Open Access Multidisciplinary Online Magazine

Agri-India TODAY

Monthly e-Newsletter

ISSN : 2583-0910

Volume 04 | Issue 01 | January 2024

www.agriindiatoday.in

Editorial Board

INDEX

INDEX

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 04/I/01/0124

CANINE VAGINAL EXFOLIATIVE CYTOLOGY

B.V.S. Bhavya Charitha[1*] and G. Chaitanya[2]

[1]Assistant Professor, Department of Veterinary Gynaecology and Obstetrics, SoVAS, Centurion University of Technology and Management, Paralakhemundi, Odisha.
[2]Assistant Professor, Department of Veterinary Physiology, SoVAS, Centurion University of Technology and Management, Paralakhemundi, Odisha.
*Corresponding Email: bhavyabaddula97@gmail.com

Abstract

Canine vaginal exfoliative cytology is a valuable diagnostic tool that offers essential insights into the reproductive health and overall well-being of female dogs. This non-invasive technique involves the collection and microscopic examination of cells shed from the vaginal epithelium. This article provides an overview of the significance and applications of canine vaginal exfoliative cytology.This diagnostic method serves multiple purposes, including assessing the stage of the estrous cycle, monitoring hormonal changes, detecting infections, identifying pathological conditionsand evaluating the effectiveness of therapeutic interventions. By examining the cellular composition of vaginal smears, veterinarianscan conclude a dog's reproductive status, health, and fertility.

Introduction

Canine vaginal cytology is a fundamental diagnostic procedure that holds significant importance in canine breeding management.This non-invasive and cost-effective technique involves the examination of vaginal smears to assess the cellular composition and changes in the vaginal epithelium of female dogs. The female dog's reproductive system undergoes intricate and cyclical changes during the estrous cycle, which is divided into four distinct stages: proestrus, estrus, diestrus, and anestrus. Each stage is characterized by specific hormonal and physiological shifts, influencing theappearance of vaginal cells. By analyzing these cellular changes, veterinarians can gain insights into the timing of estrus, detect reproductive abnormalities and monitor infections.

Principle

During anestrus, when estrogen levels are low, the vaginal epithelium consists of just a few layers (2-4), with the basal cell layer situated close to the underlying blood vessels. As estrogen levels rise during estrus, the vaginal epithelium thickens, making it more resilient and capable of withstanding potential damage during intromission of the penis. As proestrus begins, the number of epithelial cell layers increases to 20-40 layers. The formation of these new cell layers leads to the older basal cell layers moving away from the blood supply, which eventually results in their demise. The death of these formerly healthy cells causes them to enlarge and assume irregular shapes. Simultaneously, the nuclei within them become progressively smaller, then pyknotic, and ultimately disappear, leaving behind cells without nuclei.

Technique of obtaining the vaginal smear

The technique of making a vaginal smear is very simple. To collect vaginal epithelial cells, a cotton-tipped swab is used. The cotton-tipped swab is introduced in a craniodorsal direction into the caudal vagina after gently separating the lips of the vulva. It is then rotated completely in both directions before being removed. It's essential to be cautious and avoid the clitoral fossa since its cells resemble the superficial cells, potentially affecting the interpretation.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Once the swab is obtained, it is gently rolled from one end of a clean grease-free glass slide to the other. After that, the slides are left to air dry, fixed in 95 to 100% methanol and stained using either Leishman's, Wright's, Wright's Giemsa, PAP or Diffquick stain. The stained smears are examined under high power or oil immersion.

Epithelial cells observed in typical vaginal smears of dogs

The vaginal epithelial cells are described starting with the deepest layer adjacent to the basement membrane and moving towards the layers closer to the vaginal lumen.

Basal cells: These basal cells are the initial cells that ultimately give rise to various other types of epithelial cells. They are typically small and round in shape, and they do not exfoliate, making them infrequently seen in vaginal smears.

Parabasal cells: Among vaginal epithelial cells, parabasal cells are the smallest cells. They are round in shape with a large vesiculated nucleus and a small amount of cytoplasm.

Intermediate cells: These cells are slightly larger or twice the size of parabasal cells. They are oval, round or irregularlyround in shape with a smaller vesiculated nucleus when compared to parabasal cells. The amount of cytoplasm is more. This change in morphology signifies the initial stages of cell death. Cells are further classified as small and large intermediate cells.

Superficial cells: These are the largest cells found in vaginal cytology. They are named "superficial" because they are located at a superficial position in the vaginal epithelium at the time of maximum estrogen concentration. They have sharp, flat, angular cytoplasmic borders and small, pyknotic or fading nuclei.

Cornified or anuclear cells: These are large, dead, irregular vaginal cells with angulated borders and no nucleus. They represent the last stage of cell death, a process that begins with healthy round parabasal cells. Thesecells are also known as fully cornified or fully keratinized cells.

Foam cells: Foam cells are parabasal cells and intermediate cells with vacuoles within the cytoplasm. These cells are mostly seen during diestrus and anestrus.

Apart from these cells, other cells found in vaginal smears are the clitoral fossa epithelial cells (keratinized epithelial cells), red blood cells, white blood cells and bacteria.

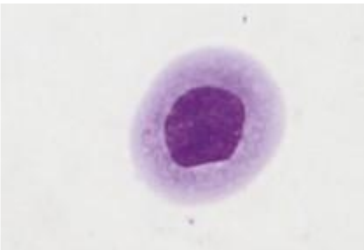


Fig 1: Parabasal cell

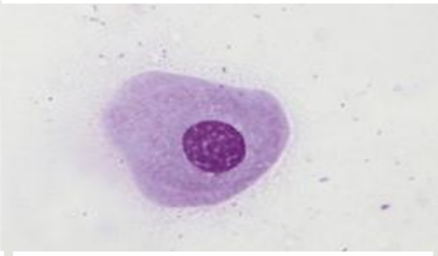


Fig 2: Small intermediate cell

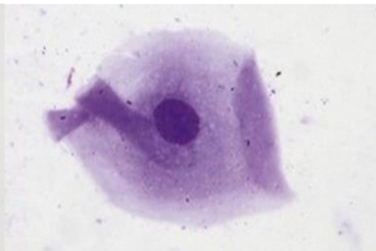


Fig 3: Large intermediate

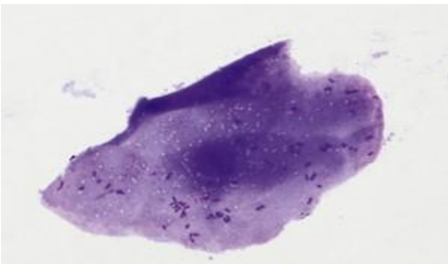


Fig 4: Superficial cell

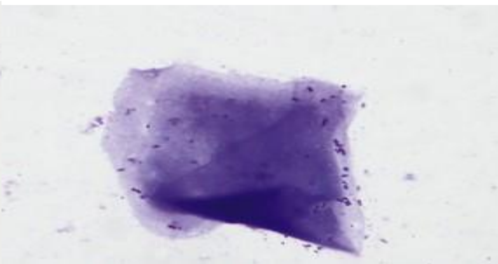


Fig 5: Anuclear cell

Interpretation of vaginal smears

Analysis of sequential vaginal smears, collected daily or every other day, is a valuable method for characterizing the stages of the canine estrous cycle and estimating the optimal time for breeding.

Proestrus: During the early to late proestrus phase, vaginal smears show a gradual transition from intermediate and parabasal cells to a predominance of superficial cells. This stage is marked by the presence of a high number of neutrophils and red blood cells (RBCs), with varying levels of bacterial presence.

Estrus: Cytologically, estrus is defined by the dominance of superficial cells, accounting for more than 80% of the cell population. Neutrophils are typically absent, and the presence of RBCs may vary.

Diestrus: The onset of diestrus is characterized by a sudden reduction in the proportion of superficial cells to less than 20-50%, along with the reappearance of intermediate and parabasal cells, making up more than 50-80% of the cell population. Diestrus usually begins approximately 6 days after ovulation, and determining day 1 of diestrus from a series of daily vaginal smears is crucial for predicting the whelping date. Whelping typically occurs 58 days after day 1 of diestrus.

Anestrus: Cytological smears from bitches in anestrus mainly consist of parabasal and intermediate cells.

Clinical significance

1. Used as an aid to routine breeding management of bitches.
2. Utilized to predict the approximate date of whelping since whelping typically occurs 57 days after the onset of diestrus.
3. Used for diagnosisof follicular cyst, as bitches with follicular cysts often experience prolonged proestrus or estrus.
4. Used for diagnosing vaginitis, as vaginal smears from bitches with vaginitis usually contain a large number of neutrophils.
5. Used to identify the presence of sperms in vaginal smears within 48 hours of mismating.
6. Used for the identificationof transmissible venereal tumour.

Conclusion

Vaginal exfoliative cytology is a very useful technique due to its simplicity, accessible equipment, and the potential for swift results in clinical canine reproduction. It serves as a valuable adjunct to any reproductive diagnostics for female dogs. Despite being a common technique, there are still unexplored areas, such as how copulation and artificial insemination affect the dynamics of vaginal cell populations in canines.

Acknowledgment

The images included in the manuscript were sourced from the internet and ChatGPT, an AI-powered chatbot (https://www.openai.com/chatgpt) was used for language modulation.

References

Antonov A. L (2017). Application of exfoliative vaginal cytology in clinical canine reproduction – a review Bulg J Vet Med 20(3): 193–203.

Sridevi P (2015) Canine Reproduction: The theory and practice. Hyderabad, India.

Veteriankey.com–vaginal-cytology:
https://r.search.yahoo.com/_ylt=AwrKEiKI8H9lKcsg72a7HAx.;_ylu=Y29sbwNzZzMEcG9zAzEEdnRpZAMEc2VjA3Ny/RV=2/RE=1702912265/RO=10/RU=https%3a%2f%2fveteriankey.com%2fvaginal-cytology%2f/RK=2/RS=OyD.2QhBc1bQuzcF1oyZOE99QBk

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/02/0124

ARRESTING INCREASING DEMAND OF FERTILIZERS IN INDIA

K. N. Tiwari*
Ex. Director, International Plant Nutrition Institute,
India Programme, 7A Lakhanpur Housing Society, Lakhanpur, Kanpur 208024
*Corresponding Email: kashinathtiwari730@gmail.com

Abstract

India is facing the challenge of meeting its requirement of fertiliser due to disruption in supply chain and increase in price of fertilisers. No country has as much area under farming as India. At 169.3 million hectares (mh) in 2019, its land used for crop cultivation was higher than that of the US (160.4 mha), China (135.7 mha), Russia (123.4 mha) or Brazil (63.5 mha). India has a legacy of having no dearth of land, water and sunshine to sustain vibrant agriculture. But there’s one resource in which the country is short and heavily import-dependent - Mineral Fertilisers. India is heavily dependent on imports for fertilisers. In Fiscal Year 2021-22, imports of all fertilisers touched an all-time high of $12.77 billion. In this context, India today needs to cap and reduce the consumption of fertilisers and reduce its import bill.

Introduction

Meeting global demand of safe and healthy food for the ever-increasing population now and into the future is currently a crucial challenge. Increasing crop production by preserving environment and mitigating climate change should thus be the main goal of today’s agriculture. Conventional farming is characterized by use of high-yielding varieties, irrigation water, chemical fertilizers and synthetic pesticides to increase yields. However, due to either over- or misuse of chemical fertilizers or pesticides in many agro-ecosystems, such farming is often blamed for land degradation and environmental pollution and for adversely affecting the health of humans, plants, animals and aquatic ecosystems. Of all inputs required for increased agricultural production, nutrients are considered to be the most important ones.

Fertilizer: The King Pin

Fertilizer, water and seeds are vital inputs for higher agricultural production.Increasing use of fertilizers has contributed significantly in enhancing food grain production and bringing self-sufficiency in food grain production in the country. India is the second largest consumer and third largest producer of finished fertilizers in the world. India is net importer of fertilizers, both finished products as well as raw materials. Amongst the major fertilizers, against the total requirement, around 75% of Urea, 40% of DAP, and 85% of NPKS are produced in the country by PSUs and private companies. The rest is imported on account of Government of India (as in case of Urea) and by the companies in case of P and K (under Open General Licenses) to bridge the gap between requirement and production of fertilizers.

Fertilizer Scenein India

Fertilizer production

Fertilizer production at 18.58 million ton (Mt) (N+P_2O_5) during 2021-22 witnessed a marginal increase of 0.5% over 2020-21. While production of nitrogen (N) increased marginally by 0.9% to 13.87 Mt, phosphate (P_2O_5) declined by 0.5% to 4.71 Mt in 2021-22. In terms of products, production of urea at 25.08 Mt, DAP at 4.22 Mt and SSP at 5.35 Mt during 2021-22 marked increase of 1.9%, 11.9% and 8.9%, respectively, over 2020-21. However, production of NP/NPK complex fertilizers at 8.31 Mt witnessed a sharp decline of 10.9% during 2021-22.

Fertilizer Import

Except DAP, import of major fertilizers declined during 2021-22. Import of urea at 9.14 Mt, MOP at 2.46 Mt and NP/NPK complex fertilizers at 1.17 Mt during 2021-22 declined by 7.1%, 41.8% and 15.8%, respectively, over 2020-21. However, import of DAP at 5.46 Mt recorded an increase of 11.9% during the period.

Fertilizer Consumption

Total fertilizer nutrient consumption ($N+P_2O_5+K_2O$) was estimated at 29.80 Mt as against 32.54 Mt in the previous year registering a negative growth of 8.4%. The consumption of N, P_2O_5 and K_2O at 19.44 Mt, 7.83 million MT and 2.53 Mt during 2021-22 declined by 4.7%, 12.8% and 19.8%, respectively, over 2020-21. In terms of products, consumption of urea at 34.18 Mt, DAP at 9.27 Mt, MOP at 2.46 Mt and NP/NPK complex fertilizers at 11.48 Mt during 2021-22 witnessed decline of 2.5%, 22.2%, 28.3% and 2.8%, respectively, over 2020-21. However, consumption of SSP at 5.68 Mtrecorded a sharp increase of 26.6% during the period. Total consumption of fertilizer products 63.94 Mt during 2021-22 showed a decline of 5.4% over 2020- 21. All-India NPK use ratio widened from 6.5:2.8:1 during 2020-21 to 7.7:3.1:1 during 2021-22. Per hectare use of total nutrients ($N+P_2O_5+K_2O$) reduced from 160.1 kg in 2020-21 to 146.7 kg in 2021- 22. Apparently, fertilizer consumption is unbalanced so the nutrient use efficiency is quite low.

The consumption of major fertilizers in the country is around 63.6 Mt, which consist of Urea, NPK, DAP, MoP and SSP. The production of urea in the country till last year was around 25.0 Mt which has now increased to almost 28.0 Mt. The domestic production of P and K fertilizers consisting of NPK, MoP, DAP, SSP, etc. is in the range of 18.5 Mt. Last year, the import of urea was around 9.13 Mt and that of P and K fertilizers was 9.09 Mt. The country does not import SSP. But in the case of MoP, the country is fully dependent on the imports.

Myseries of Fertilizer Use

Theurea and di-ammonium phosphate driven agriculture for a long period of time, has created deficiency of other essential nutrients led to soil nutrient depletion, especially when the entire crop biomass is removed from land. **Fig.1** depicts all India use of fertilizer products which apparently shows unbalanced use of fertilizers. Apart from this, it is also clearly seen that the nutrient use efficiency over the years is showing a declining trend. The Indian government has implemented several measures to promote balanced fertilization. Despite these efforts, the consumption of urea has risen, leading to imbalanced fertilization, decreased nitrogen use efficiency, and a decline in crop yield response to fertilizer use.

ALL-INDIA USE OF FERTILISER PRODUCTS

	UREA	DAP	MOP*	NPKS	SSP
2009-10	266.73	104.92	46.34	80.25	26.51
2010-11	281.13	108.7	39.32	97.64	38.25
2011-12	295.65	101.91	30.29	103.95	47.46
2012-13	300.02	91.54	22.11	75.27	40.3
2013-14	306	73.57	22.8	72.64	38.79
2014-15	306.1	76.26	28.53	82.78	39.89
2015-16	306.35	91.07	24.67	88.21	42.53
2016-17	296.14	89.64	28.63	84.14	37.57
2017-18	298.94	92.94	31.58	85.96	34.39
2018-19	314.18	92.11	29.57	90.28	35.79
2019-20	336.95	101	27.87	98.57	44.03
2020-21	350.43	119.11	34.25	118.11	44.89
2021-22	341.8	92.72	24.57	114.79	56.81
2022-23	357.25	105.31	16.32	100.73	50.18

*For direct application, excluding supply to complex fertiliser units.


Gettyimages

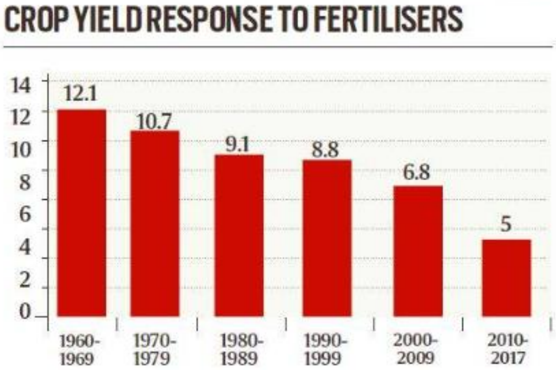


Fig.1 Use of fertilizer products (Lakh ton) and crop yield response (kg grain/kg NPK) to fertilizers in India

Source: Drishti - The Vision Foundation, April 26, 2023.

N and P-fertilizer application at levels exceeding plant requirements due to low acquisition efficiency leads to significant environmental consequences due to N losses, such as: NH3 volatilization, nitrate (NO_3^-) and phosphate (PO_3-) leaching, and nitrous oxide (N_2O) emission. The negative environmental consequences associated with fertilizer inputs in particular urea and DAP, emphasize the need of technological approaches to improve nutrient use efficiency through fertilizer best management practices in modern intensive agriculture system. The current agricultural activities contribute upto 20% to the annual atmospheric emissions of GHG, such as methane (CH_4) and carbondioxide (CO_2). Even higher contribution was noted for N_2O (about60%), which is a potent GHG and catalyst for stratospheric ozone depletion, with more than 300 times, the global warming potential than CO_2. Its emission is closely related to mineral fertilizer input. Apparently, in addition to harming the environment, unbalanced use of fertilizers is adversely affecting soil health and also can make plants weaker over time, which makes them more susceptible to insects and diseases. This is because pests can only feed on plants that have metabolic imbalances (i.e. that are not healthy) since they lack the enzymes necessary to break up the proteins found in thriving plants. Furthermore, soil that's lacking key nutrients will produce plants that are more prone to disease, just like a vitamin deficiency in humans can lead to a host of illnesses.

Alternative Fertilizers

Undoubtedly, traditional fertilizers are still a critical tool in crop production, a portion of this market has given way to alternative fertilizers which are tailored to provide optimal nutrition for a given application (**Fig. 2**).

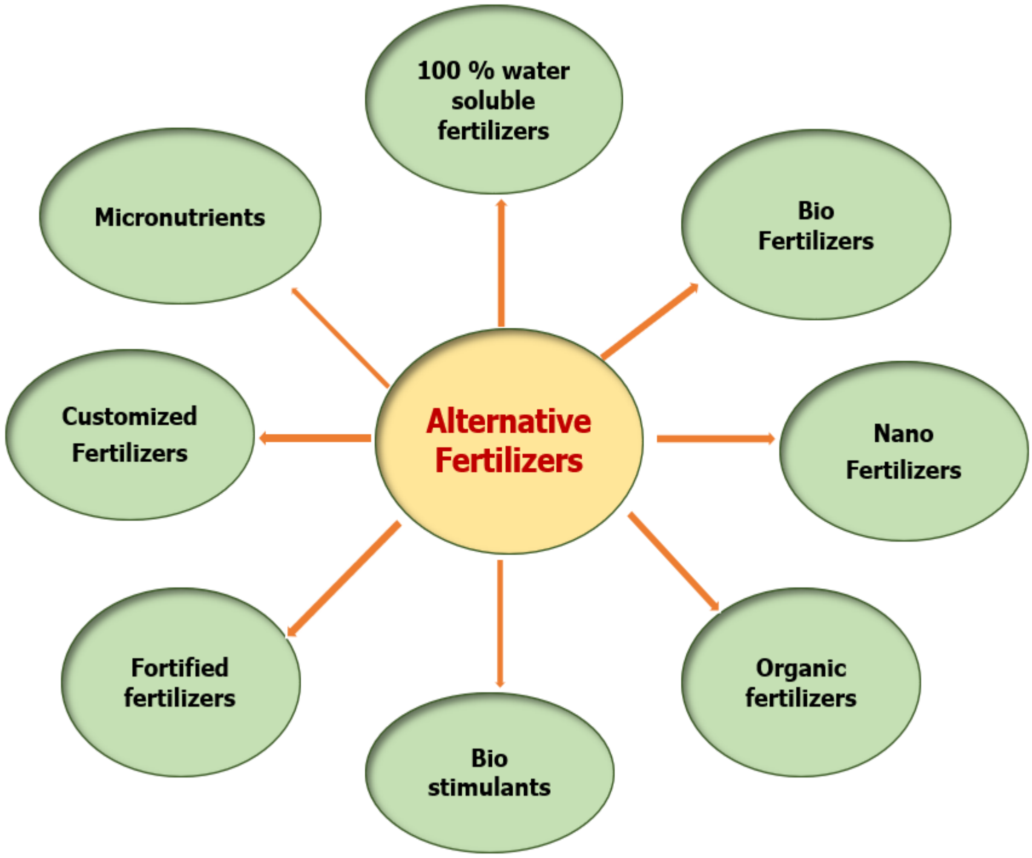


Fig. 2. Alternative fertilizers can push towards climate resilient system and help arresting increasing demand of fertilizers by increasing efficiency of inputs and agriculture system

Alternatives to Arrest Ever Increasing Fertiliser Demand

While the use of mineral fertilisers is the quickest and surest way of boosting crop production, their cost and other constraints frequently deter farmers from using them in recommended quantities and in balanced proportions. A sizeable portion of the nutrient needs of agriculture, horticulture, forestry and aquaculture can be met through appropriate recycling of a number of wastes and byproducts. Many of these are produced by agriculture itself or by the utilization of agricultural produce by man, domestic animals or industry.Waste recycling can bring tremendous benefits to agriculture and land management in the long run. In addition, there are the benefits of a cleaner environment and a healthier habitat. Proper recycling produces a number of gains ie. supplying essential plant nutrients, improving soil chemical, physical and biological properties, enhancing environment quality and providing employment and income, all at the same time. The major sources of plant nutrients are: (i) Soil reserves, (ii) Chemical fertilizers and (iii) Organics. A variety of organic resources are available for recycling in agriculture. These are Livestock wastes: Cattle shed wastes, slaughter house wastes, piggery and poultry wastes, human excreta, crop residues, tree wastes and aquatic wastes, green manures, urban and rural wastes: sewage sludge, biogas slurry etc.

Sustainable Integrated Nutrient Management System to ArrestIncreasing Fertilizers Demand

Basic principle of sustainable integrated nutrient management system,and estimated potential nutrient supply through organic and that through industrial wastes resources aregiven below.

Basic Principles

- Replenish the nutrients removed by crops through integrated nutrient supply and maintain or enhance soil productivity through a balanced use of mineral fertilizerscombined with organic and biological sources of plant nutrients,
- Improve the stock of plant nutrients in the soil through balanced fertilization,
- Maintain and enhance organic carbon levels through organic recycling,
- Maintain and upgrade soil physical conditions,
- Improve the efficiency of plant nutrients, thus limiting losses to the environment
- Sustain soil quality with respect to soil acidity/toxic elements build up,
- Control degradation of land due to soil erosion and
- Minimise the buildup of abiotic stresses by adopting crop rotations

CROP ROTATIONS

- Crops in the cropping systems should be decided according to their nutrient demands ie. Preceding crops with high nutrient demands should follow the crops with low nutrient demands.
- Deep-rooted leguminous crops should follow shallow rooted cereal crops so as to get benefit of the surface and sub-surface soil fertility and residual nitrogen.
- Crops and cultivars with high nutrient mobilizing capacities for deficient nutrients should be followed by the less efficient ones and
- Crops and cultivars leaving relatively high amount of residues should be followed by the crops with relatively high nutrient demands.

Potentials of Organic Resources Towards Nutrient Supply

- The estimated potential nutrient ($N + P_2O_5 + K_2O$) supply through human excreta, dung and crop residues during 2000 were 2.00, 6.64 and 6.21million ton (Mt), respectively. Nutrient potential of all biological and industrial wastes has been estimated at 19.11 Mt.
- The annual production of dung and urine from bovine population in India is 1228 and 800 Mt, respectively with potential nutrient supply through entire wet dung and urine excreta if conserved for manurial purposes, worked out at 6.96 Mt of $N+P_2O_5+K_2O$.
- It is estimated that India generates around 500 Mt of crop residue annually (GOI, 2016) with wide regional variability. The uneven distribution and use of crop residue depends on the crops grown, cropping intensity and productivity across the nation.Thehighest crop residue estimate was recorded for Uttar Pradesh (60 Mt). Other high crop residue producing regions were Punjab (51 Mt) and Maharashtra (46 Mt). Cereals, fibres, oilseeds, pulses and sugarcane contributed the majority of crop residue with production estimates of 352, 66, 29, 13 and 12 Mt, respectively. Among cereal crops, rice, wheat, maize and millets together contributed 70% of crop residue followed by fibre crop (13%). Rice and wheat straws account for 70% of crop residues generated in India with nutrient supplying potential of about 9Mt NPK.
- About 500 g municipal solid waste per individual is generated daily. These wastes can be converted into valuable compost by following appropriate bioconversion technology. Household and commercial organic wastes can be collected and composted to form a safe nutrient-rich amendment for application on local farms and gardens.
- Studies conducted at TNAU, Coimbatore showed that urban sewage and sludge at low levels of application can help to reduce the amounts of chemical fertilizers up to 25%

without any loss of yields. It was also ruled out any toxicity of heavy metals in crops and advocated their use for crop production. Short-term use of sludge showed no toxic effects of heavy metals on soil and plants.

- India ranks third among the coconut production countries of the world with a production potential of 6000 million nuts. The average proportion of coir to pith is 1:1. The pith is a waste material and is dumped on road sides or burnt and disposed. But, it can be efficiently composted and utilized as manure (0.25% N, and 0.8% K). Poultry droppings can be mixed with coir pith for composting.

Potentials of Industrial Wastes Towards Nutrient Supply

- ***Pressmud*** **:**About 10 million tons of pressmud cake (PMC) is produced annually from the sugar industries in India. The PMC produced from the sugar industries employing sulphitation process contains about 1.8-2.25% N, 0.8-1.2% P, 0.4-0.6% K in addition to several other plant nutrients; 2.5 g Fe kg^{-1}, 1.5 g Mn kg^{-1}, 0.27 g Zn kg^{-1}, and 0.13 g Cu kg^{-1}. Pressmud can supply large quantities of nutrients, particularly N and P and its application will improve soil fertility.
- ***Phosphogypsum:***Large quantities of phosphogypsum are available from industries manufacturing phosphoric acid by wet process in which rockphosphate is treated with sulphuric acid. For every ton of rockphosphate used about 1.5 tons of phosphogypsum is generated.
- ***Rice Husk:***About 15 Mt of rice husk is available in India every year, which contains about 0.35% N, 0.1% P and 0.30% K. It can be applied directly to agricultural land or may be used in composting. A significant portion of rice husk is used as fuel by rice shelling industry, resulting in problem for disposal of burnt rice husk.

  As fertilizer use in most areas is sub-optimal, organic resources can supplement available fertilizer supplies. About 25% nutrient needs of Indian agriculture can be met by utilizing various organic sources. The availability of several organic resources will increase with time. For example, additional 1.2-1.5 Mt crop residues will be generated with every Mt increase in grain production. Additional 0.25 Mt excreta $year^{-1}$ will be discharged with every million increase in human population. Apart from supplying major nutrients, organic resources are rich sources of secondary and micronutrients.

Integrated Nutrient Management System

Promotion ofIntegrated nutrient management (INM): Unbalanced nutrient supply through fertilizers neglecting organic manures have caused onslaught of multiple nutrient deficiencies, catalyzed the soil degradation, reduced the productivity and deteriorated the quality of natural resource base. Integrated use of all the nutrient resources (fertilizers, FYM/compost, green manures, crop residues, industrial wastes etc.) help not only to supply nutrients to the crops but help improving soil quality (chemical, physical and biological properties), protect environment and also cut to increasing demand of fertilizers.Use of Plant Growth Promoting Rhizobacteria (PGPR) helps in increasing yields in addition to conventional plant protection. The important PGPR are Azospirillum, Azotobacter Pseudomonas fluorescens, Phosphate Solubilizing Bacteria (PSB) and *Bacillus subtilis* (**Picture 2**). These inputs not only help supply nutrients to crop plants but also improve microbial soil health and optimize fertilizer consumption.

Picture 1. Various components of integrated plant nutrient supply system to improve soil health and arrest increasing demand of fertilizers

Benefits of Integrated Plant Nutrient Supply System (IPNS)

Effectiveness of Conjunctive Use of Fertlisers and FYM/Compost: In India, cattle dung is abundantly available for use as FYM/compost. The use of organic manures not only helps to substitute partly for chemical fertilisers but also improve overall soil productivity through beneficial effects on physical, chemical and biological properties of soil. Organic manures also play a significant role in correcting secondary and micronutrient balance. Integrated use of organic manures and chemical fertilisers has been found to be promising not only in maintaining higher productivity but also for providing sustainability in crop production.

A series of experiments conducted under All India Coordinated Research Project on Cropping Systems Research wherein the best yields were obtained when 50% N needs were met by FYM along with 50% recommended dose of fertilisers (RDF) in respect of NPK in rice followed by 100% RDF to wheat. This was also true for rice – rice system. Experiments conducted at Ludhiana indicated that replacement of 75% N with FYM in rice consistently produced the highest wheat yields, which were significantly higher than wheat yields produced by 100% inorganic N in three out of 14 crops due to residual effect of FYM. Regular use of FYM @ 6 t ha^{-1} in soybean-sunflower system produced crop yields comparable to recommended doses of fertilisers.

In vegetables and fruits, the role of organic manures for improving productivity and quality is well documented. The vermin-compost @ 8 t ha^{-1} has been found to give yields of onion and garlic similar to those obtained with recommended doses of chemical fertilisers. Similarly, the addition of organic manures such as FYM, neem cake and groundnut cake gave rhizome yields of 48.2, 48.1 and 46.3 q ha^{-1}, respectively compared to 48.8 q ha^{-1} with chemical fertilizers. Organic manures improved the curcumin content in the rhizome compared to chemical fertilisers. In rice – wheat cropping system under rainfed condition in Himanchal Pradesh, an application of 5t FYM/ha along with 50% of RDF (N90 + P40 + K40) produced 14% more rice and 32% more wheat as compared to 100% RDF.

Crop Residue Management

In India, approximately 500-550 million tons of crop residues are produced every year of which ~ 70% are contributed by cereals. While a substantial quantity of these residues is used for animal feeding, soil mulching, manuring, roof thatching and fuel purposes, a large remaining portion is burnt on-farm for timely clearance of fields for sowing of the next crop. Burning of crop residues not only causes environmental pollution adding to global warming but also results in depletion of valuable nutrients like N, P, K and S. With the poor availability of labour and increasing cropping intensities in the coming years, the problem is expected to assume greater dimensions. Hence, efficient management of crop residues is vital for long term sustainability of Indian agriculture. Though several technologies are available for residue use in conservation agriculture, lack of affordable and suitable mechanization remains a constraint. Efforts are required to quantify the economic, social and environmental benefits of residue management practices under different situations. These can then form a basis for policy decisions in relation to carbon sequestration, erosion control, fertilizer-use efficiency and incentives to retain crop residues.

Burning of large amounts of crop residues in open fields leads to soil fertilization in form of ash input and it is a source of atmospheric pollution with significant impacts on atmospheric chemistry, global climate and with great threat to human health (**Picture 1**). For example, burning wheat residues generates huge amounts of particulate material less than <2.5 µm (PM 2.5), GHG (i.e., CH_4,N_2O,CO_2), volatile organic carbon (VOC), NH_3, sulphur dioxide (SO_2)and other pollutants. While the main effect of straw burning is on the atmospheric chemistry and air quality, this practice has additionally negative consequences on soils affecting the soil OM quantity and quality, the activity and colonization of top soil by microorganisms, biological diversity and nutrient dynamics among other negative environmental implications. Ideally, site specific crop residue management practices should be selected to optimize crop yields with minimal adverse effects on the environment.


Picture 2. A view of burning of rice and wheat crop residue

Promoting Conservation Agriculture:To improve soil health and environment and to enhance resource use efficiency, productivity and profitability - conservation agriculture (CA) technologies such as zero tillage, residue retention and crop diversification need to be promoted in irrigated as well as rainfed agro-ecologies. It would be essential to have suitable farm machinery for recycling of these crop residues for which Government has made provision to make available various machineries to the farmers at subsidized rates.There is a growing demand for suitable farm machineries for small and marginal farmers. which can do sowing, place fertilizer and also work under residue conditions.Scientific way of crop residue recyclingis shown **Picture 3**

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Picture 3. Scientific way of crop residue recycling

Recycling through Biogas Slurry: Biogas technology has generated a worldwide interest because it is among the most feasible ones as renewable source of energy to meet the challenges for depleting reserves of fossil fuels and escalating deforestation. The anaerobic fermentation animal wastes are converted into fuel without sacrificing their manurial value. Biogas slurry (BGS) is the end product of biogas plants when organic materials are converted into CH_4 and CO_2. Biogas plants serve dual purpose as they provide fuel as well as good quality manure. Mean biogas production potential of faecal organic matter is about 200 M^3/t dry matter. BGS is generally richer in N than FYM containing 1.2-2.0% N, 0.5-0.7% P and 0.5-1.0% K (dry weight basis) along with significant quantities of micronutrients.

BGS may be applied directly with irrigation water or after drying as manure. In India it can be one of the potential renewable sources of energy from the 1800 Mt of animal dung per annum. Even if two-third of the dung is used for biogas production it is expected to yield biogas not less than 120 million m^3 day^{-1}. Therefore, construction of biogas plants by the farmers should be encouraged in the country. Experiments conducted at IARI, New Delhi showed that N applied through BGS was as effective as urea for rice and wheat.

Poultry Manure: Poultry manure (PM) is relatively richer in nutrient contents (1.8% N, 2.5% P and 1.4% K) and the release of nutrients is also quite fast. In field experiment at Ludhiana, application of 4t/ha of PM + 60 kg N/ha was as efficient as 120 kg N/ha.

Conjunctive Use of Fertilizers and Leguminous Green Manures: Green manuring with legumes has long been known to be beneficial for sustainable crop productivity due to their symbiotic N fixation capacity. Green manures may be plants of grain legumes green gram, blackgram, cowpea etc. or nongrain legumes like *Sesbania, Crotolaria, Centrosema, Stylosanthes, and Desmodium*. Quick growing leguminous shrubs grown as a part of the cropping system and incorporated into the soil at an appropriate stage as green manure, leguminous trees grown in hedge rows and their lopping used as mulch materials or incorporated into the soil of the cropped alleys between them and forage or food legumes properly inoculated with NPK Consortia or Rhizobium grown in cropping sequence help providingsignificant quantity of N to the crops and also increasing availability of other nutrients along with improving soil physical and biological properties. NPK

Consortia help increasing the availability of all the three major nutrients and other nutrients.

Incorporation of green leguminous biomass into soil significantly increases the availability of many other plant nutrients also. Leguminous green manures decompose rapidly upon incorporation into the soil at high temperature and under alternate aerobic/anaerobic conditions. Therefore, only a small fraction of GM-C was converted into stable soil humus. The effects of GM on SOM are governed by soil texture climate, and soil organic C status. An ideal green manure should have the quality of early establishment and high seedling vigour, tolerant to drought, shade, flood, and adverse temperature, possesses early onset of N fixation and its efficient sustenance, have an ability to accumulate large biomass and N in 4-6 weeks, quickly decomposable, and tolerant to insect and diseases.

Experiments conducted in India have clearly shown that legume green manures grown together with or before rice can reduce, and sometimes eliminate, the need for N fertilizers. Transition period of 45-60 days between harvesting of wheat and transplanting of rice could be utilized by planting fast growing legumes as green manure crops. Symbiotic bacteria present in nodules that develop on the roots of legumes fix nitrogen from 40-120 kg N ha^{-1} directly from the atmosphere. Estimated contribution of N by green manures sometimes exceed 100-120 kg N/ha. Where the N input through green manure is high, occasional residual effect might be expected on second crop as this N is in organic form. Nitrogen from GM and urea has been found equally efficient in increasing yield and N use efficiency in rice.

Initiatives Taken to introduce Innovative/Alternate fertilizers

People express concern on the ill-effects by the use of chemical fertilizers on the human health, soil and environment. The farmers are tempted to use urea since it is available at a very cheap price. Only 30-40% of the nitrogen in the Urea is actually utilized by the plant, the rest is wasted and reaches the ground water or evaporates as ammonia which is bad for the environment. The Committee emphasised on the need to give a serious consideration for gradually scaling down of amount of Urea used by the farmers.

Nanofertilizers to Arrest Ever Increasing Fertilizer Demand

The safe and enough food production were and will still be the global emergingissue. Fertilizers are one of the most important inputs in enhancing the agriculturalproductionbut their over use leads to environmentalpollutionand the low nutrient use efficiency (only 30–40% for N, 15-20% for P and 50% for K from total applied fertilizers, whereasthe rest is lost from the agro-ecosystem through leaching/evaporation/ degradation (Tiwari and Kumar, 2023 a). To improve the nutrient use efficiency, nano-based slow-release or controlled-release fertilizers have the tremendous potential. Using nanofertilizers or nanonutrientsin right quantity by right method and at right time will enhance nutrient use efficiency, crop productivity, as well as the help arresting the increasing demand of fertilizers (Tiwari and Kumar, 2023b) and environmental pollution. Therefore, to produce enough and safe food for all people, new strategies for smart farming with nano fertilizers would be essential and inevitable. Therefore, among different agricultural inputs, nano fertilizers can be consider edquite promising in enhancing plant growth, nutrition and finally the crop productivity as well as regulating the release of nutrients and improving nutrient use efficiency (Yuvaraj and Subramanian2015;Subramanianetal.2015,2016).Thus plant nano-nutrition can be considered as one of the most important tools for a high nutrient use efficiency with significant saving of conventional fertilizers.

Important benefits of nanofertilizers over conventional chemical fertilizers rely on their (a) nutrient delivery system as they regulate the availability of nutrients in crops through slow/control release mechanisms. Such a slow delivery of nutrients is associated with the covering or cementing of nutrients with nanomaterials. By taking advantage of this slow nutrient delivery, growers can increase their crop growth because of consistently long-term delivery of nutrients to plants. For example, nutrients can be released over 40–50 days in a slow release fashion rather than the 4–10 days by the conventional fertilizers (b) In addition, nanofertilizers required in small amount which reduce the cost of transportation and field application (c) An additional major advantage is over accumulation of salt in soil can be minimized as it required in small amount (d) Another advantage for using nanofertilizers is that they can be synthesized according to the nutrient requirements of planned crops. In this regard, biosensors can be attached to a new innovative fertilizer that controls the delivery of the nutrients according to soil nutrient status, growth period of a crop or environmental conditions (e) The miniature size, high specific surface area and high reactivity of nanofertilzers increase the bioavailability of nutrients (f) Providing balanced nutrition, nanofertilizers facilitate the crop plants to fight various biotic and abiotic stresses (Tiwari and Kumar, 2023a). It is reported in several crops, that use of nanofertlizers and nanomaterials enhanced the growth and yield in several crops relative to plant treated with conventional fertilizers.In arid soil, it was observed that the engineered nanoparticles may be successfully utilized for mitigating the acute problem of moisture retention. Apart from moisture retention, nano-based slow-release fertilizers may augment crop production by mobilizing nutrients in the rhizosphere (Raliya et al. 2013).Apparently,Nanofertilizers could be good complement to conventional fertilizers and as such help arrest increasing demand of conventional fertilizers.

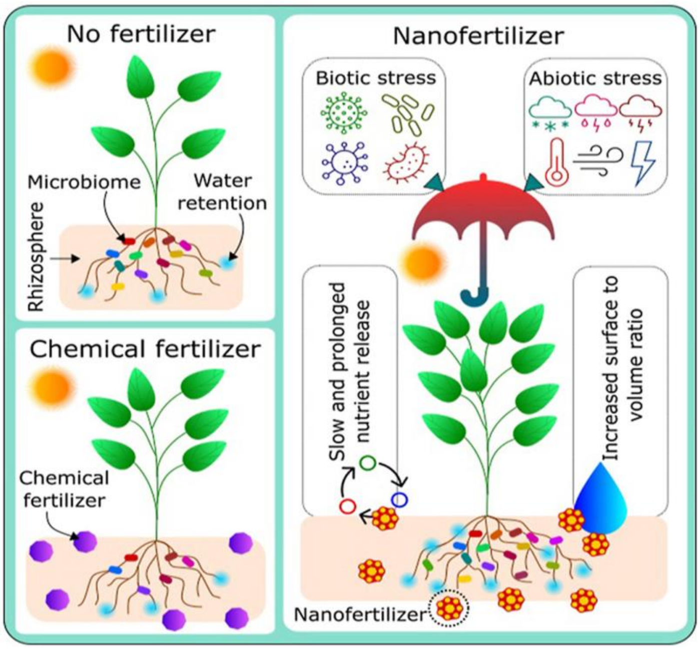


Fig. 1. Benefits of Nanofertilizers vis a vis. Conventional fertilizers

To promote Nanofertilizers it is need of the day that “if a farmer asks for, let us say, five bags each of urea and DAP, then it is proposed to give him two bottles each of Nano Urea and Nano DAP and three bags of Urea and DAP. But there can be complaints against this.” Considering the positive side of use of Nano Urea and Nano DAP, the proposal may be legalized and efforts be made so that Nano urea and Nano DAP may gradually replace the conventional Urea and DAP.

Value Addition in Fertilizers to Enhance Nutrient Use Efficiency and optimize Increasing Demand of Fertilizers

In India's fertilizer industry, neem-coating of urea represents a significant technological achievement. A slow-release ingredient, neem oil, is used to urea, a common nitrogenous fertilizer. This coating increases how effectively plants use urea while reducing nitrogen losses due to volatilization.InIndia, urea coated with neem is frequently used to increase nutrient utilization effectiveness and lower environmental pollution.The Government, as part of its initiatives to promote alternate fertilizers, is considering use of two new fortified Urea combinations in the country viz (i) Sulphur Coated Urea(SCU) also called as Urea Gold and (ii) a combination of Single Super Phosphate and Urea (SSP+Urea) which is used instead of DAP. As per the study conducted by ICAR, use of SCU leads to reduction in urea consumption by 25% and therefore, it is proposed to introduce SCU as a premium urea in the market in 40 kg bags which will also meet the deficiency of Sulphur content in the soil. Its two main advantages are its slow-release mechanism and increased nitrogen adsorption efficiency by 40%. It also improves the plant growth/ quality and the yield of seeds, especially oilseeds. Rashtriya Chemicals and Fertilizers Limited (RCF) has produced inhouse laboratory scale SCU with specifications of FCO, 1985. The pilot scale plant/ commercial production is yet to be set up by RCF and results are yet to be seen. The initial studies conducted by RCF are at laboratory scale. Field trials of SCU are going on by RCF. Keeping in view the numerous benefits of the SCU and (SSP+Urea), the Committee hope that the Department/RCF would expedite the field trials in respect of (SSP+Urea) and SCU and soon start their pilot scale plant/ commercial production.

Other Measures toEnhance Nutrient Use Efficiency and Optimize Increasing Demand of Fertilizers

Micro-Irrigation and Fertigation:Promoting micro-irrigation (drip and sprinkler system) and fertigation, on a very large scale, can be highly efficient towards increasing water and nutrient use efficiency and help cutting increasing fertilizer demand. Priority should, therefore, be given to empower farmers with micro-irrigation for which Government is helping farmers through subsidy.

Foliar Feeding : Foliar feeding is an effective method of fertilizer application. A large number of specialty fertilizers are available in the market, if applied judiciously help improving nutrient use efficiency with less quantity of fertilizers. These fertilizers are used in fertigation, where both water and nutrient use efficiency is quite high.

Climate Resilient Agriculture to Arrest Increasing Demand of Fertilizers

India's agriculture system is facing serious challenges and risks due to climate change through significant greenhouse gas emissions, in consequence to injudicious and unbalanced use of fertilizers and faulty water usage, and deforestation.In recent years, the frequency ofclimatic extremes has increased. Onemodelling study has recently projected the loss in crop production to the order of 10-40% by 2100. And, if unsustainable farming practices continue, the strain on our environment will only get worse. Complex, systemic issues like these call for big solutions.To address the issues of climate change, we must ensure proper management of natural resources (land, water and biodiversity), explore more efficient inputs (smart fertilizers like slow-release fertilizers, water soluble fertilizers, biofertilizers, bioenhancer like Sagarika, Nanofertilizers, biopesticides etc.), along with nutrient enriched quality composts, green manure, crop rotation, residue management, conservation agriculture etc. and adopt crop and fertilizer best management practices as climate resilient improved farm technologies which in turn arrest the increasing demand of fertilizers.

***Nutrient Management**:* Efficient management of nutrients can help in climate change adaptation by enhancing root growth and early vigour of plant and improving soil microbial activities that lead to adequate supply of plant nutrients under climate-stress conditions. Soil test-based, balanced fertiliser application, use of efficient fertilisers, site-specific real time N application and integrated nutrient management are some options of efficient nutrient management practices. Use of neem-coated urea, soil health card and leaf colour chart for enhancing fertiliser use efficiency were successfully utilised in India. Integrating all these options will further improve the efficiency of applied fertilisers (Pathak et al., 2019). Microbe-based technologies for nitrogen fixation, nutrient recycling, bio-residue management and alleviation of abiotic and biotic stress will be very useful in the changing climate scenario.

Conservation Agriculture: Conservation agriculture helps (i) reduce the carbon footprint of the production system, (ii) improve productivity and (iii) enhance adaptability, by modulating soil moisture and temperature regimes (Somasundaram et al., 2020) and finally arrest increasing demand of fertilizers. Such practices are followed by farmers on a large scale in the Indo-Gangetic Plains. However, refinement and promotion are required to extend the technology in climatic stressed, dry land areas. The state department of agriculture and horticulture, SAUs, KVKs, FPOs and fertilizer industry should create greater awareness among the farmers about importance of adopting climate resilient improved fam technologies on the principle of "*Reaching the Unreached*". This is essentially needed in view of the fact that fertilizer use is proposed to be nearly 20% less by 2030 with adoption of best farming practices to ensure about 85% of global agricultural production (Tiwari and Kumar 2023)).

IFFCO'sInitiative to Arrest Increasing Demand of Fertilizers

IFFCO is rising to the challenge, providing a myriad of specialty fertilizers like 100% water soluble fertilizers, bio-enhancer like Sagarika liquid, Nanofertilizers (Nano Urea, Nano DAP), secondary and micronutrients, organic products, biofertilizers including NPK Consortia and bioenhancer (Sagarika granular and liquid) and many more including recently developed Nano Urea and Nano DAPthat promise to deliver optimal nutrition and higher efficiency as well as other benefits (**Picture 5**). This revolution can be seen in the growing market of these smart products.

Government's Initiative to Arrest Increasing Demand of Fertilizers

The Government has launched a National Mission on Soil Health Card to promote soil test based balanced and judicious fertilizer application in the country.

Organic farming : Organic farming, with use of organic sources of nutrients, is proposed as a sustainable strategy for producing safe, healthy and cheaper food and for restoring soil fertility and mitigating climate change. However, there are several myths and controversies surrounding the use of organic versus inorganic sources of nutrients. Organic farming is being promoted under *Paramparagat Krishi Vikas Yojana* (PKVY) and Mission Organic Value Chain Development for North East Region (MOVCD-NER) in the country. Trainings and demonstrations are organized through ICAR institutions including *Krishi Vigyan Kendras* (KVKs), and agricultural universities to educate farmers on all *these aspects.*Considering the current organic sources of nutrients in the developing countries, organic nutrients alone are not enough to increase crop yields to meet global food demand and that nutrients from inorganic and organic sources should preferably be applied at 75:25 ratio.

Natural Farming:Natural farming is a method of agriculture that seeks to create a balanced and self-sustaining ecosystem in which crops can grow without the use of synthetic chemicals or genetically modified organisms.Instead of relying on artificial inputs like synthetic fertilisers and pesticides, natural farmers rely on techniques like croprotation, intercropping, and composting to enhance soil health and support crop growth.Natural farming methods are often based on traditional knowledge and practices and may be adapted to local conditions and resources.The goal of natural farming is to produce healthy, nutritious food in a way that is sustainable and environmentally friendly.

Programme for Restoration Awareness and Nourishment and Amelioration of Mother Earth (PM-PRANAM): Promotion of organic fertilizers, bio-fertilizers, etc. The Government has announced PM-PRANAM in the budget 2023-24 with an objective to restore the health of the Mother Earth through promoting balanced/sustainable use of chemical fertilizers; adopting alternate fertilizers like organic/bio and nano fertilizers; promoting natural/ organic farming; etc. which will thus save the soil, human health, ground water and environment. The scheme which is still under consideration of the Ministry of Finance aim to incentivize States and UTs which are involved in promotion of organic fertilizers, natural farming and organic farming.

Scheme for providing Market Development Assistance for production and use of organic manure, compost, etc.:The Government in budget 2023-24 has made announcement of the SATAT and GOBARdhan Schemes for promotion of organic manures, compost, etc. SATAT programme promotes compressed bio-gas plants wherein the by-product is fermented organic manure (FOM). GOBARdhan scheme promotes bio-gas plants and FOM is the by-product which is a bio-manure. The Department of Fertilizers will be promoting the use of bio-manure which is produced under these two schemes as a by-product. There is an EFC Proposal for granting Market Development Assistance for FOM/ PROM/ other organic fertilizers & bio-fertilizers with focus on SATAT and "GOBARdhan scheme. 5000 compressed biogas plants are to be set up under SATAT scheme by 2023 while 400 bio gas plants are to be set up under the GOBARdhan scheme. The Government shouldtake cogent measures for ensuring the availability of trained technical manpower at the village/ block/ district levels for maintenance of the bio-gas plants and constituting of a Central monitoring agency for ensuring their effective and efficient operation.

Picture 2. IFFCO Biofertilizers and Bioenhancer (A), Water soluble fertilizers (B) and Secondary and micronutrients (C).

In conclusion, India is almost entirely dependent on inputs for production of fertilizers. Therefore, we have to strive to reduce our import dependence and reduce our carbon footprint in line with national climate goals. This would require use of renewable energy in fertilizer production and exploitation of all indigenous inorganic and organic sources for meeting the nutrient requirement of Indian agriculture.

References

FCO, 1985. Fertilizer Association of India, New Delhi, Amended, March 2023.

Kumar, Yogendra., Tiwari, K.N., Singh, T., Sain, N. K. 2020A. Nanofertilizers for enhancing nutrient use efficiency, crop productivity and economic returns in winter season crops of Rajasthan. Annals of Plant and Soil Research 22(4), 324-335

Kumar, Yogendra., Tiwari, K.N., Nayak, R.K., Rai, A. 2020B. Nano fertilisers for enhancing nutrient use efficiency, crop productivity and economic returns in winter season crops of Uttar

Pradesh. Indian Journal of Fertilisers **16(8)**, 772-786.

Kumar, Yogendra., Tiwari, K.N., Singh, T. and Raliya, Ramesh. 2021. Nanofertilisers and their role in sustainable agriculture. Annals of Soil and Plant Research, **23(3)**, 238-255.

Subramanian K S, Manikandan A, Thirunavukkarasu M, Rahale CS (2015) Nano-fertilizers for balanced crop nutrition. In: Rai Metal (eds) Nano technologies in food and agriculture. Springer, Cham, pp69–80.https://doi.org/10.1007/978-3-319-14024-7_3.

Subramanian KS, Muniraj I, Uthandi S (2016) Role of actinomycete-mediated nanosystem inagriculture. In: Subramaniam G et al (eds) Plant growth promoting actinobacteria. Springer,Singapore,pp233–247.https://doi.org/10.1007/978-981-10-0707-1_15.

Tiwari, K. N. and Yogendra Kumar (2023a) Nano Fertilizers for Smart Agriculture: A Review. Indian Journal of Fertilizers, **19 (7)**: 632-653.

Tiwari, K. N. and Yogendra Kumar (2023b) Nano-fertilizers: An Effective Way to Alleviate Biotic and Abiotic Stresses in Agriculture. Indian Journal of Fertilizers, 19 (8): 768-784.

Yuvaraj M, Subramanian K S (2015) Controlled-release fertilizer of zinc encapsulated by a manganese hollow core shell. Soil Science and Plant Nutrition, **61(2):**319–326. https://doi.org/10.1080/00380768.2014.979327.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/03/0124

LAND AND WATER RESOURCES OF INDIA: PAST, PRESENT AND FUTURE

V. R. Vagadiya[1], P. H. Rank[2*], Deepak Kumar[3], R J Patel[4]and P. B. Vekariya[5]

[1]Head, Department of Farm Engineering, College of Agriculture, Junagadh Agricultural University, Junagadh-362001. Gujarat State, India.
[2]Department of Irrigation and Drainage Engineering, College of Agricultural Engineering & Technology, Junagadh Agricultural University, Junagadh – 362001. Gujarat State, India.
[3]Department of Agricultural Engineering, School of Agriculture, GIET University, Gunupur, Odisha – 765022, India.
[4,5]Department of Irrigation and Drainage Engineering, College of Agricultural Engineering & Technology, Junagadh Agricultural University, Junagadh-362001. Gujarat State, India.
***Corresponding Email:** prasangpatel83@gmail.com

ABSTRACT

India's vast landscape, once brimming with fertile fields and sparkling rivers, now faces a critical cinch with its land and water resources. A burgeoning population, the spectre of climate change, and unsustainable practices threaten to it jeopardizing food security, clean energy production, and the future of its 1.3 billion people. This article explores the land and water resources availabilities during the past, present and future, present status of agricultural production and demands, issues of land and water resources management for agriculture and management strategies. This is not just a status of resource scarcity, but a force to action, urging us to manage smartly the land and water resources, transforming them from a source of vulnerability to a driver of sustainable prosperity.

Keywords : Land, water, resources, climate change, food security, management strategies

INTRODUCTION

Amidst a surging population and changing climate, India's food-water-energy security is delicately poised on the tightrope of its land and water resources. With a colossal population exceeding 1.3 billion, optimizing these resources is not just a choice but an imperative. Climate change, marked by erratic rainfall and rising temperatures, exacerbates the challenge, disrupting the fragile equilibrium between land, water, and energy demands (Kelaiya and Rank, 2019; Paghadal et al., 2019a; Kumar and Rank, 2021; Rank et al., 2020; Kumar and Rank, 2023). Crop yields, hydropower generation, and access to clean water are threatened by land degradation, groundwater depletion, and extreme weather events, posing risks to the nation's food security and energy independence. To secure a sustainable future, India must prioritize integrated resource management, incorporating climate-resilient agricultural practices, efficient water technologies, and renewable energy sources (Patel and Rank, 2020; Vekariya et al., 2022; Patel et al., 2023a, b; Rank et al., 2023b; Vekariya et al., 2023). Recognizing that over 95 percent of our food originates from these resources, the symbiotic relationship between soil water and nutrient absorption by plants must be preserved, as it forms the bedrock of our agricultural systems.

Amidst a surging population and changing climate, India's food-water-energy security is delicately poised on the tightrope of its land and water resources. With a colossal population exceeding 1.3 billion, optimizing these resources is not just a choice but an imperative. Climate change, marked

by erratic rainfall and rising temperatures, exacerbates the challenge, disrupting the fragile equilibrium between land, water, and energy demands (Kelaiya and Rank, 2019; Paghadal et al., 2019a; Kumar and Rank, 2021; Rank et al., 2020; Kumar and Rank, 2023). Crop yields, hydropower generation, and access to clean water are threatened by land degradation, groundwater depletion, and extreme weather events, posing risks to the nation's food security and energy independence. To secure a sustainable future, India must prioritize integrated resource management, incorporating climate-resilient agricultural practices, efficient water technologies, and renewable energy sources (Patel and Rank, 2020; Vekariya et al., 2022; Patel et al., 2023a, b; Rank et al., 2023b; Vekariya et al., 2023). Recognizing that over 95 percent of our food originates from these resources, the symbiotic relationship between soil water and nutrient absorption by plants must be preserved, as it forms the bedrock of our agricultural systems.

Land resources availabilities: Past, Present and Future

Earth's total surface area exceeds 510 Mkm2, but less than 30% is land; the majority lies underwater. Land, the solid part beneath our feet, is vital, supporting our lives, economy, and society. It categorizes into Residential, Commercial, Wet, Range, Agricultural, Forest, and Barren Land. Soil, a biologically active medium in the Earth's uppermost layer, acts as a reservoir for water and nutrients, filtering and breaking down harmful wastes. The four main soil types based on texture are Sand, Silt, Clay, and Loamy.India's agricultural landscape, the world's second-largest arable land area, presents both promise and challenges. While fertile grounds yield diverse crops feeding over 1.3 billion people, issues like land fragmentation, soil degradation, and unequal water distribution pose vulnerabilities. Climate change intensifies these challenges. Yet, India's land resources harbor immense potential. Through sustainable practices, such as crop rotation and water conservation, strategic investments in irrigation networks, and support for small farmers, India can fortify food security and unlock the full potential of its agricultural land for a prosperous future.

As per ICAR Soil Classification, India has 8 main soil types. Alluvial Soil covers 40%, found in northern plains with a sandy loam to clay texture. Black Cotton Soil, constituting 15%, is clayey and present in the Deccan Plateau. Red and Yellow Soil makes up 18.5%, located in the eastern and southern Deccan Plateau, deficient in N, P, and humus. Laterite Soil is 3.7%, found in Karnataka, Tamil Nadu, and hilly regions, deficient in organic matter but rich in iron oxide and potash. Mountainous or Forest Soil exists in forest regions. Arid or Desert Soil, comprising 4.42%, is sandy to gravelly, found in western Rajasthan. Saline and Alkaline Soil have sandy to loamy texture, deficient in calcium and nitrogen, found in western Gujarat, eastern coast deltas, and Sundarban areas. Peaty and Marshy Soil, found in high rainfall regions, are rich in humus and organic matter, mostly in the southern UK, northern Bihar, and coastal areas of WB, Odisha, and TN.The Fig 1 shows that the per capita availability of land for the agriculture decreases continuously till 2060.

Water resource availabilities: Past, Present and Future

India receives 4000 BCM of annual precipitation. The country's utilizable water resources stand at 1123 BCM, with 690 BCM from surface water and 433 BCM from groundwater. Future water demand, driven by population growth and rising living standards, is projected to reach 1447 BCM by 2050. This surpasses the present utilizable water resources (1123 BCM), with 1074 BCM earmarked for agriculture. Of the 140.13 Mha sown area, 48.7% (68.38 Mha) is irrigated, leaving 71.74 Mha unirrigated. Focusing on efficient irrigation management and enhancing land and water resources is crucial. The challenge lies in producing more with less water, particularly in irrigated areas, and sustainably using grey water for agriculture production to meet the projected 2050 water demand.The Fig 2 shows that the per capita annual water availability decreases continuously till 2060.

Present status of agricultural production

India, occupying only 2.4% of the land and 4% of water resources, sustains 17% of the global human and 15% of the livestock population. It leads in milk, spices, pulses, tea, cashews, and jute production, ranking second in rice, wheat, oilseeds, fruits, vegetables, sugarcane, and cotton. The food grain production reached 330.5 MT, up by 15 million tonnes from the previous year. Horticulture production rose to 351.92 MT in 2022-23, a 1.4% increase. Pulse, oilseed, cotton, and sugarcane production reached 27.5 MT, 41.0 MT, 34.35 million bales, and 49.42 MT, respectively, showing growth. However, a significant concern is the oilseed deficit, demanding a breakthrough similar to BT Cotton or extensive cultivation. Fruit production is estimated at 108.34 million tonnes in 2022-23, a slight increase from the previous year. The productions and demands of agricultural production in India is depicted in Table-1 below.

Vegetable production is estimated at 212.91 million tonnes in 2022-23, a slight increase from 209.14 million tonnes in the previous year. Plantation crop production is expected to rise from 15.76 million tonnes in 2021-22 to 16.05 million tonnes in 2022-23, a 1.78% increase. Potato production is projected to reach 60.54 million tonnes, up from 56.18 million tonnes the previous year. The total milk production in the country is estimated at 230.58 million tonnes in 2022-23, showing a growth of 3.83% over the 2021-22 estimates.

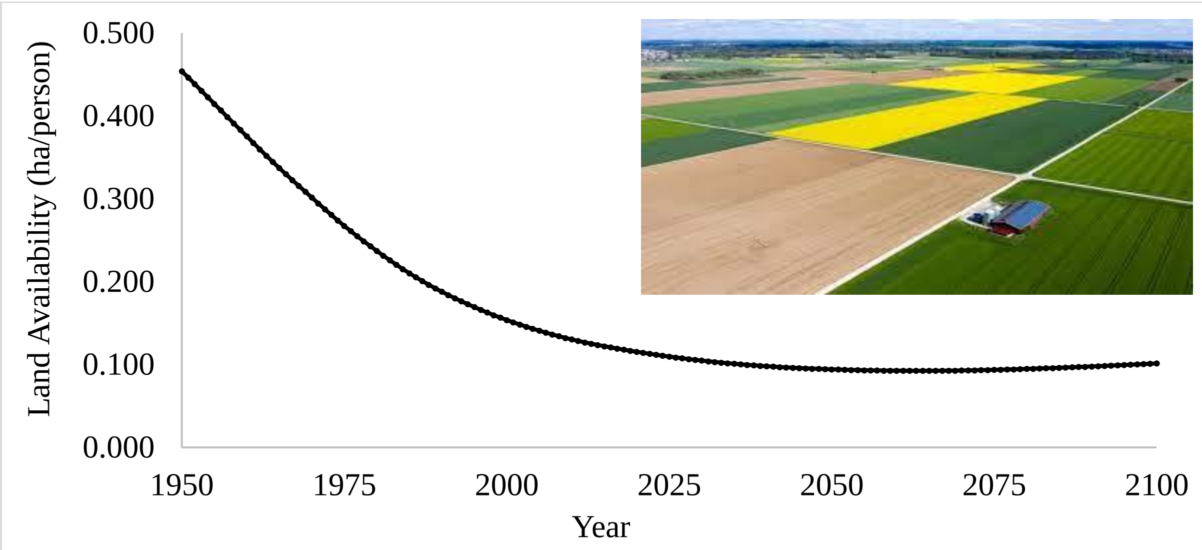


Fig. 1 Per capita land availability in India

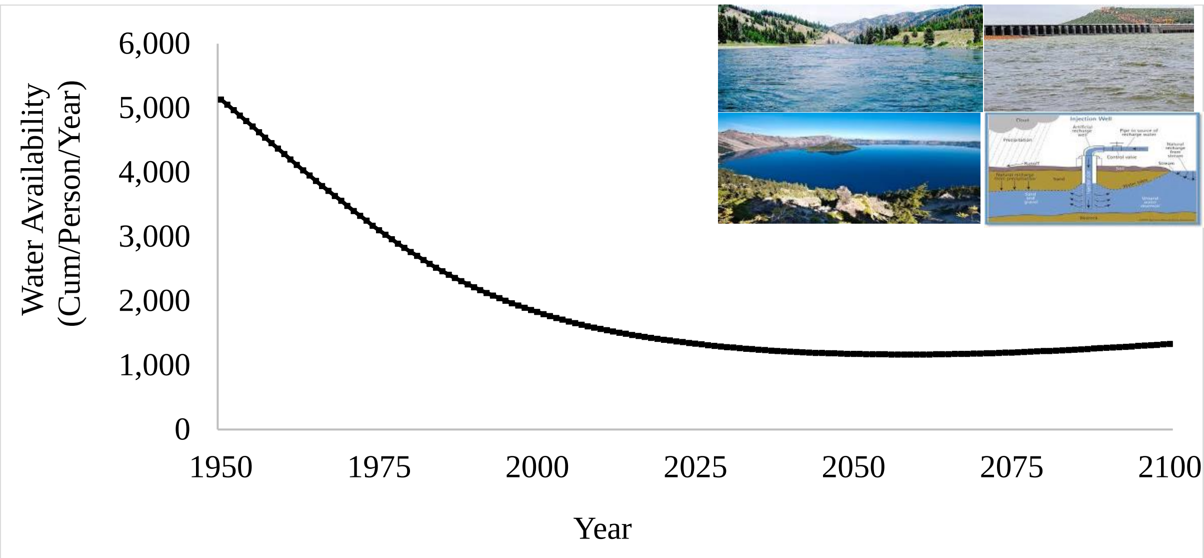


Fig. 2Per capita annual water availibility in India

Table1: Productions and demands of agricultural produce in India

Food Composition	Requirements As per ICMR (g/day/person)	Requirements (Million MT)	Production (Million MT/Y)
Cereal	360	187.2	330.5
Millets			
Sub Total		187.2	330.5
Pulses(Legumes)/ Fresh food	120	62.4	27.5
Sub Total			27.5
Green Leafy vegetables	100	52.0	212.91
Other vegetables	200	104.0	
Roots and Tubers	100	52.0	
Sub Total		208.0	212.91
Fruits	150	78.0	108.34
Milk	300	156.0	230.58
Fats and Oils	30	15.6	11.3
Oilseeds and nuts	30	15.6	41+0.9

Issues of Land and Water Resources Management for Agriculture

- Land and water resource management in Indian agriculture faces multiple challenges:
- Land degradation, including soil erosion, nutrient depletion, salinization, and desertification, threatens food security.
- Land fragmentation, characterized by small and scattered holdings, hinders efficient farming and technology adoption.
- Unsustainable land use, such as deforestation and urbanization, pressures land resources and biodiversity.
- Inadequate land tenure security discourages long-term investments in land improvement.
- Climate change induces extreme events like droughts and floods, disrupting agricultural production.

- Water scarcity, uneven rainfall, and limited access challenge irrigation and rural communities.
- Groundwater depletion from agricultural extraction threatens future availability.
- Water pollution from industrial waste and agricultural runoff impacts crop yields and human health.
- Inefficient water management, including leaks and evaporation, wastes valuable resources.
- Rising temperatures and altered precipitation patterns due to climate change stress water resources.
- Institutional challenges like weak governance and insufficient infrastructure hinder effective management.
- Lack of awareness and adoption of sustainable practices by farmers due to limited resources.
- Equity issues, with unequal access to resources exacerbating poverty and marginalization.

Management Strategies

- To address the identified issues, a comprehensive strategy includes:
- Promoting sustainable land management practices like soil conservation, crop rotation, cover cropping, and integrated pest management to enhance soil health and minimize degradation.
- Investing in efficient water management technologies such as drip irrigation, precision agriculture, and rainwater harvesting to optimize water use and reduce wastage.
- Strengthening institutional frameworks through effective policies, regulations, and enforcement mechanisms to support sustainable resource management.
- Promoting research and development by investing in studies on climate-resilient crops, water-efficient technologies, and innovative resource management approaches.
- Empowering communities through farmer education, capacity building, and participation in decision-making processes to ensure successful resource management.

CONCLUSION

The challenges of limited land and water per capita, a growing population, and climate change demand urgent strategies for sustainable land and water management in India. Innovative agricultural practices like precision farming and agro ecology can optimize land use efficiency with minimal environmental impact. Investment in water-saving technologies and watershed management initiatives can increase water availability for agriculture and domestic use. Promoting renewable energy sources, such as solar and wind power, can alleviate pressure on conventional resources and promote clean energy. A holistic approach, incorporating community engagement and policy reforms, is crucial for a resilient future, ensuring food and energy security while preserving vital natural resources for future generations.

REFERENCES

Kelaiya, J., Rank, P.H., (2019). Assessment of water balance components of bhadar river basin using SWAT model. International Journal of Bio-resource and Stress Management 10(2), 181–184.

Kumar, D. and Rank, P. H. (2023). Estimation of crop evapotranspiration and crop coefficient for coriander using portable automatic closed canopy chamber. Journal of Agrometeorology, 5(4):547-552. DOI: https://doi.org/10.54386/jam.v25i4.2315

Kumar, D., Rank, H.D. (2021). Comparison of Fenugreek Crop Evapotranspiration Measured by a Micro-lysimeter, Field Water Balance Method and Automatic Closed Canopy Chamber. International Journal of Agriculture, Environment and Biotechnology, 14(1): 29-49.

Paghadal, A. M. Rank, H. D., Prajapati, G. V. Rank, P. H., Pipaliya, P. S., Pipaliya, J. S. (2019a). The Trend Analysis of Various Components of Water Resources System of Ozat River Basin, Gujarat, India. Int. J. Curr. Microbiol. App. Sci., 8(11), 241-267. https://www.researchgate.net/publication/362948568_The_Trend_Analysis_of_Various_Components_of_Water_Resources_System_of_Ozat_River_Basin_Gujarat_India. DOI: https://doi.org/10.20546/ijcmas.2019.811.030

Paghadal, A. M., Rank, P. H., Rank, H. D., Limbasiya, B. B., Vekariya, P. B., Vadar, H R. (2019b). Modelling and Simulating the Groundwater Level Behavior to Climate Change for the Ozat Basin., Int. J. Curr. Microbiol. App. Sci 8 (10), 1156-1165. DOI: 10.20546/ijcmas.2019.810.135

Patel RJ, Rank HD (2020) Water use efficiency of wheat under different irrigation regimes using high discharge drip irrigation system, AgricEngg Today 44(2):19-31 Patel RJ (2019) Laboratory and field manual on irrigation engineering. Scientific Publishers Patel RJ, Rank HD, Ajudiya BH, Dhanani NV (2014) An assessment of ground water recharge potential through tube well, International Journal of Engineering Research and Technology 3(10):155-160.

Patel RJ, Rank PH, Vekariya PB, Vadar HR, Parmar HV, Rank HD, Damor PA, Modhvadiya JM (2023a) Study on physicochemical properties of clay loam soil of Junagadh region, International Research Journal of Modernization in Engineering Technology and Science 05(06):3912-3919 https://www.doi.org/10.56726/IRJMETS42550.

Patel, R. J., Rank, P. H., Vekariya, P. B., Rank, H. D., Vadar, H. R., Parmar, H. V., and Lunagaria, M. M. (2023b). Enhancing Wheat (Triticumaestivum L.) Crop Yield and Water Use Efficiency: A Study on Canopy Air Temperature Difference-Based Drip Irrigation Scheduling in a Semi-Arid Region of Western India. DOI: https://doi.org/10.21203/rs.3.rs-3376468/v1

Vekariya, P. B., Rank, H. D., Patel, R. J. and Rank, P. H. (2022). Studies on Open Well Recharge Techniques for Junagadh Region. International Research Journal of Modernization in Engineering Technology. 04(08): 354-362. https://www.researchgate.net/publication/363262672_STUDIES_ON_OPEN_WELL_RECHARGE_TECHNIQUES_FOR_JUNAGADH_REGION#fullTextFileContent

Vekariya, P.B., Patel, R. J., Rank, P. H., Modhvadiya, J. M., Rank.H. D. (2023). Connector well recharge techniques for junagadh region. International Research Journal of Modernization in Engineering Technology and Science. 5(9): 385-397. https://www.irjmets.com/uploadedfiles/paper/issue_9_september_2023/44526/final/fin_irjmets1694165214.pdf

Rank, P. H., Rank, H. D., Vekariya, P. B. Patel, R. J. and Kar, G. (2022a). Effectiveness of gaussian distribution mapping for bias correction of rcm simulated temperature for junagadh region. International Research Journal of Modernization in Engineering Technology and Science, 04(11): 160-175 DOI: 10.56726/IRJMETS31007

Rank, P.H. and Satasiya, R.M. (2022). Sweet corn crop (Zea mays L.) performance under various irrigation water management strategies. J. Pharm. Innov., 11 (6):1525-1531.

Rank, P.H. and Vishnu, B. (2019). Automation of pulsed drip irrigation. Int. J. Engg. Sci. Comp., 9 (7): 23265-23276.

Rank, P.H. and Vishnu, B. (2021a). Design concept of pulse drip irrigation, Int. J. Modern. Engg. Tech. Sci., 03(12): 414-420.

Rank, P.H. and Vishnu, B. (2021b). Pulse drip irrigation: A review. J. Pharmacognosy and Phytochemistry., 10 (1): 125-130.

Rank, P.H. and Vishnu, B., (2023). Validation of Models for Simulating the Soil Moisture Characteristics. Agric. Sci. Dig., 43 (2):157-163.

Rank, P.H., Satasiya, R.M., Limbasiya, B.B., Parmar, H.V. and Prajapati, G.V. (2023a). Sweet corn crop yield response to aerated drip irrigation under various irrigation water management strategies, Emer. Life. Sci. Res., 9(1):10-21. DOI: https://doi.org/10.31783/elsr.2023.911021

Rank, P.H., Satasiya, R.M., Patel, D.V. and Shitap, M. (2022b). Cost economics of irrigation water management strategies for Sweet Corn (Zea mays L.), Multi-Logic in Sci., 12(43):49-52.

Rank, P.H., Satasiya, R.M., Vekariya, P.B., Limbasiya, B.B., Sardhara, V.K., Patel, R.J., Pandya P.A. and Mashru H.H. (2022c). Simulating the Water Footprints of Sweet Corn (Zea Mays L.) Under Various Irrigation Water Management Strategies Using AquCrop Model. Int. J. Modern. Engg. Tech. Sci., 04 (08): 1572-1581.

Rank, P.H., Unjia, Y.B. and Kunapara, A.N. (2019). Soil wetting pattern under point and line source of trickle irrigation. Int. J. Curr. Microb. Appl. Sci., 8 (07):785-792.

Rank, P.H., Vaghasiya, D.R., Lunagaria, M.M., Patel, R.J., Tiwari, M.K., and Rank, H.D. (2023b). Climate change impacts on water flux dynamics in Shingoda basin having agriculture and forest ecosystems: A comprehensive analysis. Journal of Agrometeorology, 25(3) : 397-403. DOI: https://doi.org/10.54386/jam.v25i3.2284

Rank, P.H., Vekariya, P.B. and Rank, H.D. (2020). Climate change impact on hydrologic system in Aji River Basin. Res. Biotica., 2 (2): 30-39.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 04/I/04/0124

Oryza coarctata : AN OUTSTANDING VISTA FOR SALINITY TOLERANCE

V. B. Rana[*] and Soumyanetra Saha

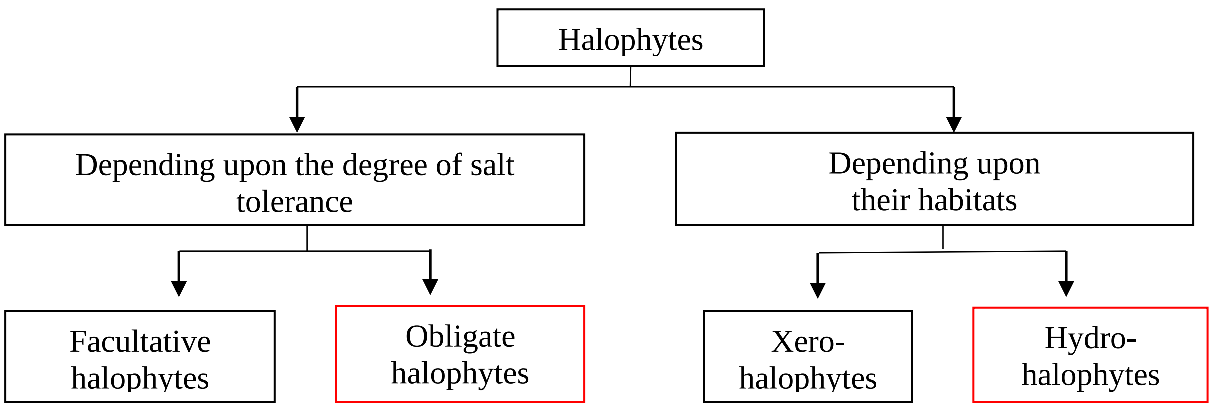
Ph.D. Research Scholar, Department of Genetics and Plant breeding, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat – 396 450, India.
Corresponding Email: 4849vasu@gmail.com

Abstract

Abiotic stressors brought on by climate change are one of the main obstacles to crop development and growth. The percentage of soil salinization has increased as a result of rising ocean levels and expanding irrigated areas, making soil salinity one of the main pressures to be concerned about. Precision breeding methods and biotechnology can be effectively applied to deal with this abiotic stress. To use this strategy, though, you must have the right genetic resources, such as salt stress-responsive genes that can be used to combat this stress. It is well recognized that wild relatives are a great source of these advantageous genes. The sole wild halophyte of the genus Oryza, *Oryza coarctata,* has unique anatomical, morphological, and physiological traits that enable it to tolerate salt levels of up to 40 ds/m. This plant's metabolites and their corresponding genes have been thoroughly studied in relation to their function in granting salt tolerance.

Introduction

Three main physiological reactions to salinity stress occur in plants: tissue tolerance to accumulated ions, ion exclusion, and osmotic adjustment. These imbalances cause a decrease in plant development and, in severe cases, may even cause cell death. This is due to the fact that salt stress hinders vital metabolic functions, cell division, ion accumulation, and necrosis of cells, which results in cell death, all of which impede plant growth. Salt-loving plants called halophytes may eliminate excess salt through salt glands by coordinating the activity of many genes. (Yu *et al.,* 2011).Halophytes are distinguished as below:



(Fig. 1: Classification of halophytes)

Oryza coarctata

- Among all the wild halophyticeoryza species, *Oryza coarctata* is the most exceptional since it is an obligatory halophyte of a wild rice species that can survive in both highly salinized and submerged environments.
- Family: *Poaceae*, Genus: *Oryza*
- Chromosome no.: 2n=4x=48
- Genome size 665 Mb (Mondal*et al.* 2017)
- C_3 Plant
- Locally called as 'Uri-dhan' in India
- Fruit type is caryopsis
- Seed is recalcitrant nature
- It can withstand saline water as high as 40 ds m^{-1}ECe

(Fig. 2: *Oryza coarctata*)

Botanical description

- *Oryza coarctata*is semi-aquatic as well as high tolerance nature.
- It is a perennial herb with a maximum height of 1 meter. The leaves have a linear shape with a short petiole and are leathery. The stems are prostrate, soft, green in color, coated in hair, and spherical.
- The leaves are waxy and succulent, and they lack a midrib, which helps to regulate the plant's relative water content by monitoring transpiration rate.
- The coriaceous leaf blades have two types of salt hairs: peg-shaped hairs on the bottom surface and finger-shaped hairs on the top surface. Each stomatal guard cell has two hairs.
- Every root node, which is heavily branching and located on the soil's surface, has rhizomes. It frequently generated pseudo-taproots up to a depth of one meter to withstand high intertidal flow, and from the tips of those pseudo-tap roots and the internodes of a vast underground stem known as a sobole, fibrous roots grow.
- Mature blooms are found on the top end of the spikelets that make up the inflorescence. It has been discovered that stomata made up glumes.
- The filament holds the six oblong-shaped, yellow anthers that are linked to the plant. The fruits are caryopsis-type and range in size from 0.5 to 1 cm. The ovaries are white in color. The embryo is big, has a brief life, and is resistant.

Salt hairs and salt exclusion

- In *O. coarctata*only two genes were related to microhair formation

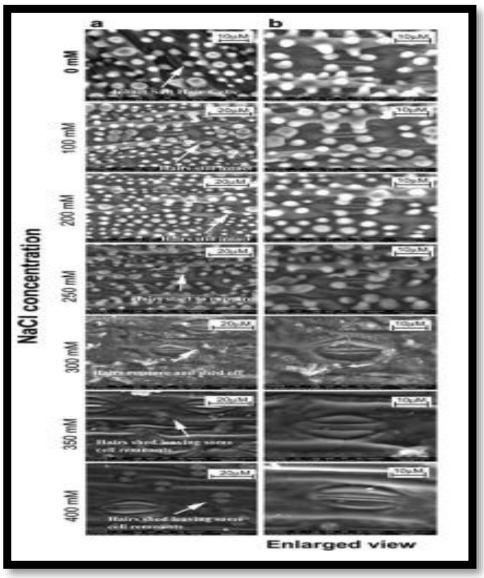
1. *Ocwax3b*
2. *HL6*

- *O. coarctata*have two types of hairs:

the upper surface hairs are finger-shaped which never rupture at high salt conc. whereas, lower surface hairs are peg-like which are swell, rupture, and collapse at high salt conc.

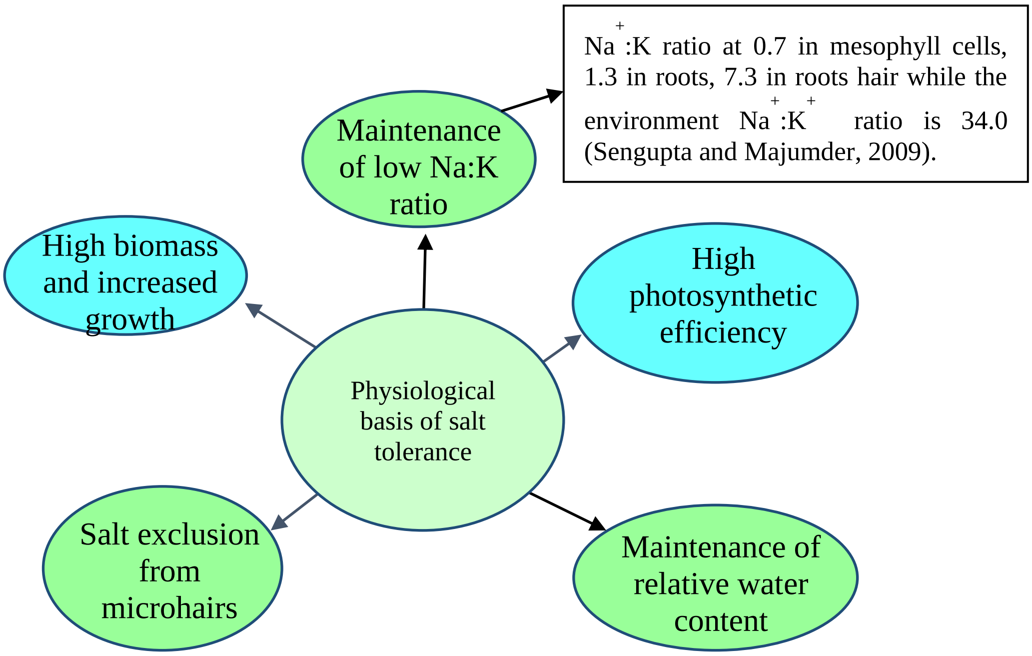
Table 1: NaCl concentration and hair condition

NaCl conc.	Hair condition
0 mM	Intact salt hair cells
100 mM	Hairs still intact
200 mM	Hairs still intact
250 mM	Hairs start to rupture
300 mM	Hairs rupture and shed off
350 mM	Hairs shed leaving some cell remnants
400 mM	Hairs shed leaving some cell remnants



(Fig. 3: NaCl conc. and hair condition)

Physiological basis of salt tolerance



(Fig. 4: Diagrammatic presentation of physiological basis of salt tolerance)

Molecular basis of salt tolerance

- **Ion homeostasis and ion compartmentalization:**
  - SOS pathway involved three gene *SOS1, SOS2, SOS3*
  - First Ca^{2+} binding protein directly active *SOS3* then *SOS3* recruits *SOS2* on the cell membrane and *SOS2-SOS3* complex phosphorylates *SOS1*, a Na^+/H^+ antiporter on cell membrane, which extrudes Na^+ out of the cell
  - Invovle*HKT1* (high affinity potassium transporter)

- The amino acid sequence of *OcNHX1* showed 96% similarity with rice NHX1 (*OsNHX1*). It performed more efficiently than *O. sativa.*

- **Different transporters involves in *O. coarctata*salt response**
  - Salinity stress conditions during signal received by salt sensor which present at plasma membrane of the cell then activated SOS pathway.
  - This components also activated different transporters.
  - Na^+/H^+antiporters (*OcSOS1*)
  - Non selective cation channel (*NSCC*)
  - K^+/ Na^+ Symporter (*OcHKT1*)
  - Vascuolar Na^+/H^+ exchangers (*OcNHX 1-4*)
  - Endosomal Na^+/H^+ exchanger (*OcNHX 5*)
  - H^+/Ca^+ antiporter (*OcCAX1*)
  - Vascuolar chloride channel (*OcCLC1*)

Conclusion

Even though African rice has a lot of potential, it is not currently being fully utilized for the advantage of rice consumers throughout the continent, particularly in sub-Saharan Africa (SSA), where very few nations have achieved rice production self-sufficiency. Research initiatives must concentrate on creating more intraspecific and interspecific breeding lines with the intriguing characteristics of African rice in order to overcome this difficulty. The current genomic revolution presents an opportunity for the African rice scientific community to better conserve and utilize existing variety, thus it should be seized. Utilizing the current genomics advances will require increased human, technological, and infrastructure capacity.

References

Yu G. Q., Bao Y and Shi C. H. (2011). Genetic diversity and population differentiation of Liaoning weedy rice detected by RAPD and SSR markers. Biochem Genet 43:261–270.

Mondal T. K., Rawal H. C. andGaikwad K. (2017). First de novo draft genome sequence of Oryza coarctata, the only halophytic species in the genus Oryza. F1000Research 6:1750.

Sengupta S., Patra B., Ray S. andMajumder A. L. (2009). Inositol methyl tranferase from a halophytic wild rice, PorteresiacoarctataRoxb. (Tateoka): regulation of pinitol synthesis under abiotic stress. Plant Cell Environ 31:1442–1458.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/05/0124

PROSPECTS OF BIOCHAR APPLICATION TO LOW-FERTILE SOILS

Sudarshan Varma[1*], Ravichandra[2] and Shilpa[3]

[1] Department of Soil Science, CoA, KSNUAHS, Shivamogga, Karnataka, India
[2]Department of Plant Pathology, CoA, KSNUAHS, Shivamogga, Karnataka, India
[3]Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi, India
*Corresponding Email: sudarshanvarma95@gmail.com

ABSTRACT

The utilization of biochar in addressing the challenges of low-fertility soils has garnered significant attention in agricultural research. This abstract explores the promising prospects of biochar application in such soils. Biochar, derived from the pyrolysis of organic materials, demonstrates remarkable potential in enhancing soil quality and agricultural productivity. Its unique properties, including high porosity and stability, contribute to improved water retention, nutrient availability, and microbial activity in low-fertility soils. Current research highlights biochar's ability to mitigate soil degradation, increase nutrient efficiency, and foster sustainable farming practices. Despite challenges related to variability in production methods and cost-effectiveness, ongoing studies focus on optimizing biochar's efficacy, tailoring its application to specific soil types, and evaluating its long-term impact on soil health. The future outlook for biochar application in low-fertility soils appears promising, signalling a pathway toward sustainable agricultural practices, soil restoration, and environmental stewardship.

Introduction

In the quest for sustainable agricultural practices, biochar has emerged as a promising solution to rejuvenate low-fertility soils. This black carbon-rich material, derived from the pyrolysis of organic waste, holds the potential to revolutionize farming by enhancing soil quality, improving crop yields, and mitigating environmental challenges. Let's delve into the current state of biochar application in low-fertility soils and its promising future prospects.

Understanding Biochar

Biochar, often referred to as "black gold," is a charcoal-like substance produced by heating organic biomass, such as agricultural residues, wood chips, or manure, in an oxygen-limited environment. This process, called pyrolysis, converts the biomass into a stable form of carbon, resistant to decomposition. The resulting biochar can retain moisture, nutrients, and microbial activity in the soil, fostering a conducive environment for plant growth.

Current Status of Biochar Application

Scientists and farmers worldwide have been experimenting with biochar application in diverse soil types to assess its impact on crop productivity and soil health. Studies reveal that incorporating biochar into low-fertility soils can significantly improve soil structure, water retention, and nutrient availability.

In regions with depleted soils or facing challenges like erosion, salinity, or nutrient depletion, biochar shows promise. Its porous structure acts as a sponge, holding water and nutrients, thereby reducing the need for frequent irrigation and fertilization. Moreover, biochar's high cation exchange capacity helps retain essential nutrients like nitrogen, phosphorus, and potassium, preventing leaching and making them more accessible to plants.

Furthermore, biochar enhances microbial activity in the soil, promoting the growth of beneficial microbes crucial for nutrient cycling and plant health. This, in turn, contributes to increased soil fertility and resilience against diseases.

Challenges and Future Prospects

Despite its numerous benefits, widespread adoption of biochar faces challenges. Factors like variability in biochar properties based on feedstock and pyrolysis conditions, cost-effectiveness, and scalability hinder its widespread application.

However, ongoing research focuses on optimizing biochar production methods, tailoring it to specific soil types and crops, and evaluating its long-term effects on soil health. Scientists are exploring innovative approaches like blending biochar with compost or other soil amendments to maximize its benefits.

Future prospects for biochar are promising. Its potential to sequester carbon in the soil for centuries could contribute significantly to mitigating climate change by reducing greenhouse gas emissions.

Conclusion

Biochar represents a promising solution for revitalizing low-fertility soils and promoting sustainable agriculture. While challenges persist, ongoing research and technological advancements offer hope for harnessing biochar's full potential. As we continue to explore its applications and refine production methods, biochar stands poised to play a pivotal role in building resilient, fertile soils for future generations.

By incorporating biochar into agricultural practices, we can foster a harmonious relationship between human activities and the environment, ensuring food security while preserving our precious natural resources.

References

Das, S.K., Ghosh, G.K. and Avasthe, R. (2020). Application of biochar in agriculture and environment, and its safety issues. *Biomass Conversion and Biorefinery*,1-11.

El-Naggar, A., Lee, S.S., Rinklebe, J., Farooq, M., Song, H., Sarmah, A.K., Zimmerman, A.R., Ahmad, M., Shaheen, S.M. and Ok, Y.S. (2019). Biochar application to low fertility soils: A review of current status, and future prospects. *Geoderma*, 337: 536-554.

Hossain, M.Z., Bahar, M.M., Sarkar, B., Donne, S.W., Ok, Y.S., Palansooriya, K.N., Kirkham, M.B., Chowdhury, S. and Bolan, N. (2020). Biochar and its importance on nutrient dynamics in soil and plant. *Biochar*, 2: 379-420.

Kandel, A., Dahal, S. and Mahatara, S. (2021). A review on biochar as a potential soil fertility enhancer to agriculture. *Archives of Agriculture and Environmental Science*, 6: 108-113.

Qian, S., Zhou, X., Fu, Y., Song, B., Yan, H., Chen, Z., Sun, Q., Ye, H., Qin, L. and Lai, C. (2023). Biochar-compost as a new option for soil improvement: Application in various problem soils. *Science of The Total Environment*, 870: 162024.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/06/0124

GEOGRAPHICAL INDICATIONS OF SOUTH INDIAN STATES IN AGRICULTURE SECTOR

Motukuduri Chanakya[1*], Tekkam Shirisha[2] and L. Raja[3]

[1]M.sc (Ag) Agricultural Economics,
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Naida , West Bengal, 741252.
[2] Ph.D scholar, Department of Vegetable Science,
Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India, 413722.
[3]Assistant Professor, Department of Agricultural Extension,
PJTS Agricultural University, Hyderabad, Telangana, 500030.
*Corresponding Email: chan051423@gmail.com

Introduction

Geographic Indication

The term "geographical indication" refers to a characteristic of industrial property that designates a country or an area within it as the country or place of origin of a certain good. Due mostly to its provenance in that specific geographic location, region, or nation, such a name typically carries an assurance of quality and uniqueness.

Products related to agriculture, cuisine, wine and spirit drinks, handicrafts, and industry are generally classified according to their geographic origin India boasts 417 registered Geographical Indication (GI) products, with 150 of them falling under the agriculture sector. . Notably, in the Telugu states, Guntur Sannam Chilli, Banaganapalli Mango, Araku Valley Arabica Coffee, and Tandur Redgram have been designated with GI tags.

Geographical indicators are protected as an aspect of intellectual property rights (IPRs) under Articles 1(2) and 10 of the Paris Convention for the Protection of Industrial Property. In addition, they fall under the purview of Articles 22 through 24 of the Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement, which was a component of the agreements that concluded the GATT Uruguay Round.

India's Geographical Indications of Goods (Registration & Protection) Act, 1999, was passed as a World Trade Organisation (WTO) member and went into effect on September 15, 2003.

Rights that give rise to a geographical indication

A geographical indication right gives the person allowed to use the indicator the ability to stop a third party whose product doesn't meet the relevant requirements from using it. For example, the producers of Darjeeling tea, for instance, are not permitted to use the term "Darjeeling" for tea that is not produced in their tea gardens or in accordance with the guidelines outlined in the code of practise for the geographical indication in jurisdictions where the Darjeeling geographical indication is protected.

It is not possible for the holder of a protected geographical indication to stop someone from producing a product using the same methods as described in the standards for that indication. Typically, obtaining ownership of the sign that makes up the indication is the first step towards obtaining protection for a geographical indicator.

Protection of Geographical Indications

There are **four** primary methods for safeguarding a geographical indication

1. Sui generis systems or specific regimes of protection
2. The use of collective or certification marks
3. Business practice-focused techniques, such as administrative product approval schemes
4. The application of unfair competition statutes.

Regarding significant issues like the terms of protection or the extent of protection, these views diverge. However, two of the defence mechanisms, sui generis systems and collective or certification marks. In general, geographical indicators are protected in many nations and regional systems utilising a wide range of strategies, frequently combining two or more of the previously mentioned strategies. These methods have been created within the confines of certain historical and economic contexts, as well as in compliance with certain legal traditions.

Validity of protection for geographical indications

A lot of sui generis laws do not place a time limit on the validity of geographical indication registrations. This implies that unless the registration is revoked, the protection afforded to a registered geographical indicator will not expire. Geographical indicators that are certified marks or registered as collectives are typically protected for ten years, renewing each time.

A protected geographical indicator is applicable to whom?

Producers within the designated geographic area who meet the product's unique production requirements are entitled to utilise a protected geographical indication.

LIST OF REGISTERED GEOGRAPHICAL INDICATIONS IN AGRICULTURE SECTOR OF SOUTH INDIAN STATES

S. No	Geographical Indications	Goods (As per Sec 2 (f) of GI Act 1999)	State
	FROM APRIL 2005 – MARCH 2006		
01	Coorg Orange	Agricultural	Karnataka
	FROM APRIL 2006 – MARCH 2007		
02	Mysore Betel leaf	Agricultural	Karnataka
03	Nanjanagud Banana	Agricultural	Karnataka
	FROM APRIL 2007 – MARCH 2008		
04	Mysore Malligae	Agricultural	Karnataka
05	Udupi Malligae	Agricultural	Karnataka
06	Hadagali Malligae	Agricultural	Karnataka
07	Navara Rice	Agricultural	Kerala
08	Palakkadan Matta Rice	Agricultural	Kerala
09	Malabar Pepper	Agricultural	India (Kerala, Karnataka & Tamilnadu)
10	Monsooned Malabar Arabica Coffee	Agricultural	India (Karnataka & Kerala)
11	Monsooned Malabar Robusta Coffee	Agricultural	India (Karnataka & Kerala)

S. No	Geographical Indications	Goods (As per Sec 2 (f) of GI Act 1999)	State
12	Alleppey Green Cardamom	Agricultural	India (Kerala & Tamilnadu)
13	Coorg Green Cardamom	Agricultural	Karnataka
FROM APRIL 2008 – MARCH 2009			
14	Eathomozhy Tall Coconut	Agricultural	Tamil Nadu
15	Pokkali Rice	Agricultural	Kerala
16	Nilgiri (Orthodox)	Agricultural	Tamil Nadu
17	Virupakshi Hill Banana	Agricultural	Tamil Nadu
18	Sirumalai Hill Banana	Agricultural	Tamil Nadu
FROM APRIL 2009 – MARCH 2010			
19	Vazhakulam Pineapple	Agricultural	Kerala
20	Devanahalli Pomello	Agricultural	Karnataka
21	Appemidi Mango	Agricultural	Karnataka
22	Kamalapur Red Banana	Agricultural	Karnataka
FROM APRIL 2010– MARCH 2011			
23	Guntur Sannam Chilli	Agricultural	Andhra Pradesh
24	Central Travancore Jaggery	Agricultural	Kerala
25	Wayanad Jeerakasala Rice	Agricultural	Kerala
26	Wayanad Gandhakasala Rice	Agricultural	Kerala
27	Byadagi Chilli	Agricultural	Karnataka
FROM APRIL 2011 – MARCH 2012			
28	Udupi Mattu Gulla Brinjal	Agricultural	Karnataka
FROM APRIL 2012 – MARCH 2013			
30	Madurai Malli	Agricultural	Tamil Nadu
31	Bangalore Blue Grapes	Agricultural	Karnataka
FROM APRIL 2013 – MARCH 2014			
32	Kaipad Rice	Agricultural	Kerala
FROM APRIL 2014 – MARCH 2015			
33	Chengalikodan Nendran Banana	Agricultural	Kerala
FROM APRIL 2017 – MARCH 2018			
34	Banaganapalle Mangoes	Agricultural	India (Telangana & Andhra Pradesh
35	Nilambur Teak	Agricultural	Kerala
FROM APRIL 2018 – MARCH 2019			
36	Coorg Arabica Coffee	Agricultural	Karnataka
37	Wayanaad Robusta Coffee	Agricultural	Kerala
38	Chikmagalur Arabica Coffee	Agricultural	Karnataka
39	Araku Valley Arabica Coffee	Agricultural	India (Andhra Pradesh & Odisha)

S. No	Geographical Indications	Goods (As per Sec 2 (f) of GI Act 1999)	State
40	Bababudangiris Arabica Coffee	Agricultural	Karnataka
41	Sirsi Supari	Agricultural	Karnataka
42	Erode Manjal (Erode Turmeric)	Agricultural	Tamil Nadu
43	Marayoor Jaggery (Marayoor Sharkara)	Agricultural	Kerala
FROM APRIL 2019 – MARCH 2020			
44	Kodaikanal Malai Poondu	Agricultural	Tamil Nadu
45	Gulbarga Tur Dal	Agricultural	Karnataka
46	Tirur Betel Leaf (Tirur Vettila)	Agricultural	Kerala
FROM APRIL 2021 – MARCH 2022			
47	Kuttiattoor Mango (Kuttiattoor Manga)	Agricultural	Kerala
48	Edayur Chilli	Agricultural	Kerala
49	Kanniyakumari Clove	Agricultural	Tamil Nadu
FROM APRIL 2022 – MARCH 2023			
50	Attappady Aattukombu Avara	Agricultural	Kerala
51	Attappady Thuvara	Agricultural	Kerala
52	Onattukara Ellu	Agricultural	Kerala
53	Kanthalloor Vattavada Veluthulli	Agricultural	Kerala
54	Kodungallur Pottuvellari	Agricultural	Kerala
55	Tandur Redgram	Agricultural	Telangana
56	Ramnathapuram Mundu Chilli	Agricultural	Tamil Nadu
57	Vellore Spiny Brinjal	Agricultural	Tamil Nadu
58	Authoor Vetrilai	Agricultural	Tamil Nadu
59	Cumbum Panneer Thratchai	Agricultural	Tamil Nadu
60	Indi Limbe	Agricultural	Karnataka
61	Sholavandan Vetrilai	Agricultural	Tamil Nadu
62	Kari Ishad Mango	Agricultural	Karnataka
FROM APRIL 2023 – MARCH 2024			
63	Kanyakumari Matti Banana	Agricultural	Tamil Nadu

GI TAGS OF TELUGU STATES

GUNTUR SANNAM CHILLI

The name of the chilli itself conveys two things: first, it describes the fruit, and second, it highlights the significant historical influence from Andhra Pradesh. In Telugu, the word Sannam signifies long or thin. There are believed to be at least four grades of Sannam chillies (Fig 01).

They are

- S.S. stands for Sannam Special, which is shiny, bright red, and at least 5 cm long.
- Sannam General, or S.G., has glossy skin, a light red colour, and measures three to five centimetres in length.
- Sannam Fair or S.F., is a 3 to 5 cm long, dull red, blackish-purple insect.
- Non-Specified (N.S.): This grade is not a regular one; rather, it is intended to satisfy some buyer criteria that conventional grades do not address.

Guntur Sannam Chilli's unique selling points include its extraction and derivation of capsaicin, as well as its use for its pungency.

Particulars of the Guntur Sannam Chilli

1. The long fruits, which range in length from 5 to 15 cm and in diameter from 0.5 to 1.5 cm, are indicative of the Capsicun Annum var longhum variety of chillies.
2. The chilli is red with an ASTA colour value of roughly 32.11; it has thick skin; it is fiery and pungent with an average pungency of 35,000 to 40,000 SHU.
3. The percentage of capsaicin is around 0.226%.
4. The best months to harvest are December through May. This chilli has a high protein content (11.98g/100g) and vitamin C content (185 mg/100g).

Fig 01

Fig 02

BANGANPALLI MANGO

The town in Andhra Pradesh's Kurnool District is named for the farmers who originally brought the mango variety to the area. Banaganapalli's Nawab promoted the fruit's cultivation. Because of its sweet, meaty pulp that lacks fibre, it is widely eaten as a table fruit around the world. It is mostly grown in the mandals of Kurnool District's Banaganapalli, Panyam, and Nandyal. Additionally, this cultivar is grown in the coastal and Rayalaseema regions. There is also cultivation in the districts of Khammam, Mahabubnagar, Rangareddy, and Medak in the state of Telangana. In 2017, the Geographical Indication registry awarded it a GI tag under the category of horticulture products. Another name for this is "King of Mangoes."

The Banaganapalli Mango (Fig 02) is unique in that it has a higher pulp content of 80% (small sized seed) and contains 80% water, which makes it juicier than other mangos. The appealing features include a large, oblique shape, fiber-free tasty meaty pulp, thin skin with light dots, and all of the above.

ARAKU VALLEY ARABICA COFFEE

Grown organically, Araku Valley Arabica Coffee (Fig 03) is renowned for its potent combination of flavour, energising scent, and purity. Through the "integrated coffee development project," tribal people in the Visakhapatnam district and Odisha cultivate coffee from the hilly regions. The tribespeople employ green, organic manures and use organic pest control techniques. In April 2016, the AP government's Girijan Cooperative Corporation, which is in charge of marketing Araku

Valley Coffee, submitted an application for a GI tag at the Chennai-GI registry, and in 2019 it was granted one.

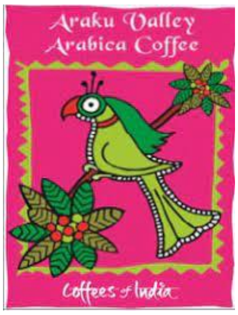


Fig 03

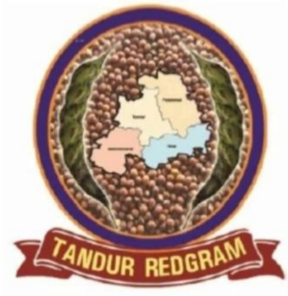


Fig 04

TANDUR RED GRAM

The rain-fed tract of Tandur and the surrounding areas of Telangana are the main growing grounds for this native type of pigeon pea, also known as Tur dal. More than two years have passed since the Yalal Farmers Producer Company Ltd. submitted an application in September 2020 for the Tandur redgram's (Fig 04) GI registration. Prof. Jayashankar Telangana State Agricultural University assisted with the GI registration process. The rich, dark, fertile soil that is particularly rich in Attapulgite clay mineral deposits.

Particular qualities of Tandur red gram include

Good taste, improved cooking quality, and improved storage quality, protein content of roughly 22–24%, about three times that of cereals.

Conclusion

"The GI certification will allow our agricultural products be specifically identifiable with their unique quality qualities, which is a good development. It will also increase the likelihood that our native or local brand products will receive the best possible value and pricing.

References

Controller General of Patents, Designs, and Trade Marks: https://ipindia.gov.in/registered-gls.html

The World Intellectual Property Organization official website: https://www.wipo.int/portal/en/index.html

Wikipedia website: https://en.wikipedia.org

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 04/I/07/0124

FIELD DIAGNOSIS OF MAJOR NEMATODE PROBLEMS IN RICE

Gayatri B*, Kiran Gandhi B, Shyam C S, B B Panda
ICAR-NRRI- Regional Coastal Rice Research Station, Srikakulam, Andhra Pradesh-532186
*Corresponding Email:bandaru.gayatri@gmail.com

Introduction

Nematodes are the most abundant multi-cellular invertebrates on earth. They occupy every habitable niche on the planet and can inhabit in both fresh and marine waters. Nematodes belong to different categories like free-living, plant feeding, invertebrate and vertebrate parasitic nematodes of which plants and vertebrates parasites holds major importance because of the risk they pose to plant and animal health. Plant parasitic nematodes (PPNs) inhabit in soil, mainly feeding on plant roots (except for foliar nematodes) causing serious root damage, accounting for yield reduction in annual and perennial crops. Rice is an important food crop in India and it is attacked by a number of root and foliar nematodes causing yield loss ranging from 10-25%. Major PPNs infecting rice are Rice root knot nematode (*Meloidogyne graminicola*), Rice root nematode (*Hirschmaniella spp.*), white tip nematode (*Aphelenchoides besseyi*) and Rice stem nematode (*Ditylenchus angustus*). Lesion nematodes (*Pratylenchus spp.)* Spiral nematodes (*Helicotylenchus spp.*) and Rice cyst nematodes (*Heterodera oryzicola*) are other PPNs infecting rice with minor importance. Nematode-infected plants commonly exhibit yellowing and stunned growth in patches. These symptoms are commonly misinterpreted as nutrient deficiencies and goes unnoticed which leads to further spread of infection to new areas. Hence it is necessary for creating awareness on symptoms exhibited by plants upon nematode infection for timely management and to avoid further spreading of nematodes to new areas. Some important PPNs infecting rice, their field symptoms and management are discussed below.

Rice root knot nematode (*Meloidogyne graminicola*, Golden & Birch field 1968)

Root knot nematodes are a major problem in rice which is grown both under upland and irrigated conditions. It is prevalent in major rice growing states of India where rice is grown as sole crop and also in rice-wheat cropping systems. Typical symptoms caused by this nematode infection include the formation of hook-shaped gall sat tips of young roots which hampers the nutrient uptake by plants. Other host crops include wheat, onion, banana, finger millet and weeds *Echinochloa colona*, *E. crusgalli*, *Cyperus compressus*, *C. rotandus* and other monocot hosts. This nematode infects rice both under nursery and main fields and can cause a yield loss ranging from 17 to 32%. Infected rice plants show typical yellowing, stunting, with reduced tiller numbers, and delayed maturation in patches under field conditions (Fig.1.B). When plants are uprooted and observed, typical hook shaped galls can be seen on roots (Fig.1.A).

A-Hook shaped galls on roots, B- Stunted plants in patches

Fig.1 : Symptoms caused by rice root knot nematode, *Meloidogyne graminicola*

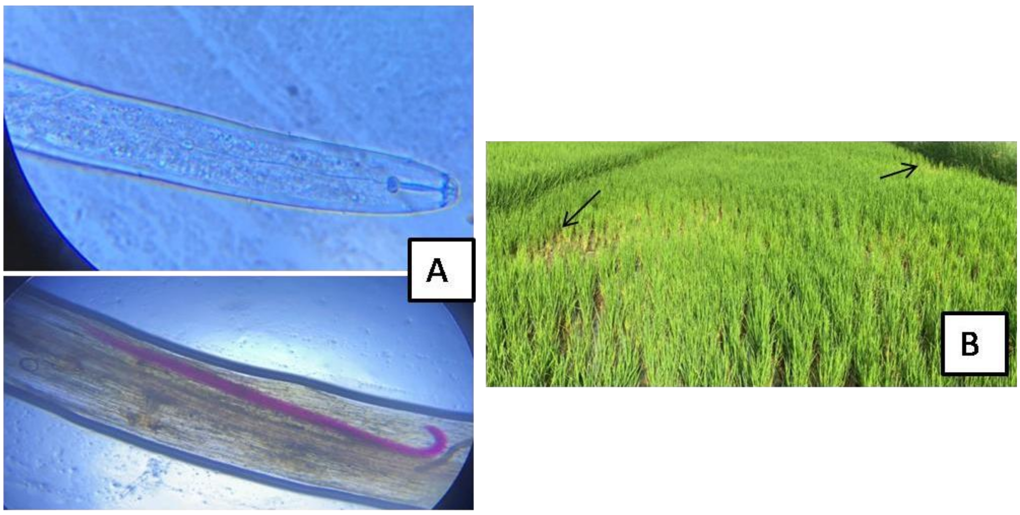
ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Management:

1. Soil solarization and deep summer ploughing reduces the nematode numbers in soil thereby reducing the nematode load on next crop.
2. Crop rotation with non-host crops like black gram, green gram, sesame, mustard reduces nematode numbers in soil.
3. Removal of alternate weed hosts from fields which harbor nematodes in absence of rice crop.
4. Application of bio-control agents *Trichoderma spp.*, *Pseudomonas fluroscences*, nematophagus fungi, *Paecilomyces lilacinus* @ 2-3 ml/litre to reduce root infection by nematodes.
5. Chemical treatment with carbofuran3G@100mgai/m^{2}nurseryareaand field application @ 1kg ai/ha will minimize soil nematode population.

Rice root nematode, (*Hirschmaniella spp.*)

Rice root nematodes are important plant parasitic nematodes in irrigated rice and can survive prolonged submerged conditions. They are reported from irrigated rice and rice grown under semi-deep water and deep water conditions. *Hirshmaniella oryzae* and *H. mucronata* are common species found in rice fields under Indian conditions. Direct sown irrigated rice is more prone to damage than the transplanted rice crop. As this nematode is a migratory endoparasite, it feeds on root cortex by moving inter-cellularly inside the root system. Adult and juveniles stages are parasitic and readily infect rice. Other host crops are wheat, okra, tomato, cotton, sugarcane and weeds like *Echinocloa crusgalli*, *Cyperus rotandus, Eclipta prostrata, Echicornia crassipes, Eleocharis spiralis, Fimbristylis ferruginea, Ludwigia perennis* etc. Nematode infected roots show brown necrotic lesions on roots which act as entry points for other soil-borne pathogens. Heavy infestation leads to death of younger plants and yellowing and stunting in mature plants under field conditions in patches (Fig.2.B). They are also adapted to survive on rice stubbles in dormant condition (anhydrobiosis) until the arrival of favorable conditions for revival.



A-Nematodes inside rice roots, B- Yellowing and stunting of plants in patches

Fig.2 Rice root nematode, *Hirschmaniellaspp.* Infected rice field

Management:

1. Soil solarization and deep summer ploughing reduces the nematode numbers in soil.
2. Removal of weed hosts from infected fields which harbor nematodes during off season.
3. Application of carbofuran 3G@1kgai/ha will reduce the nematode population in soil.

White tip nematode, (*Aphelenchoides besseyi*, Cristie1942)

Aphelenchoides besseyi is a foliar nematode majorly feeding on aerial parts of plant. It causes white tip disease in rice. It is distributed in all major rice growing states of the India. It is a seed borne nematode, where infection starts and spreads through seed. After germination of seed, Nematodes revive from dormant condition and move to the growing leaf tips for feeding which causes whitish tip which further turns brown and necrotic (Fig. 3.A). Later they migrate to the emerging panicle, enter the spikelets feeding on developing embryo, stamens, and lodicules. After the grains are formed, they become dormant inside the seed and can survive in this state for 3 years. When the infected seed is sown, nematodes will revive and infect a new host which leads to further spread of infection. Apart from rice, other host crops are strawberry, tuberose, onion, garlic and other grassy weeds. The infected plants show white leaf tips which will dry eventually. Infected plants show poor growth with deformed flag leaf and panicle (Fig. 3.B & Fig. 3.C).

A-Infection at seedling stage, B-Deformed flag leaf, C-Deformed panicle due to nematode feeding

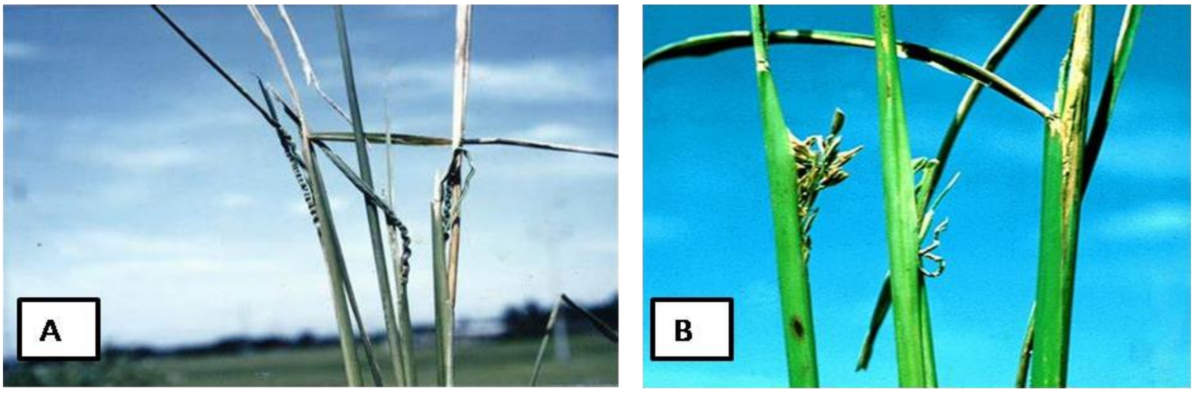
Fig.3 : Rice crop infected by whitetip nematode, *Aphelenchoides besseyi*

Management:

1. Pre-soaking the seed and hot water treatment @52-53ºC for 15minutes will kill nematodes in seed.
2. Destroy infected plants and avoid mixing of infected seed with healthy seed.
3. Chemical treatment with Carbofuran3G @ 1 kg ai/ha in nursery one week prior to transplanting minimize nematode load on main crop.

Rice stem nematode (*Ditylench usangustus*, Butler 1913, Filipjev 1936)

Rice stem nematode is a major problem in semi deep water and deep water rice. It infects cultivated and wild rice species and also grassy weeds. It feeds on developing leaves near leaf sheath, developing panicles and seeds. Major symptoms under field conditions include appearance of yellow colour streak on older leaves with leaf distortion (Fig.4.A). Panicles show crinkled appearance with boot leaf enclosing the panicle (swollen ufra) or panicle partially emerged out of boot leaf (ripe ufra) (Fig.4.B) with only few filled grains.



Source: CABI PlantwisePlus Knowledge Bank

A- Crinkled leaves, B- Partial emergence of panicle from boot leaf

Fig.4 Symptoms of infection by Rice stem nematode, *Ditylenchus angustus*

Management:

1. Removal and destruction of infected plant material, which is a major source of infection, reduce nematode population on next season crop.
2. Avoiding transfer of planting material from endemic areas to new areas.
3. Application of carbofuran3G @ 1kg ai/ha helps in minimizing nematode population.

Acknowledgement

The images of symptoms caused by rice stem nematode included in the current manuscript were sourced from CABI plant wise plus knowledge bank website (https://www.cabi.org/publishing-products/plantwise-knowledge-bank)

References

Khan, M. R., Haque, Z., Ahamad, F., & Shah, M. H. (2023). Nematode problems in rice and their sustainable management. In *Nematode Diseases of Crops and their Sustainable Management* (pp. 133-166). Academic Press.

Berliner, J., Pokhare, S.S., Mishra,C.D., Sahu, S.C., & Prakash, A.(2014).Rice nematodesand their management. *NRRI Tech. bulletin* 104

Kyndt, T., Fernandez, D., & Gheysen, G. (2014). Plant-parasitic nematode infections in rice: molecular and cellular insights. *Annual review of phytopathology*, *52*, 135-153.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/08/0124

DIGITAL TECHNOLOGIES FOR DISEASE MONITORING IN GREENHOUSE FLORICULTURE

Kottam Sushma[1*], K. Gopal[2] and Malepati S N V S Sripriya Bhargavi
[1,2]Department of Plant Pathology, Dr. YSRHU, CoH- Anantharajupeta-516105
[3]Ph.D Scholar, Department of Floriculture, TNAU, Coimbatore-641003
*Corresponding Email: sushmakottam1927@gmail.com

Abstract
This abstract explores the integration of digital technologies for disease monitoring in greenhouse floriculture. Leveraging sensors, data analytics, and Internet of Things (IoT) devices, the system provides real-time insights into environmental conditions affecting plant health. Continuous monitoring enables early detection of diseases, optimizing resource utilization and minimizing crop loss. The synergy of advanced technologies enhances precision in disease prediction, offering growers proactive strategies for mitigation. This study showcases the transformative potential of digital solutions in greenhouse floriculture, paving the way for sustainable and efficient disease management practices that contribute to the overall productivity and resilience of the industry.

Introduction

Greenhouse floriculture plays a crucial role in meeting the growing global demand for ornamental plants, cut flowers, and potted plants. However, the controlled environment of greenhouses also creates favorable conditions for the development and spread of plant diseases. Early detection and effective monitoring are essential for disease management in greenhouse settings. In recent years, the integration of digital technologies has revolutionized disease monitoring, providing growers with advanced tools for proactive and precise management. This paper explores the use of digital technologies for disease monitoring in greenhouse floriculture, emphasizing their significance, challenges, and potential for enhancing sustainability.

Digital Technologies in Disease Monitoring

Sensor Networks

Sensor networks are deployed within greenhouses to monitor environmental parameters such as temperature, humidity, and light intensity. These data points contribute to the creation of predictive models that can forecast disease outbreaks based on optimal conditions for pathogen proliferation. Advanced sensors can even detect subtle changes in plant physiology, providing early indicators of stress or infection.

Remote Sensing and Imaging

Remote sensing technologies, including drones and satellite imagery, offer a bird's-eye view of the greenhouse, enabling rapid assessment of plant health and disease prevalence. High-resolution images can be analyzed using machine learning algorithms to identify specific symptoms associated with diseases, allowing for quick and accurate diagnosis.

Data Analytics and Decision Support Systems

The integration of data analytics and decision support systems helps growers make informed decisions based on real-time and historical data. Predictive analytics models can assess the risk of disease outbreaks, recommend appropriate interventions, and optimize resource utilization. These systems empower growers to implement targeted control measures, reducing the reliance on broad-spectrum pesticides.

Challenges and Considerations

Data Security and Privacy

The increased reliance on digital technologies raises concerns about data security and privacy. Protecting sensitive information, such as crop health data and greenhouse layouts, is crucial to prevent unauthorized access and potential misuse.

Integration with Traditional Practices

While digital technologies offer advanced monitoring capabilities, their successful integration with traditional disease management practices is essential. Growers need to adapt to and trust these technologies as valuable complements to their existing knowledge and experience.

Cost Considerations

The initial investment in digital technologies can be a barrier for some growers, particularly small-scale operations. However, the long-term benefits, including improved disease management and resource efficiency, often outweigh the upfront costs.

Potential for Sustainability

The incorporation of digital technologies into greenhouse floriculture holds immense potential for promoting sustainability:

Reduced Chemical Inputs

Precise monitoring allows for targeted interventions, minimizing the need for broad-spectrum chemical treatments. This reduction in chemical inputs aligns with sustainable farming practices, promoting environmental health and reducing the ecological impact of greenhouse operations.

Optimized Resource Utilization

Data-driven decision-making enables efficient use of resources, such as water and energy, contributing to the overall sustainability of greenhouse operations. Smart irrigation systems, informed by real-time environmental data, can significantly reduce water wastage.

Early Detection and Rapid Response

The ability to detect diseases at an early stage facilitates prompt action, preventing the spread of pathogens and minimizing crop losses. This proactive approach is a key component of sustainable agriculture, fostering resilience in greenhouse floriculture.

Conclusion

Digital technologies are transforming disease monitoring in greenhouse floriculture, offering growers unprecedented capabilities to monitor, diagnose, and manage plant diseases. Despite challenges, the potential benefits in terms of sustainability, resource efficiency, and improved disease control make the integration of these technologies a worthwhile investment for the future of greenhouse floriculture. As technology continues to advance, growers can look forward to even more sophisticated tools that enhance the resilience and productivity of their operations.

References

TraversariS,Cacini S,Galieni A, Nesi B, Nicastro N and Pane C (2021). Precision Agriculture Digital Technologies for Sustainable Fungal Disease Management of Ornamental Plants. Sustainability.13:3707.

Pekkeriet E. J, Van Henten E. J and Campen J B (2015). Contribution of innovative technologies to new developments in horticulture. Acta Hortic.1099:45-54.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 04/I/09/0124

SCOPES OF ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES FOR ENGINEERING THE AGRICULTURE

R. J. Patel[1], P. H. Rank[2], Deepak Kumar[3] and P. B. Vekariya[4]

[1,4]Department of Irrigation and Drainage Engineering, College of Agricultural Engineering & Technology, Junagadh Agricultural University, Junagadh-362001. Gujarat State, India.
[2]Department of Irrigation and Drainage Engineering, College of Agricultural Engineering & Technology, Junagadh Agricultural University, Junagadh – 362001. Gujarat State, India.
[3]Department of Agricultural Engineering, School of Agriculture, GIET University, Gunupur, Odisha – 765022, India.
*Corresponding Email: prasangpatel83@gmail.com

ABSTRACT

This article explores the expansive horizons of Artificial Intelligence (AI) in revolutionizing agricultural practices. Examining the integration of AI-based technologies, it delves into precision farming, crop monitoring, and predictive analytics, showcasing their potential to optimize yields and mitigate challenges such as climate change and resource scarcity. The discussion extends to autonomous machinery, elucidating how AI-driven technologies streamline operations and enhance productivity. The article emphasizes the role of AI in resource management, water conservation, and knowledge dissemination, presenting a comprehensive outlook on its applications in engineering sustainable and efficient agricultural systems. As AI continues to advance, its multifaceted contributions to precision, productivity, and sustainability make it a key player in shaping the future of agriculture.

INTRODUCTION

The agricultural sector grapples with myriad challenges, including population growth, climate change, and resource shortages (Kelaiya and Rank, 2019; Kumar and Rank, 2021; Rank et al., 2020; Kumar and Rank, 2023). Efficient water use, particularly in water-scarce regions where 80% of India's freshwater is allocated to agriculture, is vital (Paghadal et al., 2019a). Strategic land management is equally crucial for productivity and sustainable water resource management (Patel and Rank, 2020; Vekariya et al., 2022; Patel et al., 2023a, b; Rank et al., 2023b; Vekariya et al., 2023). Amid a growing population, technological interventions in land and water management are imperative for enhanced productivity (Rank et al., 2019; Rank et al., 2022a, b, c; Rank and Satasiya, 2022; Rank and Vishnu, 2019, 2021a, b, 2023c). Addressing these challenges is crucial for global food security, and the adoption of Artificial Intelligence (AI) emerges as a transformative solution, promising climate resilience, improved productivity, pest control, streamlined supply chains, and ethical development across the agricultural value chain.

1. Scopes, Limitations, Advantages, and Disadvantages of AI Technologiesfor engineering the agriculture Sector

The scopes, limitations, advantages, and disadvantages of AI applications in various fields of Agriculture are described in the subsequent heads.

1.1Soil and Water Conservation

Scope:

- AI-powered sensors can monitor soil moisture, nutrient levels, and erosion risks, enabling farmers to implement targeted conservation practices.

- AI models can predict water infiltration and runoff rates, aiding in designing effective drainage systems.
- Machine learning algorithms can analyze satellite imagery to identify areas prone to desertification and develop strategies for land restoration.

Limitations:
- Soil data collection and management can be complex and expensive.
- AI models for complex soil processes still require further development and validation.
- Lack of standardization in data formats and connectivity can hinder information sharing and collaboration.

Advantages:
- Improved water management leading to reduced water use and increased crop yields.
- Reduced soil erosion and improved soil health for sustainable agriculture.
- Enhanced resilience against droughts and other extreme weather events.

Disadvantages:
- Initial investment in sensors, data infrastructure, and AI software can be high.
- Reliance on AI models could lead to reduced knowledge and skills in traditional conservation practices.
- Potential for data bias and inaccurate predictions if models are not properly trained.

1.2 Irrigation and Drainage Management

Scope:
- AI-powered irrigation systems can optimize water delivery based on real-time soil moisture data, ensuring efficient water use and minimizing waste.
- Machine learning algorithms can analyze historical weather data to predict evapotranspiration rates and develop dynamic irrigation schedules.
- AI models can identify areas with inefficient drainage systems and suggest targeted improvements.

Limitations:
- Integration of AI systems with existing irrigation infrastructure can be challenging and require retrofitting.
- Lack of reliable internet connectivity in rural areas can hinder real-time data transmission and control.
- Cybersecurity risks need to be addressed to protect sensitive data from unauthorized access or manipulation.

Advantages:
- Increased water use efficiency leading to reduced water costs and increased profitability.
- Improved crop yields and quality due to optimal water management.
- Reduced environmental impact of agriculture through minimized water wastage and pollution.

Disadvantages:
- High initial investment in AI-powered irrigation systems and infrastructure upgrades.
- Dependence on technology could lead to neglect of traditional knowledge and skills in irrigation management.
- Potential for data breaches and manipulation if cybersecurity measures are inadequate.

1.3Farm Mechanization

Scope:

- AI-powered robots can automate tasks such as weeding, harvesting, and sorting produce, reducing labor costs and improving efficiency.
- Machine learning algorithms can analyze machine performance data to predict potential failures and schedule preventive maintenance, minimizing downtime and costs.
- AI models can optimize route planning and navigation for autonomous agricultural vehicles, leading to increased efficiency and productivity.

Limitations:

- High initial investment in robotic equipment and development of AI algorithms.
- Concerns about job displacement for agricultural workers due to automation.
- Regulatory frameworks for autonomous vehicles in agriculture still need to be developed.

Advantages:

- Reduced labor costs and improved efficiency in agricultural operations.
- Increased productivity and output due to automation and precision tasks.
- Improved working conditions for agricultural workers by reducing exposure to hazardous tasks.

Disadvantages:

- Potential for job displacement and negative impact on rural communities.
- High dependence on technology and potential vulnerabilities to software errors or malfunctions.
- Ethical considerations regarding animal welfare in automated livestock farming practices.

1.4 Agricultural Product Processing, Value additions and Food

Scope:

- AI-powered systems can analyze agricultural produce to determine optimal processing parameters for maximizing quality and yield.
- Machine learning algorithms can predict shelf life and detect spoilage risks in food products, reducing waste and ensuring food safety.
- AI models can optimize processing lines and packaging systems for improved efficiency and reduced costs.

Limitations:

- Data collection and analysis for food quality and safety require specialized expertise.
- Development and training of AI models for complex food processing systems can be expensive and time-consuming.
- Integration of AI systems with existing food processing infrastructure may require modifications and upgrades.

Advantages:

- Increased value addition to agricultural products through improved quality and shelf life.
- Reduced food waste and spoilage losses due to real-time monitoring and predictive analytics.
- Enhanced food safety and traceability through AI-powered quality control systems.

Disadvantages:

- High initial investment in AI-powered systems and integration with existing infrastructure.
- Potential for bias in AI models leading to unfair pricing or rejection of certain agricultural products.

- Ethical considerations regarding consumer acceptance and transparency of AI-powered food processing technologies.

1.5Renewable Energy for farming

Scope:
- AI-powered systems can optimize the design and operation of solar panels, wind turbines, and other renewable energy sources for agricultural applications.
- Machine learning algorithms can predict energy generation potential and manage energy usage efficiently across agricultural facilities.
- AI models can help farmers make informed decisions about adopting and integrating renewable energy solutions into their operations.

Limitations:
- Initial investment in AI-powered systems and renewable energy infrastructure can be high.
- Lack of awareness and knowledge about renewable energy technologies among farmers.
- Regulatory barriers and complex permitting processes for installing renewable energy systems.

Advantages:
- Reduced reliance on fossil fuels and greenhouse gas emissions.
- Increased energy independence and resilience for agricultural operations.
- Lower energy costs and improved profitability for farms.

Disadvantages:
- High initial investment can be a barrier for small-scale farmers.
- Dependence on weather conditions for renewable energy generation.
- Potential for negative environmental impacts from improper disposal of solar panels and wind turbine blades.

CONCLUSION

The exploration of Artificial Intelligence (AI) in the context of agriculture reveals a transformative landscape marked by innovation and efficiency. The article has navigated through the diverse applications of AI, from precision farming and crop monitoring to predictive analytics and autonomous machinery. The potential of AI in addressing challenges such as climate change, resource scarcity, and labor limitations is evident, promising a sustainable and resilient future for agriculture. As we embrace these technological advancements, it becomes clear that AI is not merely a tool but a catalyst for engineering smarter, more efficient agricultural practices. The synergy between AI and agriculture is poised to usher in a new era, where precision, productivity, and sustainability converge to meet the evolving demands of our global food ecosystem. The journey towards AI-driven agriculture is an exciting trajectory, with the potential to redefine our approach to food production and ensure a flourishing, resilient agricultural landscape for generations to come.

REFERENCES

Kelaiya, J., Rank, P.H., (2019). Assessment of water balance components of bhadar river basin using SWAT model. International Journal of Bio-resource and Stress Management **10**(2), 181–184.

Kumar, D. and Rank, P. H. (2023). Estimation of crop evapotranspiration and crop coefficient for coriander using portable automatic closed canopy chamber. Journal of Agrometeorology, **5**(4):547-552.DOI: https://doi.org/10.54386/jam.v25i4.2315

Kumar, D., Rank, H.D. (2021). Comparison of Fenugreek Crop Evapotranspiration Measured by a Micro-lysimeter, Field Water Balance Method and Automatic Closed Canopy Chamber. *International Journal of Agriculture, Environment and Biotechnology,* **14**(1): 29-49.

Paghadal, A. M. Rank, H. D., Prajapati, G. V. Rank, P. H., Pipaliya, P. S., Pipaliya, J. S. (2019a). The Trend Analysis of Various Components of Water Resources System of Ozat River Basin, Gujarat, India. Int. J. Curr. Microbiol. App. Sci., **8**(11), 241-267. https://www.researchgate.net/publication/362948568_The_Trend_Analysis_of_Various_Components_of_Water_Resources_System_of_Ozat_River_Basin_Gujarat_India. DOI: https://doi.org/10.20546/ijcmas.2019.811.030

Paghadal, A. M., Rank, P. H., Rank, H. D., Limbasiya, B. B., Vekariya, P. B., Vadar, H R. (2019b). Modelling and Simulating the Groundwater Level Behavior to Climate Change for the Ozat Basin., Int. J. Curr. Microbiol. App. Sci 8 (10), 1156-1165. DOI: 10.20546/ijcmas.2019.810.135

Patel RJ, Rank HD (2020) Water use efficiency of wheat under different irrigation regimes using high discharge drip irrigation system, AgricEngg Today **44**(2):19-31 Patel RJ (2019) Laboratory and field manual on irrigation engineering. Scientific Publishers Patel RJ, Rank HD, Ajudiya BH, Dhanani NV (2014) An assessment of ground water recharge potential through tube well, International Journal of Engineering Research & Technology **3**(10):155-160.

Patel RJ, Rank PH, Vekariya PB, Vadar HR, Parmar HV, Rank HD, Damor PA, Modhvadiya JM (2023a) Study on physicochemical properties of clay loam soil of Junagadh region, International Research Journal of Modernization in Engineering Technology and Science **05**(06):3912-3919 https://www.doi.org/10.56726/IRJMETS42550.

Patel, R. J., Rank, P. H., Vekariya, P. B., Rank, H. D., Vadar, H. R., Parmar, H. V., and Lunagaria, M. M. (2023b). Enhancing Wheat (Triticumaestivum L.) Crop Yield and Water Use Efficiency: A Study on Canopy Air Temperature Difference-Based Drip Irrigation Scheduling in a Semi-Arid Region of Western India. DOI: https://doi.org/10.21203/rs.3.rs-3376468/v1

Vekariya, P. B., Rank, H. D., Patel, R. J. and Rank, P. H. (2022). Studies on Open Well Recharge Techniques for Junagadh Region. International Research Journal of Modernization in Engineering Technology. 04(08): 354-362. https://www.researchgate.net/publication/363262672_STUDIES_ON_OPEN_WELL_RECHARGE_TECHNIQUES_FOR_JUNAGADH_REGION#fullTextFileContent

Vekariya, P.B., Patel, R. J., Rank, P. H., Modhvadiya, J. M., Rank.H. D. (2023). Connector well recharge techniques for junagadh region. International Research Journal of Modernization in Engineering Technology and Science. **5**(9): 385-397. https://www.irjmets.com/uploadedfiles/paper/issue_9_september_2023/44526/final/fin_irjmets1694165214.pdf

Rank, P. H., Rank, H. D., Vekariya, P. B. Patel, R. J. and Kar, G. (2022a). Effectiveness of gaussian distribution mapping for bias correction of rcm simulated temperature for junagadh region. International Research Journal of Modernization in Engineering Technology and Science, 04(11): 160-175 DOI: 10.56726/IRJMETS31007

Rank, P.H. and Satasiya, R.M. (2022). Sweet corn crop (Zea mays L.) performance under various irrigation water management strategies. J. Pharm. Innov., **11** (6):1525-1531.

Rank, P.H. and Vishnu, B. (2019). Automation of pulsed drip irrigation. Int. J. Engg. Sci. Comp., **9** (7): 23265-23276.

Rank, P.H. and Vishnu, B. (2021a). Design concept of pulse drip irrigation, Int. J. Modern. Engg. Tech. Sci., **03**(12): 414-420.

Rank, P.H. and Vishnu, B. (2021b). Pulse drip irrigation: A review. J. Pharmacognosy and Phytochemistry.,**10** (1): 125-130.

Rank, P.H. and Vishnu, B., (2023). Validation of Models for Simulating the Soil Moisture Characteristics. Agric. Sci. Dig., **43** (2):157-163.

Rank, P.H., Satasiya, R.M., Limbasiya, B.B., Parmar, H.V. and Prajapati, G.V. (2023a). Sweet corn crop yield response to aerated drip irrigation under various irrigation water management strategies, Emer. Life. Sci. Res., **9**(1):10-21. DOI: https://doi.org/10.31783/elsr.2023.911021

Rank, P.H., Satasiya, R.M., Patel, D.V. and Shitap, M. (2022b). Cost economics of irrigation water management strategies for Sweet Corn (Zea mays L.), Multi-Logic in Sci., **12**(43):49-52.

Rank, P.H., Satasiya, R.M., Vekariya, P.B., Limbasiya, B.B., Sardhara, V.K., Patel, R.J., Pandya P.A. and Mashru H.H. (2022c). Simulating the Water Footprints of Sweet Corn (Zea Mays L.) Under Various Irrigation Water Management Strategies Using AquCrop Model. Int. J. Modern. Engg. Tech. Sci., **04** (08): 1572-1581.

Rank, P.H., Unjia, Y.B. and Kunapara, A.N. (2019). Soil wetting pattern under point and line source of trickle irrigation. Int. J. Curr. Microb. Appl. Sci., **8** (07):785-792.

Rank, P.H., Vaghasiya, D.R., Lunagaria, M.M., Patel, R.J., Tiwari, M.K., and Rank, H.D. (2023b). Climate change impacts on water flux dynamics in Shingoda basin having agriculture and forest ecosystems: A comprehensive analysis. Journal of Agrometeorology, **25**(3) : 397-403. DOI: https://doi.org/10.54386/jam.v25i3.2284

Rank, P.H., Vekariya, P.B. and Rank, H.D. (2020). Climate change impact on hydrologic system in Aji River Basin. Res. Biotica., **2** (2): 30-39.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/10/0124

EPIGENOME EDITING: DYNAMICS OF GENOME EDITING BEYOND DNA SEQUENCE

Soumyanetra Saha[*] and V. B. Rana

Ph.D. research scholar, Department of Genetics and Plant Breeding,
N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat-396450
*Corresponding Email: netrasaha@gmail.com

Abstract

The term "epigenome editing" describes the targeted modification of chromatin marks at particular genomic loci by the use of targeted EpiEffectors, which are made up of catalytic domains from a chromatin-modifying enzyme and tailored DNA recognition domains (such as zinc finger, TAL effector, or modified CRISPR/Cas9 complex). With numerous applications in fundamental research, such as the examination of the regulatory roles and logic of chromatin changes and cellular reprogramming, epigenome editing is a promising strategy for long-term gene regulation. Targeted regulation of genes associated with disease presents new treatment opportunities for numerous disorders, as seen from a clinical perspective. Here, we summarize the developments in this area and talk about future directions in targeted EpiEffector administration, strategies to improve the specificity of epigenome editing, and remaining questions in epigenetic regulation and stability.

Introduction

What is epigenome editing?

Within an organism with multiple cells, all of the cells' genetic information is nearly identical. Cells can differentiate into hundreds of different cell types, each with its own cellular initiatives, morphologies, and functions, despite this. The remarkable accomplishment is made possible by the so-called epigenetic processes, which in combination control gene expression and chromatin accessibility. These mechanisms include histone post-translational modifications (PTMs), DNA methylation and hydroxymethylation, and non-coding RNAs (ncRNAs). The epigenome, which is distinct for every type of cell in an organism, is the totality of this record of chemical modifications made to the DNA and histone proteins. The epigenome is an extra layer of regulation that is placed on the genome. It plays essential functions in determining and preserving the cellular phenotype and is both reversible and heritable. Enzyme complexes or chromatin modifying enzymes introduce chromatin modifications. The dynamic modification state of a given chromatin region is determined by the rates of histone turnover and DNA replication, as well as the corresponding activity levels of neutralizing connects of enzyme complexes at the target site.

Key feature of epigenome editing

To create targeted EpiEffectors, the catalytic portion of a chromatin-modifying protein is fused with a DNA recognition domain. This is the fundamental principle of this technique. In order to modify gene expression, cellular differentiation, or other biological processes, the attached functional domain must be delivered to specific target loci in the genome by the DNA recognition domain, which binds a unique DNA sequence (Figure 1).

The highly promising method of epigenome editing has the potential to open up new avenues for fundamental science and molecular medicine. The discovery of the CRISPR/Cas9 DNA-binding system, which makes it easier to construct the DNA recognition domains required for the application, has lately given it a significant boost. Furthermore, the ongoing advancements in our comprehension of epigenetic mechanisms, such as the identification of new effector domains like those of DNA demethylation-related enzymes, have bolstered our capacity for logical editing.

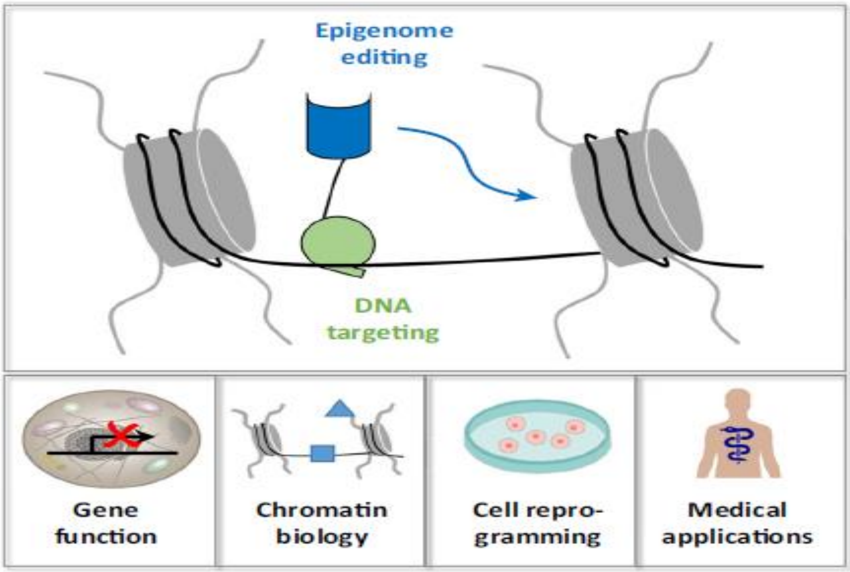


Fig 1: Principle and Application of Epigenome Editing

DNA targeting molecule

One zinc-finger module mostly binds to three base pairs (plus one contact to the neighboring base pair). Zinc-finger proteins (ZFP) of the C2H2 type were the first example of DNA-binding proteins shown to interact with DNA in a modular and predictable fashion. Two further programmable DNA recognition domains were found: the CRISPR/Cas9 system, which relies on Watson/Crick base-pairing between a guide RNA and one strand of the target DNA, and transcription activator-like (TAL) effector (TALE) arrays, in which one TALE repeat identifies one base pair. It has been demonstrated that a catalytically inactive Cas9 variation can be fused to and target functional domains to modify gene expression and enable epigenome editing, despite the fact that the natural Cas9 protein is a nuclease.

Concept of Epigenome Editing

The intended DNA recognition domains in genome editing are coupled to nuclease domains, which cause preset modifications in the DNA sequence at their target places. On the other hand, related techniques called genome reprogramming and epigenome editing seek to modify the target site's chromatin state and gene expression without affecting the genome's sequence.

While the targeting modules for epigenome editing are linked to chromatin-modifying enzyme domains such as DNA methyltransferases and demethylases, histone acetyltransferases and deacetylases, and histone lysine methyltransferases or demethylases, genome reprogramming uses gene silencing or activating factors as fusion partners of the DNA recognition domains. The purpose of these targeted EpiEffectors is to cause long-lasting changes in gene expression or other chromatin-templated activities by altering the chromatin state at the target region.

Notably, genome reprogramming has the potential to produce persistent modifications in gene expression even though it is usually temporary. If that's the case, the targeted activating or repressing domain will cause secondary epigenetic modifications that will facilitate this. Due to this, all chromatin state modifications will be referred to here as epigenome editing, regardless of the original cause. About 20 years ago, two groundbreaking publications introduced and empirically verified the concept of targeted DNA and histone methylation. These experiments, along with a number of others that followed, contributed to the remarkable advancement of epigenome editing techniques and applications, as outlined below. These days, the multidisciplinary area of synthetic biology includes epigenome editing as a fundamental component.

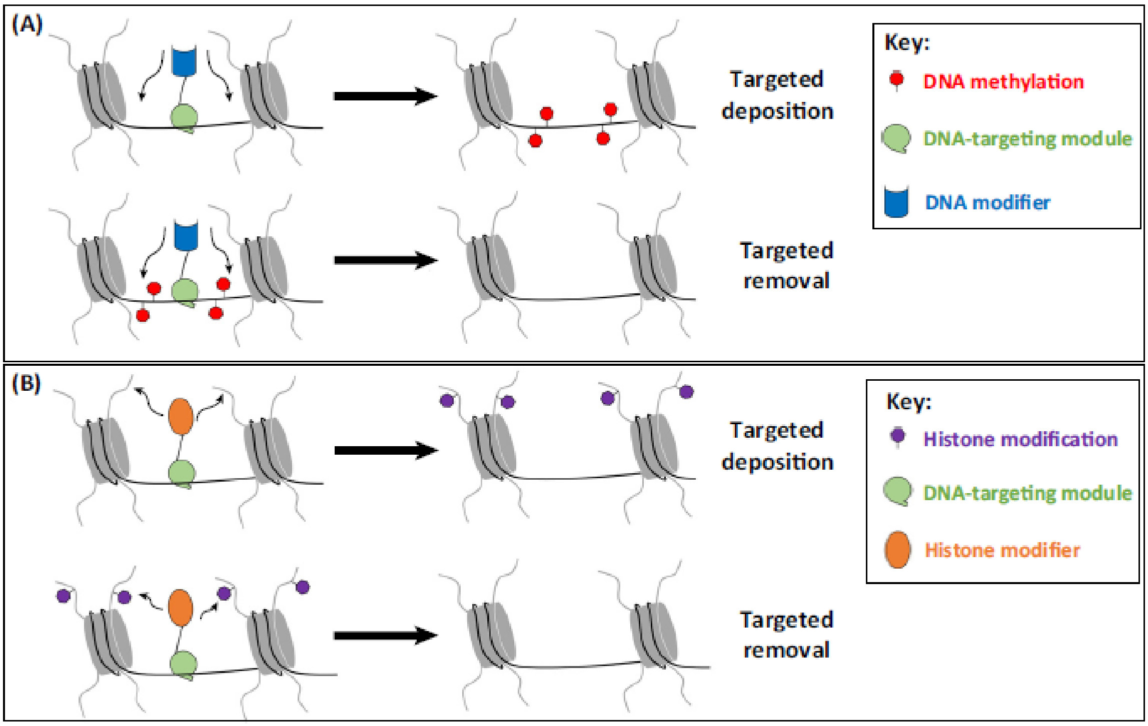


Fig 2: Concept of targeted Epigenome Editing.

Basic research application of Epigenome Editing

Chromatin biology, molecular epigenetics, and cellular reprogramming are entering a new age with the developing field of epigenome editing. Firstly, it can be used individually or in clusters to dissect the functional grammar of chromatin alterations in various nuclear processes. Unlike correlative or untargeted techniques, epigenome editing has the unique ability to enable experimental examination of the functional significance of various chromatin changes at defined genomic areas by direct interrogation.

Second, epigenome editing should provide a new method for studying gene function that can extend and supplement the RNA interference toolkit by enabling direct and stable control or fine-tuning of target gene expression. Third, another developing area of biology called "cellular reprogramming" could be completely transformed by epigenome editing. The introduction of transcription factor combinations is the current basis for cellular reprogramming and differentiation approaches. This causes the epigenome reprogramming required to change the cellular phenotype in an untargeted and wide way.

By directly and precisely reprogramming the required cellular genes, epigenome editing will enable us to rationally accomplish the same goals once the molecular foundations of this process are established. This might greatly enhance and optimize the process.

Reference

Greer, E.L. and Shi, Y. (2012) Histone methylation: a dynamic mark in health, disease and inheritance. Nat. Rev. Genet. 13: 343–357.

Bashtrykov, P. *et al*. (2015) Correction of aberrant imprinting by allele specific epigenome editing. Clin. Pharmacol. Ther. Published online November 4, 2015.

Mussolino, C. *et al*. (2014) TALENs facilitate targeted genome editing in human cells with high specificity and low cytotoxicity. Nucleic Acids Res. 42: 6762–6773.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/11/0124

IMPORTANCE OF PROTECTED CULTIVATION IN HORTICULTURE CROPS

Sojitra M A[1]*, Patel M L[2] and Satasiya R M[3]

[1*]Research Associate – Centre of Excellence in Soil and Water Management, MDFRS, J.A.U., Targhadia (Rajkot)
[2]Assistant Research Scientist, MDFRS, J.A.U., Targhadia (Rajkot)
[3]Associate Research Scientist, MDFRS, J.A.U., Targhadia (Rajkot)
*Corresponding Email: manojsojitra@yahoo.com

ABSTRACT

The practice of protected cultivation has emerged as a critical component in modern horticulture, offering a range of benefits and addressing various challenges in crop production. This abstract explores the significance of protected cultivation in horticultural crops. Protected cultivation involves growing crops in controlled environments such as greenhouses, poly houses, and shade net house, allowing precise regulation of factors like temperature, humidity, and light. This method plays a pivotal role in safeguarding plants from adverse weather conditions, pests, and diseases, thereby enhancing crop productivity and quality. Protected cultivation promotes efficient resource utilization, including water and fertilizers and minimizing weed infestation. It enables year-round and off-season production of horticultural crops, ensuring a consistent and reliable supply of fresh produce. Moreover, it facilitates the propagation of healthy planting material, improving germination rates and disease resistance. However, the adoption of protected cultivation also presents challenges, including the high initial capital costs, the need for skilled labour, and maintenance requirements. Ensuring a secure market for the produce is essential, given the substantial investment of resources.

INTRODUCTION

Protected cultivation is a method for cultivating crops in a controlled environment agriculture (Jensen, 2002). This means that factors such as temperature, humidity, and light can be adjusted to meet the specific needs of the crop (Choab*et al*., 2019, Santosh *et al.,* 2017a). This approach promotes healthier and more abundant crop yields. Sojitra *et al.* (2023) emphasizing the importance of controlled environments in sustainable farming practices. There are several techniques for protected cultivation, including forced-ventilated greenhouses, naturally-ventilated poly houses, insect-proof net houses, shade net houses, plastic tunnels, and the use of mulching, raised beds, trellising, and drip irrigation (Ayas*et al.,* 2011). These techniques can be employed individually or in combination to create an optimal environment that protects plants from adverse weather conditions and extends the cultivation season, enabling off-season crop production (Santosh *et al.* 2017b, Pahuja*et al.* 2013). The adoption of drip irrigation in conjunction with raised beds covered with mulch films not only suppresses weed growth but also retains soil moisture for an extended period, reducing evaporation losses ((Iqbal*et al.,* 2020).

Objectives of Protected Cultivation

1. Protecting plants from environmental stressors, including extreme temperatures, water fluctuations, and pest or disease pressures.
2. Optimal water management to minimize weed growth and maximize efficiency. Maximizing crop yield within confined spaces to enhance productivity.

3. Reducing reliance on pesticides for crop cultivation.
4. Encouraging the growth of high-value, top-quality horticultural produce.
5. Improving the propagation of planting materials for better germination rates, uniformity, disease resistance, and resilience.
6. Facilitating year-round and out-of-season production of flowers, vegetables, or fruits.
7. Generating disease-resistant and genetically superior seedlings for transplantation.

Limitations of Protected Cultivation

1. Significant upfront infrastructure costs pose a hurdle in terms of initial investment.
2. A lack of skilled labour and limited local replacements present challenges.
3. Inadequate technical knowledge in cultivating crops within sheltered settings.
4. Labour-intensive operations demanding sustained dedication.
5. Requires meticulous oversight and continuous vigilant monitoring.
6. Control of specific pests and soil-borne pathogens poses challenges.
7. Overcoming obstacles related to repairs and maintenance.
8. Necessitates a secure market guarantee due to substantial investment of resources, including time, effort, and finances.

Table 1: Various crop under protected structure

Flowers	Roses,Orchids, Gerberas, Tulips, Chrysanthemum, snapdragon, Carnation,Lilium, Gladiolus, etc.
Vegetables	Broccoli, Cabbage, Cauliflower,Tomato, Capsicum, Cucumber, Lettuces etc…
Fruits	Strawberry, Melons, Figs, Grapes, Papayas, Berries, Passion fruit
Nursery	Vegetables, Flowers, Tissue Culture, Clonal for Forestry, Fruit Grafting

Site Selection and Suitable Crops for Protected Cultivation

- Ensure ample sunlight exposure: Avoid locations near tall trees, buildings, or the leeward side of hills.
- Optimal distance from low-lying areas: Steer clear of places prone to waterlogging.
- Level ground surface: Aim for a 0–2 per cent slope; if outside this range, consider levelling. On steep terrains, construct separate greenhouses aligned parallel to contour lines.
- Soil pH and electrical conductivity: Soil with pH 6.0–6.5 and electrical conductivity below 0.5 dS/m is preferable.
- Continuous supply of good-quality water: Aim for 1–2 liters/m2/day, adaptable based on seasons and cultivation stages.
- Water pH and electrical conductivity: Maintain irrigation water pH within 6.5–7.0 and electrical conductivity below 0.7 dS/m.
- Uninterrupted electricity supply, especially during the day.
- Adequate transportation facilities for timely delivery to nearby markets.
- Sufficient land for future expansion: Maintain a 10–15 meter gap between greenhouses for potential expansion.
- Accessible labor force in the vicinity, typically four laborers required for one-acre flower cultivation.
- Reliable communication facilities on-site.
- Plant windbreaks like poplar, silver oak, or casuarina, about 20 meters away on the western side to mitigate strong west winds.
- Awareness and adherence to relevant occupational safety and health standards.

Types of greenhouse/polyhouse based on cost

1. **Low-Tech greenhouse/polyhouse:**A low-tech is low-cost greenhouse is a simple structure typically assembled using locally available or affordable materials like PVC pipes, polyethylene film, or recycled materials. It provides a protected environment for plants, extending the growing season and shielding crops from harsh weather conditions. While it may lack automated systems, these greenhouses offer an economical solution for small-scale farming, enabling basic climate control through natural ventilation and manual adjustments. They are user-friendly, easy to construct, and serve as an entry point for growers with limited resources, fostering local food production and community gardening initiatives.

Low cost bamboo made greenhouse

2. **Medium-Tech greenhouse/polyhouse:**A medium-tech is medium-cost greenhouse stands as a balanced solution between sophisticated and budget-friendly options. Constructed with sturdier materials like galvanized steel frames and polycarbonate panels, it offers durability and improved insulation compared to lower-cost alternatives. These greenhouses often integrate some technological features such as manual or semi-automatic ventilation systems, basic climate control mechanisms, and improved structural resilience. While not as advanced as high-tech models, they provide a reliable environment for cultivating a wide range of crops, enabling better control over growing conditions without the substantial investment required for cutting-edge technology.The frame typically enjoys a lifespan of around 10 years, while the covering material lasts for about 3 years.

Poly-cum-net house

3. **High Tech greenhouse/polyhouse:**High-tech, high-cost greenhouses represent a cutting-edge approach to modern agriculture, incorporating advanced technologies to optimize growing conditions. These state-of-the-art structures often feature climate control systems, automated irrigation, precise nutrient delivery, and sophisticated environmental monitoring. They utilize sensors, artificial lighting, and computerized controls to maintain ideal temperature, humidity, and light levels, allowing for year-round cultivation of high-value crops. While their initial investment and operational expenses are relatively high, these greenhouses offer increased efficiency, higher yields, superior crop quality, and reduced environmental impact compared to conventional farming methods. Their utilization of technology enables precise resource management and minimizes risks, making them an attractive option for growers seeking consistent and sustainable production.

Fan pad automated greenhouse

4. Other protective measures:

a. Low tunnels: Low tunnels are protective structures used in agriculture, typically constructed using lightweight materials like hoops and covers to create a sheltered environment for crops. These tunnels are designed to shield plants from adverse weather conditions, pests, and certain climatic variations, while also providing a controlled microclimate that can extend the growing season. They are particularly beneficial for early or late-season cultivation, offering localized warmth and protection to foster plant growth and yield, contributing to improved crop quality and increased resilience against environmental challenges. The height of the low tunnels are kept below 1.0 meter. These low tunnel are also covered with various covering material like shade net, insect net and plastic cover with 50 µ thickness.

Plastic Low tunnel

b. Net houses: Net houses find application in the cultivation of vegetables, fruits and flowering seedling. These structures feature a flat-top design or arc and stand at a lower height than poly house. They are covered with shading nets ranged from 35 to 90 %shade. The choice of colour of covering shade depend on crop are to be grown.

Net House

c. Row cover:A row cover is an essential tool used to protect plants from various environmental factors. This is lightweight fabric, often made of materials like spun-bonded polyester or polypropylene. It, serves as a protective shield for crops against frost, insects, and harsh weather conditions. However, row cover allows sunlight, air and moisture to permeate while creating a microclimate that encourages plant growth. Its versatility and ease of use and ensuring healthier and more robust yields. It also extending the growing season for numerous crop.

Row Cover

d. Mulching:

Mulch refers to a layer of soil covering material, such as wood chips, straw, plastic, or compost, placed on the soil surface around plants. It serves multiple purposes in gardening and agriculture, including moisture retention, weed suppression, soil insulation, and erosion control. Mulch helps regulate soil temperature, preventing extremes that can stress plants. Additionally, it promotes soil health by gradually decomposing and enriching the soil with organic matter, improving overall fertility and supporting a healthier root environment for plant growth.


Mulching Vegetables and fruits

Climate control under protected environment: The climatic condition *viz* Temperature, Relative humidity and Light intensity need to be optimized for good growth and development. The Table 2 shows the various range of climatic parameter inside the protected cultivation.

Table 2: Climatic requirement of crops under protected cultivation

Crop	Temperature (°C)		Humidity (%)	Light Intensity (lux)
	Day	Night		
Tomato	22-27	15-19	50-65	50000-60000
Cucumber	24-27	18-19	60-65	50000-60000
Capsicum	21-24	18-20	50-65	50000-60000
Nursery	22-27	16-19	50-65	50000-60000
Carnation	16-20	10-12	60-65	40000-50000
Chrysanthemum				
a. Cut flower	22-24	15-16	60-65	35000-40000
b. Pot	23-26	16-19	60-65	35000-40000
Gerbera	20-24	18-21	60-65	40000-50000
Orchid	22-24	18-20	70-80	25000-30000
Anthurium	22-25	18-20	70-80	25000-30000
Rose	24-28	18-20	65-70	60000-70000

Conclusion

Protected cultivation is a vital technique in horticulture that offers numerous advantages, from enhanced crop protection to improved yield and quality. Its continued adoption and innovation are essential for sustainable and efficient horticultural production in a changing agricultural landscape.

Reference

Ayas, S., Orta, H. and Yazgan, S. (2011) Deficit irrigation effects on broccoli (Brassica oleracea L.var. Monet) yield in unheated greenhouse condition. *Bulgarian journal of Agricultre Science,*, 17: 551-559.

Choab N, Allouhi A, El Maakoul A, Kousksou T, Saadeddine S, Jamil A (2019) Review on greenhouse microclimate and application: Design parameters, thermal modeling and simulation, climate controlling technologies. *Solar Energy* 191:109-137.

Iqbal, R., Raza, M. A. S., Valipour, M., Saleem, M. F., Zaheer, M. S., Ahmad, S., ...&Nazar, M. A. (2020). Potential agricultural and environmental benefits of mulches—a review. *Bulletin of the National Research Centre*, *44*(1), 1-16.).

Jensen M H. (2002). Controlled environment agriculture in deserts tropics and temperate regions – A world review. *ActaHoriculture*, 578: 19–25.

Pahuja R, Verma HK, Uddin M (2013) A wireless sensor network for greenhouse climate control." *IEEE Pervasive Computing* 12(2): 49-58.

Santosh DT, Tiwari KN, Kumar Vikas Singh Raja, Gopala Reddy A (2017a) Microclimate control in greenhouse. *Int J CurrMicrobiolApplSci*6 (3): 1730-1742.

Santosh DT, Tiwari KN, Singh VK (2017b) Influence of different protected cultivation structures on water requirements of winter vegetables. *Int J Agricult, Environ Biotechnol*10(1): 93-103.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 04/I/12/0124

ISABGOL (Psyllium)

Suchitra Dadheech* and Ramawtar

College of Agriculture Bhilwara (Rajasthan) 311001
*Corresponding Email: sdjobner@gmail.com

Introduction

Botanical name	**: *Plantago ovata L.***
Family	**: Plantaginaceae**
Origin	**: Persia**
Part used	**: Seed and husk**
2n	**: 8**

Isabgol known as Blod psyllium in English. Thename Isabgol is derived from the two Persian words "*Isap* and *ghol*" meaning a horse's ear due to characteristics boat shaped appearance of its seed. It is 10-45cm short stemmed plant, herbaceous in nature having annual growth habit. The seed coat is known as husk (epicarp of seed). The seeds are enclosed in capsules that opens at maturity. The seed husk is thin boat shaped white, translucent odorlesswith mucilaginous taste. The root system is tap rootwith few secondary roots.India ranksfirst in Isabgol production. Gujarat and Rajasthan are the major Isabgol producing states in the country.

Uses

In India use of Isabgol is as old as Ayurveda system of medicine. The seeds contain a glycoside - *aucubin.*The Isabgolhuskis used mainly for treatment of stomach disorders, tridosha, burning sensation, habitual constipation, gastritis, chronic diarrhoea, dysentery and dueodenal ulcer.Now a day it is used in food industries to preparation of ice-cream, candy etc.

Climate

Isabgol is originated from Mediterranean region and commercially grown in N-W-India.It is cool and dry rabi season crop. The temperature requirement for germination is 20-25°C. Whereas at the time of maturity 30-35°C with clear sky for quality coop production.

Soils

Suitable soil for the Isabgolis well drained, sandy to sandy loam soils. It can also be cultivated in clay loam, medium textured black and black cotton soils and heavy soils with good drainage conditions. The crop can tolerate slight salinity with a pH7.2-7.9.

Land preparation

Field must be free form weeds and clods. Isabgol seeds are small in size, hence require fine seed bed with good soil tilth for good gemination.

Varieties

Gujrat Isabgol-1 (G.I.-1) (1975) AAU Gujarat - Yield 8-9 q /ha
Gujrat Isabgol-2 (G.I.-2) (1987) AAU Gujarat - Yield 9-10 q /ha, Maturity 118-125 days.
Gujrat Isabgol-3 (G.I.-3) (2011) AAU Gujarat - Yield 13-15 q /ha, Maturity 115-120 days.
Jawahar Isabgol-4 (MIB 4) CJNKVV -Jabalpur - Yield 13-15 q /ha.
Haryana Isabgol-5 (HI-5) HAU, Hisar - Yield 10-12 q /ha.
Niharika (CIMAP- Lucknow) - Yield 10-12 q /ha.

Rajasthan Isabgol1 (RI-1) - Yield 12-16 q /ha, Maturity - 112-123 days.
Rajasthan Isabgol 89 (RI-89) - Yield 12-16 q /ha, Maturity - 110-115 days.

Seed and Sowing

Good quality seed is essential for obtaining good production. Seed should be procured from reliable source. The sowing period of psyllium is from second half of October to the first half of November. The seed yield decreased with delay in sowing.Isabgol is photosensitive. Seed rateis 5-6 kg / ha

Crop geometry - Row to Row spacing 25 cm to 30 cm

Seed treatment - Carbendazim 50 WP @ 2g /kg seedorMetalaxyl35WP @ 5g/kg seed.

Broadcasting is common practice followed by the farmers since long. But line sowing is good to obtain better harvest and facilitate better interculture operations. The seeds are small, therefore mixed with soil or sieved FYM for easy sowing.

Nutrient Management

The nutrient requirement should be based on soil testing. As general recommendation 5 t/ha FYM should be applied. 25-30 Kg N+ 20-25 kg P/ha is required. The full dose ofphosphorus should be applied as basal dose along with 50% nitrogen. Rest 50% nitrogen should be applied 35-40 DAS. The potassium and other nutrients should be applied if needed in the soil based on testing.

Irrigation

In sandy loam soils 3 irrigations, each at sowing, 30 and 70 days after sowing. The last irrigation should be given at milk stage. The irrigation can be applied through sprinkler also at 8, 20, 40, 55 and to DAS, respectively by running sprinkler 3hrs.

Weed Management

First 15-20 days from plantingare critical for weed control. Two hand weedings 15-20 DAS and 35-40DAS are sufficient to weed control. Herbicide Isoproturan @ 600 ga.i/ha can be applied in the standing crop at 25-30 DAS to weed Control.The common weed flora of rabi season affectsthe crop like *Chenopodium spp., Melilotus spp,* wild onion, Bermuda grass etc.

Harvesting

The crop takes 110-120 days to mature. At maturity leaves become yellowish and spikes turn brownish in colour. The crop is harvested when plants are completely dried and seeds turn dark brown. The harvesting is done from ground level by cutting the plants by using sickle. The crop should be harvested when the weather is dry without rains to better quality produce.

Post harvest processing

It is critical to obtain end quality of the product. Use a clean surface / use of tarpaulin sheet forclean harvest. The seeds are threshed by motor/ tractor operated threshing machine or simply by trampling using tracks / bullocks.Processing of husk from seeds is done in mills. About 25-27% husk is obtained on weight basis of seeds.

The process of removing husk is called dehusking (Husk – 25-30 %). The main by production in dehuskingare 7% - Lali - used as cattle feed, small quantity - Chito - used as pig feed, 5% - Khakho - prevent ice slipping and 60%Gola - used as cattle feed.

Yield

On an average 8-10 q/ha seed yield is obtained. However, 15-20q/ha can be obtained using better crop management practices.

Insect Pests

Aphid is the major insect pest. Spraying the crop with 0.2 % Dimethoate or Nuvacronto effectively control the insect.

Diseases

Downey Mildew is the major disease caused by *Perenospora plantaginis*. Spraying the crop with Mancozeb @0.2%. is used to control the disease.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/13/0124

MARKER-ASSISTED SELECTION (MAS) REVOLUTIONIZING CROP IMPROVEMENT: A COMPREHENSIVE EXPLORATION

Praveen Kumar Yadav[1], Shashikumara P[1], Jyotsna Srivastava[2], Sakshi Singh[2] and Rahul Kaldate[3*]

[1]ICAR- Indian Grassland and Fodder Research Institute, Jhansi-284 003
[2]CSIR- Central Institute of Medicinal and Aromatic Plants, Lucknow- 226015
[3]DBT-North East Centre for Agricultural Biotechnology, Jorhat, Assam- 785013
*Corresponding Email: rkaldate@gmail.com

Abstract

Crop improvement has historically relied on conventional breeding methods, but the advent of Marker-Assisted Selection (MAS) has ushered a new era in agriculture. MAS utilizes molecular markers linked to specific genes to enhance the precision and efficiency of crop breeding. This article comprehensively explores MAS, detailing its principles, applications, advantages, limitations, and future potential in crop improvement.

1. Introduction

Traditional breeding methods have long been the cornerstone of crop improvement, playing a pivotal role in shaping the agricultural landscape. However, these methods often entail extensive time, resources, and imprecision in selecting desired traits. The pressing demand for a more efficient, precise, and expedited approach to crop breeding has sparked the emergence of Marker-Assisted Selection (MAS). MAS represents a revolutionary leap in agricultural science, harnessing the power of genetic markers to streamline and enhance the breeding process. By identifying and utilizing specific DNA sequences—known as markers—associated with desired traits, MAS enables breeders to make more informed and precise selections during the breeding process (Ari and Lavi, 2012). Unlike traditional breeding, which relies on observable characteristics and genetic trial and error, MAS facilitates the identification of genes linked to key traits. These markers serve as guides, allowing breeders to pinpoint and select plants with desirable traits at a molecular level, significantly accelerating the breeding cycle.

The promise of MAS lies in its ability to expedite the development of crop varieties with improved characteristics, such as disease resistance, higher yields, tolerance to environmental stresses, and enhanced nutritional profiles(Hasan et al. 2021). By leveraging the information encoded in the plant's DNA, MAS holds the potential to revolutionize crop breeding by enabling faster, more accurate trait selection and development of resilient and high-performing crop varieties. As agricultural demands escalate globally, the advent of MAS offers a beacon of hope for meeting these challenges by providing a more efficient, precise, and sustainable approach to crop improvement. This technology not only accelerates the breeding process but also holds the promise of addressing pressing agricultural issues, contributing to global food security, and advancing sustainable farming practices.

The integration of MAS into traditional breeding programs signifies a significant shift in agricultural paradigms, paving the way for a new era in crop improvement. As research continues to advance and technologies evolve, MAS stands poised to play an increasingly pivotal role in shaping the future of agriculture by empowering breeders to create resilient and high-yielding crop varieties more efficiently and effectively than ever before.

2. Understanding Marker-Assisted Selection (MAS)

MAS involves identifying specific DNA sequences (markers) associated with desirable traits and using them as indicators during breeding. These markers, often Single Nucleotide Polymorphisms (SNPs) or Simple Sequence Repeats (SSRs), allow for more precise selection of desired traits (He et al. 2014).MAS starts with identifying markers associated with the trait of interest through genetic mapping. Breeders then analyse these markers in potential parents to predict which offspring will inherit the desired traits without waiting for phenotypic expression. This accelerates the breeding process by enabling selection at the molecular level, saving time and resources compared to traditional methods that rely solely on observing the physical expression of traits.

3. The Process of Marker-Assisted Selection

The MAS process entails marker discovery, genetic mapping, marker-assisted breeding, and genotype selection. Through marker-assisted breeding, plant breeders can identify and select plants with desired traits at earlier stages, significantly reducing breeding cycles.The basic procedure of MAS using molecular markers is presented in **Fig. 1.**

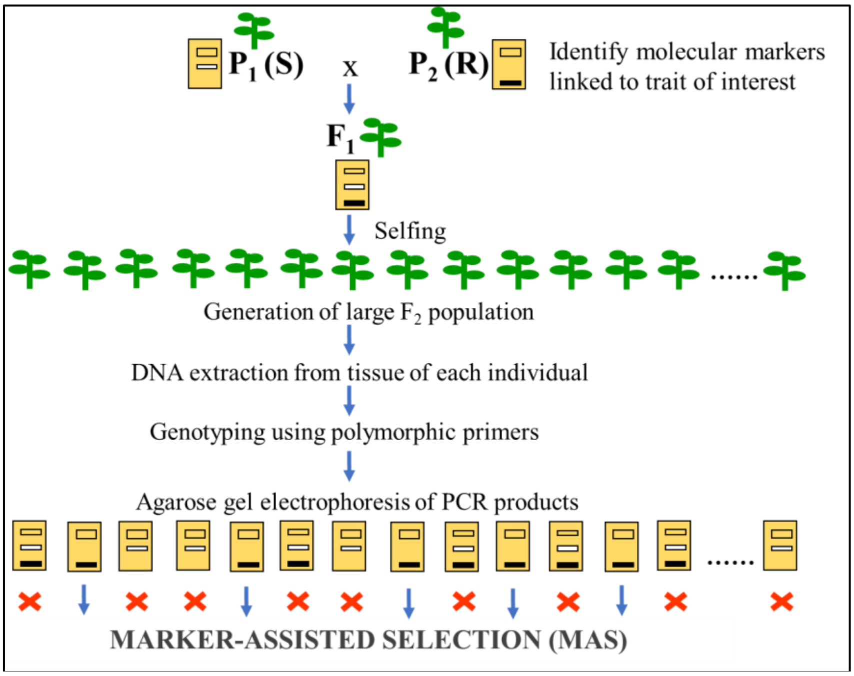


Fig. 1 The figure showing basic procedure for marker-assisted selection.

It involves four key steps:

- ✓ **Marker Identification**: DNA markers linked to target traits are identified through genetic analysis.
- ✓ **Genetic Mapping:** These markers are mapped onto the plant's genome, providing precise locations of desired genes.
- ✓ **Marker-Assisted Breeding:** Breeders use these markers to select plants containing the desired genes during the breeding process.
- ✓ **Genotype Selection:** Plants with the targeted traits are identified at early stages, accelerating the breeding cycle and enabling more efficient crop improvement.

In essence, MAS expedites the selection of desired traits by leveraging genetic markers, reducing the time and resources needed for traditional breeding methods.

4. Advantages of Marker-Assisted Selection

MAS revolutionizes traditional breeding methods by leveraging genetic markers to enhance the selection process. Its advantages include precision, speed, and efficiency. Firstly, MAS allows for the identification of specific genetic markers linked to desirable traits, enabling precise selection without the need for phenotypic expression, which can take longer. This accuracy streamlines the breeding process, saving time and resources.

Secondly, MAS facilitates the selection of traits that are otherwise challenging to assess directly, such as disease resistance or complex traits controlled by multiple genes. By targeting these markers, breeders can expedite the development of improved varieties or breeds. Moreover, MAS promotes genetic diversity preservation by aiding in the selection of diverse parental lines. This fosters resilient and adaptable populations, crucial for withstanding environmental changes or disease pressures.

Overall, Marker-assisted selection accelerates breeding programs, increases precision in trait selection, and contributes to the development of superior, resilient, and high-yielding crop varieties or livestock breeds.

5. Applications of Marker-Assisted Selection in Crop Improvement

The applications of MAS span various crops, including cereals, fruits, vegetables, and legumes.MAS has extensive use in crop improvement (Tiwari et al. 2022, Mori et al. 2023). It expedites the breeding of high-yielding, disease-resistant, and stress-tolerant varieties. MAS identifies genetic markers associated with favourable traits, enabling precise selection without waiting for phenotypic expression. This accelerates the development of crops with improved nutritional content, enhanced yield, and resistance to pests, diseases, or environmental stresses. Additionally, MAS aids in pyramiding multiple desirable traits into a single cultivar efficiently. It's instrumental in preserving genetic diversity, enhancing breeding efficiency, and creating resilient crop varieties vital for sustainable agriculture and global food security.

6. Challenges and Limitations

Marker-assisted selection (MAS) comes with its set of challenges and limitations:

- ✓ **Cost and Technology:** Initial setup costs for genotyping and marker development can be high. Additionally, the need for specialized equipment and expertise in molecular genetics might pose barriers for some breeding programs, particularly in smaller-scale operations.
- ✓ **Marker-Trait Association:** Not all traits have known genetic markers, and for complex traits controlled by multiple genes or influenced by the environment, identifying reliable markers can be challenging. This limits the effectiveness of MAS for these traits.
- ✓ **Linkage Disequilibrium:** Over time, the association between markers and desired traits can weaken due to genetic recombination. This can reduce the accuracy of selection based on markers alone.
- ✓ **Ethical and Regulatory Challenges:** Issues related to patenting of genetic markers and regulatory frameworks concerning genetically modified organisms (GMOs) can affect the adoption and implementation of MAS in certain regions.
- ✓ **Limited Genetic Diversity:** Relying solely on identified markers might inadvertently reduce genetic diversity if not managed properly, leading to potential vulnerabilities in crops or livestock against evolving pests, diseases, or environmental changes.

Despite these challenges, ongoing advancements in genomic technologies and computational tools continue to address many limitations, making MAS increasingly valuable in modern breeding programs. Collaboration among scientists, reduced genotyping costs, and improved marker identification methods can mitigate these challenges over time.

7. Future Prospects and Emerging Technologies

The future of marker-assisted selection (MAS) is promising, with emerging technologies poised to revolutionize breeding practices:

- ✓ **Genome Editing:** CRISPR and other gene editing tools offer precise manipulation of specific genes, allowing breeders to directly alter traits. This technology complements MAS by validating gene-trait associations and enhancing the efficiency of trait introgression
- ✓ **High-Throughput Sequencing:** Advancements in sequencing technologies enable cost-effective analysis of entire genomes. This facilitates the identification of new markers and understanding complex trait architectures, expanding the scope and accuracy of MAS.
- ✓ **Machine Learning and Big Data:** Integration of machine learning algorithms with genomic data accelerates trait prediction and marker discovery. Predictive models can enhance breeding strategies, optimizing selection and combination of desired traits.
- ✓ **Multi-Omics Approaches:** Integrating genomics with other omics data (such as transcriptomics, metabolomics, and proteomics) provides a comprehensive understanding of trait mechanisms, allowing for more precise trait prediction and selection.
- ✓ **Phenotyping Technologies:** Advancements in high-throughput phenotyping technologies enable rapid and accurate trait assessment, complementing genomic data and improving selection accuracy.
- ✓ **Gene Editing in Non-Model Species:** Techniques are being refined to enable gene editing in non-model organisms, broadening the application of MAS across various crops, trees, and livestock.

These emerging technologies hold immense potential to overcome current limitations, accelerate breeding cycles, enhance precision, and address complex traits more effectively. Integration of these advancements with MAS will further revolutionize agriculture, fostering the development of resilient, high-yielding, and nutritionally enhanced crops and livestock essential for sustainable food production.

8. Ethical and Societal Implications

The adoption of MAS raises ethical concerns related to genetically modified organisms (GMOs), intellectual property rights, and equitable access to advanced breeding technologies. Responsible governance and consideration of societal implications are imperative in harnessing the benefits of MAS.

9. Conclusion

Marker-Assisted Selection represents a paradigm shift in crop improvement, offering unparalleled precision and speed in breeding programs. While challenges persist, the potential of MAS to transform agriculture is undeniable. Continued research, technological innovations, and ethical considerations will shape the responsible implementation of MAS for sustainable agriculture and food security.

10. References

Ben-Ari, G., & Lavi, U. (2012). Marker-assisted selection in plant breeding. In *Plant biotechnology and agriculture* (pp. 163-184). Academic Press.

De Mori, G., & Cipriani, G. (2023) Marker-Assisted Selection in Breeding for Fruit Trait Improvement: A Review. *International Journal of Molecular Sciences*. 24(10):8984. https://doi.org/10.3390/ijms24108984

Hasan, N., Choudhary, S., Naaz, N., Sharma, N., & Laskar, R. A. (2021). Recent advancements in molecular marker-assisted selection and applications in plant breeding programmes. *Journal of Genetic Engineering and Biotechnology*, *19*(1), 1-26.

He, J., Zhao, X., Laroche, A., Lu, Z. X., Liu, H., & Li, Z. (2014). Genotyping-by-sequencing (GBS), an ultimate marker-assisted selection (MAS) tool to accelerate plant breeding. *Frontiers in plant science*, *5*, 484.

Tiwari, J.K., Yerasu, S.R., Rai, N., Singh, D.P., Singh, A.K., Karkute, S.G., Singh, P.M. and Behera, T.K. (2022). Progress in marker-assisted selection to genomics-assisted breeding in tomato. *Critical Reviews in Plant Sciences*, 41(5), pp.321-350.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 04/I/14/0124

MEETING FUTURE CHALLENGES OF DOUBLING FARMERS' INCOMES

K.N. Tiwari[1*] and Himanshi Tiwari[2]

[1]Ex. Director, International Plant Nutrition Institute-India Program,
7A, Lakhanpur Housing Society, Lakhanpur, Kanpur 208024
[2]Ph. D. Scholar, Dr. Ram Manohar Lohiya National Law University, Lucknow 226012
*Corresponding Email: kashinathtiwari730@gmail.com

Abstract

Undoubtedly, doubling crop productivity and farmers income by 2022 was a great challenge and test of our capacity to successfully employ all possible growth-inducing measures. The goal could not be achieved because the valuable research findings and the recent Government policies were not implemented in letter and spirit through robust extension services. This was possible by putting proven scientific findings into practices on individual farm holdings and revitalizing support services such as research, extension, supply chain and infrastructure and reasonable price of the produce to the farmers. Matching product supply with soil nutrient deficiencies and taking care of all production inputs was needed. Crucial issues concerning doubling crop productivity and farmers income are discussed primarily to ensure desired inclusive growth in the Indian context.

Introduction

India is the world's seventh largest country covering an area of 328 million hectares (mha). Nearly half of this land (156.4 mha) is arable (FAO, 2018), and only 42.6 percent of the total geographical area (about 140 mha) is actually cultivated (as of 2015-16). India's irrigation cover is 48.7 percent of the country's cultivated area while its agriculture output is valued at USD 524.7 billion in 2017 (Gulati and Gupta, 2019). Agriculture is the largest enterprise in the country. An enterprise can survive only if it can grow consistently. And growth is incumbent upon savings and investment, both of which are afunction of positive net returns from the enterprise. The net returns determine the level ofincomeof an entrepreneur, farmer in this case.

The agricultural sector has witnessed significant changes over the years, in terms of area under cultivation, land holding and cropping patterns, cropping intensity and productivity, among other things. Food grains (cereals, millets, and pulses) used to occupy 73% of the gross cropped area in the triennium ending (TE) 1982/83, but this gradually reduced to 68% in TE 1992/93 and further to 62% in TE 2015/16 (latest data available). The share of oilseeds and fruits and vegetables has increased over the same period. Farmers are increasingly moving towards more commercial crops such as oilseeds, fruits and vegetables, spices, etc. compared to staples. Though food grain production still dominates in terms of area cultivated, the change in the value of different segments of agriculture, including livestock and fishery, is the real indicator of agricultural diversification.

Past strategy for development of the agriculture sector in India has focused primarily on raising agricultural output and improving food security. This strategyinvolved (a) an increase in productivity through better technology and varieties, andincreased use of quality seed, fertilizer, irrigation and agro-chemicals; (b) incentivestructure in the form of remunerative prices for some crops and subsidies on farminputs; (c) public investments in and for agriculture; and (d) facilitating institutions.The strategy paid dividends as the country was able to address severe food shortagethat emerged during mid-1960s. During 1965 to 2015, sincethe adoption of Green Revolution, India's food production multiplied 3.7 times whilethe population multiplied by 2.55 times. The net result has been a 45 % increasein per person food production, which has made India not only food self-sufficient ataggregatelevel, but also anetfood exporting country (Chand 2017). The strategy did not explicitly recognize the need to raise farmers' income resulting in low income of farmers. Farmers' income also remained low in relation to income of those working in the non-farm sector. India also witnessed a sharp increase in the number of farmers suicides due to losses from farming, shocks in farm income and low farm income. The low farm income is forcing more and more cultivators, particularly the younger age group, to leave farming. This can have an adverse effect on the future of agriculture in the country, leading to food insecurity. Therefore, there is need to double farmers income to promote farmers' welfare, reduce agrarian distress and bring parity between income of farmers and those working in non-agricultural professions. Unless the incomes of farmers go up, we cannot have sustained high growth of overall GDP. This is because the manufacturing sector starts facing a demand constraint soon after meeting the demand of well-off urban consumers. This paper aims at analyzing strength and weaknesses of achieving the goal of doubling farmers' income by 2022 as dreamed by Prime Minister Narendra Modi.

Doubling Farmers' Income

In 2016, Prime Minister Narendra Modi shared his dream of doubling farmers' incomes in the year when India completes 75 years of Independence and enters *Amrit Kaal*. Now that we have entered *Amrit Kaal*, it is a good time to revisit that dream and see if it has been fulfilled, and if not, how best it can be done. A committee was formed to recommend strategies for achieving the target which submitted its report in September 2018. It recommended that policy focus must shift away from just increasing farm output, since increased output may not always lead to an increase in farmers' income. The Committee submitted its final report in 2018 containing the strategy for DFI through various policies, reforms and programmes. To achieve the objective, the Committee identified following seven sources of income growth:

- Increase in crop productivity
- Increase in livestock productivity
- Resource use efficiency, reduction in cost of production
- Increase in cropping intensity
- Diversification to high value agriculture
- Remunerative prices on farmers' produce
- Shift of surplus manpower from farm to non-farm occupations

The premise of the strategy is based on the following primary principles:

- Increasing total output across the agricultural sub-sectors through realising higher productivity
- Rationalising/reducing the cost of production
- Ensuring remunerative prices in the agricultural produce
- Effective risk management
- Adoption of sustainable technologies

It noted that input prices, the level of input used, and the price of the output also has an impact of farmer incomes. Hence, it recommended that with an increase in the level of output, the cost of production be reduced, remunerative prices for agricultural produce be ensured, and sustainable technology be used.

Issues

- Over 20% of the farmers live below official poverty line.
- Large tracts of arable land have turned problem soils, becoming acidic, alkaline and saline.
- Anotherprimaryfactor of production, namely, water is also under stress.
- Change is beginning tochallenge the farmer's ability to adopt coping and adaptation measures that are warranted.
- Technologyfatigueismanifestingintheformofyieldplateaus.India'syieldaveragesformost crops at global level do not compare favorably.
- The costs of cultivation are rising.
- Themagnitude of food loss and food waste is alarming.
- The markets do not assure the farmer ofremunerativereturnsonhisproduce.

Other issues are being mentioned below:

Fragmentation of landholdings: India's agricultural sector is dominated by marginal and small farm holdings. Over the past several decades, the number of farm holdings have increased while the area under farming has declined. This has led to a reduction in the average size of a landholding. 86% of India's farmer are small farmers which ask difficult to scale up the operation. Fragmented landholdings may affect agricultural growth as it implies reduced capital expenditure on a farm. Smaller farmers find it difficult to invest in tube wells, drip irrigation, bulk inputs or storage of produce.

*Low Productivity :*The productivity of Indian agriculture is low compared to other countries. The yield per hectare of major crops in India is lower than that of China, Brazil, and the United States.

Dependence on Monsoon : A large proportion of Indian agriculture is dependent on monsoon rains. Delayed or inadequate rainfall affects crop production and farmers' income.

Climate Change : Climate change has a significant impact on Indian agriculture. Erratic rainfall, rising temperatures, and extreme weather events such as droughts and floods affect crop production and reduce farmers' income.

Poor infrastructure : Wth inadequate irrigation facilities, storage structure, transportation network results in low return to farmer.

Price Volatility : The agriculture sector in India is characterized by price volatility due to the lack of a stable pricing policy. Fluctuations in prices of agricultural commodities, coupled with high input costs, make it difficult for farmers to plan their production and marketing strategies.

Agriculture policies: Sometimes trade and marketing policies adopted by the government suppress farmers' incomes, for example, the ban on exports, the suspension of several commodities from the futures markets, and the imposition of stocking limits on certain commodities. These are hidden policy instruments of "implicittaxation" of farmers' incomes. The policy of heavy subsidisation along with assured and open-ended procurement of paddy and wheat is creating challenges for the environment.

Inadequate Institutional Support : The lack of institutional support in the form of credit, insurance, and marketing facilities for farmers is a significant challenge. Access to credit and insurance remains low for small and marginal farmers.

Pro-farmer vs pro-consumer approach : While input subsidies do help raise farmers' incomes, there could be output trade and marketing policies that suppress farmers' incomes. For example, the ban on exports of wheat.

Impact of subsidies on environment : Subsidies from fertilizers, power to farm machinery for custom hiring centres, if combined, would easily cross Rs 4 lakh crore per annum. Overuse of fertilizers or pesticides can result in soil degradation, groundwater depletion and other negative environmental impacts. Policies of "implicit taxation" of farmers' incomes: For example, unloading 2.5 mt of wheat right now to bring down prices of wheat in mandis, so that the government can buy at MSP, which is lower than the market price. In short, sustainability of agricultural growth faces serious doubt, and agrarian challenge even in the midst of surpluses has emerged as a core concern.

Current Scenario of the Farmers' Income:

As per the survey results, conducted by the National Sample Survey Office (NSSO), the average monthly income per agricultural household, from all sources, was estimated at Rs 6,426 in 2012-13. The benchmark estimated annual income was Rs 96,703 in 2015-16 which was taken as a base year. This comes to Rs 8,059 per month. However, the estimated monthly income of farm households in 2018-19 was Rs 10,218 per month in nominal terms compared with the target income for doubling by 2022 is Rs. 21,146 per month (taking inflation also into account). Thus, it is nowhere near the targeted income of Rs. 21,146 per month. Apparently, the farm income had risen by 59% till 2019. The 77th NSS round data, in 2018-19, showed that the average monthly income has gone up, of which the highest income comes from wages, followed by income from crop cultivation and production. Income from wages was 32% in 2012-13 which was recorded to be 40% in 2018-19. This implies that farmers are turning into daily wage laborers. There is a substantial rise in income from animal farming. The farmers are also earning comparatively higher income from non-farm businesses and are leasing out land. Composition of average monthly income of agricultural households is displayed in **Figure 1**.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

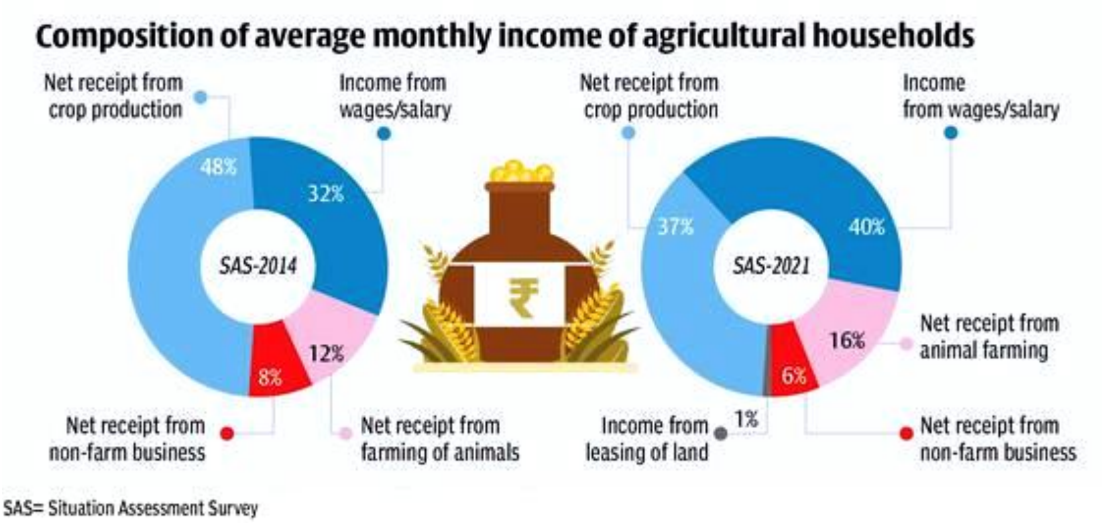


Fig. 1. Farmers' Earnings from different sources

Strategies to Double Farmers' Income

In this regard the Government of India had constituted an Inter-Ministerial Committee (in April, 2016) to examine issues relating to DFI and recommended strategies to achieve the same. The Committee submitted its final report in 2018 containing the strategy for DFI through various policies, reforms and programmes. To achieve the objective, the Committee identified following seven sources of income growth:

- Increase in crop productivity
- Increase in livestock productivity
- Resource use efficiency, reduction in cost of production
- Increase in cropping intensity
- Diversification to high value agriculture
- Remunerative prices on farmers' produce
- Shift of surplus manpower from farm to non-farm occupations

The premise of the strategy is based on the following primary principles:

- Increasing total output across the agricultural sub-sectors through realising higher productivity
- Rationalising/reducing the cost of production
- Ensuring remunerative prices in the agricultural produce
- Effective risk management
- Adoption of sustainable technologies

Government Initiatives to Supporting Farmers for Doubling Farmers Income

Minimum Support Prices: The government has taken several measures to improve agricultural marketing and ensuring remunerative prices to farmers. These include procuring certain crops at the *Minimum Support Price* (MSP). Factors such as the cost of production, price trends, and ensuring a 50% margin over the cost of production are used to determine the MSP for a season. Wheat MSP for 2023-24 is fixed at Rs 2,125 per quintal. The cost of cultivating wheat for the year is Rs 1,065. Paddy MSP for 2022-23 is fixed at Rs 2,040 per quintal, whose cost of cultivation is Rs 1,360.

The National Commission on Farmers (2006) had recommended that MSP be at least 50% greater than the weighted cost of production. The Ministry adopted that recommendation in 2018-19, and MSP for all kharif and rabi crops was increased to reflect a return of at least 50% of the cost of production.The Ministry also fixes a Fair and Remunerative Price (FRP) for the purchase of sugarcane by sugar mills. FRP for 2022-23 was fixed at Rs 305 per quintal.

Agricultural Credit: Availability and accessibility to adequate, timely and low-cost credit is necessary for profitable farming. Over the past ten years, the total institutional credit availed by farmers has increased at CAGR 7.8%.[19]. In 2021-22, the Ministry had targeted to provide Rs 16.5 lakh crore worth of credit to the farmers. It exceeded its target by 13%. It aims to provide Rs 18.5 lakh crore as agricultural credit in 2022-23. As access to credit has increased, the proportion of short-term credit has been reducing since 2012-13. However, it rose from 57% in 2020-21 to 60% in 2021-22 (as of December 2022). A higher share of short-term credit indicates that farmers are borrowing to meet their recurring expenditure needs, rather than funding long-term investments.
Fertilizer subsidy: Fertilizers are subsidised through a urea subsidy (which contains nitrogen) and a nutrient-based subsidy for P and K fertilizers. Subsidy is provided to fertilizer manufacturers and importers so that farmers can directly purchase them at subsidised rates. In 2023-24, Rs 1,75,103 crore was budgeted for fertilizer subsidies 22% less than the revised estimates of 2022-23. However, the subsidy for 2023-24 is 66% greater than the budget estimates for 2022-23.

In 2022-23, Rs 1,05,222 crore was budgeted for fertilizer subsidies, which increased to Rs 2,25,222 crore (114% increase) at the revised stage. In November 2022, the central government increased the subsidy rates for nutrient-based fertilizers for the Rabi season 2022-23 (October 1, 2022 to March 31, 2023). The increase was mainly on account of increased subsidy to indigenous urea, which was driven by an increase in *international prices of fertilizers.*

Institutional credit for agriculture sector: Increased from Rs. 8.5 lakh crore in 2015-16 with a target to reach Rs. 18.5 lakh crore in 2022-23. Benefits through Kisan Credit Cards (KCC) at 4% interest per annum have also now been extended to Animal Husbandry and Fisheries farmers for meeting their short-term working capital needs.

Income support through transfers: To supplement the financial needs of farmers, they are being provided with income transfers. PM-KISAN is a direct benefit transfer scheme that was launched in February 2019.It provides landholding farmer families with income support of Rs 6,000 per year (in three instalments of Rs 2,000).In 2023-24, Rs 60,000 was allocated towards the scheme, same as the revised estimates for the previous year. The Scheme receives the highest allocation (48%) from the Ministry.

Constant income transfers with rising rural inflation: PM-KISAN was operationalised in December 2018 and aims to enable farmers to procure inputs to ensure crop health and yield. It is currently applicable to all landholding farmer families irrespective of the size of landholdings. Between 2019-20 and 2021-22, the amount to be disbursed to each family has remained constant (Rs 6,000). However, during this period rural inflation was between 4-6%. Rural inflation includes prices of vegetables, housing, and transport.

Farmer pensions: The *Pradhan Mantri Kisan Maan Dhan Yojana* (PMKMY), launched in 2019 is a central sector scheme to provide pensions to small and marginal farmers with cultivable land of up to two hectares.Eligible beneficiaries are entitled to a monthly pension of at least Rs 3,000. As of November 2019, 18.8 lakh farmers have registered under the Scheme. Farmers within the 18-40 age bracket are eligible under the Scheme. In 2023-24, the Scheme has been allocated Rs 100 crore, against the revised estimates of Rs 50 crore in 2022-23, implying coverage of less than 15,000 farmers. In 2021-22, the Ministry spent Rs 40 crore.

Institutional Reforms

- *Pradhan Mantri Krishi Sinchai Yojana, Soil health card, and Prampragat Krishi Vikas Yojana:* Aiming to raise output and reduce cost.
- *Pradhan Mantri FasalBima Yojana*: To provide insurance against crop and income loss and to encourage investment in farming.
- *Interlinking of rivers*: To raise output and farm incomes.
- *Operation Greens*: to address price volatility of perishable commodities like Tomato, Onion and Potato (TOP).
- *PM Kisan Sampada Yojana:* To promote food processing in a holistic manner.

Technological Reforms

- *Initiating E-NAM*: The National Agriculture Market (eNAM) is a pan-India electronic trading portal which networks the existing APMC mandis to create a unified national market for agricultural commodities.
- *Technology Mission on Cotton*: This aims to increase the income of the cotton growers by reducing the cost of cultivation as well as by **increasing the yield** per hectare through proper transfer of technology to the growers.
- *Technology Mission on Oilseeds, Pulses and Maize* (TMOPM): The schemes implemented under TMOP are:
- Oilseeds Production Programme (OPP)
- National Pulses Development Project (NPDP)
- Accelerated Maize Development Programme (AMDP)
- Post Harvest Technology (PHT)
- Oil Palm Development Programme (OPDP)
- National Oilseeds and Vegetable Oils Development Board (NOVOD)
- *Mission for Integrated Development of Horticulture* (MIDH): It is a scheme for the holistic growth of the horticulture sector covering fruits, vegetables, root & tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa and bamboo.
- *Sugar Technology Mission*: It aimed at reducing the cost of production of sugar and improving sugar quality through steps for improvements in productivity, energy conservation and improvements in capital output ratio.
- *National Mission on Sustainable Agriculture*: It aim at promoting sustainable agriculture through a series of adaptation measures focusing on ten key dimensions encompassing Indian agriculture namely; 'Improved crop seeds, livestock and fish cultures', 'Water Use Efficiency', 'Pest Management', 'Improved Farm Practices', 'Nutrient Management', 'Agricultural insurance', 'Credit support', 'Markets', 'Access to Information' and 'Livelihood diversification'.
- *Other Schemes*: In addition, schemes relating to tree plantation (Har Medh Par Ped), Bee Keeping, Dairy and Fisheries are also implemented.

Other initiatives: Promotion of organic farming in the country, Per Drop More Crop, Micro Irrigation Fund, Fertilizer subsidies, Promotion of Farmer Producer Organisations (FPOs), e-NAM, Launch of the National Mission for Edible Oils - Oil Palm, etc.

Road Ahead

Owing to increasing population over the years, demand for food will naturally show anassociated increase. Further, socio-economic changes will also influence the trends on overall demand for food. NCAP Vision 2050 and a study by Kumar et al 2016, showed that the demand for fruits and vegetables will surpass the demand for cereals in the years to come.

Table 1Projected Demand for major food commodities in India

Commodity	Current Production (mt)	Projected Demand (mt)		Growth in Demand between 2030 to 2050 (%)
		2030*	2050**	
Cereals	250	284	359	26.4
Pulses	22	26.6	46	72.9
EdibleOils	8	21.3	39	83.1
Vegetables	175	192	342	78.1
Fruits	93	103	305	196.1
Milk	160	170.4	401	135.3
Sugar	20	39.2	58	48.0
Meat	7	9.2	14	52.2
Egg	4	5.8	10	72.4
Fish	11	11.1	22	98.2

Source:*Kumar et al. (2016) for projected demand in 2030
**NCAP Vision 2050 for projected demand in 2050

To meet this variation in demand, there will be need to diversify and shift existing are as into crops where demand is expected to grow at a higher pace. Looking at the food grain production scenario, country is self-sufficient or rather surplus in food grain requirement thus there is a possibility to shiftsome area to other crops which are high in both nutrition and in value. This will necessitateundertaking important changes in the current agriculture scenario and offers high potential inachievingdoublingof farmers'income.

Undoubtedly, income earned by a farmer from agriculture is crucial to address agrarian distress (Chand 2016) and promote farmers welfare. In this background, the goal set to double farmers' income by 2022-23 is central to promote farmers welfare, reduce agrarian distress and bring parity between income of farmers and those working in non-agricultural professions. Following strategies would be important for adaptation.

- *Technological Innovation:*The government should invest in research and development to come up with new technologies that can help farmers increase their productivity and profitability. This can include the use of solar panels on farmers' fields as a third crop.
- *Protecting the basic resources:* DFI must encompass policies that also protect the basic resources of this planet, say soil, water, air, and biodiversity. Millets, pulses, oilseeds, and much of horticulture could perhaps be given carbon credits to incentivize their cultivation. They consume less water and fertilizers. The CAG should take up the audit of all subsidies given by the Centre and states to examine their outcomes in terms of the incomes of farmers and environmental consequences.

- *Integrated farming systems*- such as fishery, beekeeping, mushrooms, apiculture, sericulture etc.
- *Improvement in Livestock Management:* In the case of livestock, improvement in herd quality, better feed, increase in artificial insemination, reduction in calving interval and lowering age at first calving are the potential sources of growth.
- *Need for Technology and New Practices:* Technology adoption, minimizing yield gaps, better and sustainable irrigation practices etc. are few areas that need attention for enhancing the productivity growth in crops. The country needs to increase the use of quality seed, fertiliser and power supply for agriculture. Adoption of agronomic practices like precision farming to raise production and income of farmers substantially.
- *Agricultural diversification:* Concentration on few cereal crops has reduced profitability, distracted investment, and dampened growth in the agricultural sector. Diversification is considered a shift of resources from one crop (or livestock) to a larger mix of crops and livestock, keeping in view the varying nature of risks and expected returns from each crop/livestock activity and adjusting it in such a way that it leads to optimum portfolio of income. Agricultural diversification can help to reverse these trends by making the sector more profitable as it becomes flexible in meeting the local and international demands and enables poor people to do something new and remunerative yet within their sphere of competencies and resources.
- *Diversification towards High Value Crops :* Diversification towards high value crops (HVCs) offers a great scope to improve farmers' income. The staple crops (cereals, pulses, oilseeds) occupy 77 % of the total or gross cropped area (GSA) but contribute only 41% of total output of the crop sector. Interestingly, almost same value of output was contributed by HVCs (fruits, vegetables, fibre, condiments and spices and sugarcane), which just occupy 19% of gross cropped area during 2013-14). Average productivity ofHVCs after adjusting for cropping intensity variations was estimated as Rs. 1,42,777 per hectare as compared to Rs. 41,169 per hectare for the staple crops. With thisdifferential in productivity, shifting one hectare area from staple crops to commercial HVC has the potential to increase gross returns upto Rs 1,01,608 per hectare.
- *Expansion in Required Areas:* Area under irrigation has to be expanded by 1.78 million hectares and area under double cropping should be increased by 1.85 million hectares every year. Besides, the area for fruits and vegetables is required to increase by 5% each year.
- *Production balance and Marketing:* Farmers' income is directly related to both production and the marketing of the produce. There is need to grasp the gains inform of income enhancement along with maintaining the production balance in commodity status. Moreover, moving to sync with changes in the consumer preference for specific commodities and for better quality will also foster trade across the nation, which will further increase the share from farming income and allied activities.
- *Food processing industries* - will help farmers to decrease post handling loss and assured prices of products.
- *Realignment of Support Policies:* The government should incentivize the cultivation of crops that are environmentally friendly and consume fewer resources such as water and fertilizers. Millets, pulses, oilseeds, and horticulture crops could be given carbon credits

to encourage their cultivation. The subsidies/support should be crop-neutral or skewed in favour of the crops that are beneficial for the planet's resources.

- *Aligning policies for procurement of millets*: Greater procurement of millets instead of cereal centric procurement will help to increase income.
- *Restructuring of existing extensionsystems* towards more participatory methods and provision of small term loans in terms ofmicro-finance options has been found to be an effective means of strengthening the linkages between farmers and the research community. The training of farmers in new technologies and processes involved in diversification willimprove their technical ability to engage in diversification.
- *Promotion of FPOs* for better risk management and greater bargaining power.
- *Diverting the excess manforce* would help to reduce burden on agriculture.
- *Collaboration with Corporations:* The government can collaborate with corporations to provide farmers with better market access and an assured buyback arrangement to reduce their market risk. Corporations can also offer farmers better prices for their produce by using them for making value-added products such as tofu, soya milk powder, soya ice cream, and frozen soya yoghurt.
- *Reforms in Marketing structure:* The Dalwai Committee in Doubling the Farmers income had recommended substantial reforms in Marketing structure including reforms in APMCs, and placing agricultural marketing in the Concurrent list.
- *Intervention of the Government:* The government schemes will not help them double their income unless the government policies on agriculture are comprehensive, grant freedom of technology and market, and infuse more money into infrastructure development.
- *Ad hoc policies and schemes* will not help farmers as long as the government intervenes in the market to control prices to keep the consumers happy at the cost of farmers.
- *Need for Comprehensive Reforms:* About one-third of the increase in farmers' income is easily attainable through better price realization, efficient post-harvest management, competitive value chains and adoption of allied activities.This requires comprehensive reforms in market, land lease and raising of trees on private land.
- *Cooperation with local NGOs and producer group* with regards to extension work has proved very beneficial so as to fulfil the needs of women, small and marginal farmers.
- *Regional and international networking and contractual research* are considered important to quickly resolve a wide variety of constraints in diversification that differs from region to region.
- *Establishment of fruitful corporations between native entrepreneurs and foreign businesses :* There is the need for enabling the establishment of fruitful corporations between native entrepreneurs and foreign businesses and by serving local businesses to upgrade their standards so as to conform to international quality requirements.

Most of the development initiatives and policies for agriculture are implemented by the states. States invest much more than the outlay by the Centre on many development activities, like irrigation. Progress of various reforms related to marketand land lease are also state subjects. Therefore, it is essential to mobilize states to own and achieve the goal of doubling farmers' income. If concerted and well-coordinated efforts are made by Centre and all the States, the country can achieve the goal of doubling farmers' income within 7 to 10 years period. But for all this to be successful farmers need assistance in acquiring the technical knowledge of these arrangements and assistance in accessing related markets.

Conclusion

We need innovations in technologies, products, institutions and policies for more diversified high-value agriculture on the principle of Integrated Farming System that is also planet friendly.Climate change remains the major challenge impacting yields of crops, livestock, dairy and fisheries; and further impacting price behaviours often locally and sometimes globally. Government introduced two major responses to climate change –National Mission for Sustainable Agriculture (NMSA) for development and National Innovations on Climate Resilient Agriculture (NICRA) for research. These key initiatives aimed at transforming agriculture into a climate resilient production system through adaptation and mitigation measures. On the question of doubling farmers' income, we must realise it is going to take time.

References

Chand Ramesh (2017) Doubling Farmers' Income: Strategy and Prospects. Indian Journal of Agricultural Economics 72 (1) 1-23.

FAO. 2018. FAOSTAT Statistical Database. Rome, United Nation

Gulati, A. and Gupta, S. 2019. From Plate to Plough: Market incentives, direct income support for farmers are far more effective in increasing agricultural productivity. The Indian Express. 31 October.

Kumar, Praduman, Joshi, P. K. and Mittal, Surabhi (2016) Demand vs Supply of Food in India-Futuristic Projection. Proceedings Indian National Science Academy, 82 (5), 1579-1586.

Majhi, B. and Kumar, A. 2018. Changing cropping pattern in Indian agriculture. Journal of Economic and Social Development, 14(1): 37-45.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/15/0124

REVITALIZING MILLETS: NOURISHMENT FOR HEALTH AND SUSTAINABILITY

P. S. Sapariya[1]* and M. N. Dabhi[2]

[1]PhD Scholar, Department of Processing and Food Engineering,
[2]Research Engineer, AICRP on Post-Harvest Engineering and Technology,
College of Agricultural Engineering and Technology, Junagadh Agricultural University,
Junagadh-362001, Gujarat, India
*Corresponding Email: parthsaparia0@gmail.com, ORCID ID: 0000-0002-8691-5732

Abstract
This article highlights the nutritional and sustainable benefits of millets, emphasizing their potential in addressing contemporary health and environmental challenges. Millets, rich in protein, fiber, and essential minerals, offer a gluten-free and nutrient-dense alternative. Innovative processing techniques have facilitated their integration into diverse food products. Millets contribute to healthy living and environmental sustainability, presenting opportunities in both food and non-food applications. Challenges in standardizing processing techniques and increasing consumer awareness require governmental support. Embracing millets can lead to a healthier, more resilient, and sustainable future, addressing global nutritional security and environmental concerns.

Introduction

In the pursuit of well-being, the importance of good nutrition cannot be overstated. Plants have long been the primary source of sustenance for human beings, offering a diverse array of nutrients essential for health and survival. Among the many grains that contribute to our dietary needs, millets stand out as ancient yet often overlooked gems. As we navigate modern health challenges and environmental concerns, the revitalization of millets emerges as a promising pathway towards a healthier and more sustainable future.

Unlocking the Potential of Millets

Millets, a diverse group that includes finger millet, kodo millet, and little millet, boast nutritional profiles that outshine conventional staples like rice. Rich in protein, dietary fiber, energy, and minerals, millets offer a compelling alternative for those seeking a nutrient-dense diet. Their gluten-free nature, coupled with bioactive compounds and high micronutrient density, positions millets as ideal candidates for developing functional and value-added food products. However, their potential has been underutilized, largely due to a lack of standardized processing techniques.

Minor Millets - Nutrient Powerhouses

Minor millets, categorized as nutri cereals, belong to the Poaceae family, encompassing up to thirty-five species of grasses. Finger millet, foxtail millet, proso millet, barnyard millet, kodo millet, and little millet are among the crucial cultivated species. Notably, barnyard millet stands out as the richest source of calcium, surpassing rice and wheat by tenfold. Minor millets are laden with essential micronutrients like magnesium, calcium, manganese, tryptophan, phosphorus, fiber, and B vitamins, serving as antioxidants crucial for human health. Their unique feature of requiring minimal water for cultivation and resilience to severe climatic conditions further enhances their significance.

Innovative Millet Processing

Efforts to unlock the potential of millets have led to the development of innovative processing techniques. The transformation of raw millet grains into edible forms such as rice, flour, and sprouts has been a key focus. These processing methods not only enhance the quality of millet products but also facilitate their integration into a variety of popular foods. From traditional recipes to bakery items, pasta, and instant food mixes, millets are finding their way into the mainstream.

Millets and Healthy Living

As health-conscious individuals seek alternatives to pharmaceutical solutions, millets have emerged as a beacon of wellness. The richness of tryptophan, magnesium, and niacin in millets contributes to mood stability, migraine reduction, and cholesterol control. Beyond their nutritional benefits, millets play a role in environmental sustainability. As low-input crops adaptable to marginal lands, they offer a solution for cultivating food in diverse climates.

Diverse Millet Applications

Millet-based products, deeply rooted in the culinary traditions of various regions, encompass a rich array of both food and non-food items. These can be broadly categorized into whole-grain foods, flour-based foods, and both alcoholic and non-alcoholic beverages.

In the realm of **whole-grain foods**, popping millet grains is a common practice, involving a meticulous process of moistening, tempering, and agitation in hot sand beds. This method results in popped grains like pearl millet, finger millet, and foxtail millet, which are either consumed as snacks or further processed through milling. Germinating millet seeds, especially finger millet, little millet, and kodo millet, enhances their protein, mineral, and vitamin content, making them suitable for consumption, particularly for infants and the elderly. Additionally, direct cooking methods, such as the preparation of rice-like dishes like Kichadi using whole grains like pearl millet, foxtail millet, kodo millet, and little millet, showcase the diverse culinary applications of millets.

Foods made from millet flours represent another dimension of millet utilization. Staple flatbreads in Africa, like kisra and injera, undergo specialized fermentation, resulting in soft leavened textured bread with acidic flavor. Unfermented flatbreads, such as rotis or chapatis, prominent in Indian cuisine, are soft pancakes with a flexible puffed texture, often served with pickles, vegetables, chutney, meat, or sauce. Dosas and idlis, popular in southern India, utilize semifermented millet flour and are typically served with sambar or chutney. Couscous, a pasta-like culinary delight from North Africa, is prepared from millet semolina. Boiled dough dumplings, known as dingwa in Africa and mudde or ragi balls in India, and snacks like ponganumis, prepared by frying steamed millet dough in India, highlight the diverse applications of millet flours. Porridges from various millet meals, classified based on consistency, solid content, serving temperature, and pH ranges, are consumed globally.

The versatility of millets extends to the realm of **alcoholic beverages**, with traditional opaque beers from fermented pearl millet and finger millet being popular in Africa and India. Beverages like Busa or Bouza in Egypt and Turkey, tella and katikalla in Ethiopia, and Chhang or Jaanr or Jnard in the Indian Himalayas, showcase the varied cultural significance of millet-based alcoholic drinks. In West Africa, traditional beers like Sulim, Burukutu, Dolo, talla, or Pito, made from fermented pearl millet grains, present sweetish and fruity options with alcohol content ranging from 1% to

5%. **Nonalcoholic beverages**, such as Oskikundu in Namibia and Togwa in Tanzania and Nigeria, contribute to the rich tapestry of millet-based drinks, emphasizing their importance beyond the alcoholic domain.

Moving beyond the culinary domain, millets play a crucial role in **non-food products.** Rich in starch, millets serve as raw materials for manufacturing bioethanol, offering potential applications in bio-industries. Starch wet milling, while yielding ethanol as a by-product, faces challenges due to the poor quality of extracted starch, influenced by the high content of polyphenolic pigments in millet glumes or pericarp. Additionally, millet grains containing Kafirin, a hydrophobic prolamin storage protein, become essential in the production of biopolymers and bioplastics. Bioplastics, created by combining Kafirin with glycerol, polyethylene glycol 400, and lactic acid as a plasticizer, exhibit superior properties compared to commercial zein plastics from maize. These bioplastics are commercially used in Africa for coating pears, reducing stem-end shriveling, increasing shelf life, and delaying ripening. Moreover, millet grains contribute to bio-coatings, with sorghum pericarp wax combined with carnauba palm wax being employed as edible coatings for candies and confections.

In summary, millets with their diverse applications in both food and non-food products, emerge as invaluable contributors to global culinary traditions and industrial innovations.

Challenges and Opportunities

While the revitalization of millets is a promising endeavour, it is not without challenges. Standardizing processing techniques and increasing consumer awareness are critical steps. The cultural shift towards embracing millets in daily diets is essential for their widespread acceptance. Governments and agricultural agencies play a pivotal role in promoting millet cultivation, offering incentives, and fostering research into advanced processing methods.

Conclusion

In conclusion, the journey to revitalize millets is not just about resurrecting ancient grains but about redefining our approach to health and sustainability. Millets offer a nutritional renaissance, addressing contemporary health concerns while providing a sustainable alternative in the face of climate change and environmental degradation. As we continue to explore their processing potential and nutritional benefits, millets stand poised to play a transformative role in achieving global nutritional security and environmental sustainability. It's time to embrace the goodness of millets for a healthier, more resilient, and sustainable future.

References

Chandra A., Singh A. K.and Mahto B. (2018). Processing and value addition of finger millet to achieve nutritional and financial security–case study, International Journal of Current Microbiology and Applied Sciences, 7(1): 2901-2910.

Deshpande S.D. and Nishad P.K. (2021). Technology for Millet Value-Added Products. In: Kumar, A., Tripathi, M.K., Joshi, D., Kumar, V. (eds) Millets and Millet Technology. Springer, Singapore. https://doi.org/10.1007/978-981-16-0676-2_14

Sapariya P. S., Sangani V. P. andDavara P. R. (2022) Effects of Process Parameters on Rice Based Extruded Snack Food. International Journal of Agriculture, Environment and Biotechnology, 15(Special Issue): 407-415.

Sapariya P. S., Sangani V. P. andMuliya M. H. (2020). Development of Nutrient Rich Extruded Product using Rice, Finger Millet, Soybean and Mango Seed Kernel Flour, Int. J. Curr. Microbiol. App. Sci, 9(7): 1207-1216.

Singh A., Kumar M. and Shamim M. (2020). Importance of minor millets (Nutri Cereals) for nutrition purpose in present scenario, International Journal of Chemical Studies, 8(1): 3109-3113.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/16/0124

OPEN-SOURCE SOFTWARES FOR COST-FREE DIGITAL FARMING

Nishtha Pradarshika Rai

Research Scholar, Department of Agricultural Statistics,
Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal-736165
Corresponding Email:* agriindiatoday@gmail.com

Abstract

The popularity of open-source technology has been increasing over the past few years. Open-source softwares are applications for executing certain tasks that are programmed in such a way that they can be used, developed, and altered. Stakeholders and farmers who use open-source technology receive cost and time-saving benefits. Open-source softwares are important for training and education, precision agriculture, collaboration, and cost management. They are very effective in digitizing agriculture and increasing production. The easy accessibility and no-cost feature of free open-source software enables farmers to manage their farms, reap maximum benefits in terms of time, employee, and farm management, income generation, education, and co-ordinate farm activities.

Introduction

The agriculture industry is a transitioning industry. It has transformed technologically in the past years with the additional support of open-source technology. The advancement of smart farming technology in India has made farmers embrace optimum techniques for sustainable farming, determining the timing of cultural practices, reducing irrigation-related problems, and increasing yield. Partners in the supply chain are receiving cost-saving and flexible benefits from open-source software and hardware development approaches. This in turn helps agri-tech organizations to promote and improve precision farming to reach an extensive pool of customers.

India in recent years has seen a surge in the number of consumers using IoT gadgets and high-speed networks (4G or 5G). This makes precision agriculture easier to incorporate into both the young and old minds of the nation. The agri-tech industry through the use of open-source softwares and hardware can take care of special requirements to make precision agriculture an extensive practice.

Open-Source Software

Open-source software or programs are free applications that enable a user to examine, use, download, and develop the source code (Medevel, 2023). Source code is the programming code used by programmers and developers to give structure to a program and manipulate the manner in which it is to be executed. The open-source codes are stored in an accessible repository so that they can be distributed widely. Open-sourceTechnology makes it possible to alter the codes and make improvements in the structure and function for software developers, users, and organizations depending on the need and suitability. Open-source softwares are usually licensed with terms and conditions on how it can be managed, altered, used and propagated.

Importance of Open-source Technology

The extensive use of technology has made way for open-sourcetechnology that offers some advantages to farmers and stakeholders for training and education, collaborations, infrastructure and the capacity to fit technology according to local requirements (Verma, 2023). The impact of open-source technology is evident in:

1. **Education:**Open-source technology provides wide opportunities for training and education of learners and especially farmers for providing accessible information and solutions to general as well as specific problems. The online platforms render virtual training programmes including joint effort partnerships for reaching a wide audience. Institutions make use of open-source technology for free videos, images, learning materials and courses for self-paced learning.

2. Precision agriculture: The open-source technology is associated with precision agriculture for the holistic development of agriculture. They are effectively customizable, flexible, and inexpensive. Open-source software and hardware assemble information on crop development and soil conditions which assists farmers in arriving at solutions for fertilizer, pesticide application, irrigation, and other crop management practices.

3. Community: Farmers and stakeholders teaming up on projects, ideas, and assets cultivate a harmonious relationship among them. This brings in a spirit of oneness and brotherhood where people trust each other for their common objectives. These types of collaborations result in knowledge sharing.

4. Collaboration: As a whole, not only do individuals and communities benefit, but this free share of insights, data, and projections brings the agriculture sector to greater heights. Organizations unite stakeholders, agri-tech workers, and farmers to work on building open-source platforms.

5. Cost minimization: The usage of open-source technology empowers stakeholders and farmers to get access to free hardware and software without making significant expenditures in the purchase of licensed and restricted systems.

6. Localization: The adaptability of open-source technology permits it to be custom-fitted to meet the specific necessities of different regions.For instance, artificial intelligence based on open-source algorithms can be utilized to recognize plant infections that are specific to a particular locale. By adjusting to local requirements, developers can make the platforms more available and pertinent to farmers, showing the capability of open-source softwares to engage and serve the various communities in a locality.

Digital Farming

Digital farming is the application of precision agriculture methods and internal and external farm networking along with web-based platforms and big data. Digital farming is often called as e-agriculture or smart farming in which agriculture data is collected, analyzed, stored, and shared electronically. Digital farming encompasses multiple technologies such as IoT, big data analysis, machine learning, blockchain technology, digital communication technology, e-commerce platforms and precision agriculture technologies. Digital farming aims to take over the food value chain from pre-harvest operations up to post-harvest management.

Agriculture-based Free Open-Source Softwares for digital farming:

Open-source software has the support of a community of developers and users due to its availability at low or free cost. The execution of open-source software empowers farmersto operate and organize a farm for proficiency in production and profit.This assists in making open source significantly more available and adaptive for problem-solving than other restrictive options. Given below is a description of the best free open-source softwares for agriculture:

1. FarmOS

Fig. 1 Logo of farmOS software

It is an online software used primarily for record-keeping, planning, tracking, and farm management. It is one of the best and top free open-source softwares in the world. This software is run by a community of developers, researchers, farmers, and associations that work towards rendering a platform for data collection and farm management. It is maintained by Drupal,a free content management system. The farmOS Field Kit application which is a mobile appmakes available data entry in offline mode through a web app at farmOS.app. These are free and registered under the GNU General Public License. The source code for the app is accessible through farmOS GitHub.

The application is helpful when setting the area of the resources. By the use of geometry, you can draw, zoom, address search and geolocate. One can make changes and strategies for cultivation practices through the Planning Ahead option. All the daily farm activities, inputs, and observations are displayed in the calendar. This application also helps you assign tasks to people. This is an efficient tool for farm resource management.

2. Tania

Fig. 2 Logo of Tania software

Tania is an open-source journal and software that provides you with accessible information for agricultural management. It was initiated in the year 2017 by Tanibox OU. The source codes are available on GitHub and licensed under Apache 2.0. It is built on the Go programming language and requires a MySQL/SQLite database. The creators have designed the digital software to make it cost-free for smart farming. The community of experts, farmers, and developers are active on Telegram as well.

The dashboard provides information on the area of crop cultivation. It gives you guidance on the crop variety to be applied, areas that require management, and the ongoing crop plan(Richards, 2023). Theclimate sensors in farms and irrigation keep records of the climate scenario. Water reservoirs installed can also be included in the farm management plan for timely irrigation.

3. LiteFarm

Fig. 3 Logo of LiteFarm software

LiteFarm is an interdisciplinary collaboration of Centre for Sustainable Food System staff, open-source enthusiasts, farmers, specialists, designers, and donorsinitiated by the University of British Colombia. It is a cloud-hosted, web-based application developing constantly since 2020. Developers can access the source codes through GitHub.The software is being used by over 140 countries to equip farmers with decision-making skills for the sustainability of the livelihood of the farming community.

The software helps make appropriate measurements, observe market changes, track crop growth and monitor weather activities in real time. It helps you keep track of the organic matter input, and the amount of water added in the soil.This is useful in making a comparison of the crops cultivated based on time, location, and price. The software offers tutorials on topics related to farm management.

4. FarmVibes.AI

Fig. 4 Microsoft's FarmVibes.AI at GitHub

It is a platform for modelling multi-modal geospatial machine learning modelsand spatiotemporal datasets. FarrmVibes.AI is a product of Microsoft Research's Project FarmVibes which develops technologies for sustainable farming. FarmVibes.AI is a combination of data sources such as drone and satellite imagery, terrain elevation and weather data to build efficient AI models. The datasets are available to the public and can be downloaded. It is based on a Kubernetes or K8s computing cluster consisting of a REST API or a Python client for monitoring workflows and results, a harmonious model for work execution; workers for processing the data; and a cache for storing results (Alford, 2022).

The workflows implement different models for feature identification of farm infrastructures, carbon sequestration, the number of emissions and water conservation. These models are built by fusing the spatiotemporal and geospatial data from field observations to get insights regarding the nutrition (protein and yield) of the food, carbon dioxide and other equivalent emissions from fertilization and cover crops and soil moisture content.

Conclusion

Advanced technology has played a huge part in developinghigh-quality crops and new creative agri-horticultural practices.Futuristic technologies developed in the recent past such as the Internet of Things, data analytics, artificial intelligence, and robotics have made farming activities convenient. Open-source technology will help in the increase of food productionthrough digital agriculture incorporating a single system.

References

Alford A (2022). Microsoft Open-Sources Agricultural AI Toolkit FarmVibes.AI. In: AI, ML & Data Engineering. INfoQ. Available via: https://www.infoq.com/news/2022/12/microsoft-farmvibes/

Medevel (2023) 10 Open Source Free Farm Management Software. In: Evergreen.Available via: https://medevel.com/os-farm-software/

Richards P (2023). The Best 7 Free and Open Source Farm Management Software. In: Farm Management Software. GoodFirms. Available via: https://www.goodfirms.co/farm-management-software/blog/best-free-open-source-farm-management-software

Verma A (2023) Adoption of open-source tech into agriculture: What agritech players can make happen. In: Voices. The Times of India.Available via: https://timesofindia.indiatimes.com/blogs/voices/adoption-of-open-source-tech-into-agriculture-what-agritech-players-can-make-happen/

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 04/I/17/0124

PROTEINS IN THE DEEP SEA: APPLICATIONS OF PROTEOMICS IN AQUACULTURE

Gowhar Iqbal

[1]ICAR-Central Institute of Fisheries Education, Versova, Mumbai, India 400061
Corresponding author. E-mail: drgowhariqbal@gmail.com

Introduction

Proteomics, the study of proteins and their functions, has emerged as a groundbreaking field in the realm of biological sciences. As an integral component of systems biology, proteomics plays a crucial role in deciphering the complex interplay of proteins within cells, tissues, and organisms. This article delves into the fundamentals of proteomics, its methodologies, and its profound impact on understanding life at the molecular level. Aquaculture has made use of proteomics—the study of proteins and their worldwide functions—in a number of ways. The farming of aquatic organisms, including fish, shellfish, and plants, is known as aquaculture, and it has grown to be an essential part of the world food chain. Proteomics is the comprehensive study of the entire proteome or all the proteins expressed by a single cell, tissue, or organism. It goes beyond analysing individual proteins in a static manner. Proteomics sheds light on the dynamic and functional elements of biological systems, in contrast to genomics, which is primarily concerned with genes and their sequences. The application of proteomics in aquaculture contributes to improving the understanding of various biological processes, enhancing the efficiency of aquaculture practices, and addressing challenges related to the health and productivity of aquatic organisms (Rodrigues*et al.,* 2017). This article delves into the fundamentals of proteomics, its methodologies, and its profound impact on understanding life at the molecular level and applications of proteomics in aquaculture.

Technological Advancements

Technological developments in the field of proteomics have allowed researchers to investigate the complexities of the proteome with a level of precision never before possible. Proteomic investigations utilise several important techniques, including mass spectrometry, protein microarrays, and two-dimensional gel electrophoresis. Researchers can now analyse complicated protein mixtures with amazing sensitivity and accuracy thanks to the advancements made in mass spectrometry, which has completely changed the identification and quantification of proteins (Zhou*et al.,* 2012).

Applications of Proteomics in Aquaculture

1. Disease Diagnosis and Management:

Proteomic techniques allow for identifying proteins associated with various diseases affecting aquatic species. By comparing protein profiles between healthy and diseased individuals, researchers can identify potential biomarkers for early disease detection. This information is critical for the development of diagnostic tools and the implementation of effective disease management strategies in aquaculture.

2. Vaccine Development:

Proteomics plays a crucial role in vaccine development for aquaculture species. Through the identification and characterization of proteins implicated in aquatic creatures' immune responses, scientists can develop vaccines that elicit a defensive immune response. Aquaculture facilities can use a focused approach to lessen the risk of infectious disease outbreaks.

3. Nutritional Studies:

Understanding the nutritional requirements of aquatic species is essential for optimizing feed formulations in aquaculture. Researchers can examine the protein content of different feed ingredients and how they affect the development and well-being of fish and other cultured organisms by using proteomics. Creating nutritionally balanced diets that support ideal growth and lessen environmental effects is made easier with the use of this knowledge.

4. Functional Proteomics:

Investigating the functions of proteins within cellular pathways is a central focus of proteomics. Functional genomics seeks to understand the biological importance of genes and their functions in diverse cellular processes, in contrast to genomics, which is primarily concerned with the sequencing and study of genomes. These are some important concepts and methods related to functional genomics. Through the mapping of subcellular localization, post-translational changes, and protein-protein interactions, scientists can better understand the dynamic processes that control cellular function.

5. Drug Discovery and Development

Understanding the proteome is essential for drug discovery and development. Proteomic techniques aid in identifying target proteins implicated in particular illnesses, enabling scientists to create medications that specifically alter these targets. Proteomics also helps in assessing the possible adverse effects and effectiveness of medications.

6. Disease Biomarker Discovery:

Proteomics has proven invaluable in the search for biomarkers associated with various diseases. By comparing proteomic profiles of healthy and diseased tissues, researchers can identify potential biomarkers that may aid in early disease detection, prognosis, and treatment monitoring. By comparing protein profiles between healthy and diseased individuals, researchers can discover biomarkers for early disease detection. This information is crucial for developing diagnostic tools and implementing effective disease management strategies, helping minimise aquaculture economic losses.

7. Reproductive Biology:

Proteomic analysis contributes to the understanding of reproductive processes in aquaculture species. Proteins involved in fertilisation, gamete formation, and embryonic development can be studied by researchers. This information is helpful for boosting reproductive success, strengthening breeding programmes, and guaranteeing the long-term viability of aquaculture businesses (Martin et al., 2009).

8. Environmental Monitoring:

Proteomics can be applied to assess the impact of environmental factors on aquatic organisms in aquaculture settings. By studying changes in protein expression patterns in response to environmental stressors such as pollution or changes in water quality, researchers can develop early warning systems and management strategies to mitigate the effects of adverse environmental conditions.

9. Quality Control and Traceability:
Proteomic techniques can be employed for quality control in aquaculture products. By analyzing the protein composition of fish and shellfish, researchers can verify the authenticity of species, detect adulteration, and ensure compliance with food safety standards. This is particularly important for maintaining consumer confidence and meeting regulatory requirements (Gomes*et al.,* 2017).

10. Stress Response and Welfare:
Proteomics helps understand how aquatic organisms respond to stressors, such as handling, transportation, or changes in environmental conditions. Monitoring stress-related protein changes can contribute to developing practices that minimize stress and improve the overall welfare of cultured species.

11. Environmental Monitoring:
Proteomic techniques are applied to assess the impact of environmental factors on aquatic organisms. By studying changes in protein expression in response to environmental stressors, researchers can monitor the health of aquatic populations and ecosystems. This information is valuable for sustainable aquaculture practices and environmental conservation efforts.

Challenges and Future Perspectives:
Despite its many successes, proteomics faces challenges such as the dynamic nature of proteins, the vast complexity of biological samples, and the need for improved data analysis tools. Ongoing advancements in mass spectrometry, data integration, and computational biology are expected to address these challenges and further enhance the capabilities of proteomic research.

Conclusion
Proteomics has become an indispensable tool in unravelling the mysteries of life by providing a comprehensive understanding of the dynamic and functional aspects of the proteome. Proteomics will surely become increasingly important as technology develops, helping us understand disease mechanisms and cellular processes better and ultimately leading to the creation of novel therapeutic approaches. Proteomics is a complex field with great potential for major discoveries that will influence biology and medicine in the future.

In conclusion, applying proteomics in aquaculture has broad implications for improving aquaculture operations' health, productivity, and sustainability. In aquaculture, proteomics plays a major role in disease control, vaccine development, nutritional optimisation, reproductive tactics, stress reduction, product quality control, and environmental sustainability. Proteomic techniques are expected to become more significant as technology develops in tackling the opportunities and problems facing the aquaculture sector. By providing insights into the molecular processes governing various aspects of aquaculture, proteomics contributes to developing targeted interventions and informed decision-making in the industry.

REFERENCES
Rodrigues, P.M., Campos, A., Kuruvilla, J., Schrama, D. and Cristobal, S., 2017. Proteomics in aquaculture: Quality and safety. *Proteomics in food science*, pp.279-295.

Gomes, T., Albergamo, A., Costa, R., Mondello, L. and Dugo, G., 2017. Potential use of proteomics in shellfish aquaculture: from assessment of environmental toxicity to evaluation of seafood quality and safety. *Current Organic Chemistry*, *21*(5), pp.402-425.

Zhou, X., Ding, Y. and Wang, Y., 2012. Proteomics: present and future in fish, shellfish and seafood. *Reviews in Aquaculture*, *4*(1), pp.11-20.
Martin, S.A., 2009. Proteomics in aquaculture. *Molecular Research in Aquaculture*, pp.147-173.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 04/I/18/0124

HEALTH BENEFITS OF MILLET-THE MAGICAL CEREAL

Sandhya Dhyani[1] and Simran Kaur Arora[2*]

[1]Department of Foods and Nutrition, College of Home Science,
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar
[2]Assistant Professor, Department of Food Science and Technology, College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar
[*]Corresponding Email:sim_n@rediffmail.com

Introduction

Millet is often considered the Magical Cereal due to the several health benefits associated with its consumption.In India, millets are considered delicacy and are part of various dishes based on traditional Indian recipes (Bhat, 2019). According to the FAO STAT (2022), India is the fifth largest exporter of millet in the world.The major millet-producing states in India are Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Haryana, Gujarat, Madhya Pradesh, Uttarakhand, Andhra Pradesh and Tamil Nadu.Worldwide, millet plantshave been used as staple crops to overcome problem of hunger in various underprivileged areas. To promote and utilize millets, the United Nations General Assembly, has declared the year 2023 "The International Year of Millets" (https://www.fao.org/millets-2023/en).This hadbrought attention of policy makerstoward sustainable millet production andof consumers, to reap multiple health benefits fromthe consumption of millet.

Millet grains belong to the family "*Poaceae*", and are generally classified as major millets or minor millets. There is one additional category known as pseudomillets. Pseudomillets are millets that do not belong to the family "*Poaceae*", yet they have almost the same nutritional composition and appearance as millets. The major millet categories include Sorghum millet (*Sorghum bicolor*), Pearl millet (*Pennisetum glaucum*) and Finger millet (*Eleusine coracana*). The minor millets include Barnyard millet (*Echinochloa esculenta*), Foxtail millet (*Setaria italica*), Little millet (*Panicum sumatrense*), Porso Millet (*Panicum miliaceum*) and Kodo millet (*Paspalum scrobiculatum*). The pseudo millet category includes Buckwheat (*Fagopyrum esculentum*) and Amaranth (*Amaranthus cruentus*). Along with various health benefits, millet can increase dietary diversity. Soaking, germination, fermentation and puffing are four types of processing methods that are followed to reduce the contents of antinutritional componentsof millet and to enhance the nutritional quality (Birania, 2020; Singh and Arora, 2023).

MILLETS FOR CURING DISEASES

Millets and Cardiovascular Diseases

Heart disease accounts for 30% of deaths worldwide (Arora and Balodhi, 2022). A plant-based diet is generally related to a low risk for cardiovascular diseases (Joshi, Acharya and Arora, 2023). Millets are helpful for curing various health problems such as CVD, hyperlipidemia, and obesity. The consumption of millet can help reduce the level of bad cholesterol and increase the level of good cholesterol in the body.A study has shown that the wax present in sorghum have a compound called policosanol which helps reduce highcholesterol levels in the body and maintain the blood lipid profile(Ambati and Sucharitha, 2019).The dietary fibre present in millet also hasthe ability to bind to bile acid and steroids contributing to its hypocholesterolaemic activity and thus preventing hyperlipidaemia and reducing the risk of various cardiovascular diseasessuch as atherosclerosis (Hou *et al.,* 2018). The consumption of millets in large quantities helps reduce triglycerides in the body, thereby preventing blood platelet clumping and reducingcoronary artery diseases. The lignans of millet are fermented by the gut microflora which helps in the formation of enterolactone which maintains heart health (Rao*et al.,* 2017).

Millets and Obesity

Obesity can be defined as the root cause of various conditions, such as diabetes and CVD. Obesity predisposes individuals to various metabolic disorders and causes several other health issues. Milled grains especially polished rice and refined wheat flour (*maida*), contain reduce amount of dietary fiber and are concentrated source of energy (Arora, 2022). Less processed millet grains are full of complex carbohydrates which are unavailableto the human body because they are resistant to the process of digestion. Millets are good sources of dietary fibre and resistant starch.A rich dietary fibre content ranging from 4-8% also contributes to feelings of satiety or fullness in obese patients and therefore helps in weight management especially in obese people (Ambati and Sucharitha, 2019). Finger millet is rich in tryptophan, an amino acid, which helps in losing weight by lowering of appetite and helping in weight control (Kaur, Kumari and Kumar, 2021). Some new products such as dessert can be developed based on millet as developed for oat bran, psyllium husk and wheat fiber (Arora and Patel, 2015; 2017) to increase its consumption in daily diet.

Millets and Diabetes

Diabetic mellitus is one of the most common chronic metabolic disorders prevailing worldwide which is characterized by hyperglycemia.India is known as the diabetic capital of the world as India has the largest number of diabetes patients in the world.A modern life style of poor dietaryhabits and stress can lead to problems like diabetes. Millet, being rich in complex carbohydrate, low in fat, with the richness of dietary fibre and the characteristic slow release of sugar are good options for inclusion in diabetic diets.The polysaccharides i.e., resistant starch present in millet, help lower blood glucose levels(Bhat *et. al.,* 2019).Compared with those in regular food crops such as rice and wheat, carbohydrates in millets are slowly digested and absorbed and are good alternative foods for diabetic patients (Jan, Nayik and Prasad, 2014).The abundance of magnesium in millet increases the efficiency of insulin hormonesas well as the glucose receptors present on the cell surface. The phenolic compounds present in millet can inactivate enzymes such as alpha-glucosidase and pancreatic amylase which are responsible for the hydrolysis of starch and its absorption. As a result, there is a reduced absorption of starch in the body, ultimately controlling the postprandial glucose level (Singh, *et al.,* 2022). Enzymes such as aldose reductase prevents accumulation of sorbitol and reduce the risk of diabetes mellitus-induced eye problemssuch as cataract disease (Ambatiand Sucharitha, 2019).

Millets and Cancer

Millets have anticarcinogenic properties.The water absorption capacity, toxin binding capacity and bulking property of dietary fibre present in millet help reduce the risk of cancer,especially colon cancers, and problems such as gastric ulcers and inflammatory bowel syndrome(Rotela, Borkar and Borah, 2021).The various phytochemicalsfound in millets, such as polyphenols, tannins and phytates help reduce the risk of cancer. Phenols, tannins and phytates alsoact as anticarcinogen agents for preventing the initiation and progression of cancer cells. Lignans present in millet under the action of the gut microflora are converted to mammalian lignans which act as anticarcinogens for various hormone-dependent cancers, such as breast cancer and reduce the risk of CVD. The linoleic acid present in the millet acts as an antitumour. Millets are responsible for preventing colorectal cancer.The lignans present in millet are prebiotic fibers that are fermented by the micro flora in the gastrointestinal system, and protect against certain chronic diseases. Upon fermentation, millet produce enterolactone which is known for its anticancerous properties against breast cancer.Polyphenols such as tannins, phenolic acids and flavonoids are considered major antioxidants that help maintain the immune system (BoraRagaeeand Marcone, 2019). Xylo-oligosaccharides and vitamin E contribute to the antioxidant activity of millet. Lignin and other phytonutrients in millet also act as strong antioxidants thus preventing heart-related diseases.Ferulic acid also acts as astrong antioxidant and hasan anti-inflammatory effect on the body.Phenolic compounds show antioxidant activityby adsorbing and neutralizing free radicals, quenching singlet and triplet oxygen, or decomposing peroxides. The antioxidant activity of millets is beneficial for healthbecause it boosts the immune system, prevents ageing and various other metabolic diseases (Chauhan, Sonawane and Arya, 2018).

Millets and Hypertension

High blood pressure is one of the leading causes of various other illnesses such as CVD worldwide. It affects quality of life. Therefore, it is a serious threat to human health. Dietary changes are the first-line treatment for curing hypertension. Consumption of foxtail millet helpsprevent hypertension. Increased whole foxtail millet intakeresults in increased amounts of fiber, phytochemicals and minerals (calcium, phosphorus, potassium, magnesium, iron and zinc). Phytochemicals such as flavonoids and phenolic acids help not only decrease oxidative damage in the body but also help in preventing various diseases such as cancers. Various in-vitro and in-vivo studies support that the phytochemicals present in the millets have serum-lipidlowering effects (Hou, *et al.,* 2018). Being rich in mineral like magnesium, the millets have blood-pressure lowering activity. Potassium acts as a vasodilator and reduces the high blood pressure. Amaranth contains a lunasin-like peptide and various other biologically active phytochemicals that have antihypertensive properties.

Millets and Celiac Disease

Millets are alternative food source for people with metabolic issuessuch as celiac disease (Rotela, Borkar and Borah, 2021). Celiac disease is an autoimmune diseasethat occurs in genetically predisposed people where the ingestion of gluten leads to damage in the small intestine. Millets such as sorghum are gluten-free and are therefore excellent sources of food for gluten-sensitive patients. The consumption of millets can help relievevarious GIT symptoms in people suffering from celiac disease (Ambati and Sucharitha, 2019). The various phytochemicals present in millets can inhibit cataracts and maintain eye health. Micronutrients like calcium, iron and magnesium are responsible for various metabolic functions. The high phosphorus and calcium contents of millet help strengthen bone and muscle health. B-complex vitamins in millet are involved in various metabolic functions in the body. These B-complex vitamins and their coenzymes are involved in the metabolism of carbohydrates, fat and proteins in the body (Banerjee, Maitra and Banerjee, 2020).

Millets and Noncommunicable Disease

Millets are good sources of various macro-and micronutrients that are essential for the maintenance and growth of the body. Extruded products such as *sev* can also be developed using millet to increase its availability and improve its taste and acceptability (Kumar, Nath and Arora, 2019). The mineral like calcium, and phosphorus can prevent various problems related to bones and teeth and maintain the growth and development of the body. Iron is important for the synthesis of haemoglobin and other metabolic functions (Amir, Singh and Raghuvanshi, 2012).Millets are also beneficial for preventing problems such as flatulence, bloating and other gastrointestinal problems (Ambati and Sucharitha, 2019). The metabolism of the human body is responsible for a number of chemical reactions taking place in the body. These chemical reactions are responsible for the production of some ill-effect producing free radicals. Free radicals may be defined as any molecule or molecular fragment that contains one or more unpaired electrons in its outer orbit, which leads to oxidative damage. Millets have antioxidant and antiageing properties (Rotela, Borkar and Borah, 2021). Oxidative stress is responsible for causing various chronic health problems such as NCDs, Alzheimer's disease, Parkinson's disease and auto-immune diseases. Oxidative stress can be decreased by the antioxidants present in millet. The antioxidants in the millet such as polyphenols, tannins, flavonoids, and xylo-oligosaccharides, are responsible for decreasing oxidative cellular damage and preventing some non-communicable diseases (Liang, and Liang, 2019).

Conclusion

Millets are considered to be the oldest and first crops consumed by humans. They are still eaten as staple foods in various parts of the world. Millets are grown in almost all countries around the world. Worldwide, problems such as malnutrition and non-communicable diseases particularly cancer, obesity, diabetes and CVD areprominent.Health and wellness are gaining popularity and people around the globe are focusing on nutrition-oriented health food items such as millets. Millets, due to their phytochemical components are considered beneficial for good health and well-being of human beings.Millet foods can also be considered potential prebiotics which enhance the activity of probiotics and lead to health benefits.All the countries in the world are vouching for the remarkable health benefits of millets for preventing various lifestyle diseases.

References

Ambati, K. and Sucharitha, K. V. 2019. Millets-review on nutritional profiles and health benefits.*International Journal of Recent Scientific Research.*, 10(7):33943-33948.

Amir, G., Singh, P. and Raghuvanshi, R. S., 2012. Finger millet for food and nutrition security, *African Journal of Food Science,* 6:77-84.

Arora, S K and Patel, A.A. (2017). Effect of Fiber Blends, Total Solids, Heat Treatment, Whey Protein Concentrate and Stage of Sugar Incorporation on Dietary Fiber-Fortified *Kheer. Journal of Food Science and Technology.* 54(11):3512–3520.

Arora, S K. 2022. Cereals for prevention of disease conditions for better health. In: Cereals and cereal-based foods. Eds. M. R. Goyal, K. Kaur and J. Kaur., Apple Academic Press, Inc. Canada. 273-291p.

Arora, S. K. and Balodhi A. 2022. **VfeZukfy;k vtqZu ds vkS"k/kh; xq.k**(*Terminalia arjuna* ke aushadhiya guna – The medicinal properties of *Terminalia arjuna*). *Kisan Bharati*. 53 (12) 22-23.

Arora, S. K. and Patel, A.A. (2015). Development of Yoghurt "Rich-in" Dietary Fiber and its Physico-chemical Characterization. *International Journal of Basic and Applied Agricultural Research* 13 (2): 148-155.

Banerjee, P., Maitra, S. and Banerjee, P., 2020. The Role of Small Millets as Functional Food to Combat Malnutrition in Developing Countries. Indian Journal of Natural Sciences, 10(60):20412-20417.

Bhat, B.V., Arunachalam, A, Kumar, D, Tonapi, V.A. and T. Mohapatra (2019), Millets in the Indian Himalaya, Indian Council of Agricultural Research, New Delhi. 84p.

Birania, S., Rohilla, P., Kumar, R. and Kumar, N., 2020. Post-harvest processing of millets: A review on value added products. *IJCS*, 8(1): 1824-1829.

Bora, P., Ragaee, S. and Marcone, M. 2019. Effect of parboiling on decortication yield of millet grains and phenolic acids and in vitro digestibility of selected millet products. *Food Chemistry*. 274:718-725.

Chauhan, H. M., Sonawane, S. K. and Arya, S. S. 2018. Millets: A Nutritional source of booster. *Clinical Journal of Nutrition and Dietetics*. 1(1):10.

FAO (2022). https://www.fao.org/newsroom/detail/international year of millets unleashing the potential of millets for the well-being of people and the environment.

Hou, D., Chen, J., Ren, X. *et. al.,* 2018. A whole foxtail millet diet reduces blood pressure in subjects with mild hypertension. *Journal of Cereal Science*. 84:13-19.

https://www.fao.org/millets-2023/en

Jan, R., Nayik, G. A. and Prasad, K., 2014. Significance of Finger millet in nutrition, health and value-added products: A Review. *Journal of Food Processing & Technology,* 3(3):1601-1608.

Joshi, A., Acharya, R. and Arora, S. K. 2023. Plant-based Diet and Occurrence of Cardio Vascular Diseases. *International Journal of Enhanced Research in Science, Technology & Engineering*. 12(6) 58-63.

Kaur, G., Kumari, L. and Kumar, P., 2021.A technical review report on Millets as nutri-cereals of India. *International Journal of Advances in Engineering and Management.* 3(5):1512-1523.

Kumar, N., Nath, N. and Arora S. K. 2019. Process Optimization and Characterization of 'Sev' (a Traditional Indian Extruded Snack) with the Incorporation of Mushroom Powder. *Journal of Food Science and Technology.* 56(4): 1723-1731.

Liang, S. and Liang, K., 2019. Millet grain as a candidate antioxidant food resource: A review. *Int. J. Food Prop.,*22(1):1652–61.

Rao B. D., Bhaskaracharya K., Arlene Christina G.D., Devi G. S., Vilas, A. Tonapi, 2017. Nutritional and Health benefits of Millets. ICAR Indian Institute of Millets Research (IIMR), Rajendranagar, Hyderabad, 112 pp.

Rotela, S., Borkar, S. and Borah, A. 2021. Health benefits of millets and their significance as functional food: A review. *The Pharma Innovation Journal*, 10(5): 158-162

Singh, J. and Arora, S. K. 2023. Antinutritional Factors in Plant Based Foods - A Review. *International Journal of Agricultural Sciences*. 19(1)366--375.

Singh, N., Nainwal, P., Dhyani, A. and Kumar, S. 2022. Potential health benefits of millets as dietary supplement for diabetics. *J. Med. P'ceutical Allied Sci*., 2 (2):224-227.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 04/I/19/0124

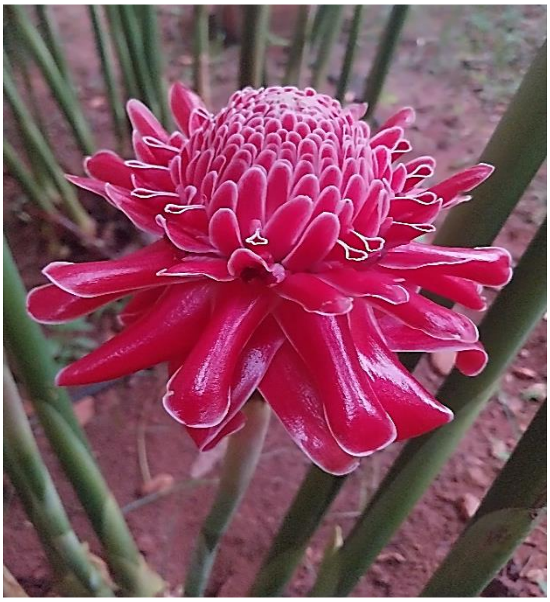
TORCH GINGER: A RESILIENT NEGLECTED GEM IN HORTICULTURE AND CUISINE FOR A SUSTAINABLE FUTURE

Maya Priya* and Labdhi Dedhia

ICAR-Indian Institute of Horticultural Research, Bengaluru-560 089
*Corresponding Email: mayapriyaiihr@gmail.com

Etlingera elatior, a popular cut flower commonly known as torch ginger belongsto the family Zingiberaceaeandisknown for its adaptability and robustness. It is native in Thailand, Indonesia, Malaysia, and widely cultivated in Southeast Asia.More than 15 species of the genus *Etlingera* is recorded from Malaysia.

It is a corarse herb or a psuedostemwith a strong growth as clumps, and can be propagated sexually (seeds) and asexually (rhizomes). The genus thrives well in tropical and sub-tropical climatic conditions with partial shade to full sunlight. This perennial herb has several closely grouped pseudo stems reaching up to 5-6 m tall and its aromatic rhizomes are stout (3-4 cm in diameter) and are just below the ground level. The leaves are entirely green with a truncated base. Young leaves are sometimes lushed pink with petioles 2.5-3.5 cm in length. Their inflorescences are torch-like, borne on erect stalks up to 1.5 m tall arising from fleshy underground rhizomes. The flower head is composed of multiple individual bracts that range in color from pink to red to orange, with some varieties even having white or yellow flowers. The true flowers are small and are hidden within the bracts. The inflorescences colors vary from red and pink to white. When rhizomes are used as a planting material, flowering starts after a year, however a longer time is required to develop the fully grown plants if seed propagated. Mature heads are globular, greenish or red, bearing many black seeds.The flowers remains fresh for about 10 days while intact on plant, while as cut flower its shelf life is for 3 – 5 days. The flowers are to be harvested at a fully opened stage. In Indonesia, the inflorescence bud is cultivated especially for culinary purposes to add flavorto traditional dishes and as a nutritional source.



E. elatior is widely used as a traditional medicine, as it is rich in several secondary metabolites such as phenols, flavonoids, glycosides, saponins, tannins, steroids, terpenoids.High amount of total phenolic and flavonoids contents were found in in the leaves, flowers, stems and rhizome, while flavonoids likeQuercetin, kaempferol-3-O-glucoside and kaempferol were found in the flowers and stems. Due to the presence of these phytochemicals the flowers and leaves have been used as spices for food flavoring asa common ingredient of sour curry dishes.They also have pharmacological properties that include anti-inflammatory, anti-hyperglycemic, anti-hyperuricemic, anti-inflammatory, anti-microbial, anti-oxidant, and anti-tumor activity. The plant is thought to have low levels of heavy metal pollution and a high nutritional value due to its abundance in unsaturated fatty acids, proteins, amino acids, and other mineral compounds. The dried flower's protein, fat, and fiber contents were 12.6 %, 18.2 %, and 17%, respectively.The high level of fiber content in this plant can potentially reduce blood cholesterol levels, hypertension, heart disease risk, and constipation. In addition, it's been utilized historically as an ingredient in regional items like soap, shampoo, and perfume, and to heal earaches and clean wounds. In addition, the health and beauty industry utilizes torch ginger inflorescence as a natural ingredient for skin whitening, anti-aging, and lipstick production.In Southeast Asia, the flower portion of torch ginger is frequently used as a component in Malay, Nyonya, Indonesian, and Thai cuisine. In Malaysia, flower buds are typically cooked with mixed vegetables or added to curries or other culinary dishes. Additionally, it is a necessary condiment component for the popular local cuisine "Penang laksa." While the seeds are consumed raw, while the ripe fruits are edible with a sour taste are used for making candies.

Along with its use in cooking and medicine, torch ginger has become becoming increasingly popular as an appealing landscape plant in urban areas. Moreover, the crop is highly resiellient to several pest and pathogens and also thrive well under changing climatic conditions. Although torch ginger grows best in constantly moist soil, once established, it can withstand prolonged droughts due to its strong rhizomatous root system.Incorporating torch ginger as a drought-resistant plants into water-conserving landscaping techniques like xeriscaping is one way to make landscape sustainable. The inflorescences of torch ginger from the tight bud to the blooming stage could be utilized as cut flowers, depending on the need in the market. landscapers and flower growers are continuously looking for new ways to diversify their ideas due to consumers' growing desire for adaptability, durability, and low prices. Thus, to meet the demand of the cut flower market, landscaper and pharma industries *E. elatior*could be one of the choiciest crop for future expansion. The underutilized *E. elatior* needs an urgent attention for unveiling its hidden potential.

References

Chan, E. W. C., Lim, Y. Y. and Wong, S. K. 2011. Phytochemistry and pharmacological properties of Etlingera elatior:A review. *Pharmacognosy Journal*, 3(22): 6–10.

Choon, S. Y. and Ding, P. (2016). Growth stages of torch ginger (Etlingera elatior) plant. Sains Malaysiana, 45(4): 507–515.

Juwita, T., Puspitasari, I. M. and Levita, J. 2018. Torch ginger (Etlingera elatior): A review on its botanical aspects, phytoconstituents and pharmacological activities. *Pakistan Journal of Biological Sciences*, 21(4): 151-165.

Luky, P. L., Winarni, A. T. andNurcahya, D. E. *Etlingera elatior* as a natural deodorizer towards the steeping of ulvalactuca seaweed.

Purwoko, A., Turnip, H. and Maser, W. H. 2019. The pattern of Etlingera elatior cultivation in agroforestry systems and its use as traditional medicines and food by local people of Kabanjahe, North Sumatra, Indonesia. *Biodiversitas Journal of Biological Diversity*, 20(7).

Wardiningsih, W., Sopyan, M., Pradana, S., Pudjiati, P. and Rudy, R. 2022. Characterization of natural fiber extracted from Etlingera elatior stalk for textile applications. *Journal of Natural Fibers*, 19(14): 9384-9395.

Yunus, M. F., Ismail, N. A., Sundram, T. C. M., Zainuddin, Z. and Rosli, N. M. 2021. Commercial potentials and agronomic status of Etlingera elatior, a promising horticulture plant from Zingiberaceae family. *AGRIVITA, Journal of Agricultural Science*. 43(3): 665-678.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/20/0124

PRE-BREEDING: PROTECTOR OF GENETIC BASE

Soumyanetra Saha* and V. B. Rana
Ph.D. research scholar, Department of Genetics and Plant Breeding,
N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat-396450
*Corresponding Email: netrasaha@gmail.com

Abstract
Pre-breeding is the term used by the Global Partnership Initiative for Plant Breeding Capacity Building (GIPB)/FAO and Biodiversity International to refer to the many plant breeding research efforts that must come before the stages of cultivar development, testing, and release. Pre-breeding is further described as "the art of identifying desired traits, and incorporation of these into modern breeding materials" by the Global Crop Diversity Trust. By using a larger pool of genetic material to boost yield, resistance to diseases and pests, and other desirable qualities, pre-breeding seeks to minimize genetic homogeneity in crops.In commercial breeding programs, where desired traits are continuously sought for and identified from source genotypes for use in cultivar development, pre-breeding is frequently used. All operations aimed at identifying desired crop features and/or genes and then transferring them into a suitable pair of parents for additional selection are together referred to as pre-breeding. The process finds a useful trait or genes that can be used to the production of new cultivars (Ortiz, 1999).

Introduction
Pre-breeding is the process of introducing beneficial genes into agronomically acceptable background / breeding material from exotics or wild (unadapted) sources. Pre-breeding is further described as "the art of identifying desired traits, and incorporation of these into modern breeding materials" by the Global Crop Diversity Trust. Pre-breeding, to put it briefly, is the introduction of genes or gene combinations from unadapted sources into breeding materials, including those that have undergone any sort of improvement-oriented selection despite being adapted.

The most important and promising way to connect genetic diversity originating from wild relatives and other related species is to start any crop development effort with this stage. Its main purpose is gene transfer for biotic and abiotic stressors.

Jones (1984) coined the phrase "genetic enhancement" first. Transferring beneficial genes from unadapted material into agronomically appropriate backdrop was his definition.

Rick (1985) used the term pre-breeding or **developmental breeding** to explain the same activity.

The main objectives of pre-breeding:
1. In order to decrease genetic homogeneity
2. Improved resistance expression and diversity by improved germplasm and related genetic knowledge
3. Better selection techniques and parental stocks that are easily employed in breeding programs
4. Locate genes that may be helpful in a well-maintained and recorded gene bank.
5. Create plans of action that result in better germplasm that is prepared for varietal development.

Need for pre-breeding

Sufficient genetic diversity must be available for any crop development program to be successful, but the variability must be in a form that can be used routinely. Lack of variety hinders breeding progress (Shimelis and Laing, 2012). It appears that food security is threatened by a limited genetic base. In agro-ecosystems, highly diversified native cultivars and landraces are gradually being replaced by genetically homogeneous modern kinds. Increased genetic susceptibility to illnesses and pests resulted from genetic uniformity. In order to improve tolerance to climatic changes, changing populations of pests and diseases, and other factors, it is primarily necessary to search gene banks for novel sources of resistance and inspire plant breeders to pursue them.

The most promising method of tying genetic resources and breeding programs together is pre-breeding. Genetic enhancement has at least three unique components. Preventing genetic homogeneity and the ensuing genetic susceptibility is the primary goal. Pre-breeding has recently evolved into an essential, regular, and scheduled component of all plant breeding initiatives and germplasm diversification plans.

Prerequisites for pre-breeding:

1. Gathering underrepresented diversity using eco-geographic data, taxonomic classifications, and comprehensive passport information
2. Coordinated assessment and exchange of pre-breeding products across environmental circumstances
3. Better communication and feedback exchanged between the fundamental and applied research communities, particularly with reference to genotypic andphenotypic data

Activities in Pre-breeding

1. Characterization of landrace populations
2. Creation of new parent populations
3. Introgression of new traits from other useful sources
4. Creation of novel traits
5. Creation of polyploidy
6. Acquisition of new information on crop genetics
7. Development of new plant breeding techniques
8. Cultivar development

Classical approaches to use PGR in pre-breeding

1. Introgression
2. Incorporation
3. Wide crosses

Other approaches followed for successful pre-breeding

1. Conventional cytogenetic approaches
    a. Alien addition lines
    b. Alien substitution lines
2. Embryo rescue
3. Use of mentor pollen
4. Cis-genesis
5. Reciprocal crosses
6. Bridge crosses

7. Genetic Transformation

Pre-Breeding work attempted in different crops

Wild Species possesses the greater amount of genetic variation which can be exploited to improve the crops. LAMP is a real example of pre-breeding program, which includes 12 countries (Argentina, Bolivia, Brazil, Colombia, Chile, U.S., Guatemala, Mexico, Paraguay, Peru, Uruguay and Venezuela). LAMP evaluated 15,000 accessions in the first stage, with close cooperation of the public and private sectors.

Table 1: Useful Genes Transferred from Wild Species – Rice

Crop	Trait of value	Source
Rice	Resistance to bacterial blight	*Oryza longistaminata,Ominuta ,* *O. latifolia , O. Officinalis,* *O. australiensis*
	Resistance to brown plant hopper (BPH)	*O. latifolia, O. officinalis* *O. australiensis, O minuta*
	Tolerance to drought	*O. glaberrima, O. rufipogon*
Wheat	Black rust resistance	*Ae. speltoides, Ag. elongatum*
	Yellow rust resistance	*Ae. comosa*
Maize	Yield	*Teosinte (Zea mexicana),* diploid *Tripsacum*
Sugarcane	hardiness, disease /insect resistance	*S. spontaneum*

Conclusion

There is enough genetic diversity in the form of landraces and wild relatives to improve field crops, as they carry multiple valuable genes for cultivar improvement. Nevertheless, it takes time and resources to use these resources in breeding projects. Pre-breeding efforts should be started in order to overcome this, employing promising landraces and wild cousins to create new genetic variability that breeders can exploit in crop improvement initiatives. Pre-breeding should not be done with the intention of increasing yield; rather, it should be done with the constant supply of valuable variability into the breeding pipeline to generate new high-yielding cultivars with a broad genetic foundation. Pre-breeding is a time-consuming and challenging process, even if it is beneficial for improving cultivars by enriching the basic gene pool.

Reference

Ortiz R (1999) Genetic enhancement and base broadening efforts. pp. 191–203. In: Gass T, Frese L, Begemann F, Lipmann E (eds) Conservation and sustainable utilization of plant genetic resources for food and agriculture – implementation of the global plan of action in Europe. International Plant Genetic Resources Institute (IPGRI), Rome, Italy.

Shimelis, H. and Laing, M., 2012. Timelines in conventional crop improvement: pre-breeding and breeding procedures. Aust. J. Crop Sci., 6(11):1542-1549.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/21/0124

SEED PRIMING: A SEED INVIGORATION TECHNIQUE FOR GERMINATION AND VIGOR ENHANCEMENT IN VEGETABLE CROPS

Pradeep Kumar[1], Sumit Barupal[2] and Archana Sanyal[3*]

[1]Senior Scientist, ICAR-Central Arid Zone Research Institute, Jodhpur (Rajasthan) 342003
[2]Junior Research Fellow, DST funded Project, ICAR-Central Arid Zone Research Institute, Jodhpur (Rajasthan) 342003
[3]Scientist, ICAR-Central Arid Zone Research Institute, Jodhpur (Rajasthan) 342003
*Corresponding Email: archana.sanyal@icar.gov.in

Abstract
Low productivity in vegetable crops is a major challenge for nutritional security in the Indian scenario. Seed priming is a promising seed invigoration technique in vegetable crops where earliness and high vigor are essential for harnessing maximum yield within a short period. Priming techniques including hydropriming, halopriming, osmopriming, hormonal priming, solid matrix priming, and biological priming have been shown to enhance the germination percentage, germination rate, and seedling vigor in low vigorous seed lots of vegetables by controlling the hydration process. Further, this technique has been evolved to mitigate the negative impact of climate change on the yield and quality of vegetable crops.

Introduction
Recently, Indian agriculture has witnessed tremendous progress in the vegetable sector due to the advent of high-yielding varieties and improved technologies. Enjoying the second place in world vegetable production, India still lags behind many countries in the quantum of produce per hectare. Among several factors implying low productivity, low germination percent and non-synchronous seedling emergence are of considerable significance. Further, climate change-driven uncertain weather during seed emergence and seedling establishment imposes limitations on yield maximization. For successful crop establishment, seed priming could play a vital role in increasing a vegetable's productive capacity under varying growth environments. Seed priming is a pre-sowing treatment technique in which seeds are soaked in water or any other osmotic solution that allows them to imbibe water and complete the first phase of germination, but does not permit radicle protrusion. Seed priming is popularly known as "**Double technology**", as it is a tool to enhance and achieve rapid and uniform germination but also a method to achieve high vigor for better yield. The comparison of the seed germination process in the primed and non-primed seed is illustrated in Figure 1.

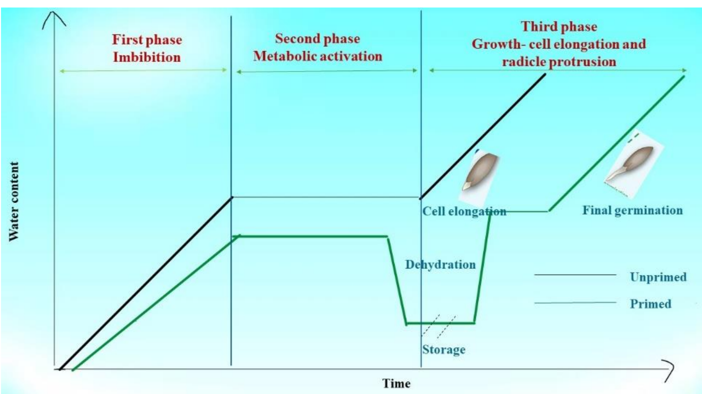


Figure 1. Comparison of seed germination process in primed and non-primed seed

Steps involved in seed priming

The generic steps followed in seed priming are illustrated in Figure 2.

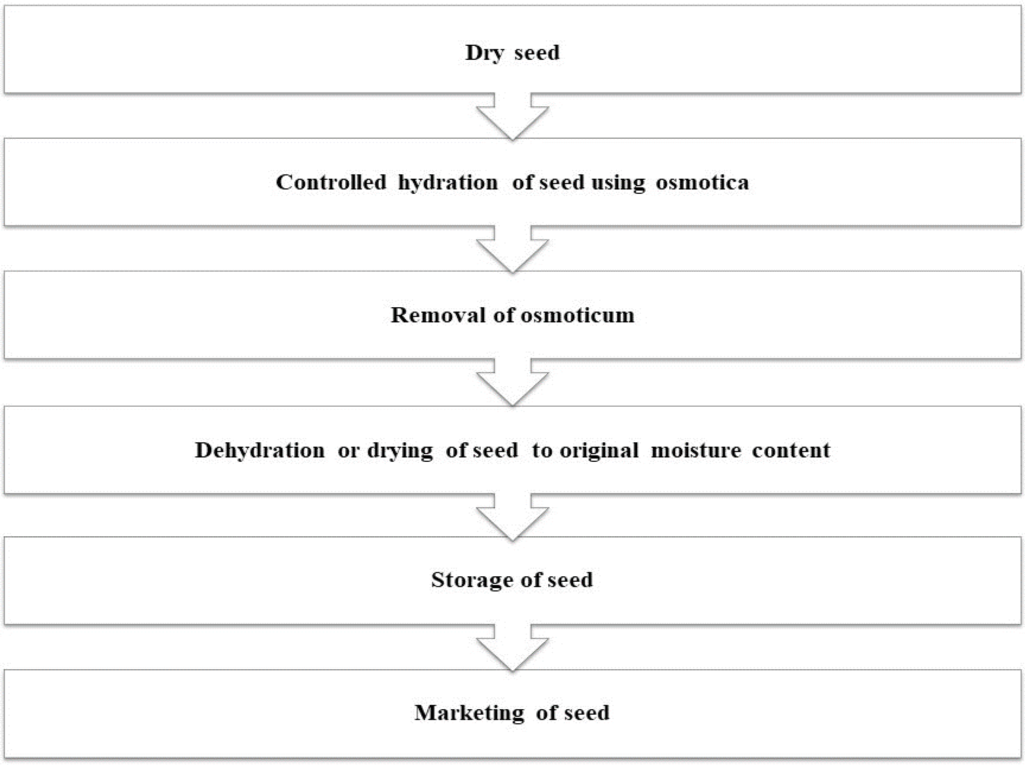


Figure 2. Flow diagram of seed priming process

Methods of seed priming

Seed priming techniques includes: hydropriming, osmo-priming, halo-priming, hormonal priming, solid matrix priming and bio-priming (Fig. 3; Table 1). The vegetable seeds are affected by priming agent, priming duration, oxygen supply to seed and drying.

Table: Priming methods and their application in different vegetable crops

Methods of priming	Substrate used for control hydration	Vegetable crop	Benefits of priming	Remarks
Hydro-Priming	Water	Okra	Rapid germination	Yadav, et al., 2011,; Sharma, et al., 2014
		Watermelon	Improve seed germination and initial growth of seedlings	Singh et al. 2001
		Pumpkin	Improve metabolism activities	Pritima, et al., 2017.
		Tomato	Increase seedling growth	Maiti, et al., 2009
		Bean	Improve plant performance	Ghassemi-Golezani et al 2010
	Osmotica	Okra	Increase seed germination and	Barupal et al 2018

Methods of priming	Substrate used for control hydration	Vegetable crop	Benefits of priming	Remarks
Osmo-Priming	(mannitol, polyethylene glycol (PEG)) or salts (like potassium chloride, potassium nitrate) and organic compounds viz., agrosan, cycocel, citric, and uridine diphosphate.		field performance	
		Chilli	Reduce soil and seed-borne pathogens. Uniform seed germination	Lanteri, et al., 2009
		Capsicum	Improves seed germination over non–primed seeds and also reduces mean days to germinate	Pandita et al., 2007
		Brinjal	Increase flowering, fruit yield, fruit length	Satishkumar, et al., 2005
		Carrot	Increase seed germination	Peluzio et al., 1999
		Reddish	Increase seed quality parameters	Alverado and Bradford, 1988
		Lettuce	Improve seed germination, field emergence	Cantliffe et al., 1981
Halo-priming	salts such as NaCl, KNO_3, $CaCl_2$, and $CaSO_4$,	Cabbage	Improve seedling size	Jagadesh et al., 1994
Hormonal Priming	GA_3, kinetin, NAA ascorbate	Tomato	Increase germination	Soubhagyabehera, 2016
		Sponge gourd	Increase in shoot length	Pill and Kilian, 2000
Solid matrix priming (SMP)	insoluble matrix (vermiculite, diatomaceous earth, crosslinked highly water-absorbent polymers	Capsicum	Improve seed germination	Pandita et al., 2007

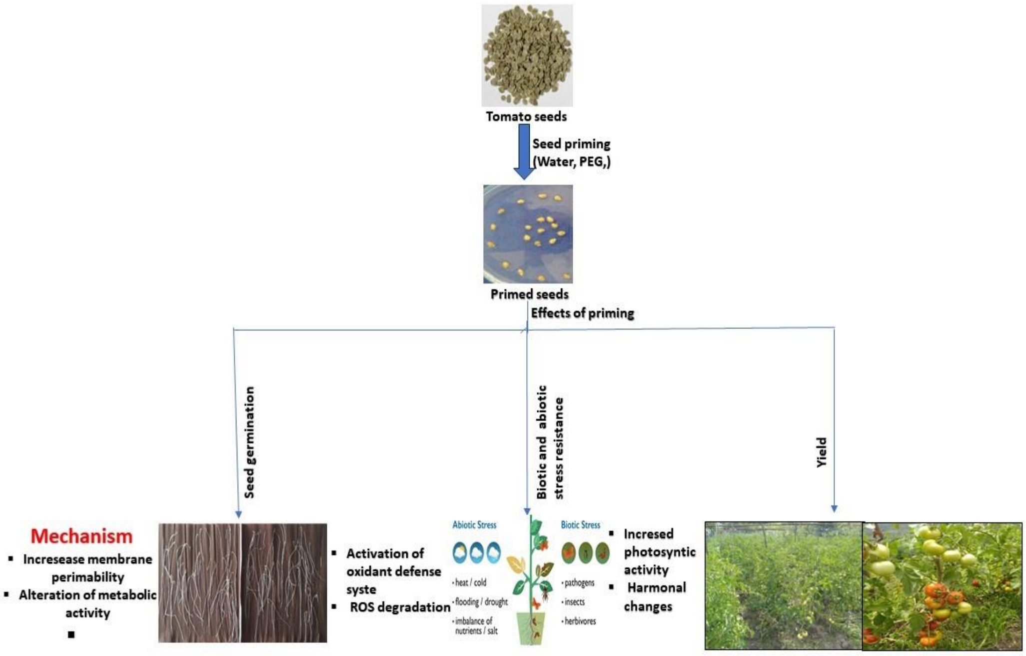


Figure 3. A schematic representation of seed priming effects: a) regulation of seed germination via metabolic activities and permeability of cell membrane; b) abiotic and biotic stress resistance in plants through activation of the antioxidant defence system and regulating reactive oxygen species; c) photosynthesis and hormonal changes resulting in better crop stand and yield improvement.

Advantages of Seed Priming

- Enhances the germination percentage.
- Enhances the speed and uniformity of germination.
- Improves the resistance towards temperature and water stress.
- Highly suitable for small seeds.
- Improve vigor of low vigor seed lots hence, used in crop production.
- Enable early emergence and rapid establishment of seedlings which avoids weed infestation
- Enhance the yield.

Limitations of seed priming

- Osmotic seed treatment is expensive, especially when osmotica such as PEG are used. Only low-volume, high-value seeds are suitable for this treatment.
- The solution needs continuous aeration, otherwise the seed will suffer from the ill effects of anaerobic aeration.
- As the treatment is done over a long period, proper caution against microbial attack should be taken.

References

Barupal S, Sharma R, Kumar M, Dilta, B.S, Sarma C.L, Verma R, Kumar M., Thakur P, Kumar A.S and Yadav Y (2022). Standardization of priming duration of okra seed. The Pharma Innovation *J.* 11(2): 428-431.

Behra S(2016). A study on the effect of hormonal priming (ga3) on seed quality parameters of solanaceous vegetables. Int J Agri Sci Res 6(3):337-348.

Kanwar R and Mehta D (2017). Studies on solid matrix priming of seeds in bitter gourd (*Momordica charantia* L.). J. App. Nat. Sci. 9 (1): 395 - 401

Mal D, Verma J, Levan A, Reddy M.R, Avinash A.V and Velaga P.K (2019). Seed Priming in Vegetable Crops: A Review. Int. J. Curr. Microbiol. App. Sci. 8(06): 868- 874.

Sharma A.D, Rathore S.V.S, Srinivasan K and Tayagi R (2013). Comparison of various seed priming method for seed germination, seedling vigour and fruit yield in okra [*Abelmoschus esculentus* (L.) Moench]. Scientia Hortic 165: 75-81.

Tajbakhsh M, Brown P.H, Gracie A.J, Spurr C.J, Donovan N and Clark R.J (2004). Mitigation of stunted root abnormality in onion (*Allium cepa* L.) using seed priming treatments. Seed Sci. Technol 32(3):683-692.

Yadav S.K, Kumar D, Kumar V, Hussain Z, Sharma A.D and Kumar A (2012). Seed priming effects on diverse germplasm of okra [*Abelmoschus esculentus* (L.) Moench]. Vegetos 25(1):202-209.

Article ID : 04/I/22/0124

SHRIMP CULTURE

Angida[1] and M. K. Yadav[2]

[1]PG Scholar, Dept. of Aquaculture, School of Agriculture,
Sanjeev Agrawal Global Educational University, Bhopal. MP
[2]Assistant Professor, Dept. of Aquaculture, School of Agriculture, Sanjeev Agrawal Global Educational University, Bhopal. MP
*Corresponding Email: angidabenikapasi99@gmail.com

Abstract

Shrimp culture is an aquafarming that includes both freshwater and marine environments. It is culture to meet the demands of the growing population. Shrimp culture provides sustainability and livelihood to thousands of families in rural areas who settle down beside the coastal region. However, several threats or challenges bring about shrimp farming. To culture shrimp, the farmer should attain a pond size of 0.5-1.0 ha which is in a rectangular or square shape with dykes to hold the water holding capacity. The depth should be 1.5-2.0 meters deep, feeding rate is according to shrimp size. 100% of body weight for larvae and fry and graduallybring down to 50%, 20%, 10%, 5%, and 2-3% as the shrimp grow to marketable size. Shrimp culture enhances production, is low in price, and reduces the resistance to diseases as it is culture in a controlled environment. To get a good production farmers should be persistent in work and improve the culture from year to year.

Keyword: Healthy, Sustainable, Environmental, and Socio-economic, Performance

Introduction

Shrimp is widely traded, and shrimp aquaculture is considered a success story in modern aquaculture, generating millions of jobs uplifting the socio-economic status of many rural people engaging in the field, and foreign exchange in developing countries. Effective management practices are crucial for successful shrimp farming, including knowledge of pond preparation and pre-stocking management. Pond preparation is a critical aspect of pre-stocking management measures necessary for optimal shrimp growth in farming systems. Feed quality is also a vital factor in shrimp culture to meet food and energy demands and to maintain a healthy structure. Assessing feed quality before feeding aquatic animals can save time and money. Therefore, assessing the feed quality as quickly as possible is essential. Additionally, eco-based technologies such as Biofloc technology (BFT) in shrimp culture have improved water quality, feed utilization, reduced stress and disease susceptibility, lowered production costs, and decreased carbon concentration through autotrophic microbes. Biofloc technology has received positive reviews in the shrimp-farming industry.

Pond preparation for shrimp culture

After each harvesting cycle, the pond water is drained out and left to dry for 7-10 days. This helps to break down the decomposed organic components and any leftover material from the previous culture. Drying out the pond also reduces the risk of disease outbreaks. To spread out the nutrient-rich soil and promote fast mineralization and oxidation of organic compounds and harmful gases, the pond bottom is ploughed. The top black soil is removed to prevent the development of anaerobic conditions during the culture period. It must be disposed of far from the pond site to avoid re-entering the pond. Liming is applied to optimize the pH and alkalinity of the soil and water. The type and amount of lime used depend on the soil and water pH. Stocking of water in the pond should be done in a controlled manner with proper filtration to avoid the entry of any unwanted and pathogenic agents into the culture pond. Fertilizer is applied to enhance primary productivity and improve water transparency. The amount of fertilizer used depends on the fertility of the pond. Organic fertilizers like cow dung are applied at a rate of 500-2000 kg per 1ha. Inorganic fertilizers such as urea and single superphosphate (SSP) are applied at a rate of 25-100kg/ha, depending on the organic carbon content in the pond. Selection of shrimp seeds for stocking is essential, and they should be free of specific diseases. Post-larvae should be checked for their color, size, activity, etc. before purchasing. If any abnormality is found in the batch, it should not be purchased. Post-larvae should be treated with formalin at a concentration of 100 ppm for at least 30 minutes in a well-aerated tank to remove weak post-larvae. Disease outbreaks in shrimp are directly related to the pond bottom and water quality. Therefore, zero water exchange must be followed throughout the culture period to avoid the existence of the disease. Health monitoring should be done once a week to check the shrimp's external appearance, such as the color of their gut. A pale whitish gut shows gut infection, while a white normal gut shows a light or golden-brown color. The application of yeast organic preparation (60 kg rice flour, 30 kg yeast, and 3 kg yeast) improves the balancing of all microbes in the pond culture. Keeping a record is necessary to identify various risks and rectify the problems at the earliest period of the culture. Record-keeping also helps the farmer to improve farming from the earliest mistakes. Harvesting should be done early in the morning or evening and avoided during the molting period. Three to four days before harvesting, agricultural lime can be applied. After harvesting, the packing case should be layered with crushed ice for better preservation and transport.

Feeding

The quantity requirement for feeding rate varies according to the size and stage of growth of the shrimp. The daily feed ration is calculated based on their body weight. Larvae and fry are given 100% of their body weight as feed which is then gradually reduced to 50%, 20%, 10%, 5%, and finally to 2-3% when they reach their marketable size. If the average weight of the stocked shrimp is W grams and there are Y number of shrimp in the pond, the total biomass in the pond is W x Y grams which is equal to W x Y/1000kg. If feed is to be given at 10% of body weight, then the quantity of feed required per day would be (W x Y/1000) x 10/100 kg.

It is not possible to estimate the shrimp biomass in the pond accurately, so netting is a must once a week or after every 10 days to calculate the average weight of the shrimp. The total biomass is calculated by multiplying the average weight by the number of surviving shrimp at that time. This is done by counting the number of shrimp and taking into account the area covered by each netting and the total area of the pond.

Feeding of grown-out shrimp should start with the feed at 15-20% of body weight and depend on their biomass in the culture pond, gradually reducing to 2-3% towards the end of the culture period. Shrimp should be fed every 3-4 hours in small doses and food should be offered in the evening or during night hours as they are very active during this time. Overfeeding leads to uneaten food and later causes pollution to the pond, which can cause stress to shrimp. Shrimp feeds should be stored properly and kept away from moisture to prevent mold growth.

Biofloc Technology

Biofloc technology is an eco-friendly method that promotes better biosecurity and is free of pathogens. It acts as a tool that helps shrimp maintain an active immune system by exposing them to various microbes. Cultivating shrimp in biofloc prevents theoutbreak of diseases, reduces water and protein requirements, and compensates for the nutrient requirement of shrimp through natural food in the form of microbial biofloc. The preparation process for culturing shrimp varies based on factors such as the design and similarity of the system, the species to be cultured, stocking density, and buffering time for biofloc generation. Standard Operating Procedures (SOP) should be followed, such as drying the system, refilling with aged water, or disinfecting soil cautiously through a 60-100 micro-screen, and adhering to all biosecurity protocols.

Conclusion

The sustainability of aquaculture is heavily dependent on the maintenance of a healthy environment. It is important to implement well-designed and effective tools to improve productivity, soil and water quality, and the overall health of the shrimp. Regular monitoring of environmental parameters and making timely modifications is crucial in protecting against potential losses due to stress and the risk of bacterial infections. By regularly monitoring and understanding the ecological processes occurring in shrimp culture ponds, we can have a positive impact on shrimp production.

Reference

Beam, M and Gebhart, G (2000). *Aquaculture*. Langston University, Agricultural Research and Extension Programs.

Panigrahi, A. and I. S. Azad, (2007a). *Microbial intervention for better fish health in aquaculture*. 33:429-440.

Baldwin, W. J., 1983. *The design and operation of an automatic feed dispenser.* Aquaculture, 34: 151-155.

Avnimelech, Y. (2007) *Feeding with microbial flocs by tilapia in minimal discharge bio flocs technology ponds.* Aquaculture 264:140-147.

Apud, F. D., Primavera, J. H., Torres, P. L., 1983. *Farming of Prawns and Shrimps*. SEAFDEC Aquaculture Department, Iloilo, Philippines. Extension Manual-5, p.67

Ghanekar, A. (2009) *How bio floc technology reduces feed and filtration costs in recirculated shrimp nursery systems*. Aqua Culture Asia Pacific 2009 Vol. 5 No. 3pp. 10-11.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/23/0124

REVERSE BREEDING: A WAY THROUGH ENGINEERED MEIOSIS

V. B. Rana[1*] and Soumyanetra Saha[1]
[1]Ph.D. Research Scholar, Department of Genetics and Plant breeding, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat – 396 450, India.
Corresponding Email: 4849vasu@gmail.com

Abstract
One of the most coveted outcomes in plant breeding is the direct production of ancestral lines for every heterozygous plant through the innovative process known as reverse breeding (RB). By manipulating meiosis, RB creates homozygous parental lines that are properly complemented. By preventing meiotic crossing over, the strategy aims to decrease the amount of genetic recombination in the chosen heterozygote. These plants can produce homozygous DHs when their male or female spores are cultivated *in vitro*. The spores include a mixture of non-recombinant parental chromosomes. Complementary progenitors can be chosen from these DHs and employed to recreate the heterozygote indefinitely. RB has the potential to drastically alter plant breeding in the future since present methods cannot address heterozygous genotypes that are unknown. We cover a number of additional uses for RB in this paper, such as breeding per chromosome.

Introduction

The idea originated in the Netherlands in 2009 and was presented byRob Dirks. Since it is unable to repair heterozygous genotypes in plants using standard methods, RB has the potential to drastically alter plant breeding in the future.

The two fundamental processes of reversebreeding are the regeneration of DHs from spores containing non-recombinant chromosomes and the prevention of crossover recombination in a chosen plant. An idealized crossing arrangement using RB is shown in Figure 1. It illustrates how a genotypically uncharacterized plant with a favorable mix of features is chosen from a segregating population (in this case, a segregating F_2). This plant suppresses crossing over, and achiasmatic gametes are gathered, cultivated, and used to produce diploid hybrids. The elite heterozygote can then be commercially recapitulated using the DH lines. RB can also be used on plants with a known background in another application (Figure 2). In the event that crossing over is eliminated in the F_1 hybrid as opposed to the F_2 generation, chromosomal replacement lines might be produced using RB. In the backdrop of the other parent, these lines have one or more chromosomes from one parent. Populations that segregate only for the heterozygous chromosome(s) can be obtained by backcrossing the chromosomal substitution lines to the original parental lines.

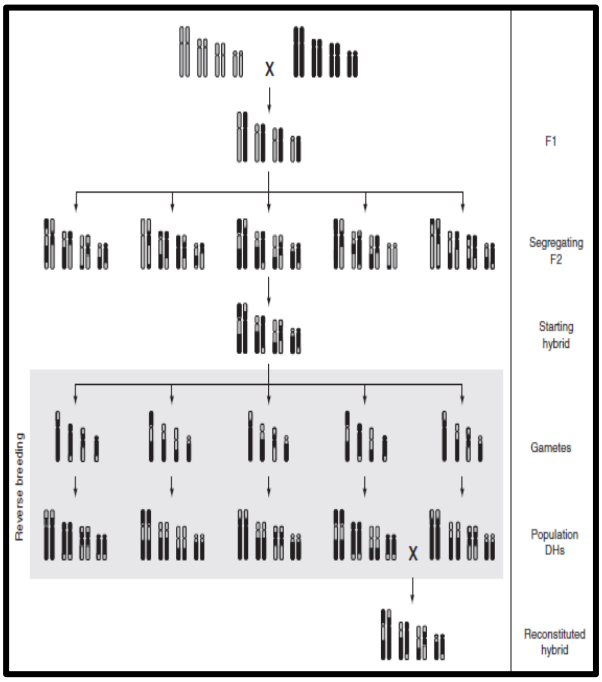


Fig. 1: Fixing unknown heterozygotes by reverse breeding

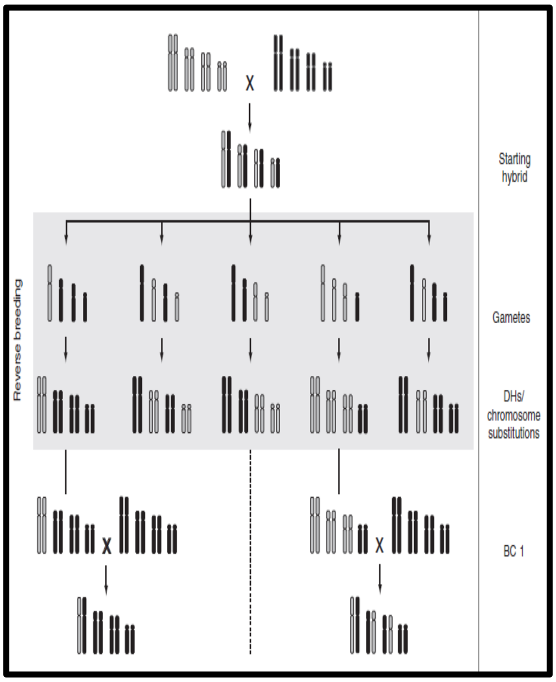


Fig. 2:Reverse breeding as advance breeding tool

Objectives of reverse breeding

- To offer a different approach to achieving homozygous and more adaptable parental line combinations for hybrid production.
- To enable the creation of chromosomal replacement lines that will make breeding easier to investigate at the individual chromosome level.

Needs of reverse breeding

- To preserve the hybrid stability.
- To boost the performance of the hybrid by genetically improving the parental lines.
- To create the breeding lines for heterozygotes that are not described.
- Generating a very heterozygous plant from parental lines that are homozygous.

Reverse breeding applications

1. Reconstruction of heterozygous germplasm

For plants where an extensive range of breeding lines remains lacking, RB can speed the generation of variants. It is possible to establish superior heterozygous plants in these crops without having any prior understanding of their genetic make-up. It's astonishing how few DHs are actually needed.

2. Breeding on the single chromosome level

Many fascinating traits in crops are dependent on multifaceted gene relationships, frequently located on distinct chromosomes. These quantitative traits are therefore not easy to breed on. Plants with a single heterozygous chromosome will separate their progeny according to the qualities found on that chromosome alone. Selfing plants that carry a substituted chromosome (or using recurrent backcrosses) will allow breeders to fine-tune interesting characteristics on a single chromosome scale. This could bring forth improved breeding lines carrying introgressed traits. The few instances were provided here demonstrate that RB presents breeders with complete authority over homo- or heterozygosity at the single chromosome level.

3. Reverse breeding and marker assisted breeding

Particularly when used with (high throughput-) genetic testing, reverse breeding is a versatile technique. Undoubtedly, high throughput genotyping accelerates up the procedure of recognizing complementary progenitors in communities of DHs in early stages. But probably more potent is its application in the investigation of gene interactions of the different heterozygous inbred families (HIFs) that may be formed by breeding and backcrossing various forms of RB (as was discussed above). The selection of groups that segregate for features on a single chromosome permits the fast identification of QTLs, when genotyping is supplemented with –for instance, transcriptome or metabolome analysis. These HIFs facilitate the creation of fine-grained maps of genes and alleles as well as chromosome-specific linkage maps. As such, RB can offer extremely useful insights on the characteristics of heterotic effects.

Benefits of reverse breeding

- Breeders can respond to farmers' requirements with improved varieties much faster because to RB, which speeds up the breeding process and increases the amount of genetic combinations accessible.
- Makes it easier to choose superior hybrid plants.
- Without prior knowledge of genetic background, a large population of plants can be created, screened, and well-performing plants can be regenerated forever.

Conclusion

Breeding applications become new and potent when crossover suppression is combined with haploid spore regeneration into diploid hybrids. One major application is the creation of complementary homozygous lines that can be utilized to generate specified F_1hybrids. One may also create chromosomal replacement lines using RB application on F_1 heterozygotes, which enables single-chromosome targeted breeding. Commercial CMS lines that are widely utilized in contemporary agriculture are entirely compatible with RB. However, the method can only be applied to crops in which spores can regenerate into diploid hybrids (DHs) and in which the number of haploid chromosomes is 12 or less. There is also another reconstruction method based on omitting the second meiotic division, which results in unreduced second division restitution (SDR) spores; this method has been proposed for polyploids or organisms with high chromosomal counts. By using these SDR spores, it is possible to obtain chromosome substitution lines and achieve close reconstruction of desired phenotypes (Van Dun and Dirks, 2006). The creation of plant breeding methods based on meiosis alterations is gaining popularity (Wijnker and de Jong, 2008). But the majority of methods are really variations on the "classic" plant breeding approach, which aims to introduce features from foreign backgrounds into crops more effectively.

Future thrust

- Reverse breeding mediated by RNAi is a relatively new technique that needs a great deal of research to solve technical issues.
- Further investigation is necessary to enhance the effectiveness of the DH production process.
- In crops where seed production is a challenge, such as cucumber, onion, broccoli, and cauliflower, emphasis should be placed on producing hybrids.

References

Van Dun, C.M.P. and Dirks, R.H.G. (2006). Rijk Zwaan Zaadteelt en Zaadhandel B.V. Near Reverse Breeding, WO/2006/094773.

Wijnker, E. and de Jong, H. (2008). Managing meiotic recombination in plant breeding. Trends Plant Sci. 13, 640–646.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/I/24/0124

THE GROWING POTENTIAL OF ARTIFICIAL INTELLIGENCE (AI) BASED TECHNOLOGIES IN AGRICULTURE

Deepak Kumar[1], P. H. Rank[2*], R. J. Patel[3] and P. B. Vekariya[4]

[1]Department of Agricultural Engineering, School of Agriculture,
GIET University, Gunupur, Odisha – 765022, India.
[2*]Department of Irrigation and Drainage Engineering, College of Agricultural Engineering & Technology, Junagadh Agricultural University, Junagadh – 362001. Gujarat State, India.
[3,4]Department of Irrigation and Drainage Engineering, College of Agricultural Engineering & Technology, Junagadh Agricultural University, Junagadh-362001. Gujarat State, India.
*Corresponding Email: prasangpatel83@gmail.com

ABSTRACT

The article delves into the burgeoning influence of Artificial Intelligence (AI) in agriculture, uncovering its transformative impact on traditional farming practices. Highlighting the convergence of AI and agriculture, it explores the potential of precision farming, crop monitoring, and predictive analytics in optimizing yields. The discussion extends to the advent of autonomous machinery, elucidating how AI-driven technologies streamline operations and enhance productivity. Emphasizing resource optimization and environmental sustainability, the article underscores AI's role in efficient water and energy management. Moreover, it explores how AI empowers farmers through knowledge dissemination, bridging information gaps and fostering informed decision-making. In essence, the article unfolds the promising trajectory of AI-based technologies, heralding a new era of innovation and sustainability in global agriculture.

INTRODUCTION

The agricultural sector faces a multitude of challenges, from increasing population demands and climate change to land and water resource scarcity and labor shortages .(Kelaiya and Rank, 2019; Kumar and Rank, 2021; Rank, *et al,* 2020; Kumar and Rank, 2023). The judicious use of water through irrigation water management can be the best option in the water scared region as out of 80% of available freshwater of India is used in agriculture (Paghadal et. al., 2019a; Paghadal et. al., 2019a). It is crucial to manage land resources effectively to enhance productivity and ensure the sustainability of water resource management(Patel and rank, 2020; Vekariya et. al., 2022, Patel et al., 2023a; Patel et al., 2023b; Rank, *et. al*., 2023b; Vekariya et. al., 2023). With an ever-increasing population, the need to enhance productivity from limited resources becomes crucial. This can only be achieved through the implementation of various technological interventions in land and water management (Rank, *et. al*., 2019; Rank, *et. al*., 2022a; Rank and Satasiya, 2022; Rank and Vishnu, 2019; Rank and Vishnu, 2021a; Rank and Vishnu, 2021b;Rank and Vishnu, 2023; Rank *et al.,* 2022b; Rank *et al.,* 2022c; Rank *et al.,* 2023c). To navigate these complexities and ensure food security for a growing world, innovative solutions are desperately needed (. Artificial intelligence (AI) has emerged as a powerful tool with immense potential to revolutionize agriculture, offering a range of benefits across the entire value chain. It can help farmers to make agriculture climate change resilience, enhance productivity and efficiency, combat pests and diseases, optimize supply chains and market access, transform labor and skills and make ethical and responsible development.

1.1 Agriculture climate change resilience

AI can equip farmers with tools to adapt to the changing climate. Predictive models can forecast weather patterns and climate extremes, allowing farmers to prepare for droughts, floods, and other challenges. Additionally, AI-powered systems can help develop drought-resistant crops and optimize water use efficiency, promoting climate-smart agricultural practices.

1.2 Enhanced Productivity and Efficiency:

AI-powered technologies like precision agriculture are transforming how crops are grown and managed. Sensors and data analytics provide farmers with real-time insights into soil conditions, crop health, and environmental factors, enabling them to optimize resource use and make data-driven decisions. This translates to increased yields, reduced water and fertilizer consumption, and improved overall farm management efficiency.

1.3 Combating Pests and Diseases:

Traditional pest and disease control methods are often ineffective and environmentally harmful. AI algorithms can analyze vast amounts of data to predict outbreaks and identify the most effective interventions, minimizing reliance on pesticides and herbicides. Machine vision systems can even detect pests and diseases at early stages, allowing for targeted treatment and preventing widespread damage.

1.4 Optimizing Supply Chains and Market Access:

AI-powered logistics platforms are streamlining transportation and storage of agricultural produce. By predicting demand and optimizing routes, AI reduces spoilage and ensures timely delivery, leading to lower costs and increased market access for farmers. Additionally, AI-driven e-commerce marketplaces connect farmers directly to consumers, eliminating intermediaries and maximizing profits.

1.5 Transforming Labor and Skills:

While concerns about automation displacing workers exist, AI can also create new opportunities in agriculture. AI-powered robots can handle tedious tasks such as weeding, harvesting, and sorting, freeing up human labor for higher-value activities. Additionally, AI can provide farmers with valuable training and support, enhancing their skills and knowledge base.

1.6 Ethical Considerations and Responsible Development:

Despite the vast potential of AI in agriculture, ethical considerations must be addressed. Data privacy, transparency in algorithms, and equitable access to technology are crucial aspects to ensure that AI benefits all stakeholders in the agricultural sector. Responsible development and implementation of AI technologies are essential to ensure inclusivity, sustainability, and long-term success.

CONCLUSION

AI-based technologies have the potential to revolutionize agriculture by transforming every aspect of the field. From boosting productivity and efficiency to combating pests and diseases, optimizing supply chains, and building climate resilience, AI offers a plethora of solutions to address the challenges facing the agricultural sector today. By embracing responsible development and addressing ethical concerns, AI can unlock a future of sustainable and prosperous agriculture, ensuring food security for generations to come.

REFERENCES

Kelaiya, J., Rank, P.H., (2019). Assessment of water balance components of bhadar river basin using SWAT model. International Journal of Bio-resource and Stress Management **10**(2), 181–184.

Kumar, D. and Rank, P. H. (2023). Estimation of crop evapotranspiration and crop coefficient for coriander using portable automatic closed canopy chamber. Journal of Agrometeorology, **5**(4):547-552.DOI: https://doi.org/10.54386/jam.v25i4.2315

Kumar, D., Rank, H.D. (2021). Comparison of Fenugreek Crop Evapotranspiration Measured by a Micro-lysimeter, Field Water Balance Method and Automatic Closed Canopy Chamber. *International Journal of Agriculture, Environment and Biotechnology,* **14**(1): 29-49.

Paghadal, A. M. Rank, H. D., Prajapati, G. V. Rank, P. H., Pipaliya, P. S., Pipaliya, J. S. (2019a).The Trend Analysis of Various Components of Water Resources System of Ozat River Basin, Gujarat, India. Int. J. Curr. Microbiol. App. Sci., **8**(11), 241-267. https://www.researchgate.net/publication/362948568_The_Trend_Analysis_of_Various_Components_of_Water_Resources_System_of_Ozat_River_Basin_Gujarat_India. DOI: https://doi.org/10.20546/ijcmas.2019.811.030

Paghadal, A. M., Rank, P. H., Rank, H. D., Limbasiya, B. B., Vekariya, P. B., Vadar, H R. (2019b). Modelling and Simulating the Groundwater Level Behavior to Climate Change for the Ozat Basin., Int. J. Curr. Microbiol. App. Sci 8 (10), 1156-1165. DOI: 10.20546/ijcmas.2019.810.135

Patel RJ, Rank HD (2020) Water use efficiency of wheat under different irrigation regimes using high discharge drip irrigation system, AgricEngg Today **44**(2):19-31 Patel RJ (2019) Laboratory and field manual on irrigation engineering. Scientific Publishers Patel RJ, Rank HD, Ajudiya BH, Dhanani NV (2014) An assessment of ground water recharge potential through tube well, International Journal of Engineering Research & Technology **3**(10):155-160.

Patel RJ, Rank PH, Vekariya PB, Vadar HR, Parmar HV, Rank HD, Damor PA, Modhvadiya JM (2023a) Study on physicochemical properties of clay loam soil of Junagadh region, International Research Journal of Modernization in Engineering Technology and Science **05**(06):3912-3919 https://www.doi.org/10.56726/IRJMETS42550.

Patel, R. J., Rank, P. H., Vekariya, P. B., Rank, H. D., Vadar, H. R., Parmar, H. V., and Lunagaria, M. M. (2023b). Enhancing Wheat (Triticumaestivum L.) Crop Yield and Water Use Efficiency: A Study on Canopy Air Temperature Difference-Based Drip Irrigation Scheduling in a Semi-Arid Region of Western India. DOI: https://doi.org/10.21203/rs.3.rs-3376468/v1

Vekariya, P. B., Rank, H. D., Patel, R. J. and Rank, P. H. (2022). Studies on Open Well Recharge Techniques for Junagadh Region. International Research Journal of Modernization in Engineering Technology. 04(08): 354-362. https://www.researchgate.net/publication/363262672_STUDIES_ON_OPEN_WELL_RECHARGE_TECHNIQUES_FOR_JUNAGADH_REGION#fullTextFileContent

Vekariya, P.B., Patel, R. J., Rank, P. H., Modhvadiya, J. M., Rank.H. D. (2023). Connector well recharge techniques for junagadh region. International Research Journal of Modernization in Engineering Technology and Science. **5**(9): 385-397. https://www.irjmets.com/uploadedfiles/paper/issue_9_september_2023/44526/final/fin_irjmets1694165214.pdf

Rank, P. H., Rank, H. D., Vekariya, P. B. Patel, R. J. and Kar, G. (2022a). Effectiveness of gaussian distribution mapping for bias correction of rcm simulated temperature for junagadh region. International Research Journal of Modernization in Engineering Technology and Science, 04(11): 160-175 DOI: 10.56726/IRJMETS31007

Rank, P.H. and Satasiya, R.M. (2022). Sweet corn crop (Zea mays L.) performance under various irrigation water management strategies. J. Pharm. Innov., **11** (6):1525-1531.

Rank, P.H. and Vishnu, B. (2019). Automation of pulsed drip irrigation. Int. J. Engg. Sci. Comp., **9** (7): 23265-23276.

Rank, P.H. and Vishnu, B. (2021a). Design concept of pulse drip irrigation, Int. J. Modern. Engg. Tech. Sci., **03**(12): 414-420.

Rank, P.H. and Vishnu, B. (2021b). Pulse drip irrigation: A review. J. Pharmacognosy and Phytochemistry.,**10** (1): 125-130.

Rank, P.H. and Vishnu, B., (2023). Validation of Models for Simulating the Soil Moisture Characteristics. Agric. Sci. Dig., **43** (2):157-163.

Rank, P.H., Satasiya, R.M., Limbasiya, B.B., Parmar, H.V. and Prajapati, G.V. (2023a). Sweet corn crop yield response to aerated drip irrigation under various irrigation water management strategies, Emer. Life. Sci. Res., **9**(1):10-21. DOI: https://doi.org/10.31783/elsr.2023.911021

Rank, P.H., Satasiya, R.M., Patel, D.V. and Shitap, M. (2022b). Cost economics of irrigation water management strategies for Sweet Corn (Zea mays L.), Multi-Logic in Sci., **12**(43):49-52.

Rank, P.H., Satasiya, R.M., Vekariya, P.B., Limbasiya, B.B., Sardhara, V.K., Patel, R.J., Pandya P.A. and Mashru H.H. (2022c). Simulating the Water Footprints of Sweet Corn (Zea Mays L.) Under Various Irrigation Water Management Strategies Using AquCrop Model. Int. J. Modern. Engg. Tech. Sci., **04** (08): 1572-1581.

Rank, P.H., Unjia, Y.B. and Kunapara, A.N. (2019). Soil wetting pattern under point and line source of trickle irrigation. Int. J. Curr. Microb. Appl. Sci., **8** (07):785-792.

Rank, P.H., Vaghasiya, D.R., Lunagaria, M.M., Patel, R.J., Tiwari, M.K., and Rank, H.D. (2023b). Climate change impacts on water flux dynamics in Shingoda basin having agriculture and forest ecosystems: A comprehensive analysis. Journal of Agrometeorology, **25**(3) : 397-403. DOI: https://doi.org/10.54386/jam.v25i3.2284

Rank, P.H., Vekariya, P.B. and Rank, H.D. (2020). Climate change impact on hydrologic system in Aji River Basin. Res. Biotica., **2** (2): 30-39.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 04/I/25/0124

THREE GEMS OF W FOR PROTEIN STRUCTURE PREDICTION

Vishwa Gohil [*], Alok Shrivastava, Yogesh Garde,
Nitin Varshney and Jay Delvadiya

Department of Agricultural Statistics,
N. M. College of Agriculture, NAU, Navsari, Gujarat
***Corresponding Email:** gohilvishwa1717@gmail.com

Abstract
Proteins are essential biomolecules with diverse functions and their three-dimensional structures are integral to their biological roles. Protein structure prediction, a computational field, is pivotal for understanding these structures and their implications in biology and medicine. In this article, we explore recent progress in prediction methods *i.e.*, homology modeling. We emphasize the importance of open-access protein structure databases and experimental data in improving prediction accuracy. This article underscores the evolving synergy of computational biology, shedding light on the potential impact of protein structure prediction on Agriculture.

Keywords : Deep learning, evolutionary algorithms, scoring functions, protein structure prediction.

Introduction

Protein Structure Prediction is three individual words. It has wide applicability in many fields. The above title is classified under three gems of W *i.e.,* 1. What, 2. Why and 3. Where. First Gem tells us about what is protein and second and third tell us about why and where this prediction will help the scientific community and ultimately the end users.

1. What

Before prediction first, we have to understand what is protein and its structure along with its prediction for a wide range of sectors. Important molecules known as proteins are involved in many biological activities.

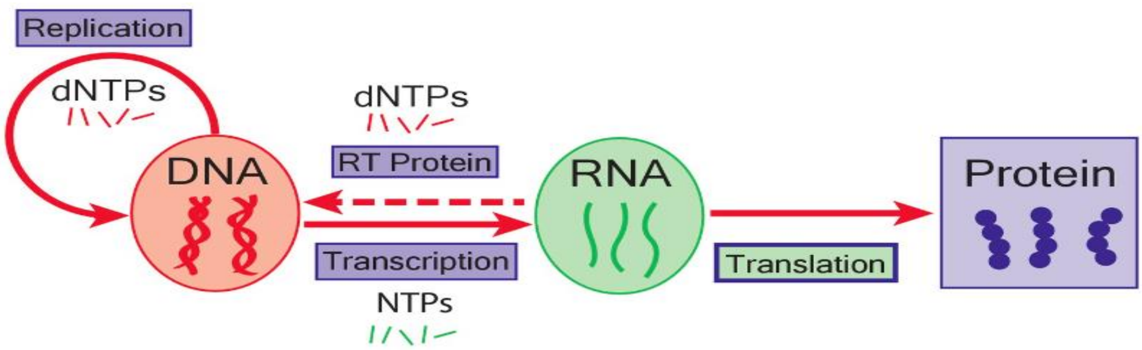
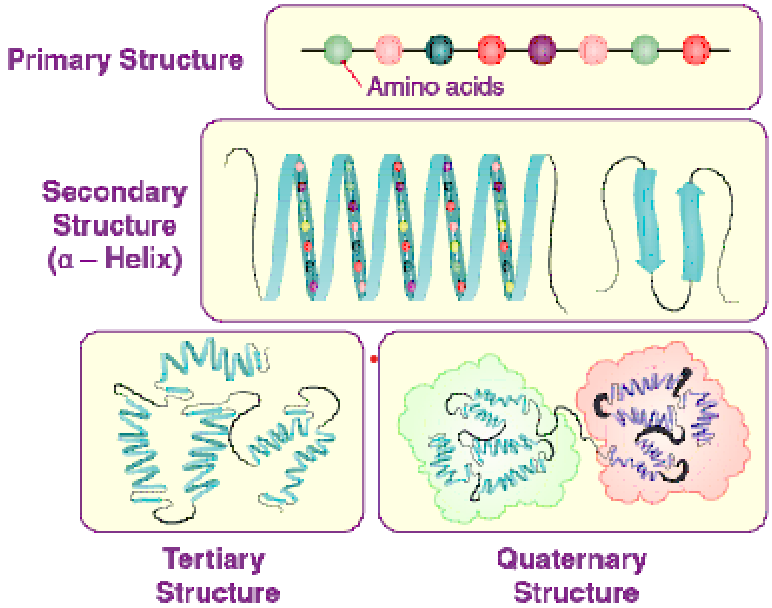


Fig. 1: - Transcription Process

Levels of Protein Structure

1.1 Primary Structure of Protein

The precise arrangement of amino acids that make up a protein's chain forms its primary structure. Since it dictates the protein's ultimate fold and, consequently, its function, the precise sequencing of the proteins is crucial. Proteins are made up of many polypeptide chains joined together. These chains include amino acids organized in a certain order that is unique to that particular protein. The entire protein is altered by any alteration in the sequence.



1.2 Secondary Structure of Protein

Local folded structures that arise within a polypeptide as a result of interactions between backbone atoms are referred to as the secondary structure of proteins. Simple chains of polypeptides are not the only form that proteins take. The interaction between the amine and carboxyl groups of the peptide link is typically what causes these polypeptide chains to fold. The shape that a lengthy polypeptide chain can take is referred to as its structure. They are discovered to exist in two distinct types of structures: pleated sheet structures (β) and helix structures (α). The regular folding of the polypeptide chain's backbone, which results from hydrogen bonding between the peptide bond's -NH and -CO groups, gives rise to this structure. On the other hand, individual protein chain segments can develop their local fold, which is considerably more straightforward and typically takes the form of a loop, spiral, or extended shape. The secondary structure of the protein is made up of these local folds, which are known as secondary elements.

(a) α – Helix

One of the most popular forms for a polypeptide chain to form every possible hydrogen bond is the α-helix. This type of chain twists into a right-handed screw, with the -NH group of each amino acid residue hydrogen-bonded to the -CO of the turn that it comes after. The polypeptide chains formed a screw with a right-hand twist.

(b) β – pleated sheet

The polypeptide chains in this configuration are stretched out next to one another and subsequently joined by intermolecular H-bonds. All of the peptide chains in this structure are arranged side by side and stretched to almost their maximum length, keeping them together with intermolecular hydrogen bonds. The structure is called β, or a pleated sheet, because it resembles the pleated folds of drapery.

1.3 Tertiary Structure of Protein

The protein's secondary structure continues to fold into this configuration. This structure is stabilized by disulfide connections, electrostatic forces, H-bonds, and Vander Waals forces.

Proteins' tertiary structures are the result of additional secondary structure folding and overall polypeptide chain folding. Fibrous and globular are the two main molecular forms that result from it. The van der Waals, disulfide bonds, hydrogen bonds, and electrostatic forces of attraction are the primary stabilizing forces of proteins' secondary and tertiary structures.

1.4 Quaternary Structure of Protein

The quaternary structure is created by the spatial arrangement of different tertiary structures. Identified as sub-units, some proteins are made up of two or more polypeptide chains. Quaternary structure is the spatial arrangement of these subunits about one another.

2. Why

A better knowledge of a protein's function is possible thanks to its structure, which also enables us to formulate theories about how to influence, regulate, or change it. For instance, being aware of the structure of a protein may help in the creation of site-directed mutations intended to alter function.

Protein structure determination, a part of structural biology, is essential to have a comprehensive understanding of how protein functions and its interactions with other biological macromolecules. Furthermore, we touch on emerging applications, including drug discovery, protein engineering, and disease-related structural insights.

3. Where

Protein structure prediction is primarily based on sequence and structural homology. Protein structure modeling and prediction are important because the primary determinant of a protein's function is its 3D structure. To determine the structure of proteins, DNA, or RNA, three main methods are commonly employed: cryogenic electron microscopy (cryo-EM), nuclear magnetic resonance (NMR) spectroscopy, and X-ray crystallography.

When Watson and Crick used X-ray fiber diffraction to conjecture the DNA double helix structure in the 1950s, structural biology gained widespread recognition for the first time. Shortly afterward, myoglobin and hemoglobin—the first two protein structures determined by X-ray crystallography—were published. When determining the structural characteristics of biological macromolecules, scientists began to use NMR spectroscopy in the 1980s. By utilizing nuclear magnetic resonance (NMR), we can examine the motion and interactions of our target, gaining insight into its behavior.

Nevertheless, a low molecular weight protein's size limits NMR. Richard Henderson, Jacques Dubochet, and Joachim Frank developed the technologies that allowed cryo-EM analysis to be used to analyze such macromolecules, starting with electron microscopy. The structure of large supra-molecules and protein complexes, such as the photosystem complex and ribosome assembly, could be determined thanks to cryo-EM technologies, which were awarded the 2017 Nobel Prize.

Likewise, the arrangement of amino acids determines a protein's three-dimensional structure. There could be significant structural differences in the native structure due to a little change in the protein sequence. While precise 3D structure knowledge of proteins is crucial, it can be challenging to understand a protein's native structure when it exists in the body under physiological settings. These methods for determining the experimental structure are expensive, time-consuming, and complicated (Baker and Sali, 2001). Due to the advancement of computing facilities and algorithms, it is now possible to create a model from amino acid sequences using a theoretical understanding of protein dynamics, structure, and folding.

Each technique—X-ray crystallography, NMR spectroscopy, and electron microscopy—has advantages, disadvantages, and restrictions of its own. In X-ray crystallography, X-rays are delivered through the protein crystal, and the pattern of diffraction is then recorded and analyzed using computerized frameworks to learn more about the coordinates of the atoms in the molecule. For determining the structure of tiny molecules or small-size protein–ligand complexes, NMR spectroscopy is thought to be useful. The advantage of the NMR technique is that it allows for the study of the protein in aqueous conditions that may resemble its native physiological state. Small-size proteins with less than 150 amino acids in length are the only ones that can be studied using the NMR technique. Building a tertiary model of a single particle can be aided by electron microscopy, which is appropriate for studying big macromolecules or even cell organelles (Cheng, 2015).

3.1 X-ray crystallography

This method involves crystallizing and purifying the target protein before exposing it to X-ray beams. Based on the diffracted X-ray photons scattered by the crystal, an electron density map was computed. This electron density map was then used as the basis for a computationally constructed structural model. For many years, X-ray crystallography has been a popular method that has produced structures with atomic resolution (Shi, 2014 Colantoni, *et al*., 2021).

3.2 Protein NMR

Protein NMR makes use of the atomic nuclei's magnetic spin characteristics. To make the nuclei NMR-active, protein molecules are isotopically labeled. When NMR-active nuclei in protein molecules in a solution are exposed to a magnetic field, they will resonate at distinctive frequencies that are identified as NMR peaks (Howard, 1998). Despite the possibility of solving protein structures at the atomic level through solution NMR, this method is frequently restricted to low molecular weight proteins. The signal-to-noise ratio of higher molecular weight proteins is frequently low. Solid-state nuclear magnetic resonance (ssNMR) is the preferred method for analyzing a protein that is unstable in solution or aggregates. The structure of misfolded proteins, lipid bilayer membranes, membrane proteins, and aggregates like amyloid membrane aggregates have all been solved using single-photon nuclear magnetic resonance (ssNMR) (Van, 2018). It has recently been reported that single-cell, whole-cell, or isolated membrane protein studies can be conducted using surface plasmon resonance (ssNMR) (Narasimhan *et. al*., 2021).

4. To predict the protein structure through SWISS-MODEL

By extending experimental data from a template protein structure that is evolutionary-related, a 3D protein model of a target sequence is produced in comparative modeling (Waterhouse et al., 2018). The protein sequences from the online database will be subjected to the SWISS-MODEL homology modeling online tool (Arnold *et al.*, 2006). The following key phases comprise the default modeling workflow in SWISS-MODEL:

Input data: The amino acid sequence of the target protein can be supplied in FASTA, Clustal, or plain text format. An UniProtKB accession code can be provided as an alternative. It is necessary to provide the amino acid sequences or UniProtKB accession codes for each subunit of a heteromeric target protein, which is made up of distinct protein chains as subunits.

a) **Template search**: Data provided in step 1 serve as a query to search for evolutionary-related protein structures against the SWISS-MODEL template library SMTL.
b) **Template selection**: After the template search is finished, the templates are ranked based on the Quaternary Structure Quality Estimate (QSQE) and Global Model Quality Estimate (GMQE), which estimate the quality of the final models. The top-ranked templates and alignments are examined to see if they cover distinct areas of the target protein or represent alternate conformational states. The best model will be selected based on GMQE score which ranges from 0 to 1, with a higher value indicating better reliability.
c) **Model building**: Target-template alignment-defined conserved atom coordinates are transferred to automatically create a 3D protein model for each chosen template.
d) **Model quality estimation**: Using the QMEAN scoring function, SWISS-MODEL can quantify modeling errors and provide estimates of expected model accuracy. Global and per-residue quality estimates are produced by QMEAN using statistical potentials of mean force. The QMEAN Z-score provides an estimate of the “degree of nativeness” of the structural features observed in the model on a global scale. QMEAN Z-scores around zero indicate good agreement between the model structure and experimental structures. Scores of − 4.0 or below is an indication of models with low quality (Benkert *et al.*, 2009 and Studer *et al*., 2020).

References

Arnold, K.; Bordoli, L.; Kopp, J. andSchwede, T. (2006). The SWISS-MODEL workspace: a web-based environment for protein structure homology modeling. *Bioinformatics*,**22**(2):195–201.

Baker, D. and Sali, A. (2001). Protein structure prediction and structural genomics. *Science*, 294(5540), 93-96.

Benkert, P.; Tosatto, S. C. and Schwede, T. (2009). Global and local model quality estimation at CASP8 using the scoring functions QMEAN and QMEAN clust. *Proteins Structure Function Bioinformatics*,**77**(9):173–180.

Cheng, Y. (2015). Single-particle cryo-EM at crystallographic resolution. *Cell*, **161**(3), 450-457.

Colantoni, A.; Rupert, J.; Vandelli, A.; Tartaglia, G. G. and Zacco, E. (2020). Zooming in on protein–RNA interactions: a multi-level workflow to identify interaction partners. Biochemical Society Transactions, 48(4): 1529-1543.

Howard, M. J. (1998). Protein NMR spectroscopy, *Current Biology* **8**(10): 331-333.

Narasimhan, S.; Pinto, C.; Lucini Paioni, A.; van der Zwan, J.; Folkers, G. E. and Baldus, M. (2021). We are characterizing proteins in a native bacterial environment using solid-state NMR spectroscopy. *Nature protocols*, **16**(2): 893–918.

Shi, Y. (2014). A glimpse of structural biology through X-ray crystallography. Cell, 159(5): 995-1014.

Studer, G.; Rempfer, C.; Waterhouse, A. M.; Gumienny, R.; Haas, J. and Schwede, T. (2020). QMEAND is Co—distance constraints applied on model quality estimation. *Bioinformatics,***36**(6):1765–1771.

Van Der Wel, P. C. A. (2018). New applications of solid-state NMR in structural biology. *Emerging topics in life sciences*, **2(1)**: 57–67.

Waterhouse, A.; Bertoni, M.; Bienert, S.; Studer, G.; Tauriello, G.; Gumienny, R. and Schwede, T. (2018). SWISS-MODEL: homology modelling of protein structures and complexes. *Nucleic acids research*, **46**(1): 296-303.

Official Address :
Peshok Tea Estate
P.O.- Peshok, Dist.- Darjeeling
West Bengal, India
PIN-734312

Contact No : +91 7501389678
email : agriindiatoday@gmail.com