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Tracking the emergence and usage of farmer led innovations (FLIs) in maize ecosystem: A pan India exploration

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The study was carried out, by using case study method, to investigate the distinctive characteristics of a few selected farmer-led innovations (FLIs) in maize cropping systems created at the grassroots level across India. A total of five maize-based innovations produced at the grassroots level in various parts of India were purposefully chosen. The originality of these innovations is that they are based on the culture from which they originate and are based on local expertise. This study discovered that all farmer-led innovations generated by farmers were more useful than other existing options since these innovations were built with farmers' needs in mind. Furthermore, these were discovered to be and determined to be sustainable, owing to the fact that these inventions were produced using local resources and wisdom. All five innovations were discovered to be less expensive than alternative market-available technologies. The majority of selected technologies were determined to be profitable, with farmers benefiting after a specified period of hard labor and investment. All of the chosen technologies were discovered to be compatible with the needs of local farmers. The ideas generated by respondents were not commercialized due to several difficulties faced by the farmers to translate the innovations into marketable items, combined with the low demonstrability of these technologies.

Keywords: Attributes, Case study, Farmer-led innovations, Indigenous technical knowledge, Maize farmers

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Maize is one of the most important cereal crops in the world and contributes to food security in most developing countries like India[1]. Maize is utilized for a variety of uses in our daily life, including food, feed, fuel, and other things[2]. Maize has a larger genetic base and a remarkable level of genotypic variety which permits it to survive in a variety of environments in over 168 different countries[3]. Maize crop leftovers are an excellent supply for mulching in crop fields, composting, vermicomposting, and straw preparation for mushroom production[4]. Maize is grown in India during all seasons, including Kharif (rainy), Rabi (winter), and summer. Despite the fact that maize production is rising in India, productivity is still lower (3.02 t/ha) than the global standards (5.92 t/ha)[3,5].

Since the beginning of time, innovation has been a fundamental component of Indian agriculture, and farmers in India are no exception. Farmer-led innovations are those that are created, developed, or tested by a farmer or group of farmers on their own or using ideas from outside sources without the direct assistance of outside agencies or recognized academic institutions[6,7]. Farmers have developed a number of grass-roots improvements over the course of evolution that have increased their profits and made farming a sustainable practice. It is being more understood that farmer-led innovation, in which farmers take the lead in developing new information, technology, and working methods, is essential to ensuring the social, economic, and environmental sustainability of farming[8]. Farm innovators are those who frequently work to address local issues and typically operate outside of established

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organizations[9-11]. Indian farmers continuously work to make farming more efficient and economical in an effort to raise their standard of living, and these inventions over time serve to enhance farming practices and provide better living possibilities. It is anticipated to gain an understanding of the innate traits and characteristics of such "Innovations" being developed at the grassroots level[12]. A large farmer base cultivating maize provides numerous opportunities to investigate various FLIs at the field level. It is useful for food, feed, and industrial applications, and offers huge potential for documenting improvements in production, processing, and management. Documentation and sharing of innovative farmers' best practices will go a long way toward encouraging other farmers and replicating such innovations elsewhere in comparable conditions. FLIs will be useful for better vertical and horizontal information flow among stakeholders, which would aid in the overall improvement of the maize industry.

Keeping all of the aforementioned and discussed issues in mind, this study on some 'Farmer Led Innovations in Maize' developed at the grassroots across various states of India, with a particular emphasis on the upsurge and utilization of innovations in the concerned agro-climatic scenario.

Methodology

The exploratory "Case study" approach was used due to the nature and importance of the investigation. The open-ended and semi-structured questionnaire was adopted from a study done Wettasinha C. *et al.*[6] from their comprehensive study on the impacts of farmer-led research supported by civil society organizations. The cases were selected purposively on the basis of field-level investigation of the All-India Co-ordinated Research Project (AICRP) on Maize centers. The centers are distributed across the length and breadth of the country and ICAR-Indian Institute of Maize Research, Ludhiana acts as a nodal agency for coordinating the research trails in different locations. Beside using the database compiled and documented by National Innovation Foundation (NIF), Ahmedabad, other sources such as NGOs, Farmers Associations (FA) of different states and personal interactions with Scientists and KVK staff working at the grassroots also helped in this study. The criterion considered for innovations was the innovation's association with maize with any aspect of production, processing, post-harvest management, and value addition. Only the innovations associated with maize farming *i.e.,* five were selected for this study in the year 2021-22 in the survey, although several innovations can be used for greater use and benefit. Finally, a total of five cases namely 'Modified Organic Fertilizer'(Meghalaya); Wind Operated Bird Scaring Fan (Telangana); Innovative Maize Sheller (Jammu & Kashmir); Indigenous practice of Detasseling in Maize (Assam); Indigenous storage techniques of Maize Grains (West Bengal) were selected for the study. In the case study-based innovation, the method of data collection typically involves multiple approaches to gather the detailed and in-depth information. The methods generally combine personal interviews, Observations, Cross-sectional surveys and specified innovation-based questionnaires, document reviews, Focus Group Discussions (FGDs) and analyzing the case narratives. Each of the five innovators were questioned in person about the characteristics of selected grassroots ideas. In addition to personal interviews, the observation method was employed to document the characteristics of selected innovators. Data were collected twice with an interval of three months.

Results and Discussion

The identified technologies were anticipated to have distinctive characteristics depending on local culture and geography wisdom. An attempt was made to identify the one-of-a-kind characteristics of the chosen innovations as people at the grassroots created it. All of the selected "Farmer Led Innovations," including the associated "attributes", have been provided below:

Innovation -I 'Modified Organic Fertilizer': (Developed by Mr. Kynshew Dapsuk Kharkrang)

Mr. Kynshew Dapsuk Kharkrang hails from Umeit village in Ri-Bhoi District in Meghalaya. He has a Bachelor of Arts Degree in Economics and his primary occupation is farming. He has a landholding of 4 hectares and his annual income is near about Rs. 1.5-2.0 lakhs. He is mainly engaged in cultivation of rice and sweet corn but in the off-season, he grows different vegetables.

Chemical fertilizers are generally not preferred for cultivation purposes in the North-Eastern States of India. Since North East India is being encouraged to go organic by the state and central governments, a fertilizer at par with inorganic NPK needed to be developed, so that the crop plants can derive optimum

Fig. 1 — (a) Preparation of modified organic fertilizer (b) Sprinkling of water (c) Application in the field (d) Harvested produce ready for sale

nutrition. Since economic cost and availability are big hindrance factors to purchasing chemical fertilizers, these organic fertilizer acts as a viable solution for farmers to provide optimum nutrition to crops and fetch a good price (Fig. 1).

Description and working principle

Trichoderma preferable at 5-10 g powder mix 1 liters of water and Pseudomonas powder also in the ratio of 5-10 g@ 1 liters of water is sprinkled and mixed with wet farmyard manure (FYM) made from poultry litter cow dung along with bio NPK. The mixture is covered with rice straw of the previous harvest till the white mycelium growth covers the entire compost within one week and the modified compost is now ready for use. This is generally done in the month of March when the weather starts to warm up. Going by experience, the returns are better than when inorganic NPK is used. Inorganic fertilizer is generally not referred for cultivation purposes here in Meghalaya. Since North East India is being encouraged to go organic by the state and central governments, a fertilizer at par with inorganic NPK needed to be developed so that the crop plants can derive optimum nutrition.

Attribute Identification of the Innovation

Parameters	Innovation Characteristics
Utility	Highly beneficial (ecological cost reduction by 20%)
Cost	Low-cost innovation (cost reduction by 20-30% as compared to inorganic fertilizer)
Benefits	Optimum yield returns (Yield returns is little bit low compared to the commercial fertilizer)
Demonstrability	Can be demonstrated easily (result demonstration can be easily done in the farmers field)
Compatibility	Can be used across crops (scientifically validated in the field by the farmer)
Sustainability	Highly sustainable (Practice is popular in the local region and the farmer is acting as a master trainer in different programs to popularize the practice)

The parameters for the attributes have been taken from the studies which have been scientifically validated by several experiments across different regions[13-15]. This innovation is completely developed by the farmers' individual efforts and needs further dissemination efforts by state agricultural universities (SAUs), *Krishi Vigyan Kendras* (KVKs) and State Agricultural departments. If proper assistance is provided in terms of physical and monetary support, the innovation can be out scaled in other areas with proper demonstrations and training. However, lack of marketing facilities, insect infestation in the compost, and social recognition of the farmers are some of the lacunas associated with this innovation identified by the farmer.

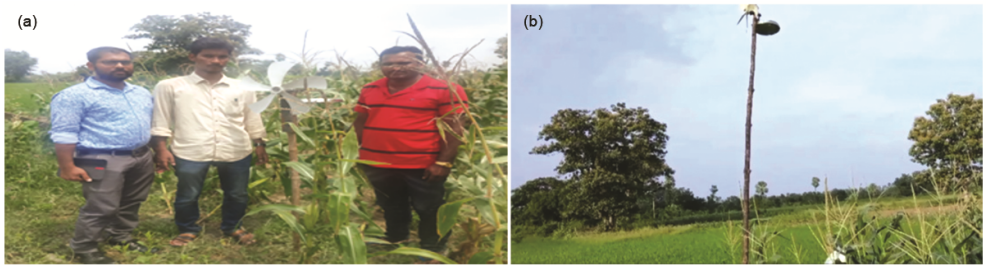

Fig. 2 — (a) Wind-operated bird scaring fan/machine (b) Installation of Wind operated bird scaring fan/machine in the maize field

Innovation -II 'Wind Operated Bird Scaring Fan': (Developed by Mr. Thirupathi Enuganti)

Mr. Thirupathi belongs to the Angal village of Chandurthi mandal in Rajanna Siricilla district of Telangana State. Maize is one of the major crops grown in the village. The yield of the maize crop is determined not only by good cultural and insect and disease management practices but also by the prevention of damage from birds and wild boars. Usually, manual labour and electrical fence are used for scaring birds and wild boars respectively. Mr. Thirupathi has been searching for a way out to avoid the difficulties being faced by engaging manual labour and the danger involved in using an electric fence.

By prompting after watching YouTube videos about the different mechanisms of a fan and how it can be used in the agriculture fields for reaping economic benefits, Mr. Thirupathi developed a wind-operated bird scaring machine by using a cycle hub, cycle chain, steel plate, and table fan blades preferably with 24-26 inches. He has attached table fan blades on one side and a piece of cycle chain on the other side of the cycle hub. The cycle hub is then joined to an iron rod of sufficient length for erection in the field. A steel plate is attached below the level of the cycle chain such that the cycle chain hits the steel plate while rotating (Fig. 2).

Mode of operation

The blades of the table fan which are generally 24 inches start rotating when wind passes in the field. This intern leads to the rotation of the cycle chain through the cycle hub. The cycle chain hit the steel plate while rotating. The loud noise created by the plate when the cycle chain hits on it will help in scaring the birds and wild boars.

Utility

The machine works by itself when placed in a windward direction. Hence the difficulty in engaging manual labour is solved. The machine works by creating a loud noise which is not life-threatening to animals or humans. The machine can be used as a bird scarcer exclusively and wild boar scarcer to some extent. The machine can be used in other crops for greater use and benefit which leads to cost-saving and sustainable energy option.

Details	Manual bird scarcer/ electrical fence	Wind-operated bird scaring fan/machine
Cost involved	Rs. 6000/- (@ Rs. 200/- per day for 30 days)	Rs. 250 for making the machine
Threat involved	Life threat due to electrical shock to animals /humans	No life threat
Effect or increase in yield	5-10%	15-20%

Attribute Identification of the Innovation

Parameters	Innovation Characteristics
Utility	Beneficial and user friendly
Cost	Low-cost innovation as compared to traditional means
Benefits	Sustainable energy use
Demonstrability	Demonstrated easily in fellow farmers' fields
Compatibility	Can be used across crops
Sustainability	Highly sustainable

Innovation -III 'Innovative Maize Sheller': (Developed by Mr. Nisar Ahmed Malik)

Mr. Nisar Ahmed Malik belongs to Qammar Kapran area of the Anantnag district of Jammu and Kashmir State. Qammar Kapran along with its adjoining areas involves more than 65 villages spread over an area of 2000 hectares of land, wherein maize hybrids are cultivated to a large extent and the crops are enjoying an outstanding position. These varieties have a special significance for this area, as each and every part of the crop including the shell is put to some use and has a bearing on the economy of the region. The introduction of short saturated improved varieties of Maize C-15, C-8, KG-1, and KG-2 has proved to be a boon for high-altitude maize farmers of Kashmir because of its high yield and resistance to various diseases, but threshing

Fig. 3 — (a) Lateral view of the innovative Maize Sheller (b) Lateral (Motor) view of the innovation

remains a major constraint in these areas. Different short-duration maize hybrids, though high yielding, are not gaining popularity amongst farmers as these are relatively hard to shell. The introduction of mechanization through innovative Maize Sheller' shall bring about a revolution in increasing production of these grain crops and thereby surging the development of sustainable livelihood opportunities and improvement in the quality of life. In addition to the Shellers, the introduction of adjustable winnowing fans is also a remarkable tool in farm mechanization which will also increase farm efficiency and productivity manifold.

Uniqueness of the innovation

The concerned innovative maize sheller is very much unique in its operation and its modus operandi. The innovation is demonstrative and replicable in nature with tremendous commercial viability in the hilly areas. It is much more efficient than manual threshing due to lost cost, affordability, accessibility, and availability in the region (Fig. 3). It creates job avenues as it can be available for custom hiring for fellow farmers in the nearby villages. It can also contribute toward efficient farm mechanization to improve productivity and reduce the drudgery of the workers.

Maize Sheller a profitable innovation: *Specifications and characteristic features*

S. No	Innovative Maize Sheller	Conventional Maize Sheller
1.	Machine weight= 0.35 q	Machine weight= 1 q
2.	Height= 4 ft	Height= 5 ft
3.	Breadth= 2.25 ft	Breadth= 6 ft
4.	Semi drier cum winnower present. (18"x 2.25" dia)	Absent
5.	Hand-driven cart tyre for mobility.	No such cart tyre is present.
6.	Attached on wheels to facilitate mobility on the doorstep of the farmer	No wheel attachment, difficult to carry from one farmer to another.
7.	It has 1.25 feet huller.	It has 3-5 feet huller.
8.	7 inches specially designed pulley to ensure more revolutions per minute which ensures the least seed damage and therefore better seed germination.	8-10 inches pulley thereby less revolutions per minute which damages the seed and thereby least seed germination.
9.	Shells about 12 quintals/hr, therefore suitable for marginal land holding farmers and involves least operational as well as maintenance cost.	Shells 30 Quintals /hr suitable for big land holding farmers and involve more fuel and maintenance costs.
10.	Very popular among poor farmers to the extent that about 65 villages of Shahabad, Breng, Matigauran, use this machine during the season.	Not affordable and least popular among farmers.
11.	It has a specially designed Semi-drier, which facilitates proper winnowing and cleaning of the seed.	No such drier is present.

Innovation -IV 'Indigenous practice of Detasselling in Maize': (Adopted by NGO named Rwikati)

Rwikati is a women's NGO formed in Pakriguri Village in Kokrajhar district in Assam. The NGO is mainly engaged in the cultivation of different crops. They are mainly engaged in Rabi maize production as the area is mainly tribal dominant. They have started this indigenous practice of detasseling after hearing its benefits from the senior people of the community. This has been practiced through generations but proper documentation has not been done yet (Fig. 4).

The maize is predominantly grown in the *rabi* season in these areas. People generally follow a paddy-maize cropping sequence. The maize sowing is done in the January and February months. Hence harvesting sometimes coincides with land preparation of the next crop, that is *Sali* paddy. Therefore, if the harvesting time can somehow be hastened that helps the farmers a lot. Then the farmers started to remove the tassels of the maize crop after pollination. This leads to hastening of maturity and harvesting by

Fig. 4 — (a-b) Detasselling of Maize before harvesting

7-10 days approximately. They feel that after the pollination is over there is no need for the tassels. Again, the detasselling helps in boosting the cob yield by reallocating the food to the cob only. This also minimizes the disease attack by removing the non-utilizable part. The plant parts after detasselling can be utilized as fodder for domestic cattle. The process also helps in minimizing the attack of birds during harvesting as the protruding maize stems hurt the eyes of the birds while trying to feed upon the cobs. Hence, the technique got popularity and now almost all the maize farmers in the district follow this innovative method.

Scientific support is needed to make this practice more efficient, popular, and acceptable. Although it is popular in the concerned pilot area, it will need time to commercialize in the neighboring areas. The main constraint was the labour required for the operation to be done. But it was overpowered by the benefits obtained. Proper awareness, training, and support from state and central research organizations will pave the way to validate and refine this technique for further dissemination.

In the maize sector, this can mean innovations like improved seed varieties, efficient irrigation techniques, or integrated pest management strategies, which can significantly boost yields and reduce costs. Entrepreneurial skills also help farmers identify market opportunities, build value chains, and form cooperatives or partnerships, thus increasing access to markets and resources.

Moreover, by fostering a mindset that emphasizes problem-solving and resilience, farmers become more adaptive to changing conditions, such as climate change or economic fluctuations. As these innovations spread through peer networks and local communities, they can transform the broader maize sector. Therefore, investing in entrepreneurial training can significantly enhance the diffusion and scaling of farmer-led innovations, improving productivity, sustainability, and the overall competitiveness of the maize industry.

Innovation -V 'Indigenous storage techniques of Maize Grains': (Adopted and Popularized by Mr. Rabindranath Burman)

Mr. Rabindranath Burman belongs from Konachatra village of Coochbehar District of West Bengal. He has a master's degree and his primary occupation is agriculture. He is a small farmer with a landholding of mere 3 acres and engaged in the cultivation of Rice, Maize, and Tobacco.

This simple method was developed by the maize farming community in the northern districts of West Bengal. Preserving maize grains for long periods after harvest is challenging due to insect pests and diseases. To ensure a steady supply of maize for household consumption year-round and sometimes to obtain a better market price, it is essential to store and preserve the grains in good condition. In this method, the grains are not separated from the cob after harvest. A bundle of 4-5 cobs is made, with the outer 2-3 husks tied together to form a bunch for hanging, while the remaining 1-2 husks stay on the cob. Some farmers follow a variation by removing all the husks before forming the bunch and hanging it. The bundles of 4-5 cobs are then suspended from a wooden support or string in a well-ventilated area. This technique allows maize cobs to be preserved for up to one year without any loss of quality, with some farmers claiming it can last up to two years. This is a general belief of the farmer about the quality considerations which needs to be scientifically validated over time. The cobs and grains remain healthy and undamaged. In hilly areas, where traditional maize varieties and self-saved seeds are common, farmers use this method to preserve seeds for the next season. Additionally, this low-cost method helps farmers preserve maize grains and potentially sell them at higher prices during times of scarcity. It is a simple, cost-effective solution for maize preservation (Fig. 5).

Traditionally, onions and garlic were stored in these places for a long period, and the technique was applied to maize with success. Any sort of innovation

Fig. 5 — (a) Indigenous storage technique of maize (b) Dehusked cobs for hanging (c) Bamboo stacks used for preserving the grains

requires government promotion and protection in order to gain special momentum. Commercialization of this method can help the whole community of maize growers.

Attribute Identification of the Innovation

Parameters	Innovation Characteristics
Utility	Better preservation of maize grains and seed
Cost	Low cost *viz;* Rs 4000/ha
Benefits	Beneficial for all maize farmers
Demonstrability	Easily demonstrable
Compatibility	Compatible with farmers
Sustainability	Very much sustainable

Conclusions

This study attempts to investigate the characteristics of chosen farmer-led maize innovations in the maize ecosystem. This analysis found that the selected innovations were developed primarily in response to a 'problem' encountered by the farmers. According to the findings of this study, all five grassroots innovations made use of local materials and/or wisdom. As a result, these innovations can only be generalized for that specific social structure. As a response, it is necessary to provide seed funding to grassroots innovators in order for their discoveries to be commercialized. It was also discovered that grassroots ideas were more cost-effective, more useful, and more sustainable than existing technologies. Institutions play a vital role in popularizing farmer-led innovations in the maize sector by providing technical support, resources, and creating an enabling environment for knowledge sharing. Agricultural research institutions collaborate with farmers to identify local challenges and co-develop innovative solutions, ensuring they are context-specific and effective. Extension services help disseminate these innovations through training, workshops, and field demonstrations, reaching a broader audience. Financial institutions, including microfinance organizations, support farmers by providing funding for innovation adoption, while policy-making bodies create favourable policies for scaling up farmer-led innovations. NGOs and farmer organizations facilitate networking and collaboration, allowing farmers to exchange ideas and best practices.

By strengthening linkages between farmers, research bodies, and extension services, institutions help farmers adopt and scale innovations, improving maize productivity, sustainability, and market access. These efforts contribute to the long-term success and widespread adoption of farmer-led innovations in the maize sector. Participatory technology development may involve grassroots innovators. This research has opened up new avenues of investigation into Farmers-Led Innovations in India.

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Author Contributions

PK, RS, SL, SN & SR: Conceptualization, Methodology supervision, visualization, draft writing-review and editing; and SB, ZA, SD, DS, &NB: Data collection and Documentation.

Conflict of Interest

The authors declare that no conflict of interest exists.

Informed Consent

All the respondents provided prior informed consent. Additionally, permission was obtained from individuals, whose images have been used in the paper.

Data Availability

Data will be made available by the corresponding author upon reasonable request.

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