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# THE DETERMINATION OF ECONOMICALLY OPTIMUM NITROGEN DOSE IN *RABI* RAJMA PRODUCTION UNDER MIDDLE GUJARAT CONDITIONS

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**Abstract:** A field experiment conducted during *rabi* season of the year 2012-13 at College Agronomy Farm, Anand Agricultural University, Anand, Gujarat. Nitrogen fertilization assumes substantial influence in improving the yield of rajma crop. The relationship between *rajma* seed yield and nitrogen dose applied was determined quadratic model and the economically optimum nitrogen dose was calculated *via* marginal analysis for yield maximization and profit over fertilizer cost. To determine optimum nitrogen dose in rajma production under middle Gujarat conditions, data obtained by field experiments carried out in 2012-13. Economically optimum dose of nitrogen for rajma was found to be 138.57 kg $ha^{-1}$ under middle Gujarat conditions during 2012 -13. Over-fertilized condition of nitrogen for maximum output did not bring out any significant advantage viewing almost identical seed yield both at physical and economic optimum of nitrogen indicating a saving of nitrogen 1.7 kg $ha^{-1}$.

**Keywords:** Economically optimum, Marginal analysis, Quadratic function, Nitrogen dose, rajma seed yield.

## 1. INTRODUCTION

India is the largest producer of pulses, accounting for about 25 per cent of the global share. Being an inseparable ingredient in the diet of the vast majority of vegetarian population and mainstay of sustainable crop production, pulses continue to be an important component of the rain fed agriculture, since time immemorial. About a dozen pulse crops *viz,* chick pea, pigeon pea, mung bean, urd bean, lentil, field pea, lathyrus, cowpea, common bean, moth bean, horse gram and rice bean are cultivated under varied agro-ecological conditions.

Pulses are second most important group of crops after cereals. During the year 2010-2011, the global pulse production was 68 million tones from an area of 70.6 million ha, with an average yield of 871 kg $ha^{-1}$ (Anon. 2012). In India, the pulses crops are grown over an area of 24.78 million ha with an annual production of 17.09 million tones and average productivity of 694 kg $ha^{-1}$ (Anon. 2013). In Gujarat, during the year 2011-2012, it was

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cultivated in 8.85 lakh hectares with an annual production of 7.83 lakh metric tones leading to average productivity of 881 kg ha$^{-1}$ (Anon. 2013).

In India, pulses are least preferred by farmers because of high risk and less remunerative than cereals; consequently, the production of the pulses is sufficiently low and doesn't meet the daily requirement of the growing population. The net capita availability of pulses day$^{-1}$ has been reduced from 61 g in 1951 to 32 g in 2000 (DES, 2004) against the minimum requirement of 60 g and optimum requirement of 104 g per day. Among the different strategies to increase pulse production, the introduction of promising pulse crop such as *rajma* (*Phaseolus vulgaris* L.) to non-traditional areas holds one of the options. Dry seed contain 22-25% protein, 11.7% fat and 70% carbohydrates. The green pods contain 1-2.4% protein**.** *Rajma* (*Phaseolus vulgaris* L.), is also known as french bean. These common beans are annual plants that are cultivated throughout the world for their edible beans. *Rajma* seeds are red in color and have a shape quite similar to that of a human kidney.

Among the different production factors, irrigation and nitrogen application on different levels have a greater importance. This crop is a poor nodulator or does not nodulate with native *Rhizobia* (Dhanjal *et al.* 2003). Consequently, heavy dose of nitrogen is required to meet the needs of the crop and exploiting its yield potential. Apart from major plant nutrients (N, P and K), nitrogen (S) fertilization assumes greater significance for improved seed yield and quality produce (Hussain *et al*., 2011; Kumar *et al*., 1981; Mc Grath and Zhao, 1996 and Wani *et al.*, 2001). There is no doubt that the increased use of inputs induces an upward shift in production function to the extent that a technological change is embodied in them. But, it is economically and environmentally important to supply sufficient amount of fertilizer to the crop plants for exploiting the desired yield potential. Optimum fertilizer application in the recent years has gained substantial importance to ensure a high quality product, optimum yield, more net profit and less environmental pollution (Alivelu *et al.,* 2006 and Belanger *et al.,* 2000). Contrary to this, sometimes over fertilization and insufficient fertilization application lead to economic losses (Grant, 2006). Therefore, it becomes imperative to fine tune fertilizer application as per the crop demand to make it more judicious, environmental friendly and economical (Antoniadou and Wallach, 2002 and Henke *et al.,* 2007). When we consider fertilizer and product prices, increasing the amount of the nitrogen will result in loss rather than profit for the producer and fertilizing the plant with nitrogen which exceeds the optimum amount will lead to a considerable loss in terms of yield (Engel and Bergman, 1997). In cases when the income to be obtained at the end of additional nitrogen application can not cover the additional cost. Due to the above-listed reasons, it is of great importance to determine appropriate fertilizer doses to be applied in *rajma* crop. Therefore, the present investigation was planned to find out the cost effective economic optimum dose of nitrogen for *rajma* crop in middle Gujarat region of India.

## 2. MATERIALS AND METHODS

The experiment was conducted during *rabi* season of the year 2012-13 at, Anand, The chemical test values of soil were low in organic carbon (18.69 kg $ha^{-1}$), low in available nitrogen (N) (242.32 kg $ha^{-1}$), medium in available phosphorus (23.60 kg $ha^{-1}$) and available potassium (174.2 Kg $ha^{-1}$). The total rainfall received during the crop growth period was 876 mm in 2012-13. Twelve treatment combinations given in *rabi rajma* crop comprised of four irrigation schedule and three nitrogen levels i.e. $N_1$ (80 kg $ha^{-1}$), $N_2$ (120 kg $ha^{-1}$) and $N_3$ (160 kg $ha^{-1}$) were tested in a factorial randomized block design with four replications. The plot size for each treatment was 2.40 m x 4.00 m. The pure seeds of *Rajma* variety Gujarat *Rajma*-1were used in the experiment. Sowing was done manually in line in the previously opened furrows at 30 cm apart using the seed rate of 100 kg $ha^{-1}$ on 5$^{th}$ November in 2012. The seeds were covered with soil manually for better germination. Half dose of nitrogen as per treatments and full dose of phosphorus (60 kg $P_2O_5$ $ha^{-1}$) were applied as basal dose through urea, and Diammonium phosphate, respectively. Remaining half dose of nitrogen was top dressed after one month as per schedule. Standard cultural practices as per state recommendations were followed till the harvest of the crop. At maturity, *rajma* crop harvested from the net plot, dried and threshed manually to determine the seed yield which was then expressed in kg $ha^{-1}$.

To know the yields-fertilizer relationship, linear, quadratic, square root and mitscherlich models were tried. It was observed that the relationship between seed yield obtained and quantity of S applied was determined using quadratic model.

$$Y= a + b*X + c*X^2 \quad \ldots\ldots\ldots\ldots \; .1$$

Where, Y = seed yield in kg $ha^{-1}$, X = quantity of S applied in kg $ha^{-1}$and a, b and c are the constants.

In the test analysis, only the seed yield of sunflower was considered as the dependent variable and the expected yields were worked out accordingly. The estimated maximum yield values in the model were obtained by finding the value of ‘X’ by equating the first derivatives of the reaction equations to zero and replacing the same with whatever the figure stated above is obtained. On the other hand, economic optimum dose was determined via marginal analysis. The nitrogen fertilizer dose where the Marginal Revenue (MR) is equal to Marginal Cost (MC) was designated as the economically optimum dose. Total revenue (TR) function was calculated by multiplying production function with unit product price (Py). Accordingly, TR function was calculated as; TR = Py

*Y= Py (a + bX + cX2) … ....................................................… 2

MR was calculated by differentiating the first order derivative of TR function. In the light of this explanation, MR can be calculated as;

$$MR = \frac{\partial TR}{\partial X} = bP_y + 2P_y cX \quad ..................................................3$$

Total cost (TC) function was obtained by multiplying the price of the input used with the input amount. Accordingly, TC function is calculated as;

TC = Px*X ….… ..............… ………………..………… 4

Marginal cost (MC) function was calculated by differentiating the first order derivative of TC function. Maximum yield is achieved when the marginal production (MP) is equated to zero. MP can be worked out by differentiating the first order derivative of production function Y. MP is calculated as;

$$MP = \frac{\partial Y}{\partial X} = b + 2cX \quad ………………………………5$$

The average unit price of nitrogen (irrespective of the source) was taken as Rs. 6.1 $kg^{-1}$. However, the market price of rajma seed was Rs. 40 $kg^{-1}$during 2012 -13.

## 3. RESULTS AND DISCUSSION

The best fit response equation as explained by quadratic model to study the nitrogen management in rajma crop under middle Gujarat conditions is given in Table 1. The test analysis indicated that more than 91 per cent of the total variation in rajma seed yield was due to application of nitrogen during year 2012-13. Based on the regression analysis, the maximum possible yield potential that can be exploited with respect to the amount of nitrogen applied is shown in Figure 1.

**Table 1: Estimation of the model determining the relationship between the nitrogen doses applied and *rajma* crop yield obtained during 2012-13**

| Variable | Coefficients | Standard error | t-value | p-value | $R^2$-value |
|---|---|---|---|---|---|
| **Constant** | -166 | 188.199 | -0.88 | <.04007 | 0.912 |
| **X** | 18.937 | 3.326 | 5.69 | 0.0003 | |
| **$X^2$** | -0.0678 | 0.0137 | -4.91 | 0.0008 | |

The costlier fertilizers, poor resource base as well as lack of knowledge and aptitude of cultivators towards using fertilizers up to the recommended level still arise the question that up to what extent fertilizer application should be made to achieve the sustainable and profitable production level rather than using fertilizers to target maximum possible yield potential without keeping in view the economic returns and impairing environmental quality. Therefore, it becomes imperative to consider whether the additional income (MR) brought out by each unit of nitrogen added covers the risk of additional fertilizer cost (MC) or not. In this context, additional income obtained from the production amount (X) by adding each additional unit of input used (X) is taken in to consideration. The ratio of the additional change observed in Y product to additional change in X factor and the ratio of X factor price to Y factor price should be equal at the point where MR is equal to MC for a profitable production to determine the economically optimum nitrogen dose.

To meet the objective of the study, the relationship between the amount of nitrogen applied and *rajma* crop yield obtained for the year 2012-13 was worked out using a quadratic equation as under;

$$\mathbf{Y = -0.0678X^2 + 18.93X - 166 \qquad R^2 = 0.912}$$

TR function was obtained by multiplying the production function for the year 2012-13 with the product price (Rs 40 $kg^{-1}$) as;

$$\mathbf{TR = = -2.712X^2 + 757.2X - 6640}$$

MR function was obtained by first order derivative of TR function as;

$$\mathbf{MR = -5.42X + 757.2}$$

TC function was obtained by multiplying the price of the input used (Rs 6.1 $kg^{-1}$) with the input amount as; TC = 6.1 N. Marginal cost (MC) function was obtained by differentiating the first order derivative of TC function as; MC = 6.1

Optimum level of nitrogen was determined by equating MC with MR as; 6.1 = -5.42X + 757.2, and X = 138.57 kg $ha^{-1}$ was found to be the economical optimum dose of nitrogen for *rajma* crop. However, the maximum seed yield due to nitrogen application, i.e., physical optimum dose can be achieved by the equating MP to zero as;

$$MP = \frac{\partial Y}{\partial X} = b + 2cX = 0$$

**18.93 + 2* (-0.0678)*X = 0**, and N = 140.22 kg $ha^{-1}$. The optimum and maximum seed yield recorded with application of nitrogen was 1155.2 and 1155.4 kg $ha^{-1}$ (Table 2).

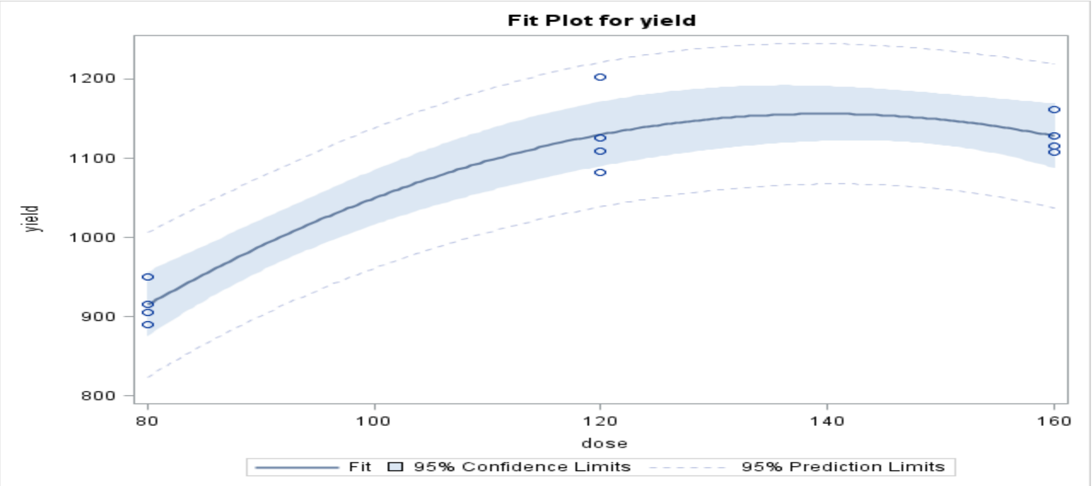


**Fig 1: Predicting *rajma* yield at different levels of nitrogen under middle Gujarat conditions using the regression equation (2012-13)**

**Table 2: Response function, optimum dose and seed yield in relation to nitrogen management in *rajma***

| **Particular** | **2012-13** | |
|---|---|---|
| | **Economic optimum** | **Physical optimum** |
| **Response equation** | $Y = -0.0678X^2 + 18.93X - 166$ | |
| **Nitrogen dose (kg ha$^{-1}$)** | 138.57 | 140.22 |
| **Seed yield (kg ha$^{-1}$)** | 1155.20 | 1155.40 |

The data presented in Table 3 further revealed that over fertilized condition of nitrogen did not show any significant yield advantage and the *rajma* seed yield obtained with physical optimum and economic optimum of nitrogen was observed to be almost identical during the year. Thus, there can be a saving of nitrogen from 1.7 kg ha$^{-1}$ without any reduction in seed yield of rajma crop.

## Conclusion

Based on the results, it can be concluded that economic optimum yield of *rajma* could be obtained with the application of nitrogen 138.57 kg ha$^{-1}$ Profit can be increased by decreasing the nitrogen dose from maximum yield to the economically optimum dose**.**

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