min^{-1}) = 0.159×HR (beats min^{-1}) - 8.72

Where: EER = Energy Expenditure Rate (kJ min^{-1}); HR = Heart rate (beats/min)

Cardiac cost at work

Cardiac cost at work (beats) = Average heart rate (AHR) x Duration of activity

Where, AHR = Average working HR – Average resting HR (beats/min)

Output

Output (kg hr^{-1}) = weight of sunflower cob x duration/average time

Threshing efficiency

$$\text{Threshing efficiency } (\acute{\eta}_{th})\ (\%) = \frac{\text{Mass of threshing seeds (seed output)}}{\text{Total mass of seeds}} \times 100$$

The detailed demonstration programme conducted at KVK, Subarnapur and Mayurbhanj is given in Fig. 2 to Fig. 5. The significance of difference in terms of their performance parameters and ergonomic parameters were compared by using paired 't' test.

RESULTS AND DISCUSSION

To evaluate the threshing through ergonomic point of view, 10 respondents each in the age group of 25 to 45 years were selected randomly from Subarnapur and Mayurbhanj district of Odisha and average age was counted respectively as 35.5 and 29.5 years. The basic body dimensions for both the districts were measured and averages were worked out as height (153.2 cm and 153 cm) and weight (51 and 49 kg) respectively (Table 1).

Table 1. Anthropometric dimensions of farm women involved in sunflower threshing (n=10)

Parameters	Mean	
	Subarnapur District	Mayurbhanj District
Age (year)	35.5	29.5
Height(cm)	153.2	153
Weight(kg)	51	49

Performance evaluation

As per comparison with traditional threshing of sunflower by hand with Sunflower threshing bench for both Subarnapur district and Mayurbhanj district the threshing efficiency was recorded as 96.1% and 96.5% by hand and 98.2% and 98.7% by sunflower threshing bench respectively.

During demonstration, data was collected to compare the performance of sunflower threshing bench and their traditional practices. The threshing efficiency of sunflower threshing bench was 98.2% and 98.7% as compared to their local practice of hand rubbing with threshing efficiency 96.1% and 96.5% respectively in both the district (Table 2), which causes significant losses to the farmers. Sunflower threshing bench also significantly saved 60 and 26.6 man-hour per q respectively in both the district as compared to traditional practices. The output of sunflower threshing bench was found to be 7.71 kg hr^{-1} while the output of threshing by rubbing with hand was only 1.37 kg hr^{-1} in Subarnapur district. Similarly

Fig. 2. Threshing of sunflower by threshing bench in Subarnapur district

Fig. 3. Threshing of sunflower by threshing bench in Mayurbhanj district

Fig. 4. Traditional method of threshing of sunflower

Fig. 5. Output measurement

the output of sunflower threshing bench was found to be 11 kg hr^{-1} and 2.8 kg hr^{-1} in traditional method in Mayurbhanj district, which is significant at both 5% and 1% level of significance. The difference of output in traditional practices in two districts may be due to the fact that there are separate methods of threshing and in sunflower threshing bench the difference may be due to varied moisture content of flowers during threshing. Similar results were also obtained by Goel et al. (2009).

Table 2. Performance parameters while performing sunflower threshing with traditional and improved

Parameters	Subarnapur			Mayurbhanj		
	Hand threshing	Sunflower threshing bench	't' value	Hand threshing	Sunflower threshing bench	't' value
Threshing efficiency (%)	96.1	98.2	3.27*	96.5	98.7	6.12**
Labour required (Man-hour q^{-1})	72.9	12.9	46.99**	35.7	9.1	33.39**
Output (kg hr^{-1})	1.37	7.71	70.37**	2.8	11	81.67**

*Significant at 5 per cent level of significance **Significant at 1 per cent level

Ergonomic evaluation

During execution of FLD, data was collected to compare the ergonomic performance of sunflower threshing bench and their traditional practices and given in Table 3. The average heart rate during resting period was found almost similar in case of sunflower threshing bench and their traditional practices such as 77, 76 beats/ min by using sunflower threshing bench where as 78 beats/min in traditional method of threshing respectively for both the districts.

The average working heart rate was observed as 110 and 112 beats/min in case of sunflower threshing bench and traditional method of threshing in Subarnapur district. There is no significant difference of average working heart rate between two methods of threshing. Whereas, in Mayurbhanj district it was 109 and 115 beats/ min respectively in case of sunflower threshing bench and traditional practices and found significant at both 5% and 1% level of significance. With the use sunflower threshing bench the farm women of both Subarnapur and Mayurbhanj district found light rate of perceived exertion compared to traditional method.

The average energy expenditure by using sunflower threshing bench for threshing sunflower was found to be 9.08 kJ min^{-1} while in traditional practice it was 8.77 kJ min^{-1} in Subarnapur district. There is significant difference of average energy expenditure in Mayurbhanj district whereas it insignificant in Subarnapur district. The average energy expenditure was found to be 9.56 kJ min^{-1} and 8.61 kJ min^{-1} in case of sunflower threshing bench and traditional method respectively in Mayurbhanj district.

The cardiac cost of the farm women using sunflower threshing bench and in traditional practice was observed to be 990 and 1020 beats in Subarnapur district where there is no significant difference between two methods but there is significant difference of cardiac cost of the farm women between sunflower threshing bench and traditional practice in Mayurbhanj district and was found to be 990 and 1110 beats.

Table 3. Ergonomic parameters while performing sunflower threshing with traditional and improved technique

Parameters	Subarnapur			Mayurbhanj		
	Hand threshing	Sunflower threshing bench	't' value	Hand threshing	Sunflower threshing bench	't' value
Average Heart Rate during rest (beats/min)	78	77	1.02	78	76	1.84
Average working Heart Rate (beats/min)	112	110	1.53	115	109	6.06**
Average energy expenditure (kJ/min)	9.08	8.77	1.53	9.56	8.61	6.06**
Cardiac Cost(beats)	1020	990	0.55	1110	990	2.37*
Rate of perceived exertion	Moderately high	Light	-	Moderately high	Light	-

*Significant at 5 per cent level of significance **Significant at 1 per cent level

Table 4 revealed that in traditional practice the percentage of respondents of both Subarnapur and Mayurbhanj district reported the occurrence of hand pain (70%, 70%), shoulder pain (80%, 90%), backache pain(70%, 70%) and finger injury (90%, 80%) whereas during threshing through sunflower threshing bench the occurrence of hand pain (10%, 20%), shoulder pain (20%, 10%), backache pain (10%, 10%) and finger injury (0%, 10%) respectively. With the use of improved equipment farm women found light rate of perceived exertion as compared to traditional method.

Table 4. Comparisons of health hazards in sunflower threshing bench and traditional

Health hazard	By hand				By sunflower threshing bench			
	Subarnapur		Mayurbhanj		Subarnapur		Mayurbhanj	
	Yes	No	Yes	No	Yes	No	Yes	No
Hand Pain	70	30	70	30	10	90	20	80
Shoulder Pain	80	20	90	10	20	80	10	90
Backache Pain	70	30	70	30	10	90	10	90
Finger injury	90	10	80	20	0	100	10	90

CONCLUSION

Manual threshing of sunflower by hand is a time consuming and tedious operation. The heart rate responses showed that the activity is light. Though the activity is light, women feel it as a maximum drudgery prone activity because of its monotony in performance, continuous sitting and performing it for a longer period of time. It eliminated the chances of injury to finger and is very comfortable hand-operated tool to thresh sunflower. The work efficiency with the use of this tool to thresh the sunflower is very high and efforts are very low. Hence, it can be concluded that the wire mesh type sunflower threshing bench was found effective in reducing the drudgery of farm women. It was better in threshing efficiency and labour requirement than their traditional practice. It has also reduced the health hazards like hand pain, shoulder pain, backache and waist pain in majority of the respondents. Majority of the farm women perceived the sunflower threshing bench as 'most handy and convenient technology.

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Economic utilization of water for *Labeo rohita* Hamilton seed production in a portable FRP carp hatchery

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ABSTRACT

An experiment was conducted to quantify the volume of water required for spawning and hatching operation of Rohu (Labeo rohita Hamilton) in a portable Fiber Reinforced Plastic (FRP) carp hatchery at Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar. Minimum water requirements for breeding and hatching operations were quantified to be 6.946 and 82 cubic meter, respectively by using flow meter (Star log Version 4, Data Logger Management Software, Model 6308A/AUE, the Australia) in which Minimum and maximum velocity and flow rates were measured in breeding and hatching pool. The minimum water requirement for the whole process was quantified to be around 90 cubic meters for a production of 1 Million spawn. Water qualities like temperature (26 to 28°C), dissolved oxygen (4.4-4.8 ppm), NH_4+, pH (7.03) and NO_3- (0.3-0.6 ppm) were recorded during the process. The present study thus pave a way for judicious use of available water in the hatchery unit.

Key words: Rohu, spawning and hatching operation, FRP hatchery, velocity distribution

INTRODUCTION

Indian Major Carps are the important groups of fishes cultured in the Indian subcontinent and accounts for more than 95% of the world aquaculture production (Kalla et al., 2004). Rohu (*Labeo rohita*) belongs to family Cyprinidae, found commonly in rivers and freshwater lakes in and around the South Asia and South-East Asia. Hatchery production statistics released by the Food and Agriculture Organization of the United Nations (FAO) revealed that 58 billion fry or fingerlings were produced in 1996, i.e., almost 160 million juveniles per day. Of these, 99% were finfish (FAO, 1999).

The fish feed and seed are considered as major concerns for the fish farmers. Fish feed is considered to be one of the major prerequisites for successful fish farming (Jhingaran, 1969). A major share of India's fish seed supply comes from riverine collections which comprises a mixture of undesirable species of fishes. The developing eggs need a continuous high oxygen concentration. The oxygen consumption of eggs is negligible in the initial stages, but increases very considerably as development progresses. Maximum oxygen is required just before hatching. It has been found that reduced dissolved oxygen (DO) retards the development of fish embryo, while high oxygenated water accelerates the process (Kinne and Kinne, 1962). Dissolved oxygen level of 4.2-6.8 mg l^{-1} is considered to be the best for development of the eggs. According to Tapiador et al. (1977), D.O. concentration of more than 4 mg l^{-1} is considered to be good for the development

of eggs. The prime requirements for the development of eggs are proper oxygenation and water devoid of poisonous gas (Waynarovick and Horvath, 1980). Dwivedi and Zaidi (1983) indicated that water quality and meteorological conditions have a critical role in the hatching success and spawn are extremely sensitive to water quality. Generally, two doses are administered: the first dose is the introductory or preparatory dose and the second dose is the decisive or final dose. The use of exogenous hormones to induce ovulation and spawning of fishes is well established (Lam, 1982) and different doses of hormones and sex steroids tried for various clariid catfishes gave varied responses. Further, clean and plankton free water is another basic requirement in hatcheries. Water for hatcheries operation should be filtered properly as filamentous algae can be a great nuisance in hatcheries. Deposition of silt on egg surfaces and gills of spawn prevents proper diffusion of oxygen through the gill membrane or egg cells. During the developmental processes, the eggs excrete certain harmful materials, such as CO_2 and NH_3 which, if allowed to accumulate, may poison the eggs. Therefore, it is essential to maintain a constant flow of water to remove the extraneous debris and other filthy materials from the surface of developing eggs. A sudden flow of strong water current through the incubator may destroy all the eggs within a short period. Proper water flow velocity helps in even distribution of fertilized eggs in the water and keeps them moving slowly. According to Sengupta et al.(1984), initially, a flow rate of 2.5 l s^{-1} is to be maintained in a hatchery. The egg membrane is thinner in early stage of development of eggs. Therefore, to prevent the premature hatching, the flow is reduced to 2 l s^{-1}. After the embryos are hatched, the flow is again increased to 3.5 l s^{-1} to prevent the newly hatched hatchlings from sinking. Oxygen deficiency could be one of the reasons for mortality in certain parts of the incubator devices where the exchange of water is poor or nil. Unsuitable temperature also kills the eggs, usually during embryonic development. Sahoo et al. (2006), estimated the total capital expenditure about four million rupees incurred in detailed design and infrastructure development for different facilities including water supply of a carp seed production complex for 30 lakhs of eggs per cycle for a period of one year. FRP hatchery plays a major role to meet the gap between the ever increasing demands of seeds in the off seasons. Continuous seed supply has got some scientific loopholes like off season mating, water availability etc. The quantity of water is an important factor to be taken into consideration, since the hatchery water becomes polluted due to dissolved organic matter and must be replaced. Recirculation of the already used water would be re-usable only if a suitable cleaning mechanism is incorporated into the overall water circulation system. The recirculatory system is usually too complicated and expensive to maintain and afford by marginal fish farmers. In this back drop, an experiment was executed to assess the minimum flow rate required for hatching operation in the carp hatchery and to quantify the total water requirement in a portable FRP carp hatchery for rohu.

In the present study an effort has been made to optimize the quantity of water use during the hatching process of rohu. Efforts have been made to quantify the minimum water requirement for the whole process; and to maintain a minimum flow rate so that, neither the eggs should settle at the bottom of incubator nor should they collide with each other.

MATERIALS AND METHODS

Description of the study area, available infrastructure, water quality monitoring, experimental set-up, methodology and procedures are briefly discussed in this section.

Study area and infrastructure

The trial was undertaken at one of the portable FRP carp hatchery units of the Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar. The infrastructure such as breeding pool, hatching pool, spawn collection tank, water storage tank, water outlet etc (Fig.1) required for the experiment are available at the institute. The important water quality parameters such as temperature, dissolved oxygen (DO), pH, ammonia, nitrate etc. were monitored during the hatching operation (ref. of APHA).

The Chronological operations during the experiment

Brooders were collected prior to the breeding process from riverine source. Healthy brooders free

from any diseases were taken for this purpose (Fig. 3.8). By weight male and female should be equal. On the other hand; the number of males should be twice that of the females. The broods were transported by hamack (Canvas bags) filled with water to avoid stress to the brooders. The important water quality parameters viz. temperature, dissolved oxygen (DO), pH, ammonia, nitrate etc. were monitored during the hatchery operation. The arrangement of suitable water supply units for breeding and hatching pools were done. Induced breeding in the breeding pool was carried out. Spawns to the hatching pool were transferred. Hatching operation through the continuous flow of water carried out.

Detailed Processes during Hatching Operation

First hatching operation with minimum discharge

In our study a minimum discharge of 0.25 l s^{-1} was used for hatching and observations were recorded at three different depths, viz. surface (at a depth of 32 mm), mid-depth (450 mm) and bottom (832 mm depth).This minimum discharge may be accepted as optimum as the eggs did not settle at the bottom and also maintained a hatching efficiency of 80- 85%. A total of 9 points at three depths and three radial distances inside the tank, namely, near the wall of the tank, at the middle of the tank and near the screen were selected for taking observations. Different observations such as velocity, temperature, depth and flow rate of water were recorded in the hatching pool and the survival rate of fertilized eggs was assessed for three different hatching operations.

Hatching and assessment of Survivability

Hatching took place within 14 to 18 hours based on the maturity of brooders and water quality parameters. During hatching operation, velocity and discharge were measured with the help of a flow meter. Velocity distribution was measured in nine points, at different radial and vertical locations. Survivability assessment was also done by manual counting with the help of a petri dish. Both spawning and hatching were carried out at different discharges to determine the minimum possible discharge for carrying out these operations. Attempt was made to determine the minimum discharge at which the eggs should not settle at the bottom and the water quality parameters in terms of DO, NH_4-N, NO_3-N and pH could be maintained.

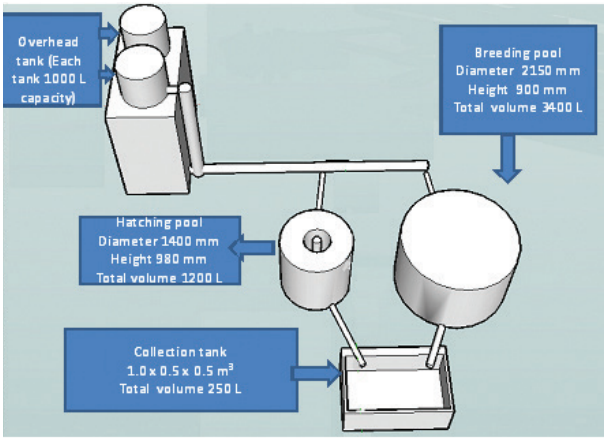

Fig.1. Hatchery unit (front view)

RESULTS AND DISCUSSION

Flow requirement for spawning

Different observations such as velocity, temperature and flow rate of water were taken in the breeding pool and the survival rate of fertilized eggs was assessed by using different discharges on different dates. At a discharge of less than 0.28 l s^{-1}, the eggs started settling at the bottom and thereby most of them died within a short period. Therefore, observations were recorded for the minimum discharge at which the eggs did not settle. From the observations it was found that a minimum flow rate of 0.28 l s^{-1} through the breeding pool was sufficient for spawning. For this discharge, the average velocity through the outlet pipe ranged between 359 and 371 mm s^{-1} and almost a constant survivable rate of 80-85% was obtained. A discharge higher than this led to wastage of water and did not produce higher survival rate of fertilized eggs. A discharge lower than this resulted in settling of number of eggs at the bottom of the tank and finally most of them died. Therefore, a discharge of 0.28 l s^{-1} can be regarded as the optimum discharge for release and fertilization of carp eggs for the specified size of the breeding pool.

Flow requirement for hatching

Hatching of the eggs was carried out with several discharges on several days. Discharge, velocity of flow, different water quality parameters were measured and

hatching efficiencies were assessed to arrive at the minimum water requirement for hatching operation. However, details of the first hatching operation with minimum discharge are only presented in this paper. The observed data on the surface, mid-depth and bottom for different locations are presented in Table 1. It can be seen from Table 1 that for a flow rate of 0.25 l s^{-1} through the hatching pool, the average velocity gradually increases from wall of the tank towards the centre (screen of the tank). The variation in surface velocity was ranged 52 to 74 mm s^{-1} from the outer wall towards the screen. But with depth the velocity increased up to the middle and then reduced towards the bottom. Velocity at surface of the tank was higher than bottom of the tank in the same vertical column. The measured velocity was actually the resultant of the tangential and the radial velocities. Water enters into the inner chamber through the screen for finally discharging out through the stand pipe. Therefore, radial velocity was recorded to be highest near the screen. This might have caused the stratification of velocity distribution along the radial distance from the centre and as a result the velocity distribution was not uniform in a horizontal plane. The velocity distribution in the hatching chamber presented in Fig. 2 and 3.

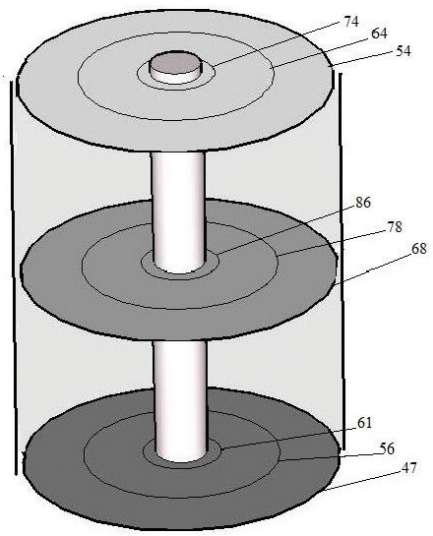

Fig. 2. Velocity (mm s^{-1}) distribution for a discharge of 0.25 l s^{-1} at different levels of the hatching pool

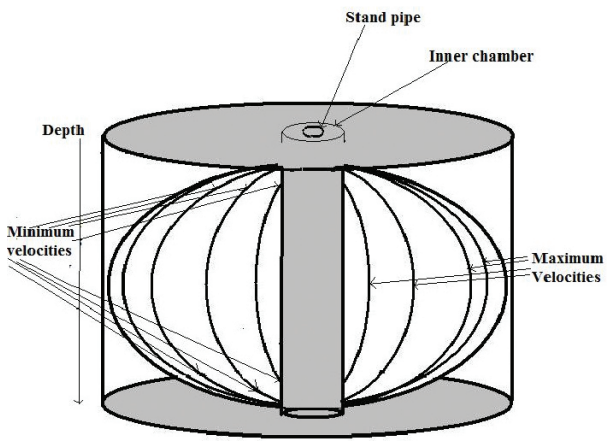

Fig. 3. Three dimensional velocity distributions in a hatching pool

The vertical velocity distribution was also not uniform. The hatching chamber is made of conical shape and vortex formation takes place in the flow phenomena. Apart from that water enters into the inner chamber through the middle of the inner wall fitted with the screen. As a result maximum velocity is obtained at the center. Although as per the flow phenomenon in an open channel, the maximum velocity is expected at the top, it does not occur in this case as the top of the inner wall is closed to water flow.

Table1. Velocity distribution at different depths and locations in the hatching pool for a discharge of 0.25 l s^{-1} during first hatching operation

Date and Time	Velocity, mm s^{-1}		
	At 32 mm depth	At 450 mm depth	At 832 mm depth
Near the outer wall of the tank			
05-08-08 07: 00: 00	52	68	45
05-08-08 07: 01: 00	54	68	45
05-08-08 07: 02: 00	52	67	48
05-08-08 07: 03: 00	53	67	48
05-08-08 07: 04: 00	54	66	47
At the middle of the tank			
05-08-08 07: 07: 00	64	77	54
05-08-08 07: 08: 00	65	78	54
05-08-08 07: 09: 00	67	76	55
05-08-08 07: 10: 00	66	78	55
05-08-08 07: 11: 00	66	77	57
Near the screen			
05-08-08 07: 15: 00	74	85	62
05-08-08 07: 16: 00	73	85	60
05-08-08 07: 17: 00	73	84	61
05-08-08 07: 18: 00	72	87	59
05-08-08 07: 19: 00	73	86	62

Observations on water quality parameters

Observations on changes in water quality parameters like dissolved oxygen, pH, ammonia (NH_4-N), nitrate (NO_3-N) due to breeding and hatching were recorded. The above parameters of the incoming water as well as after breeding and hatching were recorded. They are presented in Table 2.

Table 2. Water quality parameters before and after breeding and hatching

Sl No	Incoming water quality ppm				Water quality after breeding, ppm				Water quality after hatching, ppm			
	DO	pH	NH_4-N	NO_3-N	DO	pH	NH_4-N	NO_3-N	DO	pH	NH_4-N	NO_3-N
1	4.8	7.03	0.3	0.6	4.7	7.03	0.4	0.7	4.4	7.03	0.6	0.8
2	4.7	7.03	0.3	0.5	4.6	7.03	0.4	0.6	4.3	7.03	0.6	0.7
3	4.8	7.03	0.2	0.6	4.7	7.03	0.3	0.7	4.4	7.03	0.5	0.8

It can be seen from Table 2 that all the water quality parameters are within the tolerable range. The minimum DO requirement is about 4 ppm, whereas, the outflow water either from breeding or hatching pool has higher DO. The optimum pH requirement was between 6.5-7.5 whereas, the actual pH during the experiment is 7.03 and it does not change during either breeding or hatching. Maximum tolerable limit

of NH_4-N or NO_3-N was 1.0 ppm. The actual values of 0.3 to 0.8 ppm after breeding or hatching are well within the tolerable limit. It can be concluded from the observation that the minimum velocity of water was the limiting factor. Once that is attained, water quality parameters are automatically maintained provided that the incoming water has qualities at least equal to that of the experimental water. From the above observations, the minimum water requirement for the FRP type of hatchery developed by CIFA, Bhubaneswar for one million Spawn production of *Labeo rohita* L. was calculated and is presented below.

Water requirement in the breeding pool

i. Initial filling = 2950 l
ii. For 5 hours showering = 1980 l
iii. Water requirement for 2 hours spawning = 0.28 x 7200= 2016 l
iv. Total water requirement in the breeding pool = 2950 +1980 + 2016 = 6946 l.

Water requirement in the hatching pool

Initial filling of hatching pool = 1275 l

Minimum average flow rate in hatching pool = (0.25+0.245+0.255)/3 = 0.25 l s^{-1}

Eggs hatch out at in 14-18 h and remain in the pool for 72 h.

Total time of operation in the hatching pool = 72 +18 = 90 h

Total water requirement in hatching pool = 1275 + (0.25 x 3600 x 90) = 82, 275 l.

Therefore, total water requirement for breeding and hatching operation = 6946 l+ 82, 275 l = 89, 221 l = 90 m^3 (approx).

CONCLUSION

Following conclusions can be drawn from the study;

i. Optimum flow rate required for breeding operation in the carp hatchery was 0.28 l s^{-1}

ii. Optimum flow rate required for hatching operation in the carp hatchery was 0.25 l s^{-1}

iii. Optimum water requirement in hatchery for production of one million spawn = 90 m^3

iv. Water quality parameters do not affect the hatching efficiency as long as there is continuous flow through the tank to keep the eggs floating. Therefore, there is a possibility of reuse of water for hatching operation.

Apart from this, there are scopes for further research such as:

a. Experiment may be conducted by using more numbers of different types of hatching and breeding pools so that the results will be more generalized and acceptable,

b. Efforts should be made for reuse of water (more than once) in the hatchery system without treatment,

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A study on butterfly diversity in Singur, West Bengal, India

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ABSTRACT

The present study was carried out to understand the butterfly diversity in Singur, West Bengal, India from March 2015 to November 2016. A total of 69 species of butterflies belonging to 54 genera and five families were recorded from the present study. From the observed butterflies, family Nymphalidae was the most dominant among the five families with 22 species, followed by Lycaenidae comprising of 19 species, Hesperiidae with composition of 12 species, Pieridae with 8 species and Papilionidae with 7 species. Among these 69 species, five species were found to be protected under the Indian Wildlife (Protection) Act, (1972). The present study added valuable information on diversity of butterfly fauna and will contribute in developing effective conservation measures in Hooghly district of West Bengal.

Key Words: Butterfly, diversity, conservation, Singur, Hooghly

INTRODUCTION

Butterflies are one of the most known groups of insects. They are also very popular among nature-lovers for their fascinating beauty and attractive colors. Butterflies are known to be good pollinators and very sensible to environmental factors such as temperature, humidity, rainfall, solar radiation, air temperature, wind speed and significantly availability of larval host plants (Ribeiro and Freitas, 2012; Hill et al., 2002). Both the adults and caterpillars are highly reliable on specific plants for their life cycle and therefore, they also have been used as models to monitor temporal changes in plant-insect interactions (Padhey et al., 2006; Kunte, 1997). Due to their high sensitivity to environmental changes, abundance and advanced taxonomy, butterflies are identified as ideal indicator taxa of habitat disturbance (Kocher and Williams, 2000; Bonebrake et al., 2010; Castro and Espinosa, 2015). It is found that any minor changes in their natural habitat due to anthropogenic factors can lead to their migration or local population extinction (Blair, 1999; Menecheze et al., 2003). In the field of conservation planning and management, they are also considered as anumbrella species (Betrus et al., 2005).

However, butterfly fauna is not always reported from many parts of the Indian sub-continent. Although, there are some several checklists available on butterfly diversity, no study was conducted in Singur situated in Hooghly district in West Bengal, India. Hence, an attempt was made to understand the butterfly diversity in Singur through the present investigation.

MATERIALS AND METHODS

Study area

Singur (N 22°48’33” E 88°13’46”) is a block that comes under Hooghly district in West Bengal (Fig. 1). This block covers 155 km2 area of Hooghly at an elevation of 16 m. Average temperature is 26.8°C with monthly variations of 16°C to 33°C. Summer is very hot and strongly dominated by the south-westerly winds where summer easily cross 40°C. peak average rainfall is around 115mm, with minimum of 7.34mm

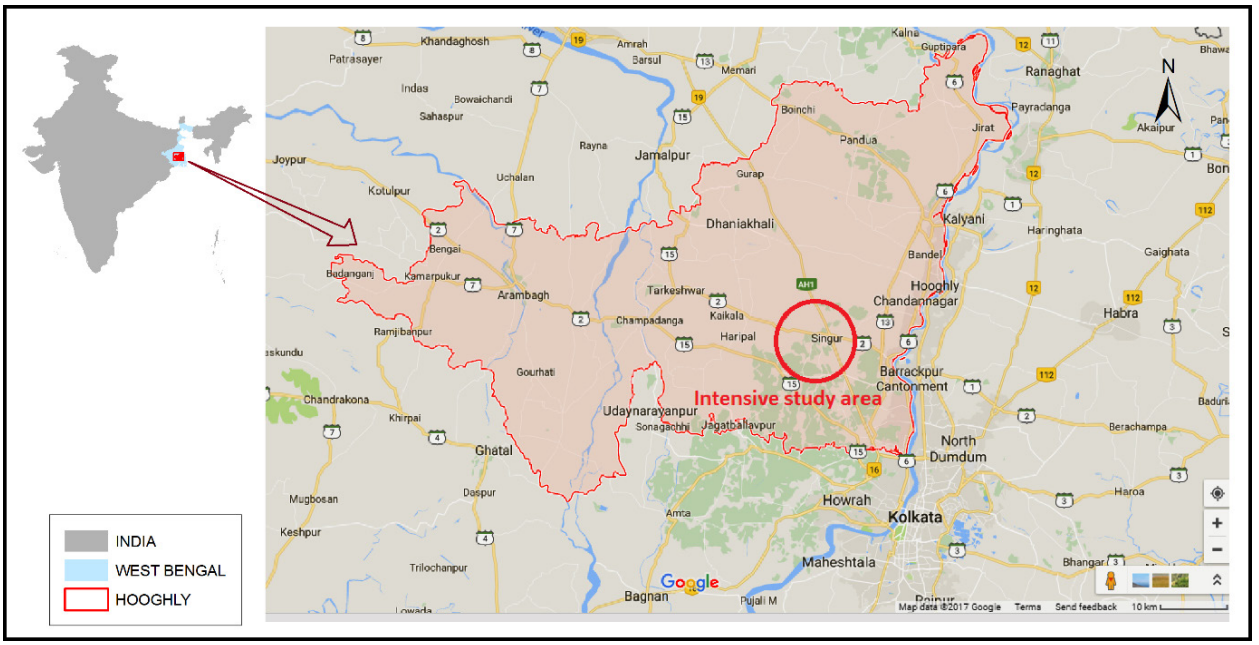

Fig. 1. Location of Singur, Hoogly district, West Bengal

from December to February and maximum of 245.5mm from July to September. Winter is very pleasant with an average temperature of 16°C but sometimes it drops below 10°C with strong north-easterly wind. Excellent soil quality result in a dominated land cover of cultivated land followed by residential and forest areas. Forests are mainly dominated by the human planted trees and bushy shrubs.

Field data collection

The survey was carried out between March 2015 and November 2016 to suitably access the butterfly diversity of the region. Most of the observations were recorded in the mornings (8 am to 12 am) and sometimes surveys were conducted between 4.30 pm to 6 pm for shade loving butterflies. Every habitat in Singur Block was covered by random observations as well as opportunistic sampling during walking through the roads, village path, agricultural lands, both sides of the railway tracks, flowering garden, residential vegetation etc. In the field, photographs of the specimens were taken with Nikon L310. The specimens were identified with the help of available literature (Evans, 1932,; Talbot, 1939/ 1947; Moore, 1890-1905; Wynter-Blyth, 1957; Kehimkar, 2008; Haribal 1992).

Based on the frequency of sightings, butterfly species were divided into three categories, they were a) common, b) uncommon and c) rare. Any species with count more than 50 times were placed in common category, count within 20-50 were placed in uncommon, count within 1-20 were categorised as rare.

RESULTS AND DISCUSSION

A total of 69 species of butterflies belonging to 54 genera and five families were recorded from the study area (Table 1). Family Nymphalidae was the dominant among the five families with 22 (31.88%) species belonging to 17 (31.48%) genera, followed by Lycaenidae comprising of 19 (27.53%) species from 17 (31.48%) genera, Hesperiidae with composition of 12 species (17.39%) belonging to 11Genera (20.37%), Pieridae with eight species (11.59%) from seven Genera (12.96%) and Papilionidae with seven species (10.14%) from three genera (5.55%) (Fig. 2 - 33). Nymphalidae and Lycaenidae were the most frequently sighted groups during this survey. Status of all species are categorized depending on the direct sightings during the survey, which showed 27 species out of 69 species (39.13%) were common, 29 (42.02%) species were uncommon and 13 species (18.84%) were

rare. Of these, eighteen (11%) species are of special concern and are listed in Wildlife (Protection) Act, 1972. Among the 69 recorded species, two species (Lampides boeticus and Hypolimnas misippus) are in schedule II (part II) and three species (Hyarotis adrastus, Appias libythea and Euploea core) are listed in schedule IV of Wildlife (Protection) Act, 1972.

Although, the present study is short in nature, but added valuable information on diversity of butterfly fauna and will contribute in developing effective conservation measures in Hooghly district of West Bengal.

Table 1. Checklist of the butterflies recorded in the study area

Sl. No.	Common Name	Scientific Name	Status	WPA, 1972 status
Family Hesperiidae				
1.	Common Snow Flat	*Tagiades japetus,* (Möschler, 1878)	U	
2.	Indian Skipper	*Spialia galba* (Fabricius, 1793)	U	
3.	Chestnut Bob	*Iambrix salsala* (Moore, 1865)	C	
4.	Indian Palm Bob	*Suastus gremius* (Moore, 1877)	C	
5.	Tree Flitter	*Hyarotis adrastus* (Stoll, 1782)	U	Sch IV
6.	Common Redeye	*Matapa aria* (Moore, 1865)	U	
7.	Dark Palm Dart	*Telicota bambusae* (Moore, 1878)	R	
8.	Straight Swift	*Parnara guttata*	U	
9.	Small Branded Swift	*Pelopidas mathias* (Fabricius, 1798)	C	
10.	Swift	*Pelopidas sp*	R	
11.	Forest Hopper	*Astictopterus jama* (Felder and Felder, 1864)	R	
12.	Grass Demon	*Udaspes folus* (Cramer, 1775)	U	
Family Papilionidae				
13.	Common Jay	*Graphium doson* (Felder and Felder, 1864)	U	
14.	Tailed Jay	*Graphium agamemnon* (Linnaeus, 1758)	C	
15.	Blue Mormon	*Papilio polymnestor* (Cramer, 1775)	U	
16.	Common Banded Peacock	*Papilio crino* (Fabricius, 1793)	R	
17.	Common Mormon	*Papilio polytes* (Linnaeus, 1758)	C	
18.	Lime swallowtail Butterfly	*Papilio demoleus* (Linnaeus, 1758)	C	
19.	Common Rose	*Pachliopta aristolochiae* (Fabricius, 1775)	U	
Family Pieridae				
20.	Common Gull	*Cepora nerissa* (Fabricius, 1775)	C	
21.	Common Jezebel	*Delias eucharis*	R	
22.	Western Albatross	*Appias libythea* (Fabricius, 1775)	U	Sch IV
23.	Psyche	*Leptosia nina* (Fabricius, 1793)	C	
24.	Indian Wanderer	*Pareronia hippia* (Fabricius, 1787)	U	
25.	Common Emigrant	*Catopsilia pomona* (*Fabricius, 1775*)	C	
26.	Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus, 1758)	U	
27.	Common Grass Yellow	*Eurema hecabe (*Linnaeus, 1758)	C	

Family Lycaenidae

28.	Apefly	*Spalgis epeus* (Westwood, 1851)	U	
29.	Indian Sunbeam	*Curetis thetis* (Drury, 1773)	R	
30.	Common Cerulean	*Jamides celeno* (Cramer, 1775)	U	
31.	Dark Cerulean	*Jamides bochus* (Stoll, 1782)	R	
32.	Forgetmenot	*Catochrysops strabo* (Fabricius, 1793)	U	
33.	Pea Blue	*Lampides boeticus* (Linnaeus, 1767)	U	Sch II
34.	Zebra Blue	*Leptotes plinius* (Fabricius, 1793)	R	
35.	Common Pierrot	*Castalius rosimon* (Fabricius, 1775)	C	
36.	Dark Grass Blue	*Zizeeria karsandra* (Moore, 1865)	C	
37.	Pale Grass Blue	*Pseudozizeeria maha* (Kollar, 1844)	C	
38.	Lesser Grass Blue	*Zizina otis* (Fabricius, 1787)	C	
39.	Common Quaker	*Neopithecops zalmora* (Butler, 1870)	C	
40.	Gram Blue	*Euchrysops cnejus* (Fabricius, 1798)	C	
41.	Lime Blue	*Chilades lajus* (Stoll, 1780)	C	
42.	Common Ciliate Blue	*Anthene emolus* (Godart, 1823)	R	
43.	Common Silverline	*Spindasis vulcanus* (Fabricius, 1775)	U	
44.	Yamfly	*Loxura atymnus* (Stoll, 1780)	U	
45.	Monkey puzzle	*Rathinda amor* (Fabricius, 1775)	U	
46.	Slate Flash	*Rapala manea* (Hewitson, 1863)	U	
47.	Indian Red Flash	*Rapala iarbus* (Fabricius, 1787)	R	

Family Nymphalidae

48.	Blue Tiger	*Tirumala limniace* (Cramer, 1775)	C	
49.	Common Tiger	*Danaus genutia* (Cramer, 1779)	C	
50.	Plain Tiger	*Danaus chrysippus* (Linnaeus, 1758)	C	
51.	Common Indian Crow	*Euploea core* (Cramer, 1780)	C	Sch IV
52.	Common Evening Brown	*Melanitis leda* (Linnaeus, 1758)	C	
53.	Common Palmfly	*Elymnias hypermnestra* (Linnaeus, 1763)	U	
54.	Bamboo Treebrown	*Lethe europa* (Fabricius, 1775)	R	
55.	Common Bushbrown	*Mycalesis perseus* (Fabricius, 1775)	U	
56.	Common Four-ring	*Ypthima huebneri* (Kirby, 1871)	U	
57.	Angled Castor	*Ariadne ariadne* (Linnaeus, 1763)	U	
58.	Common Castor	*Ariadne merione* (Cramer, 1777)	U	
59.	Common Leopard	*Phalanta phalantha* (Drury, 1773)	C	
60.	Lemon Pansy	*Junonia lemonias* (Linnaeus, 1758)	C	
61.	Peacock Pansy	*Junonia almana* (Linnaeus, 1758)	C	
62.	Grey Pansy	*Junonia atlites*	C	
63.	Chocolate Soldier	*Junonia iphita (*Cramer, 1779)	U	

64.	Danaid Eggfly	*Hypolimnas misippus (*Linnaeus, 1764)	R	Sch II
65.	Great Eggfly	*Hypolimnas bolina (*Linnaeus, 1758)	U	
66.	Chestnut-streaked Sailer	*Neptis jumbah (* Moore, 1857)	R	
67.	Commander	*Moduza procris* (Cramer, 1777)	U	
68.	Baron	*Euthalia aconthea* (Cramer, 1777)	U	
69.	Tawny Coster	*Acraea violae* (Fabricius, 1775/1793)	C	

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An inventory of Odonata fauna in Bonai Forest Division, Western Odisha, India

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ABSTRACT

Biodiversity inventory of Odonata was carried out in Bonai Forest Division of Western Odisha, India during 2011 and 2012. During the survey, a total 36 species of Odonates including 26 species of dragonflies (Anisoptera) and 10 species of damselflies were recorded. Overall, family Libellulidae is dominated by 22 species over others. The odonate diversity of Bonai Forest Division accounted for 37% of the Odonata diversity of Odisha. A long term studies on these lesser known fauna will be useful in understanding their status and monitoring the change over time in this habitat.

Keywords: Anisoptera, damselflies, dragonflies, Sundergarh, Zygoptera

INTRODUCTION

The order Odonata comprising both dragonflies and damselflies are believed to have evolved some 250 million years ago (Subramanian, 2005). These aquatic insects are an important and widespread component of freshwater ecosystems being the top predator at larval and adult stages (Adarsh et al., 2015). Besides that, Odonates are valuable indicator of water quality and landscape disturbance (Watson et al., 1982; Castella, 1987; Varghese et al., 2014). So far, 5952 species of Odonates have been described throughout the world of which 503 species occur within the geographic limits of India (Joshi et al., 2017). Odisha has extremely diverse landscape and habitats ranging from hill ranges to mangrove forests, marshes and water bodies, thus providing preferable habitat for Odonates. However, the ever increasing biotic pressure, deforestation and disappearance of wetlands are some of the major threats to Odonates today. Therefore, documentation of Odonata diversity in Odisha from different geographic regions and habitats is crucial for establishing baseline data for future comparison (Nair, 2011).

Odonata study in Odisha dates back to early 1900s in the Chilika lake by Laidlaw (1915) and Fraser and Dover (1922). Afterward, several collections were made by the Zoological Survey of India from different parts of the state, the results of which were documented in the State Fauna Series (Srivastava and Das, 1987). Some of the recent published works on Odonata diversity of Odisha include: Mitra (2000), Sethy and Siddiqi (2007), Das et al., (2010, 2011, 2012), Nair (2011), Debata et al., (2013), Payra et al., (2014), Kalita et al., (2014), Sajan and Mohapatra (2014), Palita et al., (2016) and Pandey and Mohapatra (2017). However, there is sporadic information from the Western Odisha region. In the present study, we summarize our findings of Odonata diversity of Bonai Forest Division, Western Odisha, India.

MATERIALS AND METHODS

The Bonai Forest Division is situated between 21º 39' to 22º8' N latitude and 84º 30' to 85º 23' E longitude covering an area of 2934.21 km² in Sundergarh district (Fig. 1). Biogeographically, the area comes under the Chotanagpur plateau of Deccan Peninsular Biogeographic Zone (Rodgers and Panwar, 1988). Vegetation of the area is represented by North Indian Tropical Moist Deciduous Forest, Northern Tropical Dry Deciduous Forest and Northern Tropical Semi Evergreen Forests (Champion and Seth, 1968) and the altitude ranges between 152 m to 903 m above MSL. Being situated within a tropical zone, the area experiences three distinct seasons: Summer (March – June), monsoons (July – October) and winter (November - February). The mean annual rainfall is about 1400 mm. Mean annual temperature ranges between 10°C and 44°C.

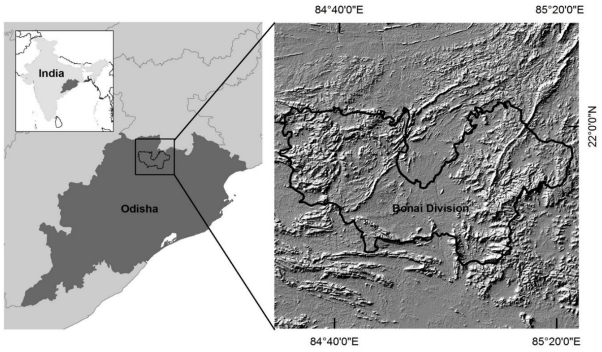

Fig. 1. Location of Bonai Forest Division

While carrying out biodiversity survey, Odonates were observed along hill streams, water bodies and temporary water logged areas. Whenever a species was encountered, close up photographs were taken and later identified using the keys provided by Subramanian (2009) and Nair (2011) and only the species with confirmed identification were taken under consideration for the checklist. The taxonomy and nomenclature of Odonates followed Subramanian (2014).

RESULTS AND DISCUSSION

During the survey, 36 species of Odonates (Table 1) including 26 species of dragonflies (Anisoptera; Fig. 2) and 10 species of damselflies (Zygoptera; Fig. 3) were recorded from Bonai Forest Division. In Anisoptera, family Libellulidae was well represented by 22 species followed by Aeshnidae and Gomphidae (2 each). Likewise in Zygoptera, Coenagrionidae was dominated by four species followed by Protoneuridae (2 species), Calopterygidae, Chlorocyphidae, Platycnemididae and Lestidae with a single species each (Fig. 4). Our observations on family wise species richness are more or less similar with the earlier studies from different protected areas of Odisha (Sethy and Siddiqi 2007; Das et al., 2011, 2012; Nair, 2011; Debata et al., 2013) and elsewhere in India (Varghese et al., 2014; Adarsh et al., 2015).

Table 1. Checklist of Odonata fauna of Bonai Forest Division, Western Odisha, India

Sub Order/ Family/ Scientific Name	Common Name	IUCN status
Sub Order: Anisoptera (Dragonflies)		
Family: Aeshnidae (Darners)		
1. *Anax guttatus* (Burmeister, 1839)	Blue tailed Green Darner	LC
2. *Gynacantha bayadera* (Selys, 1891)	Parakeet Darner	LC
Family: Gomphidae (Clubtails)		
3. *Ictinogomphus rapex* (Rambur, 1842)	Common Club Tail	NA
4. *Paragomphus lineatus* (Selys, 1850)	Common hook Tail	LC
Family: Libellulidae (Skimmers)		
5. *Acisoma panorpoides* (Rambur, 1842)	Trumpet Tail	LC
6. *Brachydiplax sobrina* (Rambur, 1842)	Little blue Marsh Hawk	LC
7. *Brachythemis contaminata* (Fabricius, 1793)	Ditch Jewel	LC

8.	*Bradynopyga geminate* (Rambur, 1842)	Granite Ghost	NA
9.	*Crocothemis servilia* (Drury, 1770)	Ruddy Marsh Skimmer	LC
10.	*Diplocodes trivialis* (Rambur, 1842)	Ground Skimmer	NA
11.	*Lathrecista asiatica* (Fabricius, 1798)	Asiatic Bloodtail	LC
12.	*Neurothemis fulvia* (Drury, 1773)	Fulvus Forest Skimmer	LC
13.	*Neurothemis tullia* (Drury, 1773)	Pied Paddy Skimmer	LC
14.	*Orthetrum glaucaum* (Brauer, 1865)	Blue Marsh Hawk	NA
15.	*Orthetrum pruinosum* (Burmeister, 1839)	Crimson Tailed Marsh Hawk	LC
16.	*Orthetrum sabina* (Drury, 1770)	Green Marsh Hawk	LC
17.	*Orthetrum triangulare* (Selys, 1878)	Blue tailed forest Hawk	LC
18.	*Pantala flavescens* (Fabricius, 1798)	Wandering Glider	LC
19.	*Potamarcha congener* (Rambur, 1842)	Yellow-tailed Ashy Skimmer	LC
20.	*Rhodothemis rufa* (Rambur, 1842)	Rufous Marsh Glider	LC
21.	*Rhyothemis variegata* (Linnaeus, 1763)	Common Picture Wing	LC
22.	*Tholymis tillarga* (Fabricius, 1798)	Coral-tailed Cloud Wing	LC
23.	*Tramea basilaris* (Palisot de Beauvois, 1805)	Red Marsh Trotter	LC
24.	*Tramea limbata* (Desjardins, 1832)	Black Marsh Trotter	LC
25.	*Trithemis aurora* (Burmeister, 1839)	Crimson Marsh Glider	LC
26.	*Trithemis festiva* (Rambur, 1842)	Black Stream Glider	LC
Sub Order: Zygoptera (Damselflies)			
Family: Calopterygridae (Glories)			
27.	*Vestalis gracilis* (Rambur, 1842)	Clear-winged Forest Glory	LC
Family: Chlorocyphidae (Stream Jewels)			
28.	*Rhinocypha bisignata (*Hagen in Selys, 1853)	Stream Ruby	LC
Family: Coenagrionidae (Marsh Darts)			
29.	*Agriocnemis lecteola* (Selys, 1877)	Milky Dartlet	NA
30.	*Agriocnemis pygmaea* (Rambur, 1842)	Pygmy Dartlet	LC
31.	*Ceriagrion coromandelium* (Fabricius, 1798)	Coromandel Marshdart	NA
32.	*Ischnura aurora* (Brauer, 1865)	Golden Dartlet	LC
Family: Lestidae (Spread Wings)			
33.	*Lestes viridulus* (Rambur, 1842)	Emerald Striped Spreadwing	LC
Family: Platycnemididae (Bush Darts)			
34.	*Copera vittata* (Selys, 1863)	Blue Bush Dart	LC
Family: Protoneuridae (Bamboo Tails)			
35.	*Caconeura ramburi* (Fraser, 1922)	Coorg Bambootail	DD
36.	*Disparoneura quadrimaculata* (Rambur, 1842)	Black-winged Bambootail	LC

Fig. 2. Dragonflies of Bonai Forest Division, Western Odisha, India

During our observation, species like Ictinogomphus rapex and Paragomphus lineatus were more commonly sighted inside the sanctuary indicating unpolluted water sources and good habitat quality where as Brachythemis contaminata was frequently sighted at the peripheral zones indicating presence of polluted water within human occupied areas (Nair, 2011). Referring to IUCN Red List classification, 29 species are classified under Least Concern, one species under Data Deficient category and six species have not been assessed yet. Although Bonai Forest Division represents hardly 1.9 % of the total geographic area of Odisha, it contributes around 37% of the Odonata diversity of the state. The present study gives a preliminary observation on Odonata diversity of Bonai Forest Division as part of multi taxa inventory. Therefore, more detailed and targeted long term studies on these lesser known fauna will be useful in understanding their status and monitoring the change over time in Western Odisha region.

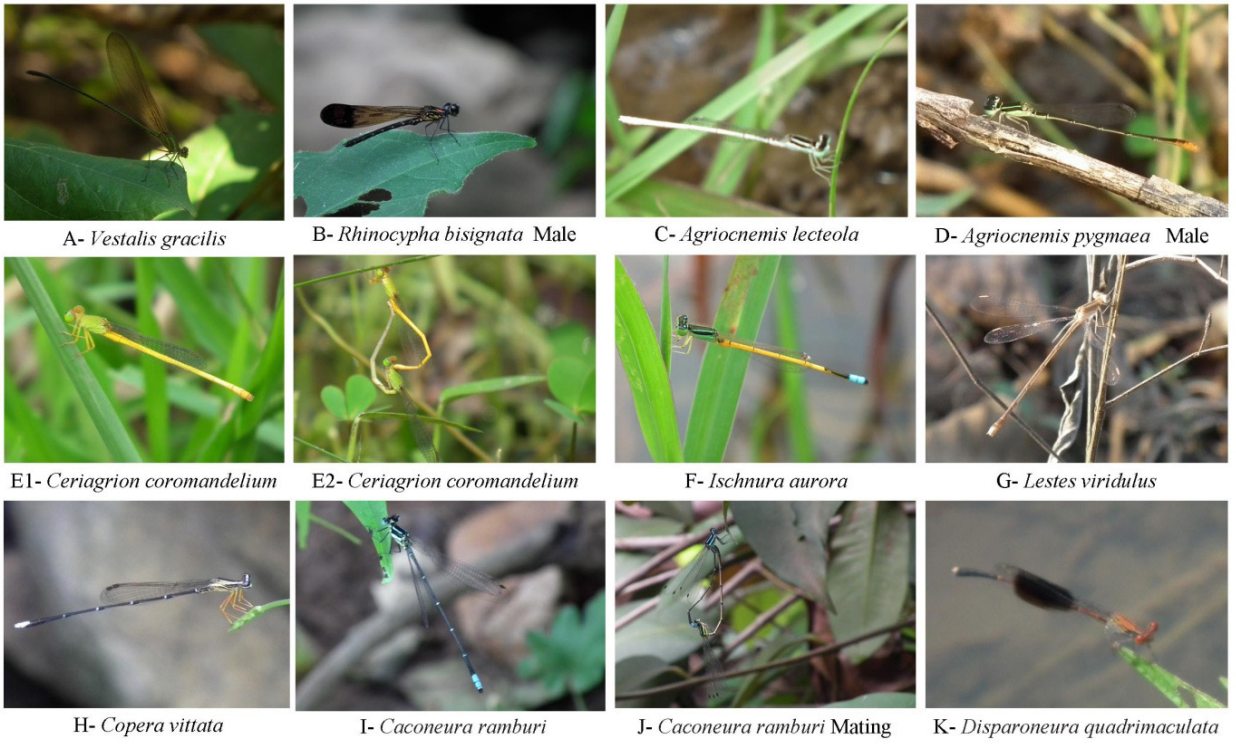

Fig. 3. Damselflies of Bonai Forest Division, Western Odisha, India

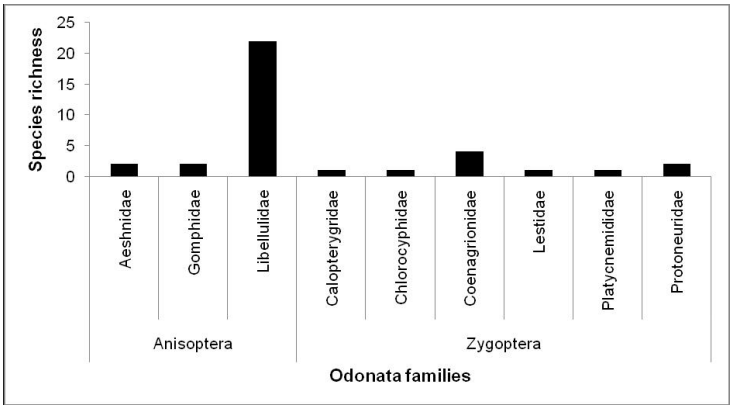

Fig. 4. Family wise species richness of Odonates in Bonai Forest Division, Western Odisha, India

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Ethnobotanical study of Malyagiri hill ranges, Odisha, India

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ABSTRACT

Malyagiri hill ranges located on the south of Pallahara town of Angul district in the state of Odisha is endowed with rich with flora and fauna. This area is rich with large number of medicinal plants and plants of other socio-economic importance. From the past floristic studies conducted by earlier workers it is evident that intensive floristic studies have not been conducted in this region. Large number of tribal people also inhabit around Malyagiri and its periphery. These people are utilizing various plants and plant products for medicinal and other purpose. Thus this area is also much rich with indigenous knowledge which is on the verge of extinction due to the advent of modern Allopathic system of medicine. Keeping these facts in mind, intensive floristic as well as ethnobotanical studies have been undertaken in various locations of this region. About four hundred medicinal plants have been collected and identified from different locations of this region. During the present investigation it is evident that large number of medicinal plants are found to be present in this region which are much useful for herbal drug industry. Some species are also on the verge of extinction in this region due to habitat loss. As such conservation and sustainable utilization of medicinal plants is an urgent need for the maintenance of ecological balance in this region.

KEY WORDS: Ethnobotanical study, Malyagiri hill ranges, medicinal plants, conservation

INTRODUCTION

Malyagiri hill ranges belong to Eastern ghats of India which lies between 23’ 30’’ N latitude and 85° 16’ 58’’ E longitude. It is Located in Pallahara sub-division of the Angul district under Deogarh forest division in the state of Odisha. Malyagiri reserve forest spreads over an area of 115sq km. The whole area is charming with rising and falling hills interspersed with small plane and winding strip of valleys. The area is rich in flora and predominant species of sal is an example of tropical dry deciduous forest (Champion and Seth 1968). The mountain heights up to 1187 mt (3894ft.) which contributes the second highest mountain in Odisha(Harish Singh and Gopal Krishna).These are four perennial water fall with dense forest in the northern part known as ‘‘Nagira’’. These provide congenital niche for luxuriant growth of various type of plant species in this tropical and sub -tropical forest (WCMC-1992). The Lord Shiv temple at the base of Khuludi reserve forest, with perennial water fall adds the natural beauty making it a tourist place. The soil of Malyagiri ranges are mainly red and form clays and clay loams in the valleys (Patra and Choudhury,

1989). The hill ranges experience an extreme climate comprising 3 distinct season summer, rain and winter. It enjoys an average rainfall of 1421 mm. The highest temperature is 43.9°C recorded in May and it drops to 14.6 °C in December.

Malyagiri hill ranges harbours tropical dry deciduous and moist deciduous forest (Champion and Seth, 1968) of Eastern Ghats India. The wide range of topographic and climatic conditions favour the luxurious growth of vegetation in the hill ranges (Patra and Choudhury, 1989). Most of the plants have immense medicinal values. Due to over exploitation of medicinal plants, for fuel wood, habitat destruction, plant diversity decreases at alarming rate (Hare et al.,. 1997, Sahu et al., 2010). Due to its peculiar geographical locations the state of Odisha is endowed with diversified vegetation. As such quite a good number of ethnobotanical work has been carried out in different parts of the state (Brahmam and Saxena, 1990; Sahoo et al., 2016; Saxena and Dutta, 1975; Saxena et al., 1990). However, not much ethnobotanical work has been carried out in Malayagiri hill ranges. Keeping the above fact in mind an ethnobotanical exploration has been carried out in different areas of the Malyagiri hill ranges and the present paper is the outcome of some of the result of this investigation.

MATERIALS AND METHODS

Malyagiri Hills lie between $21^0 23' 37''$ N latitute and $85^0 16' 58''$E longitute.

Literature pertaining to past floristic studies in the Malyagiri hill ranges have been consulted to have a clear idea about the distribution and the status of the vegetation in past. The herbarium of the Central National Herbarium has been consulted to have a clear idea about the abundance and distributional patter of different species in this region.

Regular field trips have been conducted in different seasons of the year to identify plants of ecological, medicinal and other socio-economic importance along with distributional data in and around different areas of the Malyagiri hill ranges such as Jharasahi, Sapajhara, Jambua, Jharbeda, Khuludi, Phulabadi, Jamara etc. Special attention has been given to the sociability, distributional pattern and abundance, flowering and fruiting time. Plants of ethnobotanical importance were collected for the preparation of herbarium. Ethnobotanical informations were recorded from the local people, vaidyas and medicinal practitioners .

RESULTS AND DISCUSSION

In the present investigation, intensive as well as extensive floristic and ethnobotanical surveys have been conducted in and around different areas of the Malyagiri hill ranges to identify plants of ecological, medicinal and other socio-economic importance along with distributional data. Till now as many as 436 species have been collected and identified after consulting the regional floras (Haines, 1921-25; Mooney, 1950; Saxena and Brahmam, 1994-96).

The distribution and utilization of 50 potential medicinal plants found in different areas of this region have been presented over here. The species are enlisted alphabetically. Medicinal properties of the species have been authenticated by consulting standard literatures such as Kiritikar and Basu (1935), Chopra et al. (1956), Agrawal and Ghosh (1985), Satyavati et al. (1987), Warrier et al. (1995). The locality and the field number of the taxon have been given before the description of the medicinal importance. Illustrations of some important medicinal plants have been shown in (Fig. 1-24) In particular, extensive survey was undertaken at Phulabadi, a very cold zone of Malyagiri. It was noticed that there have been luxuriant growth of *Mesua ferrea* L. (Fig. 8). which nearly occupies 4 sq. km. of the area. Hence, this has been established to be the unique feature of the bio-diversity of the region.

Fig. 1. *Michelia champaca* L.

Fig. 2. *Argemone mexicana* L.

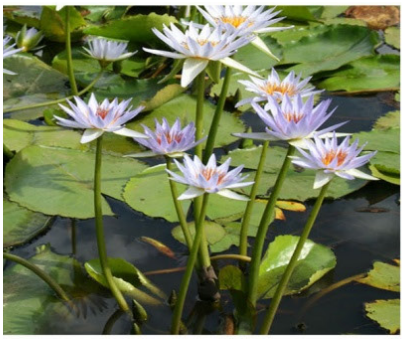

Fig. 3. *Nymphaea nouchali* Burm.

Fig. 4. *Capparis zeylanica* L.

Fig. 5. *Crateva magna*(Lour)Dc.

Fig. 6. *Hydnocarpus laurifolia (Denst.)*Sleumer

Fig. 7. *Dillenia indica* L.

Fig. 8. *Mesua ferrea* L.

Fig. 9. *Cissampelos pareira* L.

Fig. 10. *Stephania japonica (Thunb.)* Miers

Fig. 11. *Tribulus terestris* L.

Fig. 12. *Averrhoa carambola* L.

Fig. 13. *Oxalis corniculata* L.

Fig. 14. *Sapindus emarginata* Vahl.

Fig. 15. *Linum usitatissimum* L.

Fig. 16. *Shorea robusta* Gaerth.

Fig. 17. *Chloroxylon swietiana* Dc.

Fig. 18. *Ailanthus excelsa* Roxb.

Fig. 19. *Melia azedarach* L.

Fig. 20. *Celastrus paniculata* Willd.

Fig. 21. *Olax scandens* Roxb.

Fig. 22. *Cissus quadrangula* L.

Fig. 23. *Abelmoschus moschatus* Medic.

Fig. 24. *Sida acuta* Burm.

Table 1. Enumeration of medicinal plants in Malyagiri hill ranges.

Sl. no.	Botanical name Specimen no.	Family Locality	Local name	Life form	Parts used	Ethnobotanical importance
1	*Abelmoschus moschatus* Medic. 1047	Malvaceae Naunposi	Banabhendi	Shrub	Seeds, leaves and roots	Hysteria and nervous troubles. Have relaxing and stimulating properties, used in the treatment of gonorrhea and other venereal diseases
2	*Ailanthus excelsa* Roxb. 1043	Rutaceae Nuguda	Mahala	Tree	Bark	Intestinal tape worm, constipation, stomach disorder
3	*Argemone mexicana* L. 1006	Papaveraceae Sapajhara	Agara	Herb	Root, seed, latex	Juice used for healing wound. To treat constipation, chronic fever
4	*Averrhoa carambola* L. 1001	Averrhoaceae Raipal	Karamanga	Tree	Fruit	Treatment of dysentery
5	*Bacopa monnieri* L. Pennell. 1455	Scrophulariaceae Tampar	Jala Brahmi	Herb	Leaf, Stem	Cough, fever, constipation and enhances memory
6	*Caesalpinia bonduc* L. Roxb. 1072	Caesalpiniaceae Tampar	Gilla	Shrub	Root	Paste in dysentery
7	*Casearia graveolens* Dalz. 1018	Flacourtiaceae Padadiha	Giridi	Tree	Stem	Prepared comb used to prevent growth of lice
8	*Capparis zeylanica* L. 1002	Capparaceae Chhamunda	Asadua	Shrub	Flower, Fruit, Root, Leaf, Seed, Bark	Used as sedative, stomatic and antidiuretic
9	*Celastrus paniculata* Willd. 1051	Celastraceae Balimi	Pingu	Climbing Shrub	Stem	Diaphoretic in rheumatism, asthma, alzheimer
10	*Centella asiatica* L. 1273	Apiaceae Sapajhara	Thalkuri	Herb	Whole plant	Memory enhancer
11	*Chloroxylon swietenia* Dc. 1038	Rutaceae Arjunjhari	Bheru	Tree	Leaves, Bark	Paste used to cure wound
12	*Cissampelos pareira* L. 1012	Menispermaceae Raipal	Akanbindhi	Climber	Stem	Used as antiperiodic, diuretic, puragative and urinary troubles like cystitis
13	*Cissus quadrangularis* L. 1044	Vitaceae Samala	Hadajoda	Herb	Stem, leaf, seed	Used in irregular menstruation, internode used in bone fracture and digestive disorder
14	*Calophyllum inophyllum* L. 1005	Clusiaceae Rohila	Polanga	Tree	Seed	Oil mixed with hydnocarpus oil to treat rheumatic joints.
15	*Crateva magna* (Lour)Dc. 1010	Capparaceae Choraghati	Varuna	Tree	Dried bark and leaves	Treatment of bronchitis, cough and abdominal tumours

16	*Desmodium gangetium* (L.)Dc. 1098	Fabaceae Raipal	Shalaparni	Shrub	Root	Diarrhoea, chronic fever, asthma and vomiting.
17	*Dillenia indica* L. 1610	Dilleniaceae Jambua	Oau	Tree	Fruit	Juice used to treat weakness.
18	*Eclipta prostrata (L.)* L. 1284	Asteraceae Andhari	Bhrungaraj	Herb	Whole plants, and seeds	Plant decoction with Stem paste of black pepper to treat fever.
19	*Grewia subinaequalis* DC. 1074	Tiliaceae Naunposi	Pharosakoli	Shrub	Root	Bark is used in rheumatism
20	*Gymnema sylvestre* (Retz.)R.Br. 1362	Asclepiadaceae Jharbeda	Gudumari	Herb	Leaf	Powder used to treat diabetes
21	*Hydnocarpus laurifolia* (Denst.)Sleumer 1019	Flaucortiaceae Raipal	Chalmugra	Tree	Seed	Oil is applied in scabies .
22	*Ipomoea mauritiana* Jacq. 1417	Convolvulaceae Tambur	Bhuin kakharu	Climber	Leaf, Root	Treat tuberculosis
23	*Linum usitatissimum* L. 1032	Linaceae Chandposi	Alasi	Herb	Leaf	Powder used to treat gastritis.
24	*Mesua ferrea* L. 1027	Clusiaceae Phulabadi	Nageswara	Tree	Flower	Used to treat gistritis and stomach disorder
25	*Michelia champaca* L.1023	Magnoliaceae Raipal	Champa	Tree	Fruit, Seed	Used for healing of cracks
26	*Mimusops elengi* L. 1329	Sapotaceae Shikheswari	Baula	Tree	Fruit	Used in curing dysentery
27	*Mitragyna parviflora* (Roxb.)Korth. 1279	Rubiaceae Jharalo	Kelikadamba	Tree	Flower	Used in fever and colic pain
28	*Melia azedarach* L. 1044	Meliaceae Gudapada	Mahanimbo	Tree	Flower, Leaf	Applied to relieve nervous headaches
29	*Nyctanthes arbor-tristis* L. 1323	Oleaceae Mahurapani	Gangasiuli	Shrub	Bark, Leaf, Flower	Cure malaria and stomach fever
30	*Nymphaea nouchali* Burm. 1003	Nymphaeaceae Jambua	Nilakain	Herb	Root	Powder used for piles, dysentery
31	*Olax scandens* Roxb. 1052	Olacaceae Chandposi	Bhadbhadalia	Shrub	Bark	Preparation used to restore blood during fever
32	*Oxalis corniculata* L. 1041	Oxalidaceae Jambua	Ambiliti	Herb	Leaf	Juice is used locally for treatment of warts

33	*Pongamia pinnata* (L.) Pirre. 1120	Fabaceae Andhari	Karanja	Tree	Seed	Seed paste and oil to treat rheumatism and skin disorders
34	*Prosopis cineraria* (L.) Druce 1096	Mimosaceae Nuagaon	Shami	Tree	Flower	Powder eaten by women to prevent miscarriage
35	*Rauvolfia serpentina* (L.) Bent. 1598	Apocyanaceae Balimi	Patalagaruda	Under shrub	Root	Used for blood pressure and snake bite
36	*Rauvolfia tetraphylla* L. 1316	Apocyanaceae Dandahuli	Patalagaruda	Shrub	Leaf, Stem	Plant extract mixed with castor oil used for chronic diseases
37	S*apindus emarginata* Vahl. 1030	Sapindaceae Shikheswari	Rithaphala	Tree	Leaf, Fruit	Used in asthma, rheumatic arthritis
38	*Saraca asoca* (Roxb.)de Wilde. 1079	Ceasolpineae Aluri	Ashoka	Tree	Bark	Used to treat for regular menstruation
39	*Shorea robusta* Gaerth. 1034	Dipterocarpaceae Malyagiri	Sal	Tree	Seed	Seed paste mixed with white egg is very useful for relief rheumatic pains
40	*Sida acuta* Burm. 1060	Malvaceae Balimi	Bajramuli	Herb	Root	Used in nervous and urinary diseases, disorder of blood and bile
41	*Sida cordata* (Burm f.) Borssum 1005	Malvaceae Raipal	Bajramuli	Herb	Root	Paste is used in leucorrhoea, sciatica and headache
42	*Stephania japonica* (Thunb.)Miers.ann 1024	Menispermaceae Malyagiri	Sandhimali	Climber	Leaf	Useful in oral and dental diseases
43	*Syzygium cumini* (L.)Skeels. 1165	Myrtaceae Jamara	Jamukoli	Tree	Seeds, Leaves, Bark	Fresh bark juice mixed with milk used in diarrhoea
44	*Taddalia asiatica* (L.)Lam. 1056	Rutaceae Kantala	Tundapoda	Shrub	Stem	Used in treatment of cough and inflammation
45	*Terminilia arjuna* Roxb. Ex Dc. 1260	Combretaceae Andhari	Arjuna	Tree	Bark	Used in heart diseases
46	*Terminalia chebula* Retz. 1272	Combretaceae Jharasahi	Harida	Tree	Seed	Inflammation of mouth, digestive respiratory, hepatic and uro-genital disorder
47	*Trichosonthes tricuspidata* Lour. 1238	Cucurbitaceae Susubanali	Mahakala	Climber	Root	Bitter, thermogenic, purgative
48	*Uraria picta* (Jacq.)Desv. 1146	Fabaceae Kadalibadi	Iswarjata	Shrub	Roots	Applied to sore of children
49	*Phyllanthus emblica* L.	Phyllanthaceae	Amla	Tree	Fruit	Source of Vitamin C; against digestive disorders
50	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Bahada	Tree	Seed and bark	Cough, ulcer, insomnia, dropsy and digestive disorder

CONCLUSION

During the present investigation it has been observed that the flora of Malayagiri Hill ranges is rich with large number of medicinal plants and plants of other socio-economic importance. Large number of tribal people such as Kandha, Ganda and Sabara also inhabit around Malayagiri and its periphery. These people are utilizing various plants and plant products for medicinal and other purpose. Thus this area is rich with indigenous knowledge which is on the verge of extinction due to the advent of modern allopathic system of medicine. During the present investigation it is evident that large numbers of medicinal plants are found to be present in these regions which are much useful for herbal drug industry. Some species are also on the verge of extinction in this region due to habitat loss. As such in situ conservation of the existing vegetation as well as ex situ conservation of rare, endangered plants and sustainable utilization of medicinal plants is an urgent need of the hour for the maintenance of ecological balance in this region.

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   - **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-" Sukumaran, S. and Raj, A.D.S. 2008. Rare and endemic plants in the sacred groves of Kanyakumari District in Tamil Nadu. *Indian Journal of Forestry* **31**(4): 611-616." .Distinction for the same author and same year be done as e.g. 1969a, 1969b. Unpublished data, thesis and personal communication are not acceptable as references.
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