A Study of Key Challenges Faced by Farmers in Moving from Inorganic, Commercial Farming to Organic Farming

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Abstract

Fertilizers are a necessary requirement to enrich the soil and meet the growing food requirements of global population. With Indian population crossing the 1.4 Billion mark in 2021 and approaching 1.44 Billion in April 2024, the requirement of food grains and other food products will continue to pose continual challenges [19]. Fertilizers can be broadly classified as Organic or Inorganic based on their source. While organic fertilizers present immense advantages as regards environmental impact, the requirement of inorganic fertilizers emerges from their ability to provide more nutrition to soil over an extended period of time leading to an overall cost advantage from their use. The case with pesticides is similar with farmers having the option or organic or synthetic pesticides providing similar benefits. This study was carried out for farmers in the districts on the border of Rajasthan and Madhya Pradesh to assess their preferences and the challenges they face in moving to organic farming. Famers of four districts (Neemuch, Mandsaur, Pratapgarh and Chittorgarh) participated in the survey. Primary data was collected through a structured questionnaire and analysed statistically to test seven different hypotheses based on the Z-test for a 5% level of significance (α). A total of 157 farmers responded to the questionnaire and seven hypotheses were tested based on their responses. The responses by farmers demonstrate a need to further develop upon and better utilize the efforts of Agricultural Department to provide better seeds, balanced approach to plant protection as well as adding of fertilizers and automated harvesting since these steps will increase farm produce as well as the income of farmers.

Key Words: Organic fertilizer, Synthetic fertilizer, water pollution, pesticides, plant nutrition

Introduction

Fertilizers are components that enhance plant development and productivity. This is often achieved by the components or additives increasing the fertility of the soil in which plants grow. Traditionally, this was achieved by mixing manure with the soil so that the level of nutrients

required by crops was augmented periodically. This enables boosting plant growth, achieve faster plant maturity, better resistance under conditions of draught and improve quality of seeds and fruits [7]. The challenge of addressing nutritional needs of [plants can hardly be underestimated considering that there are as many as nineteen ingredients that are required to attain required standards of plant health besides yield improvements. These include Boron, Chlorine, Cobalt, Copper, Iron, Magnesium, Manganese, Molybdenum, Nickel, Silicon, Selenium, Zinc etc. Providing such a wide range of nutrients can be quite a daunting requirement and emphasizes the need for great research in fertilizer application [4]. Use of fertilizers carries several advantages including (i) quick effect on increasing crop yield without which meeting the needs of human population would be impossible; (ii) being water soluble so plants can absorb these quickly; and (iii) addressing shortage of specific nutrients through nutrient specific fertilizers. On the other hand, the downside in use of fertilizers includes: (i) Extended use of some chemical fertilizers could reduce soil fertility, damage crops and reduce the microbial activity and/or even disturb the soil pH; (ii) Cause water pollution if fertilizers reach the rivers due to leaching or any other reason; and (iii) Cause skin related problems where agriculturists depend upon manual working [9]. With increasing focus of scientific experiments in agriculture, scientists are able to validate hypotheses, within a shorter time, what may have taken several years earlier. Thus, based on prevailing soil fertility characteristics, one can deduce the optimal fertilizer application rate required for increasing yield while also ensuring that the content of toxic ingredients like heavy metals (eg. lead) is maintained at an acceptable level [1]. Given the rapidly rising global population that may reach 9.2 Billion by 2050, the food requirements for 2050 would be close to twice of 2009 requirement with the quantity and quality of land likely to reduce as years go by. This can only be achieved through use of fertilizers that ensure no adverse environmental impact and focus on genetics and biotechnology. With commercial fertilizers contributing to 40-60 percent of global food production, any increase in food production with minimal or zero environmental impact is unlikely without focus on improving commercial fertilizers, something that is an urgent requirement in the developing world because 98 percent of the chronically hungry and under nourished living in developing countries [11]. While the role of commercial fertilizers can not be ignored, it is a combination of organic and inorganic nutrient sources that has been seen to facilitate the best yield under certain conditions through applying the 4R principle (Right nutrient source at the Right time at the Right rate and the Right place) [14]. This is among the key factors causing the surge in global fertilizer market that could reach upto USD 271.6 Billion by 2030 showing a CAGR of 3.4 percent between 2021-30. This growth rate will be faster in the Asia-Pacific region and could be closer to 3.86 percent with India and China markets being the dominant players [10]. Massive use of fertilizers has, unfortunately caused problems relating to pollution, the environment and soil nutrition leading to sub-optimal food production thereby defeating the very purpose of adding fertilizers, an example being the deteriorating soil N:P ratio that has exacerbated to an extent where continental water sources are highly contaminated due to increased nitrate content. The need, therefore, appears to be to better plan application of K-N-P (potassium, Nitrogen and Phosphorous) fertilizers so that the nutrition needs are addressed while minimizing any adverse impact on the environment. It would, almost certainly, require governmental role coupled with legislation for improved application of the 4R principle [5]. This need of ensuring environmental protection does not permit uncontrolled increase in use of commercial (chemical) fertilizers and pesticides as their continuous and excessive use is seen to pollute water bodies and contribute to environmental change. One possible solution for consideration is use of sustainable agriculture that maintains microbial activity besides providing high yield from the soil. Sustainable agriculture relies on promoting microorganisms that are associated with enhancing salt and drought tolerance, heavy metal stress mitigation, resistance to diseases and yield [13]. This study is focused on assessing the dependence upon chemical fertilizers and pesticides among farmers operating in the districts on the Rajasthan-MP state border and the challenges they face in organic farming (by using organic fertilizers and pesticides).

Literature Review

Fertilizers can be broadly classified as: (a) Industrial fertilizers produced industrially through chemical reactions. These include ammonium nitrate, urea, ammonium phosphate besides others; (b) Mineral fertilizers are naturally available in readily usable form and require minimal processing before use (can include washing or some chemical treatment); and (c) Organic fertilizers comprising decomposed matter from animals or plants and often applied as manure and/or compost. The need for fertilizers emanates from multiple factors like need for increased productivity, need to enhance resistance to plant diseases and different types of environmental factors [2]. Yet another classification of fertilizers, based on nutrient content, views fertilizers as: (i) Straight fertilizers eg. ammonium sulphate or Urea that supply only a single plant nutrient that could be potassium, phosphorous or nitrogen; (ii) Complex fertilizers eg. nitro-phosphates or Diamond phosphate that supply two or more primary plant nutrients with two primary nutrients being in chemical combination; and (iii) Mixed fertilizers that are produced by manually or mechanically mixing straight fertilizers so inevitably provide primary nutrients as per the mix employed (can be two or three). When viewed from application perspective, fertilizers can be classified as solid or liquid fertilizers [16].

Organic and Inorganic fertilizers differ primarily in their source. Organic fertilizers are sourced from plants, animals or manures while inorganic fertilizers are derived synthetically from naturally occurring minerals or from chemicals. Both types of fertilizers have a role in large scale agriculture due to their unique advantages. While the big advantage of organic fertilizers include: (i) relatively slower release of nutrients; (ii) enhancing the organic content of soil; (iii) increased ability of soil to retain moisture; (iv) sequestering carbon into the soil; and (v) ease of production on a small scale. Inorganic fertilizers, however, are known to be higher in nutrient content, known to produce quicker results despite being less bulky and provide the possibility of precision in amount of fertilizer to be added [12]. As regards the limitations, despite the multiple advantages of inorganic fertilizers, it's disadvantages are: (i) possible harm to soil microbiology; (ii) possible harm to plants especially if applied in excess; and (iii) need secure storage beyond the reach of animals or children [8]. Given the pros-and-cons of organic and inorganic fertilizers, an obvious question is what fertilizer to use. A decision on the ideal fertilizer requires taking into account the kind of plant, nutrition requirements, budgetary constraints and impact on environment besides other factors. Inorganic fertilizers can disturb the ecosystem, release greenhouse gases, increase pest related problems, impact soil pH and release greenhouse gases [6].

Besides fertilizers, pesticides represent very important additions to the soil and plants. While fertilizers enrich the soil to enhance production levels, pesticides ensure that plant yield is protected and produce not lost to pests. The seriousness of the problem can be gauged from the fact that loss due to pesticides, weeds and diseases caused by them can be as high as 40 percent of the crops. This damage is caused by about 30000 species of weeds and 10000 types of insects that eat plants and destroy growth. The pesticides that agriculture uses to deal with the challenge of weeds and pests can be broadly classified into the following categories: (i) Herbicides; (ii) Insecticides; (iii) Fungicides; (iv) Rodenticides; (v) Larvicides; (vi) Molluscicides; (vii) Bactericides; and (viii) Algaecides [17]. Yet another classification, at a higher level of abstraction, is: (i) Organic; and (ii) Conventional (Synthetic) Pesticides. Choice of a particular pesticide requires balancing the need for protecting from weeds or insects and posing the least risk to the health of humans, animals, non-target species and the environment. Like with fertilizers, organic pesticides are derived from naturally occurring sources like plants, minerals or animals. Frequently used organic pesticides include neem oil and pyrethrins (extracted from chrysanthemums) besides others. Conventional (Synthetic) pesticides, based on US Department of Agriculture classification, is one that's manufactured or formulated from process(es) that cause chemical change from a naturally occurring state to the synthetic compound state. While organic pesticides are less persistent than synthetic ones and can be more selective in the targeted pests these needs quicker application too. Synthetic pesticides on the other hand, end up costing less in the short run, they tend to

be attack a broader spectrum of insects and are more persistent creating the possibility of greater environmental damage [15]. A frequent debate relating to pesticides concerns their toxicity. This is a natural effect of the fact that pesticides are inherently meant to mitigating the effect of pests by repelling or destroying the pests. From the perspective of analysing toxicity, a useful classification of pesticides is: (i) Synthetic Pesticides; (ii) Conventional Pesticides; (iii) Naturally occurring pesticides; (iv) Pesticides permitted in certified organic production; (v) Biological control agents; (vi) Biopesticides; and (vii) Reduced risk or minimal risk pesticides. For a user of pesticides, the most important thing is to look for signal words that could be 'Caution' indicating slight toxicity, 'Warning' indicating moderate toxicity or 'Danger' indicating high toxicity (often also includes 'Poison') [3].

Besides adding fertilizers to enrich the soil and pesticides to remove harmful insects and weeds, farmers often adopt different ways to sustain soil fertility i.e. soil's ability to optimize crop yield through optimal plant growth.

Research Methodology

A detailed literature survey highlights the issues around application of fertilizers and pesticides as well as retaining soil fertility. Primary data for this study was collected through a structured questionnaire developed after extensive discussions. The questionnaire was piloted and improved based on a pilot survey. Quantitative data (largely ordinal) collected was subjected to statistical analysis while qualitative views or opinions provided deeper insights into farmer experience in use of fertilizers and effects of doing so. A total of 157 responses were received through purposive sampling with no inducements whatsoever being offered to the respondents for participating in the study. Respondents were assured that their responses would be used only for academic purposes and kept confidential. Primary data collected was subjects to statistical analysis to test various hypotheses for a level of significance (α) of 5%. Given the fact that a large fraction of Indian farmers are poor, the study also examined how low income levels of farmers appear to impact their agricultural practices.

The following hypotheses were tested as part of this study:

H01: Majority of the farmers use local/traditional seeds for their agricultural needs.

H02: Majority of the farmers are dependent only on organic fertilizers.

H03: Majority of farmers always get help from Agriculture Department on important matters

H04: Majority of farmers depend upon use of pesticides for agriculture

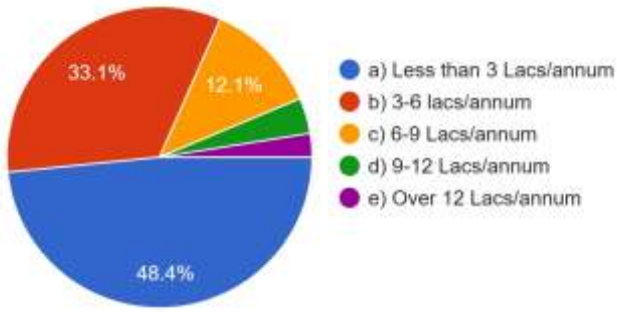
H05: No single method or approach predominates others for improving soil fertility

H06: Majority of farmers have graduated to automated methods for their harvesting needs

H07: Majority of farmers do not trust organic fertilizers and wish to move to Chemical fertilizers

A statistical analysis of the hypotheses listed above is given below after presenting a schematic of the annual income of farmers. The schematic shows that close to half the farmers are poor with an annual income of less than INR 3 Lacs/annum while another one-third earn between 3-6 lacs an year meaning that over 80 percent farmers earn less than INR 6 Lacs/annum. In terms of farming practices, it means that any change that farmers make will be greatly influenced by associated costs in the short run and will be considered only if these costs are quite low.

Fig. 1: Annual Income of Farmers



Data and Analysis

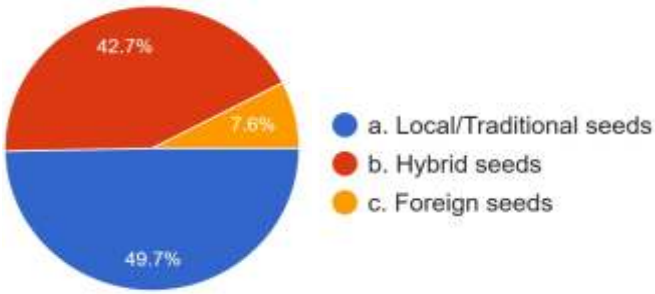
Given below is the primary data collected through a structured questionnaire and its analysis:

1. H01: Majority of the farmers use local/traditional seeds for their agricultural needs.

The percentage of farmers who use local/traditional seeds is 48.4 giving a p value significantly less than 5% meaning that the hypotheses is rejected for a 5% level of significance. This suggests that despite the high dependence on local/traditional seeds, probably, because these fertilizers cost less, the usage of hybrid and foreign seeds is also quite high. Fig. 2 below shows the choice of seeds by famers.

Outcome and Implications: H01 is rejected suggesting that proportion of farmers is distributed in their use of local/traditional, hybrid and foreign seeds. The need appears to be to build supply chains to deliver superior quality seeds to farmers that can best stand the stresses of climatic vagaries as well as pest attacks.

Fig. 2: Farmers' Choice of Seeds

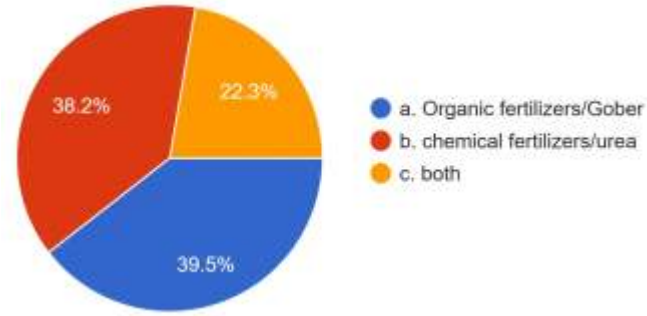


2. H02: Majority of the farmers are dependent only on organic fertilizers.

The percentage of farmers who depend solely on organic fertilizers and manure ('Gober') is 39.5 giving a p value that is far less than 0.05 leading to the hypotheses being rejected and indicating that the proportion of farmers who depend upon chemical fertilizers and organic fertilizers is comparable. Fig. 3 below shows the present usage of fertilizers by farmers in terms of organic and chemical fertilizers.

Outcome and Implications: H02 is rejected suggesting that proportion of farmers is distributed in their use of organic and chemical fertilizers.

Fig. 3: Farmers' Choice of Fertilizers (Organic versus Inorganic)

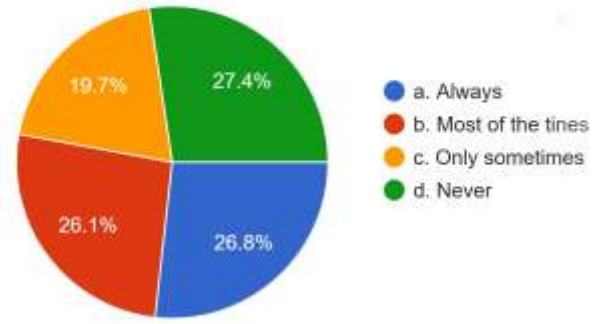


3. H03: Majority of farmers always get help from Agriculture Department on important matters

The percentage of farmers who reported that they always get help from the Agriculture Department on important matters (like fertilizer use, seeds etc) is 26.8 giving a p value of close to zero leading to the hypotheses being rejected. However, when one takes into account response, “Most of the times” also, the fraction crosses the half way mark suggesting that the Agriculture Department is extending help though there is room for improvement. Fig. 4 below gives the breakup of farmer responses to the regularity of help to farmers on important matters like fertilizers, seeds etc.

Outcome and Implications: H03 is rejected suggesting that despite Agriculture Department extending help to farmers, there is room for improvement.

Fig. 4: Regularity of help from Agriculture Department on important matters like seeds, fertilizers etc.



4. H04: Majority of farmers depend upon use of pesticides for agriculture

The total percentage of farmers who reported who reported that they use pesticides 'Always', 'Occasionally' or 'As needed' is about 65.7, a value that certainly does not fall in the rejection region so we are unable to reject this hypotheses.

Fig. 5 (a): Dependence and Use of pesticides for Agriculture

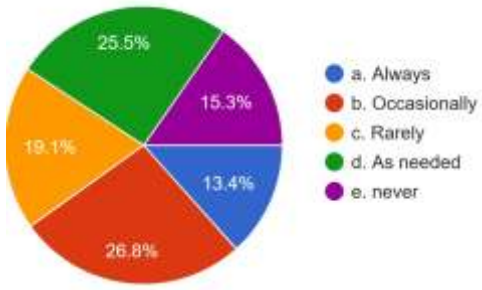
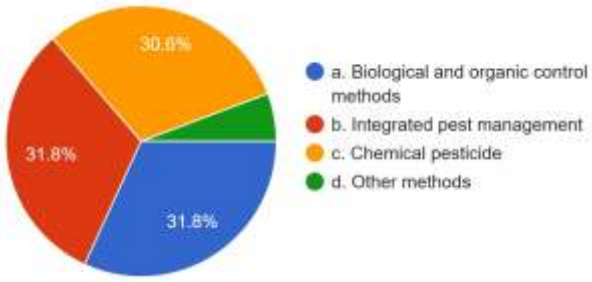
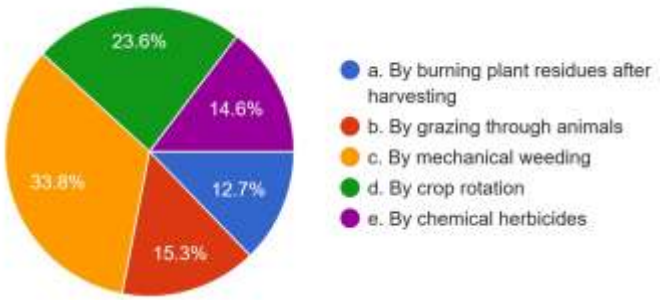


Fig. 5 (b): Pest Control Method



The choice of pest control is more or less uniformly divided between biological/organic control method, integrated pest management and chemical pesticides. An independent study may be required to establish the need and benefits of moving to biological and organic control methods over the other methods.

Fig. 5 (c): Weed Control Method



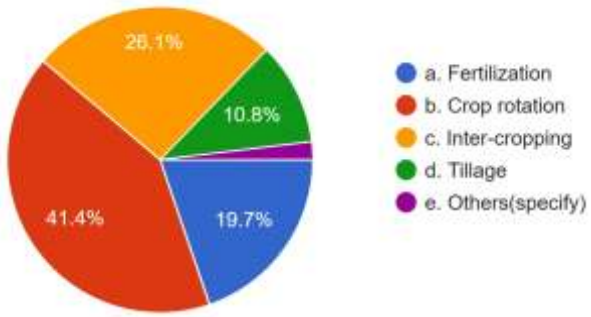
Weed control is dominated by mechanical weeding and crop rotation with grazing by animals also lending an important helping hand.

Outcome and Implications: H04 is not rejected suggesting that the dependence on pesticides is very much a part of prevailing agricultural practices and any move to use of organic pesticides would need to be very carefully planned so as to minimize any negative impact emanating from the change. At the moment, the farmers appear to have, very intelligently, designed a mix of approaches for pest control and weed control.

5. H05: No single method or approach predominates others for improving soil fertility

   While crop rotation is clearly the method-of-choice to preserve soil fertility with inter-cropping and fertilization following crop-rotation in terms of use by farmers, there is no one method that the majority of farmers employ. Thus one is unable to reject the hypotheses.

Fig. 6: Approach to preserve soil fertility



Outcome and Implications: H05 cannot be rejected indicating that soil fertilization is presently carried out in multiple ways and any technique proposed to improve soil fertilization would necessarily need to take into account the varying needs of farmers and their agricultural requirements that have brought about this variation in practices.

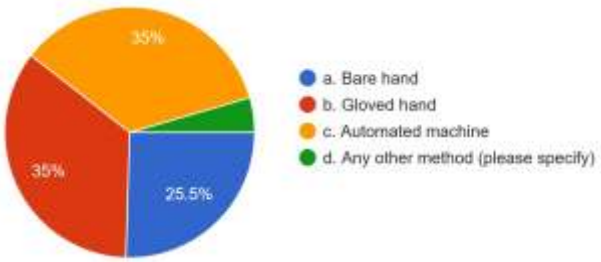
6. H06: Majority of farmers have graduated to automated methods for their harvesting needs

The data collected shows that over one in every four farmers still carry out harvesting using bare hands while a little more than one in every three farmers do so using gloved hands i.e. over 60 percent are carrying out

harvesting by hands and a little more than one in every three farmers use automated methods/machines. The p value for this is close to zero leading to the hypotheses being rejected.

Outcome and Implications: H06 is rejected indicating that farmers are very much dependent on manual methods for harvesting. This may be due to the level of poverty prevailing among farmers along with inadequate information on financing options available to them. The governments could consider developing schemes that enable increased use of automated methods for small farmers as that carries the potential to increase their earning enormously.

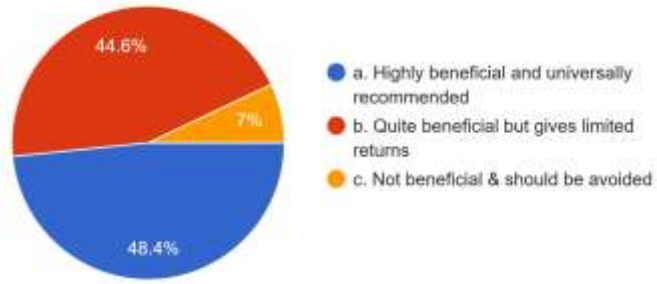
Fig. 7: Harvesting Method Adopted



7. H07: Majority of farmers do not trust organic fertilizers and wish to move to Chemical fertilizers

The percentage of farmers who find organic fertilizers highly beneficial and universally recommended is over 48 percent while about 44.6 percent find these to be quite beneficial though it gives limited returns. This an overwhelming fraction of the farming community sees organic fertilizers as being beneficial though there are questions and concerns around the returns organic fertilizers give.

Fig. 8: Overall Trust in Organic Fertilizers



Outcome and Implications: H07 is rejected indicating that organic fertilizers command immense trust among farmers. This may be due to generations of use by farmers as well as bad experiences of using chemical fertilizers. Despite all the trust farmers place in organic fertilizers, use of organic fertilizers specifically and organic farming in general require certain challenges to be overcome before these can be fully integrated into the farming process. These challenges include: (i) Relatively shorter shelf life leading to limitations in storage period and need for more efficient supply chains that can, in many cases, raise costs and make these less competitive; and (ii) Relatively lower supply caused by the first factor as well as the fact that means of production are not suited to producing organic fertilizers, a factor that again contributes to higher costs [18]. For all 7 hypotheses above, the Z and p values are summarized below :

Table 1: Summarizing Z Values & p Values (Level of significance, α = 0.05)

Sl. No.	Hypotheses	P Value
1	**H_{01}**: Majority of the farmers use local/traditional seeds for their agricultural needs.	Z value ˜ -4.01, P value ˜ 0 (Hypotheses H_{01} rejected)
2	**H_{02}**: Majority of the farmers are dependent only on organic fertilizers.	Z value ˜ -2.69, p value ˜ 0.003 (Hypotheses H_{02} is rejected)
3	**H_{03}**: Majority of farmers always get help from Agriculture Department on important matters.	Z value ˜ -6.518, P value ˜ 0 (Hypotheses H_{03} is rejected)
4	**H_{04}**: Majority of farmers depend upon use of pesticides for agriculture.	Sample proportion does not fall in rejection region so Hypotheses H_{04} can't be rejected
5	**H_{05}**: No single method or approach predominates others for improving soil fertility	Sample proportion does not fall in rejection region so Hypotheses H_{05} cannot be rejected
6	**H_{06}**: Majority of farmers have graduated to automated methods for their harvesting needs	Z value ˜ -3.94, p value ˜ 0 (Hypotheses H_{06} is rejected)
7	**H_{07}**: Majority of farmers do not trust organic fertilizers and wish to move to Chemical fertilizers	Z value ˜ -2.91, p value ˜ 0.0025 (Hypotheses H_{07} is rejected)

Conclusions and Recommendations

The outcome of statistical analysis of various hypotheses can be summarized into a cohesive conclusion to develop a plan of action that, at least partly, addresses the various challenges faced in increased use of organic fertilizers. This will ensure that the benefits of use of organic fertilizers reach a larger population.

The findings of this study are summarized in tabular form below:

Table 2: Summary of Findings

Sl. No.	Hypotheses	Outcome
1.	**H_{01}**: Majority of the farmers use local/traditional seeds for their agricultural needs.	H_{01} is rejected
2.	**H_{02}**: Majority of the farmers are dependent only on organic fertilizers.	H_{02} is rejected
3.	**H_{03}**: Majority of farmers always get help from Agriculture Department on important matters.	H_{03} is rejected
4.	**H_{04}**: Majority of farmers depend upon use of pesticides for agriculture.	H_{04} cannot be rejected
5.	**H_{05}**: No single method or approach predominates others for improving soil fertility	H_{05} cannot be rejected
6.	**H_{06}**: Majority of farmers have graduated to automated methods for theirharvesting needs	H_{06} is rejected
7.	**H_{07}**: Majority of farmers do not trust organic fertilizers and wish to move to Chemical fertilizers	H_{07} is rejected

The study and its findings are able to point out rather clearly the action steps that would help farmers enormously. These are summarized below:

There is a clear need to build supply chains to deliver superior quality seeds to farmers as farmers are already comfortable with use of different types of seeds. Further, farmers are seen to be using different kinds of fertilizers despite finding organic fertilizers highly beneficial. As far as pesticides are concerned, farmers have again demonstrated immense flexibility and willingness to try multiple options to see which one is ideal for their needs. Considering the efforts made by Agricultural Department in helping farmers, a target-based programme that facilitates an optimal combination of seeds, fertilizers, pesticides along with harvesting approach would go a long way in improving farming income as well as produce from farming.

Limitations of the Study and Scope for Further Research

While the problems associated with use of good quality seeds, organic fertilizers, pesticides and harvesting are prevalent all over the country, the study focused on farmers on the Rajasthan- Madhya Pradesh border with responses coming from four districts (Neemuch, Mandsaur, Pratapgarh & Chittorgarh). Since all these districts fall within the relatively arid region of the country, a similar study could be conducted for regions with different climatic conditions and with different soil compositions to get a more comprehensive view if the most appropriate solutions. This, then represents the main limitation of this study and area for further research.

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