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APPLICATION OF BIO-FERTILISERS IN FODDER PRODUCTION FOR COMMERCIAL ANIMAL HUSBANDRY

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Application of chemical fertiliser deteriorates soil health as well as contaminates natural water bodies. Chemical fertilisers possess anthropogenic compounds which are hazardous, result in poor soil quality, poor crop nutrition and pollute the water table (Sonali et al., 2022). Wide application of synthetic agrochemicals (e.g., chemical fertiliser) has been a significant contributor to environmental pollution (Sabki et al., 2021). The elevated use of inorganic fertilisers due to poor soil quality and the need for an increase in food production to meet the demand of the increasing global population has led to fertility decline in soil (Mukhuba et al., 2018). As a result of that, productivity of crops decreases. Fodder crops grown for feeding scientific animal husbandry are also facing the similar problems. Indiscriminate use of fertiliser also depreciates the quality of fodder crops which ultimately results in poor productivity and health problems of livestock. Application of bio-fertilisers can solve these problems by reducing the overdependence on chemical fertilisers and improving the soil health for better production of fodder crops. Increased interest in low-input agriculture in recent years has seen the growing development and use of commercial biological inoculants (bacteria and/or fungi) to increase the mobilisation of key nutrients (Owen et al., 2015). Application of bio-fertiliser can reduce the cost of fodder production and enhance the productivity in animal husbandry in the long run.

What are Bio-fertilisers?

Bio-fertilisers contain live micro-organism which improves the fertility of soil and results in increased production and nutritional quality of fodder crops. Micro-organisms capable of synthesis or assimilation of nitrogen from environment, fix nitrogen in the soil. On the other hand some micro-organism mobilise potassium and phosphate bound in soil for use in plant growth.

Benefits of Using Bio-Fertiliser in Animal Husbandry

- ✓ Through application of bio-fertiliser the productivity of fodder crops can be increased up to 20-30 percent.
- ✓ As bio-fertiliser can replace the use of chemical fertiliser, the cost of cultivation can be reduced significantly.
- ✓ Some bio-fertiliser helps in releasing enzymes fixed in soil which can increase the growth of fodder plants
- ✓ Bio-fertilisers improve soil health by mobilising phosphate and potash fixed in soil and mixing environmental nitrogen in the field. Soil texture also improves by use of bio-fertilisers.
- ✓ In some cases, bio-fertilisers enhance the immunity of fodder crops to fight against diseases.
- ✓ Application of bio-fertiliser has no ill effect on environment and eco-friendly

Application of Bio-Fertilisers in Scientific Fodder Production

Bio-fertilisers are available at markets in both liquid and powder form. Bio-fertiliser is a mixture of different bacteria, fungus, algae or other micro-organisms. Bio-fertilisers can be used along with application of manure in field or seed treatment. In some cases, roots of plants are dipped in bio-fertilisers before planting. For cultivation of green fodder, following bio-fertilisers can be used:

Rhizobium: Rhzobium is a type of micro-organism which can be found in the roots of leguminous fodder crops like berseem, lucerne, cowpea, ricebean etc. Through symbiosis, these bio-fertilisers can fix 50 to 100 kg of environmental nitrogen per hectare on yearly basis, which is equivalent to 125 kg to 250 kg of nitrogen.

Azotobacter: This type of bio-fertilisers also fixes environmental nitrogen in the soil. Application of azotobacer can enhance the height of plant as well as the amount of foliage in fodder crops which ultimately increase the yield of fodder. This type of bio-fertiliser can be used for cultivation of fodder maise or fodder sorghum through seed treatment or directly applying to soil along with manure.

Azospirillum: Azospirillum can fix 20 to 40 kg environmental nitrogen in 1 hectare of land per year which is equivalent of application of 50 to 100 kg urea in soil. This bio-fertiliser not

only fixes nitrogen but also supply some essential enzymes required for fodder growth. In different types of fodder crops like fodder maise, sorghum etc. azospirillum can be used.

Phosphate Solubilising Bacteria: *Bacillus megaterium, Bacillus subtilis, Pantoea agglomerans (*formerly knwon as *Enterobacter agglomerans), Pseudomonas putida* etc. are exploited in utilising phosphate bound in soil for plant use. These phosphate solubilising bacteria can mobilise 10 kg of phosphate per hectare per year which is equivalent to 62.50 kg of single super phosphate. These bio-fertilisers can be used for all types of fodder crops.

Potash Mobilising Bacteria: These micro-organism can release potash fixed in soil for use of plants. *Bacillus Mucilaginosus, Bacillus edaphicus* etc. are some of the example of this type of bio-fertiliser. These bio-fertilisers can be used in the field while application of manure or by seed treatment. These can also be used for all type of fodder crop cultivation.

Mechanism of Application of Bio-Fertilisers for Fodder Production

- Different species of rhizobium bio-fertilisers are used for different leguminous fodder crop like berseem, lucerne, cowpea etc. For 1 hectare of land 1.50 kg of rhizobium bio-fertiliser is required.
- If azotobacter/ azospirillum are used for seed treatment, then 1.50 kg to 1.75 kg of bio-fertiliser is required for seeds necessary to sow in 1 hectare of land. In case where these bio-fertilisers are used with manure then they may be mixed with manure one day before application to the field. In that case for per hectare of land 3.75 kg to 6.00 kg of bio-fertiliser is required.

Conclusion

Chemical fertiliser and bio-fertilisers should not be applied together. Bio-fertilisers should not be stored in high temperature, rather they should be stored in cool shaded place. The effectiveness of bio-fertilisers deteriorates as the time progresses, hence the date of manufacturing should be checked before purchase of bio-fertilisers. For effective result of bio-fertilisers, the field should contain adequate amount of humus. To ensure that, manure may be applied once or twice before application of bio-fertilisers. In case of problem soil, soil amendments like gypsum, lime etc. may be applied prior to application of bio-fertilisers. If chemicals are used for seed treatment, then bio-fertilisers may be used at least 24 hours after the use of chemical. Different types of bio-fertilisers can be used together. Scientific and methodical application of bio-fertiliser can enhance the quality and quantity of fodder crops,

which in-turn results in high economic return in animal husbandry enterprise. Replacing chemical fertiliser with bio-fertiliser can improve the soil health and can ensure farming system which is economically and ecologically sustainable.

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RICE CULTIVATION AND NEED OF COLD TOLERANCE BREEDING IN EAST AND NORTH EAST INDIA

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Rice is the important stable food crop, widely cultivated in the different season throughout the year in North East and Eastern India. Different rice growing seasons, *Aus, Aman, Boro, Ahu, Sali, Jhum* are practiced in North East and East India. Majority, the farmers grow rice for the economic sustainability by means of nature and naturally as the important farming components in farm practices and farming patterns to meet the income from the farming and contributing food grain and fodder production (Khush, 1997). Rice grain is widely used by the majority of the consumers as major food from breakfast to launch and diner as major dietary requirement by means, Rice, Puff rice, Panta bhat, Chira, Khoi or Pitha which is made up of rice flour or payas which is made up of aromatic raw rice grain or some special drink in the tribal communities. Rice straws are used and consumed as fresh or dry fodder for the cattle as major cattle feed in the region.

East and North East India

Rice cultivation in the East and North East means in the state, West Bengal, Odisha, Chhattisgarh, Bihar, Assam, Sikkim, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram and Tripura. This region contributes a major contributing to the genetic and cultivation variability in practices with the present of genetic diversity from the beginning on rice cultivation history and cultural richness with rice cultivation and rituality among the rice farmers in the region (Singh, 2002).

Rice Growing Seasons

Rice cultivated area was higher in *Kharif/Aman/Sali* followed by *Aus/Ahu* and *Boro/Summer* in the earlier days but presently drastically decreased the cultivated area under

Aus/Ahu segment. *Jhum* rice cultivation only practiced in the north eastern hill by the tribal farmers under Jhum or shifting cultivation practices.

Impact of Cold on *Boro* Rice Cultivation

Due to advancement and adoption of better irrigation and management practices, people are growing more rice in *Boro/Summer* season on the other hand due to better yield but again presently *Boro/Summer* rice area is decreasing due to high water consumption and least management crop like corn is getting place in place of *Boro* rice in some part of the region and parallel due to more cold intensity and injury *Boro* season is gradually being shifted towards late *Boro* or early *Ahu* segment due to cold affect during winter (Pathak *et al*, 2002).

Boro rice growing season is the most important due to the higher crop yield in the region, but due to cold affect germination and seedling stage are getting affected and farmers are facing challenge on raising seedling. Nurseries, at low temperature night during *Boro* season, on the other hand majority of the *Boro* varieties are cold sensitive, so challenges on raising healthy seedling is too. Different rice cultivation seasons and their brief description as have been given (Table-1).

Table 1. Rice growing seasons and their brief description

Season	***Aus/Ahu/Bhadoi***	***Aman, Kharif.Sali***	***Boro/Summer* Rice**	***Jhum* Rice**
Growing Period	February-August	June-November	November-May	June-September
Harvesting	August-September	Noverber-December	May-June	September-October
Duration of Varieties	Early	Mid-Late	Early-Mid Early	Early-Mid-Early
Duration-Days (Seed-Seed)	95-120	125-155	135-165	100-130
Type of Cultivation	Rainfed	Rainfed/Irrigated	Irrigated	Rainfed
Planting Method	Broadcasting	Broadcasting/Transplanting	Transplanting	Broadcasting
Lead Varieties	Bhadoi, Motichur, Bornhi, Moinagiri, Kala Ahu, Dhala Ahu	Ranjit, Swarna, Bhalum-3, Tulaipanji, Gobinda Bhog, Dudheswar, BB !!	IR 64,Khitish, Satabdi, Nabeen, Ajit, MTU 1010	RCM 3, Black Rice, Cha – Khao

Cropping System	Mono - cropping	Mono-Cropping	Mono-Cropping	Mixed Cropping
Land Type	Up-land	All type of land	Mid-low land	Forest Hill Terrain
Management Practices	Traditional/Low	Medium - High	High	Minimum/Natural
Major Pest and Diseases	Bird, Blast, Gandhi Bug, Brown Plant Hopper(BPH)	Blast, BLB, Stem Borer, False Smut, BLB, Brown Plant Hopper(BPH)	Blast, Stem Borer, Blast, Bacterial Leaf Blast	Blast, BPH, Gandhi Bug.
Major Abiotic Stress	Drought	Flood, Cold	Cold	Terminal Drought
Cultivation Economy	Low	High-Medium	Medium	Low
Nutritional Status of the Varieties	High	Medium-Low	Low-Medium	High-Medium
Yield Potential	Low	Medium	High	Low
Yield Potential(qt/ha)	1.5-2.5	3.5-5.5	4.5-6.0	1.5-2.0

Rice cultivation system has been evolved by means, availability of different diverse rice genotypes suitable for the cultivation in different ecology and growing season with the help cultivation practices, practiced by the growers, generation after generation and captures the knowledge. After the advancement of rice science with the dedicated effort by the researchers and passionate rice farmers, developed the different modern technology and management techniques for the better uplift- man of life of the rice farmers with the dialogue "better rice better life".

Boro Rice and Cold

The *Boro* rice season start in winter season, means while sowing started in the month of November- December, where temperature persisted very low up to 5 0^{C} in some part of the region and in the main sowing period that is 15^{th} November to 15^{th} December and in the same time germination as well as seedling development affected drastically due to cold injury and farmer failed some time to raise healthy seedling which ultimate affect the crop yield as well as economic loss to the rice farmers in the region. Cold injury during winter is the one of major stress or challenge on raising a successful crop in the region for the cultivation, the *Boro* Rice in North and North Eastern India under the climate changing world (Ghosh and Dasgupta, 2021; Singh *et al*, 2012).

Cold and Rice Growth & Development

Rice is preferred to grow under warmer, humid and clear sunny day or weather conditions for better performance by means of growth and development and yield. On the other hand 27-32 0^C is the most ideal temperature range for its normal growth and development but low temperature(<15 0^C) adversely affect the normal growth and development of rice plant. The Rice plant come under stress and indicates, its stress below 15 0^C with respect to chlorophyll synthesis, content, leaf rolling, wilting due to cold, stunting growth and development as well as weight loss, release of soluble sugar, exhibiting the reactive oxygen activities, reducing the metabolic activities and Cyto-chemical changes etc. Cold adversely affect on germination, seedling and reproductive phase, rice plant growth and development.

Germination and Affected Due To Cold

During germination phage, normal temperature reach to 5 0^C during winter, particularly in the month and end, December by which germination adversely affected. Due to poor germination rice seed rate increase naturally and cost of cultivation increased proportionately. Germination percent reduced due to cold at the time of germination by means of ridicule, promule, root and shoot development during germination stage as well as fail to establish the seedling in field or nursery (Satya and Saha, 2011).

Seedling Injury Due to Cold

Seedling development start naturally after the seed sowing, means on 15th December onwards when air and night temperature goes down up-to 5^0C which is too low with respect to rice cultivation or seedling growth and development. Due to low temperature seedling growth and development affected with cold injury and some time farmers otherwise failed to raise the healthy seedling or need more seed means seed rate increased due to cold affect on seedling raised, the seedling cost to the farmers or on the other hand due to unhealthy or poor seedling growth and development or performance of the seedling which finally affect on the crop performance with respect to yield components, the crop and ultimate loss to yield and economic yield (Lal, *et al*., 2013).

Cold and Reproductive Stage

Cold effect adversely on the growth and development of the rice plant and reproductive phase, like germination and seedling stages. Due to cold, hampered the normal growth and development at reproductive phase during mega –spore or pollen development, whereas due to cold, develop the sterile pollen development take place in the pollen sac, which ultimate leads to sterilities and failed in fertilization and as a results non development of seed. Sterile pollen development leads to sterility and development of chaffy grain in the panicle and as results, yield loss leads to economic loss to the farmers (Das, 2015).

Conclusion

Looking to the above strategies on the *Boro* rice cultivation in the East and North Eastern India, identification of cold tolerance cultivar and cold tolerance varieties may be adopted for the cultivation during the *Boro* season. Breeding program for the development cold tolerance in the background of cold sensitive popular high yielding varieties may be carried out looking to the need, the region with respect to cold during the *Boro* rice cultivation with better prosperities for the rice farmers, the region, East and North – Eastern India in the climate changing world for better sustainable future of the Rice farmers.

Some leading varieties for the region are IR 64, MTU 1010, Swarna, Swarn Sub -1, Ranjit, Ranjit Sub-1, Khitish, Satabdi, BB 11, BINA 11, BR 29, Tulaipanji, Dudheswar, Gobindabhog, Kalabhat, Paijam, Aijung, Bahadur, Kalo Nunia, Moinagiri, Aghoni Bora, Kamol, Kalirai, Jalkouri, Jalamagna, Jaladhi, Bhadoi, Pankaj, Tulsibhog, Joha, Bhalum 3 Ketaki Joha, etc.

Therefore, identification or screening, the rice varieties for cold tolerance to improvement the cold tolerance in the *Boro* varieties are importance looking to the need of the region, East and North East India.

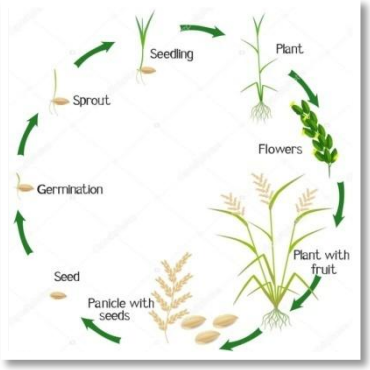

Fig 1: Cold and Rice Life Cycle.

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BEHAVIOURAL STUDY OF APHIDS

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An insect behavior refers to the various actions of an insect in response to a stimulus or to its environment. It describes a wide range of activities, such as feeding, locomotion, grooming, reproduction, learning, migration, and communication.

Aphids are major pests for all crops over the world and generally known as plant lice, green flies or black flies and they belong to the Super family- Aphidoidea and Order- Hemiptera. Most of the aphid species are polyphagous and feed on a wide range of host plants (Blackman and Eastop, 2000). Most of the female aphids are wingless but small numbers of aphids are winged that fly to the plant and find it to be a suitable host. After getting suitable host they produce several immature ones on the tender leaves. They are phloem feeder and attack all parts of plants including roots. Aphids directly damage the plant by sucking their nutrients resulting in curling and twisting of tender parts (Maji *et al.*, 2020).

In addition, aphids are often vectors of plant pathogens. Almost every crop is a host to at least one aphid species. Aphid behaviour can helps to know about the developed resistance to insecticides, they are difficult to control (Blackman & Eastop 2006). Previously, it has been demonstrated that plant resistance can be inferred from the behaviour of aphids (Pickett et al. 1992).

Patterns of Behaviour

1. **Innate behaviour-** Innate behavior is behavior that's genetically hardwired in an organism and can be performed in response to a cue without prior experience.
2. **Learned behaviour-** Learned behavior is behavior that occurs only after experience or practice. Learned behavior has an advantage over innate behavior. It is more flexible. Learned behavior can be changed if conditions change.

Importance to Study Insect Behaviour

- To understand interspecific and intraspecific interaction between insects.
- To know the reproductive strategies of different insects.
- To understand the social behaviour of insects.
- To determine the host preference by different insects.
- To understand the defensive mechanism of insects against their natural enemies.
- Insects can resist insecticides through changing their behaviour. So, understanding the behavioural resistance mechanism will help in development of IRM strategies.

1. Feeding Behaviour

Aphid antenna bears many sensilla which are used in chemoreception and for perception of leaf surface. Most of the aphid species make their colonies near mid rib on lower surface of the leaves. Younger nymphs make colonies on secondary and tertiary leaf veins. By making colonies around veins, aphids try to find place near to the phloem tissues (sun *et al.,* 2016). When aphid punctured the phloem tissue, the sap which is under positive hydrostatic pressure is forced into the aphid's food canal. Phloem sap is composed of only sugars.

Most of the time aphids are the phloem feeders but under certain stress condition they can also feed on xylem fluid. Because when they feed from phloem, high osmotic pressure created in stomach due to high sucrose concentration as a results water transfer from haemolymph to stomach and insect died. But, when they feed on xylem fluid which is much dilute as compared to phloem, helps to reduction of solute concentration and osmotic pressure (Guo *et al.,* 2016).

2. Locomotion or Movement of Aphid

Movement of Aphid

An aphid moves from its point of origin towards some other place by one of two types of transport mechanisms, either through '**inadvertent**' or '**intentional**' displacement (Awasthi, 2013).

Inadvertent displacement is an instinctive act, departure the aphid few options about its translocation. It is propelled by the force of impact, gravitational force, air currents, or a

blend of these. The inadvertently displaced aphid may, itself by walking or flying otherwise, it can be transported by animals, farm machinery or automobiles.

Intentional displacement is a pre-programmed movement, i.e. they are governed by the genetics of the organism. The environmentally sensed attack by a natural enemy or altered chemical composition of a deteriorating host plant, can create an urge in the aphid to flee, this desire might well stem from an intrinsic, genetically wired response to the initial disturbance.

Migratory Behaviour

Insect migration is the key process by which the population dynamics of many insect pests is being maintained over an enormous region. Aphid migration indicates that aphids migrate from high hill regions to plain lands of India to avoid lower temperature. In this migratory route, aphids spread their offspring both temporally and spatially, so that, a portion of their next generation can be able to build a seasonally favourable population in near future.

3. Life Cycle

There are two types of life cycle generally found on aphid species-

a. Holocyclic life cycle: it refers to those aphids which alternate parthenogenetic with sexual reproduction. Holocyclic life cycle seen in case of both heteroecy and monoecy.

b. Anholocyclic life cycle: In this type of life cycle only viviparous parthenogenetic females are present throughout the year. This is often seen in locations where winter conditions are gentle. Anholocycly is not confined to heteroecious species of aphids; approximately 3% of all aphids are completely anholocyclic throughout their range (Blackman, 1980).

4. Mechanisms of Colour Production in Aphids

There are so many factors which are responsible for coloration in aphids-

- In case of *Sitobion avenae* they change their body colour from green to pink or brown with changes in light intensity (Alkhedir *et al*., 2010).
- *Aphis gossypii* pale green colour at 25^{o}C and dark green or dark brown at 12^{o}C temperature (Dixon, 1972).

- Colour within a species can be a genetic trait, as is well documented for *Acyrthosiphon pisum*, *Myzus persicae* and various *Macrosiphum* sp. (Battaglia *et al*, 2000)
- Nutritional quality of diet also can influence the aphid colour.

Chemical coloration of aphids is determined by mainly three pigments, melanin, carotenoid, and aphin.

- **Melanin:** Melanin is one of the major pigments representing black or dark color. Melanin in the cuticle seems to purpose as a protectant from UV damage, and is synthesized from tyrosine through dihydroxyphenylalanine (DOPA) processes.

- **Carotenoids:** Carotenoids are tetraterpenes that are red to yellow in color. In some cases, carotenoid levels were shown to vary among the different color forms. For example, green aphid primarily contain yellow carotenoids, such as a-carotene, b-carotene org-carotene, whereas red clones mainly contain red carotenoids, such as lycopene, 3, 4-didehydrolycopene and torulene. Aphids have acquired capability to produce red Carotenoid by horizontal gene transfer from fungi.

- **Aphins:** Aphins are polycyclic quinone pigments present in haemolymph. Aphins exhibit colors that differ extensively, from very light yellow through orange and red to deep blue-green.

Colours for Defence

Generally three types of coloration can be found in aphid species-

Aposematic colouration (Warning colouration)

In this type of colouration aphid make them highly conspicuous as a result they can easily get noticed by predators and this aphid species contains toxic compound such as cyanoglycoside which produce hydro cyanate when consumed by the predators as a results predators avoided in next encountered (Benedek *et al.*, 2019). This type of colouration is displayed only by adults.

Cryptic Colouration in Aphids

Aphid can change their body on the basis of the plant surface colour if they colonise on leaves they are green, aphids that colonize on stem and woody part are brown, this form of

colour matching is called as homochromy. They do not match only colour but also pattern and texture (Dransfield and Brightwell, 2015).

The polymorphism appears to be maintained by balanced selection from two natural enemies- the predator, *Coccinella septempunctata* and the *parasitoid Aphidius ervi.*

Parasitoid prefers to attack green morphs generally but if the parasitoid population is high, more red morphs are born. Predator prefers to feed on red morphs but if predator population is high, more green morphs are produced.

Deimatic Behaviour

Deimatic behaviour is intimately associated to Aposematic behaviour, and means any pattern of threatening or startling behaviour. For example the sudden display of eyespots by moths. Several *Lachnus* and *Cinara* species of aphids show “leg kicking” response which is an example of Deimatic behaviour.

5. Ant mutualism

Some species of ants farm aphids in their colony and eating the honeydew which secreted by the aphids from their anal opening. Ants protect the aphids by fighting off aphid predators (Wimp and Whitham, 2001). Ants also feed on the aphids to get source of protein and sometimes to control aphid population when they can’t handle honeydew production capacity.

6. Escape and Defences in Aphids

- Aphids cannot fly for most of their lifecycle; they can escape from predators and parasitoids by dropping off the plant they are on.
- Some species of aphid, known as "woolly aphids “(Sugarcane wooly aphid, Apple wooly aphid), excrete a “fluffy wax coating” for protection from predators and parasitoids.
- Some species of aphid interact with plant tissues forming a gall, by secrete some chemicals. Aphids can live inside the gall, which provides protection from predators and parasitoids. Some gall forming aphid species are produce specialised "soldier “ forms, sterile nymphs with defensive features which defend the gall from invasion.

- The cabbage aphid, Brevicoryne brassicae, stores and releases chemicals (Iso-thiosynate) that produce a violent chemical reaction and strong mustard oil smell to repel predators.

Conclusion

In conclusion, several species of aphid infested on different crops and reduced the production. So, it is very important to control the pest population. Aphid behaviour helps to know about their mechanism of resist insecticides through changing their behaviour and helps to fixed management strategy. There is several defence strategy developed by several aphid species for escaped from their predators. The aphid behaviour needs to be assessed first in order to control the aphid species.

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COMMERCIAL TIMBER SPECIES IN HIMACHAL PRADESH

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Himachal Pradesh is a predominantly mountainous state. Its climate is more congenial to forest and it comprises four forest zones. Sub-tropical, Sub-temperate, Wet-temperate and Dry-temperate. It consists of foot hills and valleys level, it comprises dry deciduous, Chir pine, Sal (2140sq.km) and thorny forest (43 sq.km) mostly of xerophytic species and sub temperate forest are various species of pines, oaks and broad-leafed species grow. The forests of Himachal Pradesh are not only of importance for the state, but also have a strong influence on the ecology, climate and bio resources of the neighbouring states of Punjab, Haryana and Rajasthan.

The most of village in the state are either adjacent to enclosed the forest. It is deeply integrated with the livelihood of the local people. They depend on the forests for the construction of houses, firewood, agricultural implements, fodder and a variety of the other products and services, including certain medicinal herbs. Some of the users of forest products feel equally responsible for their conservation and the regular regeneration of forest. The timber distribution to local people is harvest timber legally in forests near to places of habitation, for the constructing their own houses and the timber distribution is more of a harvesting policy.

Table 1: Species with family

Species (Scientific Name)	Common Name	Family
Cedrus deodara	Deodar	Pinaceae
Dalbergia latifolia	Rose wood	Fabaceae
Eucalyptus teriticornis Sm.	Nilagiri, Forest red gum	Myrtaceae
Pinus patula	Maxican weeping pine	Pinaceae
Pinus roxburghii	Chirpine	Pinaceae
Pinus wallichiana	Blue pine	Pinaceae
Toona ciliata etc.	Tooni	Meliaceae

Distribution

The major timber species in Himachal Pradesh are conifer viz, *Cedrusdeodara, Pinus roxburghii, Pinus wallichiana, Piceasmithiana, Abiespindraw, Abiesspectabilis, Cupressus torulosa,* etc. are distributed to parts of Chamba, Kangra, Mandi, Bilaspur, Solan, Sirmour, Kinnaur and some parts of spiti.

Commercial Importance

Timber has a wide uses in construction and industrial level, about 40 per cent of the total timber are removed from the forests all over the world. There are various types of timber products like plywood, fiber boards, laminates, Particle boards and Veneers.

Timber- Wood is used for the commercial purpose like making furniture and other type bridges, boats, Houses, etc.

1) *Cedrus deodara*:

It is a most durable and strongest coniferous timber species. It is used as valuable construction material and the commercial uses such as railway sleepers, floor-boards, beams, posts, door and window frames and shingles. It is also used for bridge construction, furniture, electrical poles, battery separators and second grade pencils.

2) *Dalbergia latifolia*:

It is very durable, Fragant and strong wood species. These species have various commercial use for industry level to make premium-grade furniture, paneling, veneers, and interior and exterior joinery and the other uses are include knife handles, musical instruments, agricultural implements calico-printing blocks, mathematical instruments, and boat keels and screws. Fine furniture, decorative veneer, specialty items, joinery, bedroom suites, figured veneer, living-room suites, office furniture, tables.

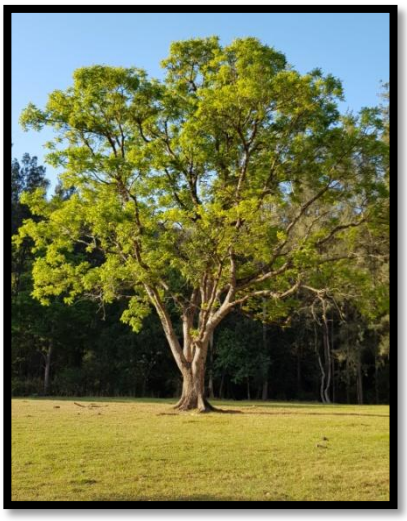
3) *Eucalyptus teriticornis* Sm.:

Eucalyptus species wood is the most durable, strong, hard and tough. It is very useful tree species and also used to commercial purpose like construction, mining timber, poles, stakes, boxwoods, bridge timber, railway sleepers and wharves and other purpose are flooring, vehicle bodies, furniture, handles, ladders, sporting goods, agricultural implements, veneer, plywood, core stock, matches, joinery, vats, toys, novelties, turnery and also making to pulp and paper, fibreboard, hardboards and particle boards.

4) Pinus Species:

All Pinus species (*Pinus wallichiana*, *Pinus roxburghii*, *Pinus patula*) to most useful timber species and also commercial uses like Furniture, packaging cases, house fitment, railway sleepers and pulp and paper production, gum and resins, etc.

5) *Toona ciliata*:



It is commercial used for making furniture, house construction, floors, boarding, panels of doors and windows and also for making boats, oars, carvings, musical instruments, masts etc and other used to commercial plywood and grade I moisture proof plywood.

Conclusion

Himachal Pradesh is a predominantly mountainous state and there are four type of forest zones. Sub- tropical, sub- temperate, wet- temperate and dry temperate. It comprises dry deciduous, chir pine, sal and thorny forest. The most of villages in the state are either adjacent to enclosed the forest. The major timber species in Himachal Pradesh are conifer viz, *Cedrusdeodara*, *Pinus roxburghii*, *Pinus wallichiana*, etc. Wood is used for the commercial purpose like plywood, fiber boards, laminates, Particle boards and Veneers, etc.

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SUSTAINABLE FOOD PACKAGING: AN INTEGRATIVE FRAMEWORK

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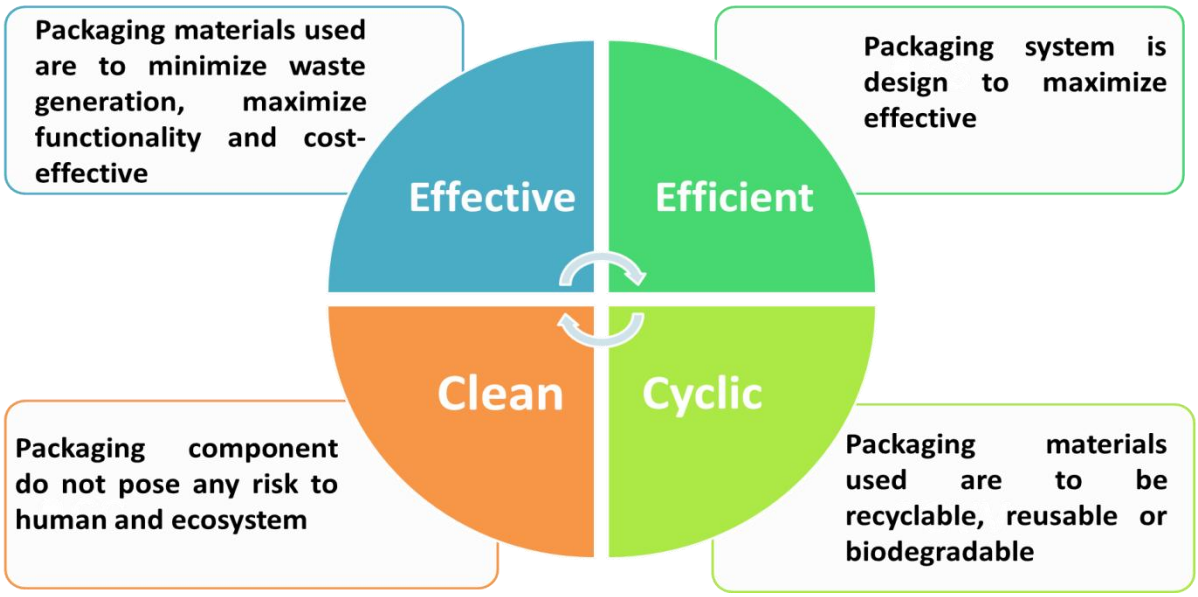
Innovative sustainable packaging is intended to address waste and loss reduction by preserving food quality. It also helps keep food safe by preventing food-borne diseases and chemical contamination. It should deal with the long-term, important problem of plastic trash piling up in the environment. Packaging is one of the most important parts of keeping food fresh. It does this mainly by controlling the exchange of gases and vapours with the outside air. This helps keep food fresh during storage, prevents food-borne diseases and chemical contamination, and extends the shelf life of food.

When food and its packaging are thrown away together, it makes the environment go terrible. Between 2015 and 2016, the amount of plastic made went up by 4.2%, to 335 million tonnes. After a single and very short use as food packaging, 40% of the plastic ends up in a landfill, which is equivalent to 9 million tonnes of plastic packaging waste that will end up in soils. Another 32% leak out of collecting and sorting systems and end up in the soil and ocean as well (Jambeck et al., 2015). This marine and soil litter first breaks down into micro-sized particles and then into nano-sized particles. Since these particles are so small, they can easily get into living things like fish and move up the food chain, all the way to humans, where they have very bad long-term effects. If production and use keep going in the same way and nothing is done, there may be more plastic in the ocean than fish by 2050.

Sustainable Packaging

Sustainable packaging means making packaging film out of materials that can be recycled. It also means using life cycle assessments and life cycle inventories to make sure that the packaging has as little of an impact on the environment as possible. Packaging that meets the criteria set out by the Sustainable Packaging Coalition is considered sustainable.



- Throughout its whole lifespan, beneficial, risk-free, and healthy for consumers, communities, and the environment;
- Complying with market requirements in terms of both performance and price;
- Renewable energy sources used in the sourcing, manufacturing, transporting, and recycling of the product;
- Maximising the use of materials derived from sources that are either renewable or recycled;
- Manufactured with the use of clean production methods and industry-standard processes;
- Produced with materials that are risk-free in any and all possible scenarios regarding their end of life;
- Physically constructed to make the most efficient use of resources and energy;
- Effectively collected and put to use in closed-loop cycles, whether biological or industrial in nature.

Eco-friendly Food Packaging

1. Glass packaging

In the United States in 2010, 9.36 million tonnes of glass packaging waste was produced, and 33.4% of the used material was recycled, making glass the most recycled packaging material in terms of weight recovered (EPA, 2010). A 10% cullet addition to recycled glass reduces energy use by 2.5%. Glass bottles are technically recyclable indefinitely, however only around 75% are recycled since the remaining 25% are lost or

broken in the process. Glass is heavier than other packing materials, therefore transporting it uses 5–6% of the total energy consumed, making it appear more expensive than transporting other materials.

2. Metal packaging

The good news is that cans made from recycled materials use as little as 4-8% of the energy necessary to create the equivalent cans from bauxite ore. Metal containers are a fantastic choice for recycling because they are inexpensive and infinitely recyclable. When compared to natural aluminium production, recycled aluminium can save 70-90% of the energy. Aluminum can be easily separated from other metals during the recycling process. Iron and other ferrous metals can be separated using a magnetic separator or flotation since they are lightweight and not magnetic. Internal coatings, ink, and any other organic pollutants are eliminated throughout the recycling process.

3. Paper Packaging

Paper is a superior material since it can be recycled and decomposed without much effort. Paper is reused and recycled at a rate of 80% and 20%, respectively. Over the past decade, there has been a rise in the percentage of recycled paper and paperboard. There were 37.7 million tonnes of paper and paperboard packaging waste in 2010. Of this, 71.3% was recycled (EPA, 2010). Due to the potential presence of contaminants introduced during the recycling process, recycled paper is unsuitable for use in most food contact packaging applications. Paper that has been recycled is never used for serving or packaging food. Physical and mechanical properties can be optimised by blending virgin and recovered fibres in varying quantities.

4. Plastic packaging

Gas from natural gas processing, as well as feedstock derived from refining crude oil, is used in the production of plastic. We all know that the extraction of oil and natural gas can have serious consequences for the surrounding ecosystem, An EPA research from 2014 found that recycling rates for plastic were only 9.5%, with 15% being burned for energy and the remaining 75.5% being dumped in landfills. PET recycling rates in India are the highest in the world. Of all PET bottles in India, 42% are recycled, 38% are sent to landfills, and 20% are incinerated.

Biodegradable and Compostable Food Packaging

Natural biopolymers developed from renewable sources that are biodegradable seem to be a promising alternative to traditional plastics in light of growing concerns about waste disposal issues and the environmental effects of plastics based on petroleum. Additionally, there has been a significant rise in oil prices recently. These facts have raised interest in biodegradable polymers made without petroleum. Biodegradation occurs as a result of the action of enzymes and/or biochemical deterioration linked to living organisms, and biodegradability depends instead on the chemical structure of the polymer and the environmental circumstances rather than the sources of the raw materials used to produce the polymer. Chemical structure, such as the chemical linkage, pending groups, etc., is related to susceptibility to degradation and environmental circumstance is related to living organisms.

It might be difficult to use biodegradable packaging materials if you want to preserve their mechanical and barrier qualities during the product's shelf life and, ideally, have them decompose swiftly after use. In filling and sealing machinery, the materials should ideally perform similarly to conventional packaging while costing the same. According to their place of origin and technique of synthesis, bio-based biodegradable polymers can be divided into three major types (van Tuil et al., 2000).

1. Directly removing or extracting polymers from biomaterials (for example, starch, cellulose, casein, etc.).
2. Monomers made from biomaterials are converted into polymers using the standard chemical synthesis process (for example, polylactide polymerized from lactic acid monomers).
3. Polymers made by microorganisms directly (for example, polyhydroxyalkanoates).

Biodegradable Polymers from Agricultural Crops

This category includes, for instance, starch-based polymers. Starch is a cheap, readily available, and eco-friendly material. When it comes to bioplastics, corn starch is by far the most popular option. Starch films are hydrophilic and have low mechanical strength if left unaltered. Forget about using them in any sort of packaging; they don't cut it. Biodegradable plasticizers such as glycerol and other low molecular weight polyhydroxy compounds, polyethers, etc., can reduce the brittleness of starch-based bioplastics (van Tuil *et al.*, 2000).

Plants produce a variety of polysaccharide resources, the most common of which being cellulose. Cellulose is a linear polymer composed of very long macromolecular chains made up of glucose monomers. Cellulose has many undesirable properties, such being extremely crystalline, brittle, infusible, and insoluble in all organic solvents (Chandra et al., 2007). Chemically modifying cellulose to make it soluble, followed by regeneration of the cellulose after it has been formed into film, yields cellophane films.

Biodegradable Polymers Synthesized From Bio-Derived Monomers

- **Polylactic acid (PLA)**

PLA is a biodegradable polymer used in food packaging. PLA is created chemically by starting with simple sugars derived from biomass and fermenting to lactic acid. The most popular method for producing PLA is ring opening polymerization by condensation of lactide with metal catalyst tin octoate at high temperatures but less than 200^{o}C. PLA is currently industrially processed using the same technology as traditional petroleum-based thermoplastics. It is marketed for single-use packaging applications such as bottles, cold drink cups, thermoformed trays and lidded containers, blister packages, overwraps, and flexible films. PLA biodegradability improved by grafting with chitosan. Polylactic acids offer good moisture and oxygen barrier qualities and are currently used in bakery and confectionery wrappers, paperboard coatings for cartons, and water bottles.

Biodegradable Polymers Produced Directly By Microorganisms

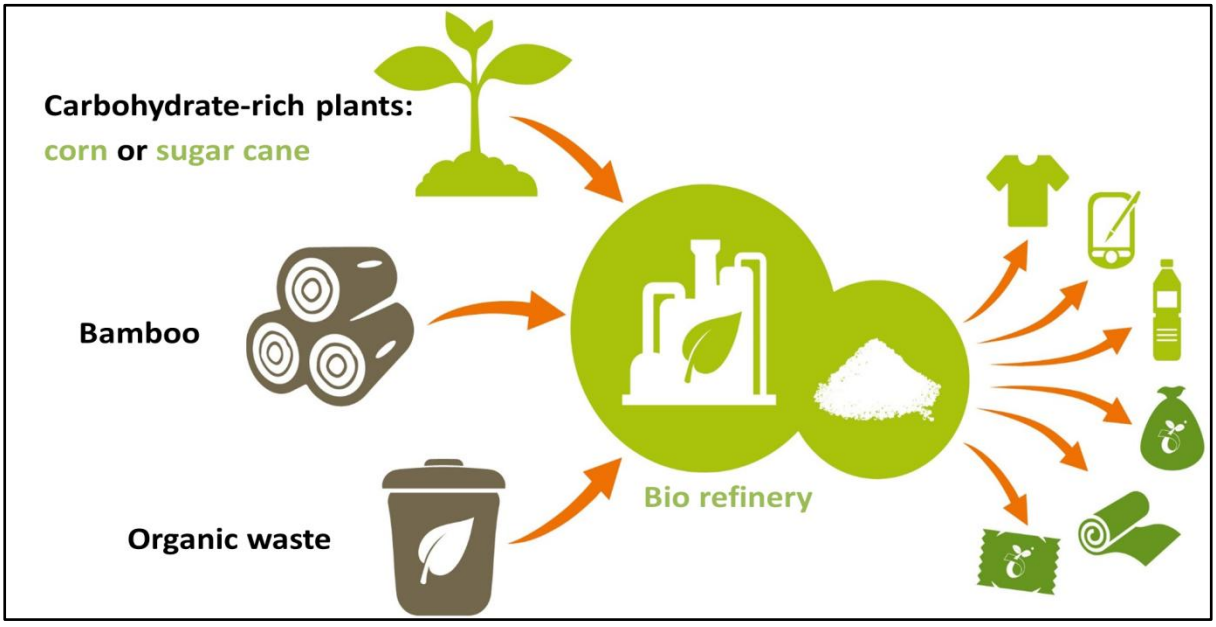
- **Polyhydroxybutyrate**

Bacteria make natural polyesters called poly (β-hydroxy-alkanoate) s (PHAs) from sugars or lipids. In response to nutritional constraints, bacteria produce and store PHA polymers as intracellular food and energy. Bacteria can store up to 60–80% of their weight in PHA to avoid hunger in the absence of key macro-elements like phosphorus, nitrogen, trace elements, or oxygen. Bacteria, fungi, and algae in different conditions break down PHAs. Poly(hydroxybutyrate) (PHB), the simplest and most common PHA, has excellent crystallinity and good gas barrier performance, making it popular for food packaging. It's possible that combining PHB with other polymers will make its qualities better.

Synthetic Biodegradable Polymers

Synthetic biodegradable polymers derived from petrochemical feedstock's with hydrolytic microbial attack-prone groups. Polycaprolactone (PCL) is a semi-crystalline aliphatic polyester with a low melting point (60℃). It degrades fully in marine, sewage, sludge, soil, and compost habitats. Another synthetic biodegradable polymer that is entirely soluble in water is polyvinyl alcohol (PVOH). Since 1970, researchers have been investigating the use of starch and PVOH as biodegradable packaging material. It is currently utilised to make starch-based loose fillers as a replacement for expanded PS. Polyesters, polyamides, polyurethanes and polyuria's, poly(amide-enamine) s, and polyanhydrides are examples of synthetic biodegradable polymers (Nair & Laurencin, 2007).

Recent Developments in Biodegradable Packaging



1. Maize Plastic: Using an industrial resin called PLA and corn kernels, a number of businesses have produced a biodegradable plastic.

2. Bamboo: Bamboo is one of the plants that grows the quickest on the planet, making it a great substitute for paper and plastic. Australian company Centaur Packaging makes plates, bowls, and cutlery from bamboo.

3. Plant fibres: Biodegradable packing materials are frequently made using cellulose derived from plant stuff.

4. Wood fibres: Paper is made from wood pulp, which is recycled into different paper goods. However, Innovia Films, founded in the UK, uses wood pulp to produce a cellulose-based film that resembles plastic.

5. Mushroom: To package their wares, marketers are utilising mushrooms. To replace polystyrene/styrofoam packaging, mycelium, the portion of mushrooms and other fungus that consists of thread-like roots, is blended with seed husks. (GoG, 2017 Agro and Food Processing).

Conclusion

Plastic packaging is not sustainable because it is difficult to recycle and detrimental to the environment. It is best to choose recyclable packaging materials that are kind to the environment, such as glass, metal, and paper, to conserve resources and have the fewest negative effects on the environment. The issue of packaging waste can be lessened by using recently created biodegradable packaging made from dairy or agricultural waste.

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