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Exploring Socio-economic Factors in Chilli Farming: A Multi Discriminant Analysis Approach in Andhra Pradesh

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Abstract

The present experiment was conducted during August, 2023 to March, 2024 in three districts of Andhra Pradesh (522 213), India i.e. NTR, Prakasam, and Kurnool, to examine the factors influencing farmers' preferences for contract, non-contract, and Farmer Producer Organization (FPO) farming for chilly. The research included three villages from each district, resulting in a total of nine villages and a sample of 135 respondents representing three types of farmers. The findings revealed that FPO farmers had lower cultivation costs, were younger, owned more land (including rainfed land), had higher education levels, earned greater annual income, and cultivated larger land sizes with higher farm prices. In contrast, contract farmers were generally older and had more wetland, higher yields, and better market prices. However, contract farmers faced significant challenges, with increased risk (65.78%) associated with implementing good agricultural practices being a major concern. On the other hand, FPO farmers encountered limited access to markets (60.22%) as their primary constraint.

Keywords: Contract, FPO farmers, multi discriminant analysis, non-contract

1. Introduction

India is renowned as the "land of spices" (Joshi et al., 2015) (Sharma, 2015) (Rao and Shivaram, 2018), the "spice bowl of the world" (Virendraand Divya, 2017), and the second-largest producer of vegetables globally (Imtiyaz and Soni, 2013). The country produces a vast array of spices (Anonymous, 2018), with chili being a particularly important one, widely used worldwide (Anonymous, 2020; Anonymous, 2021). Botanically known as *Capsicum annuum*, a member of the Solanaceae family (Singh et al., 2021), chili is commonly referred to as hot pepper (Sathish et al., 2017) or "wonder spice" (Rao and Rao, 2014; Anonymous, 2017), and it holds significant economic value (Ridwan et al., 2017). It is also known as red pepper or dry chili and was introduced to India by the Portuguese in Goa in the mid-17th century. Since then, it has rapidly spread across the country (Sharma et al., 2015).

Chili is consumed in various forms, including green chili, dry chili, chili powder, chili oil, and chili oleoresin (Murugananthi and Rohini, 2020). Red chili is one of the vegetables that exhibit high price fluctuations (Karyani et al., 2015). Globally, there are over 3,000 varieties of chili, known by various names such as hot pepper, cayenne pepper, sweet pepper, bell pepper, and red pepper. While chili's primary use is culinary-as a spice, seasoning, or coloring agent-it also has applications in pharmaceuticals, cosmetics, farm protection, paint manufacturing, and even self-defense (Anonymous, 2020).

The production and export of chili generate economic activity for a wide range of participants, including farmers, agricultural laborers, agronomists, pesticide and seed companies, traders, warehouses, auction houses, exporters, and food processing industries. As a labor-intensive crop, chili requires around 294 labor days ha^{-1} $year^{-1}$, contributing to an estimated 212 million labor days annually Anonymous (2023). This crop supports the livelihoods of over one million farmers, two million agricultural laborers, and more than 250,000 agricultural practitioners. In India, chili's economic impact is second only to wheat and paddy (agri.coop.nic.in). The cultivation cost for chili is approximately USD 3,560 ha^{-1} $year^{-1}$, with an average yield of four to five t ha^{-1}, providing farmers with around USD 2,175 in net returns annually (Anonymous, 2023; Anonymous, 2020).

Indian chilies play a crucial role in the value-added industry, available in various forms such as whole chilies, ground chili, flakes, and extracts like oleoresins and capsaicinoids for nutraceuticals (Anonymous, 2017). Over 10,000 cold storage facilities across Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu support the storage of whole chilies during the off-season to meet year-round demand (Anonymous, 2020; Anonymous, 2021).

As of 2022–2023, Andhra Pradesh ranks first in chili cultivation area and production, with 258.2 thousand hectares dedicated to dry chili farming, yielding 1,458.79 thousand metric tonnes (MT) and an impressive productivity rate of 5.65 mt ha^{-1}. Chili is grown in nearly every Indian state (Somashekhar et al., 2016), and India's total chili production stands at 2,912.8 thousand MT across 890 thousand hectares (Anonymous, 2023). This study focuses on applying discriminant analysis to identify the socio-economic characteristics of chili farmers in Andhra Pradesh's NTR, Prakasam, and Kurnool districts, analyzing the differences among contract, non-contract, and Farmer Producer Organization (FPO) farmers (Anonymous, 2017).

2. Materials and Methods

2.1. Study area

The present experiment was conducted during August 2023 to March 2024 in three districts of Andhra Pradesh (522 213), India i.e. NTR, Prakasam, and Kurnool.

2.2. Multi discriminant analysis

Discriminant function analysis is a parametric method used to determine whether weighings of quantitative variables or predictors can more effectively distinguish between two or more groups of cases than random chance. These weighings and scores on the variables are linearly combined to produce a discriminant function, which is the outcome of the analysis. The maximum number of discriminant functions is either the number of groups minus one, or the number of predictors, whichever is smaller. $Z_{jk}=a + W_1X_{1k} + W_2X_{2k} + \dots + W_nX_{nk}$

Where:

Z_{jk}=The Z-score of the discriminant function j for object k

a=Intercept.

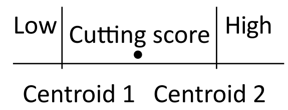
W_i=The coefficient of the discriminant for independent variable i.

X_j=Independentvariable*i*forobject*k.*

It is important to note that in some cases, the goal of the analysis is to explain the relationship rather than to predict it. In such cases, equations are typically not written when the variables are not based on objective measurements.

2.2.1. Cutting score

In a two-group discriminant function, the cutting score is used to uniquely classify the two groups. It serves as the basis for constructing the classification matrix. The optimal cutting score depends on the sizes of the groups; if the groups are of equal size, the cutting score is set halfway between the two group centroids. The formula for calculating the cutting score is shown below:



Equal group:

ZCS=(NAZB+NBZA)/(NA+NB)

Where: Z_{CS} = The optimal cut-off score between Group A and Group B. N_A = Number of observations in group A. N_B = Number of observations in group B. Z_A=Centroid for Group A. Z_B = Centroid for Group B.

ZCE=(ZA+ZB)/2

Where: Z_{CE} = The optimal cut-off score for groups of equal size. Z_A = Centroid for Group A. Z_B=Centroid for Group B.

2.3. Garrett's ranking technique

It provides a method for converting the rankings of advantages and constraints into numerical scores. The primary benefit of this method over a basic frequency distribution is that it organizes the limitations based on respondents' subjective assessments of their severity. As a result, it is possible for different ranks to be assigned to the same number of respondents across two or more limitations. Garrett's formula for converting ranks into percentages is: Percent position=100×(Rij–0.5)/Nj Where, Rij=rank given for i^{th} constraint by j^{th} individual;

Nj=The number of constraints ranked by the j^{th} individual.

The percentage position of each rank will be converted into scores using the table provided by Garrett and Woodworth (1969). The total number of respondents' scores will be summed, and this total will be divided by the sum of the individual respondents' scores for each factor. The mean scores for each constraint will be arranged in descending order, and the constraints will be ranked accordingly.

3. Results and Discussion

Table 1 presents the means and standard deviations of the considered variables. FPO farmers had lower cultivation costs, were younger, owned more land (including rainfed land), had higher education levels, earned greater annual income, cultivated larger land sizes, and achieved higher farm prices. In contrast, contract farmers were generally older and had more wetland, higher yields, and better market prices. These findings align with the results observed by Ayogu (2014) and Singh et al. (2017), but differ from those reported by Gwary et al. (2012).

Table 2 presents the Wilks' lambda values and corresponding significant p-values for the selected variables. Wilks' lambda and its p-values were calculated to assess the mean differences between the groups. The results indicate a significant difference between the means of the three groups, as Wilks' lambda approaches one for all selected variables. Similar

Table1: Mean and Standard deviation of selected variables

Sl. No.		Contact farming		Non contract farming		FPO farming	
		Mean	S.D	Mean	S.D	Mean	S.D
1.	Experience in farming	23.02	11.85	25.13	13.55	6.24	3.09
2.	Age	52.09	12.70	47.11	13.45	48.58	11.19
3.	Education	5.29	5.13	7.20	4.38	8.87	4.29
4.	Farmer income annum^{-1}	123000	99175.15	126000	69770.21	214000	92085.82
5.	Farmer's owned rainfed land	2.99	4.68	3.36	4.73	5.36	5.49
6.	Farmer's owned wet land	1.94	2.76	1.13	2.22	0.63	1.97
7.	Land size in acres	4.81	4.38	4.60	4.37	6.01	6.00
8.	COC ha^{-1}	373000	122636.75	353000	130908.35	398000	87321.25
9.	Yield ha^{-1}	46.57	14.88	44.29	11.70	45.24	11.73
10.	Farm price of chilli q^{-1}	16700	4981.79	17900	2224.07	17800	2436.47
11.	Market price of chilli q^{-1}	22100	5242.31	19800	3088.75	20600	1889.63

Table 2: Wilks lambda and significant P values of selected variables

Sl. No.	Factors	Wilk's Lambda	P-value
1.	Experience in farming	.604	.000**
2.	Age	.972	.155
3.	Education	.907	.002**
4.	Farmer income annum^{-1}	.809	.000**
5.	Farmer's owned rainfed land	.957	.056
6.	Farmer's owned wet land	.948	.030*
7.	Land size in acres	.984	.352
8.	COC ha^{-1}	.974	.175
9.	Yield ha^{-1}	.995	.701
10.	Farm price of chilli q^{-1}	.974	.170
11.	Market price of chilli q^{-1}	.932	.010*

**: Indicates significant at (*p*=0.01) level of significance and * indicates significant at (*p*=0.05) level of significance)

findings were reported by Naik and Reddy (2023) and Divya et al. (2014). However, these results differ from those of Ayogu (2014).

Table 3 shows the pooled within-group correlations between the discriminating variables and the standardized canonical discriminant functions. The highest correlation was observed for age (0.709), followed by farmers' annual income (0.385) and land size (0.238). Similar results were reported by Cotoju and Tichindlean (2013) and Divya et al. (2014). On the other hand, the lowest correlation coefficients were found for experience (-1.139), farm price of chili q^{-1} (-0.211), and farmer-owned rainfed land (-0.109). These findings suggest that the differences in chili cultivation across the three groups were not influenced by these variables.

Table 3: Correlation between discriminating variables and canonical discriminant function

Sl. No.	Factors	Function	
		1	2
1.	Experience in farming	-1.139	.018
2.	Age	.709	.195
3.	Education	-.054	-.487
4.	Farmer income annum^{-1}	.385	-.024
5.	Farmer's owned rainfed land	-.109	2.651
6.	Farmer's owned wet land	.023	1.641
7.	Land size in acres	.238	-2.773
8.	COC ha^{-1}	.087	.309
9.	Yield ha^{-1}	-.023	.229
10.	Farm price of chilli q^{-1}	-.211	-.428
11.	Market price of chilli q^{-1}	.100	.586

Table 4 presents an explanation of discriminant analysis using discriminant loadings, eigenvalues, potency index, and ranks. The variable with the highest discriminating power was farming experience, followed by farmers' annual income, education, market price per quintal, owned wetland, owned rainfed land, age, farm price, cost of cultivation (COC), land size in acres, and yield ha^{-1}.

Contract farmers were asked to rank the constraints to adopting contract farming, and the results were analyzed using Garret's ranking technique, as shown in Table 5. The primary constraint faced by contract farmers was the increased risk (65.78) associated with the use of good agricultural practices. Other significant constraints included inappropriate technology and crop incompatibility (56.11), manipulation of quotas and quality specifications (55.84), monopoly dominance (45.87),

Table 4: Explanation of discriminant analysis using discriminant loadings, eigenvalue, potency index, and ranks

Sl. No.	Factors	Discriminant Loadings	Squared loadings	Relative eigen-value	Potency value 1	Discriminant loadings	Squared loadings	Relative eigen-value	Potency value 2	Potency Index	Rank
1.	Experience in farming	-0.7180	0.5155	0.7900	0.4073	0.2360	0.0557	0.2100	0.0117	0.4190	I
2.	Farmer income annum^{-1}	0.4180	0.1747	0.7900	0.1380	-0.2480	0.0615	0.2100	0.0129	0.1509	II
3.	Farmer's owned rainfed land	0.1740	0.0303	0.7900	0.0239	-0.1490	0.0222	0.2100	0.0047	0.0286	VI
4.	COC ha^{-1}	0.1440	0.0207	0.7900	0.0164	0.0560	0.0031	0.2100	0.0007	0.0170	IX
5.	Land size in acres	0.1130	0.0128	0.7900	0.0101	-0.0290	0.0008	0.2100	0.0002	0.0103	X
6.	Education	-0.0660	0.0044	0.7900	0.0034	-0.5460	0.2981	0.2100	0.0626	0.0660	III
7.	Market price of chilli q^{-1}	0.0180	0.0003	0.7900	0.0003	0.4700	0.2209	0.2100	0.0464	0.0466	IV
8.	Farmer's owned wet land	-0.1260	0.0159	0.7900	0.0125	0.3270	0.1069	0.2100	0.0225	0.0350	V
9.	Age	0.0060	0.0000	0.7900	0.0000	0.2960	0.0876	0.2100	0.0184	0.0184	VII
10.	Farm price of chilli q^{-1}	0.0260	0.0007	0.7900	0.0005	-0.2840	0.0807	0.2100	0.0169	0.0175	VIII
11.	Yield ha^{-1}	0.0110	0.0001	0.7900	0.0001	0.1270	0.0161	0.2100	0.0034	0.0035	XI

Table 5: Constraints faced by farmersin contract farming

Sl. No.	Constraints	Meanscore (n=135)	Rank
1.	Increased risk	65.78	I
2.	Unsuitable technology and crop incompatibility	56.11	II
3.	Manipulation of quotas and quality specifications	55.84	III
4.	Corruption	38.69	VI
5.	Domination by monopolies	45.87	IV
6.	Indebtedness and overreliance on advances	41.53	V

indebtedness and overreliance on advances (41.53), and corruption (38.69). Similar findings were reported by Arun et al. (2022), Kumar et al. (2008), Mishra and Singh (2010) and Ramsundar and Shubhabrata (2014), but differ from the results of Jagdish and Prakash (2008).

The constraints faced by farmers in FPO (Farmer Producer Organization) farming are presented in Table 6. The most significant issue was limited access to markets (60.22), followed by weak institutional capacity (57.22). Other challenges ranked by FPO farmers included lack of technical knowledge and skills (55.89), fragmented and small-scale farming (54.33), and limited financial resources (52.33). These findings align with the studies of Verma et al. (2020), Singh et al. (2023), Verma et al. (2021), Tiwari and Upadhyay (2021), Nithya Shree and Vyshnavi (2022), Dharmaraj etal. (2022) Kumar et al. (2023) and Kumar et al. (2023), but differ from the results of Radadiya and Lad (2023).

Table 6: Constraints faced by farmers in FPO farming

Sl. No.	Constraints	Meanscore (n=135)	Rank
1.	Limited financial resources	52.33	V
2.	Weak institutional capacity	57.22	II
3.	Fragmented and small-scale farming	54.33	IV
4.	Limited access to markets	60.22	I
5.	Lack of technical knowledge and skills	55.89	III

4. Conclusion

FPO farmers were found to have lower cultivation costs, Were younger, and owned more land, including rainfed land. They also had higher education levels, greater annual income, larger land size, and higher farm prices. All eleven selected variables indicated significant differences among the three groups.To foster long-term relationships with farmers, several challenges must be addressed. These include providing access to credit facilities, improving market linkages, and ensuring adequate skill development related to processing, value addition, and storage of agricultural products.

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