Comparative Analysis of Farmer Profiles and Their Relationship with Fertilizer Management in Major Field Crops of Telangana, India

.

ABSTRACT

|  |
| --- |
| Fertilizer management is a critical factor influencing agricultural productivity, and understanding it at the micro-level is essential, especially among farmers cultivating major field crops. This study aimed to (i) assess the profile characteristics of farmers practicing fertilizer management in major field crops and (ii) determine the relationship between these characteristics and their fertilizer management practices. The research was conducted in 2024 using both ex-post facto and exploratory research designs. Telangana state was purposively selected due to its high nutrient consumption. Six major field crops were chosen based on cultivation area. For each crop, one cultivating district was randomly selected, followed by two mandals per district and three villages per mandal, resulting in 36 villages. Ten farmers per village were randomly selected, yielding a final sample size of 360 farmers. Fourteen independent variables and one dependent variable were studied. Results showed that the majority of farmers were middle-aged, had medium farming experience, small landholdings, annual income above ₹2 lakh, and medium levels of risk-taking ability, labour availability, and benefit from government policies, high levels of environmental orientation, confidence in fertilizer application and low levels of farm machinery possession and health orientation. Many exhibited high irrigation intensities, followed a two-crop pattern, and had high cropping intensity. The Kruskal-Wallis test revealed significant differences among farmer groups in farm size, income, machinery ownership, risk-taking ability, health orientation, labour availability, irrigation intensity, cropping pattern and cropping system at the 0.01 level. No significant differences were observed in age, farming experience, environmental orientation, confidence in fertilizer application, or govt policy benefits. Correlation analysis indicated that farm size, annual income, risk-taking ability, irrigation intensity, and farming experience had significant positive relationships with fertilizer management. Other variables showed positive but non-significant associations. These findings highlight key factors influencing efficient fertilizer use among farmers. |

*Keywords: Determinants, Correlation, Relationship, Manures, Socio Economic Characteristics*

1. INTRODUCTION

Fertilizers play a vital role in enhancing crop yield and productivity, thereby contributing significantly to meeting the growing demand for food and market needs. Despite possessing one of the largest expanses of permanently cultivated and arable land globally, India ranks third in total food grain production, following China and the United States. Among Indian states, Telangana reported the highest plant nutrient (NPK/ha) consumption in 2019, followed by Bihar, Haryana, Punjab, and Andhra Pradesh (Srinivasarao, 2021). Telangana exhibits a wide spectrum of soil types, ranging from nutrient-rich alluvial soils to less fertile sandy soils. According to the 2021–22 report by the Department of Agriculture, Government of Telangana, districts such as Nizamabad, Warangal, and Nalgonda exhibited significant nitrogen deficiencies, with levels dipping below 44%. Phosphorus deficiency, with levels under 55%, was prevalent in districts including Adilabad, Medak, Mahbubnagar, and Nizamabad. Excessive nitrogen application, ranging from 10 to 204 kg/ha, was observed in Adilabad, Nizamabad, Karimnagar, Khammam, Nalgonda, and Rangareddy. In contrast, nitrogen underuse (10–30 kg/ha) was recorded in Rangareddy, Mahbubnagar, and Warangal. Phosphorus application also varied, with severe deficiency (32–60 kg/ha) in Mahbubnagar and Warangal, and moderate deficiency (14–32 kg/ha) in Adilabad, Nizamabad, Karimnagar, Medak, Nalgonda, and Rangareddy. Khammam alone reported phosphorus overuse (3–170 kg/ha). Potassium deficiency was consistently reported across all districts in the state (Bora, 2022). Given this variability, it becomes essential to examine fertilizer management practices at the micro-level, particularly among farmers cultivating major field crops. Understanding the demographic and socio-economic characteristics of these farmers and the factors influencing their fertilizer application behaviors, both positively and negatively is crucial. The present study explores the determinants of fertilizer best management practices (FBMPs) and identifies the constraints in achieving balanced fertilizer use. To guide the investigation, two null hypotheses were proposed: (i) there is no significant difference in the profile characteristics of farmers practicing fertilizer management across different farmer groups, and (ii) farmer characteristics do not significantly influence fertilizer management practices in major crops. The specific objectives of this study were to: (i) Assess the profile characteristics of farmers practicing fertilizer management in major field crops, and (ii) Determine the relationship between these characteristics and their fertilizer management practices. While earlier research has predominantly centered around the use of macronutrient fertilizers, micronutrients and organic inputs have often been overlooked. This study aims to address this gap by offering a comprehensive analysis of fertilizer management encompassing macronutrients, micronutrients, organic manures, specialty fertilizers, and soil amendments, and by investigating how these practices relate to farmers’ personal, social, and economic profiles.

2. methodology

The present study was conducted during the year 2024, employing both ex-post facto and exploratory research designs. Ex post facto design is a type of research design in which the researcher studies the effects of an independent variable on a dependent variable after the independent variable has already occurred. Exploratory research is an approach used to investigate a research problem that is not clearly defined. It aims to gain insights, identify patterns, and establish a foundational understanding of a topic. Ex-post facto design selected because fertilizer management already occurred before the beginning of research. Exploratory research design was selected as some of the new variables were selected to identify causal relationship and get insights about crop wise variation as there was no earlier study was found. Telangana State was purposively selected for the study due to its significant standing in nutrient consumption. Telangana ranked second in overall macronutrient consumption per hectare among all Indian states and union territories during 2018–19, following Punjab. In subsequent years, it ranked seventh (2019–20) and sixth (2020–21) (Directorate of Economics and Statistics, GoI, 2022). Additionally, the investigator’s familiarity with the region and the lack of similar studies in Telangana further justified its selection. Data on the area under various field crops in both kharif and rabi seasons over a five-year period (2017–18 to 2021–22) were collected. Six major field crops were purposively selected based on the highest area under cultivation during this period. District-wise data pertaining to the selected crops were obtained. For each crop, one district was randomly chosen from among the cultivating districts. To ensure comprehensive coverage, two districts were selected from each agro-climatic zone of Telangana. The selected districts were as follows: Nizamabad (North Telangana Zone) for paddy, Nalgonda (South Telangana Zone) for cotton, Warangal (Central Telangana Zone) for maize, Vikarabad (South Telangana Zone) for red gram, Adilabad (North Telangana Zone) for Bengal gram, and Sangareddy (Central Telangana Zone) for soybean. Subsequently, mandal-wise data were gathered for the selected crops within each chosen district. From each district, two mandals were randomly selected from among the cultivating mandals of the respective crop, yielding a total of twelve mandals. Within each mandal, three villages were randomly chosen, resulting in a sample of thirty-six villages. From each village, ten farmers cultivating the selected crop were randomly selected, leading to a final sample size of 360 farmers. A total of fourteen independent variables and one dependent variable were selected for the study. An interview schedule was developed for all independent variables. Data were collected through personal interviews, and the responses were quantified using appropriate scoring procedures. The scores were then compiled into frequencies and percentages for analysis. Statistical tools employed for data analysis included frequency, percentage, mean, standard deviation, ranking, correlation coefficient, Kruskal-Wallis test, and Dunn's procedure.

3. results and discussion

**3.1 Comparative Analysis of Profiles Characteristics of Farmers Practicing Fertilizer Management**

The distribution of profile characteristics of farmers practicing fertilizer management in major fields is presented in Table 1. Pairwise comparison of farmer groups on profile characteristics based on mean rank as per Kruskal-Wallis test is presented in Table 2.

**3.1.1 Age**

The results provided in Table 1 indicated that overall, more than half (54.17%) of the farmers belonged to the middle age group, followed by the old (26.39%) and young (19.44%) age groups. The results in Table 2 indicated that there was no significant difference in the age among the farmer groups (Chi-square = 6.920, df = 5, *P* = .23), leading to the acceptance of the null hypothesis. This might be because the age group of 35–50 is generally considered a working age group, who have enough experience to perform farming and manage its complexities independently. The lower number of older farmers might be due to the physically demanding nature of farming. They may have transitioned from practicing farming to taking on advisory roles to reduce their workload and handed over active operations to their offspring. The smaller number of young farmers could be attributed to their lack of interest in farming, as youth often do not consider it a prestigious occupation in line with their educational qualifications. Furthermore, limited land ownership may make farming appear unprofitable to young people, whose growing aspirations and the heavy workload associated with farming may push them to migrate to urban areas in search of jobs aligned with their education and which enhance their social status. A higher number of young farmers in Bengal gram cultivation might be due to greater land ownership among these farmers, which made them perceive farming as more profitable than urban jobs, especially given limited employment opportunities. Similarly, the higher number of young farmers in soybean and red gram cultivation may be because young individuals with limited education and fewer urban job opportunities chose to remain in farming. Early transfer of farming responsibilities to younger generations may also explain the lower number of older farmers in soybean cultivation. Conversely, the higher number of older farmers in red gram might be due to small landholdings, which led their offspring to leave farming, while the older generation continued. The lower number of young farmers in paddy, cotton, and maize cultivation may be due to their offspring having higher educational qualifications, job aspirations, and access to better income opportunities in urbanized districts, prompting them to move away from agriculture (Bhambhoo 2013), (Ben Khadda *et al.*, 2021) and (Kemekar and Salunkhe, 2024b)

**3.1.2 Farming experience**

More than half (51.94%) of the farmers had a medium level of farming experience, followed by low (26.11%) and high (21.94%) levels of experience. No significant difference was found in farming experience among the farmer groups (Chi-square = 6.769, df = 5, *P = .24*), leading to the acceptance of the null hypothesis. Many individuals initially engaged in other occupations and settled into farming at a later stage. Lower farming experience might be due to the presence of young farmers in the field and others choosing farming at a later stage. Those farmers with higher age had been continuing in farming for decades; hence, they fell under the high experience category (Hothongcum *et al.* 2014) and (Hussain *et al.* 2017).

**3.1.3 Farm size**

Less than half (40.27%) of the farmers belonged to the small farm size category, followed by marginal (36.94%), semi-medium (17.50%), medium (4.44%), and large (0.83%) farm size categories. A significant difference was found in farm size among the farmer groups (Chi-square = 28.256, df = 5, *P =* .000), leading to the rejection of the null hypothesis. Multiple pairwise comparisons confirmed a statistically significant difference in farm size between red gram farmers compared to paddy (*P =* .004) and Bengal gram (*P =* .000), maize (*P =* .04) and soybean farmers (*P =* .02). Progressive land fragmentation due to inheritance laws might be one of the major reasons for the reduction in the proportion of medium and large holdings. Another reason could be the growing rural population preferring to live in nuclear families rather than the joint families that were prevalent earlier. Historical land distribution policies, tenancy systems, and socio-economic inequalities might also be reasons for this distribution. Additionally, the distribution of land to receive the benefits of government policies available for small and marginal farmers could be another factor. However, some farmers had semi-medium farm sizes, which they might have retained from their ancestors due to no land distribution over generations, purchasing new land, or leasing land from others (Dwivedi et al., 2020) and (Akter et al., 2023).

**3.1.4 Annual income**

Slightly less than half (47.50%) of the farmers had annual income above 2 lakh Rs., followed by 0.5 - 1 lakh Rs. (18.61%), 1 - 1.5 lakh Rs. (18.33%), 1.5 – 2 lakh Rs. (8.61%), and up to 0.5 lakh Rs. (6.94%) income. A significant difference was found in annual income among the farmer groups (Chi-square = 106.466, df = 5, *P =* .000), leading to the rejection of the null hypothesis. Multiple pairwise comparisons confirmed a statistically significant difference in annual income between cotton and red gram farmers compared to paddy (*P =* .000), maize (*P =* .000), and Bengal gram (*P =* .000) farmers, as well as between soybean farmers compared to maize (*P =* .03), Bengal gram (*P =* .04) and red gram (*P =* .000) farmers. This might be due to the farm size farmers hold and the net income earned by farmers of maize, Bengal gram and paddy farmers because of higher market price, available irrigation facilities, and cultivation of crops in two seasons. Some cotton farmers had low annual income, which might be due to lower yield, higher expenses, low market prices, lack of irrigation facilities (resulting in the cultivation of only one crop), and limited farm size. In the case of soybean, those with large farm sizes had very high annual incomes, while those with limited land had low, medium, or high incomes. Very few red gram farmers were found in the very low-income category due to the higher margin they earned per acre, as the market price is high and the cost of cultivation is low. However, most red gram farmers fell into the low-income category, possibly due to limited farm size (Verma, 2019), (Patidar, 2019) and (Kemekar and Salunkhe, 2024a).

**Table 1. Distribution of the farmers practicing fertilizer management in major field crops (n=360)**

|  |  |  |
| --- | --- | --- |
| **Variable** | **Categories** | **Farmer groups** |
| **Paddy****(n1=60)** | **Cotton****(n2=60)** | **Maize****(n3=60)** | **Red gram****(n4=60)** | **Soybean****(n5=60)** | **Bengal gram****(n6=60)** | **Overall****(n=360)** |
| **F****(%)** | **F****(%)** | **F****(%)** | **F****(%)** | **F****(%)** | **F****(%)** | **F****(%)** |
| **Age** | Young(Up to 35 Yr) | 8(13.33) | 7(11.67) | 10(16.67) | 14(23.33) | 15(25.00) | 16(26.67) | 70(19.44) |
| Middle(36-50 Yr) | 37(61.67) | 36(60.00) | 31(51.67) | 26(43.33) | 35(58.33) | 30(50.00) | 195(54.17) |
| Old(Above 50 Yr) | 15(25.00) | 17(28.33) | 19(31.67) | 20(33.33) | 10(16.67) | 14(23.33) | 95(26.39) |
| **Mean (**$\overbar{x}$**)****Rank** | 44.03(IV) | 46.23(II) | 47.20(I) | 45.93(III) | 42.75(VI) | 42.97(V) | 44.85 |
| **SD (**$σ$**)** | 8.82 | 9.28 | 10.32 | 11.63 | 8.98 | 10.88 | 10.11 |
| **Farming experience** | Low(3.00 - 17.00) | 10(16.67) | 20(33.33) | 11(18.33) | 16(26.67) | 19(31.67) | 18(30.00) | 94(26.11) |
| Medium(17.00 - 31.00) | 38(63.33) | 28(46.67) | 33(55.00) | 27(45.00) | 33(55.00) | 28(46.67) | 187(51.94) |
| High(31.00 - 45.00) | 12(20.00) | 12(20.00) | 16(26.67) | 17(28.33) | 8(13.33) | 14(23.33) | 79(21.94) |
| **Mean (**$\overbar{x}$**)****Rank** | 23.32(III) | 21.23(V) | 26.32(I) | 25.67(II) | 20.43(VI) | 23.02(IV) | 23.33 |
| **SD (**$σ$**)** | 8.48 | 9.28 | 9.47 | 11.61 | 8.68 | 10.69 | 9.93 |
| **Farm size** | Marginal | 17(28.33) | 21(35.00) | 19(31.67) | 39(65.00) | 24(40.00) | 13(21.67) | 133(36.94) |
| Small | 29(48.33) | 30(50.00) | 30(50.00) | 14(23.33) | 17(28.33) | 25(41.67) | 145(40.27) |
| Semi medium | 11(18.33) | 8(13.33) | 10(16.67) | 6(10.00) | 14(23.33) | 14(23.33) | 63(17.50) |
| Medium | 2(3.33) | 1(1.67) | 1(1.67) | 1(1.67) | 5(8.33) | 6(10.00) | 16(4.44) |
| Large | 1(1.67) | 0(0.00) | 0(0.00) | 0(0.00) | 0(0.00) | 2(3.33) | 3(0.83) |
| **Mean (**$\overbar{x}$**)****Rank** | 2.02(II) | 1.82(V) | 1.88(IV) | 1.48(VI) | 2.00(III) | 2.32(I) | 1.92 |
| **SD (**$σ$**)** | 0.87 | 0.72 | 0.74 | 0.75 | 0.99 | 1.03 | 0.89 |
| **Annual income** | Up to 0.5 lakh Rs. | 0(0.00) | 21(35.00) | 0(0.00) | 4(6.67) | 0(0.00) | 0(0.00) | 25(6.94) |
| 0.5-1 lakh Rs. | 4(6.67) | 15(25.00) | 0(0.00) | 35(58.33) | 12(20.00) | 1(1.67) | 67(18.61) |
| 1-1.5 lakh Rs. | 17(28.33) | 0(0.00) | 10(16.67) | 14(23.33) | 17(28.33) | 8(13.33) | 66(18.33) |
| 1.5-2 lakh Rs. | 3(5.00) | 1(1.67) | 9(15.00) | 1(1.67) | 6(10.00) | 11(18.33) | 31(8.61) |
| Above 2 lakh Rs. | 36(60.00) | 23(38.33) | 41(68.33) | 6(10.00) | 25(41.67) | 40(66.67) | 171(47.50) |
| **Mean (**$\overbar{x}$**)****Rank** | 4.18(III) | 2.83(V) | 4.52(I) | 2.50(VI) | 3.73(IV) | 4.50(II) | 3.71 |
| **Average Annual income (Rs.)** | 260354 | 146694 | 313034 | 115400 | 238694 | 417708 |  |
| **SD (**$σ$**)** | 1.07 | 1.80 | 0.77 | 1.02 | 1.21 | 0.79 | 1.40 |
| **Farm machinery possession** | Low(1.00 - 3.67) | 55(91.67) | 54(90.00) | 52(86.67) | 56(93.33) | 52(86.67) | 54(90.00) | 323(89.72) |
| Medium(3.67 - 6.33) | 0(0.00) | 2(3.33) | 4(6.67) | 0(0.00) | 1(1.67) | 2(3.33) | 9(2.50) |
| High(6.33 - 9.00) | 5(8.33) | 4(6.67) | 4(6.67) | 4(6.67) | 7(11.67) | 4(6.67) | 28(7.78) |
| **Mean (**$\overbar{x}$**)****Rank** | 2.58(III) | 2.27(V) | 3.05(I) | 1.72(VI) | 2.33(IV) | 2.70(II) | 2.45 |
| **SD (**$σ$**)** | 1.62 | 1.94 | 1.66 | 1.78 | 2.00 | 1.61 | 1.81 |
| **Risk taking ability** | Low(8.00 - 15.33) | 15(25.00) | 18(30.00) | 15(25.00) | 29(48.33) | 24(40.00) | 20(33.33) | 122(33.89) |
| Medium(15.33 - 22.67) | 26(43.33) | 24(40.00) | 25(41.67) | 25(41.67) | 25(41.67) | 23(38.33) | 150(41.67) |
| High(22.67 - 30.00) | 19(31.67) | 18(30.00) | 20(33.33) | 6(10.00) | 11(18.33) | 17(28.33) | 88(24.44) |
| **Mean (**$\overbar{x}$**)****Rank** | 19.65(II) | 18.98(III) | 20.55(I) | 16.03(VI) | 18.10(V) | 18.38(IV) | 18.62 |
| **SD (**$σ$**)** | 4.77 | 5.46 | 5.42 | 3.97 | 5.04 | 5.27 | 5.17 |
| **Environmental orientation** | Low(12.00 - 18.00) | 22(36.67) | 19(31.67) | 16(26.67) | 15(25.00) | 19(31.67) | 17(28.33) | 108(30.00) |
| Medium(18.00 - 24.00) | 20(33.33) | 18(30.00) | 19(31.67) | 21(35.00) | 19(31.67) | 18(30.00) | 115(31.94) |
| High(24.00 - 30.00) | 18(30.00) | 23(38.33) | 25(41.67) | 24(40.00) | 22(36.67) | 25(41.67) | 137(38.06) |
| **Mean (**$\overbar{x}$**)****Rank** | 21.03(V) | 20.75(VI) | 22.05(III) | 22.27(I) | 21.75(IV) | 22.17(II) | 21.67 |
| **SD (**$σ$**)** | 5.54 | 5.44 | 5.37 | 4.95 | 5.69 | 5.69 | 5.44 |
| **Health orientation** | Low(17.00 - 28.33) | 20(33.33) | 23(38.33) | 20(33.33) | 30(50.00) | 27(45.00) | 25(41.67) | 145(40.28) |
| Medium(28.33 - 39.67) | 15(25.00) | 19(31.67) | 17(28.33) | 20(33.33) | 21(35.00) | 20(33.33) | 112(31.11) |
| High(39.67 - 51.00) | 25(41.67) | 18(30.00) | 23(38.33) | 10(16.67) | 12(20.00) | 15(25.00) | 103(28.61) |
| **Mean (**$\overbar{x}$**)****Rank** | 34.95(II) | 33.42(III) | 35.55(I) | 30.65(VI) | 31.25(V) | 31.33(IV) | 32.86 |
| **SD (**$σ$**)** | 8.41 | 8.41 | 8.77 | 7.40 | 8.01 | 8.14 | 8.36 |
| **Confidence in fertilizer application** | Low(40.00 - 49.33) | 12(20.00) | 13(21.67) | 11(18.33) | 16(26.67) | 14(23.33) | 13(21.67) | 79(21.94) |
| Medium(49.33 - 58.67) | 22(36.67) | 23(38.33) | 21(35.00) | 23(38.33) | 22(36.67) | 23(38.33) | 134(37.22) |
| High(58.67 - 68.00) | 26(43.33) | 24(40.00) | 28(46.67) | 21(35.00) | 24(40.00) | 24(40.00) | 147(40.83) |
| **Mean (**$\overbar{x}$**)****Rank** | 57.05(I) | 55.73(IV) | 56.27(II) | 54.47(VI) | 55.08(V) | 56.13(III) | 55.79 |
| **SD (**$σ$**)** | 6.98 | 7.24 | 7.30 | 7.19 | 6.95 | 6.95 | 7.10 |
| **Government policies** | Low(3.00 - 4.33) | 14(23.33) | 15(25.00) | 13(21.67) | 16(26.67) | 15(25.00) | 16(26.67) | 89(24.72) |
| Medium(4.33 - 5.67) | 33(55.00) | 34(56.67) | 32(53.33) | 34(56.67) | 29(48.33) | 33(55.00) | 195(54.17) |
| High(5.67 - 7.00) | 13(21.67) | 11(18.33) | 15(25.00) | 10(16.67) | 16(26.67) | 11(18.33) | 76(21.11) |
| **Mean (**$\overbar{x}$**)****Rank** | 5.12(II) | 5.00(V) | 5.17(I) | 4.90(VI) | 5.02(IV) | 5.07(III) | 5.04 |
| **SD (**$σ$**)** | 0.92 | 0.86 | 0.92 | 0.92 | 0.97 | 0.95 | 0.92 |
| **Labour availability** | Low(35.00 - 43.33) | 34(56.67) | 12(20.00) | 30(50.00) | 24(40.00) | 20(33.33) | 9(15.00) | 129(35.83) |
| Medium(43.33 - 51.67) | 18(30.00) | 31(51.67) | 21(35.00) | 25(41.67) | 21(35.00) | 21(35.00) | 137(38.06) |
| High(51.67 - 60.00) | 8(13.33) | 17(28.33) | 9(15.00) | 11(18.33) | 19(31.67) | 30(50.00) | 94(26.11) |
| **Mean (**$\overbar{x}$**)****Rank** | 45.00(V) | 47.62(II) | 44.37(VI) | 46.18(IV) | 46.98(III) | 50.50(I) | 46.78 |
| **SD (**$σ$**)** | 4.90 | 4.54 | 6.67 | 4.72 | 5.04 | 5.56 | 5.62 |
| **Irrigation intensity** | Low(0.00 - 66.67) | 0(0.00) | 36(60.00) | 0(0.00) | 57(95.00) | 48(80.00) | 0(0.00) | 141(39.17) |
| Medium(66.67-33.33) | 0(0.00) | 16(26.67) | 0(0.00) | 0(0.00) | 4(6.67) | 49(81.67) | 69(19.17) |
| High(133.33-200) | 60(100) | 8(13.33) | 60(100) | 3(5.00) | 8(13.33) | 11(18.33) | 150(41.67) |
| **Mean (**$\overbar{x}$**)****Rank** | 200.00(I) | 53.33(IV) | 200.00(I) | 10.00(VI) | 33.33(V) | 113.05(III) | 101.62 |
| **SD (**$σ$**)** | 0.00 | 72.41 | 0.00 | 43.96 | 70.51 | 27.50 | 89.16 |
| **Cropping pattern** | One crop | 0(0.00) | 36(60.00) | 0(0.00) | 47(78.33) | 0(0.00) | 0(0.00) | 83(23.06) |
| Two crops | 60(100) | 24(40.00) | 60(100) | 13(21.67) | 60(100) | 60(100) | 277(76.94) |
| **Mean (**$\overbar{x}$**)****Rank** | 2.00 | 1.43 | 2.00 | 1.22 | 2.00 | 2.00 | 1.78 |
| **SD (**$σ$**)** | 0.00 | 0.50 | 0.00 | 0.42 | 0.00 | 0.00 | 0.42 |
| **Cropping intensity** | Low(100.00 - 133.33) | 0(0.00) | 0(0.00) | 0(0.00) | 47(78.33) | 36(60.00) | 0(0.00) | 83(23.06) |
| Medium(133.33 - 166.67) | 0(0.00) | 0(0.00) | 0(0.00) | 0(0.00) | 0(0.00) | 0(0.00) | 0(0.00) |
| High(166.67 - 200.00) | 60(100) | 60(100) | 60(100) | 13(21.67) | 24(40.00) | 60(100) | 277(76.94) |
| **Mean (**$\overbar{x}$**)****Rank** | 200.00(I) | 140.00(V) | 200.00(I) | 118.33(VI) | 200.00(I) | 200.00(I) | 176.39 |
| **SD (**$σ$**)** | 0.00 | 49.40 | 0.00 | 39.02 | 49.40 | 0.00 | 42.52 |

**3.1.5 Farm machinery possession**

Majority (89.72%) of the farmers had a low level of farm machinery possession, followed by high (7.78%) and medium (2.50%) levels of possession. A significant difference was found in farm machinery possession among the farmer groups (Chi-square = 84.345, df = 5, *P =* .000), leading to the rejection of the null hypothesis. Multiple pairwise comparisons confirmed a statistically significant difference in farm machinery possession between red gram farmers compared to paddy (*P =* .000), maize (*P =* .000), Bengal gram (*P =* .000), soybean (*P =* .03) and cotton farmers (*P =* .02), as well as between soybean farmers compared to maize (*P =* .000) and Bengal gram (*P =* .01) farmers and between cotton farmers compared to maize (*P =* .000) and Bengal gram (*P =* .02) farmers. It might be because nearly 5 per cent of the farmers had owned tractors across all crops. Since they owned tractors, they also owned MB plough, cultivator, rotavator, seed cum fertilizer drill, threshers and cage wheels, hence they fell into high category. Most of them had owned only power/knapsack sprayers and water pumps if they had irrigation which is why they fell under low category. Along with sprayer and pump set those who had either sprinkler or drip fell under medium category (Patidar, 2019).

**3.1.6 Risk taking ability**

More than two fifths (41.67%) of the farmers had a medium level of risk taking ability, followed by low (33.89%) and high (24.44%) levels of risk taking ability. A significant difference was found in risk-taking ability among the farmer groups (Chi-square = 25.909, df = 5, *P =* .000), leading to the rejection of the null hypothesis. Multiple pairwise confirmed a statistically significant difference in risk-taking ability between red gram farmers compared to paddy (*P =* .002) and maize (*P =* .000) farmers. Most of the maize, paddy, cotton and Bengal gram farmers had medium to higher risk taking ability. The factors contributing to this behaviour might be the annual incomes of the farmers, supported by higher net income from the crops grown, extension contact, scientific orientation, irrigation facilities, farm size, economic motivation, and education levels of the farmers. Similarly, a low to medium level of risk taking ability is observed among red gram and soybean farmers. This might be due to lower annual income because of limited land size (red gram), or lower net income from the crops grown (soybean), lower scientific orientation, lower economic motivation, limited or no irrigation facilities, limited credit facilities, lower education levels, and medium to low levels of extension contact (Chavai et al., 2015) and (Sunitha, 2014).

**3.1.7 Environmental orientation**

More than one third (38.06%) of the farmers had a high level of environmental orientation, followed by medium (31.94%) and low (30.00%) levels of environmental orientation. No significant difference was found in environmental orientation among the farmer groups (Chi-square = 4.568, df = 5, *P =* .47), leading to the acceptance of the null hypothesis. This might be due to their primary occupation in agriculture; ownership of cattle and bullocks; dependence on farming, animal husbandry, and allied activities; the presence of farm animal waste; living in close proximity with strong personal relationships; a simpler and traditional lifestyle; limited influence of modern technology and fashion; and being governed by strong rural customs, traditions, and age-old practices. Other contributing factors may include a higher influence of religion, fairs, festivals, and rituals; a community-centric way of living; strong attachment to tradition; and resistance to modern influences. Contrary to this, even with a higher environmental orientation, farmers have not demonstrated acceptable behaviour in fertilizer management. This may be due to limited resources, infrastructural facilities, knowledge, education, and scientific orientation, as well as resistance to adopting recommendations from the scientific community. Such resistance is often rooted in their vast farming experience, strong self-belief in their traditional practices, and previous unsatisfactory experiences with extension agencies (Rejula, 2015) and (Adu et al., 2021).

**3.1.8 Health orientation**

More than two fifths (40.28%) of the farmers had a low level of health orientation, followed by medium (31.11%) and high (28.61%) levels of health orientation. A significant difference was found in health orientation among the farmer groups (Chi-square = 16.956, df = 5, *P =* .005), leading to the rejection of the null hypothesis. Further, multiple pairwise comparisons confirmed a statistically significant difference in health orientation between red gram farmers compared to maize (*P =* .03) farmers. This might be due to a lack of consciousness, attentiveness, and concern among the farmers about their health. Moreover, they might not be paying attention to their physical health throughout the day, being less responsible for their health status, and only giving it importance when they were sick. There also seems to be a lack of realization that health depends on how well they take care of it, as well as a lack of commitment towards maintaining good health. Further, those who showed concern, awareness, and consciousness fell under the medium to high health orientation categories (Zhang et al., 2023).

**Table 2.** **Pairwise comparison of farmer groups on independent variables based on mean rank as per Kruskal-Wallis test**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Independent variables**  | **Farmer groups** | **Mean rank** | **P** | **C** | **M** | **R** | **S** | **B** |
| **Age** *χ2 (5) = 6.920 NS, P = .23* |
| **Farming experience** *χ2 (5) = 6.769, P = .24* |
| **Farm size***χ2 (5)=28.256,* *P = .000* | Paddy | 193.02 |  |  |  |  |  |  |
| Cotton | 173.61 |  |  |  |  |  |  |
| Maize | 181.71 |  |  |  |  |  |  |
| Red gram | 128.44 | \*\* |  | \* |  | \* | \*\* |
| Soybean | 186.63 |  |  |  |  |  |  |
| Bengal gram | 219.60 |  |  |  |  |  |  |
| **Annual income***χ2 (5) =106.466,**P = .000* | Paddy | 213.19 |  |  |  |  |  |  |
| Cotton | 127.62 | \*\* |  | \*\* |  |  | \*\* |
| Maize | 234.93 |  |  |  |  |  |  |
| Red gram | 94.97 | \*\* |  | \*\* |  |  | \*\* |
| Soybean | 179.34 |  |  | \* | \*\* |  | \* |
| Bengal gram | 232.95 |  |  |  |  |  |  |
| **Farm machinery possession** *χ2 (5)=84.345,* *P = .000* | Paddy | 203.16 |  |  |  |  |  |  |
| Cotton | 159.91 |  |  | \*\* |  |  | \* |
| Maize | 246.15 |  |  |  |  |  |  |
| Red gram | 100.92 | \*\* | \* | \*\* |  | \* | \*\* |
| Soybean | 155.94 |  |  | \*\* |  |  | \*\* |
| Bengal gram | 216.93 |  |  |  |  |  |  |
| **Risk taking ability***χ2 (5)=25.909,* *P = .000* | Paddy | 202.95 |  |  |  |  |  |  |
| Cotton | 185.48 |  |  |  |  |  |  |
| Maize | 218.48 |  |  |  |  |  |  |
| Red gram | 129.99 | \*\* |  | \*\* |  |  |  |
| Soybean | 169.88 |  |  |  |  |  |  |
| Bengal gram | 176.23 |  |  |  |  |  |  |
| **Environmental orientation** *χ2 (5) = 4.568, P = .47* |
| **Health orientation***χ2 (5)=16.956,* *P = .005* | Paddy | 207.03 |  |  |  |  |  |  |
| Cotton | 187.83 |  |  |  |  |  |  |
| Maize | 209.98 |  |  |  |  |  |  |
| Red gram | 151.89 |  |  | \* |  |  |  |
| Soybean | 162.19 |  |  |  |  |  |  |
| Bengal gram | 164.08 |  |  |  |  |  |  |
| **Confidence in fertilizer application** *χ2 (5) = 4.932, P = .42* |
| **Government policies** *χ2 (5) = 2.009, P = .85* |
| **Labour availability***χ2 (5)=43.532,* *P = .000* | Paddy | 145.38 |  |  |  |  |  | \*\* |
| Cotton | 199.26 |  |  |  |  |  |  |
| Maize | 137.83 |  | \* |  |  |  | \*\* |
| Red gram | 169.77 |  |  |  |  |  | \*\* |
| Soybean | 184.78 |  |  |  |  |  | \* |
| Bengal gram | 245.98 |  |  |  |  |  |  |
| **Irrigation intensity***χ2 (5) = 264.817,* *P = .000* | Paddy | 289.50 |  |  |  |  |  |  |
| Cotton | 127.87 | \*\* |  | \*\* |  |  | \* |
| Maize | 289.50 |  |  |  |  |  |  |
| Red gram | 81.92 | \*\* |  | \*\* |  |  | \*\* |
| Soybean | 107.07 | \*\* |  | \*\* |  |  | \*\* |
| Bengal gram | 187.07 | \*\* |  | \*\* |  |  |  |
| **Cropping pattern***χ2 (5) = 216.506,* *P = .000* | Paddy | 221.00 |  |  |  |  |  |  |
| Cotton | 119.00 | \*\* |  | \*\* |  | \*\* | \*\* |
| Maize | 221.00 |  |  |  |  |  |  |
| Red gram | 80.00 | \*\* |  | \*\* |  | \*\* | \*\* |
| Soybean | 221.00 |  |  |  |  |  |  |
| Bengal gram | 221.00 |  |  |  |  |  |  |
| **Cropping intensity***χ2 (5) = 229.714,* *P = .000* | Paddy | 223.00 |  |  |  |  |  |  |
| Cotton | 115.00 | \*\* |  | \*\* |  | \*\* | \*\* |
| Maize | 223.00 |  |  |  |  |  |  |
| Red gram | 76.00 | \*\* |  | \*\* |  | \*\* | \*\* |
| Soybean | 223.00 |  |  |  |  |  |  |
| Bengal gram | 223.00 |  |  |  |  |  |  |
| *\*\*Significance at 0.05 level of probability, \*Significance at 0.01 level of probability**P = Paddy, C = Cotton, M = Maize, R = Red gram S = Soybean, B= Bengal gram* |

**3.1.9 Confidence in fertilizer application**

More than two fifths (40.83%) of the farmers had a high level of confidence in fertilizer application, followed by medium (37.22%) and low (21.94%) levels of confidence. No significant difference was found in confidence in fertilizer application among the farmer groups (Chi-square = 4.932, df = 5, *P =* .42), leading to the acceptance of the null hypothesis. This might be because of their ability to uniformly spread fertilizers, broadcast fertilizers, band/place fertilizers, dispense fertilizers with a bullock-drawn applicator, cover a certain number of rows, prepare solutions, operate a knapsack sprayer proficiently, operate a power-operated sprayer, cover the top foliage effectively, and adjust the fertilizer dose for fertigation. However, the disparity in fertilizer management, even with high confidence in application, might be because the farmers are skilled in fertilizer application but lack knowledge about other fertilizer management practices (Panchal, 2011).

**3.1.10 Government policies**

More than half (54.17%) of the farmers had a medium level of benefit from government policies, followed by low (24.72%) and high (21.11%) levels of benefit. No significant difference was found in benefits from government policies among the farmer groups (Chi-square = 2.009, df = 5, *P =* .85), leading to the acceptance of the null hypothesis. This might be because most of the farmers had received benefits from PM-Kisan, Rythu Bandhu, Rythu Bima, and the Nutrient Based Subsidy scheme. Some of the farmers additionally received benefits from the Soil Health Card scheme, PM Kisan Mandhan Yojana, round-the-clock power supply to farmers, and MNREGA, which is why they fell under the high category. Those who did not receive benefits from some of the above schemes fell under the low category (Naik, 2016) and (Tripathi, 2023).

**3.1.11 Labour availability**

More than one third (38.06%) of the farmers had a medium level of labour availability, followed by low (35.83%) and high (26.11%) levels of labour availability. A significant difference was found in labour availability among farmer groups (Chi-square = 43.532, df = 5, *P =* .000), leading to the rejection of the null hypothesis. Further, multiple pairwise comparisons confirmed a statistically significant difference in labour availability between Bengal gram farmers compared to paddy (*P =* .000), maize (*P =* .000), red gram (*P =* .001) and soybean (*P =* .02) farmers, as well as between maize and cotton (*P =* .02) farmers. Those farmers who had a sufficient quantity of labour and timely availability fell under the high category. In the case of Bengal gram, higher labour availability was due to the presence of labourers in their locality and other labourers who migrated to their area for employment during important cotton operations. Farmers who had either moderately sufficient quantities of labour or 3–5 days delayed availability fell under the medium level of labour availability category, which was observed in the case of all crops. Those who had sufficient to moderately sufficient quantities of labour with 5–7 days delayed labour availability had a low level of labour availability. This was seen in the case of paddy, maize, and red gram crops, where labour availability in their villages was limited. Members from other farm families were not willing to work as labourers on others’ farms due to higher workloads and higher annual incomes. In the case of red gram, limited farm size and a limited number of farmers in the villages restricted labour availability. Because of the limited quantity of labour in the areas cultivating these three crops, the demand for labour was high, and supply was low, which resulted in delayed availability and a hike in labour charges (Verma, 2016).

**3.1.12 Irrigation intensity**

More than two fifths (41.67%) of the farmers had a high level of irrigation intensity, followed by low (39.17%) and medium (19.17%) levels of irrigation intensity. A significant difference was found in irrigation intensity among the farmer groups (Chi-square = 264.817, df = 5, *P =* .000), leading to the rejection of the null hypothesis. Multiple pairwise comparisons confirmed a statistically significant difference in irrigation intensity between red gram (*P =* .000), soybean (*P =* .000) and cotton (*P =* .000) farmers compared to paddy, maize, and Bengal gram farmers, as well as between Bengal gram farmers (*P =* .000) compared to paddy and maize farmers. This might be because all of the maize and paddy farmers had high irrigation intensity, as they cultivated paddy + paddy or paddy + maize. Paddy requires irrigation throughout the season, and maize, which was grown in the rabi season, also required irrigation. Meanwhile, all the Bengal gram farmers cultivated Bengal gram with irrigation and grew soybean in the kharif season, but only some of them provided irrigation for soybean. Hence, they fell under the medium irrigation intensity category. Those cotton, soybean, and red gram farmers who had no irrigation facility fell under the low irrigation intensity category. Of the remaining farmers, those who irrigated for two seasons fell under the high category, while those who irrigated only in the rabi season fell under the medium category. All of these factors contributed to the overall distribution of farmers (Vaish, 2019).

**3.1.13 Cropping pattern**

Majority (76.94%) of the farmers followed a two crop pattern, while the remaining (23.06%) followed a one crop pattern. A significant difference was found in cropping pattern among the farmer groups (Chi-square = 216.506, df = 5, *P =* .000), leading to the rejection of the null hypothesis. Multiple pairwise comparisons confirmed a statistically significant difference in cropping pattern between red gram (*P =* .000) and cotton farmers (*P =* .000) compared to all other farmer groups. The reason for these results might be the short duration of paddy, maize, soybean, and Bengal gram crops. Except for some soybean farmers, other farmers had irrigation facilities, which allowed them to cultivate crops in two seasons. Soybean farmers without irrigation facilities cultivated rabi crops without irrigation. In contrast, red gram and cotton crops require a longer duration for maturity, and many of the farmers did not have irrigation facilities, which is why they restricted themselves to only one crop. Those cotton farmers who had irrigation cultivated paddy in the rabi season, while red gram farmers cultivated red gram, sorghum, or groundnut in the rabi season. All of these factors together contributed to the overall distribution (Patil, 2013) and (Patidar, 2019).

**3.1.14 Cropping intensity**

Overall, majority (76.94%) of the farmers had a high level of cropping intensity, followed by low (23.06%), with no farmers in the medium category. A significant difference was found in the cropping intensity among the farmer groups at the 0.01 level of probability (Chi-square = 229.714, df = 5, *P =* .000), leading to the rejection of the null hypothesis. These results confirmed a statistically significant difference in the cropping intensity between red gram (*P =* .000) and cotton (*P =* .000) farmers compared to all other farmer groups. The reasons for cropping intensity results were same as discussed in cropping pattern variable (Patil, 2013) and (Dahiwade, 2018).

**3.2 Relationship between profile characteristics of farmers and their fertilizer management practices**

The correlation coefficient of fourteen variables of the overall farmers with their fertilizer management is furnished in Table 3. The data presented in Table 3 indicated that farm size (0.1247\*), annual income (0.1571\*\*), risk taking ability (0.3345\*\*), and irrigation intensity (0.2630\*\*) were found positive and highly significant with fertilizer management of farmers. Further, farming experience (0.1091\*) was found positive and significant.

**Table 3. Correlation analysis of determinants with fertilizer management of farmers (n=360)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Determinants** | **Paddy** **(*r*)** | **Cotton** **(*r*)** | **Maize** **(*r*)** | **Red gram (*r*)** | **Soybean (*r*)** | **Bengal gram (*r*)** | **Overall** **(*r*)** |
| Age | -0.0762NS | -0.0949NS | -0.0280NS | 0.0785NS | -0.0730NS | -0.2011NS | 0.0264NS |
| Farming experience | 0.1060NS | 0.1726NS | 0.0162NS | 0.0062NS | 0.0518NS | 0.0025NS | 0.1091\* |
| Farm size | 0.0845NS | 0.3605\*\* | 0.2492NS | 0.4148\*\* | 0.2614\* | 0.3510\*\* | 0.1247\* |
| Annual income | 0.4044\*\* | 0.3642\*\* | 0.3708\*\* | 0.4340\*\* | 0.0965NS | 0.1826NS | 0.1571\*\* |
| Farm machinery possession | 0.0810NS | 0.0804NS | 0.1003NS | 0.1178NS | 0.0661NS | 0.0171NS | 0.0658NS |
| Risk taking ability | 0.4243\*\* | 0.4190\*\* | 0.4656\*\* | 0.3258\* | 0.2793\* | 0.2567\* | 0.3345\*\* |
| Environmental orientation | 0.0587NS | 0.0913NS | 0.0553NS | 0.0687NS | 0.0902NS | 0.0397NS | 0.0402NS |
| Health orientation | 0.0301NS | 0.0182NS | 0.0009NS | 0.0413NS | 0.0013NS | 0.0475NS | 0.1022NS |
| Confidence in fertilizer application | 0.0792NS | 0.0784NS | 0.0566NS | 0.0789NS | 0.0146NS | 0.0536NS | 0.0684NS |
| Government policies | 0.1106NS | 0.0594NS | 0.0589NS | 0.0894NS | 0.0877NS | 0.0494NS | 0.0711NS |
| Labour availability | 0.1443NS | 0.0564NS | 0.0781NS | 0.0282NS | 0.0887NS | 0.0741NS | -0.0911NS |
| Irrigation intensity | NA | 0.3504\*\* | NA | 0.2085NS | 0.0435NS | 0.0303NS | 0.2630\*\* |
| Cropping pattern | NA | 0.3434\*\* | NA | 0.1909NS | NA | NA | -0.0522NS |
| Cropping intensity | NA | 0.3452\*\* | NA | 0.1620NS | NA | NA | -0.0645NS |

\*NA = Correlation not computed due to zero variance in one or both variables.

While, variables like age (0.0264NS), farm machinery possession (0.0658NS), environmental orientation (0.0402NS), health orientation (0.1022NS), confidence in fertilizer application (0.0684NS) and government policies (0.0711NS) were found to have positive but non-significant association. Labour availability (-0.0911NS), cropping pattern (-0.0522NS) and cropping intensity (-0.0645NS) were found to have negative but non-significant association (kemekar and Salunkhe, 2023),(Sarada and Suneel Kumar, 2013), (Waghmode *et al.,* 2020), (Akomdo *et al.,* 2023), (Dessie *et al.,* 2023) and (Rakesh and Naik, 2023).

4. Conclusion

From the above results, it can be concluded that the socio-economic and psychological characteristics of farmers significantly influence their fertilizer management practices. Specifically, factors such as farm size, annual income, and risk-taking ability emerged as key determinants that positively impact the efficiency and effectiveness of fertilizer use. Larger farm sizes often allow for better resource allocation and access to modern inputs, while higher income levels enhance the capacity to invest in quality fertilizers and adopt scientific recommendations. Likewise, farmers with greater risk-taking ability are more open to adopting improved fertilizer management techniques, thereby potentially achieving better crop productivity and soil health. These findings underscore the importance of recognizing farmer heterogeneity when designing agricultural extension programs and policy interventions. A one-size-fits-all approach may not be effective, given the diverse economic conditions, psychological orientations, and resource access across farming communities. Therefore, targeted strategies, such as customized training modules, income-based input subsidies, and psychological empowerment initiatives should be developed to cater to the specific needs of different farmer groups. Such tailored interventions can promote more judicious and sustainable use of fertilizers, reduce environmental degradation, and ultimately improve agricultural output and farm profitability. Moreover, integrating behavioural and socio-economic factors into policy planning can lead to more inclusive and impactful agricultural development strategies.

**Consent**

As per international standards or university standards, respondents’ written consent has been collected and preserved by the author(s).

Disclaimer (Artificial intelligence)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1. ChatGPT, GPT-4o, input prompt ( identify grammatical mistakes and correct it without changing original structure of the paragraph)

References

Adu, I. K., Puthenkalam, J. J., & Antwi, E. K. (2021). Environmental generation framework: case of environmental awareness among farmers and senior high school students for sustainable development. Research Square, 1-25. <https://doi.org/10.21203/rs.3.rs-196540/v1>

Akomdo, C., Bakang, J-E. A., Tham-Agyekum, E. K., Akese, I., Oye, S., Yankyerah, O. K., & Prah, S. (2023). Adoption of good agronomic practices by tomato farmers in rural Ghana: an application of the unified theory of acceptance and use of technology. Agricultural Socio-Economics Journal, 23(2), 185–197. [https://doi.org/10.21776/ ub.agrise.2023.023.2.8](https://doi.org/10.21776/%09ub.agrise.2023.023.2.8)

Akter, S., Rahman, S., Sojib, M. R., & Sheheli, S. (2023). Knowledge of Farmers on Integrated Soil Fertility Management in Selected Areas of Mymensingh Sadar Upazila, Mymensingh District, Bangladesh. Asian Journal of Agricultural Extension, Economics & Sociology, 41(11), 211–227. [https://doi.org/10.9734/ajaees/2023/v41i1 12278](https://doi.org/10.9734/ajaees/2023/v41i1%0912278)

Ben Khadda, Z., Fagroud, M., Karmoudi, Y. El., Ezrari, S., Berni, I., De Broe, M., Behl, T., Bungau, S. G., & Houssaini, T. S. (2021). Farmers’ knowledge, attitudes, and perceptions regarding carcinogenic pesticides in fez meknes region (Morocco). International Journal of Environmental Research and Public Health, 18, 1-18. <https://doi.org/10.3390/ijerph182010879>

Bhambhoo, P. K. (2013). Fertilizer use behaviour of cotton growers in Rajsamand district of Rajasthan. M. Sc. Thesis. Maharana Pratap University of Agriculture and Technology, Udaipur, India.

Bora, K. (2022). Spatial patterns of fertilizer use and imbalances: Evidence from rice cultivation in India*.* Environmental Challenges, 7, 100452. <https://doi.org/10.1016/j.envc.2022.100452>

Chavai, A. M., Yamgar, A. S., & Barange, P. K. (2015). Adoption behaviour of turmeric growers about post harvest technology. International Journal of Tropical Agriculture, 33(2), 1647-1651.

Dahiwade, P. M. (2018). Economic analysis of fertilizer use in Maharashtra. *Ph. D. Thesis.* Mahatma Phule Krishi Vidyapeeth, Rahuri, India.

Department of Agriculture, Government of Telangana. (2022). Agriculture Action Plan 2021-22. <https://agri.telangana.gov.in/open_record_view.php?ID=959>

Dessie, A. B., Mekie, T. M., Abate, T. M., Belgu, A. S., Zeleke, M. A., Eshete, D. G., Atinkut, H. B., & Takele, M. T. (2023). Measuring integrated smallholder soil fertility management practices in Megech watershed, Tana sub-basin, Ethiopia. Heliyon, 9, 1-12. <https://doi.org/10.1016/j.heliyon.2023.e16256>

Directorate of Economics and Statistics, Government of India. (2022)*.* Agricultural Statistics at a Glance 2021. [https://desagri.gov.in/wp-content/uploads/2021/07/Agricultural-Sta tistics-at-a-Glance-2021-English-version.pdf](https://desagri.gov.in/wp-content/uploads/2021/07/Agricultural-Sta%09tistics-at-a-Glance-2021-English-version.pdf)

Dwivedi, S., Sharma, S., Kachroo, J., & Isher, A. K. 2020. A comparative study on farmers buying pattern towards chemical and bio fertilizers. Agro Economist - An International Journal, 7(2), 159-162. <https://doi.org/10.30954/2394-8159.02.2020.12>

Hothongcum, K., Suwunnamek, O., & Suwanmaneepong, S. (2014). Assessment of farmers’ knowledge and attitude towards the commercialization of tailor-made fertilizers in Thailand. Asian Journal of Scientific Research, 7(3), 354-365. [https://doi.org/10. 3923/ajsr.2014.354.365](https://doi.org/10.%093923/ajsr.2014.354.365)

Hussain, Md. A., Hossain, Md. Z., & Islam, Md. M. (2017). Farmers' perception regarding effect of chemical fertilizer application on soil health. Bangladesh journal of soil science, 39(1), 35-41.

Kemekar P., & Salunkhe. S. R. (2023). Adoption of Farmer FIRST Programme beneficiaries about demonstrated technologies. Gujarat Journal of Extension Education, 35(2), 40-43. [https://doi.org/10.56572/gjoee.2023.35.2.0009](https://www.gjoee.org/papers/1447.pdf)

Kemekar, P., & Salunkhe, S. R. (2024a). Attitude of Navsari Agricultural University students towards application of distance education. International Journal of Agriculture Extension and Social Development, 7(9), 218-222. <https://doi.org/10.33545/26180723.2024.v7.i9d.1034>

Kemekar, P., & Salunkhe, S. R. (2024b). Profile and constraints faced by the beneficiaries of Farmer FIRST Programme. International Journal of Agriculture Extension and Social Development, 7(9), 155-160 <https://doi.org/10.33545/26180723.2024.v7.i9c.1044>

Naik, S. (2016). A study on Pradhan Mantri Jan Dhan Yojana (PMJDY) in Uttara Kannada district, Karnataka. *MBA Thesis.* University of Agricultural Sciences, Bangalore, India.

Panchal, A. G. (2011). Performance of skills in artificial insemination process by inseminators at village level artificial insemination centers. *M. V. Sc. Thesis.* Anand Agricultural University, Anand, India.

Patidar, V. (2019. A study on adoption of recommended bio-fertilizers technologies among soybean growers in Ujjain District of M. P. *M. Sc. Thesis.* Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, India.

Patil, A. S. (2013). Adoption of soil test recommendations by the farmers. *M. Sc. Thesis*. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, India.

Rakesh , K., & Naik , R. M. (2023). Knowledge Level of Farmers towards Use of Private Bio-fertilizers. Journal of Scientific Research and Reports, 29(10), 67–70. [https://doi.org/ 10.9734/jsrr/2023/v29i101798](https://doi.org/%0910.9734/jsrr/2023/v29i101798)

Rejula, K. (2015). A Multidimensional Analysis of Rice Farming and Related Agro Ecosystems in Kerala. *Ph. D. Thesis.* Indian Agricultural Research Institute, New Delhi, India.

Sarada, O., & Suneel Kumar, G. V. (2013). Knowledge and adoption of rice farmers on integrated nutrient management practices of rice. The Andhra Agricultural Journal, 60(1), 207-212.

Srinivasarao, C. (2021). Programmes and Policies for Improving Fertilizer Use Efficiency in Agriculture. Indian Journal of Fertilisers, 17(3), 226-254.

Sunitha, A. B. (2019). Sustainability of farming systems in selected agro-climatic zones of Karnataka. *Ph. D. Thesis.* University of Agricultural Sciences, Bengaluru, India.

Tripathi, V. (2023). Knowledge and utilization of selected government schemes by the rural women of Udaipur district, Rajasthan. *M. Sc. Thesis.* Maharana Pratap University of Agriculture and Technology, Udaipur, India.

Vaish, M. G. (2019). Awareness and attitude of farmers towards bio-fertilizer in Junagadh and Gir-Somnath districts. *MBA Thesis.* Junagadh Agricultural University, Junagadh, India.

Verma, A. K. (2019). Study on knowledge and adoption of organic fertilizers among the farmers Ailiya block of Sitapur district (Uttar Pradesh). *M. Sc. Thesis.* Narendra Deva University of Agriculture & Technology, Ayodhya, India.

Verma, N. (2016). Scarcity of labour in commercial farming: a study of Kot-beja panchayat, Kasauli tehsil Himachal Pradesh. *MBA Thesis.* Dr. Yashwant Singh Parmar University of Horticulture & Forestry, Solan, India.

Waghmode, S. S., Shelake, P. N., & Vidhate, U. A. (2020). Growth and determinants of fertilizer use in India- An economic analysis, Special Issue-11,1730-1737.

Zhang, H., Yang, Z., Wang, Y., Twumasi, M. A., & Chandio, A. A. 2023. Impact of agricultural mechanization level on farmers’ health status in Western China: Analysis based on CHARLS data. International Journal of Environmental Research and Public Health, 20, 1-20.  <https://doi.org/10.3390/ijerph20054654>