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Groundnut production performance based on chemical fertilizer practices and its profitability conditions

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ABSTRACT

From the mid of the 19th century chemical fertilizers were introduced into Bangladesh as an additional source of plant nutrients. After that the use of fertilizer in crop production increases. However, the extreme use of chemical fertilizers can create hazardous environmental degradation, which in turn can lower yields. So, the optimum level should maintain that can help in turn increase production. In this current study, 150 groundnut farmers in the research areas were taken based on their fertilizer application methods. It shows that the number of chemical fertilizer users constituted a major share of the total almost 44.67%. Among all the farmers, chemical fertilizer users incurred the highest return on investment by 1.48. Land area, cost of irrigation and chemical fertilizer affect the adoption of chemical fertilizer usage positively. The higher cost of production due to the application cost of inorganic fertilizer also increases the yield simultaneously. The study shows that farmers who avoid using fertilizer result in lower production compare to others. In that case, age and education were identified as factors that pushed the farmers towards chemical fertilizer and enjoying higher production.

Keywords: Fertilizer, Organic, Inorganic, Adoption, MVP

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Introduction

Groundnut is cultivated mostly in marginal lands during both summer and winter seasons in Bangladesh. Its area and production have steadily dropped over the past decade. Area and production of groundnut was about 86000 acres and 67000 mtons, respectively, in 2020–2021. Again, groundnut occupies only about 6.97% of the total area under all oil crops and contributes about 6.73% to the total oilseed production in 2020- 2021 (BBS, 2021). Apart from the fact that the groundnut is an excellent oil crop, it is a good source of protein, nutritious fodder for the cattle, and profitable cash crop to the farmers.

Groundnut (*Arachis hypogaea* L.) is a self-pollinated, tropical annual legume (Ntare *et al*., 2008) mainly grown as one of the important oilseed crops. Groundnut plays several roles; as a rich source of edible oil and protein, which play an important position in the human diet and livestock feed as a source of income fixes atmospheric N in soils and thus saves N fertilizer cost (Bekele *et al*., 2022). Groundnuts are mostly used as ingredients for a number of industrially processed foods and contribute little to oil production. Low organic matter content, poor soil fertility, and imbalanced use of mineral fertilizers with no organic amendments contribute to the low productivity of groundnuts (Akbari *et al*., 2011). It is an important warm-season oilseed crop and is one of the most important oil producing crops in Bangladesh and ranking second position in area and production. The soil and climate of Bangladesh are quite suitable for groundnut production. It is cultivated mostly in sandy soils and riverbeds (Nath and Alam, 2002). Though groundnuts are one of the major oilseed crops of Bangladesh, yields are low when compared to the world average, with the result that Bangladesh produces only about 40% of its domestic oil consumption. Because of poor yields due to lack of appropriate fertilizer adoption, farmers derive a limited income from the crop. The purpose of this study is to find out the suitable fertilizer practice that can contribute to increased productivity and profitability of groundnut cultivation.

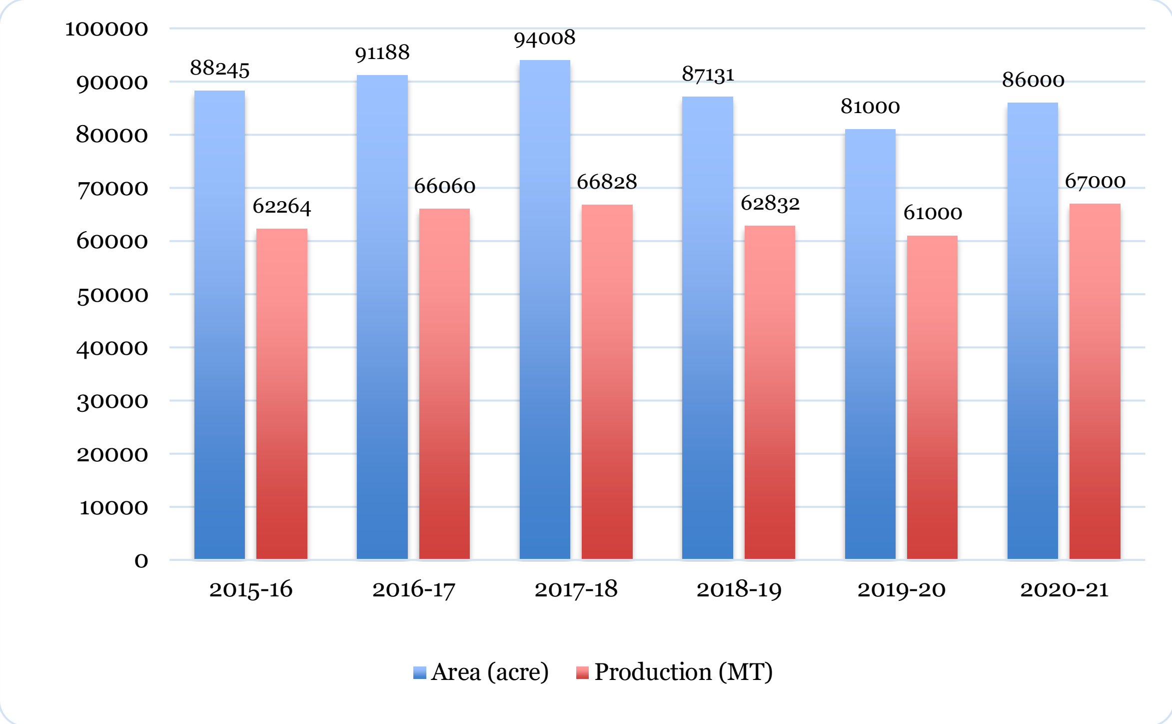

Fig. 1. Groundnut area and production.

Groundnut (*Arachis hypogea* L.) is one of the principal economic crops of the world that ranks 13th among the food crops. In Bangladesh, groundnut is the second most important oil seed crop next to mustard (*Brassica* spp.) based on the annual production and stands third next to sesame (*Sesamum indicum* L.) based on acreage. Groundnut is cultivated on 31,579 ha of land and produces 56713 metric tons of nuts with an average yield of 1.79 t ha^{-1} (BBS, 2015). The soil and climate of Bangladesh are quite suitable for groundnut production. It is cultivated mostly in sandy soils and riverbeds (Deb and Pramanik, 2015). Locally, groundnut is known as 'Badam', which is rich in nutrients and has multipurpose uses. It is used as edible oil to make cakes, biscuits and bakeries in the food industries. Traditionally it is eaten as fried badam', and oil cake is used as cattle feed. Bangladesh imports groundnut oil and shelled groundnuts regularly. It contains vegetable oil (45-50%), protein (25-30%), carbohydrate (20%), vitamin A and E (Miah *et al.*, 2014). It is the richest plant source of thiamin (B1). Groundnut contains at least 13 different types of vitamins and is rich in 26 essential minerals like niacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium. The oil content of groundnut is higher than those of soybean (*Glycine max*) and mustard. It is known as the 'king' of oilseeds. Though groundnut is the second major oilseed crop of Bangladesh, yields of groundnuts are lower in Bangladesh compared to the world average, with the result that Bangladesh produces only about 40 per cent of its domestic oil consumption. Groundnut is a versatile crop that can easily be incorporated into various cropping systems. It is generally recommended that groundnuts be rotated with cereals, whereby the latter crops (maize, sorghum, cotton, or millet) can take advantage of nitrogen fixation from groundnut and benefit from the earlier fertilizer applications. Cotton or millet can take advantage of nitrogen fixation from groundnuts and benefit from the earlier fertilizer applications (Prasad *et al.*, 2009). The productivity of groundnut depends on the proper selection of variety, fertilizer management and other management practices. It is observed that hours spent farming, cultivated land size, the price of groundnuts from the previous season, cost of seeds and pesticides significantly influence groundnut production in the area (Katundu *et al.*, 2014). Experienced farmers are less involved in groundnut production, and most groundnut farmers are engaged in other forms of business. The cost, availability, and lack of technical knowledge of inputs requirements are responsible for poor use of the inputs. Labor, fertilizer, seed and herbicides are all over-utilized except insecticide, which is underutilized (Usman *et al.*, 2013). The optimization of the mineral nutrition is the key to optimizing the production of groundnut, as it has very high nutrient requirements, and the recently released high-yielding varieties take away more nutrients from the soil. On the contrary severe mineral nutrient deficiencies due to inadequate and imbalance use of nutrients is one of the major factors responsible for low yield in groundnut. Thus, the optimum fertilizers combination is the primary concern for the maximum yield of groundnuts. Though groundnut is cultivated in many parts of Bangladesh, very little research work has so far been conducted on the appropriate fertilizer adoption that can be cost effective, increase productivity and give higher returns for groundnut production. With the above background, the main objective of this study was to determine the effect of organic and inorganic, only inorganic and no fertilizer usage on the productivity and profitability of groundnuts. Increasing this crop's production can help minimize the shortage of edible oil in the country. Information about the yield and return performance of groundnut production based on different fertilizer usage will explore the potential for Bangladesh to achieve self-sufficiency in groundnut production. Based on the above discussion this study aims to analyze the impact of different fertilizer practices on productivity and profitability of groundnut and to identify factors that affect the groundnut farmers to adapt different types of fertilizer practices.

Materials and Methods

Groundnut farmers of Jashore and Nilphamari district of Bangladesh were targets of this study. Total 150 farmers were studied based on three categories of fertilizer practices- no fertilizer, chemical fertilizer and combination of inorganic and organic fertilizer. We will observe that due to variations in the usage of fertilizer the total cost and total production of farmers will vary. Random sampling technique was adopted for selection of farmers based on their type of fertilizer usage. After collection of data, a list of tables and figures were prepared on the basis of the findings. The collected data was analyzed using tabular statistical methods and MS Excel. Traditional formulas were used to do profitability analysis and socioeconomic analysis. Besides, multivariate probit analysis was also done to observe differences between the fertilizer practices using STATA 16.0 software.

Analytical techniques

A multivariate probit specification is used to examine how different cost factors influenced the decision of farmers in adopting different fertilizer practices for their agricultural activities.

The Multivariate Probit Model (MVP) is a binary response regression model to estimate both observed and unobserved influence on dependent variables by several independent variables simultaneously which permits error terms to correlate freely (Kariuki and Loy, 2016). Moreover, it uses the cumulative standardized normal distribution function and maximum likelihood analysis is used to obtain parameter estimates (Dougherty, 2011).

The general specification for MVP would be (Greene, 2000):

$$y^*_{mj} = x'_{mj}\beta_j + \varepsilon_{mj}$$

Where, $y^m = 1$ if $y^*_m > 0$, 0 otherwise m=1, 2...M

$$E[\varepsilon_m | x_1, \ldots, x_M] = 0,$$
$$Var[\varepsilon_m | x_1, \ldots, x_M] = 1,$$
$$Cov[\varepsilon_j \varepsilon_m | x_1, \ldots, x_M] = \rho_{jm},$$
$$\varepsilon_1, \ldots\ldots, \varepsilon_M \sim [0, R]$$

Where x is a matrix of covariates, consisting of any continuous or categorical variables, β is the matrix of unknown regression coefficient and εm is a residual error, where the mean of residual error is zero and variance are unitary as presented above. Similarly, R is the variance-covariance matrix and the off-diagonal elements in the correlation matrix ρ_jm represent the unobserved correlation between the stochastic component of the jth and mth options (Idemudia, 2020).Where, m = farmer id, Ym1 = 1, if farmers using chemical fertilizer (0 otherwise), Ym2 = 1, if farmers adopting both chemical & organic fertilizer (0 otherwise), Ym3 = 1, if farmers avoiding fertilizer using (0 otherwise), X′mi = Vector of factors affecting fertilizer strategies, βj = Vector of unknown parameters (j =1, 2, 3, 4), and ε = is the error term.

In this multivariate probit analysis, three dependent variables (farmers using chemical fertilizer, farmers adopting both chemical & organic fertilizer, farmers avoiding fertilizer using and eight independent variables (own land, rented land, inorganic fertilizer cost, irrigation cost, total production, age, education, main occupation) were taken. However, here relationships are formulated with a dependent variable that is dichotomous (i.e., with only two possible values, yes or no). The dependent variable might be based on whether a farmer is aware of a particular adoption strategy or whether he has adopted a specific innovation. The dependent variable is viewed as the probability of occurrence of either of the events.

Table 1. Comparison of variables using mean values.

Description of the variables	Both Fertilizer	Chemical Fertilizer	No Fertilizer
Land area own decimal	77.91	74.03	82.00
Rented area decimal	0.00	3.39	0.21
Total Area	77.91	77.42	79.94
Seed Cost	4674.86	127261.88	146244.79
Organic Fertilizer Cost	4908.60	0.00	0.00
Chemical Fertilizer Cost	1992.79	1693.45	0.00
Insecticide Cost	160499.71	4854.33	0.00
Irrigation Cost	332.86	406.57	168.75
Labor Cost	14866.43	7703.94	6938.54
Total Production	1901.14	1409.10	1373.54
Distance from Market	12.22	9.02	3.81

Results and Discussion

Cost and profitability status of different farm

Data in Table 2 showed the percentage of different input variables in the three practices. Seed cost is highest when no fertilizer is used in production. There is no organic fertilizer application for inorganic and thus no fertilizer cost. In case of chemical fertilizer cost; the percentage is higher for this type of chemical fertilizer (96.97%), the rest cost is for both chemical, and organic fertilizer practice is 26.32%. We can see that there is no insecticide cost for the farmers who have hardly use fertilizer. However, for those who used both fertilizers it is 37.84 percent and 0.103 percent is for chemical fertilizer practice. All the three kinds of practices have very little irrigation cost incurred. For both fertilizers practice it is 0.145 percent, for inorganic practice 0.034 percent and for no fertilizer practice, it is 0.28 percent. Therefore, we can see when farmers try to avoid fertilizer they have to irrigate their land higher compare to those who uses fertilizer. Labor cost is least for chemical fertilizer practice (0.164%) and highest for no fertilizer practice (4.52%). For both fertilizer practices, it is 2.152 percent.

Table 2. Percentage of input variables costs.

Types of fertilizer user	Seed Cost	Organic fertilizer cost	Chemical fertilizer cost	Insecticide cost	Irrigation cost	Labor cost
Chemical and organic fertilizer	2.50	2.62	1.06	85.70	0.18	7.94
Chemical fertilizer	89.67	0.00	1.19	3.42	0.29	5.43
Avoiding fertilizer	95.37	0.00	0.00	0.00	0.11	4.52

Table 3. Profitability analysis of different fertilizer adopting farms.

Parameter	Chemical & organic fertilizer user	Chemical fertilizer user	No fertilizer user
Seed	163620	8526546	7019750
Organic Fertilizer	171801	0	0
Inorganic Fertilizer	69747.63	113461.07	0
Insecticide	5617490	325240.00	0
Irrigation	11650	27240	8100
Labor	520325	516164	333050
Total Variable Cost	6554633.633	9508651.068	7360900
Total Production	66540	94410	65930
Gross Return	7984800	14161500	7384160
Gross Margin	1430166	4652849	23260
BCR	1.21	1.48	1.00

**** Price of groundnut per kg: both= Tk 120, inorganic= Tk 150, no fertilizer= Tk 112*

In Table 3 showed the observed profitability condition in three cases of fertilizer practicing farms. From the table it is clearly observed that chemical fertilizer user attains higher profit compare to other farms. The farms that used chemical fertilizer during production spend most of the capital on purchasing seed and insecticides. However, the farms that used both fertilizers have to spend lots on inorganic fertilizer and insecticide. However, in case of revenue who used chemical fertilizer had observed highest return from production. That means they incur better quality production than that of the farm who used organic and no fertilizer.

Socio-economic characteristics of groundnut farmers

The decision-making pattern of an individual is determined by his socio-economic determinants. Socio-economic factors like age, education, occupation etc. affect the production process and technology use of the groundnut farmers. In the following figures socioeconomic condition of the studied groundnut farmers can be observed. The farmers have been studied based on their age, education, occupation and area of production etc.

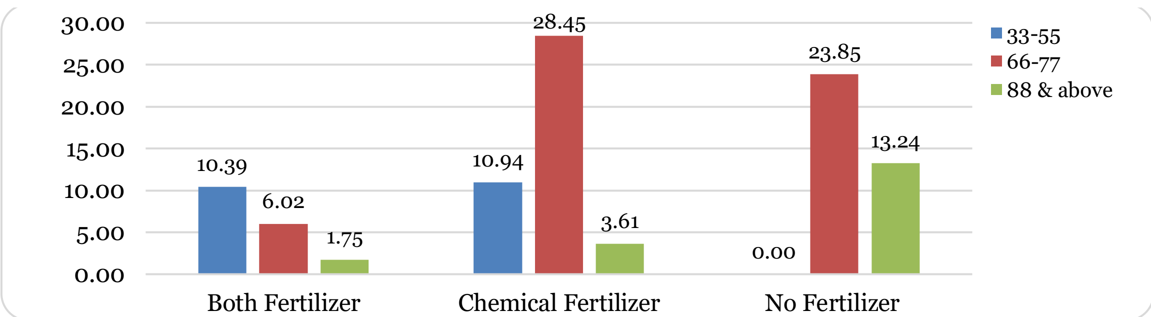

Fig. 2. Percentage of fertilizer users on the basis of education.

Education indicators of the selected farmers have been divided into three categories (Fig. 2). Farmers with education scores in between 33 and 55 are believed to have primary education; 66-77 are believed to have secondary education and 88 and above are believed to have above secondary education and some sort of training. Here we observed that in the case of farmers who use both fertilizers 10.39% are primary educated, 6.02% are secondary educated and 1.75% have higher secondary education and some sort of training. Again, among the farmers who use only inorganic fertilizer 10.94% have primary education, 28.45% have secondary education and 3.61% have above secondary education and some sort of training. But there are only 23.85% secondary educated and 13.24% above secondary educated in case of farmers who use no fertilizer. Therefore, we can say that farmers who use no fertilizer are all well educated or have some sort of training.

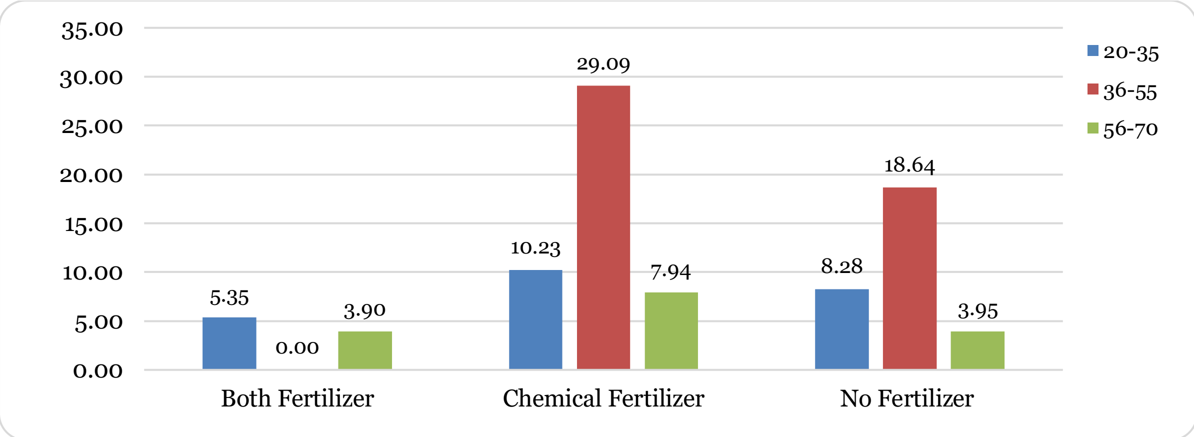

Fig 3. Percentage of fertilizer users on the basis of age.

In figure 3, we have categorized the selected groundnut farmers into three categories based on their age such as, farmers in between 20-35 years, 36-55 years and 56-70 years. Here we observed that both fertilizer users are mostly between 20-35 years (5.35%) and some are between 56-70 years (3.90%). Again, inorganic fertilizer users are mostly between 36-55 years (29.09%) and 20-35 years (10.23%) and some are between 56-70 years (7.94%). Whereas, farmers who use no fertilizer are mostly between 36-55 years (18.64%), some are between 20-35 years (8.28%) and very less between 56-79 years (3.95%).

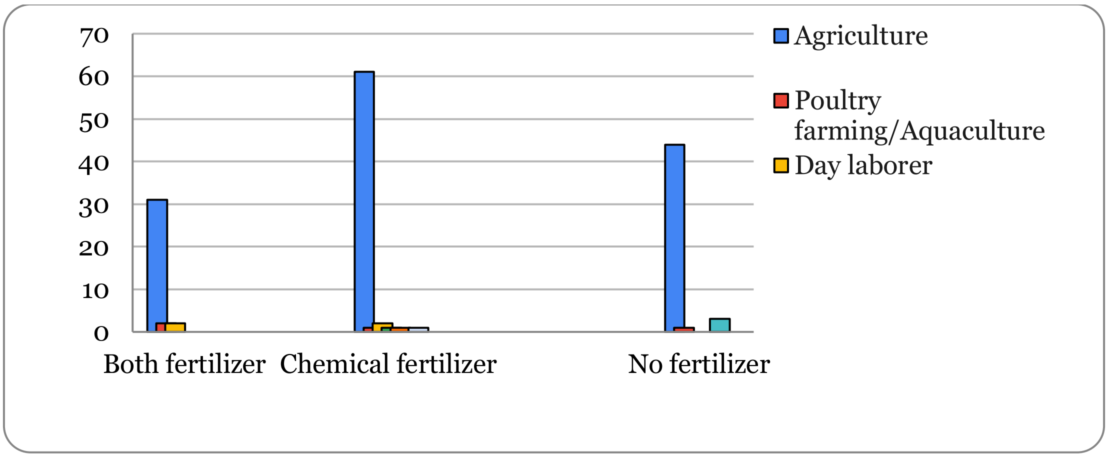

Fig. 4. Fertilizer users on the basis of occupation.

From figure no 4 we have observed that the selected groundnut farmers have a primary occupation other than groundnut farming which are poultry/fish farming, small business, day labor, auto driving and rickshaw pulling. In the case of both fertilizer users, 31 farmers are engaged in agriculture, 2 in poultry/fish farming and 2 as day labor. Again, in case of chemical fertilizer users 61 are engaged in agriculture, 1 in poultry/fish farming, 1 in small business, 1 in rickshaw pulling, 2 are day laborers and 1 has no other occupation than groundnut farming. Whereas, 44 farmers with no fertilizer were engaged in agriculture, 1 in poultry/fish farming, 3 in auto driving.

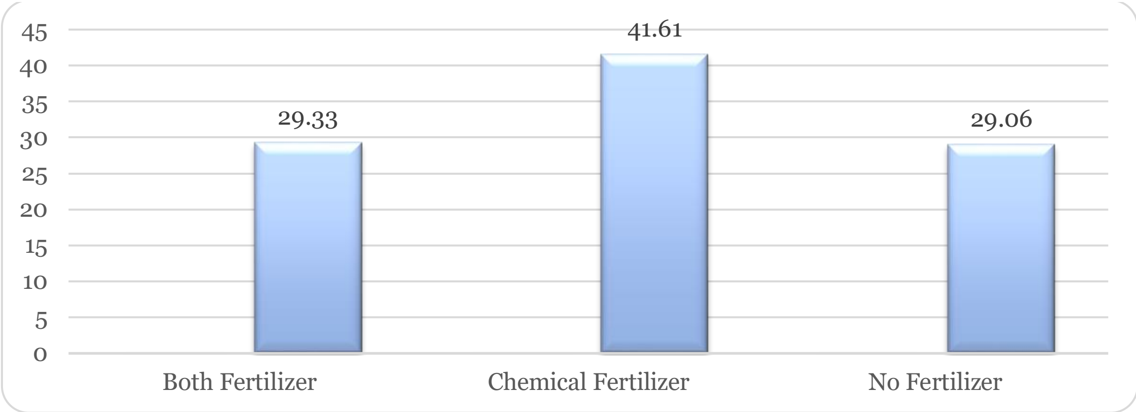

Fig. 5. Percentage of total production of organic, inorganic and both fertilizer.

According to Figure 5, the total production of chemical fertilizer users is higher (41.61%) than users who use both fertilizers (29.33%), followed by no fertilizer users (29.06%).

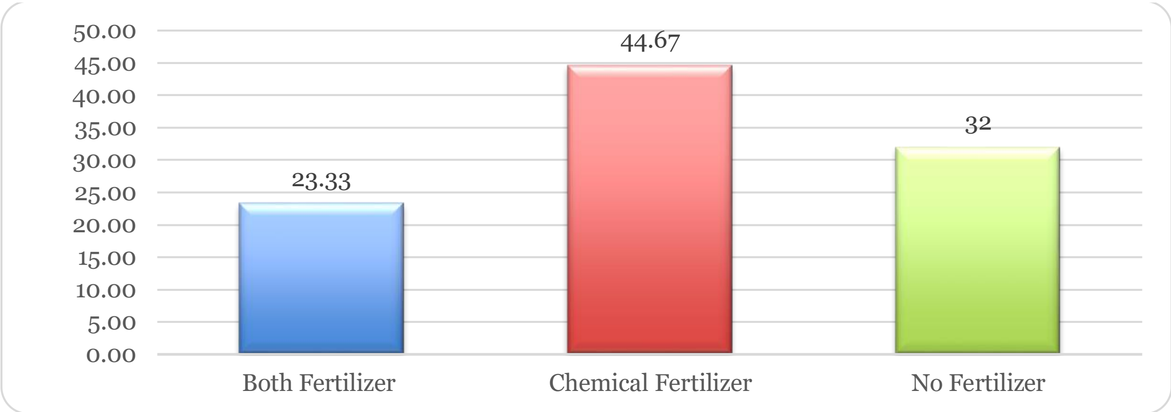

Fig. 6. Percentage of farmers following different fertilizer practices.

In figure 6, depicts that the portion of chemical fertilizer user is highest 44.67% compare to the others.

Factors responsible for practicing different fertilizer application

In the multivariate probit regression, there is an additional step of computation required to get the marginal effects once one has computed the multivariate probit regression fit. Marginal effects of the regressors are how much the probability of the outcome variable changes when one changes the value of a regressor, holding all other regressors constant at some values. Marginal effects are popular in some disciplines (e.g. Economics) because they often provide a good approximation to the amount of change in Y that will be produced by a 1-unit change in X (Cameron and Trivedi, 2009).

Eight variables were taken under consideration. According to Table 4, six variables such as land area own, rented area, inorganic fertilizer cost, irrigation cost, total production and age show significant effect upon fertilizer adoption for groundnut production. The impact of each variable in case of different fertilizer adoption for groundnut production is interpreted below.

Table 4. Maximum likelihood estimates of variable factors responsible for different fertilizer practices.

Variables	Chemical fertilizer practice	Both organic and chemical fertilizer practice	No fertilizer practices
Constant	0.5206601	0.0588829	1.210
Land area own	0.677***	0.324**	0.705***
Rented area	0.680***	0.324**	0.705***
Chemical fertilizer cost	0.0003***	-5.90e-06	-
Irrigation cost	0.0002***	0.0000539	0.0002**
Total production	0.0000255	0.0000513	-0.0002**
Age	0.0033481	0.00486**	-0.0028
Education	0.0006582	0.0000795	-0.001778
Main occupation	0.0055956	0.0100316	-0.0030

*Note: Number of observations = 150; *** significant at the 1 percent level ($p < 0.01$); ** significant at the 5 percent level ($p < 0.05$); *significant at the 10 percent level ($p < 0.10$).*

Table 5 shows that the coefficient of land area is positive for both organic and inorganic chemical and no fertilizer adoption. For chemical fertilizer adoption, it is significant at 1% level, which means that considering all the other factors constant 100% increase in the land area will increase the probability of inorganic fertilizer adoption by 67.7%. When farmers use both fertilizers, the land area will increase the probability of both fertilizer adoptions by 32.4%. As big land area is not so easy to maintain that's why farmers tend to rely on chemical fertilizer for their higher production. The coefficient of rented area also shows the same positive result like the previous variable.

Table 5. Marginal effects of the determinants.

Variables	Chemical fertilizer practices	Organic and chemical fertilizer practices	No fertilizer practices
Land area own	0.6773451***	0.3243118**	0.7051832
Rented area	0.6803026***	0.3240684**	0.7058478
Chemical fertilizer cost	0.0003376***	-5.90×10^{-6}	-
Irrigation cost	0.0002321***	.0000539	0.0001819*
Total production	0.0000255	0.0000513	-0.0001724***
Age	0.0033481	0.0048621**	-0.0028307
Education	0.0006582	0.0000795	-0.001778
Main occupation	0.0055956	0.0100316	-0.0034217

**** Significant at the 1 percent level ($p < 0.01$); ** significant at the 5 percent level ($p < 0.05$); * significance at the 10 percent level ($p < 0.10$).*

For chemical fertilizer adoption the cost is significantly increase the probability of inorganic fertilizer adoption by 0.03%. It indicates that if the cost of chemical fertilizer increases the usage of chemical fertilizer increases but at a decreasing rate. For both organic and chemical fertilizer adoption, the variable is insignificant.

Irrigation cost has shown the significance at all the strategies. Chemical fertilizer user farm observed if the cost of irrigation would increase the probability of chemical fertilizer adoption by 0.02%. The variable is insignificant for both fertilizer adoptions.

The table also shows that the coefficient of total production is negative for the farms who avoid fertilizer using. This factor decreases the probability of no fertilizer adoption by 0.017%. It indicates that for high quantity production and the farmers tend to adopt both organic and inorganic fertilizer practices and only chemical fertilizer practices.

Socioeconomic factor like age is positive for both fertilizer adoptions. If the age of the farmers grows positively it will increase the probability of adopting organic and chemical fertilizer by 0.01%. That means the aged and experienced farmers prefer both organic and inorganic fertilizer adoptions.

Table 6. Overall performance of the model (R^2).

Equation	RMSE	"R-sq"	F	P
Chemical fertilizer adoption	0.2628716	0.7195	18.66904	0.0000
Both fertilizer adoption	0.2581535	0.6450	13.22387	0.0000
No fertilizer adoption	0.2753944	0.6761	15.19093	0.0000

The coefficient of R^2 is the summary of how well the sample regression line fits the data.

The table no. 6 shows that the R^2 value for the chemical fertilizer adoption model is 0.7195, which means that 71.95% variation of choosing the fertilizer for groundnut production was explained by the independent variables included in the model respectively. The R^2 value for both the fertilizer adoption model is 0.6450, which means that 64.50% variation of choosing both organic and inorganic fertilizers for groundnut production was explained by the independent variables included in the model respectively. The R^2 value for the no fertilizer adoption model is 0.6761, which means that 67.61% variation of choosing no fertilizer for groundnut production was explained by the independent variables included in the model, respectively.

Here we can see that the inorganic fertilizer adoption model has the best fit and can be explained most by the respective independent variables compared to the other fertilizer practices.

Conclusion

Groundnut farming has turned out to have variable productivity and cost efficiency in case of the three types of fertilizer uses. The financial profitability analysis demonstrates that the gross return and gross margin of inorganic fertilizer practice was higher than different fertilizer practices. Benefit cost ratio of chemical fertilizer usage (1.48) was found higher than both fertilizer usage (1.21) and no fertilizer usage (1.00). Percentage of total production is comparatively higher in chemical fertilizer usage (41.61%) compared to both fertilizer usage (29.33%) and no fertilizer usage (29.06%).

The socio-economic characteristics revealed that the majority of the no fertilizer users were small farmers. The percentage of farmers having a primary level of education was higher in case of both fertilizer practices. On the contrary, the percentage of the farmers having a secondary level of education was higher in case of chemical and no fertilizer practices. Farmers preferring no fertilizer application to their land have the highest amount of land in possession (82 decimal) compared to farmers practicing both fertilizers (77.91 decimal) and farmers practicing only inorganic fertilizer (74.03 decimal) on average. Farmers practicing both fertilizers have no rented area. The overall effects of the determinants indicate a wider scope of chemical fertilizer practice. The statistical results also showed that farmers' total area of production, education had a positively significant effect and distance from market had a negatively significant effect for the probability of groundnut productivity and profitability in case of no fertilizer practice.

The results of the present study also show that the percentage of no fertilizer practice (33.00%) and both fertilizer practice (23.33%) is less than the inorganic fertilizer practice (44.67%). According to the results, it is significant that considerable scope apparently exists in inorganic fertilizer practice to increase the productivity of groundnut and increasing profitability of the growers.

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