**Original Research Article**

**DECISION OF HI-TECH VEGETABLE FARMERS ON NUTRIENT MANAGEMENT AND ADVISORY SERVICE PREFERENCE**

***Abstract***

***Aims:****. The study was aimed to explore their decisions on nutrient management by the adopters of precision farming and to identify preferred source of advisory immediate to adoption of precision farming and the present time. The study was also aimed at finding out whether the early adopters and late adopters differed significantly in their decisions and whether the adopters differed significantly between two time periods.*

***Study design:*** *Ex-post facto research design.*

***Place and Duration of Study:*** *The study was conducted in Palacode and Pennagaram blocks of Dharmapuri district during May and June 2023.*

***Methodology:*** *Survey was conducted among 120 randomly selected precision farming farmers.**The data on the decision of farmers on nutrient management and the concerned advisory source were collected for two time periods. The respondents were categorized into early adopters (more than 8 years of experience in precision farming) and late adopters (up to 8 years of experience).* *McNemar's test and Wilcoxon signed ranks test were used to compare the same sets of respondents over two time periods and Mann Whitney U test was used to compare the early and late adopters on their decisions.*

***Results:*** *Majority**(59.57 and 35.62 per cent) of the early and late adopters respectively were dependent on their own experience at present, which is significantly different from the period immediate to adoption with Z= -4.707 at P=0.000 for early adopters and with Z*= -2.235 at *P=0.025 for late adopters. Mann Whitney U test carried out between early and late adopters indicated a significant difference in the preference of advisory sources in the period immediate to adoption at P=0.045. Early and late adopters did not differ significantly in their advisory preference at present. 76.60 per cent of the early adopters and 60.27 per cent of the late adopters were found to have followed Integrated Nutrient Management practices immediate to adoption. It had increased to 78.72 per cent and 75.44 per cent respectively. McNemar test resulted in the probability value of 0.001 (p<0.01) for late adopters indicating that late adopters differed significantly in their decision over two time periods. The early adopters did not differ significantly between two time periods. Similarly the early and late adopters did not differ significantly in their nutrient management decisions.*

***Conclusion:*** *Majority of the early adopters had previously adopted INM and hence there was no increase the proportion of respondents in nutrient management between two time periods, on the other hand, the late adopters who had not adopted INM to a greater extent during initial adoption had now shifted to INM significantly. Hence, the public extension system and the scientists are needed to intervene and promote the INM practices among the non-adopters keeping view of the sustainability, soil health and reducing cost of cultivation to farmers.*

**Key Words:** Decisions in precision farming, Decision making in nutrient management, Advisory service preference, McNemar test, Wilcoxon Signed ranks test, Mann Whitney U test.

**1. Introduction**

 Precision farming is one of the hi-tech vegetable cultivation practices which uses advanced technologies to improve yield and quality of the produce. Precision farming is characterized by numerous sophisticated tools that assist in monitoring variation and managing inputs which include Remote Sensing, Geographic Information System, Global Positioning System, Yield Monitoring and Variable Rate Technology. Due to fragmented landholdings and technological gap among farmers, precision farming is not practiced to its fullest potential in India (Ranjan, 2022). The components of Precision farming in India are good quality seed or planting material , Precise land preparation, Timely sowing/planting, Application of organics, Micro irrigation, Fertigation, Herbigation, Mulching, Plant protection measures etc., Precise and Optimal supply of nutrients through drip fertigation is the component of precision farming.

 As the concept of sustainability is emerging all over, it is the need of the hour for the farmers to follow a nutrient management strategy by integrating organic, biological and chemical methods. As precision farming adopters have already adopted a complex technology, it would not be impossible for them to adopt a complementary practice. Further, in farming, any decision is supported or influenced by information i.e., advisory services. Hence, the decision of the precision farmers regarding the nutrient management strategy and the preference of farmers towards the advisory services during initial adoption of precision farming and the present time are studied.

**2. Methodology**

 The data for the study were collected from the precision farming adopters of Dharmapuri district of Tamil Nadu. Dharmapuri district was purposively selected owing to the implementation of the ambitious Tamil Nadu Precision Farming Project in Dharmapuri district from 2004 to 2007, and the subsequent undertaking of the scheme by the Government of Tamil Nadu. A sample of 120 farmers were randomly selected from the sampling frame obtained from the Deputy Directorate of Horticulture of the district. Field survey was conducted during May-June 2023.

 The current study was undertaken with a view of the exploring the differences in decision making among the adopters of precision farming between the period immediate to adoption and the current period. The data on the decision of farmers on nutrient management and the concerned advisory source were collected for two time periods. The data on nutrient management was nominal with scores '1' and '0' for following Integrated Nutrient management and usage of chemical fertilizers alone respectively. The data on advisory service preference was collected as ordinal data with scores 1,2,3,4,5,and 6 respectively for fellow farmers, own experience, input dealers, representatives of companies, Extension officials of the state department, and scientists. The respondents were divided into two categories such as early adopters and late adopters. Those who had experience in precision farming of more than 8 years were considered early adopters and those with experience up to 8 years were considered late adopters based on the mean and median value of the experience.

 Regarding the statistical analysis, McNemar's test and Wilcoxon signed ranks test were used to compare the same sets of respondents over two time periods and Mann Whitney U test was used to compare the early and late adopters on their decisions. The objective of the study is to test the following hypotheses.

**For Advisory Service Preference**

**I . Null Hypothesis (H0)**: There is no significant difference in advisory service preference between early adopters and late adopters.

**Alternative Hypothesis (H₁)**: There is a significant difference in advisory service preference between early adopters and late adopters.

**II. Null Hypothesis (H0):** There is no significant difference among the farmers in advisory service preference over two time periods.

**Alternative Hypothesis (H1) :** There is a significant difference among the farmers in advisory service preference over two time periods.

**For Nutrient Management Strategy**

**III. Null Hypothesis (H0)**: There is no significant difference in nutrient management decisions between early adopters and late adopters.

**Alternative Hypothesis (H₁)**: There is a significant difference in nutrient management decisions between early adopters and late adopters.

**IV. Null Hypothesis (H0):** There is no significant difference among the farmers in nutrient management strategy over two time periods.

**Alternative Hypothesis (H1) :** There is a significant difference among the farmers in nutrient management strategy over two time periods.

**3. Findings and Discussion**

**Table 1. Distribution of early adopters and late adopters according to their preference of advisory source.**

|  |  |  |
| --- | --- | --- |
| **Advisory source** | **Early adopters (n=47)** | **Late adopters (n=73)** |
| **Immediate to adoption** | **Present** | **Immediate to adoption** | **Present** |
| **Fellow farmers** | 10(21.28) | 9(19.15) | 18(24.66) | 19 (26.02) |
| **Own experience** | 2(4.26) | 28(59.57) | 8(10.96) | 26(35.62) |
| **Input dealers** | 11(23.40) | 10(21.28) | 21(28.77) | 16(21.92) |
| **Representatives of companies** | 4(8.50) | 0 | 2(2.74) | 6(8.22) |
| **Public extension officials** | 10(21.28) | 0 | 24(32.88) | 6(8.22) |
| **Scientists** | 10 (21.28) | 0 | 0 | 0 |

**Fig. 1. Distribution of early adopters according to their preference of advisory source**

**Fig. 2. Distribution of late adopters according to their preference of advisory source**

 Table 1 illustrates the distribution of early adopters and late adopters according to their preference of advisory sources over two time periods such as immediate to adoption and at present time. Among the early adopters, Input dealers, fellow farmers, Public extension officials and scientists were equally preferred sources by over 80.00 per cent of the respondents. Very low proportion of the respondents had opted for advisory service from representatives of private companies and self immediate to adoption. Over time, relying on their own experience had become the most preferred advisory source for a majority (59.57 per cent) of the early adopters. Those who had depended on scientists and public extension officials previously had seemingly become self-reliant. On the other hand, the late adopters had predominantly relied on public extension officials, input dealers and fellow farmers for advisory services immediate to the adoption of precision farming. This is in line with the findings of a study (Diagne *et al.,* 2022) in which adoption of improved maize seeds in the late adopter group increased with their frequency of access to agricultural advice and access to development projects. The results are also in line with those of Lambrecht *et al.* (2014), and Barham *et al.* (2018) who had illustrated the importance of access to information for adoption. While learning by doing applies to all technologies, according to Chavas and Nauges (2020), social learning i.e., learning from peers is particularly relevant for late adopters who have greater opportunities to learn from others. Whereas, at present, the late adopters who relied on public extension officials had drastically plummeted from 32.88 per cent to 8.22 per cent and those who relied on their experience had soared from 10.96 per cent to 35.62 per cent. This observation aligns with a study examining farmers' adoption of nutrient management best practices found that self-efficacy and stewardship motivation were significant predictors of adoption (Gao and Arbuckle*.* 2021*)* . This suggests that as farmers gain experience and confidence, they tend to rely more on their own judgment. The results also adds to a empirical evidences showing that farmers’ confidence in their capacity to implement practices might be leading to an increase in voluntary adoption of conservation practices (Zhang *et al.* 2016; Wilson *et al.* 2018). The reliance on input dealers had slightly declined over time among the late adopters.

 Wilcoxon signed ranks test conducted for the early adopters resulted in a z value of -4.707 with p value of 0.000 (p<0.01). This necessitates the rejection of null hypothesis in case II and thus rendering us to accept the alternative hypothesis. Thus, it is evident that the early adopters had differed significantly in their preference for advisory sources over time. Wilcoxon signed rank test for late adopters yielded the test statistic value of z= -2.235 with probability value of 0.025 (p<0.05), thus leading to rejection of null hypothesis in case II. Thus, the late adopters differed significantly in their preference for advisory sources during initial adoption of precision farming and the present time.

 As both early and late adopters were found to differ significantly in their advisory source preference between two time periods, Mann Whitney U test was carried out to confirm whether the preference of advisory source differed significantly among them over two time periods. For the immediate period to adoption, the p value was 0.045 (p<0.05) indicating a significant difference among the early and late adopters in their preference for advisory sources. whereas for the present time, the resultant test statistic value was found to have p value greater than 0.05 for present time signifying that null hypothesis in case I to be accepted. Thus, there is no significant difference in the advisory source preference between the early adopters and late adopters in the present time.

 This implies that the early adopters and late adopters had significantly differed in their choices over time as well as between each other immediate to adoption. As the early had limited examples in their social system, around 30.00 per cent of them had to rely on the advisory sources external to their immediate social network such as scientists and company representatives for advisory during the initial adoption, which is different among the late adopters, as they had fellow farmers and public extension officials to cater their information needs. Many of the late adopters than early adopters had approached the public extension officials because the farmers became more aware of the monetary benefits of the schemes as well as they were convinced to adopt the precision farming technology by witnessing the success of the technology among their fellow farmers. As the public extension service was approached by the farmers mainly for getting access to inputs and monetary benefits, it was preferred by both early and late adopters only during initial adoption of the technology. Input dealers had played a consistent role in providing advisory service despite the time period. Early adopters have had access to reach out to scientists for information on nutrient management as during the implementation of the TNPFP project and as a spillover effect, few interested non-beneficiary farmers had also gained the contact of the scientists and approached them for information as the technology was relatively new to them and they could not get reliable information from other sources. As the early adopters had accessed information from institutional sources, they might have had better understanding of the principles of the technology than the late adopters, thus resulting in the increased preference of own experience by early adopters at present than late adopters.

**Table 2. Distribution of early adopters and late adopters according to their decision on nutrient management.**

|  |  |  |
| --- | --- | --- |
| **Nutrient management decision** | **Early adopters (n=47)** | **Late adopters (n=73)** |
| **Immediate to adoption** | **Present** | **Immediate to adoption** | **Present** |
| **Use of Chemical Fertilizers** | 11(23.40) | 10(21.28) | 29(39.73) | 18(24.66) |
| **Integrated Nutrient Management** | 36(76.60) | 37(78.72) | 44(60.27) | 55(75.44) |

 Table 2 depicts that more than three-fourth of the early adopters had followed integrated nutrient management during the period immediate to adoption of precision farming and at the present time. Studies have shown that early adopters are more likely to implement comprehensive nutrient management strategies and maintain the practices over time (Wilson *et al.*, 2014). The proportion of the respondents using chemical fertilizers alone had only slightly declined by around 2.00 per cent over time. Whereas, among the late adopters, the proportion of those using chemical fertilizers had considerably declined and those who followed Integrated nutrient management had increased from 60.27 per cent to 75.44 per cent. Previous studies highlight that late adopters often begin with simpler practices and gradually adopt more integrated approaches as they observe positive outcomes and gain confidence (Gao and Arbuckle*.* 2021).

**Fig.3. Distribution of early adopters and late adopters according to their decision on nutrient management**

 Further analysis of the data using McNemar test resulted in the probability value of 0.001 (p<0.01) for late adopters. It means that we reject the null hypothesis in the case IV, thus indicating that the late adopters differed significantly in their decision making on nutrient management between two periods. The late adopters, were not ready for complementary adoption and they began with adopting the fertigation technology only initially and over time, with their own experience and observing from fellow farmers, and due to reduced intervention of input dealers, they started adopting Integrated nutrient management thus bringing out a significant difference in their decisions between two time periods. But the Mann Whitney U test conducted to ascertain whether the two groups differed in their nutrient management decisions resulted in p values greater than 0.05, rendering us to accept the null hypothesis in case III. Though there is a visible difference in the proportion of the early adopters and late adopters in each category, the difference is not statistically significant. Literature also suggests that initial differences in advisory source preferences between early and late adopters tend to converge over time as both groups accumulate experience (Chavas and Nauges, 2020).

**4. Conclusion**

 Though the respondents differed significantly in their advisory service preference, and nutrient management decisions between initial period of precision farming adoption and present time, there is no significant difference among the respondents pertaining to their period of adoption. Additionally, notably higher proportion of the respondents were found to follow Integrated Nutrient Management practices over time. The non adoption of INM practices by few of the farmers highlight the scope for the intervention of public extension officials and scientists, which is missing at present, in educating the farmers, promoting sustainable inputs at affordable cost and regular follow up of the farmers to understand their constraints and clarify their queries. It is understood from the findings that despite being an early adopter or a late adopter, over time, the farmer becomes content with his own experience for making operational decisions if no new technology is introduced. The role of Public extension and Scientists is needed in this scenario also to ensure consistent growth in farming practices and yield, rather than letting it take a stagnant state.Farmers had adopted precision farming upon understanding either the importance of water conservation or the potential of precision farming technology in profit maximization. Either way, it was possible to make farmers adopt a technology by creating awareness. Similarly, it is necessary to create awareness among the farmers on soil health, sustainability and reducing cost of cultivation to shift them gradually towards Integrated Nutrient Management practices.

**Reference**

1. Barham, B. L., Chavas, J.-P., Fitz, D., & Schechter, L. (2018). Receptiveness to advice, cognitive ability, and technology adoption. Journal of Economic Behavior & Organization, 149, 239–268.
2. Chavas, J.-P., & Nauges, C. (2020). Uncertainty, learning, and technology adoption in agriculture. Applied Economic Perspectives and Policy, 42(1), 42–53.
3. Diagne, A., Tamini, L., & Fall, F. (2022). Factors explaining the dynamics of agricultural technological innovations adoption: Evidence from Senegal’s rain maize farmer. Agricultural Sciences, 13, 1234–1258.
4. Gao, L., & Arbuckle, J. (2022). Examining farmers’ adoption of nutrient management best management practices: A social cognitive framework. Agriculture and Human Values, 39, 535–553. https://doi.org/10.1007/s10460-021-10266-2
5. Lambrecht, I., Vanlauwe, B., Merckx, R., & Maertens, M. (2014). Understanding the process of agricultural technology adoption: Mineral fertilizer in Eastern DR Congo. World Development, 59, 132–146.
6. Ranjan, R. (2022, October 27). What are the structural challenges in the way of adopting precision agriculture by Indian farmers at large? The Times of India. https://timesofindia.indiatimes.com
7. Wilson, R. S., Howard, G., & Burnett, E. A. (2014). Improving nutrient management practices in agriculture: The role of risk-based beliefs in understanding farmers’ attitudes toward taking additional action. Water Resources Research, 50, 6735–6746.
8. Wilson, R. S., Schlea, D. A., Boles, C. M., & Redder, T. M. (2018). Using models of farmer behavior to inform eutrophication policy in the Great Lakes. Water Research, 139, 38–46.
9. Zhang, W., Wilson, R. S., Burnett, E., Irwin, E. G., & Martin, J. F. (2016). What motivates farmers to apply phosphorus at the “right” time? Survey evidence from the Western Lake Erie Basin. Journal of Great Lakes Research, 42(6), 1343–1356.