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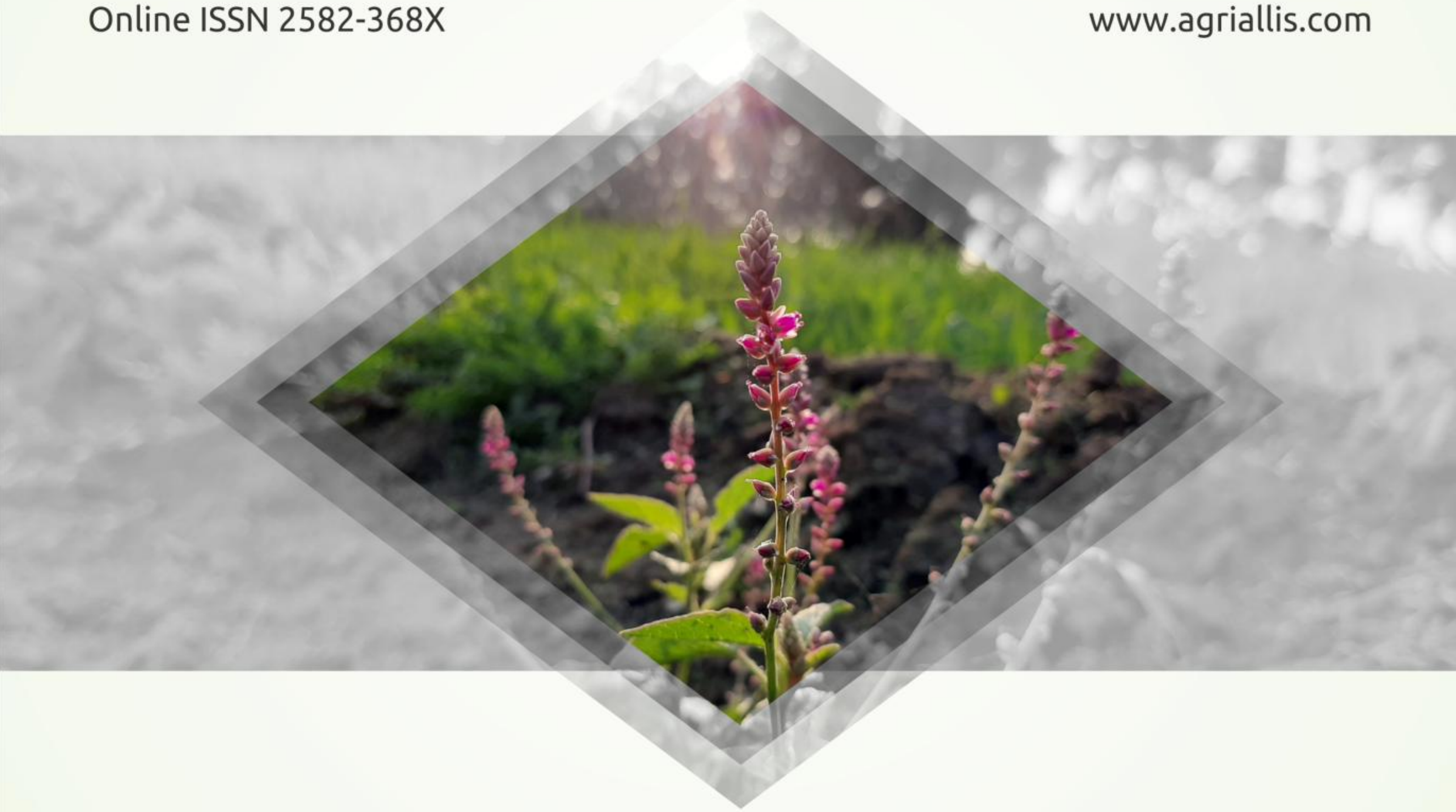

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Growing seed

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Contents

AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly e Newsletter
Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

INTEGRATED FARMING SYSTEM: A ROADMAP FOR INDIA

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Profitability and sustainability of agricultural sector in India is encountering numerous and complex hindrances such as maintenance of sustainability of our natural resources, adverse impact of climate change, declining factor productivity, nutrient mining and multiple nutrient deficiencies, overexploitation of groundwater resources, soil degradation due to intensive tillage practices, and decreased soil organic carbon (SOC) as well as diminishing trend in size of landholding which are expected to become drastic with the passage of time and these are some of the common concerns over wide range in most parts of the country resulting in stagnation in productivity of the system. Agriculture in our country is at crossroads in terms of obtaining sustainability primarily on three grounds; (a) the region is finding it troublesome to originate sufficient income and employment for its vast farming population, (b) failing to achieve environmental and energy security at the farm level, and (c) failing to confront or cope up with the climate change (Behera and France, 2016). Such types of concerns and problems posed by modern-day agriculture have given birth to new concepts *viz.* organic farming, natural farming, bio-dynamic agriculture, do-nothing agriculture, eco-farming, integrated farming system *etc*. The essence of such farming practices simply implies, back to nature to maintain the long-run productivity of the soil-plant-animal continuum. Faced with this circumstances, such agricultural strategies need to be explored that can increase productivity and generate adequate income and employment for the smallholder farmers, as well as produce renewable energy on the farm, and stop the erosion of biodiversity and offset carbon emissions (Behera *et al*., 2015). In order to keep pace with the burgeoning food requirements of such a large population pressure, there is an immediate requirement to accelerate all aspects of agricultural food production with due consideration to restoration and conservation of natural resources, which can only be accomplished through sustainable resource management and adoption of farmer participatory holistic strategies. In view of the decline in per capita land availability, it is obligatory to develop approaches and improved agricultural technologies that enable enough employment opportunities and income generation, especially for the smallholders having < 2.0 ha land who constitute the gigantic majority of the farming community in the developing world. No single farm enterprise, such as a typical monocropping system, is likely to be able to sustain the smallholder farmers. Integrated farming systems (IFS) are less hazardous if controlled effectively, as they get advantages from synergisms among several enterprises, diversification in produce, and environmental soundness. On this basis, IFS has been recommended for the development of small and marginal farms, and researchers have developed various strategies which have benefitted smallholder farmers by contributing supplementary income and employment as well as curtailing risk.

Integrated Farming System

The integrated farming system approach is recognized as a resource management strategy to obtain economic and sustained productivity that encounters the diversified requirements of the farm household whilst conserving the resource base and maintaining a high level of environmental quality (Lal and Miller, 1990). IFS is an entire complex of development, management and allocation of resources as well as decisions and activities, within an operational farm unit, or combinations of units, that results in agricultural production, processing and marketing of the products. It is a whole farm administration strategy that incorporates the ecological attention of a diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome and affordable food. The integrated farming system, on the other hand, is a dynamic concept which must have the flexibility to be relevant on any farm, in any country, and it must always be receptive to change and technological advances. Above all, IFS is a practical way forward for agriculture that will benefit society, not just those who practice it. IFS can be defined as a positive interaction of two or more components of different nature like field and horticultural crops, livestock, aquaculture or fishery, poultry, duckery, apiculture, sericulture, mushroom cultivation, biogas production, silviculture *etc*. within the biophysical and socio-economic environment of the farmers to enhance productivity and profitability in a sustainable and environmentally friendly way (Behera *et al*., 2004, Rautaray *et al*., 2005). A judicious mixture of two or more of these farm enterprises with advanced agronomic management tools may complement the farm income together with the help in recycling the farm residues. The

Volume 2 – Issue 3
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selection of enterprises must be based on the cardinal principles of minimizing the competition and maximizing the complementarity between the enterprises.

Advantages of IFS

The benefits of IFS, a strategy to ensure sustainable use of the natural resources for the benefit of present and future generations, include pooling and sharing of resources/inputs, efficient use of family labour, conservation, preservation and utilization of farm biomass including non-conventional feed and fodder resources, effective use of manure/animal waste, regulation of soil fertility and health, improved space utilization, diversified products, income and employment generation for many people and increase economic resources.

The important advantages of implementing IFS are listed below.

(a) Productivity, increased food supply and nutritional security: The significance of IFS approach lies in its ability to provide an opportunity to enhance the system's productivity or economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises to meet the demand for food, feed and fuel for ever-increasing human and animal population. Horticultural and vegetable crops can provide 2-3 times more calories than cereal crops from the same piece of land. Inclusion of beekeeping, fisheries, sericulture, mushroom cultivation under two or three-tier system of integrated farming gives substantial additional high energy food without affecting the production of food grains.

(b) Profitability: IFS improves land productivity and profitability by reducing production costs through recycling wastes and by-products of one enterprise as inputs to other enterprises.

(c) Sustainability: IFS gives emphasis on optimal and effective utilization of wastes and by-products of linked components and achieving agro-ecological equilibrium through the reduced build-up of pests and diseases.

(d) Balanced food: Different components are interlinked with each other to produce several types of products, which serve to provide a balanced diet for the farm family.

(e) Environmental safety: In IFS approach waste materials as well as nutrients are effectively recycled, resources are utilized efficiently by linking appropriate enterprises and components, and makes farming less dependent on external inputs, thereby minimizing environmental pollution occurring due to heavy use of external inputs.

Volume 2 – Issue 3
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(f) Resource recycling: Effective recycling of waste materials and by-products like crop residues and livestock wastes is performed in IFS. Therefore, there is less reliance on outside inputs (*e.g*. fertilizers, agrochemicals, feeds, energy) which leads to a more stable production system. Restoration of soil fertility is possible through organic manuring, biomass recycling, use of legumes in cropping system *etc*. Use of crop residue and plant biomass as input is observed for other enterprises, *e.g*. its use in mushroom cultivation, as mulch, a substrate in vermicomposting, feed block *etc*.

(g) Year-round income: Integrated farming system provides a flow of money to the farmers throughout the year by means of the sale of diversified farm produce *viz.* milk, egg, mushroom, vegetables, fruits, food grains *etc*.

(h) Risk minimization: IFS provides a stable and sustainable production system through diversified crops and enterprises, which helps in risk minimization and resilience to climate change.

(i) Use of marginal and wastelands: Combination of forestry, fishery, poultry, dairying, mushroom and beekeeping can be combined with crop production, and all of these activities can be undertaken on marginal & wastelands too.

(j) Increased employment: There is a 200 to 400 per cent increase in gainful employment and additional income to farm families, increasing their standard of living.

The integration of farm enterprises depends upon many factors such as availability of resources; soil and climatic features of the selected area; the present level of utilization of resources; land, labour, capital and skills; economics of the proposed integrated farming system, returns from the existing farming system and managerial skill of the farmer.

Sustainability of IFS Models:

The following features should be integral to the farming systems to become sustainable.

a) The model should be self input generating, seeking minimum requirement of external resources from the market.

b) The model should be able to generate year-round employment and perennial income in contrast to the seasonal nature of income.

c) Waste of one component should be wealth for another component, implying that complementarity should exist between/among the various components.

d) The model should be energy efficient, economically viable and socially acceptable.

Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

e) Rationality should be maintained among economic, ecological and social dimensions of IFS models.

f) The model should be capable of sustaining the farm family's nutritional needs as recommended by the Indian Council of Medical Research (ICMR).

g) While designing the IFS Models, ecosystem services should be taking into consideration.

h) The model should effectively reduce greenhouse gas emission and check soil and nutrient erosions.

i) IFS model is more likely to sustain when it is built over traditional systems, where due importance is given to indigenous crops and bio-diversity.

Conclusion

Adoption of an individual farm enterprise in isolation cannot sustain the farm family, but the IFS approach holds the promise of addressing the issues of sustainable economic growth of Indian farming communities. The integrated farming system is considered as a powerful tool for natural and human resource management as well as very effective in solving the problems of small and marginal farmers in developing countries including India. This multidisciplinary whole-farm approach aims at increasing income and employment from smallholdings by integrating various farm enterprises and recycling crop residues and by-products within the farm itself. The traditional monoculture and disciplinary approach are unable to meet the growing and changing food demand and improve the livelihood of these smallholders on a sustainable basis. Therefore, an integrated farming approach to research/extension and development is recognized as a critical implement for management of the vast natural resources, and to sustain agricultural production, maintain farm incomes, safeguard the environment and respond to consumer concern about food quality issues, to meet multiple demands, *e.g.* supporting livelihood, conserving biodiversity, off-setting emissions, adapting to climate change *etc*. It provides scope for exploring synergistic interactions of the components of farming systems and to enhance resource use efficiency. For this reason, various IFS models have been suggested by several workers for developing small and marginal farms across the country.

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STUDIES ON INNOVATIVE FRUIT GROWERS TO DRAW ATTENTION OF MARGINAL FARMERS

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Contributions of marginal farmers play a very crucial role in sustainable agricultural growth, food security and poverty alleviation of our country because of Indian agriculture is characterized by small farm holdings. According to Agricultural Census 2010-11, there are an estimated 117 million small and marginal holdings out of around 138 million total land households. The average farm size is only 1.10 ha with 93 % of farmers have less than 4 ha, and they cultivate nearly 55 % of the arable land (Agriculture Census 2010-11; Hazra, 2001). During 2005-06 the share of small and marginal farmers in landholdings was 83% (Chand *et al*, 2011). Therefore one of the best ways to upgrade their livelihood is by the introduction of high-value crops that have good prospects and market demand in our country. This thought is getting wind beneath its wings because rising income, urbanization, socio-demographic factors and increased awareness about the health benefits of fruits and vegetables have changed dietary preferences and major market drivers for the growth of high-value agriculture (Ruzlan*et al*, 2010).To encourage these peasants success stories and potentialities of some high-value fruit crops like strawberries and "Wonder fruit of 21st century" i.e. dragon fruits are discussed here.

Strawberry cultivated widely under protected and open condition of temperate and subtropical countries in plains as well as in hills. Among all different types of berries, strawberry gives the quickest return in a shortest possible period (Lyngdoh, 2014).

Dragon Fruit, a most cultivated edible fruit-producing genus of the family Cactaceae is a xerophytic vine crop, requires minimum manpower, spartan pesticides and it is of drought-resistant in nature(Le Bellec*et al*, 2006) with a long survival span of more than 20 years (Rao and Sasanka, 2015). In the best dry climate condition, one plant can produce up to four to six cycles of fruits per year (Nurliyana*et al*, 2010). It has a good prospect in India

Volume 2 – Issue 3
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because out of total geographical area 69.6% is dry land (Desertification & Land Degradation Atlas of India, 2007). Its robustness, as well as wide adaptability to different environmental condition, made it compatible with the different edaphic climatic condition and a good option for unfavourable areas (Mizrai*et al*, 2002; Telzur*et al*, 2004)

These antioxidant-rich fruits are already showing high demand in the Indian market; on the other hand, farmers are attracted towards these fruit crops due to their fast return potential which makes these crops more preferable than other fruit crops. So, it is necessary for the extension personnel to popularise these crops among farmers through sharing these success stories by organizing field day or by the campaign.

Strawberry growers

1. **The journey of a farmer to become president of "Strawberry Growers Association"**

With the help of Krishi Vigyan Kendra (KVK), Jammu, some farmers started strawberry growing in the district. One of them started his journey with strawberry from the year 2004 with 2 kanals (1 Kanal = 125 acres) of land and since he never looked back. In 2011-12 he had planted runners in 24 kanals of land and earned a net profit of Rs 2.5 lakhs. Similarly, in 2012-13 he earned a net profit of 2.7 lakhs from 20 kanals which increased to 5.6 lakhs in 2013. From 2004 onwards, his net profit was moved from Rs. 2500to Rs 5.6 lakhs in 2013-14 (Gupta*et al*, 2014). After practising for five years, he realized the potential of strawberry cultivation and formed a society under the banner of "Strawberry Growers Association". Based on his performance he was nominated as the president of the society.

2. **Strawberry cultivation leads to a horticultural revolution in Sohliya and Mawpran villages in Meghalaya**

Under the initiative of Technology Mission for the Integrated Development of Horticulture in the Northeastern Region and Government of Meghalaya, Centre of Excellence in collaboration with Horticulture Department farm ofDewlieh, in Umsning and active participation of the Ribhoi Strawberry Growers Association (RBSGA), Sohliya village located in Ribhoi district which is about 30km from Shillong, selected as a hub of strawberry cultivation in Meghalaya. The success of Sohliya village provided a momentum and East Khasi Hills leading the way by initiating 2 hectares clustered cultivation of the crop in

Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

Mawpran village which is about 58 km from Shillong. In Sohliya the total production was initially 125 Metric tonnes in 2009 had gone up to around 250-300 Metric tonnes annually in 2012-2013. Whereas in Mawpran village, strawberry cultivation was initiated only in 2008-2009, presently its production is about 10-20 Metric tonnes annually (Lyngdoh, 2014). Besides this, Indian Institute of Entrepreneurship (IIE) Guwahati and active cooperation of Ribhoi Strawberry Growers Association (RBSGA) a Horti-Eco Adventure Tourism project was launched that results in further diversification of job opportunities in the village.

3. A farmer aims to transform his village as "The strawberry village"

Farmers of the village Wanihama in Srinagar suffered from the ill associated with smallholdings and other inputs. A farmer of that village changed the fortune of his fellow men by showing the economic viability of strawberry cultivation. In 2004, he met the HorticultureOfficer working under technology Mission for the Integrated Development of Horticulture in North-Eastern states and hilly states. With the advice and all requisite inputs, he planted 1 kanal of his land with Chandler variety of strawberry under a poly house in March 2004 and that yielded an unexpected result of Rs. 50,000which encouraged him to expand the cultivation in 8 kanal system, and that resulted in Rs. 4.4 lakhs (Kumar, 2010). He has now set on a new mission to transform his village as "The strawberry village".

4. 'Strawberry Icon' of India

With scientists of CIPHET, Abohar, a farmer dared to take strawberry cultivation as a commercial venture. Now, his whole production from an area of 500 acres(Tapa, Bareta in Mansa districts; Viryamkhera in Abohar, Saharwa in Hisar) is taken by Mother Diary 'SAFAL' agency. Looking into the benefits and prospects, many farmers have started growing strawberry in Punjab, Haryana and Chandigarh. "Strawberry Icon" of the farming community earned Rs. 6 lakh ha^{-1}extra income by intercropping high-value crops like capsicum and yellow-fleshed watermelons on the residual nutrients applied for the strawberry crop. Now he started producing quality runners in biodegradable pouches that reduced runner mortality to 2–3% under poly-houses and low tunnels; to get disease-free planting materials because strawberry cultivation involves 25–30% cost on runners. Looking into the success, NHB has taken hi-tech nursery as a component of their scheme and started giving subsidy. Now he developed his own brand of strawberry fruits, "Arvind's Strawberry" (Ashrey, 2013).

Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

Dragon fruit growers

1. Dragon fruit plantation in drought-affected areas

ATMA introduced plantation of dragon fruit as an alternative crop for the drought-affected barren areas of Sangli district in Maharastra. The economic return generated from this fruit crop has augmented the income of the beneficiaries. Dragon fruit is introduced in 125 droughts prone villages of Sangli district in Maharashtra; small, marginalized farmers, women and disabled farmers have successively adopted the crop as an alternative livelihood source for income augmentation (Anonymous, 2014).

2. Dragon fruit in hilly Dediapada region

A tribal farmer with a large landholding in Dediapada region of Gujarat planted as many as 5,000 dragon fruits. Observing suitability of this fruit in that region and high market demand he decided to go for it and brought plants from a nursery in Kolkata as earlier, fruits were imported from other counties to India. Farmers from Dediapada and Nandodtalukas in Narmada district said they were confident that the quality of the fruit in their farm would be among the best in the country. This is the first time that farmers in the state have planted dragon fruit on a commercial basis. Narmada's Deputy Director of Horticulture is also very much hopeful about the crop (Kumar, 2014).

3. South Gujarat is gaining popularity in Dragon fruit cultivation

About 15,000 plants of dragon fruit have been planted in Surat, Tapi and Baruch districts. A farmer, who spends Rs. 2,75,000 per acre on dragon fruit plantation, can expect seven tonnes of fruits after two years. A farmer from the Bharuch district imported seeds from Thailand, after 18 months, he has nearly 5,000 dragon fruit plants. Another farmer told that red variety sells for Rs. 300 per kg and white one for Rs. 150 per kg. Assistant Director of Horticulture of the Gujarat Government hoped that it can be a good cash crop for many farmers and can pick up in south Gujarat where the region can aspire to be a major producer of it (Mohan, 2016).

Bottlenecks: Imperative for fruit growers

There are many drawbacks for smallholding of farmers across India. According to NCSUS (NCEUS, 2008), these are "some of the general issues that confront marginal-small

Volume 2 – Issue 3
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www.agriallis.com

farmers as agriculturalists are: imperfect markets for inputs/product leading to smaller value realizations; absence of access to credit markets or imperfect credit markets leading to sub-optimal investment decisions or input applications; poor human resource base; smaller access to suitable extension services restricting suitable decisions regarding cultivation practices and technological know-how; poorer access to 'public goods' such as public irrigation, command area development, electricity grids; greater negative externalities from poor quality land and water management, etc". Other than that education and skills are important for improving farming practices, investment and productivity. Even in a state like Andhra Pradesh small and marginal farmers depend upon 73% to 83% of their loans on informal sources (Dev, 2012). Increasing globalization has added to the problems faced by smallholding agriculture. Water scarcity, climate change are major challenges for agriculture, food security and rural livelihoods for millions of people including the poor in India. The adverse impact will be more on smallholding farmers.

Table 1. State-wise Area and Production of Strawberry

Area in '000 ha
Production in '000 Tonne

SL. No.	States/UTs	2012-13		2013-14		2014-15 (2nd Adv. Est.)	
		Area	Production	Area	Production	Area	Production
1	Mizoram	–	–	0.00	0.02	0.15	2.90
2	Meghalaya	0.10	1.04	0.10	0.74	0.11	0.82
3	Kerala	–	–	–	–	0.04	0.70
4	Himachal Pradesh	0.06	0.35	0.05	0.48	0.05	0.49
5	Jammu & Kashmir	0.02	0.00	0.05	0.37	0.19	0.30
	Total	0.17	1.40	0.21	1.61	0.55	5.21

Source: Horticulture Statistics Division, DAC&FW.

Table 2. Area and Production of Strawberry for Major Producing Districts

Area in '000 ha
Production in '000 Tonne

State	S. No.	Districts	2012-13	
			Area	Production
1.Himachal Pradesh	1.1	Sirmour	0.038000	0.342000
	1.2	Kangra	0.005000	0.004000
	1.3	Solan	0.002000	0.001000
2.Nagaland	2.1	Kohima	0.050000	0.070000
	2.2	Mokokchung	0.030000	0.042000
3.Meghalaya	3.1	Ri-Bhoi District	0.000021	0.000386
	3.2	West Garo Hills	0.000065	0.000136
	3.3	East Khasi Hills	0.000006	0.000131
	3.4	East Garo Hills	0.000002	0.000011

Source: State Departments of Horticulture/Agriculture.

Prospects

Despite the above challenges, there are ample technological and institutional innovations which can enable small farmers to raise agricultural productivity and increase income through diversification and high-value agriculture. Both these crops discussed here are loaded with nutrients and surely fetch high demand and market price in domestic as well as international markets. High levels of vitamin C in dragon fruit stimulate the activity of other antioxidants in the body (Duarte and Lunec,2005; Rastalland Gibson, 2006). It's also packed with phosphorus, calcium, fibre and B vitamin group (B1, B2 and B3). Vitamin B2 acts as multivitamin and aids to recover loss of appetite (Cheah*et al*, 2016). It's a potential source of prebiotics that improve host health by promoting certain beneficial bacterial colony (Sharmaand Jain, 2011), glucose found in Dragon fruit helps in controlling the blood sugar level for diabetes patients (Wee and Wee, 2011). Strawberries also contain many important dietary components including vitamins, minerals, folate, fibre, manganese and are a rich source of phytochemical compounds mostly polyphenols. It is one of the richest natural sources of essential micronutrients (Francesca*et al*, 2016). Strawberry intake can be beneficial in Alzheimer's disease and other forms of dementia (Khatun, 2013)and with these, organic cultivation can put an extra benefit to growers as in California, Organic strawberries rank sixth among all organic fresh commodities, with over 160 organic strawberry growers registered with the California Organic Program (Telzur*et al*, 2004) even dragon fruit also showed good response with organic culture especially cow dung manure in Bangladesh (Kumar, 2014). The exotic dragon fruit with its xerophytic nature and drought-tolerant capacity can be adapted to an area where farmers face problems like water scarcity. Data presented in table1 and 2 clearly shows the increasing area and production of strawberry ever since it entered as a commercial crop in our country. But in the case of dragon fruit, it just only entered our country and shows huge scope to extend further. Many experts left their views on high potentiality of these crops in India like, Director of Trikaya Agro, said, "Nearly 60% to 70% of our dragon fruit is consumed through the shop peddling". The company started planting Trikaya Agro dragon from six years ago, currently produces 30-35 tonnes per year of the dragon. It began to be commonly consumed in urban areas, especially in southern India. According to the Vietnam Fruit and Vegetables Association, India is only open to import Vietnam dragon since early this year, but this is a huge consumer market. However, businesses need competitive bids by Thailand also put this item on the Indian market (Joseph *et al,* 2009). In Central Island Agriculture Research Institute, a Field Day was conducted with 52 farmers from different villages of South Andaman. The visiting farmers relished the dragon fruits organically produced at the Institute and learnt the growth and development of the crop. They were highly fascinated by the new fruit crop and showed lots of enthusiasm for learning the technical know-how of this fruit crop. *Even* exploring the climatic suitability in the tropic and sub-tropic region of Rajasthan, the government is taking an initiative to cultivate dragon fruit in 5,000 sqm in Rajasthan.

Way forwards

- To cope with globalisation farmers can go for organic cultivation of these nutrient-rich high-value fruit crops to fetch high returns.
- Climate change is a big issue for agriculture nowadays and strawberry would a great option for that. Fruit crops like strawberry can be easily adaptable in different agro-climatic situations due to its wide range of varieties falls under different groups like a short day, long day and day-neutral along with this proper selection of varieties can contribute to year-round production. So, farmers can go for protected cultivation with cost-effective polytunnels, selection of proper varieties suitable for that region. In some places where water scarcity is a problem growers can go for dragon fruit cultivation with providing minimum water requirement.
- As labour requirement is minimal, women can involve which will give an opportunity to earning an additional income consequently leads to economic upliftment.
- Cooperative marketing society could be formed for providing credit facilities to the needy ones for the cultivation of crops.
- As these crops are less popular among the marginal farmers, so it should the role of extension personnel to popularising these crops through highlighting on these success stories and convey the message through conducting field day, leaflets distribution.

Conclusion

India is the hometown of small and marginal farmers; their contribution to the farming sector cannot be overlooked as they play a crucial role in sustainable agricultural growth, food security and poverty reduction. Being the driver of our society, improvement of their livelihood through the incorporation of high-value crops in cropping pattern is needed. In these regards, nowadays fruit crops as if Strawberry and Dragon fruit create a place in

Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

farmers' hearts for minimum input requirements, high return potential, abundant nutrition and as a good earning opportunity from the small piece of land. Few farmers dared to cultivate strawberry and now proudly sharing their success with other farmers of their surroundings; similarly, a few innovative farmers took an initiative and confidently cultivating dragon fruit in their farms. So, it is necessary for the extension personnel to popularise these crops among their locality through sharing these success stories by organizing field day or by the campaign.

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A GLANCE ON GENETICALLY ENGINEERED (GE) CROPS

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Any technology like modern biotechnology has its associated benefits and risk. Accordingly, products of modern biotechnology are biopharma & genetically engineered (GE) crops. Conventionally, the genetic variation necessary for crop improvement are generated through hybridization; mutagenesis and polyploidy but more recently, biotechnological approaches have become available for the creating genetic variation. The most potent biotechnological approaches are the transfer of specifically constructed genes assemblies through various transformation techniques. This constitutes genetic engineering. The organism obtained through genetic engineering contain genes usually from an altered organism such genes are called transgene and organism containing transgene or transgenes are known as genetically modified organisms (GMOs) or transgenic organisms, and the plants containing transgene are known as transgenic plants.

The first transgenic plant was produced in 1983 when a tobacco line expressing kanamycin resistance was produced. This technology also finds application in pharmaceuticals and production of seeds food and animal feed. In these products, LMOs (living modified organisms) or GMOs are used directly. The introduction of GMOs into the environment may have an impact on the receiving ecosystem such as the possible transfer of genes and subsequent modification of native species. The cultivation and spread of GE crops all over the world have been a subject of controversy in the recent past at both the national and international levels (Prakash, *et al.* 2011).

Technique to develop the Biotech Crops

In vitro gene transfer is the technique of transferring desirable gene across taxonomic boundaries into plant and animals from the other sources such as plant, animals, and

Volume 2 – Issue 3
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microbes. The gene transfer technique classified into three basic methods (i) biological gene transfer (ii) Physical gene transfer and (iii) Chemical gene transfer methods.

In the biological mediated gene transfer methods used Agrobacterium vectors, cointegrated vectors, binary vectors and as well as used some viral-mediated gene transfer virus namely caulimo virus, geminivirus, TMV etc. In some case the physical gene transfer methods likely Electroporation, Particle bombardment, Microinjection, Macro-injection, Liposome mediated, Ultrasound mediated DNA transformation as well as DNA transfer via Pollen. In other hands, the chemical transformation likely PEG mediated gene transfer, Calcium phosphate, and Polycation DMSO technique used for the transfer of foreign DNA in Bacteria, fungi, plant as well as Animal cells (fig. 1).

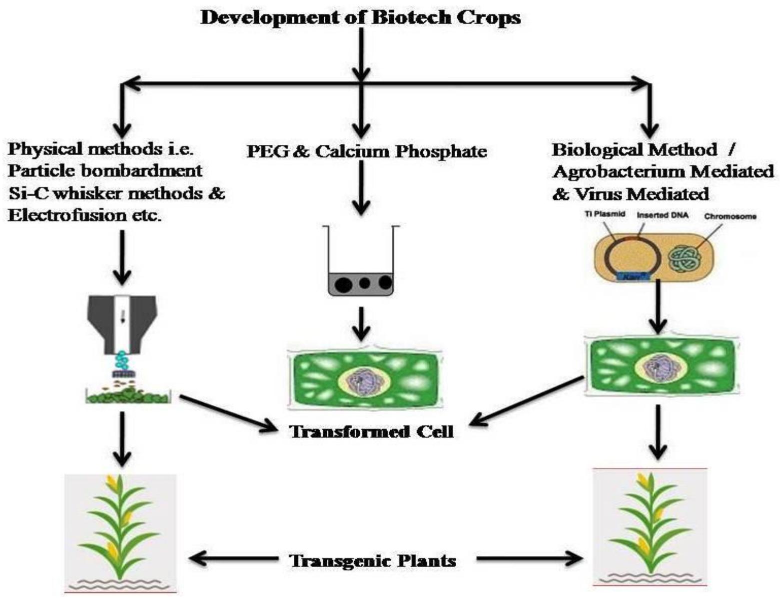

Fig. 1. The overview of the physical, chemical and biological transformation methods of the plant cell.

Current state of transgenic crops

It seems appropriate to spend a little time reflecting on the current status of the GM plant in broad terms. Despite public opposition and political difficulties in some region of the world, particularly in Europe, the area of land cultivated with the transgenic crop continues to increase. Figures the International Service for the Acquisition of Agribiotech application (ISAAA) clearly show the importance of transgenic crop in both developed and developing countries.

The biotech crops are considered as the fastest adopted crop technology in the history of modern agriculture. In 2018, the 23rd year of commercialization of biotech crops, 191.7 million hectares of biotech crops were planted by ~17 million farmers in 26 countries. From the initial planting of 1.7 million hectares in 1996 when the first biotech crop was commercialized, the 191.7 million hectares planted in 2018 indicates approximately ~113-fold increase.

Transgenic crop cultivation by country

Seven countries are responsible for 94.37 % of the area cultivated with transgenic crops.

Country	2018 – GM planted area (million hectares)	Biotech crops
USA	75.0	Maize, Soybean, Cotton, Canola, Sugar beet, Alfalfa, Papaya, Squash, Potato
Brazil	51.3	Soybean, Maize, Cotton
Argentina	23.9	Soybean, Maize, Cotton
Canada	12.7	Canola, Soybean, Maize, sugar beet, Alfalfa
India	11.6	Cotton
Paraguay	3.8	Soybean, Maize, Cotton
China	2.8	Cotton, Poplar, Papaya, Tomato, Sweet pepper

*Area is in millions of hectares. (Source ISAAA, 2018).

Distribution of Biotech Crops in Developed country and Developing country

In 2018, the 21 Developing countries cultivated 54% (103.1 million hectares) of the global biotech hectares, while five industrial countries took the 46% (88.6 million hectares) contribution of the total biotech crop production globally.

Transgenic crop cultivation by crop

The commercial use of GM varieties still focuses on soybeans, maize, cotton and rapeseed. The proportions of the total area dedicated to transgenic crop made up of the particular crop are given below:-

Crop	Area* (conventional + Biotech crop)	Area of GM*	Proportion GM
Soybean	123.5	95.94	78 %
Maize	197.2	59.16	30 %
Cotton	32.9	25.0	76 %
Rapeseed	34.7	10.06	29 %

* Cultivation worldwide in millions of hectares

The field area of GM soybean has been compared to the total soybean production per cent and stands now at 78 per cent. The driving force behind the growth in floor space in Brazil. Other producers are the USA, Argentina and Canada.

In the case of maize, the field areas are used for GM varieties 59.16 million hectares, primarily in the USA, Argentina, Brazil and Canada. Maize production across worldwide is 30 per cent of the present production, based on GM maize.

Volume 2 – Issue 3
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www.agriallis.com

The field areas for GM rapeseed are present 10.06 million hectares. Those fields are found primarily in Canada and Australia.

The field areas for GM cotton at present time are a total of 25 million hectares. Across Worldwide 15 countries (including India, USA, China, Brazil and Argentina) use GM cotton.

Transgenic crop cultivation by trait

Herbicide resistance is the trait found in by far the largest area of transgenic crop accounting for 77 %. With insect resistance, these two traits account for effectively all the area cultivated with transgenic crops.

Trait	Area*	Percentage
Herbicide resistance	40.6	77 %
Insect resistance (Bt)	7.8	15 %
Insect resistance (Bt)+	4.2	8 %

*Area is in millions of hectares (Source ISAAA, 2018).

The global value of the biotech crop market

In 2018, the global market value of biotech crops, estimated by Cropnosis was US$18.0 billion (up by 9% from US$15.8 billion in 2016); this represents 23% of the US$70.5 billion global crop protection market in 2016, and 30% of the US$56.2 billion global commercial seed market (Aldemita and Hautea, 2018).

Farmers benefited by transgenic crops

Agricultural crops are mainly cited paradigms of GMOs. Some benefits of genetic engineering in agriculture crops are improvement in Yield, reducing the costs for food or drug production, low or no need for pesticides in agriculture, improved nutrient composition and quality of food, developed pests and disease resistance plants, greater food security, and medical benefits to the world's growing population. Advances have also been made in developing crops that mature faster and tolerate the biotic stress as well as drought, salt, metal, and other environmental stress, (Phillips, 2008). The other benefit of genetic engineering in the field of research, rapid and accurate technique and no barrier for gene transfer.

Conclusion

The constant growth in the adoption of genetics modified crops is attributed to the technology's positive impact on the environment, human and animal health, also as on the development of socioeconomic health of farmers and the general public.

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CARBON FOOT PRINTING- PROSPECTS AND IMPORTANCE IN AGRICULTURE

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Present modern-day environment issue is all about to reduce concentrations of carbon dioxide (CO_2) and other greenhouse gases (GHG) in Earth's atmosphere (IPCC 2007). The fact cannot be ignored that Agriculture has always been counted as one of the biggest emitters of GHGs globally. It covers 35% of the land area and accounts for nearly 13.5% of the total global anthropogenic GHG emissions which contributes about 25, 50, and 70 % of CO_2, CH_4, and N_2O, respectively (Montzka*et al., 2011).* The goal of modern agriculture is striving towards higher-energy and higher carbon-input systems (diesel, chemical fertilizers, pesticides etc). One of the key indicators of indicators in assessing the environmental sustainability of farming system Greenhouse gas emissions is one of the keys (Gómez-Limón and Sanchez-Fernandez,2010). The term carbon footprint in agriculture is getting popularity to quantify such impacts which function is based on (a) Emissions of greenhouse gas emissions per unit of farmland—quantifying the total amount of emissions in crop production that focuses more on environmental health and (b)to produce per kilogram of grain the quantity of greenhouse gas emissions associated with— which is emphasizing both emissions while production of a crop as well as the products (i.e., grain yield) involved with per unit of emission. Carbon footprint is considered as one of the most recent terms for global warming potential that defines the total greenhouse gas emissions associated with a product or service. This carbon footprint (CF) assessment of products especially in agricultural has recently gained much attention and popularity in international society in context with climate change. It is highly essential to choose such crops and management practices as well that have low CF to maintain a win-win situation between food production and greenhouse gas emissions (GHG). Thus, information which is pertained with carbon footprinting (CF) for crops production under conservation agriculture definitely would be of immense importance and relevance in order to adopt technologies wisely which would mitigate the GHG emission and improve the environmental footprint of the agricultural systems.

The direct energy under farm operations is termed as the energy which is directly required for various operations to carry out whereas indirect energy is involved for the production of several farm inputs, such as commercial fertilizers, pesticides, herbicides etc. The amount and type of energy engaged in agricultural operations have a vast impact on the emissions of CO_2. CO_2 emitted either directly from soil respiration or indirectly due to fuel or electricity consumption can be curtailed by practices like changing agronomy package, management of nutrient, tillage/residue management and water management etc. Improved agronomic practices increase yields and also generate inputs of carbon residue and lead to an increase in soil carbon storage (Follett, 2001). Although reports of minimum or no-till effects on soil carbon are mixed (West and Post, 2002; Ogle et al., 2005; Gregorich et al., 2005), but conservation agriculture with crop residue retention and cropping system management as key components can conserve energy in crop production. This paper will deal with the factors or agricultural practice contributing towards maximum carbon footprinting along with some mitigation strategies that can be a better option to think for adaptation.

Farm Operations Contributing Maximum Carbon Foot Printing

There are many factors in crop production that responds to greenhouse gas emissions as. The most popular method to analyze this is LCA (life cycle assessment) analysis, it includes CO_2 emissions from off-farm manufacture, transportation and delivery of various input products to the farm gate as well as those emissions during the cultivation of a crop. Emissions of CO_2 from field crop production are mostly obtained from (1) decomposition of crop residues; (2) application of inorganic fertilizers to the crop; (3) manufacture, storage, and transportation of inorganic fertilizers, herbicides and pesticides to the farm gate; (4) various other farming operations such as spraying of pesticides, planting and harvesting the crop and tillage operations; (5) soil carbon gains or losses from various cropping systems; and (6) emissions of N_2O from summer fallow areas where the land is kept for the crop to be grown the following years (Chang Liu et al,2016).

Few Mitigation Strategies to Lower Co_2 Emission from Farm Operations

As a signatory country to the United Nations Framework Convention on Climate Change (UNFCCC), the United States is actively engaged in a critical international effort to combat the problems posed by climate change and presented few farming strategies to increase grain production in order to lower carbon footprint. (1) using diversified cropping

Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

systems that can reduce the system's carbon footprint by 32 to 315 % compared with conventional monoculture systems (2) improvement of N fertilizer use efficiency can decrease the carbon footprints of field crops as N fertilizer applied to these crops contributed 36 to 52 % of the total N_2O emissions; (Walter et al. 2015). (3)Intensified rotation with less summer fallow that can lower the carbon footprint by as much as 150 % compared to system with high frequency of summer fallow; (Harker et al. 2009; Menalled et al. 2001) (4) soil carbon sequestration enhancement which will reduce carbon footprint as the emissions from farm inputs can be helpful to offset partly by conversion from atmospheric CO_2 into plant biomass and gradually sequestered into the soil; (5) reduced tillage along with crop residue retention to raise soil organic carbon and reduce carbon footprints; (6) integration of all key cropping practices can increase crop yield by 15 to 59 %, can reduce emissions by 25 to 50 % and lower the carbon footprint of cereal crops by 25 to 34 %; (Yang et al. 2013) (7) addition of N_2- fixing pulses in rotations that reduces the use of inorganic fertilizer, and lower carbon footprints. Adoption of these improved farming tactics can lead to new possibilities to optimize the system performance to reduce the carbon footprint of crop cultivation.

Conclusion

Sustainable agricultural systems are aimed to produce better quality and affordable food in sufficient quantity to meet the growing global population demand of food, feed, and fuel, and at the same time ensures farming systems that must have a low impact on the environment. The key agronomical tactics include not only to diversify the cropping systems or improving N fertilizer use efficiency but also it involves overall integration of all improved farming practices together enables to reduce the use of inorganic fertilizers, increase the system productivity, and lower the carbon footprint. High time already it is to make aware even the farmers too that not only increase crop production should be a major focus but the way the crops are produced and marketed will also have significant environmental consequences. Sooner by following relevant agro-environmental policies with the adoption of improved agronomical tactics to increase food production will lead to no cost to the environment can be achieved that will be sustainable in true sense effectively, efficiently, and economically.

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ENTOMOLOGICAL SURVEILLANCE FOR PROTECTING PUBLIC HEALTH FROM MOSQUITO-BORNE DISEASES

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Vector-borne diseases account for more than 17% of all infectious diseases. Among the vectors, mosquitoes are the deadliest ones. Since 2014, major outbreaks of dengue, malaria, chikungunya, yellow fever and Zika have afflicted populations, claimed lives and overwhelmed health systems in many countries (WHO, 2017). More than half of the world's population live in areas where this mosquito species is present. Sustained mosquito control efforts are important to prevent outbreaks from these diseases (WHO, 2019). It is a well-known fact that the mosquito-borne disease control and prevention largely relies upon lowering the contact rate between human and vector and killing the vector. A proper Integrated Mosquito Management programme uses various techniques to reduce mosquito numbers and surveillance provides the data on which those actions apply. In fact, with the help of surveillance throughout the year, we can predict the chance of a disease outbreak and can deploy management strategies to prevent the havoc.

Mosquito Surveillance is the routine monitoring of both larval and adult mosquito populations over the course of an entire mosquito season based on the life cycle of the vector in interest. Through Surveillance we can monitor the fluctuation in the mosquito population in an area, can identify the major species in that area, can detect mosquito-borne diseases and can find out the efficiency of control measures based on the mosquito numbers. Surveillance is usually done by dividing an area such as a village, town or industrial facility into different zones. Within each zone, an experienced field technician collects mosquito larvae from standing water sources using standardized techniques, while they set adult mosquito traps for adult sampling (Markowski, 2015). The procedure is as follows:

Larval Sampling

Locate The Breeding Source: First, we have to find the mosquito breeding places which includes all the water sources in that locality. Different mosquito genera prefer different source of water like freshwater, dirty and polluted water, artificial collection of water and water containing certain aquatic vegetation. We can use geographical maps, land use board maps, watershed maps, soil maps, aerial photos and Geographic Information System-Global Positioning System (GIS-GPS) etc. Any place which can retain a pool of water is targeted. In rural area, we have low-lying vegetated areas, marshes, ponds, riverbeds and backwaters, irrigated fields and pastures, wells, areas of poorly drained soils and in urban areas; overhead tanks, ditches, street gutters, drainage systems, swimming pools, unused public toilets, cesspools, and any large or small natural and artificial containers at home or other building.

Monitoring Larval Habitats: The monitoring is started after locating the sources. Monitor daily or weekly or biweekly depending on the season and study. The dipping method is often used for collecting mosquito larvae. The standardized equipment is a "Dipper", a white enamel or plastic cup attached to a 3-4 feet long wooden dowel. A simple ladle can also be used. Dip it in the breeding places (edges of swamps, ditches, streams, rice fields other bodies of waters) at an angle of 450 (Srivastava and Dhariwal, 2016). The larval density is assessed in terms of average larval density per dip. A minimum of 10 dips per acre is mandatory. Collect the larvae for further identification and species determination. The larvae are stored in glass vials containing 70-80% ethanol for preservation. No more than 20 larvae should be placed in a 50 ml single vial because the water contained in the bodies of the larvae will significantly dilute the concentration of ethanol and jeopardise preservation (EFSA, 2018).
Netting using larval nets (fine-meshed (≤ 0.5 mm) aquatic net (aquarium net) and sieve) and pipetting (from tree holes etc.) are also methods for collecting larvae. For the collection of Mansonia larvae, a one-foot square bottom tin/wooden tray is kept over floating vegetation and the number of plants is counted. The plants are then removed to an enamel tray with water and the plants are then well shaken to disentangle the Mansonia larvae from the roots. Then the number of larvae and the number of plants are counted and the average number of larvae and pupae per plant estimated.

Adult Sampling

Several sampling methods are available for adult mosquito surveillance which can be used alone or together as per necessity. Broadly it can be classified as collecting techniques and trapping techniques.

Collecting techniques include

a) **Sampling Resting Population**: Most of the mosquitoes feed at dawn and dusk, and a few hours into dark except some that will feed both day and night like *Aedes*. When they take rest, they are found indoor in cool and dark corners like house ceilings, amongst thatch and cobwebs, on the underside of shelves, amongst clothing and other hanging articles, cattle sheds, pet houses, etc. When outdoor, mosquitoes are seen resting in bushes, shrubs, cracks and crevices of walls, under bridges, culverts and in tree holes, etc. (Srivastava and Dhariwal, 2016). These mosquitoes are collected and counted using a vacuum aspirator. Sampling the resting adults usually provides a representative sample of the population *viz.* males, newly hatched adults, unfed as well as fed and gravid females. When looking for natural resting places, this method is tedious, so we can provide artificial resting places and collect them.

b) **Human Landing Collection (Hlc):** This method is the simplest and most authentic one, as human beings are directly posed as bait, but ethical issues are to be taken care of. The collector or the person, on whom the mosquito sits for feeding, should be healthy. He has to stand for 2-5 min (up to 15 min in some cases) in an area where there is peak mosquito activity, at peak time, preferably between sunset and one to two hours after sunset. The mosquitoes are collected from his body using a vacuum aspirator. Landing counts must be done in a standard, consistent manner, with collections made at the same time of day, in the same place, for the same amount of time, using the same collector. Animal bite catches can also be used for collection. This is done by removing mosquitoes directly from a tethered animal host with an aspirator or inside a drop-net and also using a suction trap baited with small animals.

Trapping techniques include

a) **Light Traps (UV And Incandescent Light Traps)**: The basic principle of the light trap is that the mosquitoes attracted to the electric light, enters under the hood of the trap where they get exposed to a strong downward air current produced by a fan-operated by an electric motor. These mosquitoes are collected in a holding cage attached to it (Srivastava and Dhariwal, 2016). Traps are placed in areas away from other competent light sources (including moonlight, street and house lights) suspended about six feet above the ground, in open areas near trees and shrubs. It shall be placed at a distance of 30 feet or more from buildings. It shall not be affected by strong winds and sources of smoke or fumes. A block of dry ice (CO_2) wrapped in several layers of newspaper or in a padded envelope suspended above the trap is the common attractant used. The trap shall be operated from just before dark until just after daylight.

CDC miniature light traps, New Jersey Light Traps, BG-Sentinel traps, etc. are commonly used. BG-Sentinel traps are designed to attract *Aedes aegypti* and *Aedes albopictus* with a specific chemical lure (BG-Lure or Sweetscent). Their effectiveness can be increased by baiting the trap (e.g. a mouse in a cage) or by adding a carbon dioxide source which makes the trap attractive to a wide range of mosquito species (e.g. *Culex pipiens* and *Anopheles plumbeus*). There are other kinds of traps like Window trap and Magoon trap which do not need a light source.

b) **Gravid Traps/ Oviposition Traps:** They selectively sample blood-fed females. These traps consist of a black bucket/cup filled with water, hay or an infusion of dead leaves and are designed to collect gravid females that fed at least once and need to oviposit (EFSA, 2018). The CDC gravid mosquito trap is one example where it attracts gravid females searching for a place to lay their eggs (oviposit) and collects them in a net similar to the miniature light trap. Since the mosquitoes collected in this trap have already fed at least once, these individuals are more likely to be infected.

Conservation of Specimens

It is very important to conserve them in the right manner while transporting them to the laboratory for further processing, especially if they are sent to taxonomists for identification.

Larvae

a. For immediate morphological or genetic identification: collect in vials with 70–80% ethanol.
b. For morphological identification after further development: collect in vials/small containers with water taken from its breeding place for rearing L1-L3 larvae to L4 larvae (which are identified with higher reliability) or for keeping the larvae until adult emergence.

Volume 2 – Issue 3
Online ISSN: 2582-368X
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Adults

Tightly closed sampling nets with mosquitoes are transported to the laboratory for further processing (if possible in dry-ice containers)

c. For morphological identification (females, males): males in vials with 70–80% ethanol (for genitalia); females pinned as soon as possible in insect boxes (if not possible, keep frozen; then pin in the lab).
d. For blood meal analysis (freshly blood-fed females): abdomen squashed on filter paper (ELISA and/or PCR) or in vials with 70–80% ethanol (PCR detection + gene sequencing).
e. For pathogen detection (females): frozen or in vials with 70–80% ethanol (depending on the pathogen and subsequent techniques, do not use ethanol if virus detection is foreseen), collected every day.
f. For detection of insecticide resistance gene (e.g. knockdown resistance) (females and males): in vials with70–80% ethanol.

Specimen Submission for Identification

When specimens are submitted for taxonomic identification, Date and time of day of collection, name and phone number of collector and detailed information on locality/habitat must be included with the specimens.

Dengue Vector Sampling

Flight range studies suggest that most female *Ae. aegypti* may spend their lifetime in or around the houses where they emerge as adults and fly an average of 400 metres. For adult surveillance, human biting catches are not recommended for dengue vectors. Sentinel sites are established in areas endemic or epidemic for dengue. These are surveyed at least monthly during the dengue season. As per the guidance of WHO, the following indices are used to monitor *Aedes* population for dengue virus transmission (Sanchez *et al*., 2006), (Abdalmagid and Alhusein, 2008), (Erlanger *et al*., 2008)

Larval Surveys

1. House index (HI): percentage of houses infested with larvae and/or pupae.
2. Container index (CI): percentage of water-holding containers infested with larvae or pupae.

Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

3. Breteaux index (BI): number of positive containers per 100 houses inspected.

Pupal Surveys

1. Pupae index (PI): number of pupae per 100 houses inspected.

Conclusion

Comprehensive public health measures encompassing disease surveillance, vector surveillance and control measures with support from all sectors of the community are required to combat the old and newly emerging vector-borne diseases. Rather than relying on emergency response, monitoring and surveillance throughout the year allow timely detection of changes in abundance and species diversity of vectors providing valuable knowledge to health authorities, scientific community and entities that can manage vector populations below the threshold level, reducing their impact on public health. The short-term and long-term changes in the population are predicted by correlating the population dynamics of the species and the weather conditions. It is also important to understand the fluctuation in vector population according to the seasonal activity, to improve our control programs (Mohiddin*et al*., 2015). The vectors collected via field sampling can also be used to identify new deadly viruses using advanced technologies in different laboratories around the world.

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AGRIALLIS
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Volume 2 – Issue 3
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HYDROPONIC - A NEW METHOD OF GROWING CROPS WITHOUT SOIL

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Soil is the most accessible growing medium which gives anchorage, water and nutrients etc for crop growth but soils create severe restrictions for growth and development of plant due to disease-causing organisms and pest present in the soil, inappropriate soil reaction, soil degradation, bad drainage, compaction of soil etc. In addition to that, in some places, the soil is not available for crop productions. Under such situation, soil-less culture i.e. hydroponics can be utilized effectively.

Hydroponics is a technique of growing crops using nutrient solutions or in an inert medium, such as perlite, vermiculite, gravel, coir, or mineral wool etc. to provide mechanical support. Giro et al., (2016) reported that hydroponics system is a suitable technique to produce vegetables in urban areas to enhance food security. The basic idea behind this technology is to allow the plant roots to come in contact with the nutrient solution. Hydroponics used for the production of vegetables (tomatoes, lettuce, cucumbers and peppers), fruits (strawberry), ornamental crops (carnations, rose and marigold) and medicinal crops (Aloe vera and coleus) etc., (Sardare and Admane, 2013). Plants grown by hydroponics had high yield, rapid harvest and high nutrient content.

Different hydroponic structures

The hydroponic system is classified and modified according to space and other available resources, availability of growing medium and supporting media. Generally used systems are wicked system, ebb and flow system, drip system, deep water culture system and nutrient film technique.

- **Wick System**

Wick system is the most simple and basic form of hydroponics. It is a passive type system because it does not require electricity, pump and aerators. This system, consist of grow tray, reservoir, wick and aeration system and works on the principle of capillary action in which plants are placed in an absorbent medium like vermiculite, perlite with a nylon wick running from the reservoir of nutrient solution to plant roots. This system is useful for small plants, herbs and spice. It doesn't work effectively because it requires a lot of water.

- **Ebb and Flow system**

It is the first commercial hydroponic system which is based on the principle of flooding and draining in which nutrient solution and water are flooded from the reservoir through a water pump to growing area at a definite point and stay there for certain interval of time after that solution is drained back into the reservoir. Different kinds of vegetables are grown. The main drawback is rooted can dry rapidly when the watering phase is interrupted and the problem of root rot, algae and mould are very frequent (Nielsen et al., 2006).

- **Drip system**

In this system, the individual plant gets nutrient from the reservoir in proper quantity with the help of a pump in the root zone area (Rouphael and Colla, 2005). It is the most commonly used system with more saving of water.

- **Deepwater culture system**

It is simplest form of all active hydroponic systems. In water culture, plants root is suspended in nutrient solution and the air is provided directly to the roots by an air stone. Supervision of oxygen and nutrient concentrations is essential to check the salinity and pH (Domingues et al., 2012) as algae and moulds can grow rapidly in the reservoir. This system is useful for cucumber and tomato.

- **Nutrient Film Technique (NFT) system**

In NFT system, the nutrient solution enters into the growth tray via a water pump without a time control (Domingues et al., 2012). The system is slightly tilted so that the nutrient solution runs through roots and down back into a reservoir. Nutrient Film Technique is commercially used for lettuce production and other leafy green vegetables.

Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

Supply of nutrients to the plants

In a hydroponics system, frequency and amount of the nutrient supplied depend on the substrate type, crop type, container size, irrigation systems and the existing environmental conditions. 6.00 to 8.00 am a good time to supply the nutrient and the nutrients should be given to the roots zone to keep away from disease.

Desirable pH range of nutrient solutions

Control of pH is essential in a hydroponic system because it changes continuously as the plant grows. For most nutrient solutions, the optimum range of pH is 5.5 to 6.5 for the accessibility of nutrients for the majority of species.

Advantages of the hydroponics system

In this system, nutrient solutions are provided directly to the root of plant consequently plants grow faster compared to field crop. Hydroponics offers efficient nutrient management, higher planting density, better quality, clean product and increased yield of the produce. As compared to soil-based culture, 1/5th of total area and 1/20th of overall water are requiring to growing of plants under hydroponics system (Silberbush and Ben-Asher, 2001). In this system, no possibility of infestation of soil-borne disease, pest or weed thus reduces the use of insecticide, pesticides, fungicide and herbicide. This technique is useful for the area where cold stress, heat stress and dessert etc is a major problem (Polycarpou et al., 2005). Crops are not influenced by climate change thus offseason cultivation of produce is possible (Manzocco et al., 2011).

Table- 1: Soilless culture averages compared with ordinary soil yields (Singh and Singh, 2012)

Name of crop	Hydroponic average/acre (tonnes)	Agricultural average/acre (tonnes)
Potato	70	8-10
Beetroot	9	4
Cabbage	8	5-6
Peas	6	1-2
Tomato	180	7
Cauliflower	13	5
Lettuce	9-10	4
Cucumber	12-14	3

Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

Limitations of hydroponics system

Technical knowledge, experience and the high initial investment are essential for hydroponics system. For plant health, great care and quality water are required.

Conclusion

Hydroponics is seen as a promising strategy for growing different vegetables round the year in limited spaces with improved yield, quality of products, so hydroponics can play a great contribution in areas with limitation of soil and water and for the poorer and landless people. In India, it is projected that hydroponic industries grow exponentially in future. To encourage commercial hydroponic farm, it is important to develop low-cost hydroponic technologies that reduce dependence on human labour and lower overall startup and operational costs.

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PROSPECTS OF PLANT TISSUE CULTURE IN CROP IMPROVEMENT

Article Id: AL202053

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Tissue culture is the aseptic culture of cell, tissue, organ or total plant under-regulated nutritional and environmental conditions (Thorpe, 2007) which is utilized frequently to generate the clones of plants *in vitro* conditions. The clones produced are the true-to-type to the genotypes of the selected plants. The regulated environment provides the culture of an environment conducive for their favorable growth and multiplication. These controlled conditions include proper supply of nutrients, pH medium, suitable temperature, proper gaseous and liquid environment. Plant tissue culture technology is being extensively used for large scale plant multiplication. Apart from its use as a research tool, plant tissue culture techniques in the recent years have become important for use in the areas of propagation of plants, disease or insect reduction, crop improvement and secondary metabolites production. The explant is being utilized to produce hundreds or even thousands of plants in an uninterrupted manner. Explant can be multiplied to produce several thousand plants in a very limited period of time and even requires less space under a controlled environment, irrespective of the season and weather throughout the year (Akin-Idowu *et al.,* 2009). Rare species have been successfully grown and conserved by plant tissue culture technique because of the high rate of multiplication and limited requirements of the number of initial plants material and space. In addition to this, plant tissue culture is contemplated as the most effective technique for improving crops by the utilization of somaclonal and gametoclonal variations. The micropropagation technique has a huge capacity to develop genotypes of superior quality, isolation of desirable variants with high yielding capacity, enhanced disease and stress tolerance capabilities. Callus cultures may give rise to the clones that have heritable behaviour differing from those of parent plant due to the probability of

Volume 2 – Issue 3
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www.agriallis.com

induction of somaclonal variation, which leads to the production of commercially important improved cultivars.

Basics of plant tissue culture

Plant cells, tissues or organs are grown *in vitro conditions* on suitable artificial media, under aseptic and controlled environmental conditions. This technique relies mainly on the ability of totipotency of plant cells that means the capacity of any single cell which can express the whole genome by the division of its cells. Along with this totipotency capacity, the capacity of plant cells to alter their growth, development and metabolism is also equally decisive for the regeneration of whole plant form. Tissue culture media generally contains some or all of these constituents: macronutrients, micronutrients, amino acids, vitamins or source (s) of carbon, nitrogen supplements, growth regulators, organic supplements, and solidifying agents. Murashige and Skoog medium (MS medium) is the most widely used media for vegetatively propagating most of the plant species *in vitro* conditions. The adjustment of the pH of media is very important which affects the growth and working of plant growth regulators. It is adjusted to the range between 5.4 - 5.8. Plant growth regulators (PGRs) are necessary for plant tissue culture since they play important roles in tropism, stem elongation and apical dominance. They are generally auxins, gibberellins, cytokinins and abscisic acid (ABA). However, the ratio of auxins to cytokinins decides the type and extent of organogenesis in plant tissue cultures. The high level of auxins is responsible for root formation, however, the high level of cytokinins favours shoot formation. An equal proportion of both cytokinin and auxin leads to the formation of an undifferentiated mass of cells (called callus). Cytokinins stimulate cell division, induces axillary shoot proliferation, shoot formation and retard root formation. Gibberellins inhibit later stages of embryo development and also enhance the proliferation of shoots.

Genetic transformation

It is the recent aspect of plant tissue culture technique that provides the means to transfer genes with desirable trait into host plants and recovery of desirable transgenic plants. This technique has a great scope for genetic improvement of various crop plants by integrating various plant biotechnological and breeding programmes. It has wide and promising utility for the introduction of agronomically important traits such as enhanced yield, improved quality and increased resistance to pests and diseases. In plants, genetic transformation can be attained by either indirect gene transfer or direct gene transfer method. Among vector-mediated or indirect gene transfer methods, *Agrobacterium*-mediated gene transformation is the widely used method for the expression of foreign genes in plant cells. The successful introduction of agronomic traits in plants can be achieved through the use of root explants for the genetic transformation. virus-based vector methods offer an alternative way of rapid and transient protein expression in plant cells and thus, provides an efficient way of recombinant protein production on a huge scale. Recently successfully generated transgenic plants of Jatropha were obtained by direct DNA delivery to the mature seed-derived shoot apices through particle bombardment method (Purkayastha *et al.*, 2010). This technology has been found efficient in the reduction of toxic substances in seeds and thus, overcoming various obstacles of seed utilization in different industrial sectors. Regeneration of disease and viral resistant plants can now be achieved by employing genetic transformation technique. Scientists have succeeded in developing transgenic plants of potato, resistant to potato virus Y (PVY) which was a major threat to potato crop worldwide.

Somatic hybridization

A somatic hybridization is a useful tool for the production of inter-specific and inter-generic hybrids. This method involves the fusion of protoplasts of two diverse species or genomes followed by the selection of superior hybrids and their regeneration to form hybrid plants. It provides a useful method of gene transfer with the desired attribute from one species to another and has a remarkable impact on crop improvement. Protoplast fusion opens up a method of developing unique hybrid plants by overcoming various barriers of sexual incompatibility. This method is applicable in the horticultural sector to create new hybrids with enhanced fruit yield and better resistance to diseases and pests. The potentiality of somatic hybridization in plants is best illustrated by the production of inter-generic hybrid plants among the family Brassicaceae. To solve the problems of chromosome loss and decreased regeneration capacity, various protocols have been developed for the production of somatic hybrid plants by using two unlike types of wheat protoplast as recipient and protoplast of *Haynaldia villosa* as a donor for fusion. It has also been used as an important gene source for Improvement of wheat.

Haploid production

Through plant tissue, culture techniques such as protoplast, anther and microspore cultures facilitate the production of homozygous plants in a comparatively short interval of time. In general, haploids are sterile which are changed into homozygous diploids by an impulsive or induced doubling of chromosomes. Doubling helps to fix the fertility of plants results in the creation of doubled haploids. At the present, the haploid technique has come out as a vital part of plant breeding technique by speedy up the development of inbred lines and hence overcome the limitation of non-viability of the embryo and seed dormancy. This method used in genetic renovation by the production of haploid plants with additional resistance to various stresses. For example in wheat for drought tolerance, Introduction of genes with desirable attribute at haploid phase after that doubling of a chromosome leads to the development of double haploids inbred lines and also drought tolerant genotypes.

Somatic embryogenesis

It is an *in vitro* method of plant rejuvenation which is widely used as major biotechnological tools for clonal propagation (Park *et al.*, 1998). It is a method by which somatic cell or tissues evolved into differentiated embryos. These embryos can develop into complete plants without undergoing sexual fertilization. The somatic embryogenesis can be directly evolved from the explants or indirectly by callus. Plant regeneration by means of somatic embryogenesis arises by the initiation of embryogenic cultures from leaf, zygotic seed, stem parts and further development of embryos. The full-grown embryos are then cultured for germination and further development and lastly transferred to soil.

Conclusion

As an emerging technology, tissue culture has a great influence on both industry and agriculture, by providing a large number of plants that are needed to meet the ever-increasing food demand. It has made important contributions to the advancement of agricultural sciences in recent times and today they form a necessary tool in modern agriculture. Tissue culture offers the production and propagation of genetically homogeneous, disease-free plant materials. It is a useful tool for the induction of somaclonal variations. Genetic variability induced by plant tissue culture can be used as a source of variation to obtain new favourable genotypes. *In vitro* cultures of mature or immature zygotic embryos are applied to recover plants obtained from wide crosses that do not produce fertile seeds. Genetic engineering can make it feasible to improve crop varieties with high yield potential and even resistance to pests. Genetic transformation technique relies on the various technicalities of plant tissue culture and molecular biology for the production of improved crop varieties, disease-free plants (virus), production of secondary metabolites, genetic transformation, production of varieties tolerant to drought, salinity and heat stresses.

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RICE BLAST DISEASE AND DEVELOPMENT OF GENETIC RESISTANCE AGAINST IT

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Rice is the most important staple food in India covering a total area of 43.5 mha coupled with the total production of 159.2 MT (FAOSTAT 2013). Being a rich source of carbohydrate it is considered as the most important food grain. This crop is affected by various types of biotic and abiotic stresses which causes a substantial reduction in its yield every year. Rice blast is one of the most dangerous and dreadful diseases of rice worldwide. To control this important disease different types of management practices have been tried over time like fungicides, different agronomical practices, resistant cultivars and biotechnological approaches. Though many mechanisms are available to control or to reduce the severity of blast; host gene manipulation to impart resistance at the gene level and make the plant able to protect itself is a more effective and economic way to achieve a comparatively stable and durable performance to prevent pathogen attack (Hulbert et al., 2001). Here in this study, current advances on developing genetic resistance against rice blast have been discussed.

Rice Blast

Rice is the most important staple food of India. It occupies 43.5 mha area coupled with the total production of 159.2 MT in India (FAOSTAT 2013). As an agricultural commodity, it is on the third position from the production point of view, however, it is the most important food grain since it contributes to more than one-fifth caloric intake of human worldwide. Across the world, it is cultivated in 162.3 mha of the area to give a production of 738.1 MT (2012). But this crop goes through various types of biotic and abiotic stresses which causes a substantial reduction in its yield every year.

Among the biotic stresses which affect the rice crop, rice blast is the most extreme contagious ailment, which restricts the production of rice. Yield loss has been recorded up to 157 million tons of rice for each annum around the world. The 'Habitats for Disease Control

Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

and Counteractive action' has distinguished and proclaimed rice blast to be a potential natural weapon. Rice blast disease is spreading over the world in such a quick pace that blast was first time reported in Asia just three centuries ago, but now, unfortunately, covers almost 85 nations. *Magnaporthe oryzae* is a filamentous ascomycete, the causative living organism for rice blast. This fungus produces lesions on leaves, nodes and different parts of panicles and grains at different developmental stages. Rice blast is of two types namely leaf blast and neck or panicle blast. Leaf blast affect plants at the seedling stage whereas panicle blast shows symptom after heading or panicle formation. As panicle blast directly target panicles, the economic part of rice, it leads to huge yield loss which has been recorded up to 70%.

The occurrence of the disease is higher when the temperature is low with high moisture in nature. Thus, Eastern India experiences frequent occurrence of the malady due to the great favorable climatic conditions for the development of the pathogen. The frequency of blast was accounted for to be high in the hilly areas like Uttaranchal, Himachal Pradesh and Jammu and Kashmir, where favorable condition prevails mainly during *Kharif* season.

Genetics of Rice Blast

The gene for gene theory works for the blast disease. Rice blast resistance genes are of two types: qualitative or complete resistance and quantitative or partial or field resistance. Qualitative or true resistance is administered by major resistance genes, which may lead to the incompatible interaction against a specific race of pathogen. More than 100 blast R genes have been identified till now and they are also mapped on chromosomes of rice. Among them, thirteen genes i.e. *Pib, Pita, Pi9, Pi2, Pid2*, *Pi36*, *Pi37*, *Pikm*, *Pi5*, *Pit*, *Pid3*, *Pi21, Pi54* have been cloned and characterized.

Many times partial resistance is controlled by more than one gene each having minor contribution towards resistance development. These together are called quantitative trait loci (QTL). Though in any breeding programme, be it conventional or molecular, it is a bit difficult to derive QTL into other varieties, the most advantageous quality of QTL is that it renders durable resistance against pathogen and also active against a broad range of the pathogen. Till date, no such advancement has taken place to identify other QTL for panicle blast disease. QTLs discovered for panicle blast are 'qpbm11' (from Miyazakimochi) and 'pit' which are novel panicle blast resistant gene but are not well-characterized till date.

Volume 2 – Issue 3
Online ISSN: 2582-368X
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Control measure against Blast

Chemical control

There is an extensive variety of chemicals – fungicides which are in vogue to reasonably control the development of *M. oryzae*. The amount and time of application, their nature of the compound, stage in the life cycle of the pathogen are the determining factors for their efficacy. There are numerous fungicides and they are different in terms of their target stage of pathogen and in mechanism too. For instance, melanin biosynthetic inhibitors repress the development of the appressorium, while the choline biosynthesis fungicides influence the amalgamation of phosphatidylcholine-component of the fungal cell wall. Other than the fungicide alone, plant defence activators additionally being utilized against this malady. These chemicals will instigate the systemic acquired resistance and these chemicals give resistance not just to the parasitic pathogens but to other microscopic organisms and infections likewise. These chemicals are most certainly not a reasonable and financial burden to the poor ranchers. These are most certainly not eco-accommodating and they are dangerous to the earth and lead to the land, air and water contamination. Subsequently, these fungicides are not appropriate for long term use.

Development of genetic resistance

Broad-spectrum resistance gene

Establishing wide range resistance is a broadly embraced methodology to prevent a large variety of pathogens and lessen the danger of breakdown of the resistance. This technique has been turned out to be prudent, naturally amicable and powerful to control the rice blast disease (Skamnioti and Gurr, 2009). For instance, the resistance gene *Pi2* has been proved to be effective against 455 diverse races of *M. oryzae*, which were gathered from various districts of Philippines and 13 essential rice developing territories in China. *Pi9* is another gene, which demonstrated resistance against 43 distinctive strains of *M. oryzae*, which were collected from 13 distinct nations.*Pi39(t)*also demonstrated resistance to an extensive variety of races, gathered from different Chinese regions.

Gene pyramiding

One of the best strategies to throw challenge against pathogen is stacking different resistance genes, which together can offer imperviousness to an extensive variety of pathogen races. The effect is equivalent to broad-spectrum resistance gene. This prevents rapid genetic

Volume 2 – Issue 3
Online ISSN: 2582-368X
www.agriallis.com

modification of pathogen to evolve as a virulent strain and to break resistance barrier of plants. When genes of complementary resistance spectra are stacked in a sole plant variety it strengthens the plant and will reduce the selection pressure on the pathogen. For instance, when *Pik* and *Piz* genes were combined gave a high level of resistance.

Potential genes for conferring resistance against rice blast

R genes

Plants face many attacks from lots of pathogens every day but every time infections do not become successful because of the plant's innate immunity. Effector molecules secreted by pathogen induce an immune reaction in the plant(Effector Triggered Immunity or ETI). The receptor of effector molecules are encoded by R genes.R gene works in a dominant and race-specific manner.R genes, to mediate its effect on the pathogen, should recognize the specific Avr protein it is meant for.

This principle lies under Gene-for-Gene hypothesis given by Flor. When the product of plant dominant or semi-dominant R gene and that of specific dominant pathogen avirulence (*Avr*) gene interacts, race-specific pathogen recognition and downstream defense response take place**.** If pathogens mutate their *Avr* protein, it can escape recognition by the corresponding R gene of the host plant. However, in order to safeguard the plant from this virulent modifications, R genes also have been subjected to coevolution. Upon successful recognition of pathogen elicitor, plants can formulate different types of defense mechanism which are associated with hypersensitive response (HR), oxidative burst and superoxide production, calcium flux, cell wall reinforcement. The hypersensitive response involves the death of the host cell, may it be a single cell or a group of cells, followed by pathogen interaction. In the case of biotic stress or infection, it helps the plant to keep the pathogen confined in the location of infection by depriving the later of nutrition and thus a crucial component of disease resistance. Both compatible and incompatible plant-pathogen interactions lead to HR formation. It was recently established that HR is the consequence of two types of events: 1. Cell switch to a metabolic pathway which generates toxic compounds as by-product and 2. When pathogen Avr protein is sensitize, attacked cell go through an apoptotic response and cell death occurs.

Volume 2 – Issue 3
Online ISSN: 2582-368X
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Panicle blast 1 (*Pb1*) gene

Pb1 is panicle blast resistance gene rendering broad-spectrum protection. In one of the study, Miyazakimochi line has been found with different genetic source of defense against blast fungus. Till date, *Pb1* is the only gene isolated and conferring resistance against panicle blast identified in Modan, one indica cultivar from Japan. *Pb1* has been mapped on the middle part of the long arm of the chromosome. It shows considerable durability or 'field resistant'. It produces CC-NBS-LRR protein but distinct from that of other R genes. The dissimilarities between the NBS domain of Pb1 protein and that of R proteins increase towards N-terminus and decrease towards C-terminus of the NBS domain. The *Pb1* gene has been developed by duplication of a part of the genome and thereby achieving a new promoter region upstream of the gene. The transcript level of WRKY45 protein has been gradually enhanced up to adult stage even without pathogen inoculation. In Pb1-overexpressed lines, it was found that WRKY45 expression level is more than the normal one and the transcript level of WRKY transcription factor is dependent on that of *Pb1* gene because ubiquitin mediated degradation of WRKY45 is suppressed by *Pb1*. Nuclear localization of Pb1 protein is shown to be crucial to provide resistance since rice transformants with over expressed Pb1 fused to Nuclear Exclusion Sequence showed marked reduction in blast resistance. 1/20th part of total Pb1 protein was detected in the nucleus and sub cellular distribution of Pb1 protein remain same before and after the pathogen inoculation (Inoue et. al, 2013). Pb1 is also partially dependent on the SA pathway as blast susceptible phenotype was observed in Pb1-ox/NahG lines where NahG is a SA degrading protein. Two conceivable systems can account for the incomplete SA reliance of Pb1-interceded blast resistance. One is that Pb1 stimulate the SA pathway upstream of SA like other R proteins do, prompting WRKY45 activation through the SA pathway. Another is that lowering of basal SA levels which results in an abatement of basal WRKY45 protein level, which subsequently accelerates the decreased accumulation of WRKY45 protein in spite of the restraint of WRKY45 ubiquitination by Pb1. In the last-mentioned situation, initiation of *Pb1* by pathogen acknowledgement is definitely not essentially required in Pb1-dependent blast resistance on the grounds that incitement of WRKY45 through the SA pathway (or another pathway) and the resulting improvement of WRKY45 protein levels by nuclear-localized Pb1 can represent the Pb1-dependent blast resistance.

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Conclusion

In the concluding note, it must be stated that though there is couple of ways to fight against the potential agricultural threat i.e. 'rice blast' the only effective and sustainable way is to develop genetic resistance in the existing germplasm. In the light of this fact, *Pb1* is the only gene found to show resistance against panicle blast of rice which in turn hold the prime importance to be introduced in breeding programs to incorporate broad-spectrum genetic resistance in existing germplasm of rice to protect the later from deadly panicle blast disease.

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