Research Article

Economically optimum sulphur dose determination under middle Gujarat conditions for summer cluster bean (*Cyamopsis tetragonoloba* (L.) Taub) production

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Abstract

During the summer of 2020, on farm evaluation was carried out on the College Agronomy Farm of Anand Agricultural University, Gujarat. A significant effect of sulphur fertilizer was observed in raising crop yields of cluster bean. The ideal sulphur dose for maximizing yield and making a profit over fertilizer cost was obtained using a quadratic model of the connection between cluster bean seed yield and the sulphur dose applied. Using information from field trials conducted in 2020, the ideal sulphur dose in cluster bean cultivation under middle Gujarat conditions was determined. For cluster bean, the economically ideal sulphur dose was discovered to be 43.63 kg/ha under middle Gujarat conditions in 2020. When sulphur was over-fertilized for maximum production, the seed yield was nearly identical, even at the physical and economic optimum dose of sulphur, resulting in a 1.55 kg/ha reduction in sulphur use.

Keywords cluster bean, quadratic function, seed yield, sulphur dose

Introduction

Significant legume crop, Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub], popular as "Guar" is mostly grown in Gujarat's semi-arid and dry regions during the kharif and summer seasons. The cluster bean is a member of the Fabaceae family (Leguminosae). It is grown as a food and fodder crop for consumption by humans and animals. Its deeply penetrating roots have ability to use moisture more effectively thus, improves the possibility of summer cropping. Additionally, the crop endures mild salt and alkalinity levels. Cluster bean, which are particularly well-suited to the soil and climate of Gujarat, are the only legume crop that is resilient and drought-tolerant. With 29% of the worldwide extent and 19% of production, India stands on top for the world's highest production as well as consumption. Currently, there are 25.39 million hectares of land grown with pulses, producing 16.10 million tonnes [1]. By 2030 AD, the population of the country is anticipated to be close to 1500 million. To meet the need, the nation would then require 32.0 million tonnes of pulses. In actuality, for the past 20 years, the production and productivity of pulses have stagnated. In contrast to the FAO/WHO recommendation of 80g, the availability of pulses also decreased; from 60g/capita/day during 1951 to 47g during 2014) [2]. For better seed yield and higher-quality output, sulphur (S) fertilization

is more important than the other three plant nutrients (N, P and K) [3]. Since oilseed crops contain more S-containing molecules than cereal crops, their sulphur demand is typically higher [4]. Because crops absorb twice as much sulphur as is added through fertilizers, there is a net loss of sulphur from the soil [5]. Soil S reserves should not be mined as much in order to maintain crop productivity and soil fertility.

It's certainly that greater input consumption causes an upward swing in production that contains a technological upgrade. However, it is crucial to provide enough fertilizer to crop plants to maximize the desired yield potential from an economic and environmental standpoint. In recent years, the necessity of fertilizer application optimization has increased significantly to guarantee good product quality, optimum yield, greater net profit, and decreased environmental damage [6]. Contrarily, excessive fertilization and inadequate fertilization application might occasionally result in economic losses [7]. Therefore, it is crucial to adjust fertilizer application to the crop's needs to increase crop production [8-9, 10].

Sulfur is now correctly referred to as the fourth essential plant nutrient after nitrogen, phosphorus and potassium, regardless of the crops, although for oilseeds and pulses crops, it is just as crucial as phosphorus. Due to its widespread soil deficit, its value is currently understood. Numerous researchers have noted the usefulness of sulphur in boosting agricultural productivity, especially in oilseed and pulse crops. The soils of Gujarat are found to be sulphur deficient in about 37% of cases. Sulphur is a component of three amino acids that are typically found in plants, including cystine, cysteine, and methionine, which are necessary building blocks of proteins. The soils of middle Gujarat are light in texture, primarily in the medium and deficient range, and light in S availability. Therefore, to determine the most economical and cost-effective sulphur dose for cluster bean in India's central Gujarat region, a current study was proposed.

Methodology

Anand is located by 22o 35' N, 72o 55' E and 45.1 m above the mean sea level, where this field trial was commenced in the summer of 2020. Soil chemical test results showed that it had 7.23 pH, 0.22 dS/m EC, 0.40 % organic carbon, available nitrogen (195.2 kg/ha) as well as sulphur (12.23 mg/kg) and medium in available phosphorus (32.41 kg/ha). During 2020, a total of 1076 mm of rainfall was received during the crop growth period. Three replications in a factorial randomized block design (FRBD) was used to examine fifteen treatment combinations given to a summer cluster bean crop that included five nitrogen management treatments and three sulphur levels, namely S1 (30 kg/ha), S2 (45 kg/ha), and S3 (60 kg/ha). The plot within a block was 3.6 m × 5.0 m in size. True to seeds of cluster bean variety GG 2 (Gujarat Gaur 2) were used which were treated with fungicide Mancozeb @ 3 g/kg. On February 17, 2020, manual sowing was carried out in a straight line in furrows that had already been opened, 0.45 m apart, keeping 15 kg/ha seed rate. For optimal germination, the soil was manually applied to the seeds. Standard cultural methods were adhered until the crop was harvested to record various quantitative observations. Cluster bean crop was manually harvested and dried from the net plot when it was mature to calculate the yield in kg/ha.

For identification of the yield-fertilizer correlation, quadratic, square root, linear and Mitscherlich models were used. A quadratic model was used to determine the link between the amount of S applied and the seed yield produced.

$$Y = a + b \times X + c \times X^2 \dots\dots 1$$

Y = seed yield in kg/ha
X = quantity of Sulphur applied in kg/ha
and a, b and c = constants

Only cluster bean seed yield was taken into account in the test study, and the predicted yields were calculated accordingly. Equating the first derivatives of the reaction equations to zero and substituting the same with whatever the number indicated above is achieved to obtain the value of "X", the predicted maximum yield value in the model was determined. Another side, marginal analysis was used to establish the economic optimum dose. The economically ideal dose of sulphur fertilizer was determined to be one in which Marginal Revenue (MR) equals Marginal Cost (MC). By multiplication of the production function and unit product price, the total revenue (TR) function was determined (Py). We can calculate the TR function as:

$$TR = Py$$
$$Y = Py\ (a + bX + cX^2) \ \dots\dots\dots 2$$

By differentiating the 1st order derivative of the TR function MR can be calculated. MR can be calculated as:

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

By multiplication of the input price used with the input amount TC (Total cost) function can be obtained. TC function is calculated as:

$$TC = Px \times X \dots\dots\dots 4$$

By differentiating the 1st order derivative of the total cost function marginal cost function can be calculated. The highest yield is obtained when the marginal production is paralleled to "0". By differentiating the 1st order derivative of the production function Y MP can be worked out.

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

Mean unit cost of sulphur was taken as 50 Rs. / kg (Irrespective of the source). Whereas, the standard price of cluster bean seed was 50 Rs./kg.

Results and Discussion

With the intention of significant sulphur management in cluster bean under middle Gujarat conditions, most suitable response equation was elucidated by a quadratic model is provided in Table 1. According to the test analysis, the application of S during 2020 was responsible for more than 71% of the entire variation in cluster bean seed yield. Figure 1 depicts the highest yield potential which can be utilized in relation to the dose of sulphur used based on the regression analysis.

Table 1. Assessment of the ideal function defining the association among the sulphur dosages applied & cluster bean production attained in 2020

Variables	Coefficient	SEM	t - value	p - value	R^2 - value
Constant value	467	159.32	2.80	<.0.031	
X	29.18	7.51	3.89	0.0081	0.716
X^2	-0.3229	0.0830	-3.89	0.0081	

The higher cost of fertilizers, inadequate resource base, absence of acquaintance and skill of farmers to use optimum fertilizers still raise the problem of how much fertilizer should be applied to attain a moneymaking as well as sustainable yield level as opposed to utilizing fertilizers to aim the

highest yield prospective deprived of considering the financial revenues and keeping environment friendly. It is vital to deliberate if the risk of rising fertilizer cost (MC)
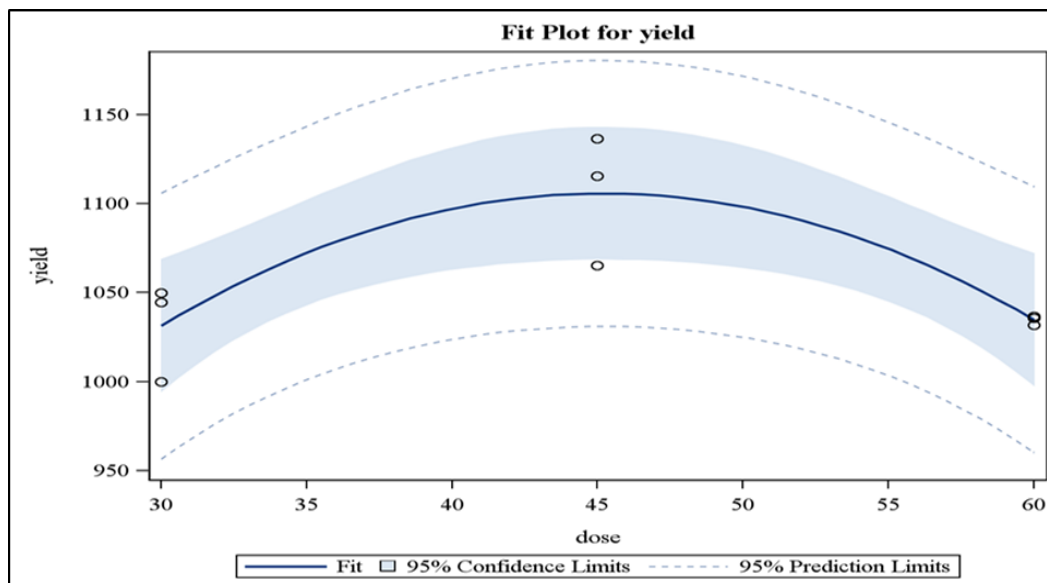

Figure 1. Predicting cluster bean yield for various level for sulphur by means of regression equation (2020)

is balanced by the higher return (MR) produced by each additional unit of sulphur. This context adds each additional unit of input used to account for the higher revenue from the manufacturing amount. For a profitable production, X factor price / Y factor price and additional change in Y product / additional change in X factor should be equal at the point when MR equals MC to calculate the economically optimal sulphur dose.

To encounter the objectives of the trial, a quadratic equation was used to regulate the association between the quantity of sulphur used with the yield of cluster bean for the years 2020-21:

$$Y = -0.3229X^2 + 29.18X + 467$$
$$R^2 = 0.716$$

By multiplying the production function for the year 2020-21 with the product price (50 Rs. / kg) TR function was obtained as:

$$TR = -32.29X^2 + 1459X + 23350$$

The Marginal Revenue function was acquired by taking the 1st order derivative of the Total Revenue function, which was MR = $-32.29X+1459$, and the Total Cost function was calculated by multiplying the cost of the input (50 Rs./kg) by the input amount, which was TC= 50S. By differentiating the TC function's 1st order derivative, the marginal cost (MC) function, with the value 50, was generated.

The economical optimum dose of sulphur for cluster bean was established by equating MC with MR as follows: 50 = -32.29X + 1459, and X = 43.63 kg/ha. However, the physical optimal dose, or maximum seed yield owing to sulphur administration, is attained by comparing MP to 0 as;

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

$$29.18 + 2 \times (-0.3229) \times X = 0$$
and
$$S = 45.18 \text{ kg/ha}.$$

The extreme and optimal (Table 2) yield of cluster bean noted with the use of sulphur was 1125.46 and 1126.24 kg/ha.

Table 2. Response function, optimal dose and yield with sulphur management in sesame

Particulars	2020	
	Economic optimums	Physical optimums
Response function	Y=-0.3229X2 + 29.18X + 467	
S dose (kg/ha)	43.63	45.18
Seed yield (kg/ha)	1125.46	1126.24

Data presented in Table 2 auxiliary revelling that over fertilization of the sulphur did not significantly improve yield. The yield of cluster bean seeds collected at the physical and economic sulphur maxima was seen to be nearly comparable. Thus, 1.55 kg/ha of sulphur can be conserved while still producing cluster bean seeds.

Conclusion

According to the findings, it was possible to apply 43.63 kg/ha of sulphur to achieve the economic maximum yield of a cluster bean seed. Profits can be raised by lowering the sulphur dose from the highest yield to the level that is most profitable. When sulphur was over-fertilized for maximum production, practically equal seed yields were seen at the physical and economic optimum sulphur dose, showing a saving of 1.55 kg sulphur/ha.

Acknowledgements

References

[1] Anonymous **(2008)**. Area and production, Retrieved from: kvkvellore.org/source/.

[2] A. K. Tiwari and A. K. Shivhare **(2016)**. Pulses in India: Published by Director, Govt. of India, Ministry of Agriculture & Farmers Welfare (DAC&FW), Directorate of Pulses Development, Vindhyachal Bhavan, Bhopal, M.P.- 462004, Publication No.: DPD/Pub.1/Vol. 2/2016.

[3] S. S. Hussain, F. A. Misger, A. Kumar and M. H. Baba **(2011)**. Response of nitrogen and sulphur on biological and economic yield of sunflower (*Helianthus annuus* L.), Res. J. Agri. Sci., **2:** 308-310.

[4] H. W. Scherer **(2001)**. Sulphur in crop production. Eur. J. Agron., **14:** 81-111.

[5] H. L. S. Tandon and D. L. Messick **(2007)**. Practical Sulphur Guide (revised). The Sulphur Institute, Washington, D. C.

[6] K. Alivelu, S. A. Rao, S. Sanjay, K. N. Singh, N.S. Raju and P. Madhuri **(2006)**. Prediction of optimal nitrogen application rate of rice based on soil test values, Eur. J. Agron., **25:** 71-73.

[7] C. Grant **(2006)**. Enhancing nitrogen use efficiency in dryland cropping systems on the Northern Great Plains.18th World Congress of Soil Science, Philadelphia, USA.

[8] G. Belanger, J. R. Walsh, J. E. Richards, P. H. Milburn and N. Ziadi **(2000)**. Comparison of three statistical models describing potato yield response to nitrogen fertilizer. Agron. J., **92:** 902-908.

[9] T. Antoniadou and D. Wallach **(2002)**. Evaluating optimal fertilizer rates using plant measurements, J. Appl. Stat., **29:** 1083-1099.

[10] J. Henke, G. Breusted, K. Sieling and H. Kage **(2007)**. Impact of uncertainity on the optimum nitrogen fertilization rate and agronomic, ecological and economic factors in an oilseed rape based crop rotation. J. Agr. Sci., **145:** 445-468.