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Canonical Correlation Among Paddy Growers' Soil Health Card Knowledge Perception and Adoption in Andhra Pradesh

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HIGHLIGHTS

- The study explores the relationships between paddy growers' knowledge, perception of Soil Health Cards (SHCs), and their adoption practices.
- Canonical correlation analysis uncovers connections between growers' comprehension of SHCs, perspectives, and degree to which they put suggestions into practice.
- Findings suggest that enhancing knowledge and medium perceptions about SHCs may improve adoption rates among paddy growers.

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ABSTRACT

The research employs canonical correlation analysis to explore the interplay between Soil Health Card (SHC) knowledge, perception, and adoption among paddy growers in North Coastal Andhra Pradesh for the years 2023-2024. Effective paddy cultivation demands careful management throughout all stages—from transplanting to post-harvest—tailored to local conditions. In response to soil degradation and the need for improved agricultural productivity, the Gujarat administration launched the Soil Health Card initiative. This study aims to reveal the relationships and factors influencing SHC utilization in the region. By examining these variables, the research seeks to enhance agricultural practices and promote sustainable farming. The findings will provide valuable insights for authorities, rural extension centres, and other stakeholders involved in SHC programs. Understanding the factors that drive or hinder SHC adoption will help develop targeted strategies to increase awareness, shift perceptions, and encourage broader implementation among paddy growers. Ultimately, this research supports the goal of advancing soil health management practices and fostering agricultural sustainability in Andhra Pradesh.

INTRODUCTION

Soil is a crucial element in farming, providing essential nutrients to plants. Soil health is vital for agriculture production, promoting ecological practices, efficient fertilizer use, and minimizing waste (Patel et al., 2017). India aims to boost agricultural output through sustainable improvements in crop and soil quality. Rice (*Oryza sativa*) is a staple food for over half of the world's population, grown in more than 100 countries, with Asia accounting for 90 per cent of global output. Rice is rich in carbohydrates, thiamine, calcium, iron, folate, vitamin B5, vitamin E, and other essential nutrients. The careless application of chemical fertilizers has degraded soil health, reduced biodiversity, and decreased fertilizer usage efficiency (crop: nutrient response ratio dropped to 8.59 in 2009–10 from 14.06 in 1990–91). This also leads to environmental pollution. Sustainable soil fertility management based on soil testing can optimize fertilizer usage, addressing these issues. Soil degradation is a major challenge for modern agriculture, impacting food production, biodiversity, and climate change. Healthy soils, which produce healthy crops, are essential for food security and

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environmental sustainability (Kaur et al., 2020). Soil quality supports human health and habitation by performing functions like carbon alteration, nutrient cycling, and pest control (Babu et al., 2021; Kibblewhite et al., 2007). Historically, excessive use of manures, reduced use of plant resources, and neglect of micronutrients have depleted soil nutrients. The farming community's understanding of soil fertility management is limited, and soil test-based fertilizer use is influenced by various factors (Chowdary et al., 2017). Soil testing is a vital, accessible method for assessing soil nutrient levels (Neufeld et al., 2006). To promote soil testing, the Indian government launched the Soil Health Card (SHC) scheme on February 19, 2015, supported by the Ministry of Agriculture and Farmers' Welfare (Ghaswa et al., 2019). This initiative encourages farmers to adopt soil testing and balanced fertilizer use, aiming to improve crop yields at reduced costs. The SHC provides detailed chemical analysis of soil, informing farmers about optimal nutrient levels for their crops (Veeraiah et al., 2019). The SHC scheme brings together agricultural experts, advanced tools, farmers, and the government to enhance the overall economic well-being (Patel et al., 2019). It promotes sustainable soil health and enhances the farm economy by effectively using SHC recommendations. This tool helps farmers monitor and improve soil health, enabling them to apply fertilizers tailored to their soil and crop needs (Bordoloi and Das, 2017). Understanding soil health management is crucial for the long-term viability of climate-smart agricultural practices (Xue et al., 2019).

Canonical correlation analysis (CCA) is a statistical method used to evaluate the linear relationship between two sets of multidimensional variables, identifying optimized bases for each variable in terms of correlations (Sahoo et al., 2024). It determines correlations that remain unchanged under internal linear transformations. CCA measures the strength of associations, offering insights into factors impacting the knowledge, perception, and adoption of the SHC by paddy growers (Hotelling, 1992; Helmer et al., 2024).

METHODOLOGY

A study was carried out in the districts of Srikakulam and Vizianagaram in Andhra Pradesh, specifically selected for this research. Employing the simple random sampling method, 3 mandals are selected from each district, with two villages chosen within each mandal. A study was conducted in the selected mandals, including Ponduru, Hiramandalam, and Ecterla from Srikakulam district, as well as Rajam, Therlam, and Bobbili from Vizianagaram district. Consequently, a total of 180 respondents have been chosen for the study. From 180 respondents, 90 respondents were selected from the Srikakulam and 90 respondents from the Vizianagaram districts

The study considered 11 independent variables (X) and 3 dependent variables (Y) specifically for Soil Health Card farmers.

$X= x_1, x_2, x_3, \ldots\ldots\ldots x_{11}$

$Y= y_1, y_2, y_3$

x_1= age, x_2= education, x_3= farming experience, x_4= occupation, x_5= social participation, x_6= land holding, x_7= annual income, x_8= extension contact, x_9= information seeking behaviour, x_{10}= scientific orientation, x_{11}= attitude towards soil testing, y_1= knowledge, y_2= perception, y_3= adoption

In the current investigation, three canonical correlation pairs were estimated, denoted as (P_1, Q_1), (P_2, Q_2), and (P_3, Q_3). P_1 and Q_1 represent the linear combination of independent and dependent variables, known as canonical variates.

$$P_1=P1_1x_1+ P1_2x_2+\ldots\ldots\ldots\ldots\ldots+P1_qx_q$$
$$Q_2=P2_1x1+P2_2x_2 +\ldots\ldots\ldots\ldots\ldots+ P2_qx_q$$
.
.
$$A_q=a_{q1}x_1+a_{q2}x_2+\ldots\ldots\ldots\ldots+a_{qq}x_q$$
$$Q_1=Q1_1y_1+Q1_2y_2+Q1_3y_3$$
$$Q_2=Q2_1y_1+Q2_2y_2+Q2_3y_3.$$
$$Q_3=Q3_1y_1+Q3_2y2+Q3_3y_3$$

Where q=11 (no of characters in set 1 or independent variable), $P1_1$, $P1_2$ ......$P1_q$ and $Q1_1$, $Q1_2$, $Q1_3$ are the standardized canonical coefficient of x and y variables, respectively. The coefficients represent the significance or size of the variables in set one (independent variables) that influence the variables in set two (dependent variables) (11).

The canonical correlation between P1&Q1 is (P1, Q1) = $\frac{cov\ (P1, Q1)}{\sqrt{var\ (P2)\ var\ (Q2)}}$

RESULTS

The results obtained from the statistical analysis presented in Table 1 demonstrate significant findings at the 0.01 level for all three sets of canonical variates, as confirmed by the likelihood ratio test. Among these pairs, the first pair (P_1, Q_1) exhibits the highest coefficient value of 0.948, followed by P_2, Q_2 with a coefficient of 0.586, and P_3, Q_3 with a coefficient of 0.493. Additionally, the square of the canonical correlation is found to be highest for P_1, Q_1 at 0.898, followed by P_2, Q_2 at 0.343, and P_3,Q_3 at 0.243.

Table 1. The profile characteristics of Paddy growers on Soil Health Card were analyzed using canonical correlation analysis

A pair of canonical variates	Canonical Correlation	Square of Correlation	Significance
P_1, Q_1	0.948	0.898	<0.001
P_2, Q_2	0.586	0.343	<0.001
P_3, Q_3	0.493	0.243	<0.001

According to Table 2, upon observing the standardized canonical correlation, it is evident that all independent variables, except education, farming experience, occupation, land holding, extension contact, information-seeking behaviour, and attitude towards soil testing exhibit a positive standardized canonical correlation with P_1. Likewise, when considering the dependent variables, knowledge, perception, and adoption display a negative standardized canonical correlation with Q_1.

In regards to the canonical loading analysis involving P_1 and Q_1, it was discovered that occupation (-0.906) followed by occupation (-0.881) exhibited a stronger correlation with P_1. On the other hand, the dependent variable knowledge (-0.496) displayed the highest correlation with P_1. Similarly, when examining the canonical loading of P_1 and Q_1, it was observed that land holding (0.402) had a higher correlation with Q_2. Additionally, adoption (0.386) exhibited the highest correlation with P_2. The analysis of $P_3$and Q_3canonical loading revealed that attitude towards soil testing

Table 2. Standardizes canonical correlation, canonical loading, and canonical cross-loading of different independent variables of Paddy growers on Soil Health Card

Independent variables	Standardized canonical correlation			Canonical loading			Canonical cross loading		
	P_1	P_2	P_3	P_1	P_2	P_3	Q_1	Q_2	Q_3
Age	0.038	0.001	-0.247	-0.029	0.171	-0.430	-0.027	0.100	-0.212
Education	-0.336	-0.617	-0.554	-0.881	-0.164	-0.215	-0.835	-0.096	-0.106
Farming experience	-0.095	-0.482	-0.113	-0.783	-0.245	-0.299	-0.742	-0.114	-0.148
Occupation	-0.431	0.710	1.236	-0.906	0.288	-0.101	-0.859	0.169	-0.050
Social participation	0.007	0.517	0.175	-0.444	0.380	-0.058	-0.421	0.223	-0.029
Land holding	-0.065	0.314	-1.115	-0.769	0.402	-0.296	-0.729	0.236	-0.146
Annual income	0.023	0.187	0.216	0.099	0.180	0.267	0.094	0.106	0.132
Extension contact	-0.033	0.178	-0.225	-0.480	0.073	0.212	-0.455	0.043	0.104
Information seeking behaviour	-0.080	0.280	0.564	-0.608	0.021	0.380	-0.577	0.012	0.187
Scientific orientation	0.002	-0.194	-0.418	-0.542	-0.099	-0.220	-0.513	-0.058	-0.109
Attitude towards soil testing	-0.214	-0.581	0.429	-0.595	-0.293	0.535	-0.564	-0.172	0.264
Dependent variable	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3	P_1	P_2	P_3
Knowledge	-0.496	-1.531	0.468	-0.943	-0.316	0.102	-0.894	-0.185	0.050
Perception	-0.390	0.648	-1.594	-0.926	0.203	0.319	-0.878	0.119	-0.157
Adoption	-0.202	0.996	1.221	-0.848	0.386	0.364	-0.803	0.226	0.180

(0.535), and age (-0.430) had a stronger correlation with P3. Furthermore, adoption (0.364) displayed the highest correlation with Q_3.

The highest canonical cross-loading of Q_1 was observed with occupation (-0.859), education (-0.835), and farming experience (-0.742). followed by P_1, the correlation was found to be higher with knowledge (-0.894). Moving on to Q_2, the correlation was highest with land holding (0.236) and social participation (0.223). As for P_2, the highest correlation was observed with adoption (0.226). Lastly, Q_3 showed the highest correlation with attitude towards soil testing (0.264), followed by age (-0.212). For P_3, the highest correlation was found with adoption (0.180).

DISCUSSION

The analysis of the knowledge, perception, and adoption of soil health cards by paddy growers using canonical correlation reveals that approximately 89 per cent of the independent canonical variable (P_1) accounts for the majority of the variation in the dependent canonical variable (Q_1). It is evident that fluctuations in P_1, such as education levels, awareness initiatives, or resource availability, are strongly linked to fluctuations in Q_1, mirroring the comprehension, attitudes, and behaviours of rice farmers towards the adoption of soil health cards. Consequently, P_1 shows a vital part in shaping awareness, attitudes, adoption practices exhibited in rice growers about soil health cards. The initial canonical pair (P_1, Q_1) stands out for its remarkable coefficient and substantial explanatory capacity (89.8%). This implies a robust correlation among the independent variables (P_1) and the dependent variable (Q_1). While P_1, Q_1 exhibit strong relationships, P_2, Q_2 and P_3, Q_3, demonstrate noteworthy results with comparatively lower coefficients. This demonstrates how important it is for campaigns to raise awareness, for resources to be readily available, and for education to play in influencing rice growers' attitudes and methods of using soil health cards.

Canonical correlation analysis (CCA) is a robust statistical method utilized to reveal connections between two sets of variables by identifying optimal linear combinations, known as canonical variates, that enhance the correlation between them. In this particular study, CCA was utilized to comprehend the factors impacting the knowledge, perception, and acceptance of the Soil Health Card (SHC) program among paddy farmers in Andhra Pradesh. The key outcomes of the CCA emphasize that variables like Education and Occupation display significant canonical loadings. This indicates that these factors play a crucial role in the collective variation of the dependent variables—Knowledge, Perception, and Adoption. Specifically, individuals with higher levels of education tend to have a stronger grasp and implementation of agricultural techniques. Educated farmers are more likely to understand the significance of soil health, interpret SHC recommendations, and incorporate these insights into their farming methods. Similarly, specific occupational backgrounds, particularly those directly linked to agriculture or agribusiness, enhance farmers' capacity to adopt new techniques. These individuals often have better access to agricultural resources and networks, which aids in the dissemination and adoption of innovative practices. On the other hand, the analysis reveals that variables such as Age and Annual Income demonstrate weaker connections with the canonical variates. This implies that these factors have a lesser impact on explaining the variations in knowledge, perception, and adoption behaviors among farmers. While older farmers may possess extensive experience, they might be less inclined to adopt new technologies or practices compared to younger, more adaptable farmers. Annual income, despite being a crucial factor in overall farming capability, may not directly influence a farmer's willingness or ability to adopt new practices if not accompanied by other supporting factors like education and occupational exposure. This study highlights the importance of social participation, landholding, and attitudes towards soil testing as key factors with significant canonical loadings. Farmers who actively engage in social groups or agricultural cooperatives tend to benefit from shared knowledge and collective problem-solving, leading to a better understanding and adoption of beneficial practices recommended by the SHC scheme. Additionally, the size of landholding plays a crucial role, as larger holdings may encourage greater investments in soil health and sustainable practices due to the higher economic returns associated with improved soil management. Positive attitudes towards soil testing reflect a farmer's willingness to embrace scientific methods and data-driven decisions, which are essential for the successful implementation of SHC recommendations. Understanding these factors is essential for developing targeted interventions and policies to enhance agricultural practices and outcomes. Tailored educational programs for farmers can improve the effectiveness of the SHC scheme by ensuring proper utilization of recommendations. Similarly, policies that promote social participation and encourage occupational shifts towards agriculture-focused roles can help increase adoption rates of sustainable practices. Moreover, recognizing the diverse impacts of demographic and occupational factors allows for more nuanced and effective agricultural policies. For instance, younger farmers may benefit from mentorship programs that bridge traditional and modern practices, while older farmers could be incentivized to adopt new practices through accessible and less disruptive measures.

To summarize, the canonical correlation analysis offers a thorough comprehension of the elements that have a substantial influence on the agricultural knowledge, perception, and adoption behaviors of paddy growers. By utilizing these findings, stakeholders can develop educational programs, support systems, and policies that are more efficient in promoting favorable agricultural outcomes. Ultimately, this contributes to the advancement of sustainable farming practices and enhances food security.

CONCLUSION

Canonical correlation analysis highlights the complex interplay among different factors that affect agricultural results. The findings reveal that numerous factors significantly influence agricultural productivity and the welfare of Paddy growers, such as knowledge levels, perception levels, adoption levels, social participation, extension contact, and education. In general, this study emphasizes the significance of focused interventions and cooperative endeavors that involve stakeholders from the agricultural industry, policymakers, and educational institutions. These efforts aim to improve the knowledge, perception, and adoption of soil health cards among paddy growers. By addressing the fundamental factors identified in this research, stakeholders can successfully advocate for sustainable agricultural practices and contribute to the long-term sustainability of rice farming ecosystems.

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