INTRODUCTION
Plants have been thought to be the best weapons for combating ailments and are recognised as a preventive cure against human diseases. The use of plants as medicines, has been done perhaps from pre-historic period. The writings indicate that the Chinese people were the first to use the natural vegetation as medicine and the practice of application of plants is as old as 4,000 to 5,000 BC. Greeks like Aristotle, Theophastrus and others have given voluminous information about drug plants in their writings. In the centuries to follow "Doctrine of signatures" was advanced which advocated that all plants useful for man possessed certain forms and shapes of some or the other plant part that indicated their specific use in the treatment of similar shaped organs in the human body. With the advancement of knowledge, such superstitions were gradually lost and several other useful remedies were discovered.

The great wealth of medicinal plants in the forest of our country has made her the pride home of Ayurvedic medicines since the vedic age. Indigenous form of medicine is still being practiced traditionally in all parts of India especially in rural and tribal belts. Plants form a major part of drug ingredient in almost all systems of medical sciences. Besides the classical work of the Atharva-veda, ancient Indian scholars like Charak, Sushrutha, Bhagvatta and several others have produced remarkable descriptions of
Indian medicinal plants. Rigveda which is considered to be the oldest available record dating back to 2000-1000 BC. recognised the importance of several medicinal plants. Vedic literature has described about 200 plants having medicinal properties. “Sushruta Samhita” (400 A.D) records the medicinal virtues of nearly 700 plants. The Ayurvedic systems of medicine make use of most of our native plants to make the health care cheap and acceptable. Such special usages of plants in ancient times and among primitive societies particularly caught the fancy of researchers.

During the last few decades, allopathic system of medicine has also started searching for medicinal plants and as such a number of plants are finding more and more use in this system of medicine. Several such medicinal plants have provided useful active ingredients being successfully used in recent times.

The scientific study in Indian indigenous drugs was initiated in the early part of the last century. In 1810, John Fleming published a catalogue of “Indian Medicinal Plants and Drugs”. Ainslie published the “Materia Medica of Hindoostan” in 1813 and Fluckiger and Handbury published the “Pharmacographia” in 1874. The study of indigenous drugs gained momentum with the publication of Chopra’s book on “Indigenous Drugs of India” in 1933. Sarmah (1968-69) has listed about 248 botanical drugs including Curcuma species from Atharvaveda and Rigveda. Chunekar (1972) published a full glossary of medicinal plants included in the ancient classical works of Charak Samhita, Sushruta Samhita and Astanga
Hridayam. Dr. Nadkarni compiled the first edition (1910) of ‘Indian Plants and Drugs’ with an aim to serve the professionals as well as the non-professionals. This book was well received by the society and second edition was published in 1927 under the title “Indian Materia Medica” (All references quoted by Tiwari et al. 1998).

A number of Ethnobotanists, Foresters and other researchers have attempted to work on medicinal plants of Madhya Pradesh. Jain (1963 a, b; 1964, 1965 a, b) started intensive field studies among tribals of Central India. He devised a methodology for ethnobotanical studies in the Indian context. Dwivedi (1985) added information on cultivation of medicinal plants. Several survey works were done on medicinal plants in different areas of the state (Tiwari et al. 1998).

Plants are the main source of medicines in all the systems of treatment i.e. Ayurvedic, Homeopathic, Allopathic and Unani etc. Therefore, they are always in great demand. At present, due to ever-increasing human population and indiscriminate exploitation of forest resources, there is an acute crisis of medicinal plants of a wide variety of species used for curing different human diseases. This situation has created interest in a large population of farmers to grow medicinal plants instead of cereals. A large number of herbaceous medicinal plants have their life span only of a few months. Thus, the outcome is received by the grower in a short time. Simultaneously the cost of medicinally important plant-part is usually high and the growers get a good economic return of their crop. But, there is a lacuna in this field.
The growers do not know perfectly which methods would be used to cultivate the plants. Since, most of the medicinal plants are wild in origin, their cultivation techniques are yet to be standardized.

*Curcuma* is a genus of about 30 species of rhizomatus herbs. It belongs to the family *Zingiberaceae*. The present work has been focussed on four species of *Curcuma* i.e. *C. angustifolia, C. amada, C. caesia* and *C. aromatic* which are ethnomedicinally important. They are perennial with the under-ground swollen stem and commonly known as ‘Turmeric’ in English or ‘Haldi’ in Hindi and used as spice also. The plants are commonly propagated by rhizomes.

Turmeric is widely used everywhere as food flavurant and yellow colourant, dyeing agent of textile fabrics, medicines and cosmetics of a wide variety in our country and abroad, in different ways. Kumkum, which is used by every married lady in India, is also a by-product of Turmeric. Turmeric finds a place in offerings on religious and ceremonial occasions. A type of starch can also be extracted from a particular type of Turmeric. India is one of the leading growers of Turmeric. It provides handsome profit to growers in the country.

Turmeric is the 2nd largest exported item from India to 87 countries as dehydrated Turmeric powder and curcuminoids every year. The export of Turmeric during 1998 has reached a new height of 24.900 metric tonnes valued Rs. 75.10 crores. India leads in Turmeric production in the world and occupies an area of 134
thousand hectares of land with an annual average production of about 487.40 thousand metric tonnes (Peter, 2000).

Turmeric is widely cultivated in many parts of the world. It is cultivated extensively in India, which is by far the largest producer and exporter of Turmeric in the world. It occupies about 6% of the total area under cultivation of spices and condiments in India. Important states growing Turmeric are Andhra Pradesh, Orissa, Tamil Nadu, Assam, West Bengal, Maharastra and to some extent Karnataka and Kerala. Andhra Pradesh leads in production with 156.6 thousand tonnes, followed by Tamil Nadu with 88 thousand tonnes per year. Over 150000 tonnes of cured Turmeric is produced annually. *Curcuma longa* is the most important species economically, accounting for about 96% of the total area under Turmeric and the remaining about 4% is under other *Curcuma* species (Kumar and Arya, 2000).

*Curcuma amada* ("Ama Haldi" in Hindi and "Mango ginger" in English)

The rhizomes of *curcuma amada* have the taste and flavour of raw mango. This species is well distributed in West Bengal, Kerala and Orissa in our country. Malayan Peninsula, West Peninsula and Malayan Archipelago are other parts in the world where this species is grown.

The rhizome of Mango ginger is sweet-bitter, cooling and medicinally used as appetiser, antipyretic, aphrodisiac, laxative, useful in biliousness, all kinds of itching and skin disease, bronchitis, asthma
and inflammations due to injuries. The rhizomes are cooling and useful in prurigo. They are topically applied over contusions and sprains. They are also used as stomachic and carminative. The roots are expectorant and astringent, useful in diarrhoea and gleet (Ambasta 1994).

*Curcuma angustifolia* ("Tikhur" in Hindi, "East Indian Arrow" in English)

- It is frequentlydistributed in Eastern and South Eastern, Moist deciduous Sal and mixed forest at the state.

The rhizome of *C. angustifolia* is used in inflammation and bone fracture among the Naga-tribe in Eastern India. The root of this species is used as tonic, useful in leprosy, burning sensations, dyspepsia, loss of taste, bronchitis, asthma, jaundice, anaemia, leucoderma, stones in kidney, urinary discharge, ulcer and diseases of blood. Root is well suited for infants and convalescents (Tiwari et al. 1998).

*Curcuma aromatic* (*"Jungli Haldi"* in Hindi and *"Cochin Turmeric"* in English)

- It is mostly grown in East and West Godavari districts of Andhra Pradesh, Tanjavoor and South Arcot districts of Tamil Nadu and scanty areas in Maharashtra, Orissa, Karnataka, West Bengal, Kerala and M.P.

*Curcuma aromatic* has several medicinal uses. Rhizome is bitter, appetiser, useful in leucoderma. It is considered as tonic and carminative. It is also applied to promote the eruption of fevers,
seldom used alone but is combined with astringents when applied to
bruises and with bitter and aromatic agents to promote eruptions. It is
used externally and suppose to be a valuable medicine in certain
cases of snake-bite. Administered in small doses and in conjunction
with golden-coloured, orpiment, obtained from Costus acobicus and
Carum copticum (Kirtikar and Basu, 1986).

Curcuma caesia ("Kali Haldi" in Hindi and "Black Zedoary" in English)

It is an important component of many ayurvedic medicines.
Present status of "Kali Haldi" is at the verge of extinction due to over-
exploitation. It is grown wild in West Bengal, Orissa, Bihar and U.P. It
is used by the tribal people to cure various ailments. The plant is
regarded very auspicious and also finds an important place in the
traditional system of medicine.

Curcuma caesia is an important medicinal plant. Its rhizome
is pungent, bitter, fragrant and destroys foul asthma. It is also
reported to be useful in leucoderma, piles, tumours, tuberculosis,
glands of the neck and enlargement of the spleen etc. The fresh
root is considered to be cooling and diuretic. It checks leucorrhoea
and gonorrhoeal discharge and purifies blood. The juice of the leaves
is given in dropsy (Tiwari et al. 1998).
<table>
<thead>
<tr>
<th>Botanical name</th>
<th>Hindi name</th>
<th>Occurrence</th>
<th>uses</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. amada</em></td>
<td>Ama-Haldi</td>
<td>Sal and Mixed forest</td>
<td>Appetiser, Anti pyretic, and skin disease etc.</td>
</tr>
<tr>
<td><em>C. angustifolia</em></td>
<td>Tikhur</td>
<td>Sal and Mixed forest</td>
<td>Dysentery, Asthma, Jaundice, Leprosy pain and wounds etc.</td>
</tr>
<tr>
<td><em>C. aromatic</em></td>
<td>Jangli-Haldi</td>
<td>Sal forest</td>
<td>Sprains, Bruses tonic and astringents etc. Leucoderma, piles, T.B. tumours etc.</td>
</tr>
<tr>
<td><em>C. caesia</em></td>
<td>Kali-Haldi</td>
<td>Sal and Mixed forest</td>
<td></td>
</tr>
</tbody>
</table>

Turmeric is native of India or China. Besides India, it is a commercial and medicinal crop of the tropics. India is well known historically as a land of Turmeric. Indian Turmerics are almost as ancient as history itself. The oldest documented record about Turmeric in India is found in the Rig Veda. The Turmeric must have been grown in India from very ancient time as it is mentioned in “Charak Samhita”. There are number of similar references to Turmeric in ancient India (Malhotra, 2000 and Sharma, 1997).
In the present scenario of "natural food", "ethnic food", "yogic food" and "back to nature" in health care, it is relevant that these valuable genetic resources are not only preserved, but also their cultivation is to be developed in order to meet the entire demand, and also to exploit their bright prospects for export. In view of the increasing demand of medicinal plant products and diversification of agriculture for high income, the farmers are motivated towards the cultivation of these medicinal turmeric crops which are grown under irrigated ecosystem with the use of high quantity of fertilizers for increasing production. The production technologies viz. planting with optimum geometry, adequate fertilizer and irrigation supplies, proper mulching, interculture management and effective plant protection measures etc., have been identified for improving the productivity of this crop. These agro-inputs are not very costly or unaffordable for most of the farmers specially poor and marginal farmers (Pruthi 1998).

The plants of Curcuma species are generally propagated from rhizomes. The leaves are long, broad, lanceolate and bright green. Flowers are pale yellow and borne on dense spikes. Pseudostems are shorter then leaves. Rhizomes are ready for harvesting about 7 to 9 months after planting. Generally the Curcuma species is sown / planted with the onset of pre-monsoon showers. The preferred method of propagation of Turmeric is through pieces of rhizome, but this is a slow process since rhizome has a dormancy period, it only sprouts during the monsoon, and few plants can be obtained from one rhizome in a year. A rapid method of multiplication is needed. Therefore, vegetative propagation with growth substances may be very useful for cultivation of Curcuma species.
Propagation

It is the art of multiplying plants by other than natural methods. The propagation of plants is a fundamental occupation of humankind. Its use began since the onset of civilization. Agriculture started some 10,000 years ago when ancient people began to cultivate plants and domesticate animals. These activities centred around stable communities and people began to select and propagate the kinds of plants that provided a greater and more convenient supply of food and perhaps other products for themselves and their animals (Hartan, 1992 and Solbring and Solbring, 1994).

Suggestions for clear and standardized terms of vegetative propagation have been made by Tukey (1938). The difference between the growth of seedling plants, on the one hand, and vegetative propagation on the other, has already been considered. Vegetative propagation may be divided into three groups i.e. separation, rooting, and grafting.

Separation involves only the removing from the parent plant of a part which would grow into a complete plant without man's intervention. This is a common method of several propagating herbaceous perennials. Vegetative propagation avoids genetic variation and the differences between vegetatively reproduced plants are ordinarily so small as to be negligible (Hayes, 1970). It is the most important propagation method used for the commercial production of many adventitious root growing species (Hartmann, et al. 1988).

Turmeric is an asexually propagated crop, because it produces seed poorly (Arya, 2000). A rhizome of Curcuma species
is a specialized stem structure in which the main axis of the plant grows horizontally, just below the ground. It is thick, fleshy, and shortened in relation to length. It appears as branched clump made up of short, individual sections. It is determinate, that is each clump terminates in a flowering stalk. The rhizome tends to be oriented horizontally with roots arising from the lower side. This is easily propagated by division of the thickened rhizome (Hartmann, et al. 1997).

Plant hormones provide growth regulation in the plants as directed by the genetic code within the chromosomes. Hormones are naturally occurring chemicals of relatively low molecular weight present within plants in very low concentration. These chemicals regulate plant growth and development (Foskett, 1994).

The five major plant hormones are usually identified as auxins, gibberellins, cytokinins, ethylene and abscisic acid (Hartmann, et al. 1997). In addition to these substances certain chemicals, some natural and some synthetic, have hormonal effects when exogenously applied to plants. These substances, along with the natural hormones, are combined into the term plant growth regulator (George, 1993).

In the mid-1930's and later, studies of the physiology of auxin action showed that auxin was involved in such varied plant activities as stem growth, adventitious root formation, lateral bud inhibition, abscission of leaves and fruits and activation of cambial cells (Preece and Read, 1993). The most widely used function of auxin in plant propagation is the induction of adventitious roots on stem cuttings. Growth promotion by auxins is thought to take place by two mechanisms- (A) by promoting the transport of H⁺ ions across
cell walls and increasing their extensibility and (B)-by inducing the transcription of specific mRNA's necessary for sustained growth (Hartmann, et al. 1997).

Gibberellins were discovered before world war II by Japanese scientists trying to explain the abnormally tall growth and reduced yield of rice plants infected with a fungus known as Gibberella fujikuroi (sexual) or Fusarium moniliforme (asexual form). An active ingredient was extracted from this fungus which was named GA₃ later on. More than 90 forms of Gibberellin have since been found in plants but only a few appear to be physiologically active. Gibberellic acid (GA₃) is the most important commercial product.

Gibberellins occur in high concentrations in developing seeds and have important functions in germination and control of dormancy. They also occur in high concentrations in stem apices, particularly in leaf primordia, roots, fruits and tubers. They are transported within the plant in the xylem and phloem. Their function in the plant is to promote shoot elongation through the increase of both cell division and cell-elongation. GAs regulate synthesis of seed enzymes in cereals, induce seed germination and stimulate flowerings in long-day plants and biennials (Hartmann et al., 1997)

The most useful synthetic auxins discovered about 1935 were indole butyric acid (IBA) and naphthalene acetic acid, (NAA) and have since been found to occur naturally and used in propagation. It was shown that two synthetic materials, IBA and NAA were even more effective than the naturally occurring or synthetic IAA for rooting of stem cuttings (Zimmermann and Wilcoxon,1935).
Today, IBA and NAA are the most widely used auxins for rooting of stem cuttings and for rooting tissue culture produced callus. It has been repeatedly confirmed that auxin is required for initiation of adventitious roots on stems, and it has been shown that divisions of the first root initial cells are dependent upon exogenous or endogenous auxin (Gasper and Hofinger, 1991).

Use of plant growth regulating substances in vegetative propagation has provided an effective tool to the researchers to manipulate the growth, development and yield of plant. Growth regulating substances are found in all parts of the plant including seeds.

The idea of vegetative propagation with growth regulators has developed since 1935 following the wake of successful use of hormone in the rooting of stem cuttings. It is expected that when hormones are applied on rhizome / seed having a dormant vegetative bud or a dormant plant embryo, the growth promoting chemicals immediately become available to the young plantlet just after emergence. Vegetative propagation with rhizome has generally been studied either for the germination ability of rhizome or for growth and yield of plant.

In many vegetative propagation studies, those growth regulators have been used commonly which have proved themselves effective in rooting of stem cuttings and flowering, namely GA₃, IBA, and NAA. These growth regulartors have been applied as pure chemicals which are used as solution. The main advantage of this method is that it is rapid and convenient procedure for treating the rhizomes (dipping them in a concentrated solution of growth regulator for a particular period).
Several synthetic growth regulators have been applied for vegetative propagation of plants by numerous investigators with the objective to accelerate the growth rate of plant and to increase the foliage (number or size or both), flowers or roots, ultimately to increase the final yield of crops.

Treatment of a few kinds of rhizomes of *Curcuma* species with the growth regulators for the purpose of stimulating growth and yield is reported to be efficacious. There is good evidence to support the idea that rhizome can make use of growth regulators over and above their natural supply.

Several research workers have evaluated the effectiveness of vegetative propagation with various growth regulators at varying concentrations. Bulb soaking in 100 ppm solution of GA$_3$ for 3 h broke dormancy, which improved the germinability, vigour index and yield, and significantly increased flowering percentage in *Allium cepa* (Vanagamudi et. al., 1988). The highest proportion of rooted plantlets (98.6%) in *Dioscorea floribunda* was obtained with stem cuttings treated with 2000 ppm solution of IBA (Singh et al., 1991). Application of 100 ppm solution of NAA to the tubers of *D. floribunda* also resulted in rooting of 80% rhizomes and gave more rapid root initiation (Singh and Singh, 1980).

More recently, attention has been centred on the plant hormones and growth substances, which, in very dilute solutions affect the growth of plants. It has been shown that a large number of these compounds promote the growth of roots. Among those, commonly used are GA$_3$, IBA and NAA. The most common form of treatment is
placing the basal end of the cutting in an aqueous solution for about 24 hours. Solution of about 0.1% is generally satisfactory.

Application of growth regulators in vegetative propagation plays a vital role in changing the morpho-physiological characters of plants. Therefore, the use of these substances have the possibilities to improve the growth and yield of medicinal crops like *Curcuma* species. The effectiveness of these substances on plant growth could be further manipulated by mentioning their techniques of vegetative propagation. Rhizome treatment with these substances can be done by soaking them in their solution.

Keeping the above facts in view, the present investigation was undertaken at the Botanical Garden, Dr. Hari Singh Gour Vishwavidyalaya, Sagar (M.P.) with the following objectives:

* To find out the suitable growth regulators for different *Curcuma* species for improving their growth and yield.

* To standardize the cultivation technique by vegetative propagation using various growth regulators.

* To analyse the benefit-cost ratio for various propagation techniques.

**********