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Predicting adoption of agricultural technologies in Indo-Gangetic Region

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ABSTRACT

Present study aims to find out how the technological interventions performed under the Farmer FIRST programme by assessing the peak adoption level and time taken to attain it. ADOPT tool was used to assess the impact of the technological interventions. Thirty farmers who have participated in the programme implemented at Haryana, India, were interviewed during 2021 to elicit data pertaining to the year 2016–21 and the modal value of their responses were used as input in the ADOPT model to estimate the parameters of interest. The results showed that the extent of peak adoption level is high for interventions related to cereal crops and animal components while the time taken to reach peak adoption level is also low indicating that the advisory system for these commodities have borne good results and this calls for streamlining the advisory system for horticultural crops to achieve the desired output from these enterprises as well.

Keywords: Adoption, ADOPT, Learnability, Scalability, Technologies, Trialability

Application of improved technologies in agriculture played significant role in eradicating poverty, reducing production costs and hunger, and enhancing rural household income (Kassie *et al.* 2011). Farmer FIRST (Farm Innovation Resources Science and Technology) (FFP) is an ICAR frontline extension programme, being implemented in many states of India. Present study was carried out at Haryana which is one of the FFP centres representing Indo Gangetic plains (IGP) where rice-wheat cropping system dominates. There are serious problems in agriculture (IGP) like lack of farm diversification, food insecurity, declining soil fertility, development hard soil pan, adverse soil structure problems and low crop productivity, monocropping, and crop yield instability (Sekar and Pal 2012, Chandra *et al.* 2020). FFP aims towards creating and sustaining a dynamic farmers-scientists interface for developing system-specific livelihood interventions through technology assemblage, application and feedback, which is achieved through partnership and institution building along with content mobilization (Kokate and Singh 2013) to alleviate the problems.

Scaling up is a proven approach for distribution of benefits of agricultural technology over a wider geographic area more quickly, more equitably and more lastingly (Menter *et al.* 2004, Hartmann and Linn 2008). A number of frameworks and approaches has been developed for scaling up of agricultural technologies, focusing on the issues in the adoption of technologies, viz. conventional top-down technology-dissemination approach (Biggs 1990), innovation platforms (Posthumus and Wongtschowski 2014), planned comparisons (Coe *et al.* 2017), contextually-appropriate interventions (Sola *et al.* 2017) and insurance approach (Sulaiman *et al.* 2018), and still there is a need for simpler approaches.

Adoption and Diffusion Outcome Prediction Tool (ADOPT) model developed by Commonwealth Scientific and Industrial Research Organization (CSIRO) enables the researchers to predict the peak adoption level and time taken to attain peak adoption level (Kuehne *et al.* 2017). This research paper highlights on the use of ADOPT to assess the impact of the "technology assemblage" interventions made under FFP in Haryana. We examined the level of adoption of technology modules under FFP interventions along with the issues that control their adoption at the farmer's level over a period of time.

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MATERIALS AND METHODS

Locale of study and technology modules: Present study was carried out in the three Farmer FIRST villages - Amarpur, Dadhota and Katesra of Palwal district in Haryana state, to assess the scalability of six proven technology module interventions involving vegetables and legumes. The first technology module was introduction of high yielding variety of Bottle Gourd, Pusa Santushti (Behera *et al.* 2015), which fetched an average yield of 171.50 q/ha with a net returns of ₹1.00 lakh/ha. The second technology intervention module was high yielding variety of Carrot Pusa Rudhira, released by IARI, New Delhi, which outperformed existing varieties in terms of about 8 q/ha higher yield and 11% more net return (Singh *et al.* 2018). The third intervention taken into account was the introduction of high yielding and black rot disease resistant vegetable leafy Mustard variety (Pusa Sag-1), which yielded significantly higher than popular varieties (Rathaur *et al.* 2016). Another intervention was the selection of high yielding paddy variety, PB-1637, which recorded the yield of 40.7 q/ha, with a net returns 0.87 lakh ₹/ha (Sharma *et al.* 2020). Likewise, the interventions on wheat with the introduction of varieties namely HD-3086, which recorded yield of 52.65N q/ha (Kirandeep *et al.* 2020) was also considered for prediction. In the animal husbandry component one of the promising technological interventions namely, supplementation of mineral mixture in cows and buffaloes, which is proven to be an immunity booster, improving cellular and other productive and reproductive functions in animal system, resulting in increased milk production (Gupta *et al.* 2017) was included.

ADOPT Model: The model was used to estimate the extent and time taken to attain peak adoption level helps in evaluating and predicting the likely level of adoption and diffusion of specific agricultural technologies, with a particular target population. The framework and model is based upon the work of Kuehne *et al.* (2017). The ADOPT framework is built on two key factors influencing the adoption process i.e. the relative advantage of the technology (Rogers 2003) and effectiveness of the process through which the farmers learn about the technology (Ghadim and Pannell 1999). The variables related to relative advantage and learning process are plotted across innovation and population dimensions to generate an adoption matrix (Fig 1).

The adoption-matrix (Fig 1) indicates how various population and innovation factors interact with relative advantage and learning process elements in four dimensions – (i) population-specific influences that determine the ability to understand the technology; (ii) learnability characteristics of the technology; (iii) relative advantage derived from application of technology for a specific population and (iv) relative advantage of the technology per se. Past studies on technology adoption indicated that first two learning dimensions of the matrix had positive influence on the time taken to reach the peak of adoption (Marsh *et al.* 2000, Leung *et al.* 2009, Straub 2009, Munguia and Llewellyn 2020). A research conducted in a high risk business-to-business environment, the trialability of the technology was found to

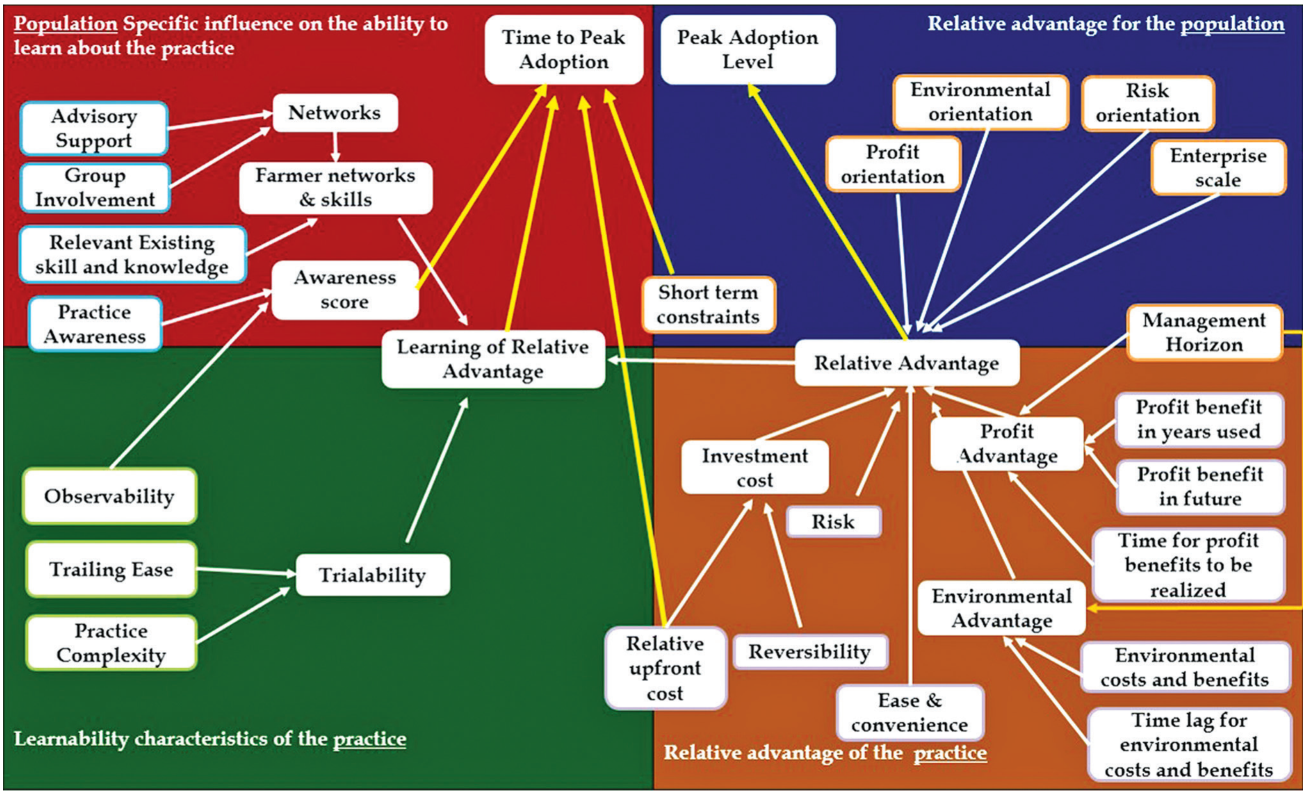

Fig 1 Adoption Matrix.

be a necessary condition for translation of adaptor's intent to actual adoption and a strong determinant of time taken for adoption (Banerjee *et al.* 2012).

The third and fourth "relative advantage" dimensions-relative advantage for the population as well as the relative advantage of the practice, directly influences the peak level of adoption through other factors (Marsh *et al.* 2000, Baumgart-Getz *et al.* 2012, Munguia and Llewellyn, 2020). While the "relative advantage to the practice" is determined by four factors, i.e. profit advantage (Griliches 1957), environmental advantage (Munguia and Llewellyn 2020), ease of convenience (Piggott and Marra 2008), risks involved and all of them together influence relative advantage of the technology.

The data were collected through a structured survey schedule from 30 farmer-partners of FFP selected randomly. These respondents were provided with twenty-two questions measuring the variables under ADOPT dimension pertaining to adoption of specific technology module implemented under FFP in Haryana. The collected data were analysed using online version of ADOPT tool inputting the modal values of the responses.

RESULTS AND DISCUSSION

The respondents rating of six technology modules across 22 ADOPT variable, which were found to perform well at various centres of FFP, given in Table 1. While the top five technologies were pertaining to crop based system, the last intervention is pertaining to livestock. Higher weightage was assigned for variables like local village/community costs and benefits; income/productivity benefit in years that it is used and future income/productivity benefit.

The table also reveals low level of variations in the responses which indicates that all these technologies were preferred by the farmers. The average respondent scores exceeded over 60% for 18 aspects of ADOPT model,

Table 1 Responses in numeric value on the six practices

ADOPT variable	Range of scale	Responses (ADOPT model inputs)*							
		P1	P2	P3	P4	P5	P6	Mean	CV%
Relative advantage for the population									
Income/ productivity orientation	1-5	4	4	4	5	5	4	4.33	12
Local community benefit orientation	1-5	3	2	3	4	4	5	3.50	30
Risk orientation	1-5	3	3	5	4	4	4	3.83	20
Enterprise scale	1-5	2	2	3	4	4	5	3.33	36
Management horizon	1-5	4	4	3	4	4	3	3.67	14
Short term constraints	1-5	3	3	3	4	4	3	3.33	15
Learnability characteristics of the intervention									
Trialable	1-5	4	4	4	5	5	4	4.33	12
Innovation complexity	1-5	3	3	3	4	4	3	3.33	15
Observability	1-5	2	3	2	4	4	2	2.83	35
Learnability of the population									
Advisory support	1-5	4	4	4	5	5	4	4.33	12
Group involvement	1-5	3	3	3	4	4	3	3.33	15
Relevant existing skills and knowledge	1-5	4	3	3	4	4	4	3.67	14
Innovation awareness	1-5	2	2	4	3	3	5	3.17	37
Relative advantage of the innovation									
Relative upfront cost of innovation	1-5	3	4	4	4	3	4	3.67	14
Reversibility of innovation	1-5	1	2	2	3	3	4	2.50	42
Income/productivity benefit in years that it is used	1-8	7	7	6	8	7	7	7.00	9
Future income/ productivity benefit	1-8	6	7	7	7	6	6	6.50	8
Time until any future income/ productivity benefits are likely to be realised	1-6	5	3	5	4	4	4	4.17	18
Local village/ community costs and benefits	1-8	8	5	6	6	8	7	6.67	18
Time to local village/community benefit	1-6	3	3	3	4	4	2	3.17	24
Risk exposure	1-8	2	4	3	3	5	4	3.50	30
Ease and convenience	1-8	3	7	4	6	6	7	5.50	30

*P1, Bottle Gourd variety Pusa Santushti; P2, Carrot variety Pusa Rudhira; P3, Leafy Mustard variety Pusa Sag-1; P4, Paddy variety PB-1637; P5, Wheat variety-HD-3086; P6, Supplementation of Mineral Mixture for Cow and Buffalo; CV, Coefficient of Variation.

Table 2 Estimation of the predictions and actual adoption of the selected technologies

Code	Practice/Technologies	Peak adoption level (%)		Time to peak adoption (yrs.)	
		Predicted	Actual	Predicted	Actual
P1	Bottle Gourd Pusa Santushti	72	88	13.0	13.3
P2	Carrot-Pusa Rudhira	96	97	13.0	13.2
P3	Sarson Sag-Pusa Sag-1	70	86	13.1	11.8
P4	Paddy-PB-1637	98	98	7.7	6.5
P5	Wheat-HD-3086	98	98	7.6	6.3
P6	Supplementation of Mineral Mixture	98	98	10.8	9.7

and only four attributes - reversibility of innovation, time to local village/community benefit, risk exposure and ease and convenience scored poorly (<50% of maximum score). Among the six practices implemented, the wheat variety - HD-3086 (Mean=4.55), paddy variety PB-1637 (Mean=4.5) and supplementation of mineral mixture for cow & buffalo (Mean=5.50) scored high. While the wheat variety obtained highest scores in all the four dimensions, the paddy variety received top scores in three dimensions (except relative advantage of the innovation dimension). The mineral nutrient supplementation had high scores in three dimensions and rated poorly on the learnability characteristics of the intervention. Precisely, the respondents were sceptical about its observability. When compared to cereal crops, non-cereals scored poorly in all dimensions indicating high relative advantage for the cereal crops. The Bottle Gourd variety Pusa Santushti and Carrot variety Pusa Rudhira scored poorly in all dimensions and obtained low scores (<50% of mean) in the local community benefit orientation, enterprise scale, innovation awareness, time until any future income/productivity benefits are likely to be realised, risk exposure and ease and convenience to use aspects. The results indicate that, though these varieties performed well under the technology module intervention, their scalability is relatively low.

Under learnability characteristics of the intervention dimension, the farmers preferred technology related to cereal crop varieties for their higher degree of trialability, innovation complexity and observability. The level of observability is abysmally low for technology related to livestock. It indicates that the technology related to crop system generate convincing evidence of benefits than that of livestock, i.e. adoption of mineral mixture, which does not show instant results. Among all the factors under learnability, the critical factor is innovation awareness as it reflects high variance. Innovation awareness was high with technologies related to livestock and low for technology related to horticultural crops like carrot and leafy mustard. This may be due to low level of knowledge and skills as indicated by poor scores of these variables for non-cereal crops. Considering the dominance of Rice-Wheat systems in the Indo-Gangetic plains and low level of knowledge and innovation awareness for commercial crops like vegetables, there is a concern which calls for intensification of extension and advisory efforts in this region.

Under relative advantage of innovation, respondent weighed high on local village or community cost and benefits followed by income/productivity benefit revealed and expected in the future. The reversibility of innovation was considered as the least preferred by the respondents as the cost of adoption of technologies does not involve any initial investment. The income/productivity benefit was similar for all interventions. However, the respondents rated that community benefits derived from these vegetable crops were lower than the cereals.

Predicting adoption of technologies: Inputting the information collected in ADOPT tool, it is predicted that the time taken for all technology modules to reach peak adoption level ranging from 8 to 13 years (Table 2). In view of the shorter variety or technology lifecycle (5–6 years), the longer time to reach the peak adoption may lead to replacement of those technologies with their improved versions. Considering the huge investment made in development and transfer of these technologies, it is essential to accelerate extension and advisory efforts to promote these

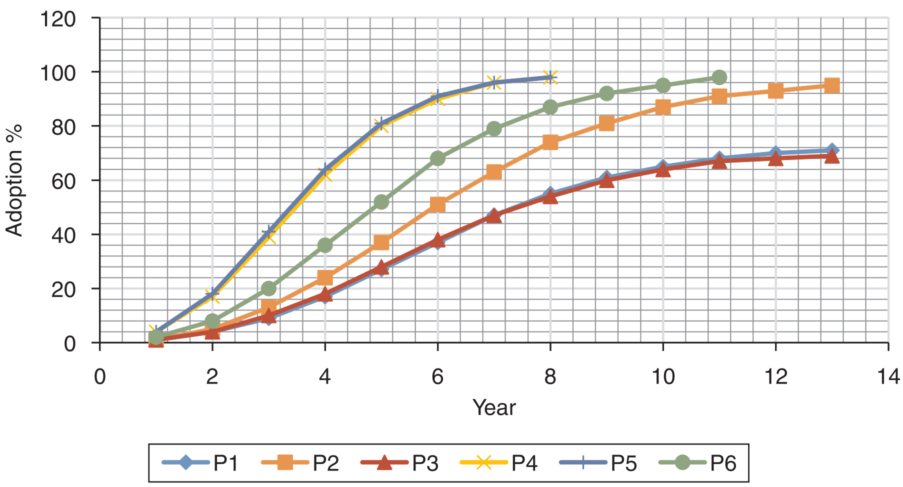

Fig 2 Yearly Adoption Level.

technologies. Further, the predicted peak adoption level for all the technologies in the study area was estimated in the range of 70–97 which is very high and desirable. A critical analysis of peak adoption level and duration indicates that cereal crop technologies reach the peak of 98% in shorter period (6–7 years) compared to the vegetables. Though supplemental mineral mixture tends to reach 98% adoption level, it takes 9–10 years (Table 2, Fig 2).

The longer duration and lower proportion of peak level of adoption of vegetables are explained by their lower scores in the relative advantage and learnability dimensions. With a potential to increase the household income at lower cost and to offer community benefits, it is essential to intensify extension efforts to promote vegetables. The yearly adoption level chart shows the technologies which were predicted to show rapid diffusion at the field level (Fig 2). Among the technologies, those related to cereal crops attains peak adoption level in a shorter span of time while that of horticultural crops takes about 13 years. Among the horticultural crops, leafy mustard variety has potential to reach closer to 100 percent indicating huge potential of this technology. By promoting adoption of this crop through effective advisory system and other promotional measures like mini kit and demos, the time for attaining peak can be considerably reduced.

For development of effective extension strategies in dissemination of various technologies, it is important to understand the effectiveness of the technology along with how long it will take for the technology to diffuse in a community and attain the peak level given the factors intrinsic to the technology and community. Six technologies including three horticulture crops, two field crops and one livestock based, identified to have greater benefits, were taken up for the study. The result shows that all these technologies were preferred by the farmers in the study area. Among the technologies, the technologies related to field crops (paddy and wheat) have peaked earlier while the extent of peak adoption level was higher for field crops and livestock interventions. The time to peak adoption was higher to the extent of 13 years for horticulture crops indicating that proper advisory services to speed up the process will result in higher benefits to the stakeholders.

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