GAU Research Journal **42** (1) : 47-51 (January 2017)

The determination of economically optimum nitrogen dose in cress (*Lepidi umsativum* L.) production under middle Gujarat conditions

G. N. MOTAKA[1], N. K. CHAVDA[2], R. A. PATEL[3] AND D.J. PARAMAR[4]

Department of Agricultural Statistics, B. A. College of Agriculture,
Anand Agricultural University, Anand - 388 110 (Gujarat)

Received : 06 September, 2016

ABSTRACT

A field experiment conducted during rabi season of the year 2014-15 at Medicinal and Aromatic Plant Research Centre. BACA, Anand Agricultural University, Anand, Gujarat. Nitrogen fertilization assumes substantial influence in improving the yield of cress crops. The relationship between cress seed yield and nitrogen dose applied was determined by 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 cress production under middle Gujarat conditions, data obtained by field experiments carried out in 2014-15. Economically optimum dose of nitrogen for cress crop was found to be 99.93 kg ha^{-1} under middle Gujarat conditions during 2014-15. 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 0.29 kg ha^{-1}.

Key words : Nitrogen dose, cress seed yield, marginal analysis, quadratic function

India is a country with more than 5000 yrs old civilization. Obviously, wealth of its traditional knowledge systems related to the use of plant species is as old and time tested. Plants have played a great role in the sustenance and development of human race offering food, fodder, fuel wood, timber, dyes, latex, gum, fibers, fruits, etc. People have been using medicinal plants from time immemorial for the treatment of various types of diseases. For instance, juice of basil tulsi (*Ocimum tenuiflorum* L.) leaves and honey partaking regularly for six months for expelling renal stones and its acting anti-diarrheal dysentery agents. The metanolic extract of neem (*Azardirachla indica* A. Juss) leaves is used as an antiviral agent (Badam *et al.* 1999).

The species sativum is native of Ethiopia and introduced to Europe, Asia and USA. In India, its cultivation is spread in patches across the states of Madhya Pradesh, Uttar Pradesh, Rajasthan, Gujarat and Maharashtra in an area of about 5000 hectare (Choudhary *et al.*, 2010). In Gujarat, it is traditionally cultivated in north Gujarat, Kutch, middle Gujarat and some part of Bharuch district. One of traditional medicinal plants having high nutrients is cress (*Lepidium sativum* L.) popularly known as Asaliyo, Sialoo, Ariya, Hali, and Halim in Gujarati and chandrasoor in Sanskrit. It is a winter season annual herb belonging to family Brassicaceae which is botanically related to mustard, sharing similar tangy flavour and aroma. The major constraint limiting production of crop is poor fertility status of soil. The nitrogen is one of the universal deficient plant nutrients in Indian soils specially the loamy sand soils of semi-arid region of Gujarat and Rajasthan. An optimum supply of nitrogen is important for vigorous, vegetative growth and development of plants. Nitrogen is also an integral part of chlorophyll, which is the primary absorber of light energy needed for photosynthesis. The supply of nitrogen is related to carbohydrate utilization. When nitrogen supply is insufficient, carbohydrates are deposited in vegetative cells which will cause them to thicken. Nitrogen also plays a major role in early establishment of the leaf area and root development which enable efficient use of available inputs. Results of an experiment conducted at various

[1] Assistant Professor, [2] P.G. Student, [3] Assistant Professor, Directorate of Research, [4] Associate Professor

parts of country indicated that cruciferous oil seed crops responded appreciably to nitrogen fertilization (Joshi *et al.*, 1998).

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). 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 cress crop. Therefore, the present investigation was planned to find out the cost effective economic optimum dose of nitrogen for cress crop in middle Gujarat region of India.

MATERIALS AND METHODS

The experiment was conducted during *rabi* season of the year 2014-15 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 850 mm in 2014-15. Twenty four treatment combinations given in *rabi* *cress* crop comprised of four nitrogen level, three phosphorus levels and two sulphur levels were tested in a factorial randomized block design with three replications. The plot size for each treatment was 3.00 m x 4.00 m. The pure seeds of *cress* variety Gujarat Asaliyo-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 3.0 kg ha^{-1} on 16th November in 2014. 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, *cress* 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 nitrogen applied was determined using quadratic model.

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

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

In the test analysis, only the seed yield of cress 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 derivative 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;

$$TR = Py * Y$$
$$Y= Py\ (a + bX + cX^2) \quad \ldots\ldots 2$$

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

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

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

$$TC = Px{*}X \text{ .... 4}$$

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;

$$MP=\frac{\partial Y}{\partial X}=b + 2cX \text{ .... 5}$$

The average unit price of nitrogen (irrespective of the source) was taken as Rs. 6.1 kg^{-1}. However, the market price of cress seed was Rs. 60 kg^{-1}during 2014-15.

RESULTS AND DISCUSSION

The best fit response equation as explained by quadratic model to study the nitrogen management in cress crop under middle Gujarat conditions is given in Table 1. The test analysis indicated that more than 99.98 per cent of the total variation in cress seed yield was due to application of nitrogen during year 2014-15. 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 Fig 1.

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 (Y) 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

Table 1 Estimation of the model determining the relationship between the nitrogen doses applied and cress crop yield obtained during 2014-15

Variable	Coefficients	Standard error	t-value	p-value	R^2-value
Constant	-147.25	32.6142	-0.4.51	0.1388	0.9998
X	36.087	0.7583	47.58	0.0134	
X^2	-0.1806	0.0041	-43.08	0.0148	

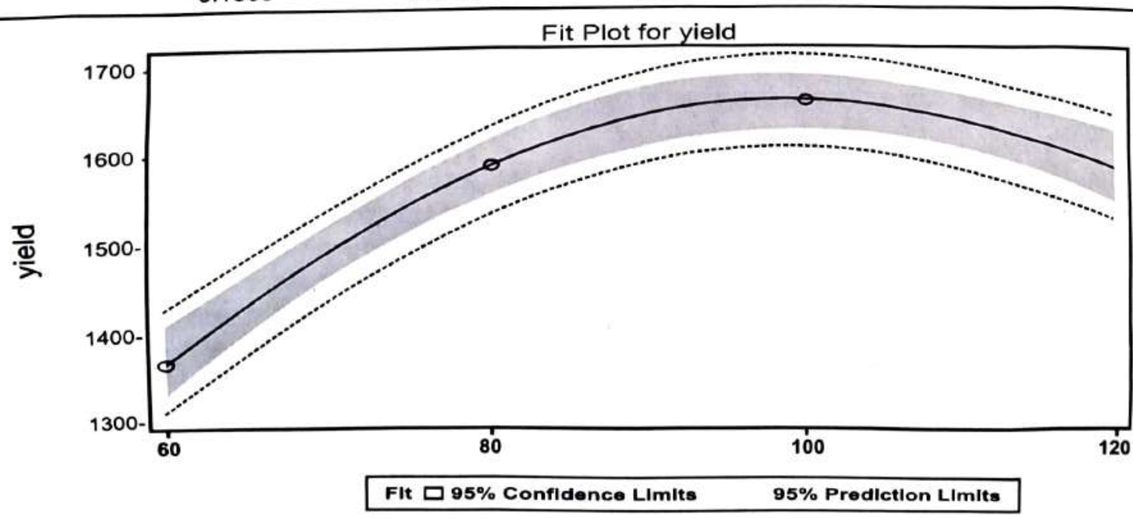

Fig 1 Predicting cress yield at different levels of nitrogen under middle Gujarat conditions using the regression equation (2014-15)

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 cress crop yield obtained for the year 2014-15 was worked out using a quadratic equation as under;

$$Y = -0.1806X^2 + 36.087X - 147.25 \quad R^2 = 0.99$$

TR function was obtained by multiplying the production function for the year 2014-15 with the product price (₹ 60 kg^{-1}) as;

$$TR = = -10.80X^2 + 2164.8X - 8835$$

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

$$MR = -21.6X + 2164.8$$

TC function was obtained by multiplying the price of the input used (₹ 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 = -21.6X + 2164.8, and X = 99.93 kg ha^{-1} was found to be the economical optimum dose of nitrogen for cress 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;

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

36.087 + 2* (-0.1806)*X = 0, and N = 100.22 kg ha^{1}. The optimum and maximum seed yield recorded with application of nitrogen was 1655.250 and 1655.480 kg ha^{-1} (Table 2).

The data presented in Table 2 further revealed that over fertilized condition of nitrogen did not show any significant yield advantage and the *cress* 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 0.29 kg ha^{-1} without any reduction in seed yield of cress crop.

Table 2 Response function, optimum dose and seed yield in relation to nitrogen management in cress crop

Particular	2014-15	
	Economic optimum	Physical optimum
Response equation	$Y = -0.1806X^2 + 36.087X - 147.25$	
Nitrogen dose (kg ha^{-1})	99.93	100.22
Seed yield (kg ha^{-1})	1655.250	1655.480

CONCLUSION

Based on the results, it can be concluded that economic optimum yield of *cress* crop could be obtained with the application of nitrogen 99.93 kg ha^{-1} Profit can be increased by decreasing the nitrogen dose from maximum yield to the economically optimum dose.

REFERENCES

Alivelu, K. Subba-Rao, A. Sanjay, S. Singh, K.N. Raju, N.S. and Madhuri, P. 2006. Prediction of optimal nitrogen application rate of rice based on soil test values. *European Journal of Agronomy,* **25**: 71-73.

Antoniadou, T. and Wallach, D. 2002 . Evaluating optimal fertilizer rates using plant measurements. *Journal of Applied Statistics.* **27**: 1083-1099.

Badam, L., Joshi, S.P., Bedekar S.S. 1999. In–vitro antiviral activity of neem (*Azardirachla indica A juss*) leaf extract against group. *Journal of Commum Dis*, **31**: (2) 79-90.

Belanger, G., J. R. Walsh, J. E. Rýchards, P. H. Mýlburn and N. Zýadý, 2000. Comparison of three statistical models describing potato yield response to nitrogen fertilizer. *Agronomy Journal,* **92**: 902–908.

Choudhary, S., Keshwa G. L. and Yadav, L. R. 2010. Effect of sowing dates, row spacings and nitrogen levels on productivity, quality and economics of garden cress (*Lepidium sativum*). *Indian Journal of Agricultural Sciences* **80** (8): 754-754.

Engel, R. and J. Bergman, 1997. Safflower seed yield and oil content as affected by water and N. *Fertilizer Facts.* No: 14.

Grant C. 2006. Enhancing nitrogen use efficiency in dry land cropping systems on the Northern Great Plains.18th World Congress of Soil Science, Philadelphia, USA.

Henke, J.; Breustedt, G.; Sieling, K. and Kage, H. 2007. Impact of uncertainty on the optimum nitrogen fertilization rate and agronomic, ecological and economic factors in an oilseed rape based crop rotation. *Journal of Agriculture Sceince,(Cambridge)*, **5**: 445-468.

Hussain, S. S.; Misger, F. A.; Kumar, A. and Baba, M. H. 2011. Response of nitrogen and nitrogen on biological and economic yield of sunflower (*Helianthus annuus* L.). *Research Journal of Agriculture Science*, **2**: 308-310.

Joshi, N. L., Mali and Anurag Sexena 1998. Effect of nitrogen and sulphur application on yield and fatty acid composition of mustard (*Brassica juncea L.). Oil-Journal of Agronomy and Crop Science* **180** (1): 59-63.

Kumar, V.; Singh, M. and Singh, N. 1981. Effect of sulphate, phosphate and molybedate application on quality of soybean grain. *Plant and Science*, **59**: 3-8.

Mc Grath, S.P. and Zhao, F.J. 1996. Nitrogen uptake, yield responses and the interactions between nitrogen and nitrogen in winter oil seed rape. *Journal of Agriculture Science*, **126**: 53-62.