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APPLICATION OF REMOTE SENSING & GIS IN FOREST CHANGE DETECTION OF KATEPURNA SANCTUARY, AKOLA (MAHARASHTRA) AND IT'S IMPACT ON RURAL LIVELIHOOD

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Abstract

Rural India has vast natural resources and one of the important natural resources in rural area is the forest. Rural India has an abundance of forest and they have been dependent on forest for their livelihood. Forest is one of the vital components of the ecosystem and the anthropogenic activities as well as the natural processes are continuously changing its cover. It is a fact that human life is dependent on the forests. But anthropogenic factors had played a degrading role in these biodiversity rich forests. To protect the rich biodiversity Wildlife Sanctuaries has been notified by our Government. Consequently, proper monitoring of forest cover becomes a matter of great concern. , and hence it turns out to be the theme of the study. This study it attempted whether due to notification as wildlife sanctuary an enhanced protection whether there has been an increase of forest or not. Hence, the major objective of this study is to detect the magnitude of forest cover change in the duration of the last 10 years (between 2008 and 2018) in Katepurna Wildlife Sanctuary, India.

The study uses a series of topographical sheets of the open series map having scale 1:50,000, and satellite imageries from Landsat-8 to recognize forest cover changes during the chosen period. A very simple method is used here to complete the study which requires generation of Land Use/Land Cover (LU/LC) map and Normalised Difference Vegetation Index (NDVI) model of the study area. On the classified map, accuracy assessment is performed, which produced error matrices and overall accuracy, the calculated overall accuracy is found 87.18% for 2008 and 86.11% for 2018. The objective of detection of net forest cover change area is done by observing the change in light vegetation and dense vegetation areas. This study shows that area was well protected and the vegetation regeneration was improved. The growth was better for the wildlife as the vegetation improved inside the wildlife sanctuary. The negative was the rural people were not allowed to graze the animal inside the sanctuary and had look for an alternative. Hence, it is a positive sign of the wildlife manager so that he can have the area for the wild animal which feed on grasses and plants

Key words : Land Use/Land Cover (LU/LC), Normalized Difference Vegetation Index (NDVI), Remote Sensing (RS), Geographic Information System (GIS).

1.1 Introduction

'India resides in rural area' is a famous anecdote. Truly Indian economy backbone i.e. agriculture is carried out in the hinterland of our country. The foods we have are derived mainly from the rural area. The forest cover and the natural resource are found abundant in the villages of India. This vegetation or the forest area is source for food for the wildlife as well as the local domestic animals. These resources should be used in a sustainable way so it is available to all the stakeholders in a measured amount.

Earth's vegetation plays a major part in shaping the composition and character of the land surface. Information about the vegetation cover is an indirect indicator of land-use and is highly relevant for environmental studies. Forests are vital for life, home to millions of species, they protect the soil from wearing away, create oxygen, store carbon dioxide, and help control climate. Forests are also essential for us to survive as they supply us food, shelter, and medications as well as many other useful materials. They also purify the air we breathe and water that we require to live.

Mapping of landscape processes like vegetation, land use/land cover, soil survey, the geological mapping is traditionally done based on hierarchical systems. Depending on the aim, diagnostic features or measures are preferred. The data required also depends on the aim of the survey, though different studies may employ the same data or different ones. Various methods are available to identify the alteration in the earth's surface, all treating the environmental variables as a set of patterns occurring at specific scales.

Now getting to the topic, i.e. the change detection in forest cover, before dealing that some basic things should be read first.

The use of GIS and remotely sensed data in mapping different natural resources management and environmental modeling are gaining appreciation in recent years. The majority of work in remote sensing was mainly focused on environmental studies in the last few decades. The implication of Remote Sensing and Geographic Information System to forest cover change and urban planning is now getting attention and interest among GIS and remote sensing professionals. Remotely sensed data provide advantages like synoptic coverage, consistency in data, global reach and readability, precision and maximum accuracy in data provision.

1.2 Aim

To precisely demarcate the net change area in the forest cover in Katepurna Wildlife Sanctuary, India by the help of temporal satellite data.

1.3 Study Objectives

The study compares two different satellite images and analyses their results to come up with an answer which can provide the end–users, using this technique, about the optimal method, spatial resolution and spectral band which can be used to detect the change in forest cover type found in the study area.

This will help not only to save time and effort but also help reduce the complications of large data handling and processing.

Main objective

- The main objective of the study is to compare the satellite images and different models (NDVI and LULC) for analyzing the forest cover change at different resolutions.

Sub-Objectives

- To make the Normalized Difference Vegetation Index (NDVI) of the study area.

2.1 Materials & Methods

Study Area

Katepurna Sanctuary is situated in the district of Akola, which comes under the Vidarbha region. Akola district has an area about 10,606, Sq. Km and has about 812 Sq. Km. of reserve forest. The

total area of the Sanctuary is 73.69 Sq. Km. The temperature ranges for 21°C to 45°C. The forest type is dry deciduous type. The sanctuary occupies a large part of catchment area of the Katepurna reservoir. Due to the presence of large amount of water, birds get attracted towards the place. The period between Octobers to June is the ideal time for visiting the place. Flora- The place is very rich in vegetation cover and mainly comprises of southern tropical deciduous forests.
forests.

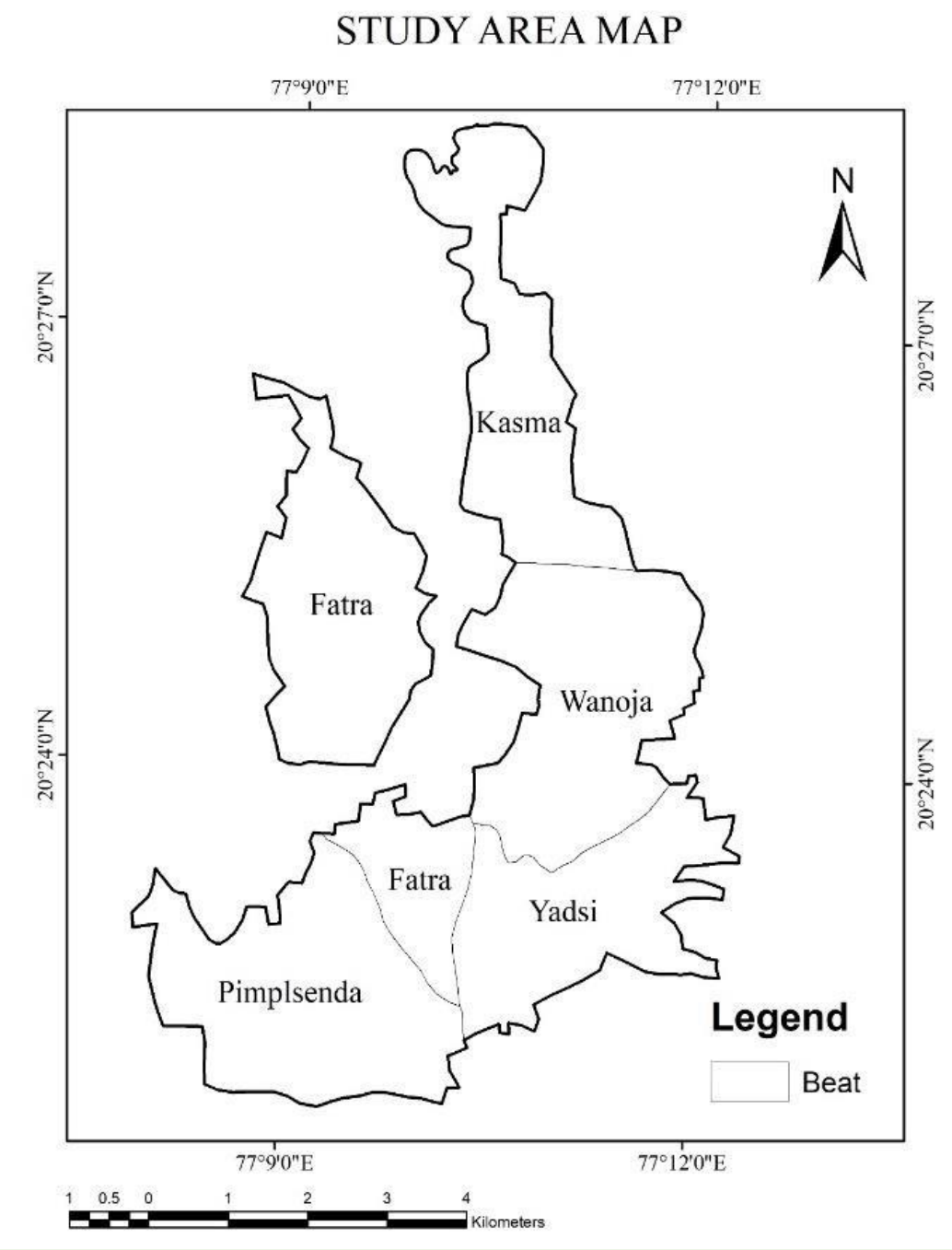


Fig-1. Location map of the Katepurna Sanctuary

In Katepurna Wildlife Sanctuary there is no large human settlement inside the sanctuary area. Only three villages are inside the sanctuary namely Devari and Chichkhed Band. But there are twelve villages on the fringes of the sanctuary which make the area susceptible. There are three villages

and two more cultivation areas inside the sanctuary. Once they are re-located outside the sanctuary area, any likely activity forest offence in future will be stopped.

a) The major part of the sanctuary area is largely free from illicit felling. However the peripheral parts adjoining to villages are susceptible for illicit cutting for timber and fuel wood.
b) The villagers on the periphery do indulge in illicit removal of tendu leaves, thatched grass, flowers and fruits.
c) Firewood wood collection is not allowed in the Wildlife Sanctuary area.
d) The Wildlife Sanctuary area is susceptible to fire during dry season.
e) The Wild Life Sanctuary is susceptible to grazing as the cattle of the villages tend to sneak in the area.

2.2 Satellite Imageries and Collateral (Ancillary) Data

Satellite imageries and ancillary data were collected in order to identify successive forest cover changes. The image data that was used for this study are Landsat TM & OLI, Topographic maps of Open Series at the scale of 1:50,000 were procured from the Survey of India (SOI), Study area boundary was generated from collateral or ancillary data that was map of the Katepurna Sanctuary, the study area.
Google Earth along with ground truthing is also most important tool for ground assessment, or to make ground verification.

The majority of primary data necessary for the study has been extracted from satellite images. Forest cover types at various times have been extracted from Landsat.

The Open Series Topographic maps of 1:50,000 scales were obtained from Survey of India (SOI) and Drainage, road networks, railway network, specific locations and places were generated from topographic maps through manual digitizing and geo-referenced according to WGS 1984 UTM ZONE 45N.

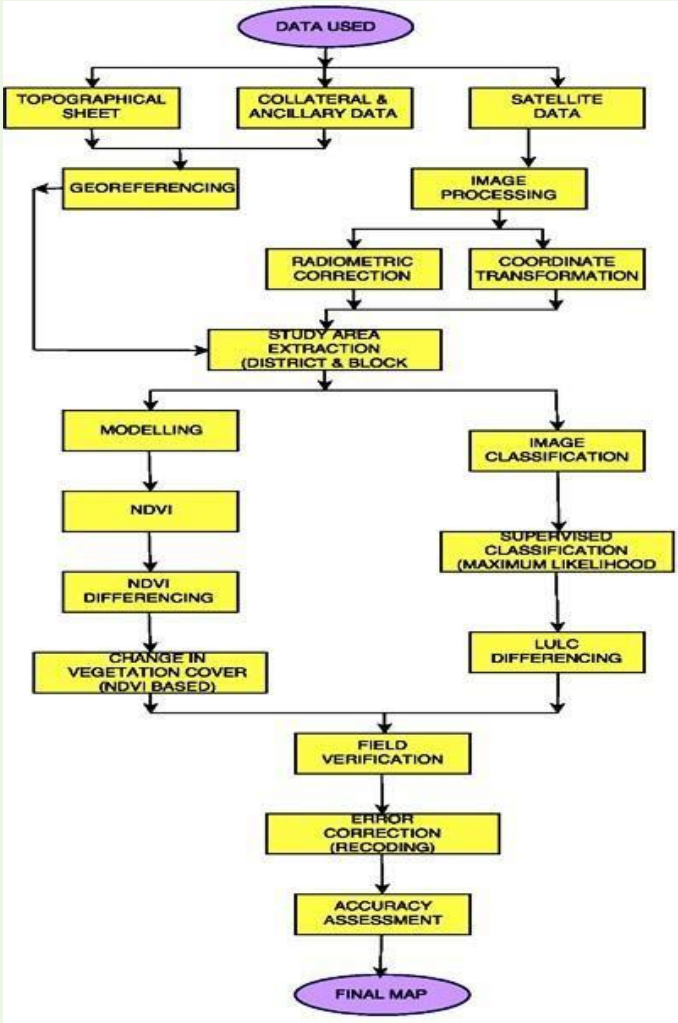
All the data and the softwares that are used in the study are enlisted in the table 1.

Table-1 : List of data sources and material

I. SATELLITE IMAGES				
Sensor	**Path**	**Row**	**Spatial resolution**	**Source**
Landsat TM	140	044, 045	30 x 30 m resolution	USGS
Landsat 8 OLI	140	044, 045	15 x 15 m resolution	USGS
II. TOPOGRAPHICAL MAPS				
			Source	
Topographic Map			SOI	
III. SOFTWARES USED				
1. ERDAS Imagine 2014 : used for Georeferencing, Resampling, and Image Processing and Image classification. 2. ArcGIS 10.3 (Arc Map) : used for GIS analysis and mapping. 3. Other software used in this study include Google Chrome, Earth, Microsoft Word, and Excel.				

2.3 Methodology

The methodological flow chart of the study, represents all about the procedure, methods, and steps used to achieve the main aim of the study that is to map the change in the vegetation cover in Katepurna Sanctuary in 10 years from 2008-18.



2.4. Modelling

The Model Maker tool of the ERDAS IMAGINE 2014 software is used to make the models required for the study. The required model for the study NDVI (Normalised Difference Vegetation Index) is the required model for the study.

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum and is adopted to analyze remote sensing measurements and assess whether the target being observed contains live green vegetation or not.

$$NDVI = \{(IR - R)/ (IR + R)\}$$

- IR = pixel values from the infrared band
- R = pixel values from the red band

This index outputs values between -1.0 and 1.0, mostly representing greenness, where any negative values are mainly generated from clouds, water, and snow, and values near zero are mainly generated from rock and bare soil. Very low values (0.1 and below) of NDVI correspond

to barren areas of rock, sand, or snow. Moderate values (0.2 to 0.3) represent shrub and grassland, while high values (0.6 to 0.8) indicate temperate and tropical rainforests.

The NDVI technique is used for extracting the various features presented in the Satellite image of Katepurna sanctuary. Vegetation indices allow us to delineate the distribution of vegetation and soil based on the characteristic reflectance patterns of green vegetation.

2.5. NDVI differencing

After making the NDVI model of both the satellite images of the study area of 2008 and 2018 Image Difference tool of ERDAS IMAGINE 2014 is used to produce the difference image of the two NDVI model images. The difference image is produced by keeping a threshold of 10% that the image will show those areas which have at least 10% of increase or decrease in the pre-existing feature. The image shows four types of areas increased, some increase, some decrease, decreased. But this differenced image does not say about the exact or net change in vegetation only. Because the NDVI describes vegetation along with the other features.

2.6. Image Classification

Image classification techniques group pixels to represent land cover features. The land cover could be forested, urban, agricultural and other types of features. There are three main image classification techniques.

Image Classification Techniques in Remote Sensing :

2.7. Unsupervised Image Classification

Pixels are grouped based on the reflectance properties of pixels. These groupings are called “clusters”. The user identifies the number of clusters to generate and which bands to use. With this information, the image classification software generates clusters. There are different image clustering algorithms such as K-means and ISODATA. The user manually identifies each cluster with land cover classes. It’s often the case that multiple clusters represent a single land cover class. The user merges clusters into a land cover type. The unsupervised classification image classification technique is commonly used when no sample sites exist.

Unsupervised Classification Steps:

- Generate clusters
- Assign classes

2.8. Supervised Image Classification

The user selects representative samples for each land cover class in the digital image. These sample land cover classes are called “training sites”. The image classification software uses the training sites to identify the land cover classes in the entire image. The classification of land cover is based on the spectral signature defined in the training set. The digital image classification software determines each class on what it resembles most in the training set. The common supervised classification algorithms are maximum likelihood and minimum distance classification. The image classification was performed by the help of Classification tool of the Raster menu of ERDAS IMAGINE 2014. Then several training sites representing different features are selected. Then on the basis of those selected training sites signature file is created. And lastly, supervised classification is performed by using Maximum likelihood algorithm.

2.9. Accuracy Assessment

The increased use of remote sensing data and techniques has made geospatial analysis faster and more powerful, but the increased complexity also creates increased possibilities for error. In the

past, accuracy assessment was not a priority in image classification studies. Because of the increased chances of error presented by digital imagery, however, accuracy assessment has become more important than ever (Congalton 1991). A common tool to assess accuracy is the error matrix. Error matrices compare pixels or polygons in a classified image against ground reference data (Jensen 2005). These matrices can measure accuracy in several ways. The overall accuracy of the classified image compares how each of the pixels is classified versus the actual land cover conditions obtained from their corresponding ground truth data. Error matrices have been used in many land classification studies and they were an essential component of this study. The change detection method was applied in different application areas ranging from monitoring the land cover and land use change using satellite imageries to difference detection on risky locations. A change detection matrix was shaped with the help of ERDAS IMAGINE software. The change in the forest cover based on the Land Use/Land Cover is shown with the help of changing image visualization properties in ArcMap10.3 and then a proper map showing the net change in the forest cover of the study area.

2.10. Field Verification

Ground truth refers to information that is collected "on location." In remote sensing, this is especially important in order to relate image data to real features and materials on the ground. The forest area surrounding the Sanctuary area is mostly degraded 'C' class forest. Naturally the area is not self-sufficient eco-system with its flora and fauna. Though the topographical features are same but vegetation of surrounding forest area defers in crop condition. Isolated populations of wild animals do occur in the adjoining forest areas. During summer, water availability is limited. The wild animals do have negative impact on the adjoining agricultural areas in certain periods of the year. The collection of ground-truth data enables calibration of remote-sensing data, and aids in the interpretation and analysis of what is being sensed.

More specifically, the ground truth may refer to a process in which a pixel on a satellite image is compared to what is there in reality (at the present time) in order to verify the contents of the pixel on the image. In the case of a classified image, it allows supervised classification to help determine the accuracy of the classification performed by the remote sensing software and therefore minimize errors in the classification.

When performing LU/LC classifications, one needs ground truth data to provide an unbiased reference necessary to conduct accuracy assessments. Because landscapes can change rapidly, it is important that training data and ground truth data are acquired at dates as close to each other as possible. While it is ideal to acquire ground truth data by visiting sites on the ground and performing direct observations, there can be factors that prevent gathering such in situ measurements. These limiting factors include prohibitive costs (Alrababah and Alhamad 2006), the sheer size of the study area (Hung and Wu 2005), an inability to temporally match ground truth data with acquisition dates for remotely sensed imagery (Madhavan *et. al.,* 2001), and inaccessibility to certain parts of the study area (Hung and Wu 2005, Campbell 2007). When in situ measurements are not possible, many researchers substitute direct observations with imagery that has a much 13 higher spatial and/or spectral resolution than the imagery used for the LU/LC classifications (Jensen 2005).

The same thing is done in this study, the in situ observations by ground truthing and using Google Earth as an ancillary data, ground truthing are used for the field verification purpose. Google Earth provides a very good spatial resolution that is from 15m to 15cm.

2.11. Error Correction

The post-classification correction technique was developed and used to improve the class assignment of a pixel after its initial Maximum Likelihood Classification. The derived LU/LC maps were noisy due to spectral similarity among different classes.

3.1 Result and Discussions

{A} NDVI of 2008 : The NDVI map of Katepurna of 2008 (Fig-2), illustrating vegetation of different health conditions of the forest cover .The image indicates high to low values. The values vary between 0.47 to 0.01. The positive values (0 to 0.47) show healthy vegetation cover of the study area and the negative values (0 to 0.01) show other features of the study area.

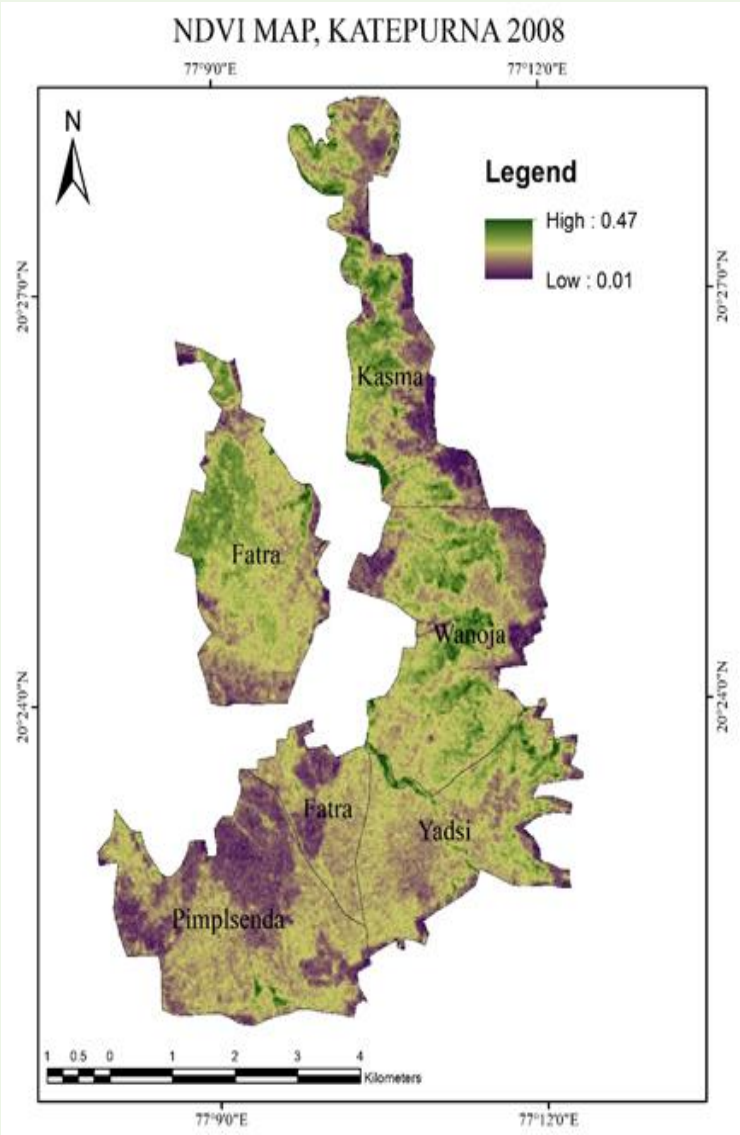


Fig-2- Map showing NDVI of Katepurna (2008)

{C} NDVI Change between (2008-2018) : The comparing NDVI map of two different years (2008 & 2018) indicates NDVI value. The decreases positive value of NDVI indicates the change of healthy and dense vegetation. On the other hand, the increase negative values of NDVI indicates increased the non-vegetated areas. **Fig-3** shows the difference image of NDVI images of 2008 & 2018.The two different NDVI image (2008 & 2018) used to prepare NDVI change map and it's found two different

changed zone namely increase and decrease. NDVI image differencing cannot provide detailed change information, particularly in the study area because it does not have NDVI value different features. It can only give overall information about the healthiness of vegetation cover in the study area based on NDVI value. The negative threshold indicates a loss in NDVI and positive threshold indicates the area of increased NDVI (restoration or healthy vegetation).

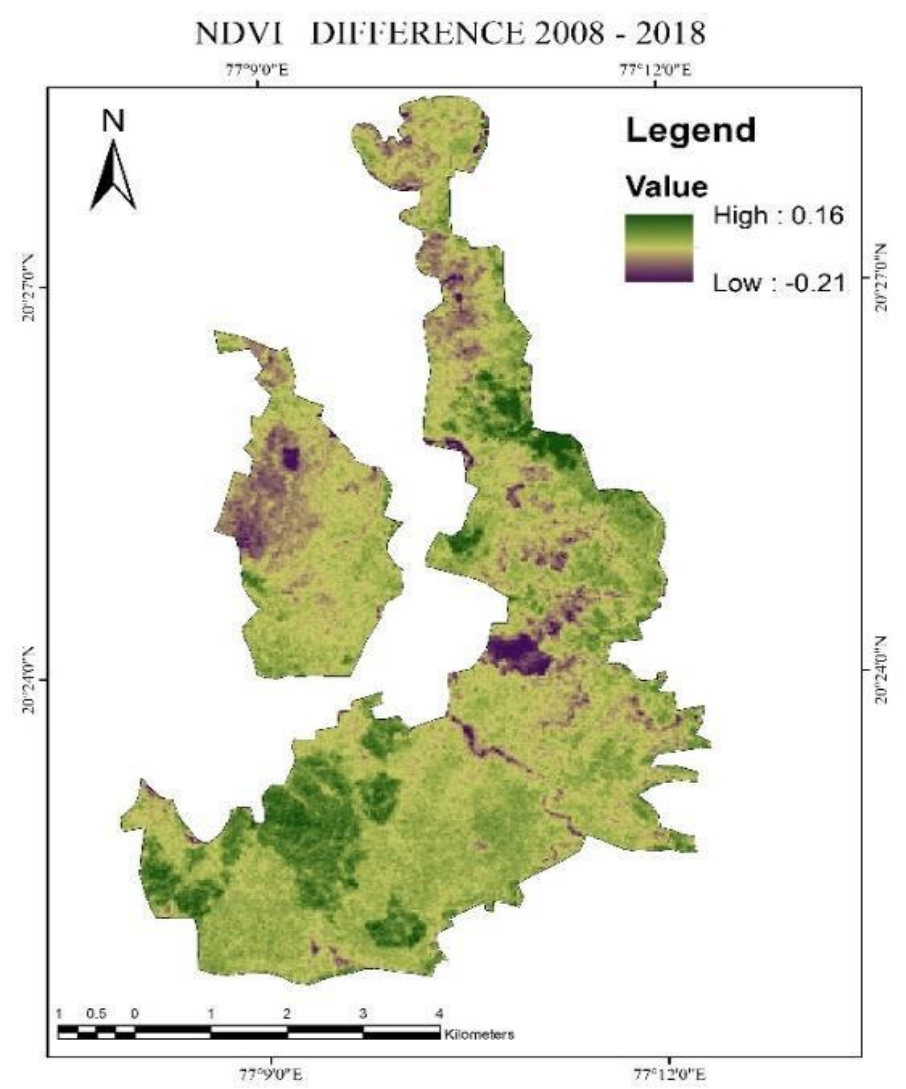


Fig-4- Map showing change detection using NDVI of Katepurna

{D} LU/LC of Katepurna in 2008 : The spatial extent of the 2008 LU/LC map after the Supervised Classification four land cover classes found in the study area **(Figure-5)**. With the wasteland occupying the highest percentage of the area (20.23 km^2). This is scattered approximately throughout the study area. Dense vegetation (9.63km^2), is the next highest area coverage located in the study area. Light vegetation comes next with 4.06 km^2 of the study area.The barren land about 4.45 km^2 of the study area.

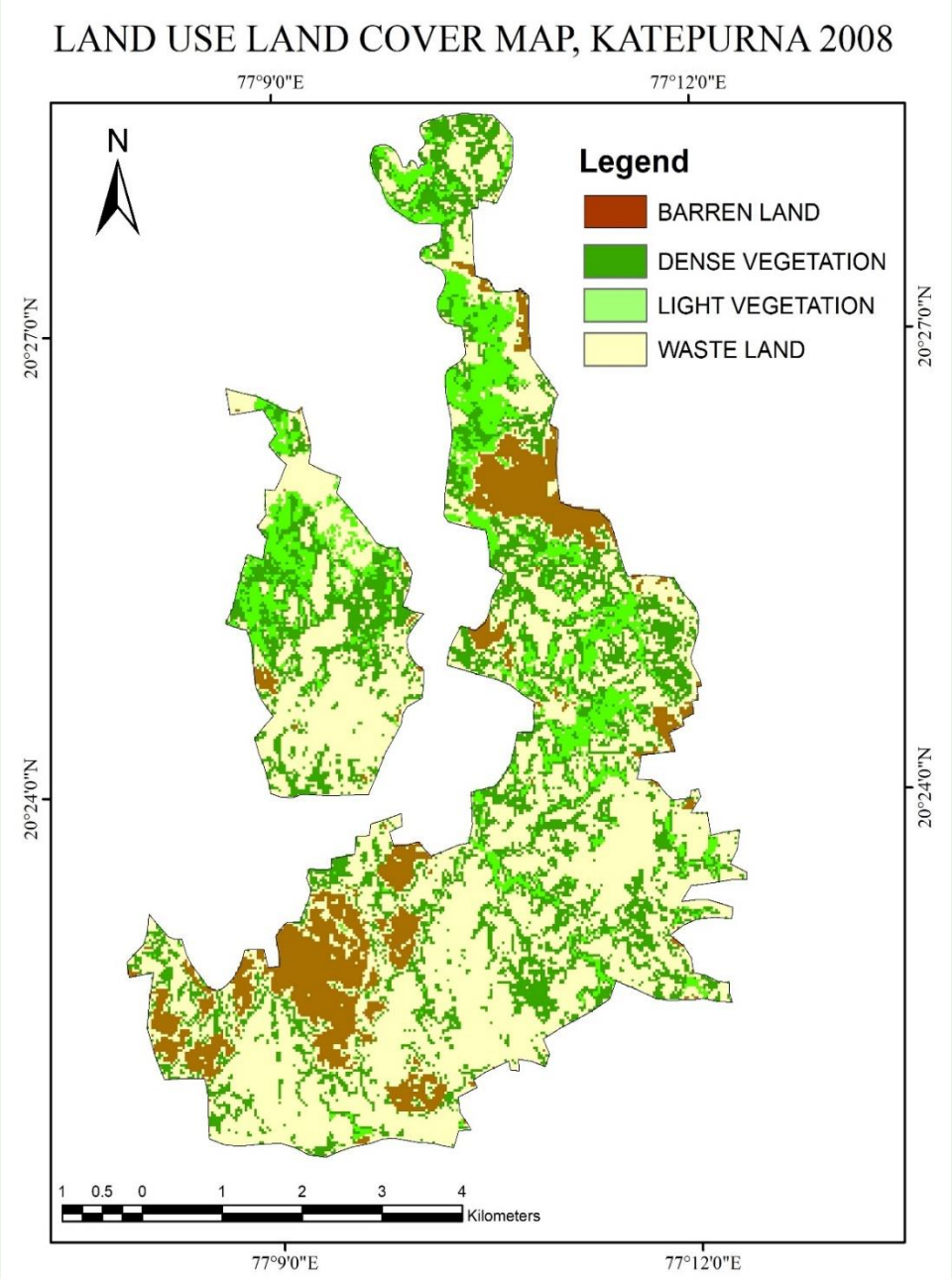


Fig -5- Land Use Land Cover classification of Katepurna of 2008.

Table 2 : Area statistics of the land use and land cover units from 2008 of Katepurna Sanctuary.

Sl. No	Land use and land cover classes	2008	%
		Area (km^2)	Total Area
1	WASTELAND	20.23	53.53
2	DENSE VEGETATION	9.63	25.48
3	LIGHT VEGETATION	4.47	11.83
4	BARREN LAND	3.46	9.16
5	WATERBODIES	0	0
6	ROAD	0	0
	Total :	**37.79**	**100**

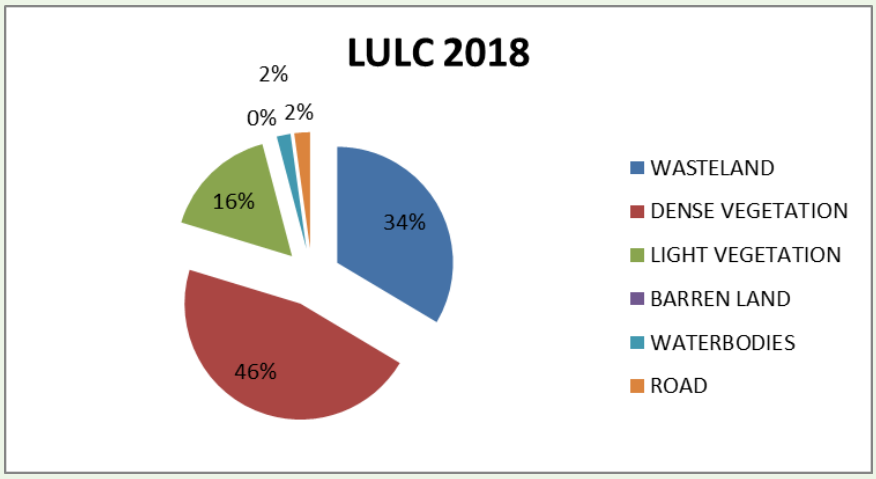


Fig-6 - Pie-Chart of LU/LC classification of Katepurna of 2018

{E} LU/LC of Katepurna in 2018 : Using supervised classification method it was classified into five LU/LC class **(Figure)** found in the study area namely dense vegetation cover 17.44 km2 which are mainly present in the study area. Wasteland covers an area of 12.68 km^2, which is scattered approximately all around the study area. Light vegetation occupies the third largest area coverage as compared to other LU/LC classes having 6.11 km^2 scattered in the entire study area. Water bodies consisting river and surface water cover an area of 0.73km^2 (0.38%) and the road consists of area 0.83 km^2.

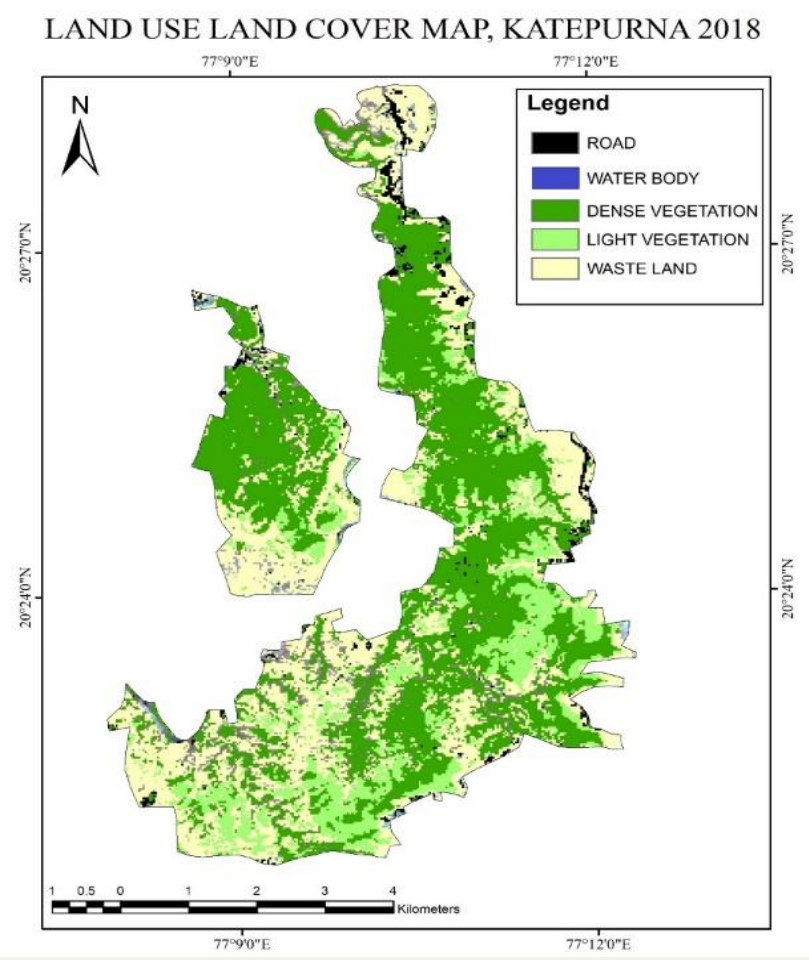


Fig-7 - LU/LC classification of Katepurna of 2018

Table 3 : - Area statistics of the land use and land cover units from 2018 of Katepurna Sanctuary.

Sl. No	Land use and Land Cover Classes	2018	%
		Area(km^2)	Total Area
1	WASTELAND	12.68	33.55
2	DENSE VEGETATION	17.44	46.15
3	LIGHT VEGETATION	6.11	16.17
4	BARREN LAND	0	0
5	WATERBODIES	0.73	1.93
6	ROAD	0.83	2.20
	Total :	**37.79**	**100**

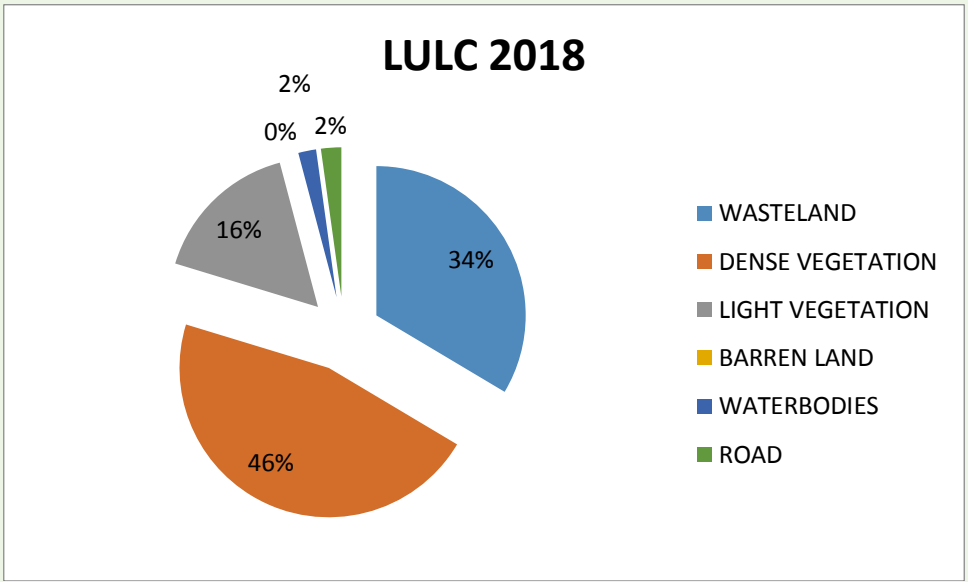


Fig-8 - Pie-Chart of LU/LC classification of Katepurna of 2018

{F} Producer Accuracy

Producer accuracy refers to the number of correctly classified pixels in each class (category) divided by the total number of pixels in the reference data to be of that category (column total).This value represents how well reference pixels of the ground cover type are classified in below(Table 4 & 5)

Table 4: - Confusion matrix for land use and land cover map of 2008 of Katepurna Sanctuary.

Classified Data	Wasteland	Dense Vegetation	Light Vegetation	Barren Land	Row Total	User Accuracy
Wasteland	3708	0	0	0	3708	100%
Dense Vegetation	9	307	15	22	353	86.96%
Light Vegetation	30	23	247	11	314	78%
Barren Land	3	60	9	351	420	83.57%
Column Total	3750	390	271	384	4795	
Producer Accuracy	98.88%	78.71%	91.14%	91.40%		
Over all Accuracy	96.20%					

Table 5: - Confusion matrix for land use and land cover map of 2008 of Katepurna Sanctuary

Classified Data	Dense Vegetation	Waste-land	Light Vegetation	Water bodies	Road	Row Total	User Accuracy
Dense Vegetation	208	11	22	5	4	250	83.20%
Wasteland	17	1305	19	115	0	1456	89.62%
Light Vegetation	0	7	1537	41	11	1596	96.30%
Water bodies	30	9	1	1802	0	1842	97.82%
Road	0	11	27	1078	1391	2507	55.48%
Column Total	255	1343	1606	3041	1406	7651	
Producer Accuracy	81.56%	97.17%	95.70%	59.25%	98.93%		
Over all Accuracy	81.59%						

{G} Over all Accuracy

It is computed by dividing the total number of correctly classified pixels (i.e. the sum of the elements along the major diagonal) by the total number of reference pixels. It showed overall results of the tabular error matrix. The overall accuracies performed in this study period 2008 was 96.20%, in 2018 was 81.59%. As mentioned for reliable land cover classification the minimum overall accuracy value computed from an error matrix should be 80%. However, Foody (2002) showed that this baseline makes no sense to be a universal standard for accuracy under the practical application. This is because a universal standard is not exactly related to any specific study area.

Conclusion

The study significantly focuses on integrated techniques of GIS and remote sensing for forest cover change mapping. The study starts from data extraction up to forest cover changed the mapping. The several methods and procedures used to find the forest cover change detection. In order to explain forest cover change, both NDVI and Land Use/Land Cover classification techniques are used. The post-classification technique used to classify the different year's satellite image to get the quantitatively changed area. The NDVI map does not represent different features of the earth surface, it only shows forest and vegetation covers with chlorophyll content. Particularly, expansion of wasteland was observed in the year 2008 (20.23 km^2) and decline of both forest cover as well as shrub land were observed but in the year 2018 the wasteland areas was declined by 8%. In the year 2008 the wasteland areas is 20.23 km^2, the wasteland in the year 2018 is 12.68 km2 it is being decreased in the area. As in the case of dense vegetation the area is 9.63 km^2 (2008) and in the year 2018 the area is 17.44 km^2 (2018) it is being seen that it may be planted the areas has been increased by 7.81 km^2 whereas the light vegetation (2008) the areas is 4.47 km^2 and the areas in (2018) is 6.11 km^2, so the areas 1.64 km^2 is increased.

Table 6 : Area statistics of the land use and land cover units from 2008-2018 of Katepurna Sanctuary.

Sl. No	Land use and Land Cover Classes	2008	2018	%Increase/ Decrease
		Area (km2)	Area(km2)	
1	WASTELAND	20.23	12.68	-37.32
2	DENSE VEGETATION	9.63	17.44	81.10
3	LIGHT VEGETATION	4.47	6.11	36.69
4	BARREN LAND	3.46	-	-
5	WATERBODIES	-	0.73	-
6	ROAD	-	0.83	-
	Total :	**37.79**	**37.79**	**-**

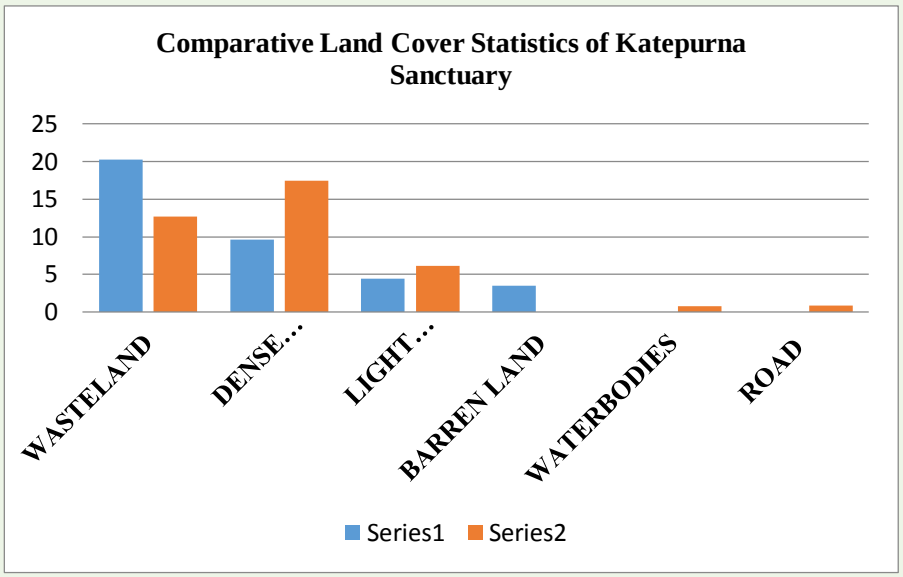


Figure 9. Comparative pie chart of Land Cover Change

Recommendations

From the whole study, GIS and Remote sensing tools are found to be very important tools for forest cover change detection mapping. It has been recognized that the forest cover land of the area has much declined. For the future application of this tool for forest cover change detection and to protect the forest resources of the study area from further depletion in particular, and to use these precious resources in a sustainable way, the following feasible suggestions are forwarded based on the findings and the conclusions were drawn.

- The integrated application of GIS and Remote sensing tools will minimize error for forest resource mapping and management, so it will be carried out in a better way in future.
- It is strongly recommended to local people and the government to take action about forest degradation & unauthorized deforestation and plan for forest restoration.
- Monitoring could be easily carried out.

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DIRECT PLANT PRODUCTION FROM THE AUXILIARY BUD IN YACON (*SMALLANTHUS SONCHIFOLIUS*) IN THE FIELD CONDITION

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Abstract

The direct plant production from the axial bud was established in the field condition in in yacon (*Smallanthus sonchifolius*) for the first time. The fructo-oligosaccharides (FOS), an active component which was enriched in tuber had health benefits. The FOS could potentially reduce glycemic index, body weight, the risk of colon cancer, the control of blood sugar levels, control of cholesterol level including boost up immune system and helping in weight loss. This perennial herbaceous plant, belongs to the family *Asteraceae* was propagated by corms. But the corm production was not fast and easy enough to meet the growing need for QPM. Yacón was also propagated from stem cutting. But the stem cutting destroyed the mother plant. Hence, alternative but efficient propagation technique like direct organogenesis from stem explant and leaf segments was reported through tissue culture which required sophisticated environment. In addition, somatic embryogenesis was also reported through tissue culture recently. Characteristically, a full grown yacon at lower altitude produced 40.51±4.51 axial bud in the Terai zone. The axial bud could be potentially explored for the novel method of QPM production as well as establishment of new plant in the field condition directly in a very low-cost way without destroying the mother plant as well. Moreover, a continuous and exponential process of propagation could be achieved without destroying the mother plant. To the best of our knowledge, the production of QPM from axillary bud is being reported for the first time directly in the field condition in a very simple way.

Key words : *Smallanthus sonchifolius*; Auxiliary bud; Quality planting material (QPM); Field condition.

Introduction

Yacon (*Smallanthus sonchifolius*) was a perennial herbaceous plant from the family *Asteraceae*. Yacon tuber had a medicinal value as it was enriched with fructo-oligosacharides (FOS) which constituted 6.4% to 70% of the dry matter and 0.7% to 13.2% of the fresh weight. The active component, FOS offered an excellent health benefits like reduced glycemic index, body weight, the risk of colon cancer, the control of blood sugar levels, control of cholesterol level, boosting immune system and helping in weight loss. With the increasing demand for yacon in the market due to its medicinal properties, farmers demand for sufficient quality planting material (QPM). Therefore, a better, convenient and effective ways to achieve mass clonal propagation was a relevant issue. Normally, yacon was conventionally propagated by the propagating roots (corms) but corm production was not fast and easy enough to meet the growing need for good planting materials. The reduced flowering emergence as well as subsequent fruit set in the cultivated yacon were

common problem in cultivated *Smallanthus* species (Leon., 1964). Moreover, high proportion of the seeds were also non-viable and/or low vigor. Aerial stem cuttings were also reported for its propagation conditioned with desiccation protection (Robinson, 1978; Castañeto and Inhumang, 2004). But this process needs the destruction of the mother plant. As alternative for multiplication and maintenance of germplasm of this species, efficient in vitro techniques have already been reported (Corrêa et al., 2009). Direct organogenesis from stem cuttings and leaf segments had been reported as a tool for germplasm conservation (Estrella and Lazart, 1994; Niwa, 2002). Even, somatic embryogenesis was developed for this species (Corrêa et al., 2009). The present innovation identified a very simple, low-cost process for clonal propagation in the field condition from the auxiliary bud is being reported for the first time. The innovation could be adopted as such by the farmers or growers or entrepreneurs directly without need any costly establishment.

Material and methods

Field experimental location and mother plant : The yacon plant was planted in first week of November and maintained in the field located at 28°19'N latitude and 89°23'E longitude and at an altitude of 43 m above the mean sea level. The plant was sown in ridge valley to avoid any excess water. The growing plant characteristically produced axial buds which were explored for new plant.

Harvesting the axial bud : The axial bud was harvested periodically as mother plant produced it continuously. The axial bud having two nodes will be considered for the QPM production.

Treatment of axial bud : The axial bud was harvested from the growing plant and touch with auxin enriched power (cutting aid).

Initial environment in the filed condition : The initial environment was crucial for root initiation. The axial bud was sensitive to humidity shock, therefore initial humid environment maintenance was mandatory for survival in the field condition. The transparent plastic cup was used for this purpose. During planting the axial bus, watering followed by covering with plastic cup was maintained.

Figure 1. The process for QPM production directly at field condition. The harvested axial bud was touched with toto-root powder at the cut end and incubation of planted axial plant in humid condition in transparent box for 14 days. The cup was removed and allowed to grow without cup.

Discussion

Tuber corm was explored for the QPM production in yacon. The process for QPM was not sufficient for fulfilling the demand. QPM production was evidenced from hormone supplemented MS media from explant. In addition to all, a new process for QPM production is being reported for the first time in a very convenient way in the filed condition. The steps for achieving the new plant regeneration from axial bud from the existing plant directly on soil through treatment of hormone, moist soil and using transparent plastic cup. First of all, the axial bud having minimum two nodes were harvested by cutting with knife. The cut end of the axial bud touched with the auxin enriched powder (**Figure 1**). The auxin enriched powder treated axial bud was transplanted into field directly (**Figure 1)**. The transparent plastic cup was used to cover the transplanted axial bud (**Figure 2**). After 14 days later, the plastic cup was removed. The 42 days plant was snapshotted (**Figure 4**) and very importantly, all the plant was survived.

Figure 2 : Close and field view of assembly of planted axial bud.

Experiment was carried out to evaluate the merit of auxin enriched powder in initiating root development (**Figure 3**). The axial bud without auxin enriched power was considered for this experiment. From the result, it was evidenced that auxin enriched power induced root initiation from nodal region of the axial bud (**Figure 3**). The auxin enriched powder induced visually higher number of root development from nodal region of the axial bud (**Figure 3**).

+ cutting aid - Cutting aid

Figure 3 : Rooting in axial bud in the field condition directly exploring the auxin hormone. The 14 days axial bud showed rooting emerged from nodal region whereas the axial bud without auxin supplementation showed poor rooting.

The cutting aid was enriched with IBA, NAA, PHB, H_3BO_3, Vitamin, Surfactant, Talc power. The direct power was used for the study for root initiation in the field condition. Characteristically, it was found that root was initiated in a better way from the nodal region in the humid region maintained in the plastic cup. The experiment was performed in the cool environment in the terai zone but no experiment was performed in the summer period or other time point in the year. The survived plant also contributed axial bud which was again explored for QPM production. As it was perennial crop, a model was developed for continuous and exponential rate of QPM production from auxiliary bud in yacon (*Smallanthus sonchifolius*) directly in field condition in a very low-cost way throughout the growing period (**Figure 5**) if the plant was survived in the Terai zone as the experimental result was presented only a short period of time only covering the winter season. The mother plant contributed axial bud which was explored for new QPM production. The new QPM will again contributing new axial bud including mother plant. hence, the process will be continued and exponential rate of QPM could be possible in the field condition directly without any requirement of sophisticated process which required huge investment.

Figure 4 : Established plant from axial bud in the field condition

Yacón, *Smallanthus sonchifolius* was a member of *Asteraceae* family and originated in the mountain regions of South America. It is a perennial herb, 2 to 2.5 m tall with a root system composed of 4 to 20 edible fleshy tuberous storage roots (Zardini, 1991). This species has received attention due to enrichment of fructo-oligosaccharides in its roots. It was a relatively low energy value despite its juiciness and sweet taste (Aybar et al., 2001). Medicinally, yacón has been used as an auxiliary in the treatment of diabetes and digestive disorders. Aybar et al. (2001) demonstrated the hypoglycemic effect of the aqueous extract of yacón leaves in diabetic rats produced an increase in the concentration of plasma insulin. Recently, analysis of the leaf and tuber extracts showed that both parts of the yacón plant represented a rich source of phenolic acids and other radical scavenging compounds, suggesting antioxidant proprieties (Valentova et al., 2005). Yacón is propagated from offset, stem cutting and tuber division (Grau and Rea, 1997). As alternative for multiplication and maintenance of germplasm of this species, efficient in vitro techniques have become necessary. Direct organogenesis from stem cuttings and leaf segments has been reported as a tool for germplasm conservation (Estrella and Lazart, 1994; Niwa, 2002). Even, somatic embryogenesis reported for this species. In the present study, QPM production from axial bud was directly developed in the filed condition. As it was perennial herb, the process could be followed

throughout the year. This is the first report of producing QPM from axial bud in the filed condition in a very low-cost way.

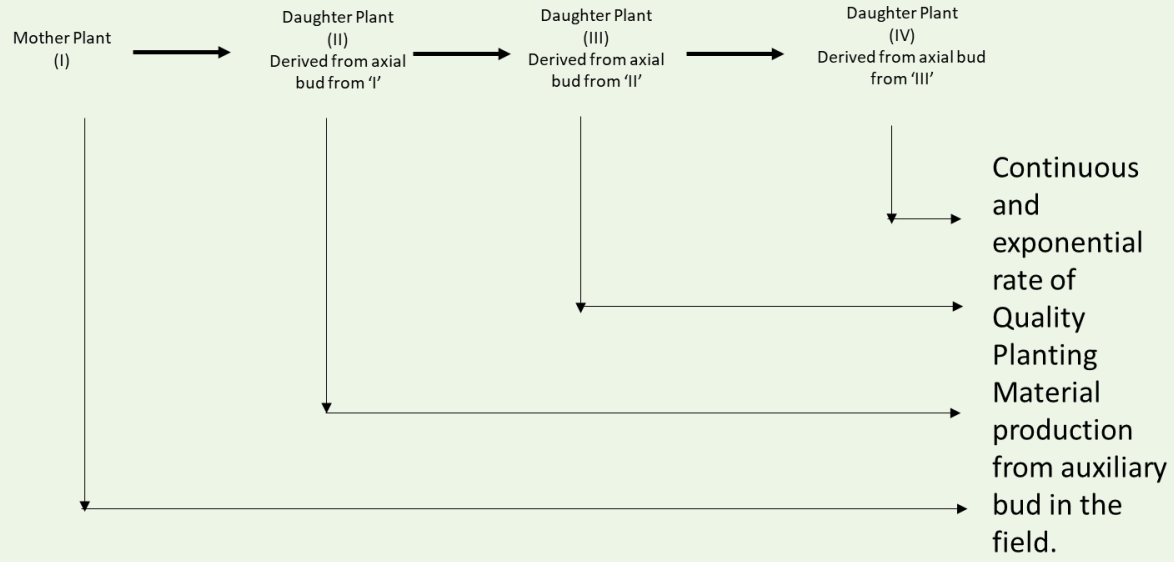

Figure 5. Model for continuous and exponential rate of Quality Planting Material production from auxiliary bud in yacon (*Smallanthus sonchifolius*) directly in field condition in a very low-cost way throughout the growing period.

Author contribution statement : HAM conceptualized the idea, performed the experiment and wrote the manuscript. BP performed experiments. SSS and MM also involved in experiments.

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A GLIMPSE OF FLOURISHING SEED INDUSTRY OF INDIA

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Introduction

Seed is the basic and vital component of agriculture. It acts as a carrier of new technology by transferring superior genetic potentialities of high yielding varieties to farmers for enhancement of agricultural production. The quality of seed increases the efficiency and response of other agricultural inputs to a larger extent. Contribution of quality seeds individually towards the total production was estimated about 15-20% depending upon the crop which can be further increased up to 45% with efficient management of other inputs (NSC, 2012).

The seed industry in India was primarily an unorganized sector during 1960's and whatsoever seed was sold was non-branded. Farmers used their own seeds popularly known as 'Farm Saved Seed' for planting during the next season, and most of the varieties were traditional and non-hybrid. In the last 30 years, Indian seed industry has witnessed a major development due to the implementation of various progressive policies by the government. The seed industry of India was given a new shape and hope by implementing policies such as National Seed Project Phase-I (1977-78), Phase-II (1978-79) and Phase-III (1990-1991) which was a need of an hour during that time, which helped to strengthen the seed industry. This can be considered as a first step in shaping of an organized seed industry. Indian Seed sector was again boosted with the implementation of New Seed Development Policy,1988 and National Seed Policy,2002, which primarily focused and laid emphasis in the areas of Research and Development, product development of various cereals and vegetable crops and introduction of GMO crops. All these policies had made a pavement to the Indian farmers in order to grab such opportunities to acquire and access quality seeds for agricultural production. Based on the current reports of growth of the graph of seed industry in the market, Indian farmers have a wide range of product choice and as a result India has emerged as the 5th largest seed market in the world. Both the private and public sectors have played a vital role in setting up and uplifting of the Seed Industry by promoting the adoption of high yielding varieties, hybrid varieties among the Indian farmers who were previously relied on planting their farm saved seeds and traditional varieties. The other factors which caused significant growth were commercialization of agriculture, rapid growth in income of famers and implementation of Protection of Intellectual Property Rights of crop varieties through PPV&FR Act (2001). It is estimated that depending upon these factors, the Indian Seed industry will show strong growth in years to come and contribute in the national endeavour of increasing food production to attain food and nutritional security.

Global Scenario of Seed Industry

One of the crucial factors for seed markets is the increasing demand of cereals, oilseeds and vegetables .As grains and cereals are the major staple food as well as daily calorie intake in most of the developing countries of the world. The farmers all around the world have given up old method of using famers saved seeds and adopted the use of enhanced varieties of seeds for production of crop. The various advantages of developed and enhanced seed varieties such as higher yield, higher

nutrition values, superior quality of product, insect and disease resistance, low cost and higher income has encouraged the farmers to adopt the commercial seeds.

In Western Countries, there is a huge demand of biofuels and large subsidies are also provided to farmers and as a result, there has been a massive increase in global biofuel production by almost 150% in between 2004 and 2010 from 42 billion liters to 104 billion liters respectively (NSAI, Company Reports and ICFA) Biofuel plays a significant role in expansion of global seed market because it is estimated that without biofuel, the growth rate of world cereal consumption is equal to 1.3%, as compared to 1.8% of biofuel. Apart from these, the area under genetically modified crop and rapid adoption of biotechnological crop and massive demand for poultry and animal feeds are increasing the farmer's per capita income which are ultimately leading to the development and growth of the seed industry. The global seeds market was valued at USD 59.71 billion in 2018, exhibiting a CAGR of 7% during 2011-2018(NSAI, Company Reports and ICFA).It is further expected to register USD 90.37 billion in 2024 witnessing a CAGR of 7.9% during the forecast period 2019-2024.

Indian Scenario of Seed Industry

In India, more than 80% of populations are dependent upon agriculture and its allied activities as the major source of livelihood which secures huge opportunities for the seed market. The farming practice in India has changed over the period of time, earlier the farmers used to sow their farm saved seeds but now a days they depend upon advanced and developed varieties for productive harvest. This shifting of farming practices and in adoption of advanced seed varieties, is not only practiced in India, but it's a worldwide activity. Therefore, in order to increase the quantity and quality of produce, efforts are made to introduce enhanced varieties of seeds with the help of advanced technology and modern agricultural methods. It is reported that in 2018, the Indian seeds market reached a value of US$ 4.1 billion, registering a CAGR of 15.7% during 2011- 2018. It is further estimated to grow at a CAGR of 13.6% during 2019-2024, reaching a value of US$ 9.1 billion by 2024 (ICFA,2018), The seed industry of India is flourishing with the increase in demand for quality seeds both in domestic and foreign countries, mainly the South East Asian countries. But the Indian seed market is majorly dominated by crops such as paddy, wheat, sorghum, maize, cotton, sunflower and millets. Grain seeds represent the largest seed type, accounting for more than half of the total seed production. Uttar Pradesh represents the largest producer, accounting for around 12% of the total market share of grain seed production.

Factors responsible for uplifting and developing Indian Seed Industry

The growth of Indian seed industry is the result of many factors working together, few of them are mentioned below :

1. Diverse agro-climatic conditions providing suitable environment for production of improved quality seeds for all important cereals, oilseeds, pulses, commercial crops and vegetables.
2. Extensive Research and Development and Technology development system both by Public and Private Sectors.
3. Enhancement in Seed Replacement Rate
4. Adoption of New Technologies
5. Well established Extension Services
6. Supportive Government policy and protection of varieties through PPV&FRA
7. Systematic plant breeding, production, product evaluation and release processes driven by both Public and Private sectors.

Role of Public and Private Seed Sector in Indian Seed Industry

In the past four decades, the Indian Seed Industry has seen vast and significant changes. Apart from Public Seed Sector, many private sectors have also entered in the Indian seed Industry and have started to play a significant role in development. The number of private seed producing and trading companies is increasing gradually. Private companies mainly focuses on high value low volume seeds such as vegetables seeds, propagating materials of horticultural crops. Apart from these, private sector is a dominant player in case of cotton, maize and sunflower seeds production and trading. The major players in private seed sectors are JK Agri-Genetics Ltd. (JK Seeds), Kalash Seeds Pvt. Ltd., Maharashtra Hybrid Seeds Company Pvt. Ltd. (Mahyco),Krishidhan Seeds Pvt. Ltd., Nuziveedu Seeds Ltd., Rasi Seeds Pvt. Ltd., etc.

At present, the Indian Seed Public sector consists of two national level seeds corporation, i.e. National Seed Corporation and State Farms Corporations of India; consisting of 15 State Seed Corporations and all these agencies produce seeds in significant amount.Public sector is much more interested in producing and marketing low value high volume crops such as cereals, oilseeds, pulses, etc. The public sector will remain dominant in terms of seed production of high volume low value crops in years to come because the private sectors are not interested to enter in the market of producing cereals, pulses, oilseeds etc. Small seed producers, such as Farmers' Societies, Farmer Producing Organization, local seed productions organizations etc. also have considerable contribution in production of low value high volumes seeds.

Major Legislations that changed Indian Seed Industry

1. Seed Act 1966
    - Compulsory labeling and voluntary certification
    - Focus on seed quality regulation and to cover notified crops and varieties
2. Seed Control order 1983
    - License for selling, exporting and importing seeds
    - Powers to State Governments to regulate seed trade under EC act 1955
3. New Policy on Seed Development (1988)
    - Encouraging commercial seed production by private sector
    - Import of vegetable and flower seeds under OGL
    - Time-bound Plant quarantine/Post entry quarantine system
4. The Seeds Bill (2004)
    - Registration of kinds and varieties of Seeds etc.
    - Regulation of Sale of Seed and Seed Certification
    - Seed Analysis and Seed Testing
    - Export and Import of Seeds and Planting Material
5. Protection of Plant Varieties and Famers' Rights Act, 2001
    - Farmers' Rights on Seeds
    - Breeders' Rights
    - Researchers' Right

Conclusion

Based on the reviews of the Indian agricultural system, seed industry has made a large scale transformation and it will continue to grow in coming years due to huge demand of quality seed in terms of both domestic and International. Both private and public sector have played a significant

role in developing the seed industry. Public sectors have improved a lot in past years and they have expanded their area of interest and activities which are recently dealing with variety of crops, high quantity of seeds that are produced and also distribution of seeds to remote areas. Major emphasis should be given in seed replacement rate by replacing traditional and lower performing varieties with hybrids and high yielding varieties especially in case of crops such as paddy, wheat, corn, sorghum, oilseeds etc. To encourage quality seed production, Government should provide attractive incentives and subsidy to farmers and private sectors. Awareness among general public and farmers about the benefits and risks associated with transgenic crops should be made clear. New technologies should be adopted and improved crop cultivars with insect –pest resistance and resistance to biotic and abiotic stress should be selected to reduce crop damage thereby leading to the increase in production. Lastly, it is necessary to encourage national and international collaborations with all the stakeholders involved in seed industry so that, India can become a worldwide exporter of quality seeds.

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AMERICAN BOLLWORM (*HELICOVERPA ARMIGERA*, HUBNER) A POLYPHAGOUS PEST OF COTTON: A REVIEW

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Abstract

Cotton (*Gossypium* sp) popularly called white gold is one of the important commercial crops of India and around 26% of global cotton production happens here only. The crop is attacked by 1326 insect pests. Among them, 12 are major pests and the bollworm complex are most destructive pest. American bollworm is one of the polyphagous, serious, and hard to control pest of cotton in the Indian subcontinent, frequently distributed in most places, alternatively feeding on nearly 181 plant species including majorly all pulses, tomato, tobacco etc crops. The brown coloured moth with a 'V'-shaped speck on the forewing and dull black border on the hind wing which usually lay their eggs singly on the bolls by inserting their head and the body is in hanging position. The persistence of the *Helicoverpa armigera* for having a large number of the host range makes it a great threat in the agricultural field. The adults are mainly nocturnal so it is difficult to control them by only the chemicals. It is advised to go for the biological, cultural, and mechanical control combinedly for the better and long term result and this are also environment friendly.

Keyword : American bollworm, *Helicoverpa armigera*, Polyphagous pest, Natural enemies, IPM Component.

Introduction

Cotton (white gold) is a very important crop for the growth of the Indian economy and livelihood of the Indian cotton farming community. In the 312 lakh hectares of total world's cotton cultivation area around 117 lakh hectares of area are from India which means it's around 37.5%of the total global cotton cultivation area with a 26% (i.e. 6.20 mt) of the global cotton produce(i.e. 23.92 mt). (Chockalingam, n.d.) According to 'The Cotton Corporation of India Ltd.' last year (2019-20) cotton has been cultivated in 125.84 lakh hectares and the total production 360 lakh bales (170kg =1 bale), and the productivity of 446 kg per hectares is recorded.(CCI, 2018)

American bollworm is one of the most serious, polyphagous insect pests in the world. In India, *H. armigera* has been recorded at least 181 plant species from 45 plant families(Manjunath et al. 1989) including major crops such as cotton(*Gossypium* spp.), tomato (*Lycopersicon esculentum* Mill.), pigeon pea (*Cajanas cajan*), chick pea(*Cicer arietinum*). (Romeis & Shanower, 1995).In every crop there are some infestation is seen in the early stages due to the voracious feeding on the leaves by the larvae of the *H. armigera.* But there is a particular stage in every crop which the infestation is more. In cotton in the boll forming stage the infestation is highest. Same like in the pigeon pea and the chick pea in the pod forming stage, the infestation is the highest. In the tomato crop the fruit forming stage, is the most infested stage. American bollworm is a brown coloured moth with a 'V' shaped speck on the forewing and dull black border on the hind wing. It has 7 days of egg period and the eggs are laid singly on the surface of the leaves. The full-grown larvae are about 2 inches long and in its 14 days of the larval period, it shows a colour variation from the greenish to brown. The 10 days of the pupal period mainly happens in the soil. (TNAU, n.d.). This has symptoms of larva's voracious feeding on leaves. The larvae eat the internal part of the boll by thrusting its head

in the boll and the rest of the body is outside of the boll so it look like a hanging larvae. Heavy infestation in the field can destroy the whole crop. The Economic Threshold Level is 10% or one larvae/egg per plant. It is a hard to control pest because of its large host range. Understanding the bio-ecology of American bollworm in relation to climatic parameters is indispensable to control the pest properly. (T.V.Prasad, 2019). When there is identification of this pest in the field for chemical management we can use the endosulfan 35EC 0.2l/ha or quinalphos 25EC 2.0l/ha. Most effective way to decrease the infestation of this pest is the use of Bt- cotton. The *Bacillus Thuringiensis* kurstaki is mainly used for the lepidopterans. And others like *Trichogramma chilonis* as egg parasitoid, *Chrysoperla carnea* as a predator and the HaNPV virus is used to control this pest. And for controlling the next generation of this pest the pheromone traps are used in which males are being trapped because of the use of the sex pheromone Heli-lure which attracts the males.

Nomenclature and systematics position

The common name of the *Helicoverpa armigera* is mainly depends on the infestation on the particular crop plant. For example in the cotton crop it mainly infest the fruit which is called 'balls', so this pest is named as cotton bollworm and in grams its mainly infest the pods so it's called pod borer and in the tomato crop its mainly infest the fruit so it's called as the tomato fruit borer. *Helicoverpa armigera* is polyphagous pest which is very hard to control.The systematic position of the *Helicoverpa armigera* is – Domain: Eukarya Carl Woese et al, 1990; Kingdom: Metazoa Ernst Haeckel, 1874; Phylum: Arthopoda Von Siebold, 1848; Class: Insecta Linnaeus, 1758; Order: Lepidoptera Linnaeus, 1758; Suborder: Heterocera Fabricius, 1775; Family: Noctuidae Latreille, 1809; Subfamily: Heliothinae Boisduval, 1828; Genus: *Helicoverpa* Hardwick, 1965. (Wikipedia).

Synonymy

Helicoverpa armigera, Hubner (1805); *Heliothis obsoleta,* Fabricius (1775);*Noctua obsoleta* Fabricius (1793); *Heliothis pulverosa* Walker (1857); *Heliothis uniformis* Wallengren (1860); *Helicoverpa armigera* subsp. Commoni Hardwick, (1965); *Heliothis rama,* Bhattacharjee & Gupta (1972); *Chloridea obsolete* Duncan & Westwood (1841). (Husain & Hasan, 2020).

Distribution

Helicoverpa armigera is a very serious pest of the whole world. In India in 181 plants species from 45 plant families this pest is recorded (Manjunath et al 1989). In India more or less in every state we can notice the infestation of this pest. Those states which are majorly affected by this pest is Punjab, Haryana, Madhya Pradesh, Bihar, Andhra Pradesh, Kerala, Karnataka, Gujrat, Tamil Nadu, West Bengal etc. (CABI, 2020).

Host range

Helicoverpa armigera (Hubner, 1805) the cotton bollworm is a polyphagous pest moth invading a large number of the plants.(Matov *et al*, 2008; Robinson et al, 2010; Paul et al, 2016; Subhalaxmi, 2018). Matov et al (2008) recorded the larvae from wide range of herbaceous plants, shrubs and trees belonging to 38 families, mostly crop of cotton and tomato. The larvae feed on a wide range of the host plants including many important plants. Examples of that plants are, cotton (*Gossypium arboreum*); okra (*Abelmoschus esculentus*); rice (*Oryza sativa*); oat or jui (*Avena sativa*); sorghum or Jwar (Sorghum bicolor); Maize (*Zea mays*); ground nut (*Arachis hypogaea*); pigeon pea (*Cajanus cajan*); chick pea (*Cicer arietinum*); urd bean (*Vigna mungo*); soyabean (*Glycine max*); pea (*Pisum sativum*); moong bean (*Vigna radiata*); the black eyed bean or cowpea (*Vigna unguiculata*); lucerne (*Medicago sativa*); the French bean (*Phaseolus vulgaris*); the castor bean (*Ricinus communis*); the capsicum (*Capsicum annuum*); tomato (*Lycopersicum esculentum*); the tobacco (*Nicotiana*

tabacum); black nightshed (*Solanum nigrum*); potato (*Solanum tuberosum*); brinjal (*Solanum melongena*); safflower (*Carthamus tinctorius*); chrysanthemum (*Chrysanthemum indicum*); the oriental plane (*Platanus orientalis*). It also attacks the weeds like pigweed or jangli palak (*Amaranthus sp.*), Bhang or Ganja (*Canabis sativa*). Major host plant of this pest in India is cotton, pigeon pea, cow pea, moong, sorghum, tomato, marigold etc.

Biology

H. armigera is a holometabola insect, so it has four distinct stages in the life cycle of the bollworm, egg, larvae, pupa, and adult. Life cycle of *H. armigera* take about 30-34 days with an average temperature of 28 degree celcius from egg to adult (Zalucki *et al* 1986) It is a multivoltine insect with diapause, highly fecund and capable of moving long distances as adults (Fitt, 1989). Thus they can rapidly exploit host crops, particularly monocultures. Female moths sized 18 to 19mm in length with a wingspan of 40mm, male moths are usually smaller in size as compared to the female moths with a wingspan of 35mm.Some research scholars from the Aligarh Muslim University conducted and detailed investigation on the *Helicoverpa armigera* with a very controlled environment in the laboratory and revealed that single female produced 413.00 ± 1.89 eggs. The incubation period of egg was 3.37 ± 0.09 days and their size varied 0.42 to 60mm in length and 0.40 to 0.55mm in breadth. The average duration of the first, second, third, fourth, fifth and sixth instar larvae were respectively; 2.27 ± 0.08, 2.42 ± 0.08, 2.67 ± 0.07, 2.83 ± 0.07, 3.40 ± 0.10 and 337 ± 0.11 days. The aged larvae showed lateral brown strips and yellow to green colour. The head as well as pro-thorasic legs were brown to black (Ali, et al., 2009).

Eggs : Freshly laid eggs of *Helicoverpa armigera* are usually pale white and changed in dark brown before hatching. Eggs are rigid and clinodome shaped and the apical area of the egg was smooth and the rest of the surface sculptured in the form of longitudinal ribs. The incubation period of the eggs is nearly 3-4 days. Those eggs did not hatched in 5 days, they are infertile. The average percentage of eggs hatched was recorded as 53.33 ± 0.47%.

Larvae : The larval period of *Helicoverpa armigera* completed through six distinct instar. The first and second larval instars were yellowish-white to redish-brown with a dark brown to black head capsule. First instar measures between 35-42mm in length. The movement of first and second instar larvae is very little. The prolegs were developed in third instar stage on 3rd, 4th, 5th, 6th, and 10th abdominal segments and remained until the last larval instar. The last instar larvae is more voracious in nature and eats about80% of the total food consumes by the larvae. A full grown larva was brown to green in colour with lateral brown strips and the head as well as prothoracic legs were dark brown to black in colour. The larval stage is of 15 to 30 days depending on the environ factors and the weather condition.

Pupa : The pupa of *Helicoverpa armigera* was obtect type and the anterior and the posterior ends of the pupa are round and two parallel spines can be seen on posterior side. Pupa is brown coloured. This stage took minimum and maximum period of 10 to 14 days respectively. The pupal stage is mainly held in the soil.

Adult : The bollworm moths are very readily seen in the cotton field and are more active at night. At night they mainly come out of their hiding points to oviposite and for the seek of food. But adults are not foliage feeder they only feed on the nectar secreted by thw cotton plants and other host plants. At the vertex of the tail, hair tufts can be seen. Male moth sized smaller and owns a wingspan of 35mm. Female moths owns a wingspan of 40mm and lay their eggs from 2nd to 7th day of their lifespan. Lifeapan of the moth depends pn the availabality and the quality of the foodstuff.

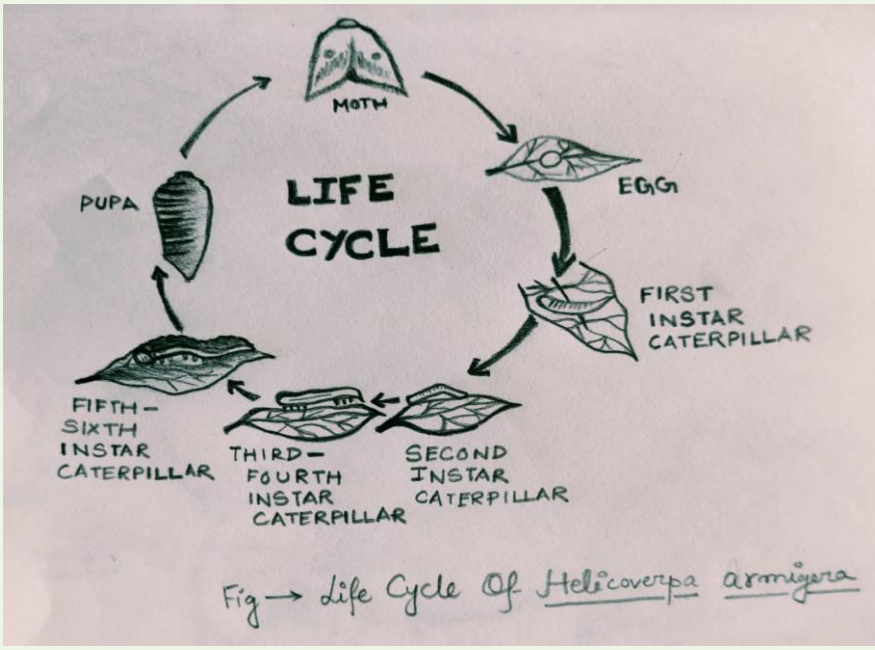

Fig → Life Cycle Of Helicoverpa armigera

Status and Extent of damage

The *Helicoverpa sp.* cause considerable economic losses to the agricultural and the horticultural crops. Both the quantity and the quality of the major agro-products like cotton, all pulses, sorghum etc and the horticultural products like the tomato, chilli, capsicum, okra, brinjal etc. are greatly damaged by this pest. The first, second and third instar larvae initially feed on the foliage but after the flower emergence they mostly feed on the flower and flower buds, after the fruit emergence the fully grown larvae mainly feed the inner part of fruit by inserting their head and where their body is in hanging position. The American bollworm attacks the plant in all stages and feeds on the leaves, flowers, and fruits. The damaging of flowers leads to the low amount of the fruit settings and then those fruits are also destroyed then we can say that the whole crop loss and the adults also feed on the nectar of the cotton flower.

Existing practices to check the infestation of the *Helicoverpa armigera*

Because of its high mobility, survival rate under adverse conditions, capacity to complete several generations in a year and ability to develop resistance against insecticides, its management is very difficult. Being polyphagous in nature, it causes damage to several crops but economic damages occur in cotton.

Monitoring

The monitoring of American bollworm is been done through pheromone trap. In the Integrated Pest Management (IPM), monitoring is one of the major components. Monitoring helps us to check the pest population in the field and also to understand the major factors behind the increase of the pest population which eventually helps to forecast its incidence in the field. Pheromone trap with the sex pheromone 'Helilure' is used to trap the male insects and after that from the pre designed models prediction of the numbers of the larvae is done. The ETL level of this pest is one egg or one larva per plant. It has been seen that the number of the trapped moths is in the pick in the two times of the year once in the April-May and another one is in December – January (Patil, Goyal1, Chitgupekar, Kumar, & El-Bouhssini, 2017). So in the cotton crop we can see an emergence from the pest from the seedling stages.

Cultural methods

Sowing time : Sowing cotton at the optimum time is one of the most important factors affecting crop yield. Weather factors such as temperature, wind speed, sunshine hours plays an important role in regulating the population of *Helicoverpa armigera*. Temperature helps in the growth of the larvae and rainfall and the humidity inhibit the growth. Early sowing is very effective process to control the pest and reduce the damage percentage (Garg 1990; Choudhary et al 2015; Parmar et al 2015).

Crop rotation : It is one of the key factors to control the American bollworm because it has been seen that if we directly cultivate the cotton crop right after the pulses then the infestation is more due to the pupae in soil. Also in single set of cultivation they got resistant to pesticides also so variation in the crop cultivation is very important.

Deep ploughing : The pupal stage of the *Helicoverpa armigera* mainly happens in the soil so the deep ploughing expose the hibernating pupae in the sunlight which helps to destroy them.

Trap crop : Trap crop is another important factor. We can use trap crop to reduce the infestation of this pest on the main crop. Trap crop is nothing but another host plant of that same pest we planted in the edges so that the pest attacks in that crop not the main crop. By this method we actually gets good amount of grains from the main crop.

Host plant resistant : Growing such varieties which are resistant to the pest or which are tolerant to some extent of the pest infestation or those which are less attractive to the pest for their oviposition is one greatest method of management of the pest in the regional area. (Kennedy et al 1987; Fitt 1988) Some resistant varieties are LD-135, L- 1245, Sujata, Abadhi, and LK- 861.

Mechanical method

Hand picking : Hand picking and destruction is one of the key management work done by the any farmer. If one can observe any larvae hanging from the bore hole of the cotton bolls pick it by your hand and destruct them in the fire or kill them.

Pheromone trap : Pheromone trap with the sex pheromone Helilure trap the male moths of the field which helps in monitoring and also control the next generation of the pest.

Biological control

Using the natural things to control the pest population is called biological controls. It includes the entomophagous insects, pathogens, predators, parasitoids, plant derived products etc.

Neem-based pesticides : Parts of the neem plant is used to make pesticides which are very effective against the insects. Pest has developed resistance against chemical pesticides hence this can be used as substitute of those insecticides. As well as it is plant product and does not leave any harmful residue to the crop plant which is very good for our health and also the farmer's health (Boeke *et al* 2004). Paul 2007, added neem based pesticides names in his list of pesticides.

Bacteria : *Bacillus thuringiensis* is the bacteria we are using in India. *Bacillus thuringiensis* is discovered in Japan in 1901 by Ishiwata, officially described by Berliner in 1915, isolated from Mediterranean flour moth in province of Thuringia in1911 and hence the name. It's a gram positive, aerobic bacterium, contains parasporal body (known as crystal) that is proteinaceous and possesses insecticidal properties. The parasporal body comprises of crystal and is tightly packed with proteins called protoxins or endotoxins. In India strain – Kurstaki, HD-1 is used to control the bollworm.

Virus : Most of the species of the cotton bollworm have at least some degree of the infestation of the Nuclear Polyhedrosis virus or NPV. IN India HaNPV is used against the *Helicoverpa armigera.* NPV is an obligate pathogen. The virus consists of a proteinaceous polyhedral occlusion body inside which the various or virus rods are embedded. Due to alkaline gut juice, the viruses are liberated, which attack nuclei of cell tissues, fat-bodies, tracheal matrix, haemocytes, ganglia, and brain.

Fungi : In the list of the entomopathogenic fungi *Beauveria bassiana* causes some infestation of some species of the bollworm.

Parasitoid : Ecto parasitoid wasp like *Habrobra conhebetor* (Hymenoptera, Braconidae) and endo-parasitoid like *Trichogramma* sp. (Hymenoptera, Trichogrammatidae) is used as the parasitoid of the *Helicoverpa armigera*. Like *Trichogramma chilonis* is used as the egg parasitoid. (Husain & Hasan, 2020).

Predator : In India *Chrysoperla carnea* is used as the insect predator of the *Helicoverpa armigera.* But other than some birds like house sparrow, black drongo, mynah etc helps naturally to control the boll worm.

Chemical control

In India for the management of the bollworm heavy use of the insecticides has been noticed and for which gradually the pest develops resistance to the most of the popular insecticides. We know that the chemical control is fastest way to control the pest we also have to keep in mind that the excessive use of the chemicals are very harmful for the environment. So proper use of the chemical insecticide with the combination of others helps to control the pest effectively and also the insect will not develops resistance so easily.

Flubendiamide 480 SC @ 75 ml/ha is found the best treatment for the minimum population of *Helicoverpa armigera* (Singh et al 2015). Chowdary et al 2010, reported that Chlorantraniliprole was effective against the okra fruit borer. Indoxacarb and Flubendiamide were found the next best treatment after the Rynaxypyr. Indoxacarb 0.01% is the most effective treatment for the bollworm.(Shinde et al 2015). Except this there are some other insecticides which are commonly used like in the early stages of the larval growth apply endosulfan 35 EC @ 0.2 l/ha. And during the maturation stage we can either apply phosalone 50EC 2.5 l/ha, quinalphos 25 EC 2.0 l/ha. Except this we can also use the Thiodicarb 75 WP 1.0 l/ha.

Conclusion

It is concluded through present review paper that the *H. armigera* is a major pest and also a big problem for the farmers cultivating cotton. The population of *H. armigera* can be controlled by the proper study of its life cycle and effect of the environment factor on it because it will help the experts for a successful pest prediction. Pest forecasting is an important component of the IPM which helps to reduce the frequency of application of the pest management measures and chemicals as well as the cost of cultivation.

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USE OF DECOMPOSED TREE LOGS IN POOR FERTILITY AND MOISTURE STRESS HILLY AREAS TO INCREASE THE YIELD OF BLACK PEPPER IN WEST GARO HILLS DISTRICT OF MEGHALAYA

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Abstract

The climate of West Garo Hills district of Meghalaya in North Eastern Region, India is the gift of god. It has the sub tropical humid climate which is suitable for horticultural crops influence throughout the year. Black pepper plantation seems to offer a better venture for earning good amount of income by tribal horticulture farmers in rural hilly area. Dryness and less nutrient content in the soil are the common problem in the horticulture orchard. Farmers are gradually adopting different indigenization technology to combat the climatic vagaries and emerging challenges in black pepper production. The study was conducted on the indigenization technology adopted by a group of Garo tribal farmers for increasing the yield of black pepper through decomposed/decay tree logs. The present paper was a single village study to trace out the farmers modification (termed as indigenization) in black pepper cultivation using decay tree log and used an index to measure extent of modification.Information was collected through a pre-tested schedule prepared for this purpose.The study reported that using of dry and decomposed tree log on the root zone area of the plant increases the fertility status and moisture retention capacity of the soil. It was also observed that it also improves the plant vegetative growth, increased the size of berries and length of fruit bearing vine and minimized the mortality rate of the plant in water stress area. The study revealed that yield of black pepper using improved variety increase upto 2.0-2.4 kg of berries/plant than indigenous variety which was recorded is 1.4-1.8 kg of berries/plant. Creating awareness and validation of this innovative indigenization technology will help many black pepper growers for large scale adoption.

Key words : *Indigenization, black pepper, decomposed tree log, yield, soil fertility, moisture stress, Garo tribe.*

Introduction

The climate of West Garo Hills district of Meghalaya is the gift of god. It has the sub tropical humid climate which is suitable for horticultural crops influence throughout the year. Indigenous knowledge linked with the manipulation and use of natural resources in various ways, forms the basis of their link with nature, and the varied levels refinement depend on the level at which the society finds itself in the social evolutionary basis (Solomon Retna Dhas Nadar Jeena et al. 2006) Rural people have been following from one generation to another generation to cope up with different situation, constraints, weather aberration, *etc.* (B. Lahiri *et al.* 2017) For that reason indigenous horticultural plants and crops are visible everywhere except in few pockets of the region. The common horticultural crops are citrus, betel nut, jackfruit, mango, drum stick, pineapple and tuber crops. In spite of abundant scope, the economy of the local settlers is very weak due to poor marketing linkage. All crop residues and farm wastes available on the farm including branches and leaves from pepper vines can be recycled, so that soil fertility is restored and maintained. It is the process of transforming organic materials of plant origin into humus (Kevin Muyang Tawie Sulok *et al.,* 2018) Black pepper plantation seems to offer a better venture for earning good amount of income. Department of Horticulture, West Garo Hills, Tura has contributed significantly to bringing

up of improved variety of seedlings of black pepper. At present, the scenario in price of dry seed of black pepper has gone up drawing the attention of farmers in black pepper production. *Jhumming* areas are dwindling as the frequent cycle in use affects the fertility of the soil reducing the crop production. It does not hamper to old experience farmers but the new farmers are confusing on the actual implementation method of crop cultivation.

Black pepper plantation using decay wooden logs

Farmer showing impact of indigenization technology

Methodology

The study was conducted in West Garo Hills district of Meghalaya, India. As research on indigenous knowledge requires an in-depth and anthropological approach, the present study was undertaken in the single village approach in a village called Arai mile. An interview schedule was designed to collect the primary information where secondary data were collected from village head, middleman, literature, research paper and internet.

Results and Discussion

Indigenization technology during detachment of young shoot from mother plants

During the plantation, when a plant attained at the age of 4 years & above then they generate new shoots near the base. This new shoots are move laterally direction to the ground. Once when such shoot touches the ground, the new roots are started to develop at the nodes. The new shoot keeps protruding forward until they find any support to climb upon. When the new shoot climb into the support at 6.0 metre heights then it can be detached from the mother plant by manually cutting. In another case while separating root of newly developed shoot or plant from the mother plant, it should be not be forcefully pulled out because it may causes damage to the roots. Due to longer in length, rough in handling may cause injured to the newly root and shoot. A careful approach to newly planted plant result good yield and healthy plant growth. While planting with new tree, its whole plant length and weight should be well supported in climbing position and required well prepared appropriate depth of the plant in advance. When a part of the black pepper plant while detaching from its parent body, it causes weaken to the shoot immediately. Undisturbed young roots in a new place attempts to function faster and in a favorable climate condition the new plants regain its strength just after a week or more. The natural growth was begins this onwards and within a year the plant length reaches to almost double. A young shoot is not strong enough to resist and withstand of weather fluctuation. But the shoots of a year old have good resistivity to weather fluctuation.

When a new plant reaches to its approachable height, half of the new appeared branches are needs to be reserved upside down. It helps to generate new shoots and transform into a bushy shape in

the process of the growth. One of the character reported by the black pepper grower that in improved variety of black pepper plant has a unique character when it attained at the height of 5.0 feet and above, the crop end started folded to downward within the same season and which help in fruit bearing early i.e. within one to 2 year.

Indigenization technology for moisture conservation and increase fertility status of the hilly soil enhance the yield in black pepper

Fast dryness of the soil after rainy season is a major concern. During those period plants suffers from moisture stress starting from the month of February end to April. To prevent from evaporation and conserve the soil moisture, a barrier is being place using the decay tree logs on the base of the plant. The dry or decaying tree logs are mounted and deposited in the base of plant on the ground. Dry woods after decomposed deposits humus and manure to the soil and retains soil moisture. The seed of black pepper which is harvested with this innovation has good odour and pungent. The ripen seed is bright red in colour whereas others are pale red in colour. It is also observed that seeds are bigger in size with minimum softness substance in between the seed and outer layer comparatively. This method is very low cost in maintenance and moreover less water is required for irrigation.

Used of dry and decomposed wooden log beside the side of the plant in soil increased the fertility status and moisture retention capacity of the soil. It was reported that it improve plant growth, increased the size of berries and length of fruit bearing vine and minimized the mortality rate of the plants in water stress area. The growers also reported that revealed that yield of black pepper of improved variety increased upto 2.0-2.4kg of berries/plant and in tradition variety recorded is 1.4 - 1.8 kg of berries/plant.

Constraint faced by the growers

Most of the farmers in the villages had small and marginal land holding. They reared livestock such as cows, pigs, goats and poultry for secondary income. During lean period (January to March) they leave the cattle for free grazing in the village. To avoid their damage, the long seedlings of 6.0 feet height and above are planted first because seedlings are not reachable by the cattle.

Advantage of the finding

a) It minimized the highly mortality rate of the plants.
b) The growth of young plants is satisfactory leading to better production.

Disadvantage of the finding

a) It is not possible for a larger scale or commercial plantation.
b) It cannot be transferred to long distance area but only to nearby areas.

Conclusions

Intensive programme is required for horticulture interested farmers because the soil has a big potentiality and still remains unexplored to the possible limit. This is a low cost innovative technology where locally available resources can be used. Creating awareness and validation of this innovative indigenization technology will help many black pepper growers for large scale adoption.

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IMPACT OF CLIMATE CHANGE ON AGRICULTURE, FOREST AND TREE SPECIES IN GARHWAL HIMALAYA UTTRAKHAND, INDIA

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Abstract

Large change observed in climatic factors whereby reported many affect on forest, agriculture and forest trees.Climatic impact on traditional crops has drastically declined (>60%) during the last three decades however many crops are at the brink of extinction.In 2013, was reduced -268 km2 (50%) of forest cover in Uttrakhand state. In Garhwal region had observed the changes in phenomena of different plant species such as *Rhododendron arboreum* and *Myrica esculenta*.

Key word : Burans, Climate, Forest, Agriculture and Species.

Introduction

Modern plant taxa have continued to exist through a long period of variable climate, including glacial-interglacial cycles with a large change in temperature, precipitation, and CO_2 concentration, over the completed 2.5 million years. Regional temperature changes were as rapid as lot degrees Celsius within slight decades or as slow as 1^0C per millennium. The changes in species circulation authentication by fossils provide a complete record of plant responses to these changes (Davis and Shaw 2001).

Global warming like climate change is the biggest and challenging issue presently globally. The whole over the world is facing it; especially in the agriculture and forest biodiversity viz flora and fauna. In the Asian continent, India country also has been highly influencing for a long time by now and observed so many drastic changes that highly deteriorate the agriculture and forest diversity such as saw the losses in large quantity as well many phenotypic changes also.

Observation

The Uttrakhand state is the part of the northwest Himalaya in India whereas reported average ann ual rainfall of 1,550 mm and an average annual temperature of 00C-430C (FSI, 2017). If the moment, looks at six to seven-year backs the moment, I observed many incidents within the mentioned period related to the natural calamities and climate change that affected the quantity and quality of forest and agriculture due to the horrible storm. The Uttrakhand state in June 2013 came flood at four districts like Chamoli, Rudraprayag, Uttarkashi, and Tehri, etc. there were losses the agriculture and forest at maximum quantities. In the Tehri district, at Ghansali Block I had seen cloud bursting and flood at many places such as Arhgar, Gonhgar, Bud hakedar, Kemar, and Nelchami in June 2013 and May 2016. There was affected highly agriculture l and and crop, whereby that reduced the agriculture and forest area, even lose the field canal, which changed the cropping pattern then there have been raising non irrigated crops only. However, there raised irrigated crops before the produced non irrigated crops. As far as I think an d what I noticed timing in crop showing and harvesting period by now, in Ravi and Kharif crops. A couple of years ago paddy crop had been transplanted in before June 15 but now currently, it is possible after June 15, even shifted harvesting time latter.

Negi & Palni (2010) were reported in the Himalayan region. The impacts of climate change on mountain agriculture. There was observed following factors such as reduced availability of water, during in rainfall period to see extremely drought event whereby failure of crop germination and fruit set, the weed's invasion (*Lantana camara*, *Partheniumodoratum*, *Eupatorium hysterophorus*) in croplands, insect and pest attack chances are more and crop-yield decline (Negi et al. 2012). Due to these factors change agri-diversity and cropping patterns. The Himalaya Mountains have been a rich warehouse of agro-biodiversity and non-rigid to crop disease viz. in Uttrakhand over 40 different crops and 100 cultivars selected by farmers, comprising cereals, millets, pseudo-cereals, pulses, and tuber crops are cultivated (Agnihotri & Palni 2007; Maikhuri et al. 1997). Twelve crops are mixed cropping (Baranaja), it is another best example for the rich agri-diversity of the region (Ghosh & Dhyani 2004). Climatic impact on traditional crops has drastically declined (>60%) during the last three decades however many crops are at the brink of extinction viz Glysine spp. *Hibiscus sabdariffa*, *Panicummiliaceum*, *Perilla frutescent*, *Setaria italic,Vigna spp* (Maikhuri et al. 2001: Negi & Joshi 2002).

As soon as the talk about forests viz forest area and forest species, it appeared to be seen phenotypical changes respective to climate change. A couple of years ago in 2013, during this time was reduced -268 km2 (50%) of forest cover in Uttrakhand state (FSI, 2015), while as per the 2013 FSI report had published the forest cover (45.82%). The report exposed the reason forest area are reduced due to the rotational felling and diversion of land for many development activities but so far as I think, it's reduced because of natural calamities or natural disaster, which happened in June 2013. If look eight to nine a year back, it observed the changes in phenomena of different plant species such as *Rhododendron arboreum* and *Myrica esculenta*. There had been noticed at Rudraprayag district in Uttrakhand at two different places like Makumath and another in 5-6 km back of NagnathPokhari. At these places was shown flowering and fruiting time 2 and 3 months before like in December and January in *Rhododendron arboreum* and *Myrica esculenta.*

It seems to plant is not getting the proper environment before the reproductive period and in case plant in a stress state then plant metabolic activity very fast therefore pre-flowering occurring in these species or these are tree species getting suitable climate. Rana.K.(2019) was conducted a study on *Rhododendron arboreum* in 2017-18 and 2018-19 respectively. He had observed first flowering in the 2nd and 3rd week of December. This was due to a great change in climatic factors viz temperature and rainfall, it observed during winter months of both the season. In 2018-19 reported high rainfall and snowfall so it was the more chilling year, therefore causing delay and extend of flowering time this year. Khanduri et al. (2008) had published that if temperature increase and humidity decrease during the reproductive period still result is a pre-flowering phenomenon and a shorter flowering period. Gaira et al. (2011) reported advancement flowering in *Aconitum hetrophyllum* over a period of the last 100 years due to increased warmth during winter months.

Soil physicochemical properties and species genetic characters to cause variation in the flowering phenomenon of the same species within homogenous environment condition (Nord and Lynch, 2009; Pollardand Briggs, 1982; Ranjitkar et al. 2013). Trees showed dominant flowering quite earlier (starting December) as compared to the remaining sample trees that flowered during late December and early January. This might be due to superior genetic characters, better access to soil moisture, organic manure, and higher sunshine hours that trees were exposed to overall, early and better flowering was seen in branches (of all trees) that are receiving better sunlight and lesser shade thought the growing season (Rana, K. 2019).

Conclusion

As per as the climate change is coming many effects on agriculture crops which are indicating the showing and harvesting time-shifted to latter so local inhabitants are adopting other alternate crops according to time and microclimate. There is shown the change s in many forest species as per as phenotypic point of view but especially changes observed in two species phenotypic characters such as *Rhododendron arboreun* (Burans) and *Myrica esculenta* (Kaphal) due to climate change and what is another reason behind it, we should conduct research so that we could find other scientific reason. In another case, there is a loss of maximum area of agriculture and forest, how to reduce the losses, and how to maintain the agriculture and f orest, government will have to make better policies and strategies for its according to the microclimate.

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BURMESE GRAPE-AN IMPORTANT AESTHETIC VALUE UNDERUTILIZED FRUIT CROP IN ARUNACHAL PRADESH, NORTH EAST INDIA

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Abstract

A survey was conducted in the East Siang district of Arunachal Pradesh, India during the period 2019-2020 for the documentation on the variability of *Bacaurea ramiflora* (Burmese grape) in this region. These plants are found wild or in the homestead garden. From the investigation it revealed that flowering period start from March upto April and the fruit are ready to harvest during July-August in North East condition. Fruiting habit is cauliflorous in nature having aesthetic value. However, due to unexplored this important underutilized fruit crop from commercial cultivation it needs conservation strategies for the near future.

Introduction

Burmese grape (*Baccaurea ramiflora*) which belongs to the family Euphorbiaceae is native to Southeast Asia region and distributed along the sub-Himalayan tract, mainly from Nepal to Sikkim, Darjeeling hills, Arunachal Pradesh, Assam, Tripura, Bhutan, Burma, Peninsular Malaysia, Tibet ascending to an altitude of 900 m and Andaman and Nicobar Islands, most chiefly in the moist tropical forests(Anon., 1998). In East Siang district of Arunachal Pradesh it is grown as an underutilized fruit crop in evergreen forest or cultivated 1 - 2 plants in homestead garden. In other North Eastern part of India it is grown in limited scale as a minor fruit crop in the lower hills and valleys of Meghalaya, Nagaland, Manipur. In West Bengal it is mainly grown as an underutilized fruit crop under homestead cultivation in few district of the northern part of the state like Cooch Behar, Jalpaiguri, Darjeeling, Uttar and Dakshin Dinajpur districts, and some part of Dakhin 24 pgs, Howrah (Dey and Pal, 2015). It is locally known by different names as *Motok Hei* in Manipur, *Bureng* in *Adi* tribe and *Gasampe* by *Garo* tribe in Arunachal Pradesh, *Sohramdieng* by *khasi* tribe in Meghalaya and *Leteku* in Assamese language in Assam (Sigh, et al, 2017). In West Bengal it is locally known as *'Latka'*, '*Latkan*', '*Lotko*' or '*Notko*' (Deb and Bhowmick, 2013).

Uses and its medicinal value : Fruit are used as a digestive and bark for skin disease treatment (Singh et al., 2014). Besides due to its cauliflorous bearing nature it is also grown as aesthetic value fruit tree in Arunachal Pradesh.

Flowering and Fruiting : *Baccaurea ramiflora* have cauliflory bearing habit in which flowers and fruits are directly coming out from trunk or old branches and flowers are appearing in clusters. Flowers are yellowish, small, dioecious, apetalous, compound into raceme panicles. Flowers start appearing from mid March and continue till mid April and fruit setting occurs during mid April in East Siang district of Arunachal Pradesh. Immature or young fruits are green in colour and it takes about 3-4 months for maturity. On maturity fruits are round to oval in shape, yellow or yellowish-brown in colour and velvety with leathery pericarp and available during July-August. The type of

fruit is berry and edible portion is aril with 3-4 seeds embedded inside pinkish-white pulp. Fruit of *Baccaurea ramiflora* have a diameter of 2-3 cm. The average number of fruits per panicle, length of panicle, fruit weight and pulp weight, seed weight is 12, 20 cm, 12 g, 4 g and 1.6 g respectively. Two types of genotype i.e. one with sweet taste fruit and another with mild acidic taste fruit is found in Arunachal Pradesh (Singh et al., 2017)

Nutritive value : Fruits of *Baccaurea ramiflora* has appropriate ratio of sodium and potassium which can help in the prevention of the non-communicable diseases significantly. It is also rich in iron which can heip in reducing the anaemic condition which has high frequency in India (Gogoi B. 2017). Burmese grape found in Northern part of West Bengal has TSS range from 11.6 ^{0}Brix to 13.1^{0}Brix (Bhowmick et al. 2013).However, Burmese grape grown in some areas of Pasighat circle of East Siang district of Arunachal Pradesh shows the TSS(total soluble solid) range from 13^{0}Brix to 16^{0}Brix i.e. fruits of higher sweetness found in this region. Fruit also shows around 4 percent total sugar, 3.8 per cent reducing sugar and 2 percent acidity (Singh, et al., 2017). Average yield of fruit varies from 70 – 80 kg/plant/year (Dey and Pal, 2015). Per 100 g of fruit pulp of *Baccaurea ramiflora* contains 35.6% water, 51.9% carbohydrate, 5.58% protein, and 20.4% fibre respectively. The fruit also contain considerable amount of minerals like magnesium (504mg), potassium (730mg), phosphorous (132mg), and iron (100mg) per 100gm of fruit pulp. It has substantial amount of ascorbic acid, which adds to the property of antioxidant. (Gogoi, 2017). It has 178 mg vitamin C per 100 g of pulp (Hossain, et al., 2017). As the fruit contain adequate amount of sodium, potassium, and minerals it plays an important role in prevention of diseases like hypertension, cardiovascular diseases, chronic kidney stone formation which is related to low potassium intake, high sodium intake and low mineral density. Presence of higher amount of Mg in the fruit can help in maintaining the nerve electrical impulse and also can act as an activator for several enzymes. However, this important underutilized fruit crop remain unexplored till now from commercial cultivation and standardization for its scientific cultivation is lacking till now.

Conclusion

Therefore, it is right time to explore the Burmese grape having aesthetic and medicinal value of such underutilized fruit crops which is hidden from mankind and documented in particulars. Besides, the study also advocates coordinated efforts among different agencies such as Government, NGOs, and research institutional for strengthening the biodiversity conservation and health care system together. These efforts may help in improvement biodiversity conservation for mankind.

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Fig 1. Cauliflorous bearing habit of Burmese grape having aesthetic value

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PULSE CROP INTENSIFICATION IN RICE-WHEAT CROPPING SYSTEM: ROLE AND SIGNIFICANCE

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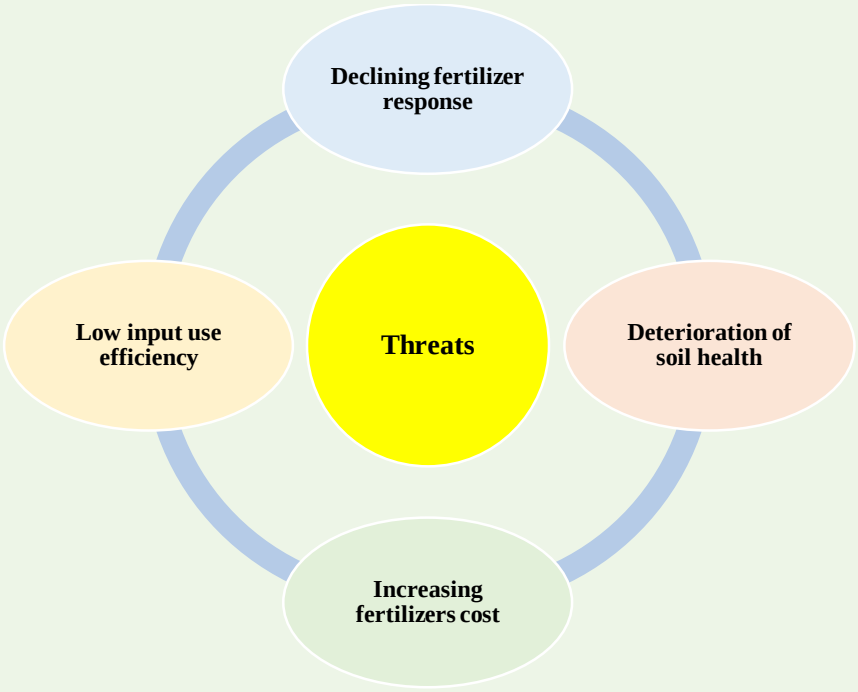
Abstract

Crop intensification involving pulses need to be popularized in larger scale chiefly under existing rice-wheat rotation for making farming more attractive, remunerative and sustainable. Crop intensification practices not only have positive impact on soil health but also hold potential to provide higher crop productivity and farm income per unit area. Keeping the above facts in view this article aims to highlight the role and significance of sustainable pulse crop intensification in rice-wheat rotation.

Introduction

Rice-wheat cropping system (RWCS) occupies almost 10.5 million hectares and is contributing ~75% to the national food basket. However, practicing intensive rice-wheat rotation over time leads to lower input use efficiencies, soil heath degradation, receding groundwater table and declining factor productivity. Therefore, crop intensification in the existing system with lower input demanding crop such as pulses is needed for sustaining food security and minimizing over-exploitation of natural resources. In India, pulse crop are grown under diversified agro-ecologies with reasonable external inputs and residual soil moisture. It provides multiple benefits such as better human nutrition, higher yield per hectare, increasing farm income, improves resource use efficiency and restoring soil fertility through the addition of soil organic matter (SOM). As they are more biologically efficient and resource conservative sequences to cereals.

Threats due cereals based cropping system



Why pulses ???

Nutritionally rich : In India, the vast majority of the population relies on the plant-based protein, pulses provide an excellent source of protein of high biological values, amino acid, vitamins and other essential minerals. Besides, the number of non-nutritional biomolecules such as saponins, and tannins present in pulses act as an antioxidant and may have anti-carcinogenic effects. Pulse crops can potentially help improve human health and nutrition, reduce hunger and help in eradicating malnutrition.

Sustain soil health : Pulse crop is known to fix atmospheric nitrogen, and increasing mineralization of organic–P and solubilization of inorganic–P. It improves the micronutrient availability in the soil due to the release of organic acid, phytosiderophores, and expands the surface area of a plant root system. Subsequently, it adds organic matter into the soil and promotes the growth and activity of soil micro-organism. The beneficial soil microbes regulate important processes such as soil nutrient cycling, nutrient acquisition by the plants and stimulates enzymatic activities; e.g. dehydrogenase, acid and alkaline phosphatase. Therefore, integration of pulses in the cereal-based system can constitute an effective strategy for improving soil health.

Table 1. Effect of different crop rotations on SOC (Mg C ha^{-1}) and other nutrients (kg ha^{-1}).

Treatments	SOC (Mg C ha^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Available S (kg ha^{-1})
Rice-wheat	13.7^{d}	231.6^{b}	15.4^{c}	164.7^{b}	10.6^{c}
mungbean	13.7^{d}	266.2^{a}	21.7^{a}	164.8^{b}	12.2^{a}
Rice-wheat-rice-chickpea	14.6^{c}	238.4^{b}	16.5^{bc}	173.8^{a}	11.9^{b}
Rice-chickpea	16.3^{b}	260.2^{a}	17.0^{b}	172.2^{a}	11.5^{ab}

(Ghosh et al., 2019)

Mini fertilizer factory : Biological nitrogen fixation (BNF) is a biochemical mechanism by which legume crop fixes atmospheric nitrogen symbiotically in the presence of nitrogenase enzyme and supplies nitrogen to the plants. Pulse cultivation increases soil nitrogen status and thus minimize the load of N fertilization of succeeding crop. This reduces the production cost and helps in improving farm profitability.

Fodder : Besides its role in human nutrition, pulses can be a good source of palatable feed and fodder for livestock and thus indirectly contribute to food security. The legume straws have higher dry matter digestibility and contains a good amount of protein and other minerals, which helps in improving the nutritional value of milk and milk products.

Improving productivity : The ever increasing population, changes in dietary pattern and limited available land resources possess a threat to global food and nutritional security. Diversifying crops fulfil dietary requirement protect soil quality, stabilized income and productivity. Thus, sound agronomic practices is an important driver determining crop productivity. Pulse crops are the integral component of many cropping systems and its intensification gives higher system productivity than existing system. Prior studies suggested that, increment in system productivity can reach up to 45 % due to the additional yield provided by pulse crop.

Table 2. Pooled rice equivalent yield (REY) (Mg ha^{-1}) affected by different cropping system.

Cropping system	2 years pooled REY(Mg ha^{-1})			
	Rainy	Winter	Summer	Total
Rice-wheat	4.6	3.3	-	8.0
Rice-wheat-mungbean	4.8	3.4	0.5	8.9
Rice-potato-mungbean	5.0	6.2	1.9	13.1
Rice-rapeseed-mungbean	4.8	3.1	1.9	9.8
Rice-clover	4.9	6.4	-	11.3
SEm ±	0.05	0.20	0.07	0.23
LSD (*p*= 0.05)	0.16	0.66	0.27	0.75

(Sharma et al., 2005)

Approaches to crop intensification

Crop intensification aims to achieve higher output from a given amount of inputs and reduces expenditure by making modifications in crop management practices. It offers a wider choice in the production of a variety of crops per unit area in a given time and reduces the risk of crop failure, provides improved nutrition, product diversification and value addition. It can be achieved through two basic approaches:

Horizontal diversification : is the common and main approach of crop diversification in which diversification takes place through substitution of a crop variety with the other.

Vertical diversification : In vertical diversification, various downstream activities are undertaken and the existing economic produce of different crops is refined and manufactured products and additional values to the produce.

Benefits of crop intensification

- Better utilization of natural resources which helps in ecological sustainability.
- Alternate crops may enhance profitability.
- Stabilized farm income and productivity
- Better human nutrition and health.
- Reduced pest incidence (Diseases, insects, weeds etc).
- Enhanced employment opportunities
- Reduced crop failure risks in dry lands.

Constrains

- Predominantly rainfed cropping: >60% crops are rainfed
- Over exploitation of soil & water resources that undermines overall sustainability
- Impeded modernization & mechanization due to small holdings and illiteracy of farmers.
- Lack of well-developed agro-based industries
- Infrastructure (Roads, power and communication) bottlenecks.
- Lack of market information support system
- Continuously decreasing agricultural investment.

Conclusion

Inclusion of pulses in rice-wheat cropping system enhances profitability, productivity and sustainability over the long run by reducing cultivation cost, enhancing input use efficiency, and

improvement in different soil properties. Thus it is concluded that pulse crops are more biologically efficient and resource conservative sequences to cereals.

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ROOTSTOCK - AN IMPORTANT COMPONENT IN FRUIT PRODUCTION

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Abstract

Rootstocks play a vital role in determining the potential of scion in terms of tree canopy, nutritional uptake, yield, fruit quality and tolerance to biotic and abiotic stresses such as pathogens, pests, extreme temperature, water stress, salinity and nutritional stress. Nowadays, use of suitable rootstock species in establishment of fruit orchard is regarded as a means of sustainable production by compensating the possible effects of external stress on the scion. Owing to its positive impact on yield and quality, improved rootstock varieties of fruit crops are developed through breeding programmes throughout the world. Appropriate rootstocks for vigour, precocity and stress management has been identified and put underutilization in several fruit crops including apple, peach, plum, cherry, mango, grapes, citrus, etc.

Introduction

Rootstock is a component of a plant, often an underground part, from which new above-ground growth are often produced. It could also be described as a stem with a well-developed root system, to which a scion bud from another plant is placed. The relationship between rootstock and scion are of more relevance to fruit production technology.

Unfavourable soil and environment conditions like stress, drought, flooding, salinity and contamination of organic pollutants hinder the production of fruits, thus doesn't meet the demands of the rising population. However, to combat this problem in fruit production, an alternative has been introduced i.e., use of appropriate rootstocks, which are capable of reducing the effect of external stresses on the scion (Higgs and Jones, 1991).

The use of rootstocks is most commonly associated with fruiting plants and trees, and is useful for mass propagating many other types of plants that do not breed true from seed, or are particularly vulnerable to disease when grown on their own roots. Rootstock not only influences the size of the tree but also provides other characteristics such as earliness in production, some attributes of disease resistance and resistance to extreme temperatures. Thus, no matter the species or variety used as rootstock, obtained plant will reach, at the adult phase, an ever smaller size than an equivalent plant if it were obtained by seeds (seedling) i.e., through sexual process.

The role of rootstocks and its use in different fruit crops has significant impact on fruit crop production by influencing canopy architecture, nutritional uptake, flowering, yield and fruit quality (Rom and Carlson, 1987). A certain rootstock can be used for a single species or cultivar since different rootstocks confer different properties, such as vigour, fruit size and precocity while others may be selected by their characteristics such as drought resistance, pests and diseases tolerance.

Another desirable feature in a rootstock is its adaptability to environmental conditions *viz*., tolerance to wet or dry soils, acidity/alkalinity of the soil or high/low air temperature. Rootstocks can be used as interstocks, a small piece inserted between the rootstock and scion to overcome

incompatibility barriers between stock and scion. These trees are known as “three piece” trees (Nimbola *et al.*, 2016).

Characteristics of Rootstocks

- It should produce strong fibrous root system
- It should have vigorous growth habit, healthy and resistant to pest, diseases and frost
- It should be easily propagated by cuttings
- It should have thick bark to hold the bud
- It should be free from suckers
- It should have uniform growth rate
- It should be for the fruiting growth and fruiting characters
- It should tolerate wide range of biotic and abiotic conditions

Description and characteristics of rootstocks in fruit crops

Sl. No	Fruits	Rootstocks	Characters
1.	Apple	M9	Dwarfing, Suitable for high density planting
		M4,M7,M106,M24	Semi-dwarf, Resistance to wooly apple aphid
		M-111, M- 104	Semi-vigorous, Drought tolerant and wooly aphid
		Merton-793	Vigorous, Resistant to collar rot, Early fruiting
		M-27 (M13 × M9)	Ultra- dwarf, Suitable for high density planting
2.	Plum	Myrobalan	Vigorous, resistant to crown rot and drought but susceptible to oak root fungus
		Marianna	Vigorous, resistant to nematodes, crown gall and oak root fungus
		St. Julien	Dwarfing
		Beach plum	Very dwarfing
		Nanking cherry	Very dwarfing
		Brompton	Semi vigorous
3.	Peach	Nemaguard	Vigorous, resistant to root-knot nematode
		Nemared	Resistant to root-knot nematode
		Hansen 536	Extremely vigorous, immune to root-knot nematode, drought tolerant, tolerant to calcareous soil conditions
		Cadaman	Vigorous, tolerates root asphyxia and iron induced chlorosis, resistant to root- knot nematode
		Cornerstone	Tolerant of high pH soil and is resistant to iron induced chlorosis
		Viking, Atlas	Vigorous rootstocks
		Fortuna, Controller 5	Dwarfing rootstocks
4.	Pear	Quince	Dwarfing rootstock
		P. pashia	Vigorous rootstock
5.	Cherry	Mahaleb	Vigorous, cold hardy, resists crown gall, bacterial canker and some nematodes
		Mazzard	Vigorous, resistant to root-knot nematodes and oak-root fungus
		Colt	Semi-vigorous

Sl. No	Fruits	Rootstocks	Characters
		Gisela 5	Semi-dwarf
		Krymsk 6	Semi-dwarf, tolerant to hot climates and also very cold hardy
		NEWROOT-1	Dwarfing, promotes early bearing
6.	Walnut	*J. hindsii*	Resistant to oak root fungus and root-knot nematode
		J. nigra	Tolerant to crown gall, phytophthora and oak root fungus
		J. microcarpa	Suitable for high boron, chloride and soil pH conditions
		J. sieboldiana	Resistant to phytophthora and cold hardy
7.	Grape	Riparia Clorie	Resistant to phylloxera
		V. rupestris	Resistant to black rot, downy mildew and PM
		St. George	Tolerant to drought
		Ramsey	Tolerant to salinity
		110 Ritcher	Tolerant to drought
		Dogridge	Tolerant to salinity and drought. It can be used in all conditions
		Salt Creek	Resistant to phylloxera, tolerant to salinity
		Freedom	Resistant to nematode
8.	Citrus	Flying dragon	Ultra- dwarfing rootstock, resistance to phytopthora root rot, nematode but highly susceptible to iron chlorosis
		Poncirus trifoliata	Dwarfing, resistant to phytopthora and nematodes, susceptible to tristeza virus
		Citrus jambhiri	High yield, vigour, suitable for deep soils, highly susceptible to nematode and phytopthora
		Citrus reshni	Salinity tolerant
		Citrus limonia	High yield and vigour, suitable for deep soils
		Citrus karna	High vigour and yield
		Citrus limettoides	High vigour and yield for sweet orange and lime
		C. pennivesiculata	High vigour and yield for sweet orange and lime
9.	Mango	Kurukkan	Salt resistant and polyembryonic
		Moovandan	Salt resistant
		Nekkare	Salt resistant
		Olour	Dwarfing rootstock, salt tolerant
		Vellaicolumban	Dwarfing rootstock
		Gomera 1	Salt tolerant
10.	Guava	*P. friedrichstalianum*	Dwarfing, resistant to wilt
		P. pumilum	Dwarfing
		P. cattleianum var. Lucidum	Resistant to wilt

Source : Anon, 2020; De and Patel, 2019; Reighard et al., 2014

Conclusion

Rootstocks provide an efficient way of raising uniform trees capable of bearing good quality fruits with high yield even under unfavourable conditions like drought, salinity, heavy metal toxicity, pests

and disease incidence, etc. However, further study regarding the rootstock-scion relationship is necessary to aid in breeding programmes and selection of potential rootstocks in future.

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SERICULTURE AS A VERSATILE ENTERPRISE

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Abstract

In this article the authors have just tried to bring the focus of the readers towards the importance of sericulture, as now a days being self-dependent is the moto for a successful life. In the article the versatility of the sericultural industry has been focused as it helps to empower the women community of the society as well as helps in the upliftment of the rural population. When small scale cottage industries will develop in the rural areas, the migration of the youth towards the urban can also be checked. The multiple use of mulberry plants and the silkworms make it a very profitable source of income. Thus, sericulture can be a blessing for the farmers if focussed properly.

Introduction

Sericulture is an Agro-based enterprise which is labour intensive as it is a combination of both agriculture-based work as well as industrial work. In the agriculture-based work there are lot of activities involved such as growing of food plants with proper care and management. Similarly, in industry-based work rearing of silkworms and spinning od cocoons are the main activities. One of the best fascinating features of sericulture is that it is multidisciplinary in nature. Moreover, women participate in the activities of this work, so they enhance or help to build up the socio-economic status of the rural community, by spreading awareness, demonstrating the techniques involved in all the activities starting from mulberry leaf production, cocoon production, silkworm egg production, silk reeling warp and weft making, printing and dying, weaving, finishing, garment designing, marketing etc.

Silk industry in India (Central silk Board, 2013)

The silkworm entry background for India is always a mystery. There are so many evidences of use of silk in the ancient times. But the documentation of these records is not well maintained as exact date or time of the start of this sericulture is difficult to mention. Systematic silkworm stock breeding and maintenance started in 19th century. Earlier only pure races were reared, hybrid silkworm rearing only started later. Sericulture provides employment opportunities, improvement in the economic development hence, uplifting the rural community (Suryanarayana and Srivastava, 2005; Rao, 2007).

Importance of sericulture (Sharma and Kapoor, 2020)

- Provide an exceptionally good quality of various silk.
- The mulberry fruits can provide lot of vitamin and minerals.
- Leaves, roots etc can be crushed and used for its herbal and medicinal properties.
- The soft wood can be used to make toys or few sport items.
- The plantation of mulberry is mostly done by stem cutting so planting seedlings may also help to prevent soil erosion.
- Eri pupae is consumed by few tribes as they are rich source of protein.
- The pupal case of silkworms is used in cosmetics as it contains essential oils.

Eco-friendly nature (Sharma and Kapoor, 2020)

Sericulture is very eco-friendly in nature because of the nature of the crop. The mulberry plants which are the host for silkworm are perennial in nature, so the soil need not to be opened frequently. The buy products are extremely useful along with the silk fibres. The pests and diseases can be managed well with the help of bio-control agents. The maintenance of the rearing houses is also very well done by using organic and safe chemicals. The perennial crop can be grown and cultivated in a wide range of soil and climate. The integration of sericulture can be done with poultry, horticulture crops and other plantation crops for a resources sustainable agricultural system. Thus, sericulture can be also considered as a versatile or multipurpose enterprise.

Mulberry silkworm is mainly reared in 5 important states of our country:

Karnataka- Mysore silk
Andhra Pradesh- APS105×APS126 (Bivoltine)
Assam- CSR46×CSR47 (Bivoltine)
West Bengal- PM×C110
Tamil Nadu- APS45×APS12 (Bivoltine)

By-products of mulberry silkworm (www.indiastudychannel.com)

1. Garlands can be prepared from the shells of the pupae that can be stored after out the silk filament.
2. In the soap manufacturing industries, the oil is extracted from the dead pupae.
3. The exuviae that is remained after oil extraction is used in poultry feed which are rich source of vitamin E and K.
4. The excreta of silkworm are rich in organic matter and can be used to feed fish.
5. Mulberry wine is also extremely popular among the wine lovers.
6. Few sports items and toys can also be prepared using the woody stems of mulberry plants.

Conclusion

The sericulture industry in India is incredibly old, since the ancient times people are fond of silk garments. If more focus can be put forward in a very systematic way sericulture can result into a booming industry. Many states are contributing towards the manufacturing of different silk clothes, earlier only indigenous varieties were grown or reared, but now hybrid is also in fashion, multipurpose nature of silkworms and the host plants also contributes towards the economy of the country.

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STUBBLE BURNING-ITS IMPACT ON ENVIRONMENT

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Abstract

Stubble burning is one of the major issues in today's agriculture. After the harvest of crops like rice and wheat farmers are left with a lot of straw or stubble. Even if they want to incorporate that in the soil for land preparation of the next crop, they cannot do it for the whole lot, so the fast and easy option left with them is to burn it in the field itself as there is shortage of store houses. But the impact of stubble burning is of great concern from the environmental point of view. It burns the soil up to at least 12 cm depth, so we need to find some alternatives as in the process the beneficial microbes and the inherent capacity of soil to rebuilt itself is also sacrificed. In this article we are discussing about this issue which may be of interest for the readers.

Introduction

Managing the stubble in the field is a very technical issue faced by our farmers during the harvesting season. Single solution that can fit for all is again a very tough job. Through burning of stubble is not preferred by most of the farmers, but they are left with no option but to burn it in the field itself. In some cases where the weeds are resistance, the burning of stubble in the field may help to get rid of the obnoxious weeds as well. The farmers try to avoid burning if they have considerable and available alternative options. The stubbles need to be managed in a very proper manner to reduce the residual effect on soil health.

Why farmers go for stubble burning: (CIMMYT, Karnal)

- The method or tactic is cheaper as compared to other strategies.
- Instant effect and result can be obtained.
- It may also aid in weed management, insect-disease management.
- The nitrogen tie-up is also reduced.

Few demerits of stubble burning

- It leads to loss of important nutrients from soil.
- Also, loss of carbon from soil.
- It implements negative impact on soil micro-organisms.
- The soil aggregation (soil structure) also gets broken-down.
- It may raise the soil acidity levels.
- Soil erosion and wind erosion may also be observed due to stubble burning.

Impact of crop residue burning

In the environment, the impact of residue burning has a lot of negative effects. The aerosols and smog caused by the residue burning depletes the air quality and creates depletion in ozone layer (Jain *et al.,* 2014). Along with carbon monoxide a lot of other gases toxic to the respiratory system which leads to respiratory hazards are also produced (Shan and Yan, 2013).

During harvesting of crops, at least 50% of organic carbon is obtained but when we are burning the stubbles it is completely lost and in return the soil flora and fauna is also harmed. So, these kind of contribution to the soil environment may lead to global warming as most of them are greenhouse gases. (Singh *et al.,* 1992).

The heat emitted from burning the residues increase the soil temperature which kills the fungal and bacterial microbes in the soil. Repeated stubble burning may kill the microbes permanently, thus deteriorates the soil inbuilt capacity to recover itself. The increase in soil temperature may also harm the balance of carbon and nitrogen in the soil profile.

Other options to manage crop residues

- The residues can be used for soil mulching.
- The crop residue helps to maintain the soil acidity for good growth of crops.
- Crop residues obtained from rice-wheat cropping pattern usually provides higher C:N ratio.
- The crop residues can be uniformly distributed by using combine harvester.
- An increase in organic carbon uplifts the fungi and bacteria which are beneficial to the soil.
- Straw bailing machines are also phenomenally successful in managing crop residue.
- Farmers can use high horse-power segmented tractor for deep cutting of straw while harvesting.
- The machines such as, use of double disc coulters, zero tillage and happy seeder would help in good mulching action.
- Intimating farmers about the chaff making process from the crop residues.

Conclusion

As discussed in the above article, we have come across a lot of issues related to our environment where the demerits are more than the advantages of stubble burning. There are some other options which can be useful if the farmers take some cooperative steps towards minimizing the hazards caused by stubble burning. Combine harvesters, Happy seeder etc. can be of better options which can be effective in managing the straw or stubbles in farmer's fields.

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A BOON TOWARDS BEATING THE HEAT WITH "RED STAR"

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Mr. Pradip Saikia, a small and a marginal farmer, resident of a small village in Gabharupar of Bamunpukhuri Gram Panchayat, situated under Dhekiajuli block of district Sonitpur Assam have set an example to small marginal farmers by adopting modern agricultural practices and techniques. He had cultivated watermelon, a horticultural crop in the year 2019-2020. The variety he had chosen was "Red Star" having a maturity period of 70 days. He had cultivated the crop in his 6 bighas of land in a nearby plot enriched with sandy loam soil by the 2nd week of Nov 2019 immediately after harvesting of Sali paddy. He solely have to depend upon this small piece of land to look after his family as he has no other source of income.

During the period of cropping season, he showed keen interest in attending farmer's technical training programme on "Scientific Production Technology of Watermelon conducted by CSS ATMA, delivered at the block level for adopting scientific techniques and methods gradually in watermelon which is considered as a very important technique to be followed by the farmers of Assam to obtain good crop population and ultimately higher yield. Adopting scientific agricultural techniques helps farmers to reduce the labour cost during intercultural operation and also reduce the application of pesticides and fertilizers thus benefit the farmers by reducing the cost of cultivation. His total cost of cultivation was Rs 6000 which was supported by his wife through the piggy bank.

Mr. Saikia believes in practising multi cropping system to maximize the use of his land and increase his income. He also grows crops such as potato, lentil, peas, blackgram, cole crops etc. He adopted and followed the techniques taught by the agricultural officials on "Scientific Production Technology of Watermelon to obtain a good yield and also in order to double his income through the market linked traders without any support of agricultural loans. During technical training programme, he shared his personal experience, and mentioned that while adopting this method, emphasis was mainly laid in maintaining spacing of 152.4 cm at the time of planting in order to maintain a uniform planting geometry. The seeds and inputs were provided by the Office of District Agricultural Officer, Sonitpur Assam. He used to apply recommended doses of fertilizers such as single super phosphate (4kg/bigha) and organic manure such as cowdung @ 10 quintals in 6 bighas of land to boost the production and productivity by improving the fertilizer use efficiency at the time of land preparation. The requirement of seeds was comparatively lesser (2000g/bigha) with 3 seeds each in an individual hole keeping a distance of 152.4 cm from each hole, altogether with 500 number of holes per bigha which was practised manually. An intercultural operation such as weeding and thinning was followed after 20-25 days of planting. Regular monitoring and supervision of the crop was done thoroughly by him to get rid of fruitfly and aphids which is commonly occured at the vegetative stage of growth in watermelon. Application of Malathion @1ml/l of water using hand sprayer was followed strictly for further control of fruitfly at its larval stage. Further at the flowering stage of the crop, he started rearing of honey bees which is collectively known as 'Apiculture' for pollination since it is a hybrid variety thereby leading to the increase in quality fruits production and popularisation of varietal development in watermelon.

Mr Saikia was immensely satisfied with the performance of the variety and had produced an estimated yield of 45 quintals/bigha with a total yield of approx 270 quintals in 6 bigha of land. He

sold the produce immediately until the arrival of the next cropping season at a fair price of Rs.20/ kg which generally weighed around 3-8 kg and earned a net profit of Rs.75000.00. Despite of facing some major constraints such as continuous lockdown affect since 24th March 2020 as well as artificial irrigation facilities which directly declined the market linkage channels of several farmers during the harvesting period, Mr. Pradip Saikia had produced a satisfactory yield and broke the barrier of hindering the potentiality of earning income.Due to suitable soil and climatic conditions as well as through his dedication and continuous efforts towards farming, he could be able to achieve higher yield and income within a short period of time as well as could motivate the other small and marginal farmers of his nearby village for further uplifting their economic status thereby preserving their ancestral occupation for future generations.

Name of the farmer	: Mr. Pradip Saikia
Age	: 46 years
Village	: Gabharupar
Gaon Panchayat	: Bamunpukhuri
Block	: Dhekiajuli
District	: Sonitpur, State: Assam
Contact number	: 7399910474

Fig. 1. Seedling stage of watermelon variety Red Star after 20 days of planting

Fig. 2. Stage of harvesting after 70 days of planting

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WATER REQUIREMENT FOR FOLIAGE INDOOR PLANTS

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Introduction

The Indoor foliage plants have become a necessity in the homes for their interior decoration attractive leaves rather than flowers. Plants are also helps to absorb Carbon Dioxide and keep Oxygen flowing, they purify the air by removing toxins, help to deter illness, ease tension and lower stress, create a relaxed and happy ambience whilst helping you to ultimately work better through improved concentration, heightened attention, enhanced creativity, increased productivity and enriched overall well-being. Foliage plants, in common terminology, are called house plants. Plants are essential for our survival. Plants also produce intangible benefits for people, such as improving our health. These benefits occur with plants outdoors and indoors. People have been bringing plants into their homes for thousands of years. The proper watering requirement for indoor plants is a major obstacle to increased plant use in the home or office. Foliage plants from the world's tropical or subtropical regions provide the basis for today's foliage plant industry. From 1956 to 1967, *Aglaonema*, *Dieffenbachia*, *Dracaena*, *Epipremnum*, *Ficus*, *Peperomia, Philodendron*, *Sansevieria*, *Syngonium*, and plants from several genera of Palmae (palm) were the major players in the industry. *Philodendron* dominated all other genera accounting for 50% and 36% of wholesale values in 1956 and 1967, respectively (Smith and Strain 1976). In 1975, *Schefflera* and ferns (Polypodiaceae) joined the list of the Census of Horticulture Specialties of the US Department of Agriculture's National Agricultural Statistics Service (McConnell et al. 1989). However, *Philodendron* was still the major genus, accounting for 20% of the wholesale value. In 1988, genus *Hedera* was added to the list (McConnell et al. 1989). The total market segment of *Philodendron* decreased from 20% in 1975 to 4.7% in 1988. No single genus exceeded 10% of the market value in 1988, suggesting increased diversification in foliage plant production. Ten years later, genera *Anthurium* and *Codiaeum*, as well as bromeliads (Bromeliaceae) and cactus (Cactaceae) were added to the 1998 list (USDA 1999). The wholesale value of foliage plants in the US increased from $13 million in 1949 to $574 million in 2000 (USDA 2001). The use of foliage plants for interior decoration or interior plantscaping has become an integral part of contemporary design, playing an important role in our life (Manaker 1997).

Indoor Plants - Watering

Over watering is a very common problem for the houseplants. Water only when the plants when need watering. The water requirement of house plants varies from one kind to another. A plant growing in a porous clay pot will need more water compared to one growing in a plastic or glazed container. Similarly, a smaller pot needs more frequent watering. A plant needs more water during its growing period and the amount is reduced appreciably during the winter which is resting for most plants. It is always better to water in good amounts at reasonable interval, which may vary from 3 to 10 days depending on the climate and species, rather than small daily doses. The amount and frequency of watering depends on many factors, such as the plant species, its growth stage, its location, the type and size of its pot, soil mix characteristics and variable weather conditions. Roots need both water and oxygen, and when surrounded by water, they cannot take up oxygen. These

roots may rot and eventually the whole plant may die. The symptoms of over-watering and under watering are similar. Both lead to poor root health, root decline and possibly death of the plant. Some plants thrive under moist conditions while other plants grow well when kept drier. Plants may slow in growth after a flush of new growth or a heavy flowering. During these periods and while it is dormant, a plant will need less water (Henny and J. Chen. 2001). Do not water with hot or cold water. The water temperature should be between 62 and 72 °F. Do not water plants with softened water because sodium and chloride will also be added to the soil mix, possibly causing plant damage. Although wilting is often an indication of the need to water, it is not always so. This inability to take up water will cause wilting, and under these conditions, watering may make the problem worse.

The rule-of-thumb is to water when necessary. The following methods may be used to determine when to water:

- Touch the soil - The most accurate gauge is to water when the potting mixture feels dry to the touch. Stick your finger into the mix up to the first joint; if it is dry at your fingertip it needs water.
- Tap the pot - When the potting mix in a clay pot begins to dry, it shrinks away from the sides of the pot. Rap the side of the pot with the knuckles or a stick. If the sound is dull, the soil is moist; if the sound is hollow, water is needed.
- Estimate weight - As potting mixtures become dry, a definite loss in weight can be observed.
- Judge soil colour - Potting mixtures will change from a dark to lighter colour as they dry.

Water quantity and quality for foliage indoor plants:

Water Quantity

Learning to water is one of the most important skills in plant care. Applying too much water can suffocate plant roots and too little water causes growth to become erratic and stunted. Watering frequency will depend on the conditions under which the plants are growing. When dealing with how much water to apply, consider the following:

- Plant type: A list of plants and their moisture requirements is listed below. Not all plants are similar in their water requirements. This information, along with the light preference, is usually included on the plant label. For example, a croton, which prefers high light, will likely need more frequent watering compared with a succulent plant such as Opuntia cactus. Both have similar light needs but dissimilar water requirements.
- Plant size: Larger plants need more water compared to smaller plants.
- Container volume: If the growing container is too small, watering may be required more frequently.
- Soil moisture: The amount of water already present in the growing medium will also affect your watering frequency.
- Light intensity: Plants under high light transpire more water compared with plants under low light.
- Improper watering causes many problems. Containers with saucers may cause an excessive build-up of soluble salts (from the applied fertilizer). High levels of soluble salts can cause damage to plant roots and a decline in growth. Discard any water that had drained in the saucer after irrigation, and apply large quantities of water to the soil to leach the accumulated soluble salts. In deciding when you should water, feel the soil by pushing a

finger an inch or so below the surface. If the soil is still moist, no further water is needed. Water devices or water meters are also available to simplify watering.

Water Quality

The quality of the irrigation water is an issue with plants that are susceptible to fluorine and chlorine, such as Corn Plant (Dracaena), Ti Plant (Cordyline), Peacock Plant (Maranta), and Rattlesnake Plant (Calathea) Alleviate this problem by letting the water stand for several days so that some chlorine and fluorine will be released from it before applying the water to the plants. Move susceptible plants away from the edge of the pool to prevent water splashes from reaching the foliage. Do not use susceptible plants around enclosed pools. In general, plants with long linear leaves (such as the Spider Plant) are more susceptible to fluorine. All indoor plants can benefit from filtered water or leaving water out overnight before using.

Some foliage indoor plants water required

1. **Aluminum Plant - *Pilea Cadierei* :** The Aluminum plant needs to be watered differently during different times of the year. During spring and summer, the top quarter inch of the soil should be kept moist. During fall and winter, allow the top quarter inch of soil to dry out before watering again. Do not permit water to stand in the saucer underneath the plant.
2. **Arrowhead Plant - *Syngonium Podophyllum* :** When the top soil becomes dry to the touch slightly - water thoroughly. Reduce watering during winter to prevent plant problems
3. **Areca Palm - *Dypsis lutescens* :** Keep the soil of an Areca palm moist but never soggy. Allow the top couple of inches to dry out before watering. This recreates its natural environment living conditions which are rather moist.
4. **Cast Iron plant - *Aspidistra Elatior* :** Water once the top one inch of soil becomes dry. Water less during winter and do not over water. Over watering to the degree that the soil becomes soggy for a period of time can cause the plant to die. The Aspidistra elatior is drought tolerant so if it misses being watered even for a month it will look unwell but be right back with you once care and water is given again.
5. **Croton - *Codiaeum Variegatum* :** The croton plant requires frequent watering, but be sure not to over-water. Too much water can cause root rot, but too little water can dry the humidity-loving plant out. Plants need less water during the winter.
6. **Dumb Cane - *Dieffenbachia Amoena* :** For the best results, keep the dumb cane plant's top inch of soil moist at all times. It will tolerate extended periods of watering neglect, but the leaves will begin to shrivel. Watering makes the leaves stiffen. Before moving the plant, allow the soil to dry out. This will give the leaves a more rubbery texture which will better survive the handling process.
7. **Golden Pothos - *Epipremnum Aureum* :** It requires watering only when the first quarter inch of soil begins to feel dry to the touch. Overwatering will cause the plant's roots to rot. Under-watering is not an issue, as this plant will withstand a high degree of abuse. It will only stunt the growth of the plant. During the fall and winter, reduce watering to allow the top quarter inch of soil to fully dry out before offering more.
8. **Heartleaf - *Philodendron Scandens* :** Heartleaf may be grown in soil or just in water. Plants that live in soil should be watered when half of the soil is dry. As with most plants, yellow leaves indicate over-watering and brown leaves indicate under-watering.

9. **Lucky Bamboo - *Dracaena Braunii*** : Lucky Bamboo plant doesn't need a lot of water. In fact, too much is bad for it. Water the plant about once a week and ensure that there's a few inches at all times, enough to cover the roots.
10. **Peace lily- *Spathiphyllum spp* :** Peace lilies should be watered once the top half of the potting soils in dry, but before the leaves begin to droop. Water thoroughly until water runs out the drainage holes. Use well-draining potting soil and avoid letting the plant sit in water, as this will lead to root rot.
11. **Swiss cheese - *Monstera deliciosa* :** Swiss plants water requires in moderately and evenly, about once a week. Wait until the soil is fairly dry before watering again.
12. **Snake plant - *Sansevieria* :** are actually succulents, which mean they store extra water in their leaves, stems, and roots and can thrive in drier environments. Water is stored in those root structures, and the meaty, fleshy leaves also contain a lot of water.

Conclusions

In conclusion, the present study strongly suggests that plants should be watered only when necessary or potting mix feels dry to the touch. If the soil feels damp, skip the watering. If excess water continues or over-watering, plants may show other drought symptoms, such as scorch, leaf drop, both lead to poor root health, root decline and possibly death of the plant. All indoor plants can benefit from filtered water or use room-temperature water to avoid shocking the plants.

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ROLE OF VEGETABLES IN BOOSTING IMMUNITY DURING COVID-19 PANDEMIC SITUATION

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Introduction

We are evident of the situation that COVID-19 pandemic is still in a motion which is a serious matter of concern. Its impact has not only affected India but all over the globe. It has affected the economy of the nations, educational scenario, agricultural systems, etc. but most importantly it has resulted in emotional disturbances to those who have suffered or are still suffering due to such pandemic. It is a bitter truth that, no such vaccine or medicine has been regulated till now to neutralize COVID-19. However, due to several issues now government are trying to normalize the activities by withdrawing various restrictions which were formulated during the initial stage of COVID-19 interference in our nation.

Through various research and statements during this pandemic situation we were familiar with the fact that proper immune system can tackle such problem and could recover after a fairly short period of time. Therefore, keeping in mind that the immunity is a key concern which needs to be taken care of, people have started adopting several alternatives such as following proper healthy balanced diet, maintaining fitness as by doing exercises, meditation, yoga, health hygiene, etc. in order to maintain and improve the immunity.

In such situation it was realised that consumption of good amount of healthy vegetable in a diet is one of the easy substitute to maintain and improve the immunity during this pandemic situation especially to the old aged people who are at more risk due to their weak immune system. Vegetable is simply a plant or part of plant which can be consumed either raw or cooked or even consumed in a processed form. According to Indian Council of Medical Research (ICMR) consumption of 300g of vegetable per day is essential for balance diet (Muthukumar and Selvakumar, 2013) which indicates the importance of vegetable in human diet. Vegetable contains a wide range of essential nutrients and bioactive compounds which is known to exhibit various antioxidants, anti-viral and anti-cancer properties which is beneficial for human health. A vegetable make up a major portion of the diet of humans and plays a crucial role in human nutrition, especially as good sources of nutraceuticals, vitamins, minerals, dietary fibre and phytochemicals which will be helpful in improving our immunity system. Nutraceuticals are the substances which are found as a natural component of food or other ingestible forms that have been determined to be beneficial to the human body in preventing or treating a number of diseases. Early before it was believed that 14 vitamins and 16 essential minerals were the key for human nutrition and health but recently, with the advancement in research, it was found that vegetables contain thousands of beneficial phytochemicals in addition to the 14 vitamins and 16 minerals (Ramya and Patel, 2019). It has been observed that it is preferable to eat fresh vegetables and salads at every meal, as well as fresh fruits to increase the efficiency of the immune system, especially for the patient of the digestive system and to clean the

body (Dhandevi amd Jeewon, 2015). As vegetables are rich in different nutrients, minerals and vitamins it is also known as protective food.

Role of some major vegetables in boosting immunity system

Several research and experiments has revealed that consumption of healthy vegetables have positive responses in improving the immunity system in human beings. The most important vegetable that improves the immune system cabbage, broccoli, broccoli, cauliflower, beetroot, carrots, pepper, radish, watercress, parsley, celery, red onion, garlic, pumpkin, eggplant, tomatoes, green beans, potatoes, spinach, artichoke, turnip, etc. (Ali *et al.*, 2019) Some of them are as follows:

Tomato : Tomato is one of the major vegetable well known for its nutritive value. It is a good source of vitamins (A, B and C) and antioxidants which is known to improve immunity and found to be helpful in prevention against several cancerous cell and other harmful diseases. Consumption of tomatoes in daily diet are effective in lowering blood pressure and reducing cholesterol levels in the human body. Tomato is a good source of chromium which is beneficial for the diabetic patients to maintain their body sugar level under control (Bhowmik *et al*., 2012).

Carrot : Carrot has a remarkable nutritional and health benefits. They are enriched with carotenoids, phenolic compounds, polyacetylenes, and vitamins which help to reduce the risk of several diseases. It has been reported that such carrot compounds exert antioxidative, anticarcinogenic, and immune enhancer effects (Shakleel *et al.*, 2017). A carrot is a rich source of beta-carotene, a potent antioxidant that fights free radical damage of cells, which in turn may take a toll on immunity (Sengupta, 2020).

Onion : Onions are low in calories and high in beneficial nutrients like vitamins, minerals, and antioxidants that can help cure a cold, cough, high fever, sore throat, and boosts immunity (Agustin-Bunch, 2020) which plays a vital role in maintaining and boosting immunity.

Garlic : Garlic and its product offer beneficial ability to enhance the immune system. It helps the body to fight against various infections, heart diseases, allergies, bronchitis, arthritis, cold and several fungal and bacterial problems which constantly threaten our health. It is also known to possess antitumor properties. In some cases garlic is also known as a natural immune system enhancer (Tripathi and Lawande, 2006).

Broccoli : Broccoli is a good source of potassium which helps to maintain a healthy nervous system and also enriched with minerals like magnesium and calcium that regulates the blood pressure. It also contains trace mineral i.e. zinc and selenium which helps to strengthen immune defence actions (Rasquinha, 2013).

Beet root : Beetroot is one of the most potent vegetable with respect to antioxidant activity. Significant amount of vitamin C, Vitamin B1, B2, niacin, B6, B12 are found in beetroot, while the leaves are an excellent source of vitamin A. Beetroot helps in curing many diseases such as anaemia, blood pressure, cancer, dandruff, gastric ulcers, kidney ailments, liver toxicity or bile ailments like jaundice, hepatitis, food poisoning, diarrhoea or vomiting (Zitnanova *et al*., 2006, Neha *et al*., 2018.)

Green Leafy vegetables : Leafy vegetables includes spinach, palak, amaranthus, lettuce, fenugreek, etc, which generally possesses various medicinal and health benefits. They are considered as an essential part of the diet for meeting the daily nutrient requirements. Green leafy vegetables are rich source of nutrients, high in dietary fibre, low in lipids, and rich in folate, ascorbic acid, vitamin

K, Mg, and K. They also carry plenty of phytochemicals such as β-carotene flavonoids (Randhawa *et. al.*, 2015). They are helpful in boosting immunity.

Conclusion

Immunity of a body is a key weapon to combat any diseases or infections threatening our body. A good immunity system in our body will restrict the invasion of several problems causing health issues. In present days, most of the people are dependent on synthetic chemicals to maintain their better health. However, some are unaware of the fact that there are several other natural sources such as consumption of healthy vegetables which not only fulfils the dietary requirements but also plays a vital role in boosting immunity, preventing and also treating several infections and diseases in human body. Even during this COVID-19 pandemic situation, consumption of healthy vegetables will be helpful in boosting immunity and prevention from several other harmful infections and pathogens which may result in serious health issue which is better to be avoided especially during this pandemic situation. Such step might also reduce the burden and dependency over the synthetic chemicals for maintaining our health which will be a positive outcome.

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DNA VACCINE IN FISHES

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Introduction

Fish disease is one of the most important consequential factors in aquaculture sector. When disease outbreaks occur, diagnostics are conducted to detect the cause, and then treatment recommended to fish like oral treatment, an immersion (a dip or a bath), or, in rare cases, an injection treatment. Expenses come from delayed production, treatment chemicals, mortalities, and labor can be significant. Two techniques of disease prevention that have been commonly utilized in other animal industries are immunostimulants and vaccines. A vaccine is any biologically based preparation proposed to build up or to improve immunity to a specific disease or group of diseases. A vaccine, if effective, can help prevent a future loss from being a major economic drain. There are limited numbers of DNA vaccine strategies that have been efficient in giving significant protection against fish diseases. The great exemptions are DNA immunization against viral hemorrhagic septicemia virus (VHSV) at experimental level and infectious hematopoietic necrosis virus (IHNV) at commercial level. According to the Norwegian Biotechnology Advisory Board DNA vaccination is "the intentional transfer of genetic material (DNA or RNA) to somatic cells for the purpose of influencing the immune system".

What should be the properties of the ideal vaccine?

1. It should be safe for the fish, the person(s) vaccinating the fish, and the consumer
2. It should protect against a broad strain or pathogen type and gives 100% protection
3. It should provide long-lasting protection, at least as long as the production cycle
4. It should be easily applied
5. It should be effective in a number of fish species
6. It should be cost effective and
7. It should be readily licensed and registered

Evolution of DNA vaccines in Aquaculture

In 1996, the first DNA vaccination of fish took place, when Anderson and his coworker vaccinated rainbow trout (*Onchorhyncus mykiss*) against infectious hematopoietic necrosis virus (IHNV). After that, several trials are performed for a good sort of fish species and pathogens. In 1999 the injection of Atlantic salmon with pCMV4-G (plasmid-encoded glycoprotein) from a rainbow trout IHNV isolate induced outstanding defense against challenges with IHNV, albeit the salmon were much larger than the rainbow trout in earlier studies. Similar to what is observed in mammalian species, DNA vaccination of fish has been shown to induce adaptive and innate immune responses and seems particularly productive against novirhabdoviruses (like IHNV and VHSV). These are simple RNA viruses with five or six genes and a single protein of the viral surface (glycoprotein, or G protein) serving as a protective antigen. An immunization against VHSV in rainbow trout allows the stimulation of cell-mediated immune responses involving both CTLs and natural killer (NK) cells and has also been shown to significantly reduce the replication of virus during challenge. In 2005, a vaccine against IHNV infection in salmonids was also one among the primary DNA vaccine ever to

be cleared for marketing (by the Canadian Food Inspection Agency). During 2017, a polyprotein-encoding DNA (CLYNAV (Elanco), vaccine against Salmon Pancreas Disease Virus infection in Atlantic salmon used within the European union, based on a positive risk benefit assessment following analysis of data. It was approved for use in Norway by the Norwegian Medicines Agency.

Recent DNA vaccination laboratory trials

Effects of DNA vaccines against different viral and bacterial disease in fish have been observed and reviewed by Tonheim et al., Kurath, Redding and Weiner, and Gomez-Casado et al. Seemingly, DNA vaccination may also give protection against bacteria and parasites but not against all.

Pathogen	Gene inserted	Host	Administration route/adjuvant
IHNV	IHNV-G plus suicidal gene	Rainbow trout	Intramuscular/none
IHNV	IHNV-G; different genogroups	Rainbow trout	Intramuscular /none
IHNV	IHNV-G	Rainbow trout	Oral/PLGA
VHSV	E. tarda as delivery vehicle of the vaccine	Olive/Japanese flounder (Paralichthys olivaceus)	Intramuscular
IPNV	VP2; Segment A of TA strain	Atlantic salmon	Intramuscular
Megalocytivirus	86-residue VP	Turbot (Scophthalmus maximus)	Intramuscular
E. tarda	D15-like surface antigen	Japanese flounder	Intramuscular
V. harveyi	DegQ or/and Vhp1	Japanese flounder	Intramuscular
Flavobacterium psychrophilum	Hsp60, hsp70	Rainbow trout	Intramuscular
Cryptobia salmocitica	Metalloprotease	Atlantic salmon and rainbow trout	Intramuscular

Table 1. Experimental DNA vaccines in fish following experimental infection

Administration of DNA vaccines

Intramuscular injection is commonly used in fish for the delivery of pDNA and typically results in clear transgene expressions at the injection site. This initial dispersion of a vaccine can be sufficient for very small fish to ensure the perfusion of intact pDNA into more distant tissues, while the injected volume would predominantly rest along the needle trajectory in large fish. Intravenous, intraperitoneal, oral delivery and particle bombardment are other routes of pDNA administration that have been investigated in fish.

Advantages, disadvantages and challenges of DNA vaccines

When provided at early life stages, DNA vaccines demonstrate high efficiency and have the advantage of inducing protective immunity across a wide temperature spectrum. The benefits of DNA vaccination continue to grow beyond mere immunological abilities. When looking at the concept from the point of view of a producer or/and investor, DNA vaccines are relatively cheap and simple to produce. For all DNA vaccines, the processes needed for development are similar,

and the simplicity of cloning also allows for rapid modifications in a way that is not normally obtainable with traditional vaccine preparations. Potential side effects include, for example, the possibility of autoimmunity, immune tolerance to the expressed antigen, excessive CTL response leading to myositis, chromosomal integration, inflammation of the injection site and loss of tissue.

Safety and regulatory aspects by DNA vaccines

Safety aspects include potential impacts on the vaccinated animals, consumer and the environment. Other safety concerns include the possible shedding of the vaccine from vaccinated animals and predatory animals into the environment. Human protection also involves possible consequences from self-injection by vaccinators. When protection aspects need to be reported, these safety aspects need to be taken into account by the appropriate authorities.

Conclusions

There is a critical need to increase the efficacy of DNA vaccines against recurrent and difficult-to-combat viral infections, which can be met by: (i) The use of vaccine carriers to increase the absorption of antigen presenting cells accompanied by increased transgene peptide antigen presentation, (ii) Use of nano-scale particles to increase the degree of cross-representation of such cells may also be helpful in generating antibody response and immunity mediated by cells, (iii) Using additional adjuvants such as TLR ligands, other than RNA and/or DNA, to substantially improve the response. Protection and regulatory uncertainties are connected to the distribution and degradation of DNA after injection, and it is important to make further effort to understand the processes of pDNA uptake, from the moment of administration to the stage of transcription and translation in the nucleus.

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DRYING AND DEHYDRATION: AN EMERGING POSTHARVEST PRESERVATION METHOD OF FRUITS

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Abstract

Drying of fruits is one the earliest and effective method of food preservation which play significant role in fruit supply chain. The dried and dehydrated fruit products are good source of energy as well as concentrated source of vitamin and minerals. Higher shelf life, easy handling, lower volume, smooth transportation and cost effective storage are few advantages of dried/ dehydrated fruit product. Lowering of moisture content which ultimately lowers down microbial spoilage is core principle of drying and dehydration. While opting drying and dehydration one must know the factor which affects its efficiency, these include factors such as type of product, cost of dehydration, quality of final product and source of energy. Drying and dehydration technologies can be one of the possible approach to meet the nutritional security as more than 20% of the world perishable crops are dried to increase the shelf life and product availability.

***Key words*:** Fruits; drying and dehydration; nutrition value; shelf life.

Introduction

Fruits and vegetables are most important products in agricultural sector. Fruits are important sources of essential nutrients such as vitamins, minerals and fibre. Since the moisture content of fresh fruits is more than 80%, they are categorized as highly perishable commodities. Drying and dehydration are one of the oldest yet most common methods used to improve the shelf life of fruits and vegetables. The fitness of drying method depends on many factors such as the type of product, thickness of product availability of dryer. Above all, the critical parameters are Energy consumption and quality of dried products.

Drying can be defined as the removal of water by conventional source like sunlight, wind under natural condition in order to protect qualities of fresh fruits such as colour, flavor, nutrients, appearance and uniformity during drying process. Dehydration is the removal of moisture under controlled conditions such as temp. RH etc. to a specific/desirable extent in order to protect qualities of fresh fruits such as colour, flavour, nutrients, rehydration, appearance and uniformity during drying process.

Objective of drying and dehydration : The main objective is to preserve food along with increasing the shelf life than that of the normal fruits. Dried fruits are easier to handle, transport and storage. They are of low volume and highly nutritious, economic value is increased after drying and dehydration. It is also diversify the supply of fruits with different flavour and texture hence gives the consumer more option to choose the fruit product.

Drying methods and their Advantages and Disadvantages : There have been many advances in the drying and dehydration technology in the last few years which helps in decreasing the consumption of energy along with production of high quality product compare to the conventional methods

which ensure the food safety. The methods of drying can be categorized into three, 1. Traditional or conventional methods. 2. Commercial methods. 3. Latest developed methods.

Traditional methods

1. Sun drying

The conventional drying was started in the 18th century, sun drying in agriculture in the in the developing area is not an option but a essential as most of the rural area does not have any link with the grid connected electricity. In sun drying source of energy is direct sun hence it is very cheap and simple among all the drying methods Some of the drawbacks are contamination of the product by insects, birds and other animals and dust thus sanitary quality is not up to the mark as well as product quality can be negatively affected by the microbial effect. A minimum temperature required is 86 °F and humidity of 60% or below is ideal for sun drying. In the open sun drying the fruits are left exposed under the direct sun. Fruits are placed on trays made of screens and wooden dowels for many days depending upon the fruit types and the temperature.

Direct solar dryers

Solar drying is different from the sun drying since it uses equipments for absorbing radiation. Some part of the incoming solar radiation are being trapped and some part being reflected back to the atmosphere, some part of the trapped radiation are absorbed by the crop materials resulting the temperature of the crop increases which helps in drying of the product. This structure is simple, and can be manufactured by the farmer by using materials available in the local market and it is suitable for crops such as cassava, banana, and mango slices.

Commercial methods

Osmotic drying : Osmotic dehydration a partial removal the moisture before actual drying. This operation is done by immersing the product in the hypertonic solution such as sugar and salt solution resulting water, vitamin, minerals, organic acids outflow from the food tissue and inflow of solutes into food tissue from the solution drying. In the Recent years it has received more attention as a method of pre-treatment prior to drying because of having some advantages such as reducing the damage in flavour, colour, inhibiting the browning, and decreasing the energy cost.

Freeze drying : It is a dehydration process which is usually used to preserve a perishable food or make the food material more suitable for transportation. Freeze drying of biological material is one of the most suitable methods of moisture removal as freeze drying is done in very low temperature all the deterioration and microbiological activity are prevented and thus provides a better quality and high value dried product along with good sensory quality and high levels of nutrient retention. Freeze-drying works by freezing the material followed by reducing the pressure which leads to sublimate the frozen water present in the product directly from the solid phase to the gas phase without going through the liquid phase also known as lyophilisation.

Vacuum drying : It a novel methods of drying which is exclusively used for drying of heat sensitive commodities. In vacuum drying removal of moisture from food materials takes place under then low pressure situation. As in the vacuum there is no air there will be no partial pressure, so the absolute pressure is called as water vapour pressure. Pressure ambitious flow is the means of transport in moisture movement in vacuum drying. The heat transfer is done by conduction method A thin layer of food is placed on a hot plate which supplies latent heat as a result evaporation of water from the food materials takes place. Some of the advantage of vacuum drying are it requires less energy, faster than many of the other method, it causes less damage to the products.

Spray drying : The Spray Drying is a well-recognized industrial drying technology used widely for drying and powdering the heat sensitive materials from liquid foods into solid or powder form**.** In spray drying the removal of moisture from slurry or liquid by breaking it into small droplets is takes place which is done in the presence of hot air with a aim to obtain a solid, dry powder. Compare to most of the other drying processes, spray drying takes less time for drying of the droplets. The drying time of depends upon many factors such as, pump rate, flow rate, heat and aspiration rate**.** Sticky products are in general difficult to dry with the spray-drying method, for avoiding the stickiness, carrier agent is being used which are of high molecular weights aids Carrier agent used in spray drying are Maltodextrin 10 DE, Arabic gum, cashew tree gum, waxy starch, maltodextrin 20 DE.

Microwave drying : It is a good approach for drying the food materials with overcoming some of the drawbacks of traditional drying. Microwaves are generated inside an oven by stepping up the alternating current from domestic power lines. Microwaves go through the inner core of the food causing water to get heated within food which leads to transfer of moisture from the food material. Microwave drying allows fast remove of moisture which results in rapid drying and the drying uniform and consume less energy compared to the conventional drying**.** However microwave drying has got some of the drawbacks which include product damage caused by extreme heating.

Latest method

Ultrasound : Among recent emerging technologies ultrasonic dehydration is one of the most promising dehydration techniques because the effects of ultrasound are more significant at low temperature which ensures the reduction of the chance of food degradation. It can be used for maintaining pre and post-harvest quality and improving the nutritional value of vegetables and fruits. The advantages of ultrasound over the heat treatment include; minimization of flavour loss, greater homogeneity and significant energy savings. However, many researches have revealed that the use of US affects the food tissue, including the cellular breakdown and formation of micro channels, which leads to breaking up of the microstructure.

Infrared drying : Infrared (IR) has been successfully applied in drying of fruit products. IR has been shown to cut the covalent bonds and release antioxidant compounds such as flavonoids, carotene, tannin, ascorbate, flavoprotein, and polyphenols in repeating polymers. It has many advantages over conventional drying, many studies revealed that infrared radiation is faster than convectional drying . The irradiated surface evaporates more water and the drying time can be shortened by up to half. Unluckily, IR does not penetrate very much into food materials instead it is used only for surface heating. Vibration is useful to allow the material to be uniformly irradiated by IR.

Low pressure superheated steam drying : Superheated steam drying has been successfully applied in many of the foods and agricultural products, it is of low energy consumption, high drying rate wiyh high quality of the final product besides it is one of the eco-friendly methods and avoids fire and explosion hazards**.** But it has some drawbacks while applying in heat sensitive food materials so to overcome this major problem a low pressure superheated steam drying concept has been developed to dry the heat sensitive products which has been effectively used in many fruits and vegetables such as banana mangosteen rind.

Conclusion

Drying is one of the most important operations for improving the shelf life while maintaining its nutritional and physical quality. It has been one of the most important operations in the food industry sector for many years and still continuing to provide food security and increasing

industrialization of foods. Many new technologies came up in the recent years to reduce the energy such as osmotic dehydration, vacuum drying, freeze drying etc which offering a great scope in the drying technology for the production of quality products. As the standard of living rising day by day the demand for dried products are increasing so developing a cost effective, eco-friendly, quality food producer dryer and energy efficient drying technology can bring a breakthrough in the drying technology.

Future thrust

Though various method have been developed in drying technology there is a still further studies needed for development of cost effective and energy efficient methods of drying. More research is needed to identify the proper process parameters for improving the shelf life and nutritional value. However, drying models that take all the variables into consideration are still non-existing, which makes it a potential area of research.

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MANAGEMENT OF LIGHT, TEMPERATURE, HUMIDITY AND CARBON DI OXIDE (CO_2) IN PROTECTED STRUCTURE

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Abstract

Environments which can be modified allow any crops for their growth and development for any season. In this article elaborately discussed about the different environmental factors which directly affect the plant life cycle in a protected structure. Light is an important growth factor and artificial sources are incandescent lamps (ILs), fluorescent lamps (FLs), high-pressure mercury lamps (HPMLs), high-pressure sodium lamps (HPSLs), and metal-halide lamps (MHLs) have been used for lighting in controlled environment. Active and passive heating as well as cooling systems are used to control the temperature. The use of cooling systems (e.g., pad-and-fan or fog) during the warmer summer months increases the greenhouse air humidity. About 70% of relative humidity should be maintained in the greenhouse for better plant growth. Different CO_2 enrichment method such as Decomposition of straw, combustion, Liquid CO_2 and Solid C_{O2} are used in controlled environment. Proper management of these components offers distinct advantage for quality, productivity and favorable market price to the growers. It increases their income in off– season as compared to normal season.

Introduction

Protected cultivation is the modification of the natural environment to achieve optimum plant growth. Modifications can be made to both the aerial and root environments to increase crop yields, extend the growing season and permit plant growth during periods of the year not commonly used to grow open field crops. One of the benefits of growing crops in a greenhouse is the ability to control all aspects of the production environment. Horticulture today forms an integral part of food, nutritional and economic security. Using protected structure virus free cultivation of tomato, chilli, sweet pepper, cucumber and other vegetables mainly during rainy season easily be grown.

Management of light intensity

Light is one of the key growth factor for plant growth and development. In a controlled environment light is maintained as per requirement of a particular crop grown.

Source of light

a. Sunlight : Sunlight is the only source of light in open field cultivation. Electrical light, in addition to sunlight, can be an additional source of light in greenhouse cultivation.

b. Artificial source of light : According to Gupta and Agarwal (2017) various conventional light sources are incandescent lamps (ILs), fluorescent lamps (FLs), high-pressure mercury lamps (HPMLs), high-pressure sodium lamps (HPSLs), and metal-halide lamps (MHLs) have been used for lighting in greenhouses and controlled environmental condition.

1. Incandescent : Incandescent lamps are available in the range of 40-500 W at 115 and 230 V and have only 7% light energy conversion ratio since lamps provide excessive heat to obtain particular light level.

2. Fluorescent lights : Fluorescent lamps provide a linear light source rather than a point source and have a specific light output of 40-60 lumen/Watt. These lamps give cool white light for plant growth. They convert about 20% electrical energy into light energy and are available up to 2.5 m length. These lamps are most commonly used in crops like cucumber, tomato and capsicum grown inside greenhouse.

3. High intensity discharge lamps : High intensity discharge (HID) lamps are compact and are less affected by temperature changes. They required less maintenance and easily convert electrical energy into photosynthetically active radiation very efficiently. The different types of HID lamps are: a) sodium lamps (High and low pressure) b) Mercury lamps c) Metal halide

a. Sodium lamps (High and low pressure) : Two types sodium lamps are categorized such as high and low pressure lamps. High pressure lamps responsible for yellow-orange part of its spectrum whereas low pressure lamps for yellow light. These lamps light are produced by the passage of an electric current at high temperature through vaporized sodium under pressure. High pressure sodium lamps are 33% more durable compared to low pressure sodium lamps. It converts 25% of electrical energy into visible light.

b. Mercury lamps : The light is produced by the passage of an electric current through a gas or vapours medium under high pressure.They are available in the sizes of 400W and 1000 W and produce a bluish-white light with a little red part of spectrum.

c. Metal Halide : Metal halide lamps releases about 50% more light than mercury lamps which can convert 20 % of electrical energy into visible light. Light they produced mostly in blue-violet part of the spectrum, which makes their common combination with high pressure sodium lamps (yellow-orange part of spectrum). These lamps are available in varying sizes up to 2000W with short span of light; lose their output fast and costly.

Gupta and Agarwal (2017) stated that these light sources have certain drawbacks such as fixed spectral output, high-power requirement, emission of heat, and short life span. Invention of light-emitting diodes (LEDs) has changed the scenario for artificial lighting in controlled environmental condition. Low power consumption and long life span of LED lamps become a ideal choice for plant lighting in small- and large-scale operations.

Table 1. Light Source Comparisons

Light Source	Efficacy* (lumens/watt)*	Lifetime (hours)
Incandescent		
Traditional	10–17	750-2,500
Energy-Saving Halogen	12–22	1,000–4,000
Fluorescent		
Straight Tube	30–100	700–24,000
Compact	50–70	10,000
Circline	40–50	12,000
High-Intensity Discharge		
Metal Halide	70–115	5,000–20,000

High-Pressure Sodium	50–140	16,000–24,000
Light-Emitting Diodes		
Cool White LEDs	60–92	25,000–50,000
Warm White LEDs	27–54	25,000–50,000

Source: Gupta and Agarwal (2017)

Controlling light by shading

Intensity of radiations can be managed by providing shades (partial or full) at the controlled environment. It can be done by painting the glazed surfaces of the greenhouse or by putting a net or shading screen under the greenhouse frame. Recently use of UV stabilized plastic covering material is being pracrticed.

Management of temperature

Solar radiation is the primary source of the latent heat in a green house which largely affect the others growth factors (Sehi and Sharma, 2007). All crop required a certain temperature range for their proper growth and development, beyond this range plants give abnormality. The majority of plants grown in greenhouses are warm-season species, adapted to average temperatures in the range 17-27°C, with approximate lower and upper limits of 10 and 35 °C respectively. Bailey (1991) recorded that the management system of temperature through fan and pad cooling system influenced by the plant canopy, green house cover and external shading. In temperate climates, heating and ventilation enable the temperature to be controlled throughout the year, while at lower latitudes; the daytime temperature is too high for ventilation to provide sufficient cooling during the summer. Positive cooling is then required to achieve suitable temperatures.

Heating

It is often necessary to heat the greenhouse or tunnel to prevent damage to the crop from extreme cold and to obtain optimum growth. Passive heating can be done by heat retention and actively by extra heating inside.

a. Passive heating

Cover of plastic film : By covering the ground with plastic film and using tunnels and greenhouses a part of the day's radiant energy can be retained thus, a form of passive heating. Generally materials of these plastic are made from low density poly ethylene (LDPE) and ethylene-vinyl acetate (EVA) or ethylene-butyl acrylate (EBA) co-polymers (Espi *et al.*, 2006)

Heat conservation in water : A part of the suns radiant energy can also be retained cheaply by placing black plastic film bags filled with water between the rows of crops on top of the soil. This water warms up during the day and gradually gives off its warmth to the greenhouse air.

Heat retaining plastic film : A better way to retain extra warmth is by choosing a more expensive plastic film for the greenhouse cover. EVA-film is most frequently used for this purpose.

Energy screens : Energy screens have also been used for a few decades to reduce heat loss during night

Reed mats : The rolling out (reed) mats over the greenhouse cover for the night.

Hotbed manure : By loading fresh straw-rich manure and covering it with layer of soil, microbial fermentation producing heat. Thus the temperature of the upper surface of the soil rises and this promotes root development and growth of the crop.

b. Active heating

Active heating of a greenhouse is also something that has been practiced for ages.

Air heating : In its cheapest form, this is done by placing one or more heaters in the greenhouse and channelling the waste fumes upwards and out of the greenhouse via gradually ascending piping. In this way you can try to get a certain degree of distribution of the heat output.

Water heating : Warm water will then be pumped around the greenhouse through pipes to give off heat evenly.

How to heat : The heating concepts that can be used for heating greenhouse are heaters, solar radiation, fuels or conventional methods and heat pumps

A. Heaters : Heat supplied by the heaters to the greenhouse must be at the same rate at which it is lost by conduction, infiltration and radiation. Load calculations in high temporal resolution facilitates the optimization of the conditions in the greenhouse installations, resulting optimal vegetable or other plants productions, as well as the optimal heating/cooling units selection especially solar and/or other RES systems (Ikonomopoulos *et al*, 2016).

B. Solar radiation : Solar radiation is the main source of heat generation. They can be effectively used for obtaining heat in the greenhouse.

C. Conventional methods

Burning of fuels : In this method, conventional fuels such as cow dung cake, coal and wood etc. are used for heat generation. The burning of fuels produces CO_2, which helps in maintaining the CO_2 level inside the greenhouse.

Use of isothermal mass : Water is usually used as isothermal mass for absorbing and releasing heat inside the greenhouse as in water storage passive and active system.

Use of heat pumps: Heat pumps are also used to increase the efficiency of the heating system for circulating hot water through heat exchangers installed inside the greenhouse.

Greenhouse cooling

In the tropics, due to high irradiance in summer, the plant temperature in greenhouse can exceed the air temperature by 5-15°C.

Methods of greenhouse cooling

Natural and forced ventilation are the two methods used in greenhouse for cooling. When ventilation is not sufficient for cooling of the greenhouse, additional arrangements are made. In both force as well as natural ventilated green houses, proper ventilation has been shown to increase the uniformity of the air temperature and relative humidity in the controlled environment (Willits, 2003).

a. Natural ventilation : Natural ventilation is induced by natural means i.e. wind forces and thermal buoyancy. It is frequently a part of ventilation schedule for greenhouses and is an intermediate step before fans or other means of cooling are activated. In moderate climates, natural ventilation may be capable of providing the majority of ventilation during a year. Natural ventilation can be very vigorous and may be designed to provide as much or more airflow than a mechanical ventilation design using conventional techniques. Increase the area of roof windows lead to improve the ventilation rate, and subsequently reduces temperature of the air, floor surface, and decreases the soil heat flux value (Abdel-Ghani and Kozai, 2006).

b. Forced ventilation: Forced ventilation by fans is the most effective way to ventilate a greenhouse help to keep green house temperature at ambient level and used when needed (Ganguly and Ghosh, 2011). The fans must exhaust air from the greenhouse; the exhaust fans

improve the temperature distribution and the distance between two fans should not exceed 8-10 m. and ventilation fans should developed a capacity of about 30 Pa static pressure (3 mm on a water gauge) (Sapounas *et al*, 2008). Sapounas *et al*. (2008) described that a space of at least 1.5 times the fan diameter should be left between the fan discharge and the nearest obstruction and the inlet opening on the opposite side of a fan should be at least 1.25 times the fan area. The velocity of the incoming air must not be too high. In the plant area it should not exceed 0.5 m/s.

Management of humidity : Humidity in the atmosphere has its own responsibility for most of the metabolic and photosynthesis activities of the plants. A relative humidity between 30-70 per cent is ideal for most of the plant growth. In case of tomato optimum humidity for proper growth and development in ranges about 50-70 percent and tomato pollination is significantly increase when it maintained around 60 percent relative humidity (Harel *et al*., 2014). Values below 60 per cent may occur during ventilation in arid climates, or when plants are young with small leaves, this can cause water stress. Very high relative humidity (exceeds 95% for long periods) enhance pathogenic organisms making the plant susceptible to fungal diseases. In controlled chamber, relative humidity between 55 to 65% and temperature of 20 to 25°C is maintained. During the day, humidity can usually be reduced using mechanical ventilation. However, at night, unless the greenhouse is heated, the internal and external temperatures may be similar; if the external humidity is high, reducing the greenhouse humidity is not easy. The use of cooling systems (e.g., pad-and-fan or fog) during the warmer summer months increases the greenhouse air humidity. Under normal conditions, about 70% of relative humidity should be maintained in the greenhouse for better plant growth.

Management of carbon dioxide (CO_2)

The amount of CO_2 present in the plant environment affects the plant growth because it is essential for photosynthesis.

CO_2 enrichment methods

Vermeulen (2014) described different source of CO_2 enrichment methods which is summarized as bellow :

Decomposition of straw : Straw is placed in the field, enriched with optimum fertilizers and wetter. CO_2 is released during decomposition and the disadvantage of this method is it takes more time and the amount of CO_2 released cannot be controlled.

Combustion : CO_2 and H_2O are produced when a hydrocarbon is burnt in the presence of sufficient oxygen and release CO_2. Fuel should have less than 0.02% of sulphur by weight to avoid toxic effects of sulphur oxides.

Liquid CO_2 : Under high pressure CO_2 is remained in liquid form which emit gas at low pressure can be regulated with the help of a set of regulating valves.

Solid C_{O2} : C_{O2} under high pressure and low temperature remained in solid form and is known as dry ice. This dry ice can be used for the enrichment of CO2 in greenhouse.

Conclusion

Adoption of horticulture, both by small and marginal farmers has increased in commercial aspect. Making available of different horticultural crops as well as their product throughout the year is a challenge to the farmers. By creating artificial environment any crops can be grown at any time through installation of protected structure and its proper management. In this article elaborately discussed about the different environmental factors which may helpful for proper management of

a artificial environment required in a protected structure. Protected cultivation of vegetables offers distinct advantage of quality, productivity and favorable market price to the growers throughout the year. It increases their income in off– season as compared to normal season.

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FOLIAR NUTRITION FOR IMPROVING CROP PRODUCTIVITY AND FERTILIZER USE EFFICIENCY

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Nutrients are essential for healthy and vigorous plants. They initiate all processes vital for crop development. Therefore, plant needs nutrients throughout its life cycle. The elements such as phosphorus, potassium and most of the micronutrients are fixed in soil complex while soluble nutrients such as nitrogen are easily leached down the soil. This leads to pollution of ground water, aquifers, green house gas (GHG) emission and harmful for humans. Granular fertilizers have many positive effects on plant growth, but sometimes they are not enough to provide healthy crop development with respect to its availability to plants. Also with increasing cost of fossil fuel, which provides raw materials for fertilizer manufacture, so there is a need to find innovations in fertilizer usage techniques and foliar application is one such important technique.

When to apply nutrients by foliar sprays

The need for foliar application of plant nutrients occurs when:

- There is a lack of a particular nutrient in the soil and basal soil application not done for that purpose.
- High loss rate of nutrients in soil occur (Coarse quartz sandy soil).
- Plant roots are not able to absorb the required amounts of nutrients needed due to unfavorable conditions.

Foliar fertilization is a simple nutrient corrective technique used in crops during the growth cycle when soil application is ineffective, impossible or expensive. There are various reasons for foliar application of nutrients that are:

Table 1. Reasons for foliar application of macro elements (N, K, P, Ca, Mg, S), micro elements (Fe, Mn, Cu, Zn, Mo, B) and beneficial element (Si)

Macro Element	Reasons for use as foliar application
N	Poor availability
	Asynchronus availability/requirement
	Soil depletion/leaching
	Low root temperature
	Increase uptake of micro elements e.g. Fe
K	Poor availability
	Positive against flattened wheat
	Low root temperature
	Flowering stage of citrus
P	Poor availability due to high pH in soil
	Low root temperature

Ca	Reduce Ca-related disorders, e.g. Blossom end rot (BER) in tomato and sweet pepper, butter pit of apples
	Improve leaf quality
Mg	Improve leaf quality
S	Oilseed rape-possible S deficiency in soil
Micro element	**Reasons for use as foliar application**
Fe, Mn, Zn, Co	Poor availability due to high pH
	Prevent deficiency at emergence
B	Enhance crop growth, number of fruits, fruit size and yield Sugar translocation
Zn	Prevent deficiency at emergence in rice
Fe and Mn	Cure chlorosis due to high pH and insufficient root development in greenhouse crops
Si	Positive effect on rice

Foliar nutrient sprays are often applied as mixtures of plant nutrients with compatible adjuvants. Adjuvant acts as a sticker, thus preventing the leaking and washing off of spray solution from the plant. A spray enhancer can help nutrients stick to the leaf and then penetrate the leaves' cuticle. Foliar application of phosphorus, zinc and iron brings the greatest benefit in comparison with addition to soil where phosphorus becomes fixed in a form inaccessible to the plant and where zinc and iron are less available.

Prior to foliar nutrient application, certain environmental factors need to be considered such as :

- Relative humidity, since it affects the permeability of the plant surface
- Temperature, since it regulates the uptake of applied plant nutrients
- Light intensity: since it affects evaporation thus indirectly affect permeability of nutrients.
- Precipitation: immediate precipitation (high intensity) affects flow down of nutrients from leaves, drizzling improves permeability.

Mechanism of foliar fertilization

- **First :** Entry into the leaf prior to entering the cytoplasm of a cell in the leaf.
- **Second :** Nutrient must effectively penetrate the outer cuticle and the wall of the underlying epidermal cell.
- **Third :** Once penetration has occurred, nutrient absorption by the cell is similar to absorption by the roots. Of all the components of the pathway of foliar-applied nutrients, the cuticle offers the greatest resistance.

Plants are able to absorb essential elements through their leaves. Absorption takes place through their stomata and also through their epidermis. Transport is usually faster through the stomata, but total absorption may be as great through the epidermis. Plants are also able to absorb nutrients through their bark. Since plants take in nutrients more efficiently through stomata on their leaves than through the root, foliar fertilization is a great way to rapidly boost plant growth.

Advantages of foliar nutrient application

The foliar spray may contain supplemental doses of macro- and micronutrients, plant hormones, stimulants, and other beneficial substances.

- Foliar feeding is intended to delay natural senescence processes shortly after the end of reproductive growth stages.
- Foliar feeding targets the growth stages where declining rates of photosynthesis and levelling off of root growth and nutrient absorption occur, in attempts to aid translocation of nutrients into seed, fruit, tuber or vegetative production.
- Foliar feeding can be an effective management tool to favourably influence pre-reproductive growth stages by compensating for environmentally induced stresses of adverse growing conditions and poor nutrient availability. Plants show very positive effects with this type of fertilization. Those effects include:
- It is a means of compensating for soil or environmentally induced nutrient deficiencies.
- Higher resistance to diseases and insect pests
- Improved drought tolerance
- Improved soil salinity tolerance
- Higher resistance to physiological disorders
- Rapid utilization of applied nutrients and therefore rapid correction of observed deficiencies
- Being highly effective for the immobilized nutrients in the soils, such as iron
- Providing faster responses with applied crop nutrients, only 3-4 days required
- Better plant nutrient absorption at early crop growth stages, when plant roots are not well developed.

Table 2. Meteorological condition favouring foliar applications

Time of Day	:	Late evening: after 6:00 p.m.; Early morning: before 9:00 a.m.
Temperature	:	Low temperature 18-19 ^{0}C (Ideal 21^{0}C)
Humidity	:	Greater than 70 % relative humidity
Wind speed	:	Less than 5 mph
Rainfall	:	Within 24 to 48 hours after a foliar application may reduce the application effectiveness, as not all nutrient materials are immediately absorbed into the plant tissue

Table 3. Rates of nutrient absorption into plant tissues

Nutrient	Time for 50% absorption	Nutrient	Time for 50% absorption
Nitrogen (as Urea)	½-2 hours	Sulphur	8 days
Phosphorous	5-10 days	Zinc	1-2 days
Potassium	10-24 hours	Manganese	1-2 days
Calcium	1-2 days	Iron	10-20 days
Magnesium	2-5 days	Molybdenum	10-20 days

Fertilizer materials

Not all fertilizers are suitable for use as a foliar spray. The primary objective of a foliar application is to allow for maximum absorption of nutrients into the plant tissue; therefore, foliar fertilizer formulations should meet certain standards in order to minimize foliage damage. Qualifications for fertilizer materials as follow:

Low salt index : Damage to plant cells from high salt concentrations can be considerable, especially from nitrates (NO_3^-) and chlorides (Cl^-).

High solubility : Reduce the volume of solution needed for application.

High purity : Eliminate interference with spraying, solution compatibility or unexpected adverse effects on foliage.

Disadvantages of foliar nutrient application

Despite many positive effects, foliar application as a good farm practice can also have certain disadvantages. Therefore, farmers have to take precautions prior to using this type of fertilization, otherwise, the following effects may occur:

- The foliar applied nutrients will have a reduced influence on plant growth, unlike soil applied.
- The wind has a major influence on the uniformity of distribution of the nutrient solution. Hence, on a windy day care should be taken to avoid spraying.
- The foliar application is most successful for micronutrients, whereas soil application is effective for both macro and micronutrients.
- Plant response to the foliar application is often only temporary. In cases of severe nutrient deficiency, several foliar applications are needed.

Farm practices to get the best out of foliar fertilization

The effect of foliar application on the plant is dependent upon species, fertilizer form, concentration and frequency of application, as well as the stage of plant growth. A common farm practice is to apply plant nutrients at specific plant growth stages, *i.e.* at vegetative (root development, shoot development) and generative stages (flowering, fruit setting). Foliar fertilization is also used in plant recovery from transplant shock, hail damage, and other bad weather conditions which may affect the plant. This is a desirable farm measure due to its positive effects on the entire crop production. It will not only increase the efficiency of plant nutrient uptake and reduce soil pollution but also maximize the crop yield and decrease the total cost of crop production.

Conclusion

Foliar feeding could be used in delivering different agro-chemicals including fertilizers, pesticides, biostimulators and some soil amendments as well as nano-agro-chemicals (nanofertilizers, nanopesticides, etc.). The efficiency of foliar process is mainly controlled with the characterization of plant leaves, the agro-chemicals and the environmental conditions including weather factors. In many crops absorption by aerial parts constitutes the only practical means for supplying specific nutrients. Leaf feeding is rapidly being standardized as an insurance against specific deficiencies and the hazards of unpredictable weather which may occur during the growth of some crops. Nutrient sprays like fertilizers applied to the soil should be used with the objective of maintaining crops at an optimal rather than at a suboptimal or marginal productivity status.

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BIO-FERTILIZERS: A NUTRIENT BOOSTER FOR PLANT

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1. Abstarct

Bio-fertilizer is a substance which is used to increase the fertility status of the soil. It contains micro-organisms which make the soil nutrient available for cultivation. Bio-fertilizer has been identified as an alternative source for increasing soil fertility and crop production in sustainable farming. Bio-fertilizer can be an important part of integrated nutrients management. Due to scarcity of land, the people has stopped using natural fertilizers and are using the chemical fertilizers and chemical pesticides to gain more productivity.

Keywords : BGA, bio-fertilizer, INM

2. Introduction

The term “bio-fertilizer” has been defined in different ways over the past 20 years, which derives from the improved understanding of the relationships occurring between the plant and rhizosphere microorganisms. A bio-fertilizer contains living microorganisms which is applied to a seed or plant surface, the soil and it colonizes the rhizosphere and promotes growth by increasing the supply or availability of nutrients to the host plant (Vessey 2003). The use of chemical fertilizers causes air and ground water pollution as a result of eutrophication of water bodies (Youssef *et al*., 2014). Organic farming is a way that not only ensures food safety and also adds to biodiversity of soil (Raja 2013). The use of bio-fertilizers leads to improve plant tolerance to biotic and abiotic factors, plant growth, nutrients and water uptake. Bio-fertilizer may be used to include all organic resources for plant growth which are rendered in available form for plant absorption through microorganisms (Khosro *et al*., 2012). The extensive uses of chemical fertilizers have adverse effects on human health. Heavy use of chemical fertilizers and chemical pesticides contributed in loss of soil productivity (Aggani 2013). The chemical fertilizers causes harm to plenty of beneficial organisms that contribute high value functions in agricultural areas (Preap 2009).

3. Importance of bio-fertilizer

Bio-fertilizers play an important role in improving fertility of the soil. Application of bio-fertilizers to soil improves the structure of the soil and minimizes the use of chemical fertilizers. The application of blue green algae (BGA) with Azospirillum proved significantly beneficial in improving yield of grain under low land conditions. Bio-fertilizers inoculation with Vesicular Arbuscular Mycorrhiza, Azotobacter and Rhizobium gave the highest increase in straw and grain yield of wheat plants with rock phosphate (Ritika *et al*., 2014). Azolla is eco-friendly, economical and provides carbon and nitrogen enrichment of soil. Growth, yield and quality parameters of certain plants significantly increased with bio-fertilizers containing bacterial nitrogen fixers, phosphate and potassium solubilizing bacteria and microbial strains of some bacteria (Khosro and Yousef 2012). Soil characteristics like salinity, acidity, drought; water logging affects the use of bio-fertilizers (Ritika *et al*., 2014).

4. Different types of bio-fertilizers

4.1. Rhizobium (RHZ)

They fix atmospheric nitrogen in association with plants forming nodules in roots. RHZ are limited by their specificity and certain legumes are benefited from this symbiosis. They belongs to family Rhizobiaceae, symbiotic in nature, fix nitrogen 50-100 kg/ ha in association with legumes only.

4.2. Plant Growth Promoting Rhizobacteria (PGPR)

These kind of soil bacteria are aggressively colonize plant roots and benefit plants by providing growth promotion. PGPR are associated with plant roots and increases plant productivity, immunity. PGPR might also preventing the accumulation of nitrates and phosphates in agricultural soils and increase nutrient uptake from soils , thus reducing the need for fertilizers.

4.3. Azospirillum

It belongs to family Spirilaceae and they are heterotrophic, associative in nature. They also produce growth regulating substances. Their nitrogen fixing ability is 20-40 kg/ha. The Azospirillum is forms associative symbiosis. It is mainly recommended for maize, sorghum, sugarcane, pearl millet etc.

4.4. Azotobacter

It belongs to family Azotobacteriaceae, aerobic, free living. They are heterotrophic in nature. They are occur in neutral or alkaline soils. The population of Azotobacter is generally low in uncultivated soils and in the rhizosphere of the crop plants. The occurrence of this organism has been found from the rhizosphere of different crop plants like sugarcane, bajra, rice, maize, vegetables and plantation crops.

4.5. Zinc solubilizers

Zinc solubilizing bacteria are potential source for zinc supplementation. They are convert applied inorganic zinc to available forms. Zinc solubilizing microorganisms solubilize zinc through various mechanisms like acidification. Zinc-solubilizing bacteria (Zn-SB) are promising bacteria which can be used for sustainable agriculture. Zn-SB have plant growth-promoting (PGP) properties such as nitrogen fixation, K solubilization, Zn solubilisation, P solubilization and production of phytohormones.

4.6. BGA and Azolla

Blue-green algae are actually types of bacteria and they are known as Cyanobacteria. They normally look green in colour and sometimes may turn bluish. BGA can fix 20-30 kg N/ha in submerged rice fields. N is required in large quantities for low land rice production. Soil N and BNF by associated organisms are major sources of N for lowland rice (Raja 2013). BGA forms symbiotic association capable of fixing nitrogen with fungi, ferns and flowering plants. Azolla contains 0.2-0.4 % N on wet basis and 4-5 % N on dry basis. It can be used as potential source of organic manure and nitrogen in rice production. Azolla is used as bio-fertilizer for rice crop due to its quick decomposition in the soil and efficient availability of its nitrogen to rice plants.

4.7. Phosphate Solubilizers

Phosphate solubilizing bacteria (PSB) are beneficial bacteria. They are capable of solubilizing inorganic phosphorus from insoluble compounds. Rhizosphere micro-organisms having P-solubilization ability is considered to be one of the most important traits associated with plant phosphate nutrition. PSB have been introduced as phosphate bio-fertilizer to the agricultural community

5. Caution in the use of Bio-fertilizers

There are several caution in using bio-fertilizers. They are as follow as given below:

- Bio-fertilizers are stored at room temperature, not below 0°C and above 35°C.
- Never expose bio-fertilizers to sunlight directly.
- Never mix bio-fertilizers with nitrogen fertilizers.
- Never apply bio-fertilizers with fungicides.

6. Different Microorganisms used in Bio-fertilizer Production :

Groups	Examples
Free living	Azotobacter, Clostridium
Symbiotic	Rhizobium, Anabaena, Frankia
Associative Symbiotic	Azospirillum
Arbuscular Mycorrhiza	Gigaspora Spp., Glomus Spp.
Bacillus Spp.	Silicate and zinc solubilizers
Pseudomonas	Pseudomonas fluorescens
Ectomycorrhiza	Pisolithus Spp., Laccaria Spp.

7. Conclusion :

Bio-fertilizers can help to solve the problem of food need of the increasing global population. It is important to realize the usefulness of bio-fertilizers so as to apply it in modern agricultural practice. Application of bio-fertilizers containing beneficial microbes promote to a large extent of crop productivity. These potential biological fertilizers would play a important role in productivity and sustainability of soil. It can also protect the environment as it is eco-friendly and cost effective inputs for the farmers (Khosro and Yousef 2012). One of the few limiting factors to bio-fertilizers usage is ignorance regarding improved protocols of bio-fertilizers application to the field . Use of bio-fertilizers can minimize the use of synthetic fertilizers, decreasing environmental hazards, improve soil structure and promote leveraging agriculture. Bio-fertilizers are cheaper and significant in affecting the yield in cereal crops. Research exertions are required for exploring better and new agronomic effectiveness of bio-fertilizers in cereals, flowers, vegetables and orchards.

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RECOGNITION SYSTEM DURING HOST-PATHOGEN INTERACTION

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Abstract

Depending upon the interaction between the host and pathogen during the process of pathogenesis mostly two types of resistance can be found viz., host resistance which are mostly governed by resistance genes and non-host resistance which are inducible and constitutive. Various signals are exchanged between the host and pathogen which leads to either virulence in pathogen or resistance in plants. Some of receptors such as PRRs in the host have the ability to recognize a wide range of microbial components, including fungal carbohydrates, bacterial proteins, and viral nucleic acids, apart from these other signalling compounds includes PAMPs and DAMPs. Different type of theories/hypothesis and models have been proposed in order to understand the signalling and recognition system during host pathogen interaction. However, there studies are limited to certain pathogen only, therefore more understanding and research is still needed in order to overcome the knowledge gap and for sustainable management of the pathogen.

Introduction

The potentiality to differentiate 'host' from 'non-host' plant is the most fundamental aspect of an immune system of plants. Basal resistance against several pathogens in plants is described by the term 'non-host resistance', is an evolutionarily ancient, multilayered resistance mechanism with inducible and constitutive components (Thordal-Christensen, 2003). Non-host resistance is active even in susceptible plants to restrict pathogen colonisation and is associated with the release of molecules like ligands or elicitors, which are derived from the pathogens and/or molecules such as oligogalacturonides and peptides, released by the host plant as endogenous elicitors, analogous to the 'danger signals' of the plant immune system (Matzinger, 2002). By contrast, host resistance referring to more recently evolved, acts within the species level and is controlled by polymorphic host genes, such as R (resistance) genes, the products of which interact, directly or indirectly, with secreted 'avirulence' proteins or effectors of the pathogen (Jones & Takemoto, 2004). The surface receptors detect both pathogen derived elicitors (pathogen-associated molecular patterns (PAMPs) if the molecule contains a conserved 'pattern') and avirulence effectors. They include receptor-like kinases (RLKs), receptor-like proteins (RLPs) and extracellular binding proteins that may form part of multicomponent recognition complexes. Intracellular receptors are the nucleotide-binding (NB), leucine-rich repeat (LRR) class of receptors for the detection of pathogen effectors (Altenbach & Robatzek, 2007; Tameling & Takken,). A signal transduction pathway for bacterial flagellin includes a LRR receptor kinase as well as a mitogen activated proteins (MAP) kinase cascade that activates defined transcription factors. (Rashid *et al.,* 2010).

Detection of pathogens

Investigation of the molecular basis of pathogen resistance shows a suite of cellular receptors that performs direct detection of pathogenic molecules. Pattern recognition receptors (PRRs) with in the cell membrane detect pathogen-associated molecular patterns (PAMPs) and wall-associated kinases (WAKs) detect damage-associated molecular patterns (DAMPs) that result from cellular damage during infection (Zipfel, 2014). Receptors with nucleotide-binding domains and leucine-rich

repeats (NLRs) are known to detect effectors that pathogens use to facilitate infection (Dangl *et al.,* 2013). PRRs, WAKs, and NLRs are responsible for initiation for one of many signalling cascades that have yet to be completely elucidated. Mitogen-activated protein kinases (MAPKs), G-proteins, calcium, ubiquitin, hormones, transcription factors (TFs), and epigenetic modifications operate the regulation of the expression of pathogenesis-related (PR) genes (Meng and Zhang, 2013). This leads to various responses preventing further infection by the pathogens: hypersensitive response (HR), Reactive Oxygen Species (ROS), cell wall modification, closure of stomata, or the production of various proteins and compounds that possess anti effect on pathogens (e.g., chitinases, protease inhibitors, defensins, and phytoalexins) (Juge,2006).

Detection of PAMPs and DAMPs by PRRs and WAKs

PRRs have the ability to recognize a wide range of microbial components, including fungal carbohydrates, bacterial proteins, and viral nucleic acids. These receptors often possess leucine-rich repeats (LRRs) which bind to extracellular ligands, transmembrane domains, necessary to localize in the plasma membrane, and cytoplasmic kinase domains for signal transduction through phosphorylation (Zipfel,2014). LRRs are highly divergent, associated with their ability to bind to different elicitors. Many PRRs depends on the regulatory protein brassinosteroid insensitive 1-associated receptor kinase 1 (BAK1) and other somatic embryogenesis receptor-like kinases (SERKs) (Monaghan and Zipfel, 2012). Extensive signalling is not always initiated, as some PRRs, upon activation, leads to the release of kinase domains that travel to the nucleus for triggering transcriptional reprogramming (Park and Ronald, 2012).

Bacterial PAMPs

FLS2 receptor (receptor-like kinase flagellin sensing 2) of *Arabidopsis thaliana* that interacts specifically with the oligopeptide flg22 of Gram-negative bacteria (Lu et al., 2010). EFR receptor (Ef-Tu receptor) recognizes the oligopeptide elf18. Receptor XA21: Identified in rice, associated with specific resistance to various bacterial strains of the *Xanthomonas oryzae* pv. oryzae species (Lee et al., 2009).

Fungal and oomycetes PAMPs

CeBIP and CERK1 receptor: LysM domains were initially identified as carbohydrate-binding domains in bacteria (Monaghan and Zipfel, 2012). Evidence that these domains (LysM- RLKs) are involved in PTI activity come from their identification in rice (CeBIP) and in Arabidopsis (CERK1) (Miya *et al.,* 2007; Macho and Zipfel, 2014), where these domains bind together and specifically recognize chitin fragments. - EiX1 and EiX2 receptors: EIX (ethylene-inducing xylanase) proteins induce ethylene synthesis, gene expression and PR (pathogen-related proteins), are plant elicitors identified in tobacco and tomatoes. Their action is associated with a HR response (Ron and Avni, 2004). - Cf-9: identified in tomato was the first protein LRR-RLP and confers resistance to the fungus *Cladosporium fulvus.*

Wall-associated kinases (WAKs) detect damage-associated molecular patterns (DAMPs)

Unlike the PRRs, other receptors interpret damage by recognizing cellular components, disrupted by pathogenic enzymes. WAKs consists of an N-terminal, extracellular galacturonan-binding domain which interacts with pectins in the cell wall, and cytoplasmic kinase domains, similar to the structure of PRRs. WAK1 and WAK2 perceive oligogalacturonic acid, resulting from plant cell wall pectin degradation by fungal enzymes (Brutus *et al.,* 2010).

Plant lectins are capable of recognizing carbohydrates that originate directly from pathogens or from damage incurred during infection. Many PAMPs and DAMPs consist of carbohydrates (i.e.,

lipopolysaccharides, oligogalacturonides, peptidoglycans, and cellulose) and are recognized by PRRs/WAKs with lectin domains, such as lectin receptor kinases (Lannoo and Van Damme 2014). Plants detect many extracellular molecules that possess an indication of pathogen infection (Gust *et al.,* 2017), like extracellular DNA, ATP, and NAD (P). Pathogens have undergone an evolution to interfere in the detection of PAMPs and reduce the efficacy of PTI. In order to recognitions of these infection-facilitating pathogen effectors, plants utilize more varied class of proteins (Andersen *et al.,* 2018).

NLRs Detect Pathogen Effectors

Effector molecules have ability to suppress basal defences and make the pathogen virulent. Plants have co-evolved with their pathogens, the R genes of plants are specific to these effector molecules, and they have co-evolved with effector molecules for recognizing them and to activate specific defence mechanism of plants. In nature every effector molecule (Avr1) has its correspondent resistance gene (R1), "gene for gene hypothesis". In absence of a specific R gene in plant Avr gene become effective in causing disease, but when it faces it's corresponding R gene it fails to produce any disease symptoms as R gene renders Avr gene paralysed. To evade this successful detection of pathogen by R genes of plants pathogen population continues to evolve, mutate and bring about changes in composition and structure of its effector molecules with the goal of that the newly synthesised effector molecules are no longer identified by the same R gene. These molecules are unstable and evolve very fast (Sarkar, 2015) NLRs, also known as R genes, are among the fastest evolving gene families. Their products, upon detection of pathogenic effectors, go through a conformational shift from a condensed, ADP-bound state to an open ATP-bound state with exposed N-terminal domains for the initiation of downstream signalling (Takken and Goverse, 2012). Most R proteins belong to a subgroup of a family of proteins which is called STAND (signal transduction ATPase with numerous domains). NBS-LRR (nucleotide-binding site; leucine rich repeats) proteins are subdivided into two subclasses depending on their N-terminal domain, -TIR- (Toll/Interleukin-1 receptors) domain or -CC- (coiled coil) domain, and are known as NBS-LRR-TIR and NBS-LRR-CC, respectively (Marone *et al.,* 2013; Wu *et al.,* 2014).

For signalling, the NBS-LRR-CC proteins generally require a GPI anchored protein named non-race specific disease resistance 1, while NBS-LRR-TIR proteins require an enhanced disease susceptibility 1 for signalling. Additionally, the NBS-LRR-CC proteins can be found in dicots and monocots whereas NBS-LRR-TIR are restricted only to dicots (Chiang and Coaker, 2015; Cui *et al.,* 2015). The mechanism that activates R proteins and the subsequent signalling cascade in ETI is still being debated.

Related to recognition, the simplest model is the direct interaction model in which there is a physical interaction between the pathogen effector and the R protein. An example of this mode of interaction occurs between the pita CC-NB-LRR immune receptor in rice and the AvrPita effector of the fungus *Magnaporthe grisea* (Liu *et al.,* 2011). The recognition process could be modelled in a more complex way through an indirect recognition. This form of recognition has led to the development of alternative recognition models:

Guard hypothesis

The guard hypothesis suggests that R proteins is able to detect alterations caused by the effector to the host "guard" protein. One of the cases reported for this model corresponds to the RIN4 (RPM1 interacting protein 4) protein of *A. thaliana*, associated with two CC-NB-LRR-RMP1 and RPS2-type proteins. RIN4 is the target protein for AvrRpm1 and Avrpt2 effectors which, because of

their protease activity, cleave the RIN4, and this cleavage is detected by R proteins (Caplan *et al.,* 2008; Van der Hoorn and Kamoun, 2008).

Decoy hypothesis

The "decoy" protein possess a mimicry of the pathogen effector target, so the decoy functions mainly to restrict the pathogen but is not involved in the immune response (van der Hoorn and Kamoun, 2008). This model has been discussed mainly from the evolutionary point of view, it is expected that in the presence of the R gene, natural selection favours the decoy protein, but in the absence of the R gene, natural selection will cause the protein to decrease its affinity for the effector (Saintenac *et al.,* 2013; Wu *et al.,* 2015).

Zig-zag model

In the most basic interaction, the zig zag model reveals an interaction between the pathogen and the host. The interaction is divided in four phases: Phase 1: plants detect MAMPs via PRRs to trigger PAMP-triggered immunity (PTI). Phase 2: successful pathogens deliver effectors that interfere with PTI, resulting in effector-triggered susceptibility (ETS). Phase 3: an effector can be recognized by an NB-LRR protein, activating effector-triggered immunity (ETI), which after surpassing a defined threshold induces hypersensitive cell death (HR). Phase 4, pathogen strains that have lost certain effector are selected. They might have also gained a new set of effectors to respond to the plant defense (Méndez and Romero, 2016).

This model is being re-evaluated, as some authors argue that describing a pathosystem as a model of interaction between molecules is a reductionist view of a process that is clearly highly complex. Other authors express concerns regarding the confusion that could arise from the terms of avirulence genes, virulence genes and effectors (Cook et al., 2014; Pritchard and Birch, 2014). The intent of this debate is not to invalidate any model, but to draw attention to certain issues discussed in the opinion article by Pritchard and Birch (2014) and he describe six limitations of the zig-zag Model: 1. Molecular approach: It does not include DAMP. Therefore, it is suggested that the model is restricted to interactions with biotrophic pathogens. 2. Environmental context: By excluding the environmental factor it eliminates the effects of the interaction of the environment with the species that could affect the activation or suppression of molecular processes. 3. Organization of interaction events: The authors suggest that interaction events do not occur in organized phases, but, on the contrary, they can be stochastic processes. 4. Timescale: A model without a timescale does not allow for an adequate explanation of Phase 4 of the model (Phase 4: Gain / loss of effectors). 5. Physical scale: As in point 4 above, there is no population context to which it must be subjected for the gain or loss of effectors. 6. Qualitative model. (Méndez and Romero, 2016).

Invasion model

This model was proposed by Cook *et al.* (2015), the authors took into consideration some limitations of the zig-zag model like the model is restricted in terms of what microbe-associated molecule patterns (MAMPs) the plants can perceive through pattern recognition receptors (PRRs).

The invasion model has been explained in a similar way than the the zig-zag model, the only exception in the aspects related to the definition of the immunogenic molecules which must be represented as a continuum, and they argue that these molecules play other roles beyond the pathogenicity. Thus, the evolution can affect these molecules and effective to an interaction model. In this sense, if a molecule has a role in a different process some evaluative forces can change them; producing changes in the interaction process or even in the fitness of the species (Méndez and Romero, 2016).

Multicomponent model

The model was proposed by Andolfo *et al.* (2016). According to him disadvantages of the zig-zag model is such as the fact that the model only describes two perception layers (PTI and ETI).

The multicomponent model has two components: activation and modulation, and it is divided in three phases as follows:

1) Interaction: two principal effects are detected: i) modifications of virulence factor targets and ii) specific alterations of primary plant metabolism. 2) Activation: modifications of virulence factor targets induce the Nibblers Triggered Signalling (NTS) or PPRs Triggered Signalling (PTS), mediated by R-genes activation. Metabolic alterations induce a feedback regulation of primary metabolic pathways resulting in a Hormone Tempered Resistance (HTR). 3) Modulation or effective resistance stage, the NTS/ PTS, and the HTR converge to confer a resistance specific to the lifestyle of pathogen (Pathogen lifestyle Specific Resistance, PSR) (Méndez and Romero, 2016).

Conclusions

Knowledge of plant–pathogen interactions will be undoubtedly continued to flourish in the 21st century, gone thorough by new molecular techniques and greater computational software. In addition to improving our knowledge of resistance, efforts will continue to alter crop genetics to develop better resistance. Continuing to alter the receptors necessary to initiate defence responses is likely the best route for development of resistance. NLRs may become a major tool of biotechnology, used to engineer resistance to any pathogen through the modified activity of the CRISPR/Cas9 system. Weeks and collaborators (2014) present a complete review of the different case studies that have been developed in species such as *Arabidopsis thaliana*, wheat and rice using CRISPR-Cas9 technology, and it is expected that soon more and more advances in the breeding for disease resistance will come from the use of this technology. One recent approach utilizes the activation of Arabidopsis NLR RPS5 by *P. syringae* protease AvrPphB cleavage of PBS1 (Shao *et al.,* 2003). Understanding the pathogen recognitions, resistance and plant immunity will greatly benefit agricultural production by reducing crop loss, and contribute to our understanding of the molecular interactions and coevolution that underlies this crop field and numerous applications to other biological systems.

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MOLECULAR CONVICTION BEHIND THE PRODUCTION OF "SUICIDE SEEDS"

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Abstract

Advancement of biotechnology and genetic engineering upon green revolution has now been emphasised by the top seed companies using sophisticated terminator gene technology to secure a much stronger monopolistic pathway in the seed market around the globe. They objectify sterile seed production in successive generations by manipulating novel genes, so that farmers cannot reuse their once harvested seeds and are forced to buy new seeds from the market every year. Antibiotic tetracycline is mostly used as an external stimuli that switches on the suicide mechanism inside the seed just after embryogenesis. United States have patented this biotechnological innovation for the first time and made a worldwide threat on food security especially in developing countries where most of the population are involved in agriculture. Therefore, Government should critically investigate and evaluate the intension of this terminator gene technology before giving it permission to be commercialised.

Introduction

The global agricultural research is continuously flourishing their potential with gradual improvisation and innovations to find out the most appropriate solution to world hunger. In this regard, biotechnologists are keen enthusiastic in discovery of terminator technology or genetic use restriction techniques (GURTs) as a nifty revelation to protect originality of inventor's findings. Although this technology has not yet been popularized in world market, the apex body of giant companies as well as top seed industries have already started promoting their brainchild as a "biosafety" tool among the farming communities. Monsanto denominated this technology as a "gene protection technology" (Mukherjee and Kumar 2014). On March 1998, United States Department of Agriculture (USDA) coupled with Delta and Pine Land (D&PL) Company of Mississippi got patent of GURTs entitled "Control of plant gene expression" (Yousuf et al. 2017). But the Indian Parliament has banned the use of suicide seeds in accordance with the "Protection of plant varieties and farmers' rights act" in 2001.

GURT: Types and Mechanism

The genetic use restriction technologies (GURTs) are new biotechnological interventions, mainly involved in protecting the IPRs of the original mastermind. It deals with specific genetic switch mechanisms that restrict the ineligible use of genetic material by altering either reproduction (V-GURT) or a specific trait expression (T-GURT) in GM crops (Eaton et al. 2002).

V-GURT is actually based on controlling a chemical inducer mediated seed development process, promoting the embryo to produce a cell-toxin that will prevent its germination if replanted (Lombardo 2014). Thus causing seeds to be sterile, V-GURT acts as a cobweb for the poor farmers. T-GURTs on the other hand, are not truly involved in affecting the viability of seeds. But, a number

of genes conferring a single trait may be switched on or off by the action of chemical inducers (Yousuf et al. 2017).

Pre-requisites

i. a repressor gene that perceives an external stimulus
ii. a recombinase gene, whose expression is blocked by the action of repressor
iii. a target gene that produces cell toxin

In V-GURTs, the repressor gene produces repressor protein which is directly involved in the activation of recombinase gene. A lethal gene RIP (Ribosomal Inactivating Protein), under the control of LEA promoter (Late Embryogenesis Abundant promoter) is separated from the promoter by a spacer sequence, which blocks RIP expression in the first generation. During late embryogenesis, RIP gets permission from its promoter to express to affect only the embryo development in the very next generation. On either side of the spacer, a recombinase gene (*CRE/LOX* system from a bacteriophage) sequence is placed to snip out the spacer sequence in between promoter and RIP sequence, so that the late promoter is able to activate the lethal gene late in the season. Repressor protein when perfectly binds to the site near a recombinase gene, transcription of the recombinase gene is inhibited and therefore no recombinase protein is produced to remove the spacer sequence (see figure 1). Hence, rest of the entire terminator mechanism gets switched off (Yousuf et al. 2017).

Upon exposure to chemical inducer like tetracycline, hybrid seeds start exhibiting inability to regrow. Tetracycline when applied to the seed lot before selling to the consumers, restricts the activity of repressor protein and promotes transcription of recombinase gene leading to successful toxin production by the lethal gene (Gupta 1998).

In contrast to V-GURT, a gene cassette is programmed to express in the seed for the production of disrupter protein in T-GURT and a particular trait of interest is altered accordingly, keeping the embryo intact. The chemical inducer upon application over the seed lot before being sold to farmers allows the trait expression in the first generation but, hinders in the successive generation (Pilger 2002).

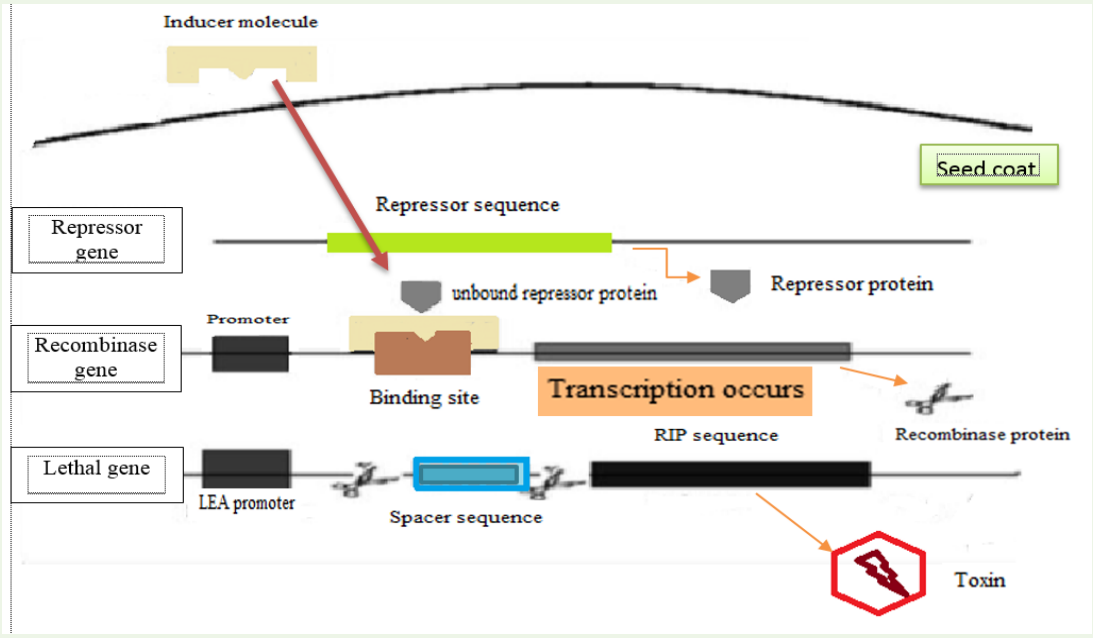

Figure 1. Suicide mechanism after treating with inducer

Relevancy of Terminator Technology

Advantages

1. Use of new seeds every year leads to maximum yield.
2. The giant private companies must compete each other to invest in agriculture which ultimately benefits the farmers.
3. Seed lethality prevents unwanted gene flow from transgenic to non-transgenic varieties (including wild relatives) via seeds, as only pollen carries the lethal genes.
4. Terminator technology promotes genetic diversity.

Disadvantages

1. Harvested seeds have to be used only for consumption purposes.
2. Pollen carrying RIP genes may transfer lethality/ seed sterility from transgenic lines to nearby wild type crops.
3. Specific genotype of a particular crop may become vulnerable to pest and diseases.

Conclusion

Terminator technology as a biotechnological novelty offers a number of amenities like checking of transgene contamination, protection of IPRs and increasing of genetic diversity. But, the scientific community working on precision agriculture has not yet been satisfied by the advancement of GURTs. Various potential hazards of using suicide seeds including inability of farmers to procure harvested seeds and extensive monitoring over terminator technology badly impact on overall biodiversity and economic symmetry. In case of developing countries like India, where maximum fraction of population is engaged in agricultural sectors GURTs need to be improvised with every efforts from the service point of view rather business motives.

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FOOD PACKAGING: MODERN TOOL FOR MANAGING INSECTS IN STORAGE

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Abstract

Protecting our food while in storage is as much important as increasing production of food to ensure food security. Safe storage of food items is really a challenge for almost all warm and humid tropical countries. Faulty storage system, different microbes, various insects and non insect-pests possess great threat in storage. To combat the pest problem particularly in storage, more thrust is to be given on preventive aspects as trying to cure an already infested food will lead to a more complicated situation. Management of stored-grain insect pests is undergoing a rapid transformation now-a-days. Modern insect-resistant packaging is one of such trick that really possesses a great possibility and scope to be explored.

Insects in the grain storage cause huge post-harvest loss of food grains alongwith unscientific storage system, rodents, micro-organisms etc. Nearly 100 species of insect pests of stored products cause economic losses. In India, annual storage losses have been estimated as 14-million tons of food grain worth of Rs. 7,000 crore every year in which insects alone account for nearly Rs. 1,300 crores. Out of these, stored-grain insects alone account for more than 10% post-harvest losses in developing countries like India.

Several measures have been adopted by the farmers, common people as well as by the scientists to ward off these insects. In present scenario, an equal thrust is being given towards production as well as protection of the foodgrains. The framework of integrated management of storage insects has been specially designed to incorporate all the possible tools to manage the insects in storage to ensure food security. Management of stored-grain insect pests is undergoing a rapid transformation from a conventional insecticide-based system to some modern approaches. Modern insect-resistant packaging is one of such concepts that really possess a great possibility and scope to be explored.

The consumers of the present age are really fond of packaged products. A wide range of agricultural or horticultural commodities like grain cereals, pulses, flours, fruits, vegetables, spices, etc along with different grocery items, medicines as well as all the stationery items – attract the customers of all age group if the products are properly packed to maintain highest level of hygiene and quality for a reasonable period of time. The interesting fact is that, the majority of the consumers have the complaints that the packets of rice, flours, pulses as well as pastas, noodles even chocolates and many other products (with the exception of canned food) are susceptible to insect attack.

Insects that commonly infest packaged food are categorized into two categories – penetrators and invaders. Penetrators are those that can chew holes directly into packaging materials. These are most dangerous at the larval stage, though some beetle species can also be dangerous as adults. Insects such as the lesser grain borer, *Rhyzopertha dominica* (Fab.); the cigarette beetle, *Lasioderma serricorne* (Fab.); the warehouse beetle, *Trogoderma* spp.; the rice weevil, *Sitophilus oryzae* (L.); the cadelle, *Tenebroides mauritanicus* (Linnaeus) and the larvae of the rice moth, *Corcyra cephalonica*

(Stainton), are known to be good package penetrators and are capable of boring through one or more layers of flexible packaging materials. Other species are classified as invaders that enter packages through existing openings. Invaders commonly enter packages through openings resulting from mechanical damage, defective seals, or holes made by other insects penetrating the package. The newly hatched larvae of invaders typically cause the serious damage because they are able to fit through holes as small as 0.1 mm wide. Some common invaders include the saw-toothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus); the red flour beetle, *Tribolium castaneum* (Herbst) and the flat grain beetle, *Cryptolestes* spp. The most important invaders are the larvae of the genus *Tribolium* or flour beetles, the genus *Oryzaephilus* or grain beetles and freshly hatched moth larvae. It is to be noted that invaders can become penetrators in certain circumstances, and vice-versa. The larvae are generally classified as invaders, although in certain circumstances, they can be penetrators as well. Both penetrators and invaders exploit package flaws or other existing openings in order to reach a food product.

The main question that can arise in the mind of anyone may be the reason, means and the path of entry of the insects in the packaged products. The easiest answer is that most of the species of stored-product insects infest packaged foods as they found easy source for nutrition to carry out life functions such as finding of food or mate, oviposition as well as to remain protected from chemicals that may be used to kill them. Olfaction is the weapon by which these insects identify the location of the packaged products. Insects, when they get the smell of the food, try to reach it. Any kind of odour coming out from the packet attracts the insects to search an access point for entry. In case of any food package, the insects take advantage of any sort of opening found in the packet to get entry. These openings are the result of chewing of penetrators or as punctures formed due to normal wear and tear during the process of handling. And then the invaders, waiting for these punctures or holes or even very minute gap, also get the chance to enter the packets. These insects, being very small, are able to enter packages through the smallest openings or they also can enlarge these openings to gain access inside the package.

Food products are packed in a wide variety of paper, plastic as well as different materials in combination of the older and the newer ones. Insects changed their strategies to enter the food packages and so the manufacturers had to change their entire packing systems of several items or products. The material and quality of the packets, type of glues or adhesives, system of sealing, providing barriers to prevent exit of the smell of the product and many other features that are continuously being added to create the resistance of the packages against the stored-grain insects.

Paper is still one of the most widely used products and is certainly one of the most easily penetrated materials. Paper offers little resistance to insect penetration although it provides excellent strength and serves as a moisture barrier. On the other hand, paper used with foil and polyethylene to form multiwall packages, performs better than the traditional packaging. Cellophane is one of the oldest materials used as packaging material after normal paper. The desirable physical characteristics of cellophane include transparency, clarity, and heat sealability. Many of these attributes were lacking until nitrocellulose was developed in 1927. Studies on cellophane-wrapped packages have shown that both dry pet food and raisins were very susceptible to penetration by a variety of stored-product insects including the Indianmeal moth, *Plodia interpunctella*, the warehouse beetle, *Trogoderma* spp. and the cigarette beetle, *Lasioderma serricorne*. Polyester (PET), first developed in 1941, has good resistance to insect penetration, but its use in packaging has been limited because of higher cost. At the same time, uses of PET and metalised PET packets are increasing now. Packages prepared for MRE (meals ready to eat) and other similar purpose are also prone to insect

penetration like red flour beetle. Flexible polymer films, even laminates used in packaging can be susceptible to insect attack.

Considering several factors it can be said that plastic has several advantages over other materials for packaging. These ensure that the contained materials remain in their original condition. Plastic packets are colourful, attractive and they are available in different sizes and shapes. Different kinds of materials made by plastic resist infestation by most stored-product insects. Plastic pouches have already become popular. These pouches alongwith zipper made from PET or metal foils, nylon, polypropylene-laminates provide strength, excellent protection (not total) from insect and at the same time these are lesser in weight if compared with other materials.

Use of odour barriers is another trick through which insect infestation can be minimised. Preventing odours of food materials from the food packages is done by several barrier materials. This creates such a condition that the insects fail to trace the food materials even if they are nearer to the food packets. PVDC (Polyvinylidene chloride) and EVOH (Ethylene vinyl alcohol) are two successful odour barriers used in modern day packaging. But even slight fault in the packaging disturbs the performance of these barrier chemicals.

From the above discussion, it is evident that complete resistance or total protection of the packaged products from the insects is not guaranteed or confirmed. Some may think that proper sealing and making the packets completely airtight do the job of complete prevention of insect-entry. But that is partially correct. This leads to other problems like swelling or shrinking of the packages as there comes the changes in temperature or pressure of the air within these. Small holes for ventilation are made in these cases so that the air pressure within and outside of the packets remain same. These vent holes, in several cases, act as improper or partially perfect sealing and result in permitting invasion of insects. To prevent this, again, lengthy and twisting (or zigzag) path for the insects are prepared. Inspite of that completely insect-resistant packaging, till date, is not available. There is a huge scope of future research in this area. It will show the way toward improvement of more sophisticated and developed packaging strategies so that packaged foods remains protected as well as the end-users are relieved from attack of any insect.

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MARIGOLD (*TAGETES* SPP.) IN ORGANIC SETTING

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Introduction

Marigold (*Tagetes* spp.) is one of the most commonly grown herbaceous ornamental annual. It is highly appreciated in the ornamental industries for its versatile uses such as potted plant, garden settings, border planting, bedding plant and loose flower for various purposes. It is less affected by the photoperiod and has wide range of adaptability makes this ornamental grown in most of the places especially in hills. Apart from the aesthetic value and adaptability factors this plant also produces some bioactive compounds which enable this crop to be a great companion in organic farming to suppress the insect-pest devastation. Because of its wide range of adaptability and capable of producing bioactive compound which can be exploited in different ways to enhance crop production aspects in organic farming, since going with organic farming we must be explorative in our approaches to make use of every bits and pieces which we can incorporate in crop production aspects for our advantages.

In organic farming where most of the synthetic chemicals for insect pest management are prohibited in such condition marigold can play versatile role as it produces bioactive compounds having nematicidal, insecticidal, fungicidal, antiviral, and cyto-toxic activities and it is very easy to grow with minimal effort. Though, many studies have revealed the potential of this crop in different aspects. However, this crop can also stand highly appreciable in organic crop production module.

There are some aspects in organic crop production in which this ornamental crop can play a very vital role in enhancing the production and sustaining the essence of organic farming.

Use as trap crop

Marigold are often used in companion planting for tomato, eggplant, chili pepper, tobacco, and potato found significant in reducing the insect pest devastation. Whiteflies are notorious pests that feed on the plant sap and act as a vector for transmission of viral diseases in many fruit and vegetables turn out from damaging by using marigold as a trap crop. The infestation of fruit borer in tomato can also be reduced in a considerable amount using the marigold as a trap crop.

Use as companion planting

Marigold can be a great companion crop with tomato, eggplant, chili pepper, tobacco, and potato. Nearly all marigolds provide some protection from nematodes, the French marigold (*Tagetes patula*) provides the greatest protection against a wide range of nematodes, French marigolds (*Tagetes erecta*) found to be a good companion crop with tomato. As an added benefit, these brightly colored flowers in shades of yellow and orange contrast well with the tomato foliage and create a pleasuring aesthetic sense. Most of the study revealed that 3:1 ratio of planting *i.e*. three row of desired crop and one row of marigold remained significant to suppress the nematode and fruit borer infestation.

Use to control nematode

Marigolds are mostly grown for ornamental purposes as bedding plants, potted plant and other loose flower purposes. However, there are other uses of this crop which is yet to be exploited for better use of this crop. Studies have found that marigold root exudes allopathic compound all as alpha-terthienyl which can help to reduce a wide range of nematodes. It can be plant as a companion planting with nematode-susceptible veggies, like tomato, pepper, beans and okra. In order to get better result marigold should be planted at least two months before the desired vegetable crop. Furthermore, it must be planted at the same site in which the vegetable crop will be planted to get the benefits from marigold root exudates.

Use as rabbit repellent

Marigolds are often found used in border plant as because it makes a good compact aesthetically appealing border. Many gardeners plant a border of marigold flowers around their gardens to help repel rabbits. Apparently this animal finds marigold plant smell unpleasant and due to this quality of marigold to repel rabbits can be incorporate in organic farming to protect crops like vegetables from rabbit by planting marigold as border crop.

Use for poultry feed additive

The quality of the poultry egg is also depend on the deep yellow colour of the yolk which can be improved by using the marigold flower powder extracts as colorants in poultry feed. These can be a good option for enhancing the poultry eggs quality organically without using other synthetic chemicals.

Use as household insecticide

Most of the insecticides which are used for household use are inorganic which tend to be harmful to the user and to the environment. Recent studies show that 75% of households use some form of insecticide, with much of this being used indoors. They are used against houseflies, ants, mosquitoes, flea and flies. Thus, alternative household insecticide utilizing the extract from marigold plant which in exposure to sunlight generates its phototoxin which makes a natural insecticide can be highly economic and eco-friendly.

Use in organic food additive colour

The florets of Marigold (*Tagetes erecta*) are rich in the orange-yellow due to the presence of carotenoid lutein which can be extracted and used as a source of the organic food coloration to substitute the synthetic food coloration for foods such as pasta, vegetable oil, margarine, mayonnaise, salad dressing, baked goods, confectionery, dairy products, ice cream, yogurt, citrus juice and mustard.

Colorful Tea

Enjoy colorful tea with 2 teaspoons of marigold petals in 250 ml of boiling water to yield a brightly-hued brew. Taste is rather bland, but the tea has been said to alleviate cramps, sore throat and fever. To enhance the flavor adding a few leaves of lemon balm or your favorite mint and that can be a great healthy cup.

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PATHOGEN ELICITORS RECOGNITION FROM MAMP AND DAMP PERCEPTION TO INDUCED RESISTANCE IN PLANTS

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Abstract

Environment, Pathogen and Host these three components form the disease triangle. Under favourable condition virulent pathogen can cause diseases in a susceptible host. We can manage the diseases of the plants by applying various chemical pesticides like fungicides, bactericides but there are so many disadvantages associated with this like chemical compounds cause environmental pollution through their residual effects and also form resistance to the pathogen due to continuous application. So, in spite of that if we focus on the plant pathogen interaction and molecular basis behind the pathogen detection, signal transduction and defense response of the plant, that will be more sustainable and ecofriendly approach. Plants' different molecules can recognise the microbe associated pattern and after successful recognition several resistance genes of the plant get activated. Recent advances and research activities in this aspect will surely increase the agricultural production and explain the complex molecular functions involved in host pathogen interaction in a simpler way.

Key Words : PRR, MAMP, Induced Resistance, Defense response.

Introduction

Agricultural revolution totally depends on the molecular basis of host pathogen interaction. Host pathogen interaction means how pathogens infect the plants, how they survive inside the plants' physiology and finally how plants can recognise and develop the defense response against the infection of the pathogens. There are so many resistance genes (R-genes) of plants and avirulent genes (Avr-genes) of pathogens which are involved in the plant defense response development and cause compatible or incompatible reactions according to their interactions (Rhoades, 1935). These R-genes are heritable in nature and through the various breeding methods like selection, introduction, mutation, somaclonal variation, hybridization, genetic engineering, resistant plants can be developed. Resistance genes can be introduced from related, unrelated species, germplasm collection, known variety, unrelated organisms like viral coat protein genes for viral resistance etc. By inoculating biocontrol agents like *Pseudomonas* sp. in the plant rhizospheres, we can incorporate the induced systemic resistance (ISR) in the plants. Biocontrol agents increase the production of reactive oxygen species (ROS), phenyl alanine ammonia lyase (PAL), phenol, superoxide dismutase enzyme (SOD) etc thus induce the resistance in plants and prevent the pathogens infection. So, it is better to emphasise more on the host pathogens interaction and proper execution of that scientific strategies than application of chemical pesticides because prevention is better than cure.

Defense response of plants, a multicomponent system

Pathogens attack the plants in a few steps like attachment, germination of spores, formation of infection structure like appressoria, infection peg, haustoria etc., penetration, infection, colonization of the host and finally multiplication, symptoms development. These sequential events form the pathogenesis. There may be two types of interaction between plants and pathogens. In susceptible reaction characteristic symptoms are developed and in resistant reaction multiplication

and symptoms development get restricted. Resistance is a rule and susceptibility is the exception. According to the Gene for Gene hypothesis 'for every resistance gene in the host there is a corresponding avirulence gene in the pathogen'. This hypothesis was postulated by H. H. Flor (1956), with his experiment on linseed rust (*Melampsora lini*) **(Flor, 1942) (Table- 1).**

	A (Dominant, Virulent)	a (Recessive, Avirulent)
R (Resistant)	AR (Incompatible)	aR (Compatible)
r (Susceptible)	Ar (Compatible)	ar (Compatible)

Table-1 Gene for Gene Hypothesis, H.H. Flor (1956)

Compatible and incompatible reaction

Homologous or compatible interaction occurs when elicitor released by the pathogens are not recognised by the plants' receptors. There are two types of elicitors like: Non specific elicitors (Glycoprotein, Lipopeptide, Amphiphilic glycolipid, Glycoprotein, Toxins, Fatty acids, Extracellular microbial enzymes-protease, pectic enzymes) and Specific elicitors (Avr gene products, hrp gene products, suppressor molecules). Sometimes degraded polysaccharides of the plant cell wall which are formed due to enzymatic activity of the pathogens are also act as elicitors. In heterologous or incompatible reaction elicitors of the pathogens interact and are recognised by plant cell receptors and resistant reaction takes place.

There are some specific avirulent genes of pathogens which resist pathogens to infect the particular crop. Like Tomato infecting bacterial spot caused by *Xanthomonas campestris pv. vesicatoria* also causes disease on pepper. Avirulent gene *avrBsT* inhibit the disease causing potential of the pathogen. When pathogen losses that avirulent gene, it becomes able to cause disease on both pepper and tomato.

Avirulent genes function in three different ways like:

1) The *avr* gene product itself functions as an elicitor and interact with the receptor in the host cell membrane. Ex. *avr9* gene of *Cladosporium fulvum* .
2) The *avr* gene regulates the synthesis of elicitor and that elicitor interacts with the receptor in plant cell membrane. Ex. avrD gene of *Pseudomonas syringae* pv. *tomato*.
3) The *avr* gene products enter into the host cell and act as elicitor or direct the synthesis of elicitor.

A) Pathogen Detection:

Plant has two layers of defense mechanism. First layer is the waxy cuticular layer, cell wall and preformed antimicrobial compound, which act as basal resistance. Second layer is the two tier innate immune response. Two tier innate immune response consists of three types of receptor. Those are Pattern recognition receptors (PRRs), Wall associated kinases (WAKs) and Nucleotide-binding domain- leucine rich repeats (NLRs).

1) Recognition of PAMPs and DAMPs by PRRs and WAKs

Pattern recognition receptors (PRRs) detect the Pathogens associated molecular pattern (PAMP) or Microbes associated molecular pattern (MAMP) (Zipfel, 2014). PRR can detect wide range of fungal, bacterial and viral components like Fungal carbohydrate (Xylanase, Chitin), Bacterial protein (Flagellin, Peptidoglycon, Elongation factor EF-Tu), Viral Nucleic Acid (DS RNA), Oomycete (elicitins, β-glucan), Insect (Aphid derived Elicitors). Fuction of PRRs depend on some regulatory proteins like somatic embryogenesis receptor like kinases (SERKs) and Brassinosteroid insensitive 1 associated receptor kinase 1 (BAK1) (Monaghan *et al*., 2012 and Prince *et al*., 2014). A prominent example of

PRR associated resistance is in wheat TaLRK10, TaRLP1.1 and TaRLK-R1-3 PRRs lead to resistance against rust, caused by *Puccinia* sp (Zhou *et al*., 2007). Transmembrane domain of PRRs helps to remain the PRRs in plsma membrane and cytoplasmic kinase domain helps in signal transduction (Zipfel, 2014).

Wall associated kinases can detect the Damage associated molecular pattern (DAMP). Cell wall components which are degraded by the pathogenic infection, act as elicitors and are recognised by the WAK (Decreux *et al.*, 2005). Fungal enzymes degrade the plant cell wall component pectin and produce oligogalacturonic acid and WAK1, WAK2 recognise that component with their N-terminal extracellular galacturonan binding domain as receptors (Brutus *et al.*, 2010). WAK contains cytoplasmic kinase domain also. PRRs and WAKs contain some specialised lectin domains, which can recognise the carbohydrate components like peptidoglycans, lipopolysaccharides, cellulose etc (Lannoo et al., 2014). Sometimes extracellular DNA, NADP, Atp also act as elicitors after pathogenic infection. In Arabidopsis WAK1 recognize the oligogalacturonides , DORN1/LecRK-I.9 percept the extracellular ATP (Choi *et al*., 2014).

2) Recognition of pathogen effectors by NLRs

Nucleotide-binding domain- leucine rich repeats (NLRs) detect the pathogen effectors. Pathogens increase the rate of infection by secreting the effectors. When NLRs can sense the presence of pathogenic effectors they change their structural appearance from a ADP bound condensed state to an exposed N-terminal domains with open ATP bound state (Takken *et al.,*2012). The NB-ARC contains various conserved motifs like Kinase-2/Walker-B, P-loop/Walker-A, MHDV, GLPL, resistance nucleotide-binding site A (RNBS-A), RNBS-B, RNBS-C, RNBS-D, and MHDV. In monocot and dicot plants CC-NBS-LRR genes (CNL genes) (Coiled coil- Nuecleotide binding site- Leucine rich repeat) and in only dicot plants TIR-NBS-LRR genes (Toll interleukin receptor- Nuecleotide binding site- Leucine rich repeat) present. *Xanthomonas translucens* using type-3 secretion system, secretes 20-40 effectors and they transfer those effectors into the Wheat Cytoplasm (Boch *et al*., 2010).

Zig-Zag Model

Pathogens try to defend the plant's recognition system and overall defense mechanism for successful infection, so they change the properties of elicitors, so that plant's immune system cannot recognise it. This is how plant microbe interaction takes place. This model is known as Zig-Zag Model (Fig- 1). This was proposed by Jones and Dangl, 2006 (Jones *et al.,* 2006). The entire mechanism can be divided into four stages like:

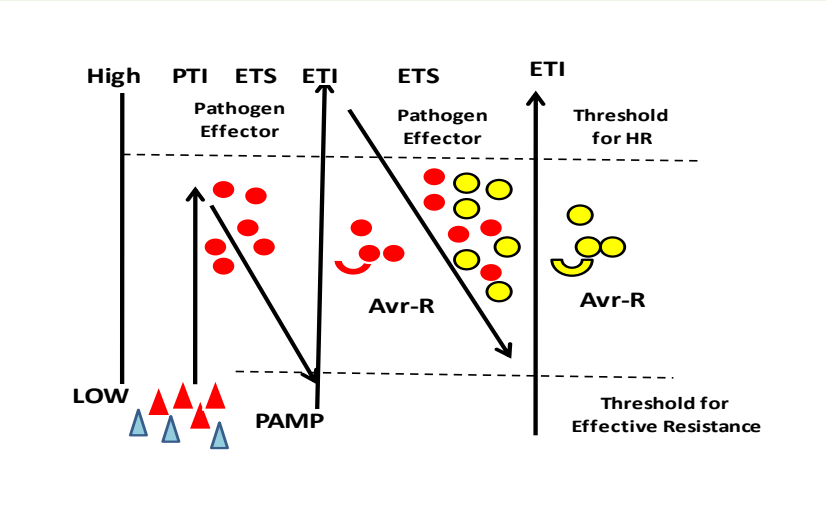


Fig-1 Zig Zag Model, Jones and Dangl, 2006

Phase 1 : Plant's immune response get activated, PRRs detect the MAMP and trigger PAMP-triggered immunity (PTI).
Phase 2 : After successful infection pathogens deliver effectors that prevent the PTI, and plant immune mechanism fails to recognise the newly secreted effectors and resulting in effector-triggered susceptibility (ETS).
Phase 3 : The newly formed effectors can be recognized by NB-LRR protein, activating effector-triggered immunity (ETI), and at threshold level plant induces resistance through hypersensitive cell death (HR).
Phase 4 : Pathogen strains that have lost certain effectors and secret new set of effectors, are selected (Fig-2).

Through Horizontal gene transfer pathogen can transfer the effectors producing genes from one species to another and increase their virulence. Some disadvantages associated with this model are Time scale and environmental effects have not been taken into consideration. This interaction mechanism is only confined to the biotrophic pathogens.

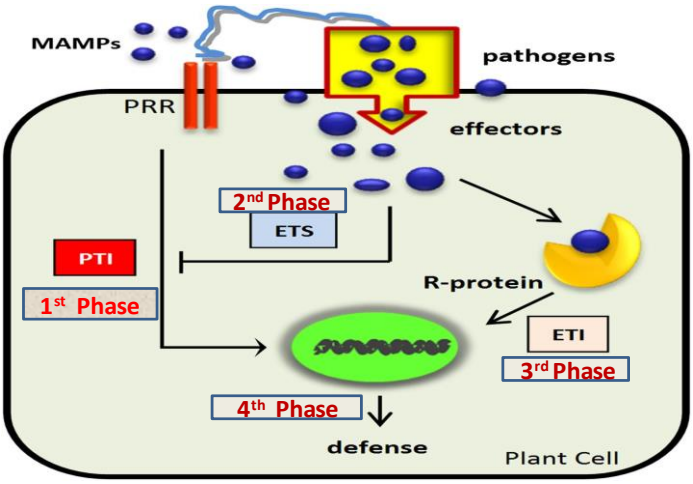


Fig-2 Steps of Zig Zag Model

B) Signal transduction

1) MAPK Signalling

After successful recognition, receptors induce some signalling mechanism. Among them one of the most prominent signalling systems is Mitogen activated protein kinase (MAPK) signalling. In initiation of MAPK signalling, Ras protein which is located in the membrane of plant cell, facilitate the formation of GDP from GTP and phosphorylates the MAPKKK (Raf) proteins which further phosphorylates the MAPKK (MEK) proteins and MAPK (ERK) proteins (Meng *et al.*, 2013). Interaction of bacterial flagellin and elongation factor with PRRs FLS2 and EFR with receptor BAK1 triggers the MAPK signalling (Chinchilla *et al.,* 2007). MAPK signalling also get activated through the perception of degraded pectin components by WAK1 and WAK2 (Kohorn *et al.,* 2012). Presence of MAPK genes

has been found in *Arabidopsis* on which 20 MAPKs, 10 MAPKKs and 60 MAPKKKs are present (Fig-3) (Ichimura *et al.,* 2002).

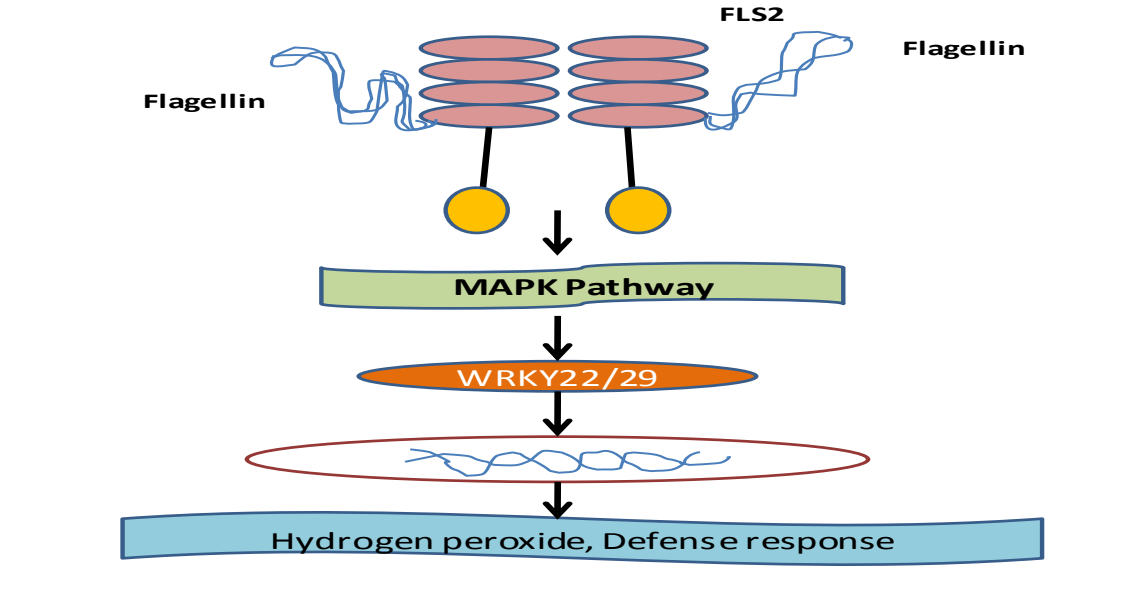


Fig-3 MAPK Signalling cascade

2) G – protein

Heteromeric G-protein and G protein coupled receptor (GPCR) are closely involved in signal transduction. GPCR interacts with the extracellular ligands and α subunit of G-protein complex get exchanged for GTP from GDP and α subunit is dissociated from β-γ subunit, this is how signalling cascade get initiated (Temple *et al.,* 2007). α subunit again get associated with β-γ subunit after GTP hydrolysis.

3) Ubiquitin

Ubiquitin is a small protein molecule found in most of the eukaryotes. Ubiquitination means deactivation of protein by proteasome activity. Proteasome is the complex of proteinases which can degrade the protein molecules. That degraded protein molecules act as signalling molecules and pathogens simultaneously produce effectors of different nature to disrupt the signalling mechanism. Plants use small ubiquitin like modifiers (SUMOs) to regulate the signal transduction (Marino *et al*., 2012).

4) Calcium ion fluctuation

In response to the PAMP or DAMP, receptors trigger the calcium ions fluctuation and activate the signalling cascade. Calcium dependent protein kinases, Calmodulin, and Calcineurin B-like protien detect Calcium ions fluctuations and activate Calmodulin-binding transcription activators (Poovaiah *et al.,* 2013). Calmodulin produces reactive oxygen species as defense response in plant immune system.

5) Hormone

There are so many hormones which are closely involved in plant immune system and defense reaction. Like:

Salicylic acid plays an important role in systemic acquired resistance against biotrophic and hemi biotrophic pathogenic infection. NDR1 effector and PAD4 (Phytoalexin deficient 4), EDS1 effectors

are recognised by the CNL receptors and TNL receptors respectively and after that recognition signals are transmitted and finally salicylic acid get activated (Aarts *et al.,* 1998).

Jasmonic acid (JA) and Ethylene (ET) play role in necrotrophic pathogen infection. In case of caterpillar predation, JA and ET induce volatile compound production which acts as signalling molecule. Production of ethylene is also get increased in presence of bacterial flagellin (Denoux *et al.,*2008).

Nitric oxide, cytokinins, abscisic acid, gibberellins, brassinosteroids also have role in defense response. ABA induces the stomatal closure in response to pathogen infection to the plant tissues (Lind *et al*., 2015).

6) Transcriptional factors

Transcriptional reprogramming acts in different level in defense mechanism like: a) Expression of basic components associated with resistance like kinases, receptors etc. b) Receptor proteins initiate the transcriptional factor's activity, c) Downstrean of receptor initiation through transcriptional factors activity (Qiu *et al*., 2008). bHLH, MYB, AP2/ERF, WRKY , TGA/bZIP and NAC these six families of transcriptional factors are directly associated with plant defense mechanism.

7) Nucleic acid activity and Pathogen derived resistance

Pathogenic infection causes changes in chromatin structure. Histone methylation/acetylation, DNA methylation, RNA interference induce the plant defense response. This kind of changes in genetic level causes downregulation of resistance inhibitors and upregulation of resistance inducers (Holeski *et al.,* 2012).

Cross protection or pathogen derived resistance can be an important source of plant defense mechanism. By inoculation of weaker, less virulent strain of pathogen to the plant, resistance can be induced against more virulent strain of the pathogen.

C) Defense response

After successful signal transduction, plants produce different type of defense response, like:

1) HR, ROS, Cell wall modification

Hypersensitive response is the most common defense response in plant immune system which further causes Programmed cell death (PCD). By PCD plants restrict the nutrient supply to the pathogen, so that growth of the pathogen is inhibited.

Reactive oxygen species formation makes the environment unfavourable for the growth of the pathogens. Peroxidase, NADPH oxidase, Amine and oxalate oxidase enzymes are directly involved in production of ROS (Karkonen *et al.,* 2015). NADPH oxidase produces superoxide, after that peroxidase generates hydrogen peroxide and it further produces ROS. Rapid transient production of huge amount ROS, is known as oxidative burst. Plants which lack the ability to detoxify ROS, have more strong immune response to the pathogens.

In post infection cell plants strengthen the cell wall through some modification like formation of Abscission layer in *Prunus* sp. against shot hole disease caused by *Xanthomonas campestris pv. pruni* and Cork layer formation against canker of potato caused by *Rhizoctonia solani* , Tyloses formation in xylem vessels inhibit the pathogen multiplication. Plants deposit lignin, callose to strengthen cell wall.

2) Enzymes and enzymatic inhibitors

Pathogenic enzymes are encountered by the plant receptors and detection of the effectors is facilitated by the plant immune system. Pathogens use different enzymes to degrade the plant cell components like cellulases, pectinases, xylanases. Similarly plants evolve enzymes like chitinases, β-1-3-glucanases to degrade pathogen's carbohydrate (Bellincampi *et al.,* 2014). Proteases enzymes are used by both plants and pathogens to reduce the enzymatic activity of Cellulase, pectinase and Chitinase respectively.

3) Defensins and Thaumatin like proteins

Defensins are small molecule of plant protein. It directly inhibit the invading pathogens. *Triticum aestivum* defensin 1 (Tad1) in wheat crown shows antipathogenic property (Koike *et al*., 2002). Defensin triggers the production of ROS.

Thaumatin like protein named from *Thaumatococcus daniellii* . Thaumatin like protein in barley binds to 1,3-β-D-glucans and induce resistance against powdery mildew. Some thaumatin like proteins are zeamatin (maize), osmotin (tobacco), avematin (oat), hordomatin (barley) and trimatin (wheat) (Osmond *et al.,* 2001).

4) Phytoalexin and PR Protein

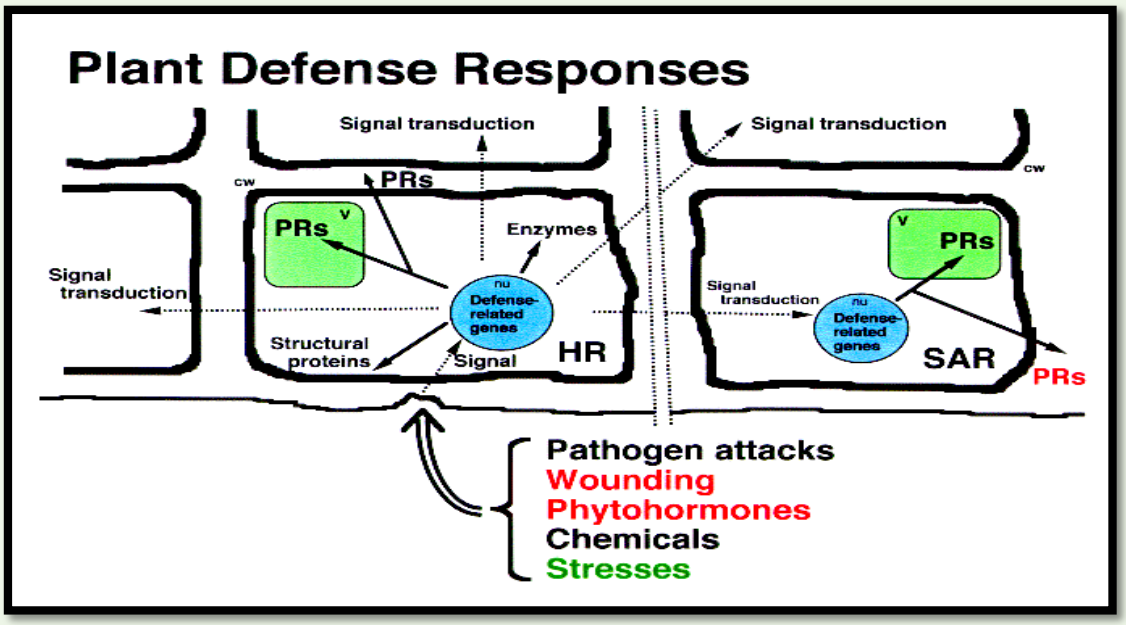
Phyto = "plant" and alexin = "to ward off; Phytoalexins are low molecular weight antimicrobial and often antioxidative substances synthesized *de novo* by plants that accumulate rapidly at areas of pathogen infection.

Pathogenesis related protein (PR protein), toxic to invading fungal pathogens, is produced intracellularly after pathogenic infection. PR proteins like PR1 (Antioomycetes, Antifungal), PR2 (β-1-3-glucanase), PR3 (Chitinase), PR4 (Antifungal), PR6 (Proteinase inhibitors), Thaumatin, Defensin, Cystein rich proteins etc.

5) Biological weapons

VAM (Arbuscular mycorrhiza) increases the DIMBOA (2,4-dihydroxy-7-methoxy-1,4-benzoxazin-3-one) production in corn which induce the resistance against insect pests and pathogens.

All the defense response has been summarily presented in **Fig-4.**



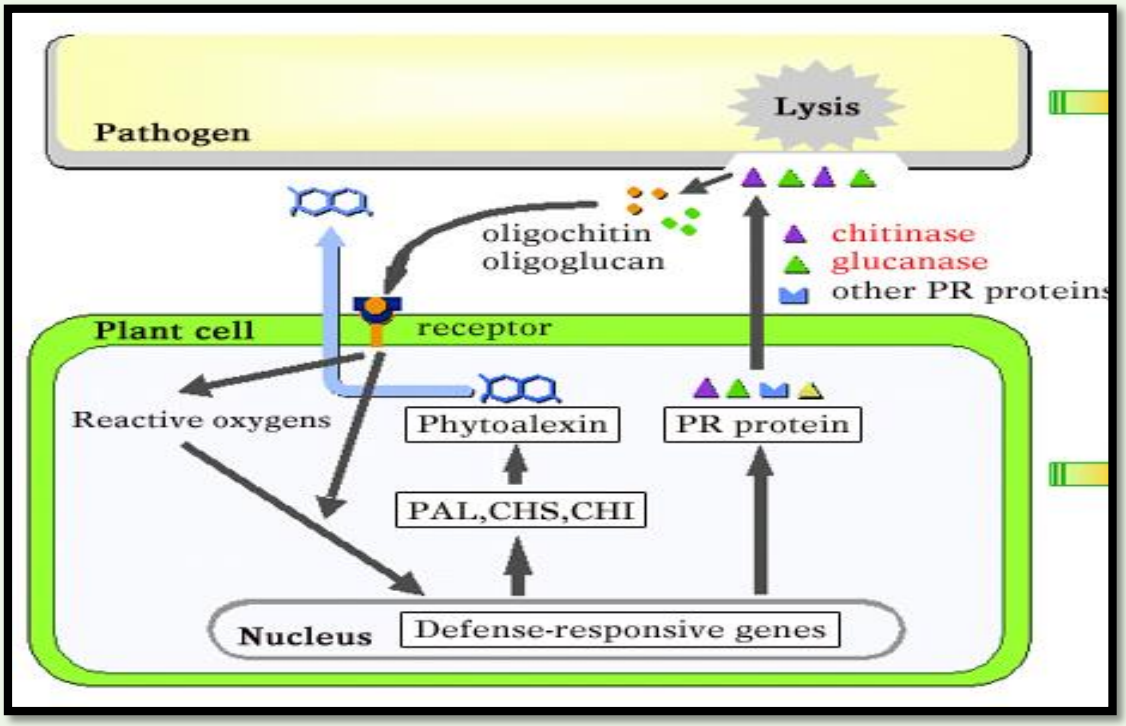


Fig-4 Defense Response in Plant after successful signal transduction

Conclusion

Detail study of plant-pathogen interaction and their molecular basis is highly important in twenty first century to maintain the production of crop with a sustainable disease management strategy. In this review the aspect of plants receptors PRRs, WAKs and pathogens effectors, PAMP, DAMP have been emphasised. The interactions are effected by several factors like Plant ontogenic resistance, plant phenology and physiology, plant genotype nature of PAMP, DAMP, environmental factors like UV radiation, climate etc. This topic is a very relevant issue in sustainable agricultural practices.

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VERMICOMPOST AS A PROMISING ALTERNATIVE TO INORGANIC FERTILIZER

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Introduction

Vermicomposting is a biotechnological environmentally-friendly process of converting organic waste into useful products using certain species of earthworms. It is a mesophilic process, utilizing microorganisms and earthworms that are active at 10-32°C (not ambient temperature but temperature within the pile of moist organic material).This process is faster than composting because the material passes through the earthworm gut where the resulting earthworm castings are rich in microbial activity and plant growth regulators and fortified with pest repellence attributes as well (Nagavallemma *et al.*, 2004). The worm casts are also rich in humic acids that condition the soil and have a perfect pH balance. Vermicompost is non-burning and it contains high amounts of nitrogen, potassium, phosphorous, calcium, magnesium and sulphur having good aeration, porosity, structure, drainage and moisture holding capacity. Vermicomposting process has several positive impacts on plant-soil systems and also enriches the fertility of soil. This organic fertilizer is therefore increasingly considered in agriculture and horticulture as a promising alternative to inorganic fertilizers.

Nutritive value of vermicompost : Nutrient content in vermicompost vary depending upon the waste materials that is being used for compost preparation. The commonly available nutrients in vermicompost are as follows (Table 1).

Table 1. Nutrient composition of vermicompost

Nutrient content	Percentage
Organic carbon	9.5-17.98%
Nitrogen	0.5-1.50%
Phosphorous	0.1-0.30%
Potassium	0.15-0.56%
Sodium	0.06-0.30%
Calcium and Magnesium	22.67 to 47.60 meq/100g
Sulphur	128-548 mg/kg
Copper	2-9.50 mg/kg
Iron	2-9.30 mg/kg
Zinc	5.70-11.50 g/kg

Source: Anonymous (2016)

Advantages of vermicompost : Vermicompost provides the macro and micro nutrients in readily available form and also enhances uptake of nutrients by plants. Sreenivas *et al.* (2000) carried out a study on integrated effect of application of fertilizer and vermicompost on soil available nitrogen (N) and uptake of ridge gourd (*Luffa acutangula*) at Rajendranagar, Andhra Pradesh, India and found significantly increased soil available N with increasing levels of vermicompost. N uptake was highest at 50% fertilizer + 10 t/ha vermicompost. Jadhav *et al.* (1997) also found highest uptake of nitrogen

(N), phosphorus (P), potassium (K) and magnesium (Mg) when fertilizer was applied in combination with vermicompost in case of rice (*Oryza sativa*) plant. Vermicompost improves growth and yield of vegetable, fruit, flower and field crops. Higher germination (93%) was recorded in mung bean (*Vigna radiata*) by the application of vermicompost compared to the control (84%). Further, the growth and yield of mung bean was also significantly higher with vermicompost application (Karmegam *et al*., 1999; Karmegam and Daniel, 2000). The yield of pea (*Pisum sativum*) was also higher with the application of vermicompost (10 t/ha) along with recommended N, P and K than with these fertilizers alone (Reddy *et al*., 1998). The fresh weight, number of flowers per plant (26), flower diameter (6 cm) and yield (0.5 t/ha) of *Chrysanthemum chinensis* were maximum with the application of 10 t/ha of vermicompost along with 50% of recommended dose of NPK fertilizer. Besides, the combined application of vermicompost at 15 t/ha and 50% recommended dose of NPK fertilizer increased the vase life of flowers for upto 11 days (Nethra *et al*., 1999). Vermicomposting reduces the C: N ratio of waste converted into compost that retains more N than the other composts (Gandhi *et al*., 1997). Earthworms also play a vital role in the recycling of N in different agro-ecosystems, especially under jhum (shifting cultivation) where the use of agrochemicals is minimal. Vermicompost has significant effects on soil pH, microbial population and soil enzyme activities (Maheswarappa *et al*., 1999). It also helps in reducing the toxicity of heavy metals and improves soil structure, texture, aeration and water holding capacity of soil. Vermicompost reduces population of pathogenic microbes and minimizes the incidence of pest and diseases.

Materials required for vermicomposting

a) A range of agricultural residues (animal manures, dairy and poultry wastes, food industry wastes, municipal solid wastes, biogas sludge and bagasse from sugarcane factories also serve as good raw materials for vermicomposting)
b) Cow dung
c) Water
d) Earthworms

Method of preparation

Selection of site : Vermicompost can be produced in any place with shade, high humidity and cool place. A thatched roof may be provided to protect the process from direct sunlight and rain. The waste heaped for vermicompost production can be covered with coconut/ arecanut fronds, banana leaves or with moist gunny bags.

Vermicompost production process : Production process may involve the following steps depending upon the area available :

i) A pit size of measurements 20'x4'x 2½' or any convenient length 4'x 2½' is dug in soil.
ii) Thick layer of cow dung slurry is covered over the cut pieces of arecanut/ coconut fronds or banana dry leaf materials over which the ratio of 80% waste and 20% cow dung should be maintained.
iii) Repeat the process of layering and then cover the pit with thin layer of cow dung.
iv) Leave it for 25 to 30 days depending on the climatic conditions for partial decomposition.
v) This process helps in partial digestion/ decomposition of the material and fit for earthworm consumption.
vi) Pit should be kept moist by sprinkling water daily depending on climatic condition by covering with gunny bags.

vii) Earthworms *viz*. *Eisenia foetida* (Red earthworm), *Eudrilus euginiae* (Nightcrawler), *Perionyx excavates* etc are released to the pit.
viii) Pits should be turned once after 30 days for maintaining aeration and proper decomposition.
ix) Compost gets ready layer by layer in 45 to 60 days depending on the quantity of biodegradable waste or number of earthworms released.

Harvesting of vermicompost

i) When vermicompost is completely decomposed and ready, it appears black, quite light weight and has a pleasant earthy smell.
ii) The vermicompost should be kept over a heap of partially decomposed cow dung so that earthworms could migrate to cow dung.
iii) The harvested vermicompost should be stored in dark, cool place.
iv) It should have minimum 40% moisture.
v) Sunlight should not fall over the composted material. It will lead to loss of moisture and nutrient content.
vi) The harvested compost material is openly stored rather than packed in over sac.
vii) Packing can be done at the time of selling. It is stored in open place, periodical sprinkling of water may be done to maintain moisture level and also to maintain beneficial microbial population.

Preventive measures : Minimum 25-30 days are needed for decomposition of cow dung and biomass to remove excess heat. Organic wastes should always be free from plastics, stones, glass pieces, chemicals, pesticides and metals. Proper aeration and 18-28^{o}C temperature with 30-40% moisture level should be maintained for proper growth and multiplication of earthworms, and decomposition of biomass. The African species of earthworms (*Eisenia fetida* and *Eudrilus eugenae*) are ideal for the preparation of vermicompost. Most Indian species are not suitable for the purpose. After completion of the process, the vermicompost should be removed from the bed at regular intervals and replaced by fresh waste materials.

Table 2: Dosage for different horticulture crops:

Sl. No.	Crops	Dosage
Vegetable crops	Cole crops and tomato	3 t/ha
	Others	2 t/ha
Fruit crops	Sapota, Mango, Grapes	3 kg/plant
	Papaya, Banana, Pomegranate	2 kg/plant
	Others	1.5 kg/plant
Flower crops	Rose, Jasmine, Chrysanthemum	2.5 t/ha
	Others	2 t/ha
Plantation crops	Coconut	2 kg/plant
	Arecanut and others	1 kg/plant

How to Use Vermicompost ?

For field crops, vermicompost (2-3 t/ha) is used by mixing with seed at the time of sowing or by row application at 12-15 cm seedling stage followed by light irrigation. In case of fruit crops, the amount of vermicompost ranges from 5 to 10 kg/tree depending on the age of the plant. A ring of 15-18 cm height can be made around the plant for efficient application. A thin layer of vermicompost (2-5 kg)

along with dry cow dung, bone meal and water is sprayed on the surface after covering with soil. For vegetables, vermicompost is applied at the rate of 1 t/ha in the nursery bed to get healthy and vigorous seedlings. But for transplants, vermicompost is applied initially at the time of planting at the rate of 400-500 g/plant and 45 days after planting followed by normal irrigation. In flowers also vermicompost is applied at 750-1000 kg/ha rate by covering with soil.

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SUSTAINABLE FLOWER PRODUCTION USING EFFECTIVE MICROORGANISMS (EM) AND JEEVAMRUTHA

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Abstract

Floriculture is associated with the heavy use of chemical fertilizers and pesticides resulting in degradation of soil and environmental pollution. For achieving sustainability, the need of the hour is to reduce or replace with some non-chemical alternatives. Many organic inputs are utilized as substrate media in floriculture like cocopeat, vermicompost, FYM, panchgavya, biofertilizers, livestock waste manures etc. Recently, use of effective microorganisms (EM) and jeevamrutha in agriculture as organic inputs has been gaining momentum and many researchers have reported its usage can improve the quality of soil, plant growth and yield.

Introduction

Floriculture is a multi-billion dollar global industry which includes the production of bedding plants, potted ornamentals, foliage plants, cut flowers, loose flowers, cut greens, dry flowers etc. This industry is huge and very profitable and it is estimated that the present worth stands at around $33 billion. Mass production has become a serious threat to the environment. These commercial flowers crops are cultivated with heavy application of chemical fertilizers and pesticides. The major chunk of nutrients required by these crops are nitrogen, phosphorous and potassium which are met by using chemical fertilizers. These has led to the neglect of the traditional good practices. Many scientists working in the field of agriculture have expressed their concern that any more efforts to persist with this chemical farming model will only prove counterproductive and cause irreparable damage to soil health and environment. The indiscriminate use of fertilizers and pesticides immensely harm biological activity of the soil in vast areas rendering it almost lifeless. Pesticides which are not easily degradable have entered the food chain and pose a number of health hazards. These pesticides secrete into soils and groundwater ending up in drinking water. Hazardous chemicals like methyl bromide is used as fumigant for disinfestation of soil in cut flower production. Apart from this, chloropicrin, dazomet, metam etc. are also used for fumigation. They are very effective against termites, insects, nematodes, weeds and soil-borne diseases but harmful. It is high time that the issue of chemical pollution coming from the cut-flower industry is addressed and move towards a practice focused on the welfare of ecosystem not only on quality and profits. Restoring soil health by reverting to non-chemical farming has assumed great importance to attain sustainability. This quest for sustainability has led to the idea of different methods of farming like integrated farming, organic farming, eco farming, natural farming etc. Though the names are different but the objective is same for all i.e to avoid or reduce the use of chemicals so as to prevent the environmental pollution.

Effective Microorganisms (EM)

Effective micro-organism (EM) was developed at the University of Ryukyus, Japan in 1989 by Prof. Dr. Terou Higa. EM is a fermented live mixed culture of 83 bacterial and fungal strains of different

species naturally isolated from the soil. The use of EM as an addiction to manure or as a spray directly in the field increase the micro-fauna biodiversity of the soil, leading to an improvement in field production. The main species involved in EM include Lactic acid bacteria (*Lactobacillus plantarum*, *L. casei*, *Streptoccus lactis*), Photosynthetic bacteria (*Rhodopseudomonas palustrus, Rhodobacter spaeroides*), Yeast (*Saccharomyces cereviasiae, Candida utilis*), Actinomycete (*Streptomyces albus, S.griseus*) and Fermenting fungi (*Aspergillus oryzae, Mucor hiemalis*). There are many uses of EM. It can be in applied in different preparations either as soil drench or directly onto plants during crop production. It can also be spread on leaves or the seeds can be soaked in its solution for disease and insect control. There are organic inputs supplemented with EM like EM enriched bokashi, EM compost etc. EM can act as a bio-control agent for suppressing and controlling insect pests through the introduction of useful microorganisms into the planting environment. EM emit odours which may repel harmful insects and can be used as a prophylactic spray. EM in FPE or EM-5 have been used for repelling insect as it is not toxic to ladybirds, spiders, dragonflies, or frogs (Ncube, 2008). Foliar application of Effective Microorganisms had a positive effect on the diameter of flowers in roses and the number of formed inflorescences and the number of leaves in case of gerberas Górski and Kleiber (2010). Prisa (2019) studied the possibility of using effective micro-organisms for germination and root growth in *Kalanchoe daigremontiana* and the results showed a significant increase in the agronomic and physiological parameters. The experiment also showed an increase in the percentage of seed germination and a significant reduction in the average germination time.

Jeevamrutha

Jeevamrutha is a fermented microbial culture of water, desi cow dung, desi cow urine, jaggery, flour of any pulse and handful of soil from farm which promotes biological activity in the soil and makes the nutrient available to the crop. Its nutrients, but most significantly, act as a catalytic agent that promotes the activity of microorganisms in the soil, as well as increase its activity. During 48 hour fermentation process, the aerobic and anaerobic bacteria present in the cow dung and urine multiply as they get to eat up organic ingredients like pulse flour. It also helps to prevent fungal and bacterial plant diseases (Babu, 2014). It is a component of Zero Budget Farming developed by Subhash Palekar. Vivili 2019 evaluated the performance of seven gladiolus (*Gladiolus grandiflorus* L.) cultivars under natural farming using jeevamrutha as an input and found that cultivars Candyman, Shagun, Psittacinus hybrid and Green Star were suitable for commercial cultivation under natural farming.

The question now is whether flowers can be grown commercially and sustainably using EM and jeevamrutha as inputs. The answer is yes but for hybrid cut flowers, use of others organic inputs and supplements are needed to meet the standards of both domestic and international markets. There are some commercial cut flower crops suitable for growing under natural farming using EM and jeevamrutha like chrysanthemum, gladiolus, tuberose, dahlia, lilium etc. and almost all seasonal flowers including indigenous flowers and local genotypes. For successful cultivation and quality production both in open and protected conditions, screening and selection of suitable varieties or genotypes is important as all will not be suitable. Considering the complexities and limitations of both organic and natural farming, it is better to come out with a more refined and cost effective ecofriendly flower cultivation or farming where the benefits from both can be taken up. The challenge is meeting the nutritional requirement of the flowers which are heavy feeders and protecting it from damages by biotic factors. EM and Jeevamrutha usually work on the mechanism

of nutrient supply by beneficial or useful microbes and can be used together with organic manures so that the quantity required is reduced.

Conclusion

The sustainable flower market is still tiny but it is growing specially in developed countries. According to the USDA, there is an increase in the number of small flower farms by about 20 percent during the past five years. From the 2012 census, it was reported that nearly 6,000 flower farms were there across the country. Many small flower growers have taken a cue from organic food growers who have successfully harnessed the farm-to-table trend. It is challenging but not impossible to go for eco-friendly cultivation. For moving towards sustainable flower farming, focus should be on flowers that thrive in local area and more native and local genotypes should be promoted. Eco friendly and farmer friendly flower farming may not replace flower cultivation using conventional practices but it is certainly a road for sustainability and a green healthy planet. More awareness is required to change the mindset of the growers as well as consumers. There is a long way to go and will always need strong demand particularly from the consumer driven to eco-friendly produce that the health of the planet and its inhabitant is more important than profit and quality.

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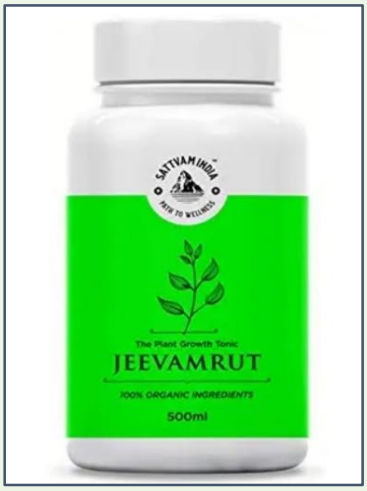
Indigenous effective microorganisms (IEM)

IEM solution



Jeevamrutha sold in market

Preparation of Jeevamrutha

EM sold in market

Fig. 1 Formulations of EM, IEM and Jeevamrutha

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REVIVING INDIAN AGRICULTURE: AFTER COVID-19

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Abstract

COVID-19 has caused a great impact in Agriculture and its allied Sectors, there is an acute shortage of farm labour for cultivation and post-harvest handling. Commercial crops are drastically affected as manpower and transport system is malfunctioning and as a result perishable crops streaming from different parts of the country are not able to reach the destination market on time and destroyed either in farmers field or in transportation. Some mitigation measures are taken by the government to help the farmer community like financial packages from the central government; ICAR has issued state-wise guidelines, RBI has also announced specific measures to address the 'burden of debt servicing' etc. The hit of COVID-19 on the economy is no doubt disastrous. No sector has escaped its impact. Their repercussion on agriculture is nexus and diversified. This impact will reverberate across the larger economy and will stay longer than a few months.

Key Words : Covid-19, Crop loans, Harvest

Challenges faced by Agriculture sector during Pandemic COVID-19

There is huge and never ending list of problems in agriculture focusing on labour availability and inability to access markets for produce due to issues in transportation as well operation of markets. Commercial crops are drastically affected as they tend to be more dependent on migrant labour for their production on large scale and marketing (Lakshman, 2020). Consequently, the shortage of migrant labor has resulted in a sharp increase in daily waged for harvesting crops. In many areas, the rise is high as 50%, making it unremunerated for producers since prices have collapsed due to either lack of market access including the stoppage of transportation and closure of borders (Thomas, 2020). This is in contrast to areas where migrant laborers have returned home from urban area and this has led to a sharp decline in agricultural wages.

The rise in labour cost and lack of access means that farmers are staring at huge losses and hence allowing crops to rot in the fields. Large buffer stocks in paddy and wheat mean that food grains shortage due to poor harvest is unlikely, at least this year. But the case of commercial crops and vegetables is more complex. A collapse in return means that farmers are likely to shift to another crop thereby substantially altering supply dynamics and with it prices. This, in turn, may have a bearing on food inflation (Dev, 2020).

Mitigation measures to ensure a sustainable food system

The end of the lockdown will not end the problems. On the contrary, they are compounded at the onset of the new agricultural sowing season. The most important issue that farmers have to face is the problem of repaying their crop loans and gold loans at least for those who have borrowed from the formal banking sector. There are some mitigation measures taken by government to help the farmer community which is listed below:

- Immediately after the nation-wide lockdown was announced, the Indian Finance minister declared an INR.1.7 trillion package, mostly to protect the vulnerable section (including farmers) from any adverse impacts of the Corona pandemic. The announcement, among a slew of benefits, contained advance release of INR 2000 to the bank accounts of farmers as income support under PM-KISAN scheme. The government also raised the wages for workers engaged under the NREGS world's largest wage guarantee scheme. Under the special scheme to take care of the vulnerable populations, Pradhan Mantri Garib Kalyan Yojana (Prime Minister's scheme for welfare of the poor), has been announced. Additional gain allotments to registered beneficiaries were also announced for the next three month. Cash and food assistance to persons engaged in the informal sector, mostly migrant labourers, have also been announced for which a separate PM CARES (Prime Minister Citizen Assistance and Relief in Emergency Situations) fund has been created.
- The Indian Council of Agriculture Research (ICAR) has issued state-wise guidelines for farmers to be followed during the lockdown period. The advisory mentions specific practices during harvest and threshing of various rabi (winter-sown) crops as well as postharvest, storage and marketing of the farm produce (**https://icar.org.in/**).
- The Reserve Bank of India (RBI) has also announced specific measures to address the 'burden of debt servicing' due to COVID-19 pandemic. Agricultural term and crop loans have been granted a postponement of three months (till May 31st) by banking institutions with 3% concession on the interest rate of crop loans up to INR 300,000 for burrowers with good repayment behaviour (**https://rbi.org.in/**).
- E-commerce and delivery companies and startups need to be energized with suitable policies and incentives to sustain the demand for agricultural commodities. The small and medium enterprises, running with raw materials from the agriculture and allied sector or otherwise, also need special attention so that rural economy does not collapse.
- To obviate the immediate concerns of scarcity of the farm labour, policies must facilitates ease availability of machinery though state entities, Farmer Producer Organizations (FPO) or custom hiring centers (CHCs) with suitable incentives. It is also suggested to explore leveraging NREGS funds to pay part of the farm labour to lessen the monetary burden on the farmer, whole ensuring wage employment to the landless laborers and workers.
- Relaxation of the norms by Agricultural Produce Market Committees (APMCs) allowing farmers to sell their products beyond the designated *mandis* will certainly ease the burdens of farmers. State Governments must gear up their machineries for smooth procurement operations of farmers marketable surpluses at MSP (minimum support price) or through other price support schemes.

Conclusion

With the burgeoning population, there is the corresponding rise in food demand in India. It is thus desirable to switch over to a suitable model with a far stronger nutrition focus where diets are more diverse. A post- COVID situation offers that unique opportunity to repurpose the existing food and agriculture policies for a healthier population.

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MEDICINAL PROPERTIES OF GINGER

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Introduction

India is known as 'The Land of Spices' and the glory of Indian spices is known throughout the world. Our nation is the largest producer, consumer and exporter of the spices in the world. According to the Spice Board of India around 63 different spices are grown in India. Commercial cultivation of such spices is limited to only about a dozen of crops, which are important in domestic market and international trade. More than 90% of spices produced in India are used for domestic consumption and the remaining are exported in raw and value-added forms.

Botany

Ginger is botanically known as *Zingiber officinale* and belongs to family Zingiberaceae. It is reported to be originated from the tropical rainforests of the Indian subcontinent to Southern Asia. Ginger is a herbaceous perennial flowering plant but are mostly grown as an annual. Height of a plant varies from 30- 90 cm. It has an underground stem also known as rhizome which is thick, flattened and covered with small scale leaves with fibrous roots that grows horizontally. The inflorescences bears flower with pale yellow petals and purple edges which arises directly from the rhizome on separate shoots. Its rhizome or root plays a major role in folk medicine and as a spice.

Major Constituents

The major constituents in ginger rhizomes includes carbohydrates (50–70%), lipids (3–8%), terpenes, and phenolic compounds (Grzanna *et al.,* 2005). Terpene components of ginger include zingiberene, β-bisabolene, α-farnesene, β-sesquiphellandrene, and α- curcumene, while phenolic compounds include gingerol, paradols, and shogaol. These gingerols (23–25%) and shogaol (18–25%) are found in higher quantity than others. Besides these, amino acids, raw fibre, ash, protein, phytosterols, vitamins (e.g., nicotinic acid and vitamin A), and minerals are also present (Shukla and Singh, 2007). In addition, the aromatic constituents of ginger include zingiberene and bisabolene and pungent constituents include gingerols and shogaols.

Medicinal properties of Ginger

Ginger possesses several medicinal properties and health benefits. Some of them includes :

Antiviral properties	Fresh rhizome of ginger is considered to have an antiviral effect against Human Respiratory Syncytial Virus (HRSV) infection. It also plays an important role in the management of common cold and fever associated with mucous secretions and management of complications due to cough and asthmatic conditions.
Anti-inflammation	Ginger is also used as the anti-inflammatory and a pain remedy. Some active constituent in ginger such as, gingerol, zingiberene, zingiberol are good effect on anti-bacterial and anti-inflammation.

Anti-tumour and anti-cancerous	Some studies also revealed that active constituent in ginger shows antitumor and anticancer properties. The 6-genero and 6-paradol had inhibitory effects on the viability and DNA synthesis of human promyelocytic.
Digestive aid	Ginger also plays a major role as digestive aid and helps in increasing appetize by secretion of different digestive enzymes inside the stomach.
Antimicrobial properties	Antimicrobial properties of ginger are effective against several intestinal problems. It is also used to avoid formation of ulcers. Ginger plays a vital role to inhibit harmful bacteria, such as *Escherichia coli*, which is responsible for most of the diarrhoea. (Wood 1998).
Antioxidant Activity	Ginger is known to exhibit a powerful antioxidant activity due to its oil which has protective effect on DNA.
Stimulation of blood circulation	Important therapeutic property of ginger includes its ability to stimulate the circulatory system that makes ginger is an important herbal remedy. It helps in nourishing the skin by increasing blood flow to the skin, removing toxin from the body, and cleansing the bowels and kidneys. (McGee2003).

Conclusion

There are several evidences from literatures on the medicinal properties of ginger. Apart from their appreciable roles in nutrition, they have been reported to possess several medicinal properties such as anti-inflammation, antimicrobial, anti-tumour, anti-cancerous and antioxidant properties. It also acts as digestive aid and helpful in stimulation of blood circulation, treating common cold and cough and several other diseases. Therefore, it can be concluded that besides its spice value ginger can also be used in various medicinal aspects for betterment of human health.

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