



## **Adoption of Intercropping Practices by the Cotton Farmers in Mancherial District of Telangana State**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author SK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MRN and RUR read the first draft and approved. Author IT managed the literature searches. All the authors read and approved the final manuscript.*

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### **ABSTRACT**

World food production shortages and estimates in the supplies of the future have promptly increased the interest in the adoption of improved crop production activities and increased the food production and helps to cope with the threats of climatic variations and food security. Intercropping is a method that efficiently uses the space and time of cultivation. In this concept of cotton-based intercropping with pulses, where cotton yields are more along with additional survivable returns to the farmers from other crops. Though the concept has beneficial effects, but the adoption of intercropping in cotton by the farmers is low due to lack of clarity about the concept of intercropping. The present study mainly focused on estimating and clarifying the decision of the farmers on the adoption and non-adoption of intercropping in cotton and the benefits of the intercropping practices by the cotton farmers in developing the conceptual framework. Logistic regression model was used to present an econometric analysis of the diffusion process. The results from the present study revealed that variables like farm size, education status and exposure to extension service and capital were statistically significant at 1% level and showing a positive influence on the adoption of intercropping in cotton. Whereas age, farming experience was statistically significant at 1% level and showing the negative influence on the adoption of intercropping in cotton and yield is the other

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variable showing the negative influence on the intercropping. Further, in the extension systems more stress is need upon the capacity building of the farmers for optimum harnessing of the benefits of new generation technologies in cotton cultivation.

*Keywords: Intercropping; adoption; non-adoption; cotton; logit model.*

## 1. INTRODUCTION

Recent shortages in the world food production and predictions of estimated supplies in the future have promptly increased the interest in the adoption of methods that increases the food production. Whereas the improvements in the crop production activities supports to cope up with the threats of climatic variations and food security. One among the crop production activities is intercropping.

### What is intercropping?

Intercropping is the growing of two or more crops simultaneously on the same field such that the period of overlap is long enough to include the vegetative stage [1]. Intercropping, double cropping and other mixed cropping practices that allow more efficient use of on farm resources are among the agricultural practices associated with sustainable crop production [2-3].

Intercropping offers the farmers an opportunity to engage the nature's principle of diversity on their farms signifies sustainable agriculture. Sustainable agriculture is a type of agriculture that is more efficient in use of resources for the benefit of humans and is in balance with the environment. In other words, sustainable agriculture must be ecologically appropriate, economically justified and socially desirable. In conventional farming and monocropping systems, although high yield per unit area requires abundant costs and energy that arise from fossil fuels. Intercropping as an example of sustainable agricultural systems following objectives such as ecological balance, more utilization of resources, increasing the quantity and quality and reduce yield damage to pests, diseases, and weeds. [4-6]. Other benefits of intercropping are yield of the crop, the productivity of various constituents, economic return, yield stability, social benefits, pest control and nutrient use efficiency. Both above ground and below ground potential complementarities of component plants are the most important advantage of intercropping systems which includes both tall and short plant components in water and nutrient exploitation for crop

production. Because of these advantages intercropping is practiced in many parts of the world, especially in developing countries. Furthermore, because of some favourable exudates from the component legumes, greater land-use efficiency, greater yield stability and increased competitive ability towards weed, intercropping is advantageous over monocropping [7].

Intercropping is not a new concept but an age-old technique of intensive farming that has been continued in many areas of the world, which efficiently uses the space and time of cultivation resulted in the maximization of land use and productivity per unit area per season [8].

The farmers have inhibited the concept of intercropping with the huge losses occurred due to the attack of major pests on the pulses and the non-availability of pesticides to control. On the other hand, with blind sense majority of the farmers alleged that, there will be more chances in the spread of major pests from pulses to cotton crop and cause massive losses. Recent development in the crop-based and need chemical pesticides and with the introduction of BT Bt (Bacillus) cotton, farmers were slowly diverting towards the concept of intercropping based on the following reasons: 1) Sustainable income to farmers with two crops 2) Soil improvement 3) Ease in the cultivation of BT cotton crop with legumes 4) With increasing crop failure or losses in monocropping cotton due to untimely rains. These are the few reasons forced many farmers towards adoption of intercropping in cotton. Intercropping farmers were benefitted in terms of time, soil enrichment, amount spend on crop sprayings, additional income from other crops.

Major area in the Mancherial district of the Telangana State is occupied by commercial cotton followed by Rice, Redgram. In this concept of cotton-based intercropping with pulses, where cotton yields are more along with additional returns to the farmers from other crops. The intercropping strategies will help to improve the crop yields and also enrich the soil fertility status under rain-fed conditions. Though

the concept has beneficial effects, but the adoption of intercropping in cotton by the farmers is low due to lack of clarity about the concept of intercropping. Now a days, Central and State Governments are taking many steps to improve soil fertility and food security. Keeping this point in view, extension systems of State Agricultural Universities and ICAR Indian Council of Agricultural Research Institutions like Krishi Vigyan Kendra's conducting the On-Farm Trials and Frontline demonstrations under rain-fed conditions in the farmers field to find out the effect of cotton intercropping strategies on crop yields and soil nutrient status. The adoption of intercropping in cotton by the farmers is low mainly occurring owing to the lack of clarity about the concept of intercropping. Many of them consider it is to be a technology of wasting the land. Subsequently, the possibilities of realizing the full benefits from intercropping in cotton are depleting day by day.

Local factors influence the economic performance of intercropping in cotton as farmers adopt technologies from a profitability point of view, in contrast to conservationist view which look at sustainability of natural resources. However, considering the resource conservation and increasing the crop failure due delay in on set of monsoon, uneven distribution of rainfall, drought and waterlogged conditions during crop growth period, monocropping and reduction in soil nutrient status many considered as a promising technology to conserve resources of soil, water, and crop residues. In this context, the present study was undertaken to study the factors which affect adoption of intercropping in cotton.

## 2. MATERIAL AND METHODS

The study was carried out in the Mancherial district of Telangana state where Cotton crop cultivable area is more compared to other crops like Rice, Redgram. Out of 18 mandals in the Mancherial district, farmers were selected purposively from four mandals because the farmers were practicing monocropping and intercropping in the cotton. The area under cotton cultivation is maximum. The total cultivated area in the district is 3.61 lakh acres out of which cotton crop only occupies 1.61 lakh acres [9]. The method of intercropping followed by the farmers is Row intercropping where the farmer grows redgram as intercrop for every 4 or 6 rows after the main crop. To know the adoption and non-adoption of intercropping in cotton in the

Mancherial district and to measure these variables, a well-structured interview schedule in English and vernacular language was prepared and used for collecting the data. From four mandals, a sample of 240 farmers both adopted and non-adopted farmers were selected using simple random technique.

### 2.1 Model for Adoption

Logistic regression model was used to identify the determinants in the adoption of intercropping in cotton. Many studies have recognised the influence of various cultural, socio-economic and political factors on the willingness of farmers to use new technologies. Adoption was used as the dependent variable, is constrained to lie between 0 and 1 and the models used were exponential functions while univariate and multivariate logit and probit models. Comprising their revised forms have been used widely to study the adoption of farmers. In this present study, a univariate logit model was used to analyze the adoption of the farmers.

### 2.2 Logit Model

The logit model assumes that the underlying stimulus ( $l_i$ ) is a random variable that predicts the probability of adoption of intercropping by cotton farmers:

$$P_i = \frac{e^{l_i}}{1+e^{l_i}} \quad (1)$$

Conceptually, the behavioral model used to examine factors influencing "intercropping" adoption is given by:

$$Y_i = g(l_i) \quad (2)$$

$$l_i = b_0 + \sum b_j X_{ji} \quad (3)$$

Where,  $Y_i$  is the  $i^{\text{th}}$  observation observed response (i.e. the binary variable,  $Y_i$  is taken as 1 for adoption of intercropping,  $Y_i$  is taken as 0 for non-adoption of intercropping).  $l_i$  is an basic stimulus index for the  $i^{\text{th}}$  observation;  $g$  is taken as the functional relationship between the field observation ( $Y_i$ ) and the stimulus index ( $l_i$ ) which defines the probability of the adoption of intercropping in cotton.

$i = 1, 2, \dots, m$  are observation on variables for the adoption model;  $m$  is the sample size;  $X_{ji}$  is the  $j^{\text{th}}$  explanatory variables for the  $i^{\text{th}}$  observation and  $j = 1, 2, 3, \dots, n$ ;  $b_j$  is an unknown parameter,

$j = 0, 1, 2, \dots, n$ , where  $n$  is the total number of the explanatory variables.

The logit model assumes that the underlying stimulus index ( $l_i$ ) is a random variable that predicts the probability of "Intercropping" adoption: from equation (1), for the  $i^{\text{th}}$  observation (an individual farmer) Engleman et al. [10].

$$l_i = \ln \frac{P_i}{1-P_i} = b_0 + \sum b_j X_{ji} \quad (4)$$

By using the Econometric model present study data was analyzed.

### 3. RESULTS AND DISCUSSION

In this section, the regression analysis was used to investigate the determinants adoption of intercropping by the cotton farmers. Because of the binary dependent variable (adopters and non-adopters), logistic regression model was applied in this study. The regression results of Logit model are given in Table 2, which show the coefficients ( $\beta$ ), their standard errors, the Wald Chi-Square statistic, associated p-values, odds ratio (Exp (B) and marginal probability (marginal effects).

In the binary logistic regression analysis,  $Y=1$  means cotton farmers who adopted the intercropping and  $Y=0$  means those who do not adopt it. The full model containing all predictors was statistically significant, chi-square (12,  $N=240$ ) =135.577,  $p<0.001$ , indicating that the model was able to distinguish between adopters and non-adopters.

The -2 Log likelihood (174.124<sup>a</sup>), Cox & Snell R Square (0.401) and the Nagelkerke R Square values (0.) (0.547) indicate the amount of variation in the dependent variable explained by the model (from a minimum value of 0 to a maximum of approximately 1). In this study, the two values are 0.401 and 0.547, suggesting that between 40.1% and 54.7% of the variability is explained by dependent variables (adopter and non-adopter). If the model were to predict the Y-values as 0 or 1, the model would be correct 80 per cent times.

Logit regression analysis shows that most of the coefficients were not consistent with hypothesized relationships and their tests of significance help to indicate their importance in explaining adoption decisions of the farmers. In this study 10 explanatory variables were used.

Based on the model results, variables like age, farming experience and yield were found to have a negative sign, while the remaining variables such as farm size, education status, family size, exposure to extension service, source of information, social participation, and capital had a positive sign of association with adoption of intercropping practices in cotton. The parameter estimates for the model were evaluated at 1% level of significance. Logit estimates for the study area (Table 1) revealed that age, farm size, education status, exposure to extension service and capital were statistically significant at 1% level. Exposure to extension services is generally known to push the adoption. The flow of information and guidance about the intercropping in cotton is important due harsh climate, untimely rains, monocropping resulting in heavy loss and leading to death of farmers. Timely information and guidance to the farmers from different sources of information on intercropping technologies is important because of aberrant weather conditions, delayed and uncertainty in rainfall, monocropping which was resulted in heavy losses leading to debts and farmer suicides. Whereas the positive sign and significance of the exposure to extension service variable implies that extension is an important factor that will promote farmers adoption of the intercropping in cotton. The results were in confirmative with the [11].

The variables capital and farm size were significant and show positive influence with the intercropping in cotton because farmers with higher capital and high farm size will take risk in adoption of intercropping in cotton than farmers with less farm size and less capital. In the same way, the influence of variable age was negative and variable education status was positive. It means, higher age and lower education make a person more sceptical to innovation and resistant to change, while lower age and higher education helps to decrease the risk aversion factors and increase adoption. The independent variable capital for farming either owned or borrowed and farm size in hectares were significant at 1 per cent level and showing positive influence with the intercropping in cotton because farmers with higher the capital and having high farm size will be ready to take more risk in the adoption of intercropping in the cotton than the farmers having less capital and less farm size holdings. Farmers having more area of land can use small piece of land towards intercropping trials in cotton, in the same way farmers having high capital can utilize the capital towards adoption of

**Table 1. Definition of variables**

<b>Dependent variable</b>	
$Y_i$	Farmer adoption value 1 - adopting and 0 otherwise
<b>Independent variable</b>	
Age (X <sub>1</sub> )	Age of the farmer, measured in years
Farm size (X <sub>2</sub> )	Farmers farm size measured in hectares
Farming experience (X <sub>3</sub> )	Experience of the farmers measured in years
Education Status (X <sub>4</sub> )	Farmer's education level; If illiterate – 0, Primary -1, High school – 2, College – 3
Family size (X <sub>5</sub> )	Size of the farmer measured as Small medium large
Exposure to extension service (X <sub>6</sub> )	Exposure with extension services measured by the frequency of contact
Source of information (X <sub>7</sub> )	Number of information sources used by the farmers
Social participation (X <sub>8</sub> )	Members in farmers organizations/ associations.
Capital (X <sub>9</sub> )	Capital for farming, own or borrowed
Yield (X <sub>10</sub> )	Yield per hectare

**Table 2. Results of maximum likelihood estimates**

<b>Explanatory variables</b>	<b>B</b>	<b>Standard error</b>	<b>Wald</b>	<b>Df</b>	<b>Sig.</b>	<b>Binary logistic regression analysis</b>
Constant	-4.664	2.051	6.481	1	0.006	.003
Age	-.020	.021	.868	1	0.005***	.982
Farm size	.172	.040	17.088	1	0.000***	1.188
Farming experience	-.041	.023	5.047	1	0.025	.950
Education Status	.308	.103	8.728	1	0.003***	1.359
Family size	.305	.127	5.728	1	0.018	1.36
Exposure to extension service	.309	.095	11.897	1	0.000***	1.378
Source of information	.074	.073	.981	1	0.312	1.076
Social participation	.445	.324	2.005	1	0.157	1.560
Capital	.530	.186	8.158	1	0.003***	1.688
Yield	-.028	.037	.530	1	0.445	.975

\*\*\* Significant at 0.01, \*\*0.05 and \*0.10 level, respectively  $\beta$ = estimated coefficient, df = degrees of freedom and Sig = significance level

new technologies or new innovations whereas the farmers having less capital and farm size cannot afford. Age and education were the two independent variables showing negative and positive influence respectively on intercropping in cotton at 1% level of significant. It means age and education were inversely proportionate. Higher education with lower the age farmers were high risk-takers. Farmers with higher age and lesser education were sceptical in nature, resist change and slow in adoption of innovation or technologies. The results were in conformity with the studies made by the [12-13].

#### 4. CONCLUSION

In the Mancherla district of Telangana State, Cotton and Rice were the two major crops cultivated in larger area during Kharif season with the introduction of Bt cotton, the percentage of farmers cultivating as a sole crop was increasing leaving behind the cultivation of other crops led to depletion of soil fertility and shortage of essential crops. The other benefits added were low cost of cultivation, high yielding, fetching good remunerative price to crop, ease of doing compared to other crops. Keeping this in view, diffusion to the adoption of the new technologies in cotton cultivation should be stressed to improve the soil fertility and help to maintain the food security through cultivation of staple crops. The results were decided that efficient land use and improved economic parameters, intercropping practice showing significant hope and scope to the farmers. A Logit regression model was employed for identifying not only the salient factors influencing the adoption decision for intercropping in cotton but also their marginal probabilities to assess the significant change in the probability of adoption. The model revealed that variables like farm size, education status, exposure to extension service and capital showing positive influence whereas age is showing negative influence on intercropping in cotton at 0.01 per cent level of significance. Other variables like farming experience and yield were showing only negative influence on the intercropping in cotton. The results were in conformity with the studies [12-13]. Further, the extension system needs to be stressed upon the capacity building of the farmers, exposure visits, organisation of field demonstrations helps in the optimum harnessing of the benefits of new generation technologies in cotton cultivation.

#### CONSENT

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

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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