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Growing seed

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HEALTH BENEFITS OF MILLETS

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Millets are a group of highly variable small-seeded grasses, which were widely grown around the world as cereal crops. Millets are tiny in size and round in shape, and it can be multi-colour like white, grey, yellow or red. Millets are highly nutritious. The millets are three to five times nutritionally superior to rice and wheat in terms of proteins, minerals and vitamins. Millets are rich in vitamin B, calcium, iron, potassium, magnesium, zinc, also gluten-free and has low GI (Glycemic index) thus millets are suitable for people allergies/intolerance of wheat and diabetic. Worldwide, millets are regarded as a Nutri-cereals, however, they are the least exploited. Millet grain is copious in nutrients and health-beneficial phenolic compounds, making it suitable as food and feed. For thousands of years, millets has been growing such as Pearlmillet, Barnyard millet, Sorghum, Foxtail millet, Little millet, Kodo millet, Proso millet and now ANI (Millet Network of India) promotes millets as Nutri-cereals instead of Coarse Cereals. The Millet Network of India supports millet farmers. It was created by one hundred women who realized the qualities and benefits of the traditional crops. The group have helped village farmers to grow millet with low water usage and organic fertilizer while highlighting the injustice of government subsidies which encourage competitor crops like rice.

Nutritional Profile of Millets

Millets are high in nutrition and dietary fibre. They serve as good source of protein, micronutrients and phytochemicals. The millets contain 7-12% protein, 2-5% fat, 65-75% carbohydrates and 15-20% dietary fibre. The essential amino acid profile of the millet protein is better than various cereals such as rice and maize.

Antioxidant Properties of Millet

Millets are rich in phenolic compounds, especially ferulic acid and catechins. These molecules act as antioxidants to protect human body from harmful oxidative stress. The generous content of phenolic compounds in millethas made it a potent source of antioxidants (Dykes and Rooney 2006). Milletgrains contained several natural occurring phenoliccompounds which include phenolic acids, flavonoids, andtannins, in addition to xylo-oligosaccharides (XOs), insolublefibres and peptides (Liang and Liang 2019). Certain lipophilic antioxidants, including vitamin E and carotenoids were extensively distributed among varieties.

Table 1

Name of the compound	Major types	Mechanism of action
Phenolic acids	Kodo millet, Finger millet, Foxtail millet, Proso millet, Little millet and Pearl millet	Free radical scavenging, anti-inflammatory activity
Flavonoids	Kodo millet, Finger millet, Foxtail millet, Proso millet, Little millet and Pearl millet	Inhibition of α-glucosidase and α-amylase activities. Reduction of postprandial hyperglycemia
Tannins	Finger millet	Formation of reactive oxygen species through futile redox cycling
Xylo-oligosaccharides	Finger millet	Strong antioxidant activity to the polysaccharides
Insoluble fibers	Foxtail millet	It could be attributed in part to their unique phytochemical composition
Protein and peptides	Pearl millet and Foxtail millet	Inactivate reactive oxygen species, Free radical scavenging, chelates pro-oxidative transition metals and reduce hydro-peroxides
Carotenoid	Finger millet, Foxtail millet, Proso millet and Little millet	Quenching of single oxygen and free radicals
Vitamin E	Finger millet, Foxtail millet, Proso millet, Little millet	Inhibiting lipid peroxidation in biological membranes

Finger Millet (Ragi)

Finger Millet is popularly known as Ragi. It is commonly consumed by fitness enthusiasts as a healthier alternative to rice or wheat. It is a gluten-free variant of Millet, rich

in proteins and amino acids. It is also high in calcium and has healthy concentrations of iron and other minerals as well. Ragi also has a good number of essential amino acids essential for the human body in the antioxidant activity of traditional Indian foods.

Foxtail Millet

It is rich in carbohydrates that help in balancing blood sugar levels in the body. These millets have a high Iron content. Foxtail Millet can improve overall humans immunity.

Sorghum Millet (Jowar)

Sorghum is a rich source of iron, protein, and fibre and, because of the presence of policosanols, can help lower cholesterol levels. People with wheat allergies can have Jowar as a healthier alternative. It also has more antioxidants than blueberries and pomegranates and is rich in calories and macronutrients. It helps to increase metabolism.

Pearl Millet (Bajra)

Bajra includes iron, fibre, protein, and minerals such as magnesium and calcium. It can be perfect for your well-being to practice regular pearl millet intake, such as helping to battle with type II diabetes.

Buckwheat Millet

It is diabetic-friendly and helps in reducing blood pressure. It is helpful for good cardiovascular health, and for weight loss. Buckwheat also fight against cancer of the breast, asthma in children, and gallstones.

Amaranth Millet

This Millet is rich in protein and dietary fibre. It is great for a healthy diet. This Millet also helps in fighting greying, hair loss, lowers cholesterol levels and cardiovascular disease risk. It is rich in calcium, vitamins, and other minerals.

Little Millet

It is loaded with vitamin B and essential minerals such as Calcium, Iron, Zinc, and Potassium. Little Millet is largely used in Southern states of India in numerous traditional dishes. It is a healthier alternative to rice.

Barnyard Millet

It is stacked with high amounts of dietary fibres that help improve bowel movement and aiding weight loss. It is rich in calcium and phosphorus, which can strengthen bone density.

Broomcorn Millet

It helps balance blood sugar levels as it has a low glycemic index. It is a good option for diabetics to be incorporated into a daily diet.

Kodo Millet

It has a significant effect on strengthening the nervous system. Kodo is a good source of B vitamins, especially niacin, B6, and folic acid. It contains calcium, iron, potassium, magnesium, and zinc minerals. It can relieve cardiovascular disorders such as high blood pressure and cholesterol levels when eaten regularly by postmenopausal women.

Table 2: Millets Nutrition Facts per 100gms

Crop / Nutrient	Protein(g)	Fat (g)	Fiber(g)	Minerals(g)	Iron(mg)	Calcium(mg)	Calories (kcal)
Pearl Millet	10.6	4.8	1.3	2.3	16.9	38	378
Finger Millet	7.3	1.5	3.6	2.7	3.9	344	336
Foxtail Millet	12.3	4	8	3.3	2.8	31	473
Kodo Millet	8.3	3.6	9	2.6	0.5	27	309
Little Millet	7.7	5.2	7.6	1.5	9.3	17	207
Barnyard Millet	11.2	3.9	10.1	4.4	15.2	11	342
Sorghum	10.4	3.1	2	1.6	5.4	25	329
Proso Millet	12.5	2.9	2.2	1.9	0.8	14	356
Rice	6.8	2.7	0.2	0.6	0.7	10	362
Wheat	11.8	2	1.2	1.5	5.3	41	348

Health Benefits of Millets

Millets are good sources of energy. They provide protein, fatty acids, minerals, vitamins, dietary fibre and polyphenols. Typical millet protein contains high quantity of

essential amino acids especially the sulphur containing amino acids (Methionine and cysteine). Millets have potential health benefits and epidemiological studies have showed that consumption of millets reduces risk of heart disease, protects from diabetes, improves digestive system, lowers the risk of cancer, detoxifies the body, increases immunity in respiratory health, increases energy levels and improves muscular and neural systems and are protective against several degenerative diseases such as metabolic syndrome and Parkinson's disease (Chandrasekara and Shahidi, 2012). The important nutrients present in millets include resistant starch, oligosaccharides, lipids, antioxidants such as phenolic acids, avenanthramides, flavonoids, lignans and phytosterols which are believed to be responsible for many health benefits (Edge *et al.*, 2005).

Conclusion

In a world where health and wellness have become a supreme lifestyle, nutrition-oriented food items like Millets and other cereals are gaining popularity. Every dietician and nutritionist is vouching for the remarkable benefits that Millets have on human health. Apart from being gluten-free, they can enhance your health and promote weight loss. Including Millets in diet is one of the best decisions to mitigate lifestyle related diseases. Hence the consumption of these nutrient rich millets can reduce the risk of lifestyle related diseases like cardiovascular diseases, type II diabetes, Gastrointestinal Disorders and cancer *etc.*

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PLANT BASED ANTIVIRAL PROTEINS: A NEW HORIZON IN PLANT VIRAL DISEASE MANAGEMENT

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Managing plant viral diseases have always been a cause of headache for all the plant pathologists, researchers, scientists and moreover for the farmers as there is no such effective chemical management practices available. Plant-based proteins with antiviral capabilities could be a boon in this situation. Antiviral proteins are produced by human or plant cells in order to prevent viral multiplication. These proteins are separated in order to prevent the virus from multiplying in the cells of the host and spreading to additional cells. Argonautes (AGOs), RNA-dependent RNA polymerases (RDRs), and members of the plant Dicer-like (DCL) protein family are all involved in the antiviral RNA silencing pathway. All of these proteins are thought to be involved in plant defence responses to viral infections and could be useful in plant viral disease management.

Mode of action of antiviral proteins:

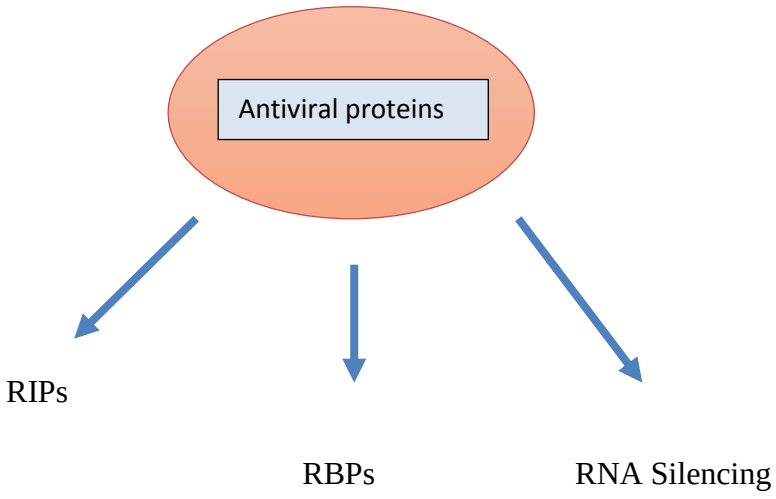

Fig 1. Mode of action of antiviral proteins

- **Ribosome Inactivating Proteins** (RIP), inhibit translation by destroying ribosomes enzymatically. Ricin and Abrin, extracted from the seeds of *Ricinus communis* and *Abrus precatorius*, respectively, were the first RIPs to be discovered (Olsns and Pihl, 1973; Knight,1979; Nielsen and Boston,2001). On the other hand, Pokeweed antiviral protein (PAP) in *Phytolacca americana* is one of many RIPs discovered in many plant species (Irvin,1983). PAP has been discovered to make tobacco and potato plants more resistant to viruses like Potato Virus Y (PVY), Potato Virus X (PVX), and Cucumber Mosaic Virus (CMV). *Phytolacca insularis* antiviral protein (PIP)-transformed potato plants were resistant to PVY, PVX, and Potato leafroll virus infection (Moon *et al*., 1997).

- **RNA binding proteins**(RBPs) are thought to interact with specific target mRNAs. RBPs are a group of heterogeneous proteins that interact directly with RNA molecules to regulate post-transcriptional regulation. They use an RNA-binding domain (RBD) to bind target RNAs, which can be sequence-specific or non-specific. They also play a role in RNA virus replication, motility, and translation inhibition. As a result, RBPs may play a role in the viral RNA-targeted defence system against RNA viruses at the transcriptional and translational levels. Arabidopsis thaliana glycine-rich RNA-binding protein 7 (AtGRP7), for example, is involved in plant defence against Tobacco Mosaic Virus (Lee *et al*., 2012). *Arabidopsis* dsRNA-binding protein 4 (DRB4) also activates plant defence against Turnip Yellow Mosaic Virus Infection (Jakubiec*et al*., 2012).

- Certain proteins also resist viral infections via **RNA silencing pathway**. Some of these are-

  - Dicer like ribonucleases:

    *Arabidopsis thaliana*DCL2 produces small interfering RNAs(siRNAs) from natural cis-acting antisense transcripts thus mediating antiviral resistance.

  - RNA dependent RNA Polymerase:

    RDRs, in addition to DCLs, are responsible for siRNA synthesis in plants. The first RNA silencing elements discovered were RDRs. Endogenous RDRs in plants convert single stranded RNA to double stranded RNA, which is then processed into siRNAs by Dicer-like nucleases. RDR1 and RDR6 from *A. thaliana* have

been shown to have antiviral activities against a variety of plant viruses, including the Turnip Yellow Mosaic Virus (Garcia-Ruiz *et al*., 2015) and Brome Mosaic Virus.

- Argonautes (AGOs):

To build the molecular platform for RNA silencing machinery, siRNAs are incorporated into AGOs, which are a component of the RNA Induced Silencing Complex (RISC). Through post-transcriptional gene silencing, they play an important role in plant defence mechanisms. The genome of *A. thaliana* encodes ten distinct AGOs that have been linked to plant defence against viruses such as Cucumber Mosaic Virus (CMV), Potato Virus X (PVX), and others.

Table 1. Some proven plant based antiviral proteinsagainst plant viruses

Protein	Family	Source plant	Target virus	References
AGO1	AGO	*Arabidopsis thaliana*	Brome Mosaic virus, Cucumber Mosaic Virus	Dzianott*et al*, 2012. Morel *et al*., 2002 & Wang *et al*., 2011.
AGO4	AGO	*Nicotiana benthamiana*	Potato Virus X	Bhattacharjee*et al*., 2009.
DCL4	DCX	*Arabidopsis thaliana*	Potato Virus X	Andika*et al*., 2015.
RDR1	RDR	*Nicotiana benthamiana*	Tobacco Mosaic Virus	Bally *et al*., 2015.
PAP	RIP	*Phytolacca americana*	Potato Virus X, Potato Virus Y, Cucumber Mosaic Virus	Lodge *et al*., 1993.

Conclusion

It's vital to remember that antiviral activity of plant proteins measured using various methods isn't always comparable. On the other hand, *In vitro* results provide some further information about the possible applications of plant antiviral proteins. The use of RNA silencing to combat virus infections has shown to be a powerful strategy in the designing of resistant crops. These proteins could be utilised to create transgenic plants that produce large levels of antiviral proteins in the presence of the pathogen, potentially improving plant resistance to virus infections, lowering crop loss, and reducing the need for pesticides. Thus this approach paves way for a more specific and eco-friendly management of plant viral diseases.

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ROLE OF ORGANIC FARMING IN SUSTAINABLE AGRICULTURE

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Modern agriculture systems are highly dependent on the use of synthetic and chemical inputs to increase crop yields. But excessive use of such synthetics and chemicals causes environmental pollution adding to health hazards. Further, the total amount of energy used in modern agriculture is also a concern, as many farm chemicals require energy-intensive production methods that depend heavily on fossil fuels. How can agriculture be less pollutive? More environmentally friendly? Less energy conservative? More sustainable? More nutritious and tastier? To answer this, over the past two decades, the farmer and consumers' attention has been drawn in the direction of organic farming or organic agriculture. Here in this article, we are explaining the organic farming role in sustainable agriculture.

Organic farming is a practice that comprises the cultivation of plants and animal rearing in natural conditions. This practice mainly uses biological materials, evading the use of synthetic substances (mainly fertilizers, pesticides, and herbicides) to maintain soil fertility and ecological balance, thereby reducing wastage and pollution. Organic farming began in the early twentieth century as a response to rapidly changing agricultural practices.

Organic farming: Goals, Principles, and Components

Organic farming is developed on understanding the ways of nature. It doesn't deplete the soil's nutrients nor humiliate it to meet the needs. The soil's living inhabitants are safe and nurtured. The normal microorganisms in the soil have not been harmed in any way. In organic farming, the soil is the main priority. The soil's health and composition are retained since it is considered to be the most essential medium. Thus, organic farming is a farming method that seeks to keep the soil breathing, preserve its good health, cultivate the ground,

and then raise the crops. This must be done in an environmentally friendly manner to maintain a pollution-free climate (Narayanan 2005). International Federation of Organic Agriculture Movements (IFOAM), defines the goal of organic farming as "Organic agriculture is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines the tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved".

Principles of Organic Farming

1. Principle of Health: Sustaining and enhancing the health of soil, thereby plants, animals, and humans.
2. Principle of Fairness: Building relationships to ensure fairness about the familiar environment and life processes
3. Principle of Ecological balance: Moving along with the ecological balance and cycles in nature.
4. Principle of Care: Managing resources/inputs prudently and responsibly to protect the health and welfare of the environment along with present and future generations.

Components of Organic Farming

1. Crop rotation: It's a systematic rearrangement for the growing crops in a regular sequence on the same piece of land over some time.

2. Crop residue: Utilization of residue from the economical and non-economical parts of the previous crop for various purposes such as animal fed, mulch, recycling nutrients, etc.,

3. Manure: The primary effect of organic manure correlates to the release of humic substances and decomposition of biological products affecting favorable growth and yield of a crop.

4. Waste: Broad range of substances such as sewage, and sludge mainly from domestic and industries. They contain heavy metals along with other harmful substances that can cause a hazard to crops, animals, and human beings. The waste is used after effective treatment and proper decomposition.

5. Bio-fertilizers: The key factors here are microorganisms, with several roles to play in many processes such as increasing water-absorbing units, mobilizing nutritive elements in available forms through a biological process.

6. Bio-pesticide: Natural plant products that have biological activity against insects, nematodes, fungi, and other organisms affecting crop growth and yield.

7. Vermicompost: Organic manure produced by the action of earthworms that live in soil, consume biomass and excrete it in digested form. The average nutrient composition of vermicompost is higher than the farmyard manure.

Organic Farming: Current Status in India

India has over 835,000 certified organic producers, accounting for nearly 30% of all organic producers worldwide. However, India accounts for only 2.59 percent of the overall area under certified organic farming, with 1.5 million hectares (57.8 million hectares) (FiBL-IFOAM report 2017). China and India have around 80 % of the total organic cultivable area in Asia. According to WHO, the current global organic food market value is around $37 billion. Of this, herbal plants and medicines account for a $14 billion market is for herbal plants and medicines, which is expected to attain $5 trillion by the year 2050. Organic farms are environmentally friendly and more profitable, as fewer chemicals are used and hence chemical residue are less. Organic farming has several environmental benefits and produces nutritious food (Pant and Mishra, 2013), and long-term organic farming can provide comparable yields or even outperform conventional methods.

The organizations working in the organic food business have to increase awareness among farmers and customers on the importance of organic farming. Sikkim is the first state in India with 75,000 ha of land under organic cultivation as a 100 % organic state. It is also estimated that by 2030, Meghalaya, a northeast state of India, will also transfer 200,000 hectares of land into organic cultivation. Over 100,000 farmers in Kerala have signed a petition endorsing organic farming (NPOF 2015-16). Under the National Mission for Sustainable Agriculture, the Indian Government is promoting organic farming through a variety of programmes (NMSA). The Government has implemented Paramparagat Krishi Vikas Yojna (PKVY) and Organic Value-Added Development. State governments under these schemes provide financial support to a cluster of 20 ha of land under organic farming, with the state governments. During a three-year transition period, the Government has

allocated approximately $730 per hectare of land. In addition, the Indian Government announced investments of $15 million and $44 million, respectively, for organic market growth and the participatory guarantee scheme (PGS)(Frick and Bonn 2015).

Key Challenges in Organic Farming

1. Low crop yield during conversion: Over the conversion cycle of three years, organic production efficiency is smaller than traditional methods, and there is no premium price for the produce.

2. Inadequate Quality standards: The majority of organic farmers struggle to achieve the desired output in organic cultivation owed to a lack of knowledge, and hence face difficulties in maintaining a continuous demand.

3. Policy support: Organic cultivation necessitates government help. Though several schemes are helping to produce an environment for organic farming in India, since agriculture is a state issue, each state's Government must make firm decisions to encourage organic farming in their respective states.

4. Inadequate Agriculture Marketing Infrastructure: Product spoilage is caused by an insufficient marketing structure, cold storage, and manufacturing facilities.

5. Inadequate market research: In India, there is a lack of funding in terms of market study and market-oriented training programs for organic farming.

6. Limited availability for organic food products in India:The lack of organic food items on the market is also posing a serious challenge to the Indian organic food industry's development. In India, there are only a few grocery stores that stock and distribute organic foods.

Strategies in the Promotion and Branding of Organic Farming in India

1. Crop Planning and diversity:If farmers want to sell their products, they must grow a variety of crops. They must therefore stagger manufacturing such that a consistent and diverse supply is available over time.

2. Marketing: The importance of publicity cannot be overstated. Direct selling models, in which a manufacturer sells their products directly to customers, have a remedy.

3. Technological uses: New technological initiatives by research institutions like the use of waste decomposers, crop residues, the biomass of shrubs and trees, vermicomposting for nutrient management, wastewater treatment, bio-agent, and predators for pest and disease management, and conservation methods are needed to be informed among stakeholders.

4. Promotion of high-value crops: In the conversion stage or at the beginning of organic farming (three years in most cases), the lower crop yield can be rewarded with a high value crops such as medicinal and aromatic crops, superfoods like millets, exotic vegetables, etc.,

5. Contract farming: Organic farming needs strict quality control in the crop growth phase and storage conditions. Contract farming can emerge as an alternate way to de-risk agriculture at various stages of the value chain. This can create a win-win situation for both parties.

6. Linking farmers to Processors and Exporters: Need to find the gap between consumers' and farmers' capacity and fill the gap through skilled training, infrastructure facilities, and technology.

7. Collectivization of Farmers: The collectivization of organic farming producers (especially small and marginal farmers) into producers' organizations is emerging as amore effective way to address challenges such as access to technologies, credit, investments, knowledge support, input, and market linkages.

8. Upgrading of Input-based enterprises: Organic-based input initiatives play a crucial role to create momentum in the conversion to organic farming. Hence input based initiatives at the local level should be encouraged.

9. Agripreneurs to provide market: Special emphasis on e-commerce platform-based Agristartups, agribusiness incubators, special incentives, and capacity building among organic farming practising farmers to meet the expectations of consumers.

10. Widespread extension activities: Farmers should be aware of the certification process and procedure, its practices with market linkages/FPOs. During promotion organic farming, extension functionaries should ensure the availability of required inputs. Hence, there is a need to develop a widespread capacity building of extension functionaries.

Summary/ Conclusion

People around the globe are becoming health-conscious, looking for food grown organically. Our farmers' lives and livelihoods will be secured as a result of such a campaign. Besides health, organic farming is the best way to nurture the land and rebuild the soil by switching to our conventional agricultural practices, which are free of toxins, pesticides, and fertilizers. Organic farming is a viable substitute production technique for farmers, but there are many challenges. Being open to various organic approaches to tackling manufacturing difficulties is one key to success. Determine the root of the problem and consider measures to avoid or mitigate the long-term issue rather than a quick remedy.Though organic farming has numerous advantages, the transition from traditional to organic farming is initially difficult. However, in the end, the producer achieves financial stability, the buyer enjoys nutritious pleasures, and nature is returned to its abundant condition.

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FEEDING AND MANAGEMENT OF DAIRY CATTLE IN PERI-PARTURIENT PERIOD

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The dairy cows go through a number of metabolic changes during the peri-parturient/transition period. The peri-parturient period means 3 weeks before and 3 weeks after calving. Many of the production diseases in transition cows, which mostly occur in the first 10 days in milk, are influenced by the nutrition and health management of dairy cows. With even minor changes in dietary habits, cows become prone to several metabolic disorders such as milk fever during the transition period. These metabolic diseases reduce the milk production, affect the fertility and have a negative impact on economics of a dairy farm. Therefore, special attention should be given on feeding and health of animals during the transition period. The transition period is marked by dramatic changes in nutrient requirements like energy, glucose, fatty acids and calcium by the mammary gland following calving. The demand for glucose, amino acids (AA), fatty acids, and net energy by the gravid uterus at 250 days of gestation and the lactating mammary gland at 4 days postpartum is 3 times more for glucose, 2 times more for AA and 5 times more for fatty acids (Bell, 1995). On the day of parturition, the calcium demand increases approximately 4 times to meet the milk production requirement.

Metabolic Adaptations in Transition Cows

During early lactation, cows cannot consume sufficient energy-yielding nutrients from voluntary dry matter intake (DMI), leading to energy deficits in urge of high milk production. This leads to negative energy balance (NEB) for a period of days to weeks after calving making the animal susceptible to ketosis. To sustain the milk production, the cow undergoes various metabolic adaptations during lactation. The primary adaptation of glucose metabolism to lactation is the simultaneous increase in hepatic gluconeogenesis (Reynolds *et al*., 2003) and a decrease in oxidation of glucose by peripheral tissues to direct glucose to the mammary gland for lactose synthesis. The lipid metabolism adapts by mobilizing body fat

stores in the form of non-esterified fatty acids (NEFA) to meet the overall energy requirements of the cow during a period of negative energy balance. The NEFA are utilized to make 40% of milk fat during the first days of lactation. Due to the sudden onset of lactation, there is a huge demand for calcium. As a result, calcium levels in the blood drop dramatically during calving, causing milk fever. Subclinical hypocalcaemia is more common, affecting more than 40% of cows in their second or third lactation. Subclinical hypocalcaemia contributes to disorders like displaced abomasum and ketosis by lowering smooth muscle function, which is necessary for normal digestive tract function and can lead to lower DMI.

Nutritional Management during Peri-Parturient Period

Dry cows, transition cows, and fresh cows should be fed and managed in a way that meets their nutritional demands while also promoting appetite and a balanced DMI following calving. In total mixed ration (TMR) systems, rather than allocating amounts of concentrate based on milk production, a diet must be formulated to meet the nutrient needs of the majority of cows within the group. To ensure that the supply of all nutrients is balanced, proper nutritional formulation of the diet is required. Some important factors to promote high DMI after calving and better management of transition cows are:

1) Minimizing environmental stressors and keeping cows comfortable- Environmental stressors may decrease DMI and predispose cows to postpartum health problem. Although not directly demonstrated in dairy cows, disruption of the gastrointestinal epithelia's barrier function is a common feature of environmental or behavioural stress in other animals, which can allow endotoxins to translocate and cause systemic inflammation.

2) Optimizing body condition score(BCS)- Cows with greater BCS (>3.5) mobilize more of the lipid reserves around calving, have poorer appetites and DMI before and after calving, have impaired immune function and may be more prone to oxidative stress. Cows should achieve a BCS of around 3.0 at dry off, rather than the usual 3.5 to 3.75 BCS. Cows with a BCS of 2 to 2.5 at calving have higher DMI and milk yield than cows with a BCS of 3.5 to 4 on a 4-point scale (Garnsworthy and Jones, 1987).

3) Managing feeding during dry period- Earlier, it was widely held concept that higher DMI during the prepartum period predicts higher DMI during the postpartum period and better transition period management. However, several reports have suggested that it is preferable to limit nutrient intakes to the requirements of the cows rather than

overconsumption of energy. Cows fed balanced restricted diets (restricted to about 80% of predicted requirements) showed increased postpartum DMI and milk yield at faster rates than cows consuming the same diets for ad libitum intake (Agenas *et al*., 2003). More importantly, allowing cows to overconsume energy during the transition period may predispose them to health problems if they face stressors or challenges that limit DMI. Controlling energy intake during the dry period improved neutrophil function postpartum, potentially resulting in improved immune function. If dry cows consume more energy than required, it must be either dissipated as heat or stored as fat in form of adipose tissue deposits. Mostly excess energy consumption in dry cows leads to greater deposition of fat in abdominal adipose tissues (omental, mesenteric, and perirenal). The NEFA released by visceral adipose tissues travel directly to the liver, causing fatty liver, subclinical ketosis and secondary problems with liver function (Drackley *et al*., 2014). On the contrary, dry cows on controlled-energy rations face less health problems. Therefore, controlled limit-feeding of moderate energy diets or ad libitum feeding of high-bulk, low-energy rations during dry period will be better than overfeeding of high energy diets.

4) Postpartum (fresh cow) dietary considerations- A major topic of concern in the fresh cow period is sudden increase in dietary energy density leading to subacute ruminal acidosis (SARA), which can decrease DMI and digestibility of nutrients. For fresh cows, a moderate starch content (approximately 23 percent to 25 percent of DM) with moderate fermentability (e.g. ground dry corn rather than high-moisture corn or ground barley) and adequate, effective forage fibre may be the best strategy for dietary management. Feeding a glucogenic (higher in starch) diet until the cows' ovarian cyclicity gets restored, then a higher fat (lipogenic) diet during the breeding period may improve reproductive performance. Fat supplementation also tends to increase dietary energy intake and improve reproduction. Dietary fat may contribute in lowering NEFA levels and preventing ketosis.

Peripartal Health Problems

During the peripartal period and early lactation, dairy cows are vulnerable to production diseases and other disorders. The time of maximum NEB, the peak in blood concentrations of non-esterified fatty acids (NEFA), and the greatest increase in milk yield all coincide with highest disease incidence shortly after parturition. Disorders like fatty liver, ketosis and impaired reproductive performance are associated with postpartum NEB. Studies showed that cows that lost >1 body condition score (BCS)unit (1 to 5 scale) had a greater

incidence of metritis, retained placenta, and metabolic disorders (displaced abomasum,milk fever, ketosis) as well as a longer interval to first breeding than cows that lost <1 BCS unit during the transition. In transition cows, inflammatory responses may also decrease DMI, cause metabolic changes, and predispose cows to higher NEB or disease. Cows that successfully adjust to lactation and prevent metabolic or physiological imbalance can maintain both high milk production and successful reproduction while being healthy. Reduced fertility despite higher milk supply might be due to a more severe case of postpartal NEB caused by poor transition management or higher disease rates.

Conclusion

Before calving, feeding a total mixed ration that limits total energy intake to requirements while simultaneously providing adequate intakes of all other nutrients can help lessen the extent of negative energy balance. Diet formulation should be such as to improve dry matter intake, maintain proper BCS and lessen the negative energy balance of fresh cows.Dry cows must not be permitted to eat too high-energy diets in order to avoid fatty liver and other metabolic diseases. Such feeding practices have the potential to lessen the impact of the transition period on the overall health and productivity of the animal.

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OVERVIEW OF SSR MARKERS

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A genetic marker is a DNA sequence with known physical location on a chromosome. Genetic markers link trait of interest with the gene governing the trait. DNA segments positioned close to each other or located on same chromosome tend to inherent together. Genetic markers aid in tracking the inheritance of gene based on their relative positions. Molecular markers find their application in identifying parent lines, gene mapping, gene pyramiding, genetic diversity analysis, DNA fingerprinting etc. Molecular markers are classified as 1st generation markers which include Restriction Fragment Length Polymorphism (RFLP), 2nd generation markers which include Random Amplification Polymorphic DNAs (RAPDs), Amplified Fragment Length Polymorphisms (AFLPs), Inter Simple Sequence Repeats (ISSRs) and Simple Sequence Repeats (SSRs), 3rd generation markers include Single nucleotide polymorphisms (SNPs).

SSRs and Their Importance as a Marker System in Molecular Plant Breeding

The segments of DNA with a variable number of tandemly repeated sequences of 2-60 bp are known as variable number tandem repeats (VNTRs). Hyper variable DNA (VNTRs) include minisatellites which contain 0.2 to 2 kb long segments of 11-60 bp long tandem repeats having identical or almost identical sequences. The other category of VNTRs include microsatellites which are usually less than 100 bp long segments containing tandem repeats of 2-7 bp. Microsatellites also called as Simple sequence repeats (SSRs) or Short Tandem Repeats (STRs) or Simple Sequence Length Polymorphism and were first discovered by Litt and Luty (1989) and were applied to plants first time by Delseny *et al.* (1983).

SSR markers are gaining popularity among other marker systems due to high reproducibility, co-dominance nature, hypervariability, high abundance, chromosome specific location, amenable to automation and high throughput genotyping (Parida *et al*., 2009). On the other side SSRs suffers limitations of being expensive and time-consuming. Low degree of repetition per locus, random scattered distribution around the genome and high degree of length polymorphism are the characteristics features of SSRs. Because of the varied amount of repeats in the microsatellite sites, the high length polymorphism may be easily and reliably detected using polymerase chain reaction. Microsatellites arise due to single-stranded DNA slippage, double stranded DNA recombination mismatch/double strand break repair and retrotransposition. Slippage of DNA polymerase III (during replication) on the DNA template strand at the repeat region might cause the newly generated DNA strand to grow or contract in the repeat region. (Wang *et al*., 2009). Slip-strand errors are corrected by mismatch repair (MMR). Thus, the stablility of SSRs depends on balance between effectiveness of mismatch repair system and slippage of DNA. SSRs are classified into mono, di, tri, tetra, penta or hexanucleotides based on the number of nucleotides per repeat unit. Microsatellites are classified (Wang *et al*., 2009) as 1) Perfect repeats are the tandem arrangements of single-repeat motif 2) Imperfect repeats are the perfect repeats interrupted by non-repeat motifs 3) Two basic repeats present together in diverse arrays (compound microsatellites).

Many species include dinucleotide repeats, however they are substantially less common in coding areas than in non-coding regions. AT repeats are abundant in plants, while AC repeat is the most prevalent in animals. This appears to be the main difference between plant and animal genomes. The genomic SSRs may be mitochondrial (mtSSR), chloroplastic SSRs (cpSSR) and nuclear (nuSSR). cpSSRs have been widely utilized to analyze genomic differences in plants and gene flow in wild populations (Provan *et al*., 2001). Exons with triplet repeats are more common in many species with AAG repeats frequent in plants, while CCG repeats common in monocots. This high frequency of CCG repeats is characteristic of monocots, which can be related to their higher GC content or abundance of particular amino acids. In rice, change in the amount of GA or CT repeats in the 5' UTR of waxy gene was linked to amylose content. Another study discovered that (CCG)n in the 5' UTR of maize ribosomal protein genes was involved in regulation of fertilisation control (Dresselhaus *et al*., 1999). Although the frequency of microsatellites in plants is inversely proportional to genome size, the amount of repeated DNA in coding areas appears to be consistent, with dicots having more mononucleotide repeats and monocots having more trinucleotide repeats.

Microsatellites have become a marker of choice for an array of applications in plants due to hypervariable nature and extensive genome coverage. A large number of monogenic and polygenic loci for various traits can be easily identified and exploited for marker-assisted selection. Genome mapping is another field where microsatellites are being extensively used. Genome mapping consists of genetic mapping, comparative mapping, physical mapping and association mapping. Microsatellite markers can facilitate comparative mapping and help to identify 'linkage blocks', major gene syntenies, chromosome rearrangements and microsyntenies among species. Advent of new technologies have not affected the use of microsatellites due to their cost effectiveness and use in large scale genotyping. However, there are several potential drawbacks including the presence of stutter bands, null alleles and heterologous amplicons. Development of transferable SSR markers from sequence information being generated from major crops will provide the initial platform for evaluation, characterization and genetic map development in minor crops. Unigene derived microsatellite markers overcome the problem of redundancy in EST database and have the advantage of assaying variation in the transcribed regions of the genome with unique identity and positions. Vast amount of genetic diversity exists in plant germplasm and more microsatellite markers will become available as genomic information accumulates. Steady progress and advancement in microsatellites markers will make this marker system more attractive for molecular breeding and plant genetics and ultimately help in major crop improvement.

Conclusion

With the development of SSR markers, they have been isolated, characterized and deployed in wide range of both agriculture and horticultural crops. SSRs are found to be important in comparative mapping studies, chromosome rearrangements, major and micro gene syntenies**.** Despite a number of potential limitations, the SSR marker system has emerged as a viable tool in molecular breeding for crop improvement, thanks to advances in science and technology.

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A SNAPSHOT ON ANTIOXIDATIVE DEFENSE MACHINERY OF PLANTS UNDER STRESS CONDITIONS

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All the crops suffer significant yield losses from various biotic/abiotic stresses and stressed plants usually stimulate the production of reactive oxygen species (ROS), which include superoxide anion radical ($O^{\bullet-}_2$), singlet oxygen ($^1O_2$), hydrogen peroxide (H_2O_2), and hydroxyl radical ($^{\bullet}OH$) which can cause severe oxidative damage to plant tissues. High levels of these ROS have the capability to damage different cellular components by lipid peroxidation (stimulating membrane permeability and fluidity), protein damage (by inactivating the enzymes, proteolytic degradation, and breakage of peptide linkage) and DNA destruction (by breaking of the DNA strands, depurination and depyrimidation). These are very lethal and extensively affect normal cellular functioning. Many factors like high temperature, high salt concentration, heavy metals, infection of pathogens etc. alter the subtle balance between ROS production and scavenging.

Oxidative stress tolerance is not a single step phenomenon but it is an integrated mechanism accompanied by changes in antioxidative/defensive enzymes, nonenzymatic antioxidants, free radical scavenging activities, signaling molecules, and osmolytes. Induced defense can be facilitated *via* defensive enzymes such as peroxidases, catalase, superoxide dismutase (SOD), polyphenol oxidases (PPO), ascorbate peroxidase (APX), phenylalanine ammonia lyase (PAL) and tyrosine ammonia lyase (TAL) along with secondary metabolites such as phenols, flavonoids, carotenoids and condensed tannins and also through the utilization of hydrogen peroxide (H_2O_2) and malondialdehyde (MDA).

Enzymatic Antioxidative Defense System of Plants

Following are the major defense related enzymes that play role during severe oxidative stress

a. Superoxide dismutase (SOD)

Itbelongs to the family of metalloenzymes present in all organisms. During various environmental stresses or pathogenic attack, SOD forms the first line of defense against ROS induced damages. The major function of SOD is to catalyze the removal of $O^{\bullet}_{2}{}^{-}$*via*, dismutating it into O_2 and H_2O_2. SODs are categorized into 3 types on the basis of binding of metal ion: Mn-SOD (localized in mitochondria), Fe-SOD (present in chloroplasts), and Cu/Zn-SOD (residing in cytosol, peroxisomes, and chloroplasts). It has been reported that H_2O_2 during contact with a transition metal ion like Iron and Copper can produce hydroxyl radicals ($OH^{\cdot}$) through Fenton's reaction.

$$O^{\bullet}_{2}{}^{-} + O^{\bullet}_{2}{}^{-} + 2H^{+} \xrightarrow{SOD} 2H_2O_2 + O_2$$

b. Catalase (CAT)

It is a tetrameric heme-containing enzyme which causes dismutation of H_2O_2 into H_2O and O_2. It has high affinity for H_2O_2 and has a completely high turnover rate (6×10^6 molecules of H_2O_2 to H_2O and O_2 in one minute). It is highly important among other antioxidant enzymes since it does not require a reducing equivalent. Various isoforms of CAT are present in plant species.

$$H_2O_2 \xrightarrow{CAT} H_2O + (^1/2)O_2$$

c. Peroxidase (POX)

It is also a heme containing protein that consumes H_2O_2, thereby responsible for decreasing levels of H_2O_2 in the cell under normal as well as stressful conditions. Peroxidases which participate in lignin biosynthesis may create a physical barrier against heavy metal toxicity or pathogen attack. The opposite organization of peroxidases scavenges H_2O_2 in the cell and utilizes glutathione, Cyt c, pyridine nucleotide and ascorbate as electron donors *in vitro.*

Ascorbate peroxidase (APX) belongs to class I superfamily of heme peroxidases. This enzyme also exists in diverse isoforms *viz.* cytosolic, stromal, thylakoidal, mitochondrial and

peroxisomal. Ascorbate peroxidase reduces H_2O_2 concentration in chloroplast and cytosol of plant cells. It utilizes ascorbate as H-donor to breakdown H_2O_2 and release water and monodehydroascorbate (MDHA). Ascorbate peroxidase is one of the vital peroxidases, of ubiquitous occurrence in plants. Thus, it is regarded as an accepted housekeeping protein inside the cytosol and chloroplasts of plant cells.

$$H_2O_2 + AA \xrightarrow{APX} 2H_2O + DHA$$

d. Glutathione reductase (GR)

It is a flavoprotein, an oxidoreductase located in both eukaryotes and prokaryotes. It catalyzes reduction of GSSG in NADPH dependent manner and thus is critical in maintaining GSH pool. It is an important enzyme of ascorbate-glutathione cycle and maintains a high cellular GSH/GSSG ratio. Mainly, it is present in chloroplasts with little amounts present inside the mitochondria and cytosol. Glutathione is a low molecular weight thiol tripeptide (γ-glutamyl-cysteinyl-glycine) frequently present in nearly all of the cellular compartments. This versatility of GSH is due to its excessive reductive capability.

$$GSSG + NADPH \xrightarrow{GR} 2GSH + NADP$$

e. Phenylalanine ammonia lyase (PAL) and tyrosine ammonia lyase (TAL)

These are the members of a enzyme family having a lyase activity that forms α, β–unsaturated acids from amino acids by removal of ammonia or a mutase activity that forms β-amino acids. PAL is one of the most entensively studied enzyme of plant secondary metabolism, consisting of tetramer with each subunit of 77-83 kDa. It is the primary enzyme in the phenylpropanoid metabolism and performs an important role in the synthesis of numerous secondary metabolites which include phenols and lignin. It catalyzes the deamination of phenylalanine; a carbon-carbon double bond is formed at some stage with the release of ammonia, yielding trans-cinnamic acid. In some plants, tyrosine is transformed to 4-hydroxycinnamic acid in an analogous way with the aid of TAL. This enzyme has been employed for production of biochemicals, aromatic compounds, or for the synthesis of stilbenes together with resveratrol, flavonoids including naringenin, or plastic precursors consisting of p-hydroxystyrene.

f. Polyphenol oxidase (PPO)

It has three domains which include N-terminal plastid transit peptide, a highly conserved type-3 copper centre, and a C-terminal part. The family of PPO enzymes catalyzes the oxidation of monophenols and/or o-diphenols to o-quinones. PPOs are broadly distributed in bacteria, animals, plants, and fungi. The decrease in PPO activity because of stress conditions is related to improved antioxidant potential. There had been several reports which depicted that PPO should directly affect photosynthesis, along with it functioning as an oxygen buffer or water–water cycle to facilitate reactive oxygen scavenging.

Non-enzymatic Antioxidants and Cell Membrane Damage Indicators

a. Malondialdehyde (MDA)

Pathogen attack prompts production of ROS that results in lipid peroxidation and membrane damage, which in turn can be a key element of pathogenesis. The level of lipid peroxidation has been used as a marker for ROS induced damage to cellular membrane under stress conditions. As the membrane balance of the plant cells gets disrupted, crucial solutes leak out from the organelles as well as from the cell and results in membrane damage and metabolic imbalances. Malondialdehyde (MDA) that is produced during lipid peroxidation, is a valuable indicator of cell membrane damage due to various stresses like fungal infection. It is the final product of the decomposition of polyunsaturated fatty acids malondialdehyde. It has been generally used as affordable biomarkers for lipid peroxidation and for membrane permeability when crops are exposed to extreme environments.

b. Phenolic acids

Phenolic compounds are produced in response to pathogen attack and their production is considered as a part of active defense response. Accumulation of low molecular weight phenolics together with benzoic acid and the phenylpropanoids in response to infection results in slower growth of pathogen and permits activation of numerous phytoalexins. Eight phenolic acids trans-cinnamic, salicylic, ferulic, chlorogenic, p-hydroxy benzoic, protocatechuic, coumaric and vanillic were identified in barley grains. These compounds are bioactive, non-nutrient secondary metabolites present in culms, vegetables, and cereals. They guard the plant against pathogen attack or ultraviolet radiation. As antioxidants, phenolic compounds prevent oxidative damage to cellular organelles, organic molecules which include proteins, membrane lipids, DNA, and RNA. Phenolic compounds can also contribute in

strengthening host cell components with the aid of lignin and suberin biosynthesis that are involved in the formation of physical boundaries which can block the spread of pathogens. Additionally, they act as reducing agents, hydrogen donors, and singlet oxygen quenchers.

c. Flavonoids

Flavonoids are abundantly present in the kingdom *Plantae*occurring typically within the leaves and floral organs. On the basis of their shape, they can be categorized into four types i.e.flavonols, flavones, isoflavones, and anthocyanins. They play various roles in imparting pigmentation to flowers, fruits and seeds and are also involved in providing protection from pathogens. Flavonoids can be considered as a secondary ROS scavenging system in plants experiencing damage to the photosynthetic pigments, due to the extra excitation power. Apart from this, they have major role in scavenging $^1O_2$ and alleviating the damages caused to the outer envelope of the chloroplastic membrane.

d. Carotenoids

Carotenoids are yellow, orange and red pigments, C_{40} isoprenoids with a long conjugated polyene chain which is responsible for their color and biological activities. The core structural element of carotenoids is a polyene backbone together with a chain of conjugated C=C bonds. This unique characteristic in most cases is responsible for both their pigmentation properties and the potential of a large number of compounds to interact with free radicals and singlet oxygen and consequently act as powerful antioxidants. Carotenoids show their antioxidative potential by protecting the photosynthetic machinery in following ways, (a) reacting with lipid peroxidation products to terminate the chain reactions, (b) scavenging $^1O_2$ and dissipating heat, (c) preventing the formation of $^1O_2$ by reacting with $^3Chl^*$ and excited chlorophyll (Chl^*).

Conclusion and Future Directions

We know that plants, being sessile in nature, encounter numerous unfavourable environmental conditions that lead to reduced productivity and yields. Although plants have developed a variety of mechanisms to protect themselves against environmental stresses, still some stressful situations such as drought results in considerable yield losses. If we look at the Indian scenario, many of our states are facing serious threats of drought stress.It is suggested that plants remember what they experience/adopt to cope with environmental stress. Such potential of plant is known “stress memory” and it is referred as imprint, training, priming,

acclimatization, which result in positive effects like better response of the plant to subsequent stressful conditions. Plants utilize antioxidant defensive strategies, accumulation of protective metabolites, expression of stress-associated genes, and epigenetic alterations as stress-protective mechanisms, which enable plant for a quicker and efficient response to the stress on next exposure to the stress. Though involvement of biochemical factors like proline, phenolics, antioxidants, MDA, defense enzymes etc. in stress tolerance has been well-established, their role in stress memory has not yet been reported. Various studies are been conducted to interrogate the role of biochemical factors in imparting stress memory.

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REACTIVE OXYGEN SPECIES (ROS) GENERATION AND OXIDATIVE DAMAGE IN PLANTS UNDER STRESSFUL CONDITIONS

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Reactive oxygen species (ROS) is a general term to describe variety of oxygen containing radicals for instance, "hydroxyl radical ($HO^{\cdot}$), superoxide anion ($O_2^{\cdot-}$), nitric oxide ($^{\cdot}NO$), perhydroxyl radical ($HOO^{\cdot}$) and non-radical species such as hydrogen peroxide (H_2O_2) and hypochlorous acid HClO". These are mainly formed as a byproduct during normal cellular metabolism but also produced as a cellular response to various environmental stresses such as biotic, abiotic, etc.

Generation of ROS in Plants

Biotic and abiotic stresses are directly correlated with enhanced accumulation of ROS. The balance between production and elimination of ROS can be disrupted through various biotic and abiotic factors, which increase the intracellular concentration of ROS. When the level of ROS is exceeded and is not countered by protection mechanisms, the cell suffers from the oxidative stress. However, high concentrations of ROS are rather very dangerous to plants, causing irreversible damage to the cells and ultimately cell death. Consequently, defense mechanisms against oxidative damage are activated during stress to regulate toxic levels of ROS.

A common consequence of various biotic and abiotic stresses is the production of ROS *viz*. superoxide anion radical ($O_2^{\bullet-}$), singlet oxygen ($^1O_2$), hydrogen peroxide (H_2O_2), and hydroxyl radical ($^{\bullet}OH$) that could cause extreme oxidative damage to plant tissues. The production of ROS is the unavoidable byproduct of aerobic life. In higher plants, as an example, lower levels of ROS have been found to regulate differentiation, redox homeostasis,

stress signaling, interactions with other organisms, systemic responses, and cell death however, high levels have the ability to harm cellular components *via* lipid peroxidation, protein damage and membrane destruction. Thus, these are very deadly and substantially affect normal cellular functioning. In this regard, plants perceive stress through their roots and send signals to alter their metabolism for the activation/synthesis of defensive genes in some plant parts.

Sites of ROS Production

Under optimal growth conditions, ROS are in particular produced at a low concentration in organelles like chloroplasts, mitochondria, endoplasmic reticulum, plasma membrane, apoplast and peroxisomes. However, during stressful conditions, their rate of production is dramatically elevated and the chloroplasts become the principal site for ROS generation. The photosynthetic fixation of CO_2 can regulate the generation of ROS. Limited CO_2 fixation accompanies reduced ATP and NADPH consumption, resulting in an excess of NADPH, especially under strong light. The reduced utilization of NADPH resulted in reduced level of $NADP^+$. Since $NADP^+$ is a major electron acceptor in photosystem I, depletion of $NADP^+$ speeds up the transfer of electrons from photosystem I to molecular oxygen resulting in the generation of H_2O_2 through $O_2^{\bullet-}$. The increased level of ROS inhibits the repair of damaged photosystem II and ends in photoinhibition.

Mitochondria are a chief source of cellular ROS production. Eleven sites related with the production of superoxide ($O_2^{\bullet-}$) and/or hydrogen peroxide (H_2O_2) associated with substrate metabolism, electron transport and oxidative phosphorylation had been identified in mammalian mitochondria. The mitochondrial ETC harbours electrons with sufficient free energy to reduce O_2 that is considered as a primary supply of ROS generation, an essential accompaniment to aerobic respiration. Pathways of O_2 intake undoubtedly exist in isolated plant mitochondria and submitochondrial debris; specifically, O_2 intake through cytochrome oxidase to produce H_2O. However, this O_2 can be reduced directly to $O_2^{\bullet-}$ within the flavoprotein region of the NADH dehydrogenase portion of the respiratory chain. In mitochondria at complexes, I and III, the ubisemiquinone intermediate is formed, which is the main electron donor to oxygen, although other complex I sites are also potential donors. Production of ROS will increase if the rate of electrons leaving the ETC *via* the terminal oxidases is slowed down and the rate of electron transport increases in excess of the ability of the two respiratory pathways to process the electrons, leading to an over-reduced ubiquinone

pool. The superoxide anion formed at complex I and III in turn is reduced through dismutation to H_2O_2 which can react with reduced Fe^{2+} and Cu^{+} ions to produce distinctly toxic $^{\cdot}OH$ which being uncharged can penetrate membranes and go away from the mitochondrion.

Peroxisomes are probably important sites of intercellular H_2O_2 production and occur in almost all eukaryotic cells. H_2O_2 is normally generated inside the peroxisomal respiration pathway *via* unique flavin oxidases. Like chloroplasts and mitochondria, plant peroxisomes additionally produce $O_2^{\bullet-}$ as byproduct of their normal metabolism. Production of $O_2^{\cdot -}$ was attributed to the matrix-localized enzyme, xanthine oxidase (XOD), which catalyses the oxidation of xanthine or hypoxanthine to uric acid, together with $^{-}O_2^{\bullet}$ and H_2O_2. The small ETC of peroxisome consists of a flavoprotein NADH: ferricyanide reductase of approximately 32 kDa and a cytochrome b.

Production of ROS in the ER stimulates Ca^{2+} transfer at the ER-mitochondria surface. Further, H_2O_2 is released out of the ER and attacks the neighboring mitochondrial membrane, bypassing the protection given by mitochondrial SOD which is present inside the mitochondrial matrix. The apoplast is a vital site for H_2O_2 production in response to abscisic acid (ABA) and environmental situations, like drought and salinity. AtRbohD and AtRbohF encode fundamental NADPH oxidases which are expressed in guard and mesophyll cells in *Arabidopsis*. They have been proven to be responsible for the apoplastic ROS production that is required for ABA-induced stomatal closure.

Impact of ROS in Plant Cells- Severe Oxidative Damage

The ROS have both beneficial as well as harmful effects on plant species. They affect the lipids, proteins as well as DNA. During stressful conditions, lipid peroxidation (LPO) increases drastically through the formation of lipid radicals. The polyunsaturated fatty acids (PUFA) like linoleic and linolenic acids are most susceptible to attack by ROS like singlet oxygen and hydroxyl radicals. Overall, LPO products increase fluidity of the membrane, inhibit the membrane receptors, various enzymes that are present in the membrane as well as ion channels. The ROS also cause oxidation and modifications of the protein that can be both direct as well as indirect. Direct changes include nitrosylation, carboxylation, formation of disulfide bonds, and glutathionylation. Interaction of LPO products with protein may also lead to indirect changes. Various amino acids like proline, lysine, threonine, arginine, methionine, and cysteine are highly susceptible to ROS attack.

ROS also cause damage to DNA at multiple sites that include changes in nitrogenous bases, breakage of DNA strands, oxidation of deoxyribose sugar etc. The hydroxyl radical interacts with double bonds of nitrogenous bases. The cross linking between DNA and protein is very harmful and deadly to the plant if it is not repaired in time.

Conclusion

ROS are unavoidable by the normal cellular metabolism and are considered as necessary evil in them. They are mainly generated from ETC of chloroplast, mitochondria, peroxisomes, apoplast and plasma membrane as a byproduct of numerous metabolic processes present in various cellular compartments. During absence of any external stress and normal metabolic conditions lower concentration of ROS works as signaling molecule for various biological processes inside the cell. However, abiotic and biotic stress related conditions leads to the overproduction of ROS that damages the lipids, proteins and DNA thereby, disrupt the cellular homeostasis. Balance between production of ROS and antioxidative defensive machinery to eliminate the ROS is necessary for normal cellular growth and development. Higher plants possess both enzymatic and non-enzymatic antioxidative defense machinery to combat deleterious effects of ROS. Although rapid progress has been made in recent years, there are many uncertainties and gaps in our knowledge of ROS formation and their effect on plants mainly due to short half-life and high reactivity of ROS. Furthermore, progression in the field of genomics, proteomics, ionomics and metabolomics will help in clear understanding of biochemical networks involved in cellular responses to oxidative stress. An improved understanding of these will be helpful in producing plants with in-built capacity of enhanced levels of tolerance to ROS using a biotechnological approach.

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ORGANIC FARMING FOR HEALTHY INDIA IN 21ST CENTURY

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With the adverse effects of conventionally grown food products, awareness about nutritionally rich and safe food has gained popularity among the consumers. Organic farming has become as a suitable alternative for the production of high quality food products along with the safeguard of soil and environmental health. Among the various organic growers, India is a national which is conferred with indigenous skills and potentiality of growth in organic farming. With initiation of various government schemes in the recent past, India has become one of the largest organic grower country. Thus, organic farming has a great impact on the sustainable development of a nation like India.

Availability of safe and quality food for common population is a vital concern for all the policy makers across the globe. In the post green revolution era, the crop productivity has attained its peak and at present a declining trend has been found in crop production in India despite higher use of synthetic fertilizers and other agro-chemicals. Unbalanced use of chemical inputs has deteriorated the soil and ground water quality along with higher input requirement and recurrent disease and pest incidences. Also, indiscriminate use of synthetic agro-chemicals has led to the deteriorated soil ecosystems services, high content of chemicals in food web and serious health hazards to both human beings and animals. Therefore, there is need for an agricultural system with maintained resource quality and system productivity. Organic farming has emerged as an alternate agricultural production system which not only produces the safe and quality food for all but also maintain and enhance the ecosystem services by maintaining harmony with environment. Organic farming can handle many problems related to soil and environmental health as it relies on the sustainable soil-plant-ecological relationship (Barik, 2017).

According to the traditional approach organic farming is the use of on-farm inputs and stoppage of synthetic chemical fertilizers for crop production. But organic agriculture is far

deeper concept besides the non-chemicalization of farm. According to the recent researches in the field of organic farming, it is an inclusive accession for maintaining soil and plant productivity leading to the enrichment of the surrounding ecology. As per the definition as given by International Federation of Organic Agriculture Movement (IFOAM) "Organic agriculture is a production system that sustains the health of soils, ecosystems and people". It confides on biodiversity, ecological processes and cycles fitting to local conditions, rather than use of inputs with harmful effects. The major objective of organic farming is to develop a self-sustainable agricultural production system in harmony with nature which provides healthy, economically and ecologically sustainable agricultural produces with endowment of enclosing biodiversity and its entire components. Organic farming basically relies on four principles i.e. Principle of health, care, ecology and fairness (fig. 1). Inspiration and enhancement of biological cycles in production system, reduction of all types of pollution and increase in long-term soil fertility, conservation of genetic diversity of food and production of high-quality food lies in the basic principles and practices of organic farming (Das *et al*., 2020). Before commencement of pure organic farming, the farms are grown for 3 years without use of any synthetic fertilizers and other agro-chemicals along with lower contamination from adjacent farms.

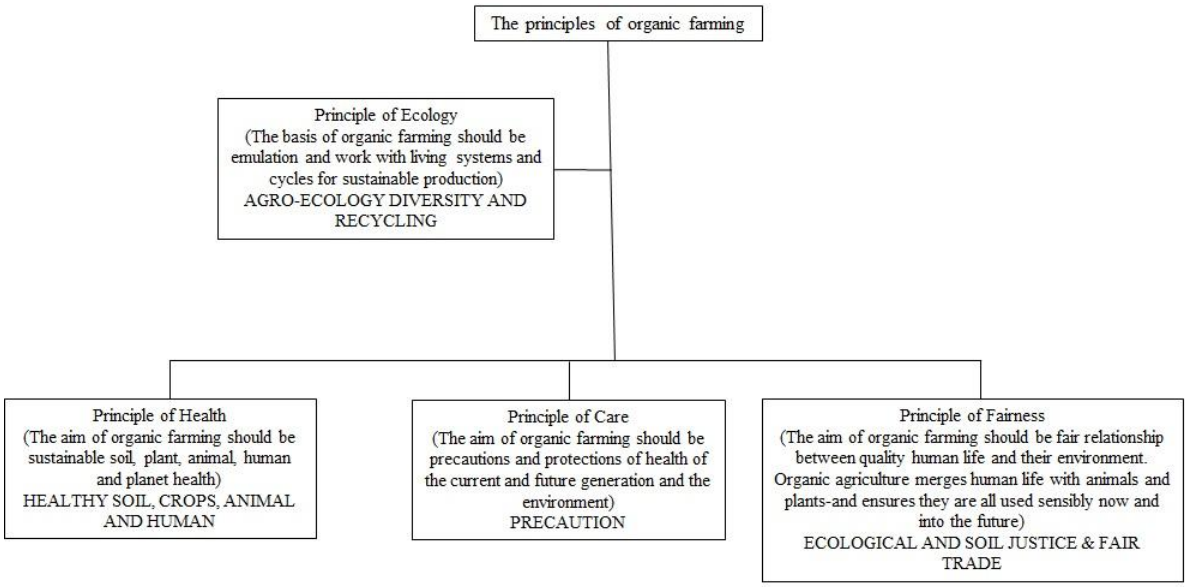

Fig. 1. Various principles of organic farming (Source: IFOAM, 1998; Das *et al*., 2020)

Benefits of Organic Farming

Organic farming has emerged as a most suitable alternative in the recent past for sustainable agricultural production; as it not only provides the safe and healthy food to both growers and consumers but also provides a safeguard to the deteriorating soil and environmental health (Das *et al*., 2020). Organic farming has several benefits; among them the major ones are as follows:

- Nutritional benefits and health safety
- Environmental impact
- Socioeconomic impact
- Organic agriculture and sustainable development

➢ ***Nutritional benefits and health safety***

In the recent past, adverse impacts of synthetic fertilizers and other agro-chemicals have created the awareness about the demands of organic products among both growers and consumers because of higher nutritional value of organic products. Among the various agricultural products grown organically have higher nutritional value over the conventionally grown products especially the leafy vegetables, tubers and other vegetable which are consumed directly and grown organically have higher dry matter and nutritional level. Also, organically grown cereals have higher quality protein and better amino acid scores over the conventional products (Wani*et al*., 2017). The study conducted by Number*get al*. (2002) showed that the meat produced from organically feed cattle contained fourfold more linolenic acid and polyunsaturated fatty acids. Also, the milk produced from organic farms recorded higher carotenoids, vitamin E and polyunsaturated fatty acids.

Among the plants, organically grown plants have higher iron, magnesium, calcium, potassium and phosphorus content. Also, the organically grown agricultural products have no pesticides residues.

➢ ***Environmental impacts***

Various studies conducted across the globe have revealed the protective role of organic farming in environmental conservation. Reduced/no use of external synthetic fertilizers and other agro-chemicals in organic farming provides a better safeguard for soil, water, local terrestrial and aquatic wildlife along with the environment. In addition to this, the organic farms maintain the higher level of biodiversity due to use of organic inputs and crop rotation.

Organic farming maintains the higher level of soil physico-chemical and biological properties because of high amount of organic matter, enzymatic activity, biomass, high water holding capacity and percolation and less soil erosion (Hansen *et al*., 2001).

- ***Socioeconomic impacts***

The higher labour requirement in the organic farming produces more income generation and employment as compared to conventional farming. Though the higher cost of organic certification, high cost of field manpower and organic inputs (10-40% higher) and lack of subsidies on organic inputs in India resulted in higher cost of cultivation under organic farming, but at the same time the premium prices of the organic products (25-70% higher than conventional products) and increasing demands of organic products results in the positive sides of the organic farming. In the recent time, most of the organic inputs are produced at the farm level, which is beneficial for the organic growers for reducing the cost of cultivation (Mukherjee *et al*., 2018).

- ***Organic agriculture and sustainable development***

The concept of organic farming integrates three crucial goals- soil and environmental health, social and economic equity and economic profitability. Organic farming approach for sustainable development basically relies on:

- ✓ Long-term maintenance of agro-ecosystem and natural landscape.
- ✓ Balanced use of natural resources and reduction in overexploitation and pollution of these natural resources.
- ✓ Increased use of renewable energy sources and minimized use of non-renewable energy sources.
- ✓ Long-term maintenance of soil and environmental health.
- ✓ Provision of safe, secure and healthy working environment at organic farms.
- ✓ Scientific use of indigenous and traditional technology for better production of organic farms.

Organic farming is a balanced strategy for rural employment, food security, conservation of natural resources, poverty alleviation, sound infrastructure and adoption of an export-oriented production system (Soumya, 2015).

Present Status and Future of Organic Farming in India

Among the 172 organic growers' countries across the globe, India holds a unique position. Among all the countries, in 2020-21; India has highest number of organic growers (1599010). Table 1 contains the details about the organic sector involvement in India during 2020-21.

Table 1. The status of organic operators in India during year 2020-21.

S.No.	Particulars	Operators (Nos.)
1.	Individual farm producers	3495
2.	ICS Groups	4781
3.	Total Processors	1703
4.	Total Traders	745
5.	Wild operators	71 (Total collectors 8724)
6.	Total operators	10795
7.	Total farmers	1599010

Source: Organic Agriculture statistics APEDA (2020-21)

At the same time; in terms of area and production; the total area under organic production during 2020-21 was 4339184.93 ha and the production was 3496800.34 MT. Table 2 contains the details about the sector wise contribution under organic farming in India during 2020-21.

Table 2. Details about the area and production under organic farming in India during 2020-21.

Area (ha)	
Cultivated area (organic + in-conversion)	2657889.33
Wild harvest collection area	1681295.61
Total area (cultivated + wild harvest)	**4339184.93**
Production (MT)	
Farm production	3468991.98
Wild harvest production	27808.36
Total production	**3496800.34**

Source: Organic Agriculture statistics APEDA (2020-21)

Indian exports of organic agriculture reached 1040.95 million USD during the year 2020-21 with total export quantity of 888179.68 MT (APEDA, 2021). Among the exported products, the largest contribution was from the processed organic food products (405383.99 MT) followed by oil seeds (100815.43 MT); cereals and millets (48677.64 MT); spices and condiments (8053.30 MT) and tea (6210.89 MT). The major countries in which Indian

organic products were exported during 2020-21 are as follows: USA > European Union > Canada >Great Britain > Korea Republic > Israel >Switzerland etc.

Future of Organic Farming in India

India's domestic market of organic farming is growing at very rapid pace with initiation of many Govt. schemes to help the organic growers. These Govt. schemes like ParamparagatKrishiVikasYojana (PKVY);RashtriyaKrishiVikasYojana (RKVY); Mission Organic Value Chain Development for North Eastern Region (MOVCDNER); National Programme for organic production (NPOP); National Mission on Oilseeds and Oil Palm (NMOOP); National Food Security Mission (NFSM) etc. have successfully helped in development of domestic organic markets in various states of India. Demands of more and more scientific technologies and packages and practices of organic farming in India and their implementation in farmers' field will ensure economically sound and viable organic agriculture in near future (Barik, 2017).

Conclusion

Increasing health and environmental awareness has created tremendous popularity of organic farming among the growers and consumers in the recent past. The higher nutritional value of organic produce ensures the safe food from farm to plate. Along with the safe food, organic farming also provides the safeguard to both soil and environmental health. In the countries like India organic farming has huge potential and the market of organic farming in India is growing at a very rapid speed. Thus, promotion of organic farming in India can build an ecologically, nutritionally and economically healthy nation in the near future.

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SMART FARMING: IS THE FUTURE OF INDIAN AGRICULTURE?

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Agriculture is the backbone of the Indian economy; the whole of India depends on agriculture for survival and it serves as a source of the basic needs of humans. The demand for agricultural produce has risen throughout time as the country's population has grown and the need for food security has increased. With the rising challenge of biotic and abiotic stresses faced by crops, the use of modern technology in Indian agriculture is unavoidable in order to fulfill the massive food grain demand of 480 million tonnes (Mt) by 2050. Like other industries, agriculture has made enter to knowledge based era rather than to resource based and future agriculture become more competitive and market driven. The WTO agreement and agricultural trade liberalization have opened up many new opportunities for agriculture, but they have also brought with them some new challenges to developing country agriculture. Inspite of the fact that India produces a huge amount of food grain, high production costs and low productivity will force farmers out of the free market's economic competitive arena. Increasing the productivity of small-scale farms is an integral part of addressing the problem of food insecurity. To meet all of these new problems, a pollution-free, high-productivity solution is required. It can be possible through the implementation of modern, environmentally friendly technologies that can effectively handle and distribute all resources for sustainable agricultural production. Smart farming, however, offers a better future with the introduction of modern technologies that seek to reduce prices, increase productivity and produce high quality products. Advances in space technology and the IT revolution in India have changed the climate and made wide room for farms in the agricultural sector.

Smart farming is a kind of farm management that incorporates modern technology in order to improve the quality and quantity of agricultural products. The Internet of Things (IoT), data processing, soil sampling, and other smart technology, such as GPS access, are all

part of this strategy. Smart farming has been valuable to all farmers, large and small, throughout time because it exposes them to technology and tools that help them enhance the quality and quantity of their products while lowering agricultural expenses.

Benefits of Smart Farming

Some of the benefits of using smart farming in agriculture include:

a) **High crop productivity:** Using better and improved farming technologies after smart farming ensures increased efficiency, as the emphasis is on optimizing inputs productivity and reducing waste.
b) **Reduced usage of pesticides, fertilizers, and water:** Farmers have traditionally utilized water, fertilizers, and pesticides despite knowing where those are needed on the land. For smart, however, you apply water and other chemicals whenever and wherever you need them, and in the right amounts which reduce the use of water and chemicals results in agricultural costs decline.
c) **Reduce environmental impact:** Nowadays, smart farming employs improved methods for increasing efficiency while decreasing the loss of pesticides, water, and other inputs to the crop.The idea is that if you can use them sparingly and where they are strongly needed you don't have to flood the world with unnecessarily harmful chemicals.
d) **Improved safety for farmers and workers:** Smart farming allows for the use of machinery and better technologies that restrict worker engagement in the field, removing the need for farmers and workers to be concerned about their safety.
e) **Low chemical deposition into groundwater and rivers:** Smart farming promotes the use of pesticides as little as possible and the use of ecologically friendly agricultural techniques. This means that little or no contaminants can be released in rivers and in general on the climate.

Smart Farming Technologies

Smart farming technologies involve the use of the following technologies:

1. Sensors for soil scanning and water, light, and temperature management
2. Telecommunications technologies include advanced networking and GPS
3. Hardware and Software for enabling the Internet of Things (IoT) based solution, robotics, automation, and specialized application.

4. Data analytics tools for decision making and forecasting.
5. Satellites and drones for gathering data.

Among the technologies that are obtainable for present day farmers:

1. Sensing technologies such as soil scanning, light, water, temperature management
2. Communication technologies such as cellular communication technology
3. Positioning technologies such as GPS, GIS
4. Hardware and software which enable IoT based solutions, robotics, automation, and specialized software solution
5. Data analytics that account for decision making and forecasting process.

Present Scenario

Though smart farming is very much talked about in developed countries, the application of smart farming technologies is presently at the nascent stage in India. Several discrete steps towards the implementation of this technology have been initiated. India's Working Groups (WGs) have recognized smart farming as one of the country's primary emphasis areas. ISRO's Space Application Center has begun a project with the Central Potato Research Institute in Shimla to explore the function of remote sensing in smart farming. The Tamil Nadu State Government has launched the "Tamil Nadu Precision Farming Project," which would first cover 400 hectares in the districts of Dharmapuri and Krishnagiriafter that it would be expanded to six additional districts (Mondal &Basu, 2009). Indian Agricultural Research Institute has made a plan to do smart farming experiments on the institutes' farms. In collaboration with the Central Institute of Agricultural Engineering (CIAE), Bhopal, the Project Directorate for Cropping Systems Research (PDCSR) in Modipuram and Meerut (Uttar Pradesh) started variable rate technology in various cropping systems. The Ahmedabad Spatial Application Center (ISRO) has begun studies to examine the effect of remote sensing in mapping space and temporal variability at the Central Potato Research Station fields in Jalandhar, Punjab. In collaboration with NABARD, the M S Swaminathan Research Foundation, a non-profit organization based in Kannivadi, Tamil Nadu, has adopted a village in the Dindigul district of Tamil Nadu for variable rate input application.

To explore the potential of the application of IT in the agro sector, Tata Chemicals Ltd., a private sector, provided extension services about the use of remote-sensing technology to analyze soil and inform about crop health, pest attacks, etc. Private sectors such as the Indian

Tobacco Company (ITC) have set up 'e-choupals,' which are village internet kiosks providing weather information, disease forecasting, modern farming practices, market prices and expert crop advice systems. LCC is becoming an effective low-technology smart farming tool for the need-based N management of rice grown in small farms of India. Laser land levelling was used as one of the tools of smart farming to increase the input-use efficiency and it achieved the average application efficiency of 65%, storage efficiency of 70%, and water distribution efficiency of 80% after laser levelling. The yield of the rice crop is increased by about 15–20% in laser-levelled fields (Rajput & Patel, 2006).

Future Prospects

In India, the major problem is farmers are poor, farming mainly subsistence and small size landholding. In India, more than 57.8% of farmers' land holdings size is less than 1ha. However, in major agricultural states like Punjab, Haryana, Uttar Pradesh, and Gujarat, more than a quarter of the population has an operating holding size of more than 4 hectares (Shanwad et. al. 2004). Although these are individual landholdings, the field sizes are considerable when considering contiguous fields with the same crop. According to aerial data, more than half of contiguous field sizes in Punjab's Patiala district are bigger than 15 hectares. For the sake of implementing smart farming, these contiguous fields can be regarded as one field. Smart farming has the potential to be used for important food-grain crops such as rice and wheat, particularly in Punjab and Haryana. In India, however, several horticultural crops with high profits have a significant potential for smart farming.

There is a scope for implementation of smart farming for major food-grain crops such as rice, wheat, especially in the states of Punjab and Haryana. However, many horticultural crops in India, which are high profit making crops, have wide scope for smart farming.

Conclusion

Smart farming has the potential to make a significant contribution to changing agricultural practices to increase efficiency and reduce the effect of agrochemical waste on the ecosystem. It lays out a road to sustainable agriculture that includes technological diversity, crop and livestock production systems, and networks including all agri-food stakeholders. There is no one policy solution that can achieve that aim of supporting and facilitating appropriate ICT use. The digital era's capabilities may lead to new types of farm diversification, as well as contribute to diversification through technological improvements.

While the "Internet of Things," such as agricultural machinery, may be utilized to handle routine farming situations, the farmer must still function as both a scientist and a watchdog, keeping an eye out for unexpected events. Farmers' free time that arises for digitalization can be spent more individually in disease control or in monitoring and handling livestock. When crop pests and diseases reach critical levels, new ICT applications are required to tackle them. Nevertheless, such a deliberate increase in diversity needs consumers, farmers, and decision-makers to be convinced of the advantages of such technological benefits. ICTs facilitate to exchange of information, cooperation, and peer review among farmers. ICT and data management allows for new ways of growing a profitable, widely acceptable agriculture that supports the diversity of environmental species and farmers. However, this can only be achievable if proactive policy development supports the appropriate legal and market structure for smart farming.

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PROBIOTICS: SUSTAINABLE APPROACH IN AQUACULTURE

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A substitutional approach for fish health management is seeking great attention in management is seeking great attention in the aquaculture industry is 'PROBIOTICS', a microbial intercessional approach. Fish health as well as fish growth has been impacted quite positively by the probiotics and made a unique place in the history of aquaculture. it is a safeguard provided for human health, these special food additives are to be promoted which could help in improving the productive performance and feed utilization as well as boosting the fish production. It also provides good water quality management for aquaculture fish species which can further provide sustainable aquaculture.

Probiotics, as 'bio-friendly agents' such as lactic acid bacteria and Bacillus spp., can be introduced into the culture environment to regulate and compete with pathogenic bacteria as well as to stimulate the development of the cultured species (Farzanfar, 2006). Encouraging these fish feed additives will help to increase product performance and feed utilization, hence increasing fish productivity as well as protecting human health (El-Saadony *et al*. 2021).

Aquaculture is seen as an essential food security industry for the world's rising human population, and it has grown rapidly as a result of improved cultural practices. Indiscriminate use of chemical additives and veterinary medicines as prophylactic and remedial measures for infections has resulted in antimicrobial resistance among pathogenic bacteria, and degraded environmental circumstances (Bachere, 2000). Probiotics are defined as "a live microorganism's adjunct that has a favorable effect on the host by modifying the host-associated or ambient microbial population, ensuring increased nutrient use or nutritive quality, improving the host immune response to disease, or increasing the quality of the host's ambient environment." The important defined of probiotics in the neighborhood of fish farming sector was also concerned with "organic wastes" and "pollutants", as a consequence

of the incorporation of "bioremediation" as well as "biocontrol" when bargaining with environmental difficulties (Verschuere *et al*. 2000).

Types of Probiotics

Probiotics are primarily of two types used in the aquaculture sector.

1. Gut probiotics, which can be mixed with feed and ingested orally to improve the beneficial microbial flora of the gut; and
2. Water probiotics, which can propagate in water medium and exclude pathogenic bacteria by having consumed all accessible nutrients. As a result, the harmful bacteria are completely eliminated by starvation (Nageswara and Babu, 2006).

Selection Methods of Probiotics

The strategies for selecting probiotic bacteria for use in aquaculture include

i. Gathering background knowledge;
ii. (ii) Acquiring potential probiotics;
iii. (iii) Assessing the ability of potential probiotic microorganisms to outcompete pathogenic strains;
iv. (iv) Evaluating the pathogenic organisms of the potential probiotics;
v. (v) Assessing the effect of the potential probiotics in the host; and
vi. (vi) Economic cost/benefit assessment (Gomez-Gil *et al*. 2000).

Probiotics used in Aquaculture

Probiotics work by supplying nutrient sources, enzymes for improved digestion, modulating the immune response, and boosting the immune system response to pathogenic bacteria. Lactic acid bacteria like Lactobacillus sp., Bacillus sp., Enterococcus sp., as well as yeast-like Saccharomyces cerevisiae are the most widely accepted probiotics used in fish farming.

Probiotics' Mode of Action

According to Fuller (1987), the most likely modes of action are

- ✓ Stimulus of humoral and/or cell-mediated immunity;

- ✓ Adjustment of microbial metabolism by increasing or decreasing relevant enzyme levels; and
- ✓ Competitive exclusion, in which the probiotic antagonizes the prospective pathogen by producing inhibitory compounds or competing for nutrient content, space (¼ adhesion sites in the digestive system), or oxygen.

Application of Probiotics in the Aquaculture Sector

Growth promoter

Probiotics have been used in fish farming to stimulate the growth of fish farming species; however, it is unknown whether these products increase appetite or, by definition, enhance digestibility. Some people believe that it could be a combination of both factors; it would also be helpful to evaluate whether probiotics taste better for aquaculture species.

Improve water quality

Probiotics are beneficial in enhancing water quality in a variety of ways. They improved organic material decomposition, diminished nitrogen and phosphorus concentration levels, and managed ammonia, nitrite, as well as hydrogen sulphide (Boyd and Massaut, 1999; Ma *et al*. 2009; Cha *et al*. 2013).

Probiotics for nutrients digestion

Taking benefit of non-aquaculture business sectors' knowledges, as well as for safety reasons, a few lactic acid bacteria and yeast strains have been immediately accepted as probiotics in fish farming. Lactic acid bacteria are among the most frequently used organisms in probiotic preparations; they are found in high concentrations in the guts of healthy animals and, according to the American Food and Drug Administration (FDA), are usually recognized as secure (GRAS status) (Parvez *et al*., 2006).

Conclusion

Probiotics have been used in aquaculture to promote the growth of cultivated species. The greatly commonly utilized organisms in probiotic preparations are the lactic acid bacteria; these are found in huge numbers in the gut of healthy animals. Probiotics are efficiently used in the aquaculture sector for growth promoters of fish species, improve water

quality, and Microorganisms for nutrients digestion. Some commercial probiotics are also available in the market.

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ARTIFICIAL INTELLIGENCE AND ITS USE IN AQUACULTURE

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Aquaculture is the rearing and production of aquatic animals and plants, including finfish and shellfish, for food and non-food purposes. Aquaculture production is mostly under controlled or semi-controlled systems. Therefore, technological applications that allow population densities management and optimizing culture management are currently the one possible solution to ensure production efficiency.

Artificial intelligence and automation technology, it is a better feasible problem to use these modern techniques in conventional animal husbandry as well as the aquaculture business. This will substantially free up human resources, increase current manufacturing efficiency, and aid in increasing output, product quality, and other conveniences. Artificial intelligence can intelligently detect animals of various weights and stages, feed them differently, and increase the output rate of high-quality feeding animals using modern animal husbandry and aquaculture technologies (Yongqiang *et al*. 2019)

Aquaculturists recognize that physiological rates of cultured species and end process outputs (e.g. ammonia, pH, and growth) may be adjusted by controlling ambient conditions and system inputs such as water, oxygen, temperature, feed rate, and stocking density in the pond. These are the types of practical metrics that will allow commercial aquaculture plants to increase efficiency while lowering labor and utility expenses. Aquaculture process control and artificial intelligence systems are expected to provide the following benefits: (1) increased process efficiency; (2) decreased energy and water losses; (3) decreased labor costs; (4) decreased stress and disease; (5) enhanced accounting; and (6) enhanced process understanding (Lee, 2000).

The utilization of computer monitoring as well as automation in the aquaculture sector. The most well-known AI paradigm is issue solution through the interpretation of an automated intelligent task. The use of AI models such as modern data science methodologies is rapidly developing in other areas. Simultaneously, within the aquaculture sector, they have not been enough harnessed (Yang *et al*. 2020).

Challenges in Adopting Innovative Techniques

Proposing and inventing novel technology is one thing, but ensuring that it is adopted is another. When a new technology is immersed and confirmed by rigorous testing, it can be difficult to adopt. Adoption of new technology is defined as an innovation decision-making process in which an individual enters the decision-making process of adoption or rejection through this first knowledge of the innovation period and verifies the decision (Mwangi & Kariuki 2015; Miranda *et al*. 2016). With the prosperous adoption of technologies, three major problems should be recognized (Van Henten, 2020): firstly, understanding that the change in technology with great skill in CIA as well as robotics is initiating a modern discipline into the technological market. Second, being data-intensive, embedding modern technology in the future farm's data infrastructure is a challenge on its own. Third, recognizing and matching technology to the needs of farmers, as well as educating farmers to operate increasingly high-tech equipment, are essential success factors in the adoption of new technologies.

Monitoring

Monitoring the aquaculture environment is crucial due to great variability, particularly in the open sea, which can pose an enormous hazard to aquaculture. It has traditionally been difficult and time-consuming, and it has the potential to endanger cultivated species if water quality anomalies are not recognized promptly. Aquaculture managers need to be able to monitor the environment, water quality (dissolved oxygen, temperature, pH, ammonia chlorophyll, nitrogen, nitrite, etc.), and fish behavior in real-time to intervene rapidly as well as decrease risks (Devi *et al*. 2017).

Multi-parameter Water Quality Meter

Water quality parameters forecast a high-quality water environment, which is critical for ensuring aquaculture productivity and quality (Chen *et al*., 2017). The water quality index determines an environment's water quality. As a result, real-time monitoring of the water

quality indicators in the aquaculture environment is critical for detecting breeding biological irregularities, preventing infections, and mitigating associated hazards (Zounemat-Kermani*et al*., 2019). Water quality characteristics in aquaculture alter throughout time and space. As a result, the acquisition of water quality measures must be monitored regularly. Simultaneously, numerous parameters impact the characteristics of an environment's water quality, causing significant difficulty in predicting water quality parameters (Yeon*et al*., 2008; Liu *et al*., 2014a).

Biomass Detection of Fish

Regular fishing detection, which often causes stress and physical injury to fish, has an impact on fish health and welfare, and is based on the human determination, is the traditional technique of getting fish biomass information. This is insufficient for modern aquaculture requirements. Machine learning in fishery aquaculture opens up new possibilities for intelligent aquaculture. Meanwhile, combining machine vision and machine learning can more correctly assess the fish size, weight, numbers, and other biological data (Zhao *et al*. 2021).

Feeding

In aquaculture, feeding is a crucial factor in production costs as well as water quality (Li *et al*. 2020). Most large-scale farming uses mechanized feeding procedures to save money and time. Automatic feeding devices work on a timer, feeding only when it's time to feed, regardless of the state of the water. As a result, using an automatic feeding system can lead to overseeing and changing the quality of the water (Liu *et al*. 2014b).

Conclusion

The utilization of computer monitoring as well as automation in the aquaculture sector. Machinel earning in fishery aquaculture opens up new possibilities for intelligent aquaculture. Aquaculture managers need to be able to monitor the environment, water quality (dissolved oxygen, temperature, pH, ammonia chlorophyll, nitrogen, nitrite, etc.), and fish behavior. Most large-scale farming uses mechanized feeding procedures to save money and time. Monitoring the aquaculture environment is crucial due to great variability, particularly in the open sea.

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