

IMPROVING CLIMATE RESILIENT AGRICULTURE THROUGH FARMERS FEEDBACK INTO e-AGROMET ADVISORIES, TELANGANA



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Abbreviation

AAS	:	Agro Advisory Services
app	:	Application
CRA	:	Climate Resilient Agriculture
DSES	:	District Socio Economic Survey
FFS	:	Farmers Field School
FYM	:	Farmyard Manure
GoM	:	Government of Maharashtra
IMD	:	India Meteorological Department
IPCC	:	Intergovernmental Panel on Climate Change
mha	:	Million hectares
NUE	:	Nutrient Use Efficiency
NGOs	:	Non-Governmental Organizations
ODK	:	Open Data Kit
UN	:	United Nations
UNFCCC	:	United Nations Framework Convention on Climate Change
W-CReS	:	WOTR Centre for Resilience Studies
WOTR	:	Watershed Organisation Trust

Executive Summary

It has been documented with a fair degree of accuracy that climate is changing and rise in temperature will be posing various challenges all across the world. Indian region is likely to bear the worst of warming planet due to its tropical location. Agriculture and food production are likely to be significantly affected by climate change. In addition to this, climatic variability leading to extreme events like drought, flood, occurrence heavy rainfall, etc. is increasing during the last one and half decades. Thus, both climate change and climate variability are causing concern on the agriculture and ultimately agro eco-system in different parts of the country. Besides, in India, much of the soil degradation in the cultivable land is caused by faulty agricultural methods, inappropriate land management practices, excess use of chemical fertilizers and pesticides, and injudicious use of irrigation. India's total consumption of chemical fertilizers has been increased by manifold in past few decades and many studies have reported that the extensive use of chemical fertilizers and irrigation leads to soil degradation. Also, in total chemical pesticides consumption, India is 3rd in Asia after China and Turkey and, the uncontrolled and haphazard pesticide usage is responsible for the presence of high pesticide residues in both natural and physical environment. Given the multidimensional impacts of climate change and climate variability, and faulty agricultural practices, there exist considerable knowledge gaps in understanding climate vulnerability, sustainable agriculture practices, socio-economic impacts, and suitable ways to build resilience. Evidently, there is a need for a transition of current agricultural systems into highly resource-use efficient systems that are profitable, but at the same time ecologically safe and socially acceptable that cover the nature-based solutions derived from locally available natural inputs which will help to revive the agro-ecosystem, rebuild the resilient to changing climate and achieve sustainable agricultural production. Agro advisories are one of the best and effective means to decimate and build capacities of farmers in this regard.

The India Meteorological Department (IMD), Ministry of Earth Sciences is providing district level Agromet Advisory Services (AAS) in the country. However, at times, these district level crop weather advisories became redundant in changing climate and diverse crop and geographical situations. On the other hand, farmers need a dynamic decision support system that is tailored to their specific farms and provides them weather-responsive advisories across key aspects of agricultural operations. In this regard, Watershed Organisation Trust (WOTR) has developed "FarmPrecise"- an android based mobile application available on "Google Play Store" that provides crop-specific weather based information on up-to-date farming techniques, fertilizer and nutrient management, integrated pest, and disease management, irrigation water management, and market prices of different crops in nearby markets.

The farmer's feedback as shown that this mobile application is a boon for profitable farming. However, WOTR is working tirelessly on how the "FarmPrecise" mobile application can help to accelerate agricultural development and alleviate the technological and knowledge gap of farmers. In this view, to assess the appropriateness and ground feedback on agromet advisories, there is a need to study the status of the adaptation of agromet advisories, their usefulness, improvements needed in agromet advisories, and any modification required in the design of the FarmPrecise app. Therefore the current study was

aimed for improving climate-resilient agriculture through farmer feedback into e-agromet advisories provided through FarmPrecise app.

Both qualitative and quantitative data for Kharif and Rabi season of the year 2020-21 was collected from selected villages from Narayanpet block of Narayanpet district of Telangana state. As paddy is one of the major crops cultivated in the region, paddy grower farmers were surveyed in the present study.

The study revealed that the FarmPrecise mobile App is effective way to disseminate agromet advisories and build resilience to climate change. The crop weather advisories helped farmers to increase their knowledge about climate resilient agricultural practices including modern technologies and eco-friendly nature-based solutions. They are able to reduce the input cost and increase the net profit for the paddy crop. However, the community level capacity building is required to increase the adaptability of appropriate nature-friendly solutions and dissemination with small videos on the good practices will greatly benefit the users of FarmPrecise. Also village/community level hands-on trainings of how to use the mobile app will be helpful to farmers, and communicating the messages in colloquial language will have a greater uptake. If the mobile app can be operated in low network connectivity as well as in offline mode with a simple user interface, it will benefit many users. To enable farmers to adopt climate-resilient agriculture technologies, the very important step required is to make them aware of future risks of climate change, it will help them prepare their mind-set to deal with climate change and respond in adverse situations. Ultimately uptake of the FarmPrecise mobile application will improve.

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Study Team,

W-CReS and WOTR

1. Introduction

The United Nations (UN) estimates that during the period 1998-2017, climate-induced extreme events (droughts, floods, cyclones) caused India an estimated loss of nearly \$80 billion, and the costs are expected to increase (Pascaline and Rowena, 2019). In India, around 36 million hectares (mha) agricultural area was affected due to hydro-meteorological calamities, including heavy rain and floods since 2016- 6.65 mha in 2016, 5.08 mha in 2017, 1.70 mha in 2018, 11.42 mha in 2019, 6.65 mha in 2020 and 5.04 mha in 2021 (downtoearth news, 2021). A report released by the Intergovernmental Panel on Climate Change (IPCC) in 2014, India will suffer more frequent and intense heatwaves, extreme rainfall events, and erratic monsoons, as well as more cyclonic activity, among other weather-related calamities, in the coming decades (Braun, 2021). Additionally, India is facing a double challenge of sustaining food security and rapid economic growth while combating the threat of climate change especially regarding its impacts on land, water, and agriculture which provide sustenance and livelihoods for nearly 60% of Indians, most of whom live in rainfed, dryland semi-arid regions (Gupta and Pathak, 2016). It has been documented with a fair degree of accuracy that overall climate is changing particularly in respect of temperature over the Indian region and India is among the countries which are likely to bear the worst of a warming planet due to its tropical location. Agriculture and food production are likely to be significantly affected by climate change (Chattopadhyay and Chandras, 2018). Besides, climatic variability leading to extreme events like drought, flood, occurrence heavy rainfall, etc. is increasing during the last one and half decades (Chattopadhyay and Rathore, 2013). Thus, both climate change and climate variability are causing concern on the agriculture and ultimately eco-system in different parts of the country (Gupta and Pathak, 2016; Rathore et al., 2013). Given the multidimensional impacts of climate change and climate variability, there exist considerable knowledge gaps in understanding climate vulnerability, socio-economic impacts, and suitable ways to build resilience (Birkmann et al., 2012). This view is strongly underscored by both the IPCC and India's Second National Communication to United Nations Framework Convention on Climate Change (UNFCCC) which recommended integrated research on operational strategies and approaches for adaptation of region and sector specific policy interventions that build resilience and adaptive capacities of communities (Raghunandan, 2020).

In India and across the world, one of the major challenges faced in the recent decade is anomalous weather which drastically affects agricultural production at the local level. Under increasing climate threats, it is becoming increasingly important for farmers to proactively manage the weather and climate risks to agriculture to protect their livelihoods (Chaubey et al., 2018). Therefore farmers, especially smallholder farmers, need advance decision support system which facilitates them to take appropriate actions under emergent weather conditions at a local level (Lobo et al., 2017). To address this issue and others, the India Meteorological Department (IMD), Ministry of Earth Sciences is providing district level Agromet Advisory Services (AAS) in the country. Crop weather advisories are helpful to farmers to get information of weather and crop specific management practices in a given weather condition. Agro-meteorological service rendered by India Meteorological Department is a step to contribute to weather information-based crop/livestock management strategies and operations dedicated to

sustainably enhancing crop production (Chattopadhyay and Chandras, 2018; Chaubey et al., 2018). However, at times, these district level crop weather advisories became redundant in changing climate and diverse crop and geographical situations.

Additionally, with the advent of green revolution, Indian farming has become more and more dependent on external inputs, most of those are synthetic and chemical products. Excessive use of synthetic fertilizers and agro-chemicals for plant nutrition and protection measures not only increasing the cost of cultivation but also degrading the natural resource base of soil and water. There is an urgent need to provide appropriate eco-friendly, non-chemical and integrated options for crop cultivation which will help farmers to reduce their input cost, maintain the production levels and reduce the environmental damages caused by conventional agricultural practices. The eco-friendly measures cover the nature-based solutions derived from locally available natural inputs which will help to revive the agro-ecosystem, rebuild the resilient to changing climate and achieve sustainable agricultural production. Agro advisories are one of the best and effective means to decimate and build capacities of farmers in this regard.

In India, most of the smallholder farmers are often have limited access to the technologies and resources. Therefore there is a great need to convert the climate information into actionable information for farmers by linking the climatic information with the available technologies and best farming practices (Kenneth, 2021). Effective climate information and advisory services have great potential to facilitate farmers' in their decision-making process, improve management of climate-related agricultural risk, and help farmers adapt to change. However, many challenges confront efforts to use climate-related information to improve the lives of smallholder farmers (Philip and Lindsay. 2021).

In this view, farmers need a dynamic decision support system that is tailored to their specific farms and provides them weather-responsive advisories across key aspects of agricultural operations. This will help them mitigate weather-induced risks, reduce losses and costs of production, increase productivity and improve incomes (Lobo et al., 2017).

A mobile or smartphone application (app) is one such platform through which farmers can avail all such information. Smartphones have revolutionized connectivity and mobile apps are being used to transfer agricultural information to farmers (Barh and Balakrishnan, 2018). According to global statistics, India is the third-largest user of smartphones after China and the United States (EMarketer, 2016). Mobile telecommunication systems are increasingly cost-effective and an efficient way of delivering weather-based agro-advisories to farmers at a large scale (Lobo et al., 2017). In this regard, Watershed Organisation Trust (WOTR) has developed "FarmPrecise"- an android based mobile application that provides crop-specific information on up-to-date farming techniques and methods used, real-time weather data, 5-day weather forecast, weather alerts, fertilizer requirement for crops its planning and application, crop-specific irrigation needs and their application, nutrient management, integrated pest, and disease management, and market prices of different crops in nearby markets (Bhagat and Gholkar, 2021). As of now, FarmPrecise mobile application provides locale specific crop weather advisories to farmers in English, Hindi, Marathi, and Telugu languages and

soon it will be available in other Indian languages. It is available for free and can be downloaded from the “Google Play Store”. Presently more than 45000 farmers have downloaded this mobile application (WOTR, 2021).

FarmPrecise mobile application has a simple interface and an additional tab connects the farmers directly to the experts of WOTR to answer the farmer's questions. In addition to this farmer's feedback has shown that this mobile application is a boon for profitable farming (Joshi, 2020). However, WOTR is working tirelessly on how the "FarmPrecise" mobile application can help to accelerate agricultural development and alleviate the technological and knowledge gap of farmers.

In this view, to assess the appropriateness and ground feedback on agromet advisories, there is a need to assess the status of the adaptation of agromet advisories, their usefulness, improvements needed in agromet advisories, and any modification required in the design of the FarmPrecise app. Therefore the study was aimed to get the farmers' feedbacks on climate-resilient agriculture on e-agromet advisories provided through FarmPrecise. Both qualitative and quantitative data was collected from selected villages from Narayanpet block of Narayanpet district of Telangana state. As paddy is one of the major crops cultivated in the region, paddy crop is selected for the present study conducted in the Telangana. The state is emerging as a key rice-producing state in the country. Also, Telangana called the rice bowl of South India which grows rice in about 44 lakh acres, has seen its share to the national rice production improve considerably from 29 lakh tonnes recorded in 2015-16 increased by four times to 1.3 crore tonnes in 2019-20 (RBI, 2021). Narayanpeth is one of the major rice-producing districts of Telangana state (Sharma and Raju, 2016) and WOTR is being actively engaged in the Narayanpet district through its various project activities. Therefore for the study, 100 farmers of five villages of Narayanpet block of Telangana state who have been using the FarmPrecise App for paddy were selected. The data collection is done for both the seasons (Kharif and Rabi) of the year 2020-21.

2. Objectives of Study

The broad objective of the study is to improve climate-resilient agriculture through farmer feedback into e-agromet advisories. The detailed objectives are as follows.

1. To study the impact of e-agro advisories through farmer's feedback
2. To study the barriers and enablers of adapting the crop specific climate resilient agricultural practices
3. To improve e-agro advisories and means of dissemination (FarmPrecise App) through farmer's feedback
4. To provide policy recommendations and programmatic interventions to improve the adoption of climate-resilient agriculture

3. Description of the Study Area

The data collection for the study was done in five districts of two states Maharashtra and Telangana for the Kharif and Rabi seasons of the year 2020-21. In Maharashtra: data collection was done in 68 villages of 08 blocks of 04 districts, and in Telangana: data collection was done in 05 villages of Narayanpet block of Narayanpet district. The details of study villages are given below. This report is specially prepared for the Telangana state only and location map of the study area is shown in Figure 1.

Name of State	Name of District	Name of Block	Name of Village
Telangana	Narayanpet	Narayanpet	1. Laxmipur 2. Ammireddypalle 3. Perapalla 4. Appireddypalle 5. Lingampalli

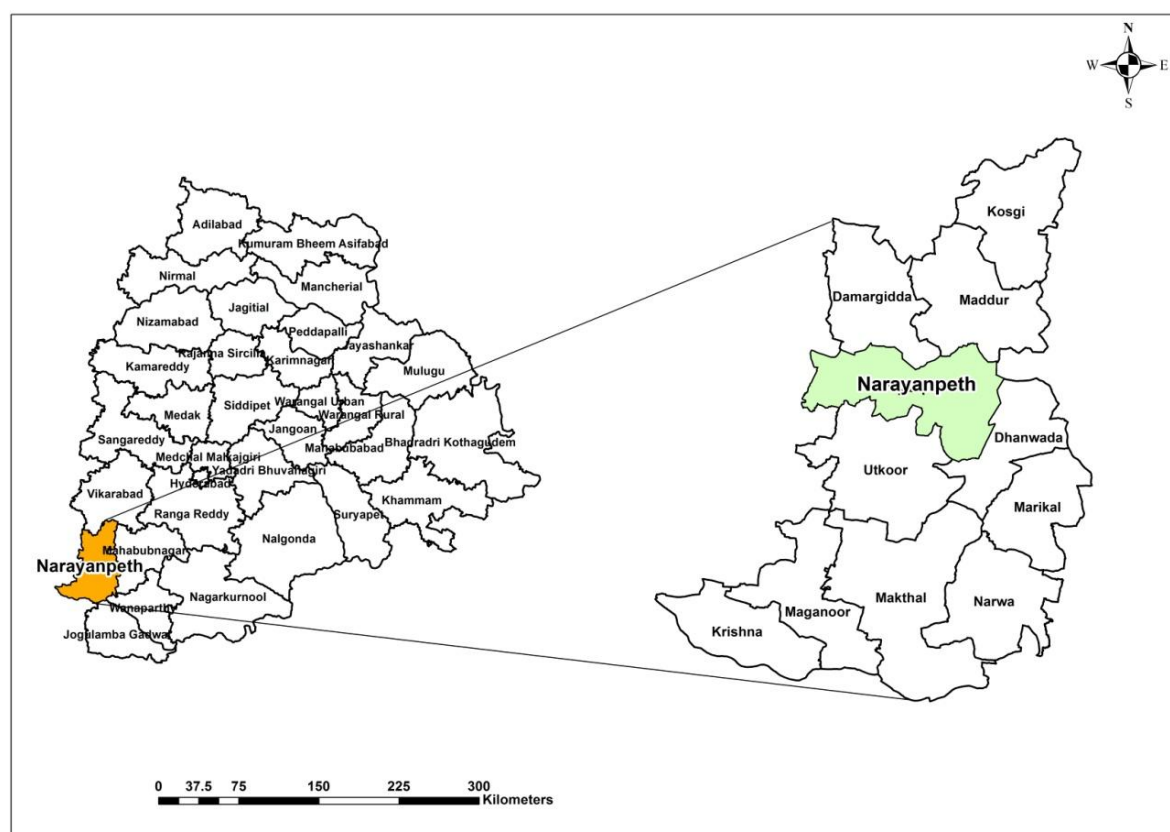


Figure 1 Location map of the study area

4. Sample Selection

Paddy (Rice) is the predominant crop cultivated in both Kharif as well as Rabi season in most of the areas in Narayanpet. The study was conducted in 5 villages of the Narayanpet block of the Narayanpet district. A questionnaire based tool was designed to collect the data from selected farmers. As the majority of farmers are Rice growers so the sample size was determined at 95% confidence level and 10% confidence interval which come about 96. So, about 20 paddy growing farmers who are recipient of agro-

advisories through FarmPrecise app were selected from each of the study village. In total, 100 farmers were interviewed to collect the feedback on e-agro-advisory services provided through the FarmPrecise.

Sr. No.	Name of Block	Name of Crop	
		Kharif Season	Rabi Season
1.	Narayanpeth (Telangana)	Paddy	Paddy

5. Information Collected in Survey

During the survey, following information was collected from selected farmers.

➤ Household Profile

- Type of family, number of male and female members, education of family holder, and household size.
- Income generated through primary and secondary occupation.

➤ Agriculture Information

- Total land, cultivated and uncultivated land, seasonal and perennial irrigated land, land for which e-agro advisories followed.
- Major crops cultivated in Kharif and Rabi seasons (the year 2020-21)

➤ Adaptability Status and Farmers Feedback on Adaptability of e-Agro Advisories

- Advisories of land preparation before sowing
- Advisories of application of organic manures
- Advisories of seed treatment at the time of sowing and related activities after sowing
- Advisories of trap crops and various traps to control pest attack
- Advisories of application of Amrutpani, Jeevamruit, and Vermi-wash spraying
- Advisories of application of bio-pesticides (Dashparni ark/NSKE/Neemark)
- Advisories of application of irrigation
- Advisories of application of a recommended dose of chemical fertilizer
- Advisories of daily weather and weather alerts
- Crop-specific e-agro advisories
- Impact of selective e-agro advisories on crop yield, input costs, labor cost, irrigation water requirement
- Scaling of the usefulness of e-agro advisories

6. Preparation of Questionnaires

Questionnaires were developed in Telugu and English languages to collect the farmer's feedbacks on agro-advisories disseminated through the FarmPrecise mobile application during the Kharif and Rabi crop seasons of the year 2020-21. The questionnaire were then converted in Open Data Kit (ODK) format so that it can be assessed online and digital data collection is possible using a mobile or a tab.

7. Data Collection

The field coordinators and survey teams were trained for the data collection using ODK Application. The online training of survey team was conducted before the data collection during Kharif and Rabi seasons. All the queries of data collectors regarding questionnaires were resolved during the training program. The data collection was divided into three stages during the cropping cycle- the early stage, mid-stage, and end/harvesting stage of the crop. Data collectors were closely monitored during the data collection process and required inputs and clarification was given to them to avoid gaps and errors in the data.



Photo 1 Field investigators during data collection (Photo Credit- WOTR)

Farmers' Feedback on Various CRA Advisories

8. Advisories of Land Preparation

The main objective of land preparation is to create a favourable environment for the plants/seeds to germinate and grow. Most of the paddy growers' follows ploughing, and puddling of the field before transplanting the rice seedlings.

- **Kharif Season (Paddy)**

Report on Farmers Feedback into e-agromet Advisories- Narayanpet Block (Telangana State)

Figure 1 revealed that the advisory of ploughing and harrowing/puddling of paddy fields followed by 100% and 99% of farmers respectively. Almost all the farmers have adopted the land preparation practices. The details of the observed benefits of land preparation are shown in Table 2 of the Appendix.

- **Rabi Season (Paddy)**

Figure1 also represents the advisory of ploughing and harrowing of paddy fields follows by 84% and 97% farmers respectively. It was observed that some farmers did not ploughing before the rabi season but they mostly prefer harrowing operation in the Rabi while ploughing was done at the start of the Kharif season only. The details of the observed benefits of land preparation are given in Table 3 of the Appendix.

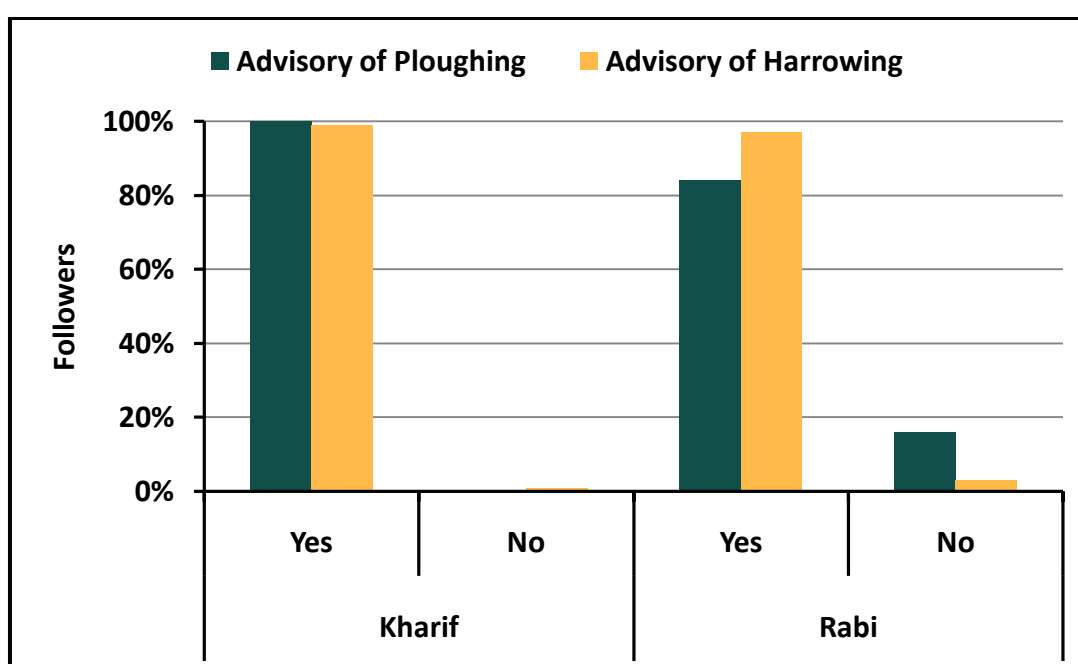


Figure 2 Status of farmer's adaptability for advisories of ploughing and harrowing for paddy crop in Kharif and Rabi seasons

9. Advisories of Application of Organic Manures

Use of organic manures will help farmers to reduce their dependency on synthetic fertilizers which are not only costly but cause soil degradation and emission of greenhouse gases. On the other hand, application of organic manure increases the soil organic matter, thereby improving the, soil water holding capacity and nutrient availability for crops, which helps to mitigate adverse effects of climate change on crop production and attain sustainable crop yield. The application of organic manure has a significant positive effect on plant growth parameters such as plant height, length, number of fruit branches, and stem diameter (Botir et al., 2019). Use of organic manures like vermi-compost, decomposed compost, green manuring are some of the key nature-based solutions which enhances crop productivity and also protect agro-ecosystems.

- **Kharif Season (Paddy)**

Figure3 revealed that the advisory of application of organic manures (FYM, Vermicompost, and Compost) during land preparation was followed by 62% of farmers while, 38% farmers had not followed the advisory, because of the insufficient availability of organic manures. From Table 4 in the Appendix, it is observed that 34% of farmers responded that either the raw material for organic manures was not available at household or, and organic manure was not ready for field application. 29% of surveyed farmers were willing to purchase the manures but it was not available in the market. 19% of farmers don't have a sufficient quantity of organic manure as they have already been applied to other crops. About 25% farmers are not using organic manures. 18% of farmers feel it is costly. 3-5% of farmers applied it in the previous year.

- **Rabi Season (Paddy)**

From Figure3, it is also observed that the advisory of application of organic manures (FYM, Vermicompost, and Compost) during land preparation followed by 60% of farmers. Still, 40% of farmers had not follow the advisory. From Table 5 of the Appendix, it is seen that 17% of farmers responded that raw material for organic manures was not available, and 13% of farmers responded that organic manure was not ready for the application while, 5% farmers are willing to purchase the manures but was not available in the market. 18% of farmers applied it in the previous year.

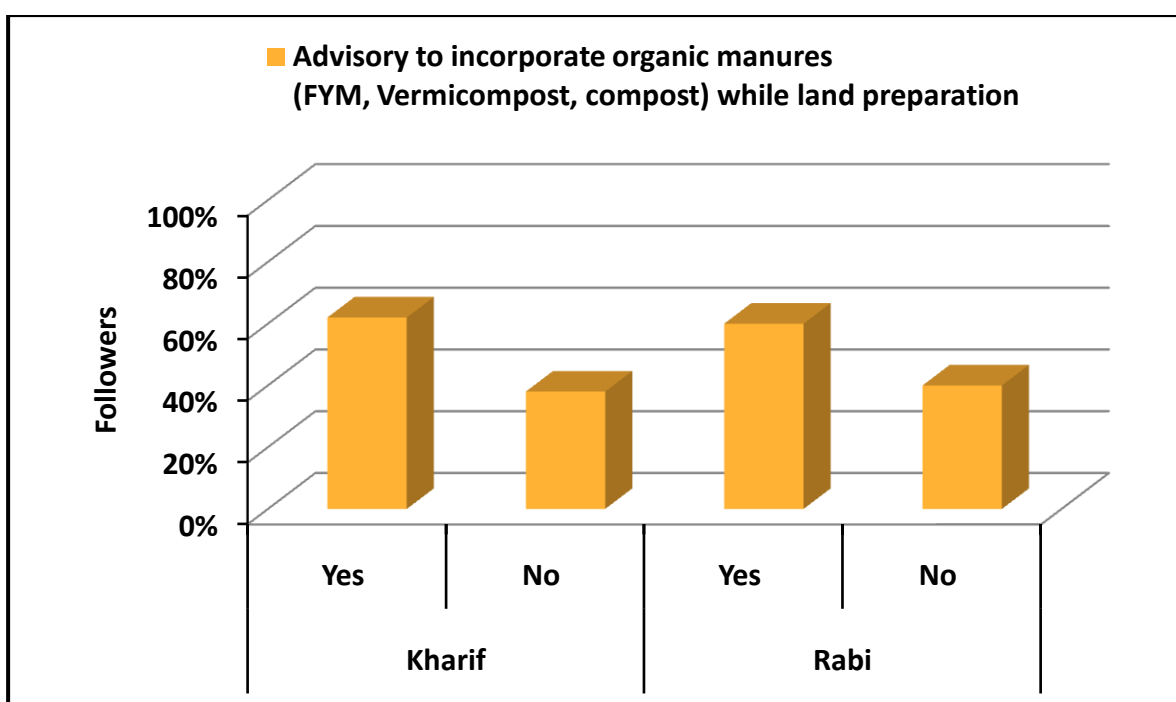


Figure 3 Status of farmer's adaptability of advisory to incorporate organic manures in the soil for Paddy crop in the Kharif and Rabi seasons

Though there is moderate use of vermi-compost and other organic manures in the region, however, most of the farmers follow green manuring in their field with

Sunnhemp and Dhaincha crops. Also, a large percentage of farmers are willing to purchase organic manures then there is scope to produce the organic manures at a commercial level and make them ready to sell during the appropriate period.

10. Advisories of Seed Preparation (treatment) before Sowing and Related Activities after Sowing

Seed treatment means treating seeds with various chemical and/or biological inoculants to reduce, control, and repels the attack of pest, disease, insects which attack the seed or seedlings. Seed quality and its germination depend on many environmental factors, like soil moisture and temperature. It is equivalent treating seed with one or more inoculants is the most economical and efficient way to protect seed from soil borne pests and diseases which improve seed germination. Along with seed treatment, plant population per unit area is also important for crop growth and ultimate yield. Optimum plant population is necessary to achieve better yield.

- **Kharif Season (Paddy)**

From Figure 4, it is clear that almost all the farmers follow the advisory of seed treatment. The detailed adaptability status of the advisory of seed treatment is given in Figure 5. The impact of seed treatment given by farmers is given in Table 6 of the Appendix. Figure 4 also revealed that 83% of farmers follow the advisory of crop geometry. The non-availability of machines or labour is major issues faced by the farmers to follow the crop geometry. The impacts of advisory of crop geometry observed by the farmers are given in Table 7 of the Appendix.

- **Rabi Season (Paddy)**

From Figure 4, it is seen that almost all the farmers follow the advisory of seed treatment. The detailed adaptability status of the advisory of seed treatment is given in Figure 5. Farmers' feedbacks on the impacts of seed treatment are given in Table 8 in the Appendix. Figure 4 also reveals that almost all the farmers follow the advisory crop geometry. The feedbacks of farmers on the impacts of crop geometry are given in Table 9 in the Appendix. In both the seasons, seed treatments have resulted in good germination, healthy seedlings, and uniform growth which also prevented pest and disease infestation/attack on seedlings. As a result, the percentage of farmers who go for the gap-filling and re-sowing was very low or equal to none. The adaptability of advisory of crop geometry can be increased by knowing the importance of optimum plant population through field training and demonstration on farmer's field plots.

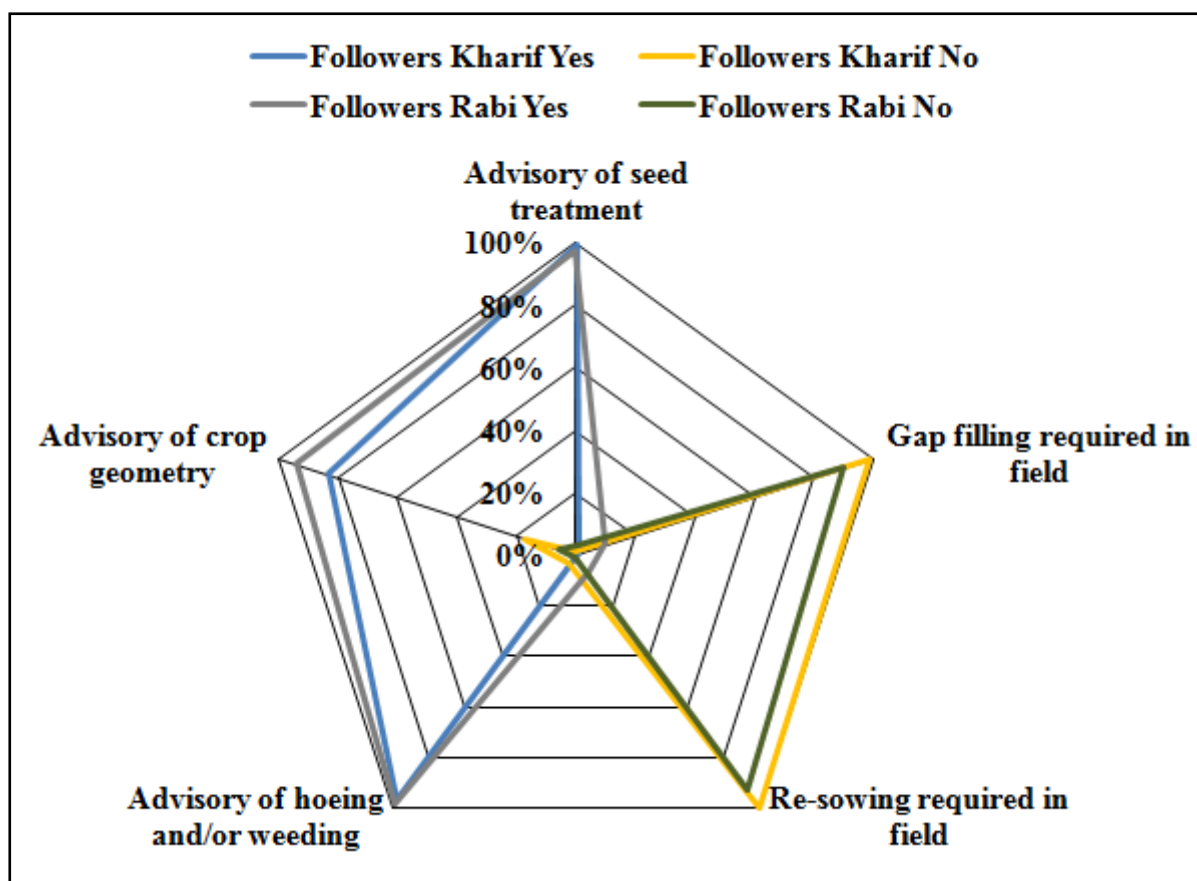


Figure 4 Status of farmer's adaptability for advisories of seed treatment, crop geometry, and weeding for Paddy crop in the Kharif season

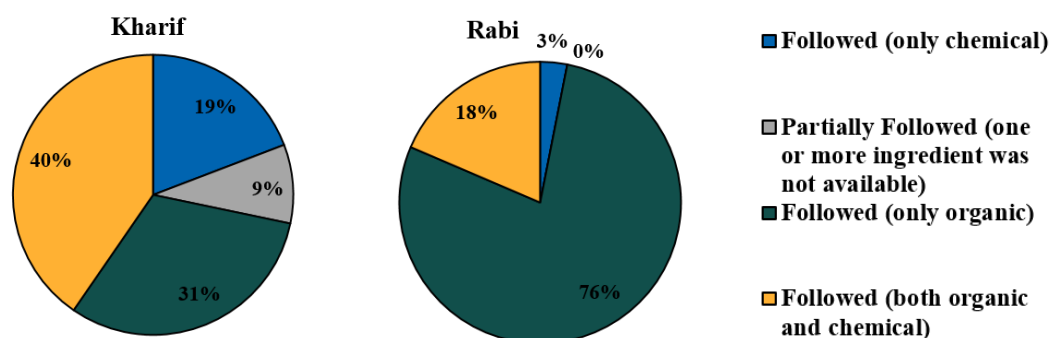


Figure 5 Details of advisory of seed treatment for Paddy crop in the Kharif season

11. Advisories of Trap Crop

Trap crops are grown to attract insects or other organisms like nematodes to protect target crops from pest attacks. Protection may be achieved either by preventing the pests from reaching the crop or by concentrating them in a certain part of the field where they can economically be destroyed. This form of companion planting can save the main crop from decimation by pests without the use of pesticides.

- **Kharif Season**

Figure6 shows that the advisory of trap crop was not followed by most of the rice farmers. Because 92% were unaware of the trap crops and their uses, and the remaining 8% thought that trap crops might create shadow to the main crop. The details of the farmer's feedback are given in Table 10 of the Appendix.

- **Rabi Season**

Figure6 reveals that the advisory of trap crop follows by 20% of farmers. The acceptance of trap crop advisory is increased in rabi season as farmers got more information about the benefits during past kharif season while, almost 78% of farmers still don't practiced the trap crop out of which 39% of farmers don't have the seeds of trap crops, 24% of farmers have difficulty in the growing of trap crop, and 16% of farmers feel that it will increase the cost of production. The details are given in Table 12 in the Appendix.

For both seasons, there is a large scope to increase the adaptability of the technique of trap crops by knowing the importance, farmers training, and field demonstration to reduce the risk of crop failure and to increase the final income.

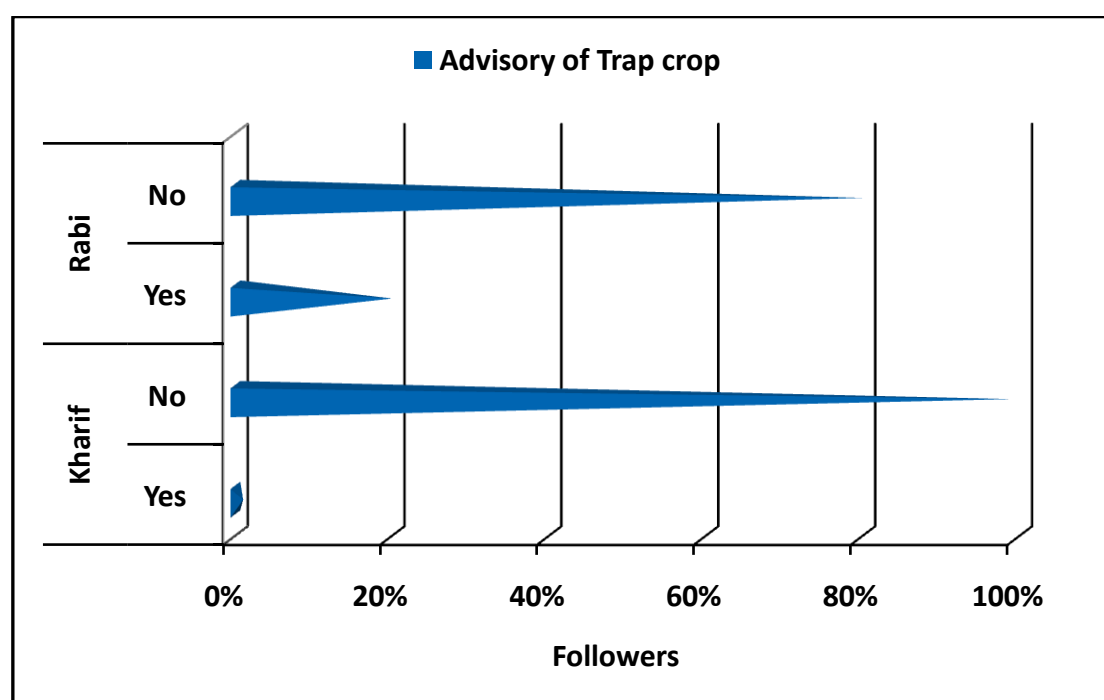


Figure 6 Status of farmer's adaptability for advisories of trap crop and intercropping for Paddy crop in the Kharif and Rabi seasons

12. Advisories of Use of Various Traps to Control Pest Attack

Insect pests are the main sources of biotic stress on crops. There are hundreds of insects that can cause serious damage to crops and are controlled by chemical pesticides, which are the main sources of pollution and cause the development and progression of several health problems in humans and animals. To avoid the excessive use of chemical pesticides, light traps and pheromone traps play a great role as control measures. Insect

traps are used to monitor or directly reduce populations of insects or other arthropods, by trapping individuals and killing them. Pheromones are chemicals used by insects and other animals to communicate with each other. Insects send these chemical signals to help attract mates, warn others of predators, or find food. Using specific pheromones, traps can be used to monitor target pests in agriculture or residential areas. Mating disruption, mass trapping, attract-and-kill, and push-pull are some of the direct pest control strategies that depend on the use of pheromones. Similar to it, the insect light trap is one of the very effective ways of insect pest management in organic agriculture as it mass-traps both the sexes of insect pests and also substantially reduces the carryover pest population. The light-trap attracted several kinds of insects i.e. rice moth, flour beetle, rusty grain beetle, foreign grain beetle, saw-toothed grain beetle, rice weevil, and lesser grain borer. Light traps could therefore be used to monitor infestation.

- **Kharif Season (Paddy)**

Figure 7 revealed that the advisory of installation of pheromone trap was followed by 78% of farmers. Still, 22% of farmers did not follow the advisory due to a lack of knowledge. Other reasons for the non-following the advisory and observed benefits of advisory are given in Table 14 of the Appendix. Figure 7 also revealed that the advisory of installation of light trap is not followed by 92% of farmers because of the non-availability of material/instrument, no idea about the technique and installation, and electricity not available at the field given in Table 15 of Appendix. Besides that 8% of farmers installed the light trap and observed that the trap kills both beneficial and not beneficial pests.

- **Rabi Season (Paddy)**

Figure 7 revealed that the advisory of installation of pheromone trap follows by 39% of farmers. Still, 61% of farmers do not follow the advisory due to the lack of knowledge given in Table 16 in the Appendix. Figure 7 also revealed that the advisory of installation of light trap does not follow 83% of farmers because of mainly the technical issue of availability of electricity in the field, and no idea about the technique and unaware that battery can also be used for functioning of the light trap, the detailed results are given in Table 17 in the Appendix. Only 12% of farmers installed the light trap and observed cost reduction on pesticides application with partial control of pests.

Therefore there is huge scope to increase the adaptability and build the capacity of farmers for appropriate use of both Pheromone and light traps technologies in the field by in-house and field training, farmer's field demonstrations, and building a network to make available the traps in the local market.

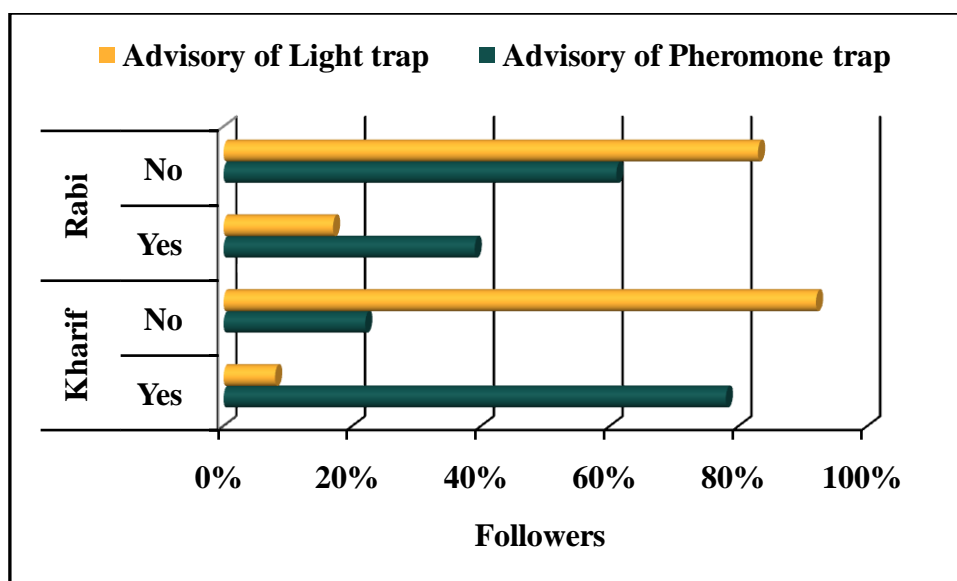


Figure 7 Status of farmer's adaptability for advisories of Pheromone trap and Light trap for Paddy crop in the Kharif and Rabi seasons

13. Advisories of Application of Amrutpani, Jeevamrut, and Vermiwash

Amrutpani is a bio-inoculants and acts like a tonic that influences the growth, quality and yield, and attributes of various crops and helps in the revitalizing and enrichment of the soil. Jeevamrut constitutes a rich source of nutrients like carbon, phosphorus, potassium along with rich soil microorganisms that help in fixing the nitrogen, solubilize phosphorus. It increases the uptake of N, P, and K, growth and yield parameters like plant height, root length, fruit yield, and yield attributes like protein and fiber content which adds to the overall yield results. This organic liquid formulates can be applied in different doses and various forms like foliar spray, soaking, drenching, and fertigation based on the requirement and goals (Patil, 2019). Vermiwash plays an important role in plant growth and development, contributing to the initiation of rooting, root growth, plant development, promotion growth rate, and improvement in crop production increasing the soil organic matter and increasing nutrient content which is readily available for the plants (Sundararasu, 2016).

- **Kharif Season (Paddy)**

From Figure 8, it is revealed that 95% of farmers followed the advisory application of Amrutpani and Jeevamruit, while 35% of farmers follow the advisory of Vermi-wash spraying. Table 18 of the Appendix gives detailed survey results.

- **Rabi Season (Paddy)**

Figure 8 revealed that 75% of farmers followed the advisory application of Amrutpani and Jeevamruit. 25% of farmers have not following due to unavailability of ingredients and raw material, lack of information about the preparation methods, and not available in the market. The detailed results are given in Table 19 in the Appendix. Table 19 of Appendix also reveals the observed benefit of the application

of Amrutpani and Jeevamruit. Also still 91% of farmers are not following the advisory of Vermi-wash spraying.

There is a wide scope to increase the usage of Amrutpani, Jeevamruit, and Vermi-wash by knowing their importance, process of preparation, and collection process at the household level to farmers by in-house and field training, field demonstration, and addition of small videos of preparation with e-agro advisories.

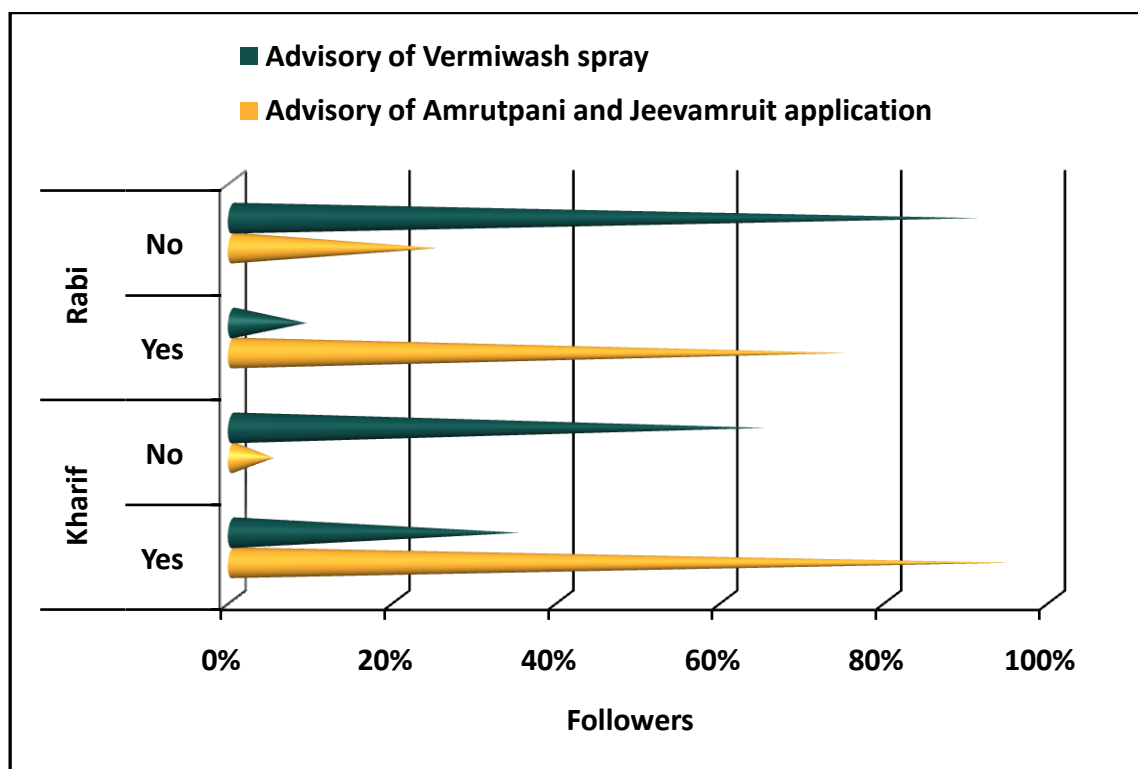


Figure 8 Status of farmer's adaptability for advisories of Amrutpani, Jeevamruit, and Vermi-wash for Paddy crop in the Kharif and Rabi seasons

14. Advisories of Application of Bio-Pesticides (Dashparniark/NSKE/Neemark)

Bio-pesticides only kill/repel/prevent the target pests and do not damage the soil, water supply, or wildlife ecosystem including the beneficial insects. The use of bio-pesticides improves root and plant growth by enhancing the soil micro-flora and results in increased agriculture production. It also can increase the farmer's income through the reduction of input costs on chemical pesticides. In addition to this, bio-pesticides support the stability and sustainability of agro-ecosystem and decompose quickly, resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides (Kumar et.al., 2021; EPA, 2016). Dashparni ark, NSKE, and Neemark extract are some of the very effective in controlling all kinds of insect pests and diseases prepared using all-natural ingredients. It strengthens the plant's overall immunity. It is antiviral and antifungal. The farmers can prepare the solution in-house (Agrostar, 2019; India Development (Vikaspedia) Gateway, 2022).

- **Kharif Season (Paddy)**

Figure 9 revealed that only 15% of farmers follow the advisory of application of bio-pesticides. Still, 85% of farmers did not follow the advice of application of bio-pesticides due to no idea about technology, the raw material was not available to prepare it, and readily not available in the market. The detailed survey results of the application of bio-pesticides are also given in Table 20 in Appendix.

- **Rabi Season (Paddy)**

Figure 9 revealed that only 9% of farmers follow the advisory of application of bio-pesticides while, 91% of farmers did not followed the advisory of application of bio-pesticides because, unavailability of the raw material, lack of knowledge of preparation methods, and readily not available in the market. Some also felt that it will increase the cost of production. The survey results of the application of bio-pesticides are given in Table 21 of the Appendix.

There is large scope to increase the adaptability of advisories and usage of bio-pesticides through capacity building of farmers, field demonstration for preparation at the household level, and also the inclusion of short videos of preparation with e-agro advisories.

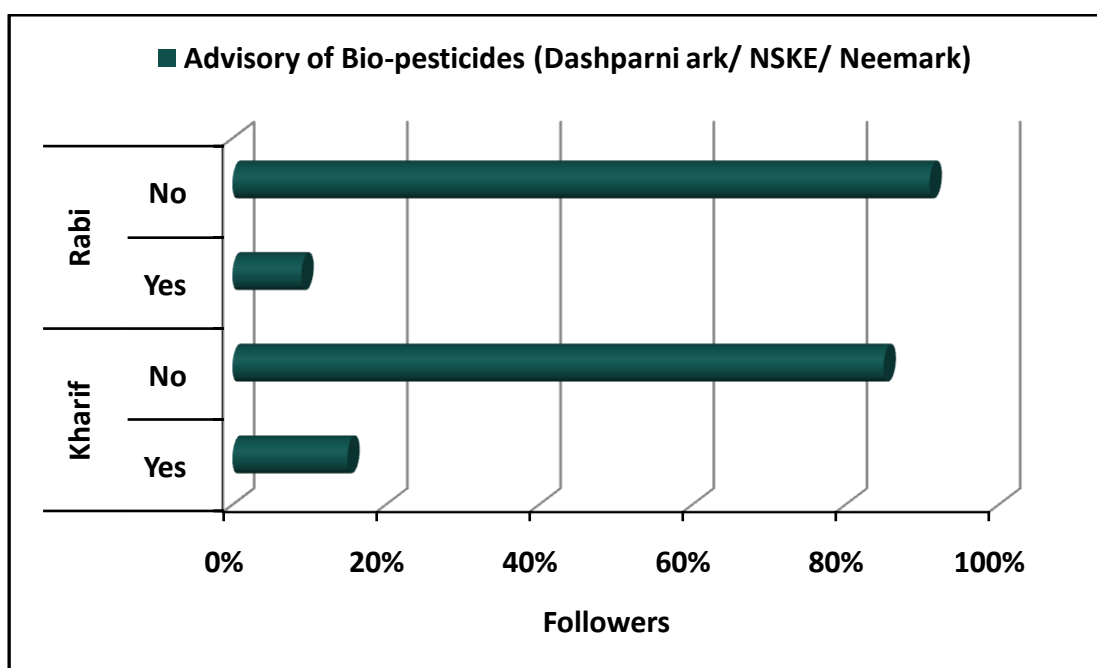


Figure 9 Status of farmer's adaptability for advisories of bio-pesticides for Paddy crop in the Kharif and Rabi seasons

15. Advisories of Application of Irrigation

The main objectives for irrigation management are to promote the proper growth of plants and maintain the right levels of moisture for the soil. Soil water affects plant growth directly through its controlling effect on plant water status.

- **Kharif Season (Paddy)**

Figure 10 revealed that 93% of farmers are following the advisory of water (Irrigation) application. The observed benefits of irrigation advisory are given in Table 22 in the Appendix.

- **Rabi Season (Paddy)**

Figure 10 also revealed that 76% of farmers are following the advisory of water (Irrigation) application. Still, 24% of farmers don't follow the advisory due to other work and sufficient soil moisture in the field. The observed benefits of irrigation advisory are also given in Table 23 in the Appendix.

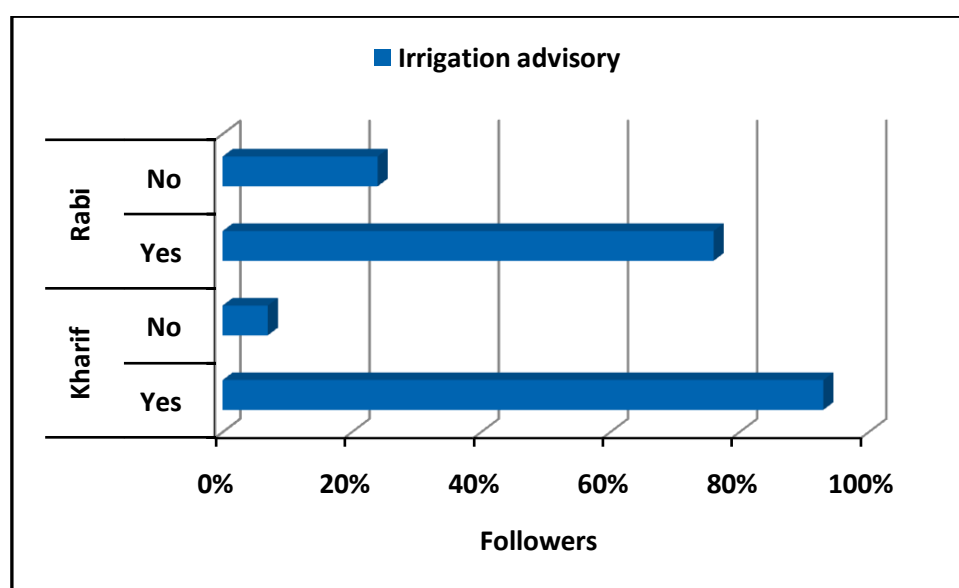


Figure 10 Status of farmer's adaptability for advisories of irrigation for Paddy crop in the Kharif and Rabi seasons

16. Advisories of Application of Recommended Doses of Chemical Inputs

Chemical fertilizers are quick in providing plant nutrients which can be easily absorbed and results in the increased productivity. However, excess use of chemical fertilisers in agriculture is harmful to soil health and ultimately the whole ecosystem. Therefore application of recommended dose of chemicals fertiliser preferably along with organic manures and inputs is an effective way to use appropriate chemicals in agriculture.

- **Kharif Season (Paddy)**

Figure 11 revealed that 94% of farmers have followed the advisories of application of recommended dose of chemical fertilisers out of which 82% of farmers follow the advisory of spilt dose application. But only 31% of farmers are using the fertilizer calculator tool in the FarmPrecise mobile app and out of which 11% of farmers have saved the cost on nutrients. The reasons for the non-adaptability of the advisories are given in Table 24 of the Appendix. The observed benefits of the use of chemical pesticides are given in Table 25 of the Appendix.

- **Rabi Season (Paddy)**

Figure 11 revealed that 85% of farmers have followed the advisories of application of a recommended dose of chemical out of which 41% of farmers follow the advisory of spilt dose application. But only 33% of farmers are using fertilizer calculator developed in the FarmPrecise mobile app and out of which 25% of farmers have saved the cost on nutrients. The reasons for the non-adaptability of advisories are given in Table 26 of the Appendix. The observed benefits of the use of chemical pesticides are given in Table 27 of the Appendix.

Therefore there is large scope to increase the use of fertilizer calculator to save the cost of fertilizers. The adaptability can be increased by developing an easy user interface of fertilizer calculator in FarmPrecise application and knowing the importance of recommended doses of chemicals in agriculture through the demonstration on farmer's field plots. The overall adaptability of advisories of chemical inputs was quite less compared to the adaptability of other advisories, evidences that the nature based solutions and organic farm inputs are playing greater role in soil health management and crop protection. On farmer's demand, the advisories of use of chemical fertilizers/pesticides/insecticides need to be updated additionally with information of their latest brands available in markets.

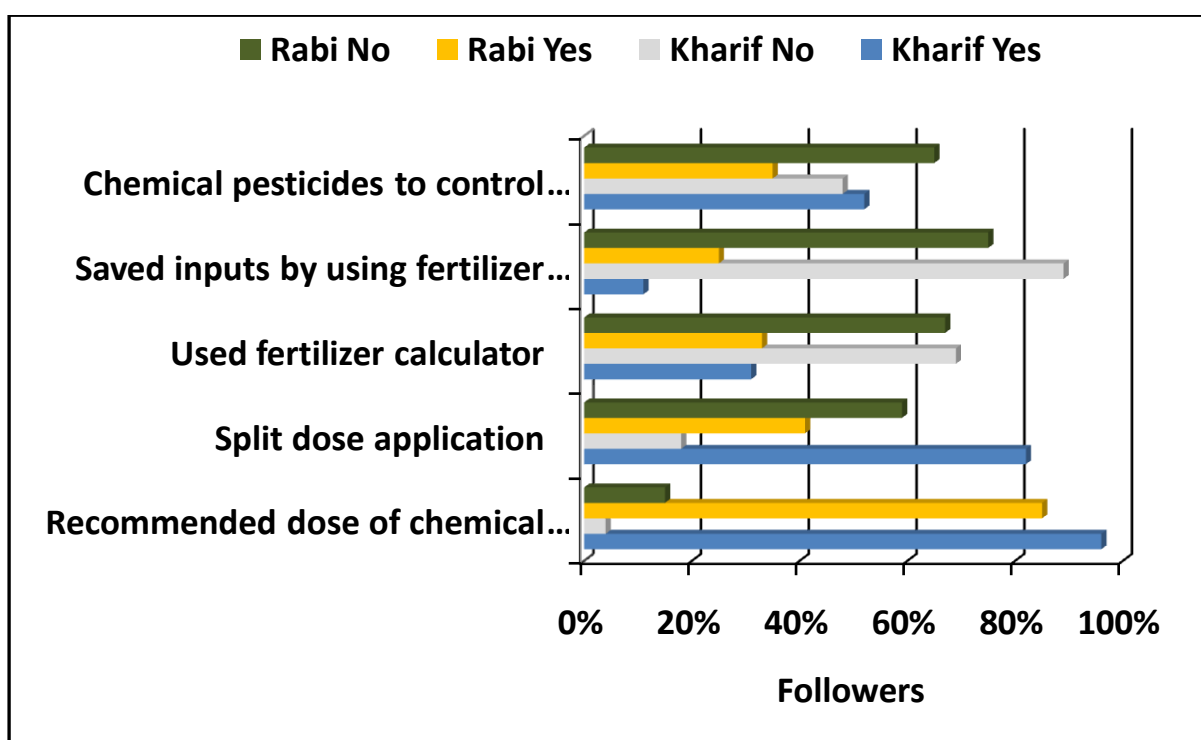


Figure 11 Status of farmer's adaptability for advisories of application of chemical fertilizers /pesticides, and use of fertiliser calculator for Paddy in the Kharif and Rabi seasons

17. Advisories of Daily Weather and Weather Alerts

Weather plays an important role in agricultural production. It has a profound influence on crop growth, development, and yields; on the incidence of pests and diseases; on

water needs; and on fertilizer requirements. Most field crops are dependent solely upon weather to provide life-sustaining water and energy. Adverse weather conditions may lead to production losses, especially if experienced during critical stages of growth. So the advisories of daily weather and weather alerts (heavy rainfall/hail storm/pest-disease attacks) are very useful in agriculture.

- **Kharif Season (Paddy)**

Figure 12 shows that almost all the farmers followed the advisories of daily weather and weather alerts and reported that those were very useful in agriculture to save the crop. The observed benefits of the advisories of the weather alerts are given in Table 28 of the Appendix.

- **Rabi Season (Paddy)**

Figure 12 also revealed that 86% of farmers have followed the advisories of daily weather and weather alerts to save the crop. 89% of farmers observed that advisories are appropriate for the region and agricultural activities in the field. The observed benefits of the advisories of the weather alerts are shown in Table 29 of the Appendix.

The adaptability of weather advisories and alerts can be increased by appropriate, accurate, and timely dissemination of advisories.

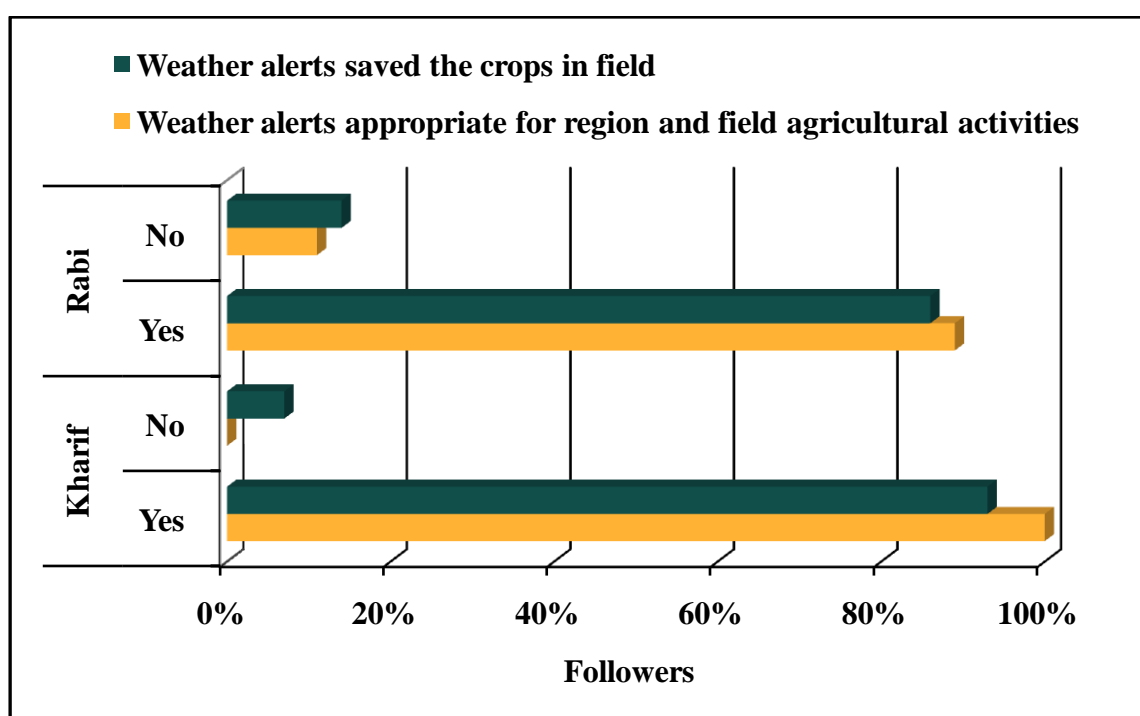


Figure 12 Status of farmer's adaptability for advisories of weather alerts for Paddy crop in the Kharif and Rabi seasons

18. Crop Specific Advisories

The crop-specific advisories cover the advisories specifically applicable for a particular crop. The status of farmer's adaptability for crop-specific advisories of Paddy in the Kharif and Rabi seasons are given in Table 30 of Appendix.

- **Kharif Season (Paddy)**

Table 30 of Appendix revealed that the advisory of nursery preparation followed by 86% of farmers; advisories of the Azolla application, and application of buried green leaves of Gliricidia not followed by most the farmers; advisory of crop geometry of paddy transplanting followed by 83% of farmers; advisory of application of Urea:DAP briquettes followed by 39% of farmers; advisory of silicon spray not followed by 86% of farmers; and advisory of application 00:52:34 and micro-nutrient spray not followed by 65% of farmers.

- **Rabi Season (Paddy)**

Table 30 of the Appendix also revealed that the advisory of nursery preparation followed by 80% of farmers, and the advisory of crop geometry of paddy transplanting followed by most of the farmers. But the advisories of Azolla application, application of buried green leaves of Gliricidia, maintain crop geometry, application of Urea: DAP briquettes, silicon spray, and application 00:52:34 and micro-nutrient not followed by most of the farmers.

The challenges faced by farmers who didn't follow the advisory are lack of awareness of the technologies, its purpose and benefits, unavailability of raw material in the nearby areas and also in the local market. One of the major reason for the lower adaptability of crop-specific advisories of pesticides/insecticides application were due to the effective precautionary measures followed by farmers using non-chemical nature-based solutions which reduced the no infestation of pests and diseases on the crops. Farmers demanded that the advisories of application of chemical pesticides/insecticides should include not only contains details of pesticides/insecticides but also the latest brands names available in markets.

19. Impacts of Agro-Advisories

The agromet advisory services provide a very special kind of inputs to the farmers as advisories that can make a great difference to agriculture production by taking the advantage of benevolent weather and minimizing the adverse impact of malevolent weather. The key impacts of agro-advisories disseminated through the WOTR developed the FarmPrecise mobile App are given below.

- **Kharif Season (Paddy)**

Table 1 revealed that 84% of farmers observed that crop yield is increased by 25% and more by following the crop weather advisories received from the

FarmPrecisemobile application while, 16% observed no change with respect to the average historical crop yield. 89% of farmers observed that the cost of field inputs (like fertilizers, pesticides, insecticides) is decreased by 25% and more after following agro-advisory while, 10% observed no much difference with average historical input cost. The cost of cultivation and labor cost is decreased by 25% and more by following agro-advisory by 84% of farmers, and 13% observed that the cost of cultivation and labor is not decreased much, but it is approximately equal to the average historical cost. Similarly, 86% of farmers observed that irrigation water requirement is decreased up to 25% after following agro-advisory; and 12% observed that irrigation water requirement is not decreased much, but it is approximately equal to average historical requirement.

- **Rabi Season (Paddy)**

Table 1 revealed that 98% of farmers observed that their crop yield is not increased much, but it is approximately equal to the average historical yield. 92% of farmers observed that the cost of field inputs (like fertilizers, pesticides, insecticides) is decreased by 25% and more after following agro-advisory while 8% of farmers observed slight increase in the input cost. The cost of cultivation and labor cost was decreased upto 25% and more after following agro-advisory by 96% of farmers while, 3% of farmers reported slight increase in the const of cultivation and labour. Similarly, 99% of farmers observed that irrigation water requirement is decreased up to 25% after following the agro-advisory.

Table 1 Impact of agromet advisories on crop yield, cost of field inputs, cost of cultivation and labour cost, and irrigation water requirement of Paddy crop in the Kharif season

Advisories	Season	Followers		
Crop yield increased after following agro-advisory	Yield	Yes (Increased by 25%)	Yes, but crop yield near about equal to average historical yield	No
	Kharif	84%	16%	0%
	Rabi	1%	98%	1%
Cost of field inputs (like fertilizers, Pesticides, Insecticides) decreased after following agro-advisory	Input cost	Yes (Decreased by 25%)	Yes, but the cost of field inputs near about equal to historical cost	No
	Kharif	89%	10%	1%
	Rabi	92%	0%	8%
Cost of cultivation and labour cost decreased after following agro-advisory	Labour cost	Yes (Decreased by 25%)	Yes, but the cost of cultivation and labour cost near about equal to historical cost	No
	Kharif	84%	13%	3%
	Rabi	96%	1%	3%
Irrigation water requirement decreased after following agro-advisory	Water Saved	Yes (Decreased up to 25%)	Yes, but irrigation water requirement near about equal to historical cost	No
	Kharif	86%	12%	2%
	Rabi	99%	0%	1%

Source: Farmer's feedback survey data 2020-21

20. Usefulness (Farmers Rating) of e-agro Advisories

The overall usefulness of agro advisories disseminated through the FarmPrecise application was rated by farmers in the spectrum of Very Low, Low, Average, Good, and Very Good. Figure13 revealed the usefulness of agro-advisories disseminated during the Kharif and Rabi seasons. Almost 70-73% of farmers rated the advisories are good to very good, and 27% of farmers rated as average. The usefulness of agro advisories can be increased by capacity building of farmers for appropriate use of agro-advisories, ensuring availability of raw material, improving agro-advisories, increasing the accuracy of the weather forecast, and field demonstration of the preparation of organic formulations and seed treatments. Also, the continued simplifying the user interface of the FarmPrecisemobile application.

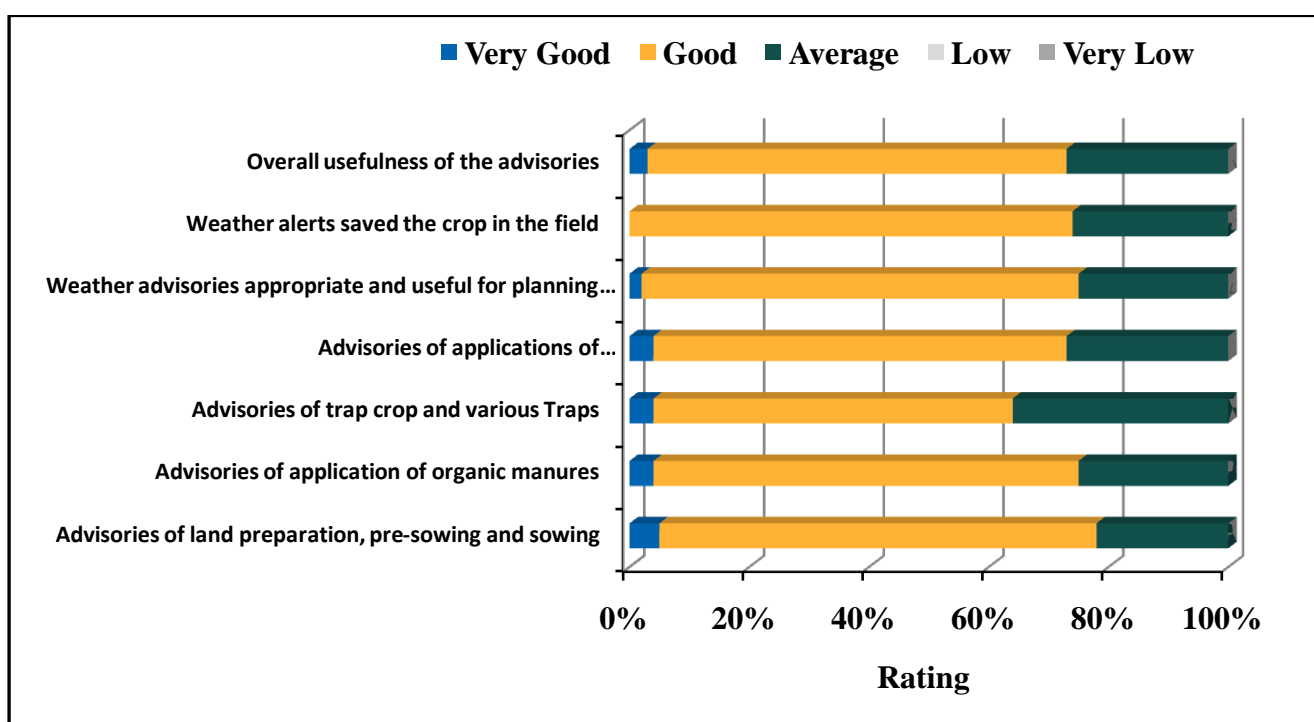


Figure 13 Status of the overall usefulness of advisories of paddy crop

21. Discussion on the Adaptability of Agromet Advisories

In this section, the overall adaptability of advisories in both seasons; difficulties faced by farmers during the use of advisories; and possible ways to increase the adaptability and reduction of difficulties are discussed.

The percentage of the followers of advisory of land preparation (especially ploughing) is higher in Kharif season than in Rabi season. This is due to the farmers doing ploughing or deep ploughing after 2-3 years and preferred to plough in the summer season because before the Kharif season, they get sufficient time for ploughing operation. The percentage of followers of the advisory of harrowing in the Kharif season is approximately similar to the number of followers in the Rabi season. Because most of the farmers avoid ploughing to conserve residue moisture for Rabi season by only performing the harrowing operation to prepare the soil for sowing. Farmers are

interested to know and use of new implements and modern tools and technologies to save both energy and time at the field level. Therefore there is scope to update the advisories of land preparation with short information on new and appropriate machines, implements, tools, and equipment etc. In addition to that, during data collection, farmers demanded that the advisories of land preparation/sowing should include names and short information on modern tools/implements/machines, and technologies to save both energy and time in the field. Therefore in the future, scope to suggest farmers for use of specific implements that saves both energy and time for specific agricultural field operation.

The adaptability of advisory to incorporate organic manures (FYM, Vermicompost, compost) while land preparation is only 60%. The adaptability percentage is lower low due to the insufficient quantity of manures are available at the household, and manures were not ready to apply at the household level. A large group of farmers is willing to purchase organic manures but are not available in the market. Therefore to fulfill the requirement of organic manures locally, there is an opportunity to produce the organic manures commercially. Else, farmers have to develop their capacity to produce a sufficient amount of organic manure (FYM, Vermicompost, compost) to apply in their field. The appropriate number of livestock as per the landholding of the household is required to fulfil the demand of FYM. Green manuring is one of the better options to address the shortage of organic manure. The adaptability of the technique of green manuring can be increased through field training, technology demonstration, and building a network for seed availability locally.

The advisory of seed treatment is follow by most of the farmers. However, to increase the accuracy of proper seed treatment and proper use of ingredients of seed treatment; field demonstrations are necessary, and also need to update the advisory with a short video of the process of seed treatment. There is huge scope to spread the technology throughout the region to increase productivity and reduce the input cost of paddy.

The advisory of crop geometry followed by 90% farmers however, farmers are facing the problem of the availability of machines during sowing or transplanting. Therefore there is an opportunity to make available the machines through custom hiring centres. Else group/communities can purchase the machine with their contribution.

The advisory of trap crop was not followed by most the farmers because almost 85% of farmers were not aware of the technique of trap crop. The adaptability of the technique of trap crops can be increased by knowing the importance of the role of trap crops through field training, technology demonstration, building a network for seed availability, and selection of appropriate trap crops.

The advisory of pheromone trap was followed by 25-40% of the farmers. Because farmers were unaware of the technique, timely availability of lures and traps in the local market and some of them feel that it is easy to use chemical spraying than pheromone trap. Therefore the adaptability of advisory of use of the pheromone trap can be increased by the field demonstration of pheromone trap installation, lure changing, and their benefits over the other techniques. The availability of the trap and lure in the local market also can be increased by the building network with the agriculture service

centre. There is a need to update the advisory of the use of the pheromone traps by the inclusion of short video of installation trap and their benefits.

The advisory of light trap was followed by 10% of farmers. The adaptability of the light trap was very low due to the no idea about the technique and installation procedure, issues of electricity availability in the field, unavailability of material/instrument, and lack of awareness of battery can also be used to operate the trap. The adaptability can be increased through proper training to use a light trap, updated facilities available in the light trap, and increasing the availability in the local market by building a network with the agriculture service centre. Similar to the pheromone trap, there is a need to update the advisory of the use of light traps by the inclusion of short video of installation trap and their benefits.

The advisories of application of Amrutpani and Jeevamruit were followed by 85% of the farmers and they observed increased crop vigor and healthy crop. But only 20% farmers reported that they use Vermiwash spray s to the crops. The adaptability of advisory of Vermiwash spray is very low due to the no proper provision to collect Vermiwash from the Vermi-bed. The importance and easiness to collect Vermiwash can be demonstrated through field training to increase adaptability. There is a need to update the advisory by the inclusion of a short video of standard installation Vermi-beds.

The advisories of bio-pesticides (Dashparni ark/NSKE/Neemark) were followed by 10% of farmers only. Because farmers were not aware of technology, the raw material was not available to prepare, and readily not available in the market. Therefore to increase the adaptability of the use of bio-pesticides; there is a need to increase the awareness and method of preparation through in-house and field training. To increase the availability in the local market, there is a need to identify the opportunity of commercial business by local preparation of bio-pesticides. The availability of raw material at the household can be done by growing the plants on field borders. There is a need to update the advisory by the inclusion of a short video of preparation of Dashparni ark/ NSKE/ Neemark.

The irrigation advisories were followed by almost 85% of the farmers. They observed good crop growth and saved the irrigation water. But some farmers didn't follow the advisories because they observed that there was sufficient moisture in their field, and some are busy with other works. The adaptability of irrigation advisory can be increased by knowing the importance of the timely and appropriate amount of application of water, and their effect on crop production and productivity through in-house training, field demonstration, and use of efficient irrigation methods. The irrigation advisories need to be updated for water application through modern technologies (drip and sprinkler). Therefore there is a need to develop the mechanism of generation of irrigation advisories in the FarmPrecise application.

The advisories of application of a recommended dose of chemical fertilizer were followed by most of the farmers, out-off which about 50% of farmers were following the split-dose application. The adaptability of split-dose application can be increased by disseminating the benefits of the split-dose application and how farmers can save the fertilizers and increase crop production through the split-dose application through in-house training and farmer's field demonstration.

About 30% farmers have used the fertiliser calculator tool provided in the FarmPrecise app of farmers out of which 20% of farmers reported that they could save the input cost on fertilizers. Therefore adaptability can be increased by developing a user-friendly interface of fertilizer calculator, knowing how to use the fertilizer calculator, and the benefits of proper use through training.

The advisories of daily weather and weather alerts were followed by most of the farmers. The adaptability of weather advisories is very encouraging, and there is a scope to increase the accuracy spatially.

The key impacts of the advisories disseminated through the FarmPrecisemobile application are: observed that crop yield of almost 85-95% of the farmer's by 25%, expenditure on field inputs (e.g. fertilizers, Pesticides, Insecticides) decreased by 25%, cost of cultivation and labor cost could be saved by 25% and irrigation water saved up to 25%. Every FarmPrecise user/farmer got benefited atleast by an increase in crop yield or reduction in the cost of field inputs or reduction in the cost of cultivation and labor cost or saving of irrigation water. The impacts are encouraging, and there is scope to increase productivity and production by reducing the inputs and input cost to a greater extent.

The scaling/rating of the overall usefulness of e-agro advisories disseminated through the FarmPrecise application revealed that 5% of the farmers observed advisories are very good, 55% of the farmers observed advisories are good, 38% of the farmers observed advisories are average, and 2% of the farmers observed advisories are low useful.

The study revealed that the advisories and media of dissemination both need to be updated timely. The appropriate use of technologies and advisories are key factors to increase the adaptability, benefits, and resilience to climate change. The crops specific strategies need to be developed to increase the adaptability of climate-resilient techniques and followers of agro-advisories. Also strictly implementation of in-house training, field training, and field demonstration of technologies through demo plots and farmers plots. Periodically/seasonally training for the field staff to update their knowledge, familiar with new climate-resilient techniques, and interaction session with internal and external experts builds their capacities.

22. Remarks

In lieu of changing climate, the study on e-agromet advisories feedback helped us to cater and provide the agromet advisories with more actionable information for farmers. The study revealed that the advisories need to be updated timely with less technical language, and simple user-friendly interface for dissemination. The appropriate use of technologies and advisories are key factors to increase the adaptability, benefits, and building resilience to climate change. Therefore the continuous capacity building program for not only farmers but also the technical staff is very much essential. The village/community level training to demonstrate the climate-resilient agricultural (CRA) practices conveyed through advisories will help to increase the adaptability and build confidence among recipients. In addition to this, the crops specific strategies need to be developed to increase the adaptability of climate-resilient techniques, and hands-on

training of the FarmPrecise app is needed to boost app usage. The detailed remarks on observed benefits of climate resilient advisories, and farmer's feedback, and future demands are given below.

Particular	Remark
Observed Benefits and incitement	<ul style="list-style-type: none"> • Agromet advisories disseminated through the FarmPrecisemobile app helped farmers to increase their knowledge about CRA farming practices, reduce the input cost and increase the net profit. • FarmPrecise users/farmers got benefited atleast by an increase in crop yield or reduction in the cost of field inputs or reduction in the cost of cultivation and labor cost or saving of irrigation water. • Farmers rated the highest utilities of advisories for management of crops under aberrant weather conditions followed by advice made for plant protection. • Farmer's rating in respect of advisories of land preparation, plant protection, use of organic manures and chemical fertilizers, seed treatment, and crop geometry were found quite encouraging. Also, the overall utility of the advisories rated by the respondents is also very inspirational. However, all agromet advisories need to be updated with not only their appropriate use but also the exact benefits.
Advisories of land preparation and Sowing	<ul style="list-style-type: none"> • On farmer demand, the advisories of land preparation need to be updated with new mechanization techniques to reduce the cost of cultivation, and new machines/implements/tools for harvesting and sowing seeds to save both energy and time. • However, to resolve the issues of availability of machines during the time period of sowing/transplanting to follow the advisories of crop geometry, there is an opportunity to make availability of the machines commercially like custom hiring centres else group/community people can purchase the machines.
Advisories of application of Bio/ Organic inputs	<ul style="list-style-type: none"> • The advisories of application of organic manures and bio-pesticides need to be updated with a short video of their preparation at household, and similarly the advisories of use insect trap updated with video of their proper installation in the field. • Needs to train/re-train the farmers for the preparation of bio/organic inputs (e.g. Vermicompost, Compost, Green manure, Amrutpani, Jeevamruit, Vermiwash, Dashparni ark/NSKE/Neemark) to increase uptake and appropriate use to reduce the input cost. Besides, there is great scope to make availability of bio-inputs locally through commercial production. • To fulfill the demand for organic manures locally, there is a need to produce the organic manures individually or commercially. Also, the current practice of green manuring is also one of the

	<p>better options to overcome the shortage of organic inputs, and to reduce input cost.</p>
Advisories of application of inorganic/chemical inputs	<ul style="list-style-type: none"> On farmer's demand, the advisories of use of chemical fertilizers/pesticides/insecticides need to be updated additionally with information of their latest brands available in markets. For better uptake, fertilizer calculator tool in the FarmPrecisemobile application needs a user-friendly interface for information on selection of better fertilizer mixtures and soil nutrient management.
Advisories of application of irrigation	<ul style="list-style-type: none"> On farmer's demand, the irrigation advisories need to explore especially during times of shortage of water supply. Also, need to be updated for water application through modern methods/technologies (drip and sprinkler).
Capacity building of farmers and staff	<ul style="list-style-type: none"> Frequent village/community level training for both male and female farmers to help them better interpret and use agromet-advisories. It will reduce the knowledge gap across the farmers and gender. Seasonally interactive region and crop-specific trainings, Farmers Field School (FFS) for discussions on agro-advisories and hands-on mobile application (FarmPrecisemobile app) for capacity building of farmers. Periodically training for the field staff to update their knowledge, familiar with new climate-resilient techniques, and interaction session with internal and external experts builds their capacities.
Field demonstration	<ul style="list-style-type: none"> The strict implementation of in-house training, field training, and field demonstration climate-resilient agricultural technologies and practices through selective farmer field plots to improve the overall adaptability and build resilience to climate change.
Language	<ul style="list-style-type: none"> Use of less technical and regional languages in advisories for easy interpretation.
Network	<ul style="list-style-type: none"> In some areas, farmers sometimes face difficulties due to poor networks so it would be great if the FarmPrecise mobile app can be operated in low network connectivity as well as in offline mode with a simple user interface.
Linkages	<ul style="list-style-type: none"> For better adaptability, climate-resilient advisories/practices need to develop a linkage between demand and supply of agricultural inputs in the local market (agricultural service centre).
Awareness	<ul style="list-style-type: none"> To enable farmers to adopt climate-resilient agriculture technologies, the very important step required is to make them aware of future risks of climate change.

23. Conclusions

Agromet advisories provide basic, timely, and accurate pre-information of different climate and weather conditions of different crops. But still there exist considerable knowledge gaps in understanding climate vulnerability and suitable ways to build resilience and adaptability. There is a need to improve agromet advisories into more actionable information for farmers. Based on the current study, the major conclusions derived are as follows.

1. FarmPrecise mobile App is effective way to disseminate agromet advisories and build resilience to climate change.
2. The crop weather advisories helped farmers to increase their knowledge about farming practices including modern technologies and good practices. They are able to reduce the input cost and increase the net profit for the paddy crop.
3. The community level capacity building is required to increase the adaptability of appropriate nature-friendly solutions. Dissemination with small videos on the good practices will greatly benefit the use of FarmPrecise.
4. Village/community level hands-on trainings of how to use the mobile app will be helpful to farmers.
5. Challenges of poor networks need to be addressed. If the mobile app can be operated in low network connectivity as well as in offline mode with a simple user interface, it will benefit many users.
6. Communicating the messages in colloquial language will have a greater uptake.
7. There is need to explore the irrigation advisories especially during times of shortage of water supply and the same have to be updated for water application through modern methods/technologies (drip and sprinkler).
8. For better uptake of fertilizer calculator tool in the FarmPrecise mobile application needs to develop a user-friendly interface.
9. To enable farmers to adopt climate-resilient agriculture technologies, the very important step required is to make them aware of future risks of climate change, it will help them prepare their mind-set to deal with climate change and respond in adverse situations. Ultimately uptake of the FarmPrecisemobile application will improve.

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Appendix

Table 2 Farmer's feedback on the adaptability of advisory of land preparation for Paddy crop in the Kharif season

Advisory of land preparation (Ploughing)			
Following		Non-following	
Feedback	Percentage	Feedback	Percentage
Done with draft animal	17%	Increasing cost of production	0%
Done with tractor	83%	Unavailability of tractor / draft animals	0%
Good germination of seeds	78%	Deep Ploughing is done last year so not needed now	0%
Good control of weeds	82%	Deep ploughing reduces fertility of soil	0%
Partial control of weeds	18%	It is time consuming	0%
Control of soil born pests and soil born diseases	0%	No need of deep ploughing	0%
Partial control of pests and soil born diseases	0%	Other	0%
No control of pests and soil born diseases	0%		
Other	0%		

Source: Farmer's feedback survey data 2020-21

Table 3 Farmer's feedback on the adaptability of advisory of land preparation for Paddy crop in the Rabi season

Advisory of land preparation (Ploughing)			
Following		Non-following	
Feedback	Percentage	Feedback	Percentage
Done with draft animal	11%	Increasing cost of production	16%
Done with tractor	73%	Unavailability of tractor / draft animals	0%
Good germination of seeds	0%	Deep Ploughing is done last year so not needed now	16%
Good control of weeds	62%	Deep ploughing reduces fertility of soil	0%
Partial control of weeds	22%	It is time consuming	0%
Control of soil born pests and soil born diseases	0%	No need of deep ploughing	0%
Partial control of pests and soil born diseases	0%	Other	0%
No control of pests and soil born diseases	0%		
Other	0%		

Source: Farmer's feedback survey data 2020-21

Table 4 Farmer's feedback on the adaptability of advisory of use of organic manures for Paddy crop in the Kharif season

Feedbacks of non-followers of advisory of use of organic manures									
Incorporated organic manures (FYM, Vermicompost, compost) while land preparation	It is costly	I don't think it is needed	I don't use any organic manure	Last year applied to this plot	Not in sufficient quantity and applied to other crops	Organic manure was not available in market	Organic manure was not ready	Raw material was not available at home	Other
	18%	5%	25%	3%	19%	29%	34%	34%	0%

Source: Farmer's feedback survey data 2020-21

Table 5 Farmer's feedback on the adaptability of advisory of use of organic manures for Paddy crop in the Rabi season

Feedbacks of non-followers advisory of use of organic manures								
Incorporated organic manures (FYM, Vermicompost, compost) while land preparation	I don't think it is needed	I don't use any organic manure	Last year applied to this plot	Not in sufficient quantity and applied to other crops	Organic manure was not available in market	Organic manure was not ready	Raw material was not available at home	Other
	2%	9%	18%	1%	5%	17%	13%	0%

Source: Farmer's feedback survey data 2020-21

Table 6 Farmer's feedback on the adaptability of advisory of seed treatment for Paddy crop in the Kharif season

Advisory of seed treatment			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Good Germination	60%	It is time consuming	1%
Healthy seedlings and uniform growth	75%	No idea about seed treatment	1%
Partial Germination	40%	Not availability of seed treatment material	1%
Prevented disease infestation on seedlings	62%	It was not needed	1%
Prevented pest attack on seedlings	70%	Observed disease infestation on Seedling	1%
Other	0%	Observed pest attack on Seedling	1%
		Sowing of seeds due to sudden rainfall (appropriate sowing condition)	1%
		No need of seed treatment	0%
		Increases cost of production	0%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 7 Farmer's feedback on the adaptability of advisory of crop geometry for Paddy crop in the Kharif season

Advisory of crop geometry			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Healthy crop	79%	It is costly	2%
Increased sustainability in strong winds	74%	Not needed	1%
Increased vegetation, number of tillers, branches	81%	Does not have time for it	7%
Does not observed any specific change	6%	It is time consuming	9%
Due to proper spacing intercultural operations can do easily	43%	Due unavailability of the machines/ labours	12%
Reduced/prevent attach of pests and diseases infestation	69%	Other	0%
Reduced seed rate	73%		
Other	0%		

Source: Farmer's feedback survey data 2020-21

Table 8 Farmer's feedback on the adaptability of advisory of seed treatment for Paddy crop in the Rabi season

Advisory of seed treatment is followed			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Good Germination	62%	It is time consuming	2%
Healthy seedlings and uniform growth	88%	No idea about seed treatment	3%
Partial Germination	7%	No need of seed treatment	2%
Prevented disease infestation on seedlings	44%	Observed disease infestation on Seedling	1%
Prevented pest attack on seedlings	64%	Sowing of seeds due to sudden rainfall (appropriate sowing condition)	1%
Other	0%	No need of seed treatment	0%
		Increases cost of production	0%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 9 Farmer's feedback on the adaptability of advisory of crop geometry for Paddy crop in the Rabi season

Advisory of crop geometry			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Healthy crop	22.0%	It is costly	0%
Increased sustainability in strong winds	16.7%	Not needed	0%

Advisory of crop geometry			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Increased vegetation, number of tillers, branches	24.7%	Does not have time for it	0%
Does not observed any specific change	0.5%	It is time consuming	1%
Due to proper spacing intercultural operations can do easily	9.6%	Due unavailability of the machines/ labours	0%
Reduced/prevent attach of pests and diseases infestation	10.4%	Other	0%
Reduced seed rate	16.2%		
Other	0%		

Source: Farmer's feedback survey data 2020-21

Table 10 Farmer's feedback on the adaptability of advisory of trap crop for Paddy in the Kharif season

Advisory of trap crop			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
To prevent pest attack on main crop	1%	It attracts pest and increased incidence of pest than natural enemies	2%
To prevent pest attack on main crop	0%	It creates shadow for main crop	6%
To get additional income	0%	Difficulty in growing of trap crop	1%
No effect of trap crop	0%	No idea about trap crops	92%
Satisfactory pest reduction	0%	Increasing cost of production	1%
Partial pest reduction	0%	It is not needed	7%
Other	0%	It reduces the area under main crop	1%
		It requires extra time and efforts	2%
		Trap crop seed not available	2%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 11 Farmer's feedback on the adaptability of advisory of inter-cropping for Paddy in the Kharif season

Advisory of inter-cropping			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Increased total income	17%	Difficulty in intercultural operations	5%
If one crop fails there is income from second crop	22%	No idea about intercropping	49%
Reduced cost of production	20%	Increased competition for water and nutrient between main and inter crop	4%

Reduced pest and diseases attack than mono cropping	2%	Increasing cost of production due to labour and other inputs	6%
Wish same fertilizer dose we get two crops	20%	Intercropping reduces yield of main crop	2%
Other	0%	Does not have time for it	6%
		Not needed	6%
		It requires extra time and efforts	4%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 12 Farmer's feedback on the adaptability of advisory of trap crop for Paddy in the Rabi season

Advisory of trap crop			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
To get additional income	18%	It attracts pest and increased incidence of pest than natural enemies	9%
To know the attack of pest	8%	Difficulty in growing of trap crop	24%
To prevent pest attack on main crop	18%	No idea about trap crops	78%
Partial pest reduction	9%	Increasing cost of production	16%
Satisfactory pest reduction	11%	It is not needed	3%
Other	0%	It reduces the area under main crop	3%
		It requires extra time and efforts	11%
		Trap crop seed not available	39%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 13 Farmer's feedback on the adaptability of advisory of inter-cropping for Paddy in the Rabi season

Advisory of inter-cropping			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Increased total income	35%	Difficulty in intercultural operations	24%
If one crop fails there is income from second crop	23%	No idea about intercropping	33%
Reduced cost of production	8%	Increased competition for water and nutrient between main and inter crop	18%
Reduced pest and diseases attack than mono cropping	2%	Increasing cost of production due to labour and other inputs	5%
Does not require additional pest control	5%	Intercropping reduces yield of main crop	21%

Wish same fertilizer dose we get two crops	29%	Does not have time for it	5%
Other	0%	Not needed	21%
		It requires extra time and efforts	5%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 14 Farmer's feedback on the adaptability of advisory of use of Pheromone trap for Paddy crop in the Kharif season

Advisory of pheromone trap followed			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Helped in identifying ETL level of pest attack	31%	No idea about the technique and Installation	20%
Reduces the cost of pesticides application	43%	It is costly	11%
Trapping other adult/moths instead of required adult/moths	28%	None availability of lures & trap	3%
Other	0%	Easy to use chemical spraying than this	15%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 15 Farmer's feedback on the adaptability of advisory of use of Light trap for Paddy crop in the Kharif season

Advisory of light trap			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Killed both beneficial and harmful pests	7%	Don't know to that battery can also be used	2%
Partial control of pests	1%	Due to night time operation it is not followed	26%
Reduced cost on pesticides application	4%	Electricity not available at field	31%
Partial control of pests	1%	No idea about the technique and Installation	30%
Other	0%	Unavailability of material/instrument	59%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 16 Farmer's feedback on the adaptability of advisory of use of Pheromone trap for Paddy crop in the Rabi season

Advisory of pheromone trap			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Helped in identifying ETL level of pest attack	20%	No idea about the technique and Installation	59%
Reduces the cost of pesticides application	31%	It is costly	16%
Trapping other adult/moths instead of required adult/moths	21%	None availability of lures & trap	7%
Other	0%	Easy to use chemical spraying than this	3%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 17 Farmer's feedback on the adaptability of advisory of use of Light trap for Paddy crop in the Rabi season

Advisory of light trap			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Killed both beneficial and harmful pests	4%	Don't know to that battery can also be used	34%
Partial control of pests	7%	Due to night time operation it is not followed	16%
Reduced cost on pesticides application	12%	Electricity not available at field	17%
Reduced pest attack in field	4%	No idea about the technique and Installation	75%
Other	0%	Unavailability of material/instrument	3%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 18 Farmer's feedback on the adaptability of advisories of Amrutpani and Jeevamruit application for Paddy crop in the Kharif season

Advisory of Amrutpani and Jeevamruit application			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Enhance flowering and increased size of fruits/pods	31%	No idea about preparation methods	1%
Increase earthworms in soil	2%	Not available in market	1%
Increasing number of natural enemies	8%	It requires extra time and efforts	1%
Increasing soil fertility and productivity	41%	Unavailability of ingredients and raw material	3%

Increased vigour growth/health of crop/ crop canopy	68%	Increasing cost of production	0%
Increased water holding capacity	30%	Labour was not available	0%
No additional benefit	1%	Non availability of operational equipment	0%
Reduced chemical fertilizer doses	53%	Not available in market	0%
Other	0%	Other	0%

Source: Farmer's feedback survey data 2020-21

Table 19 Farmer's feedback on the adaptability of advisories of Amrutpani and Jeevamruit application for Paddy crop in the Rabi season

Advisory of Amrutpani and Jeevamruit application			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Enhance flowering and increased size of fruits/pods	24%	Increasing cost of production	2%
Increase earthworms in soil	15%	Labour was not available	1%
Increasing number of natural enemies	9%	No idea about preparation methods	19%
Increasing soil fertility and productivity	6%	Non availability of operational equipment	1%
Increased vigour growth/health of crop/ crop canopy	50%	Not available in market	16%
Increased water holding capacity	32%	It requires extra time and efforts	2%
No additional benefit	1%	Unavailability of ingredients and raw material	25%
Reduced chemical fertilizer doses	57%	No idea about preparation methods	0%
Other	0%	Other	0%

Source: Farmer's feedback survey data 2020-21

Table 20 Farmer's feedback on the adaptability of advisories of use of Bio-pesticides for Paddy crop in the Kharif season

Advisory of bio-pesticides (Dashparni ark/NSKE/Neemark)			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Reduced no. of chemical sprays	12%	Increases the cost of production	6%
Reduction of pest population	12%	It is time consuming	10%
Saved cost on chemical spraying	5%	No idea about technology	69%
Other	0%	Not available in the market	6%
		Not effective in controlling pests	2%
		Raw material was not available to prepare it	9%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 21 Farmer's feedback on the adaptability of advisories of use of Bio-pesticides for Paddy crop in the Rabi season

Advisory of bio-pesticides (Dashparni ark/NSKE/Neemark)			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Reduced no. of chemical sprays	8%	Increases the cost of production	19%
Reduction of pest population	8%	It is time consuming	18%
Saved cost on chemical spraying	1%	No idea about technology	57%
Other	0%	Not available in the market	28%
		Not effective in controlling pests	7%
		Raw material was not available to prepare it	50%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 22 Farmer's feedback on the adaptability of advisories to apply irrigation for Paddy crop in the Kharif season

Advisory of Irrigation			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Crop saved due to life saving irrigation	15%	Already irrigated the crop	2%
Disease and pest control	33%	Issue of electricity supply	1%
Good crop growth	48%	Lack or faulty irrigation infrastructure	1%
Saved the irrigation water	53%	Not followed due to other work	2%
Other	0%	There was Sufficient soil moisture in the field	5%
		Water scarcity and unavailability of irrigation water	1%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 23 Farmer's feedback on the adaptability of advisories to apply irrigation for Paddy crop in the Rabi season

Advisory of Irrigation			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Crop saved due to life saving irrigation	35%	Already irrigated the crop	2%
Disease and pest control	20%	Crop already dried	2%
Good crop growth	53%	Lack or faulty irrigation infrastructure	3%
Saved the irrigation water	57%	Not followed due to other work	18%

Other	0%	There was Sufficient soil moisture in the field	6%
		Water scarcity and unavailability of irrigation water	1%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 24 Farmer's feedback on the adaptability of advisories to apply recommended dose of chemical fertilizers for Paddy crop in the Kharif season

Recommended dose of chemical fertilizer followed for the selected crop			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
-	0%	Due to continuous rainfall not able to apply the dose	3%
		It is costly	1%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 25 Farmer's feedback on the adaptability of advisories to use chemical pesticides for Paddy crop in the Kharif season

Used chemical pesticides to control the pest/disease infestation			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Pest/ disease infestation is controlled significantly	8%	Crop is healthy	42%
Control the pest/disease in some amount	39%	There is no infestation of pests/ diseases	39%
Not controlled the pest/ disease infestation	5%	Crop is about to die	0%
Maturity period is extended	12%	Suggested pesticide was not available	21%
Other	0%	Water was not readily available on field for spraying	0%
		It is Costly	19%
		I don't spray any chemicals	16%
		Can't take spray due to continuous rain	0%
		Labour was not available	0%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 26 Farmer's feedback on the adaptability of advisories to apply recommended dose of chemical fertilizers for Paddy crop in the Rabi season

Advisory of recommended dose of chemical fertilizers for the selected crop			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
-	-	Due to continuous rainfall not able to apply the dose	15%
		It is costly	6%
		Not available in market	1%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 27 Farmer's feedback on the adaptability of advisories to use chemical pesticides for Paddy crop in the Rabi season

Advisory of use of chemical pesticides to control the pest/disease infestation			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
Pest/ disease infestation is controlled significantly	14%	Crop is healthy	47%
Control the pest/ disease in some amount	31%	There is no infestation of pests/ diseases	33%
Not controlled the pest/ disease infestation	7%	Crop is about to die.	7%
Maturity period is extended	6%	Suggested pesticide was not available	17%
Other	0%	Water was not readily available on field for spraying	10%
		It is Costly	16%
		I don't spray any chemicals	15%
		Can't take spray due to continuous rain	6%
		Labour was not available	0%
		Other	0%

Source: Farmer's feedback survey data 2020-21

Table 28 Farmer's feedback on the adaptability of advisories of weather alerts for Paddy crop in the Kharif season

Advisory of weather alerts (Heavy rainfall/ hail storm/pest-disease attacks) for agricultural activities in the field to save the crops			
Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
50 % crop yield obtained	4%	Crop was already harvested	2%
Atleast 50 % crop saved	10%	Not followed due to other work	5%
Average crop yield obtained	69%	Increases the cost of production	0%
Complete crop saved	13%	Instantly material was not	0%

		available	
Disease and pest controlled significantly	8%	Not followed due to other work	0%
Average crop yield obtained	0%	Labour was not available	0%
Crop failed completely	0%	Other	0%
Other	0%		

Source: Farmer's feedback survey data 2020-21

Table 29 Farmer's feedback on the adaptability of advisories of weather alerts for Paddy crop in the Rabi season

Advisory of weather alerts (Heavy rainfall/ hail storm/pest-disease attacks) for agricultural activities in the field to save the crops

Followers		Non-followers	
Feedback	Percentage	Feedback	Percentage
50 % crop yield obtained	2%	Crop was already harvested	1%
Atleast 50 % crop saved	8%	Increases the cost of production	1%
Average crop yield obtained	25%	Instantly material was not available	10%
Complete crop saved	55%	Labour was not available	3%
Crop failed completely	1%	Not followed due to other work	14%
Disease and pest controlled significantly	10%	Other	0%
Other	0%		

Source: Farmer's feedback survey data 2020-21

Table 30 Status of farmers' the adaptability for crop-specific advisories of Paddy for Kharif and Rabi seasons

Advisories	Followers			
	Kharif		Rabi	
	Yes	No	Yes	No
Advisory of nursery preparation	86%	14%	80%	20%
Advisory of Azolla application	3%	97%	3%	97%
Advisory of application of buried green leaves of Glyricidia @3tones/ha during puddling	1%	99%	1%	99%
Advisory of Paddy transplanting at 20 x 20 cm or 25 x 25 cm	83%	17%	99%	1%
Advisory of application of Urea:DAP briquettes	39%	61%	2%	98%
Advisory of silicon spray @ 1-2 gram or 1-3 ml/liter of water	14%	86%	5%	95%
Advisory of spray of 00:52:34 @70 G, Multi Micro-Nutrients @50 G and Silicon @15 ml in 15 liters of water at Panicle Emergence Stage	35%	65%	8%	92%

Source: Farmer's feedback survey data 2020-21



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