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Research Article

Modeling Sunflower Productivity and Profitability in Relation to Adequate and Limited Sulphur Availability under Semiarid Irrigated Conditions

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Inadequate and/or imbalanced fertilization has been identified as one of the critical bottlenecks holding oilseeds production and productivity. Sustainable production requires efficient use of inputs maintaining optimum yield and high quality product. The present study aims at defining the quantitative relationship between the fertilizer S applied and the sunflower yield obtained using a polynomial function. The analysis was done to allocate the S fertilizer for maximization of net profit over fertilizer cost depending on the availability of the fertilizer. The results indicated that the cost effective economically optimum dose of sulphur for sunflower cultivation was found to be 36.70 kg S/ha under its full availability. The expected sunflower yield at this dose was worked out to be 2.619 t/ha. However, it is advisable to uniformly distribute the fertilizer to all over the cultivable area under its limited availability for exploiting the desired yield potential and maximum net monetary returns.

1. Introduction

Sulphur (S) is considered the fourth most important essential element after N, P, and K owing to greater significance for plant growth, seed yield, oil and protein synthesis, and improved quality of produce having its role in enzymatic and metabolic processes [1–5]. In general, oilseeds have high demand of S owing to oil biosynthesis [6] and approximately 16 kg S (range 5–20) is required to produce one tonne of seed containing 91% dry matter [7]. The response of S fertilization to oilseeds crops ranged between 15 and 62 kg/kg S applied depending on the inherent fertility status, prevailing weather condition, cropping system followed, and S source being used [8]. Therefore, soil S reserves and their optimal fertilization require immediate attention for sustaining the soil fertility and attainting higher crop productivity.

No doubt the increased use of inputs induces an upward shift in production function to the extent that a technological change is embodied in them. But in the context of the law of diminishing marginal utility under unlimited availability of inputs, one may recommend optimum use of the resources; that is, marginal revenue equals marginal cost. Furthermore, the farmers do not use the recommended dose of nutrients even when they are convinced of the benefits of fertilizer application mainly because of their poor resource base, costlier fertilizers, and cultivation of oilseed crops under input-starved conditions leading to poor input/output ratio.

Sunflower holds a great promise as an oilseed crop with chances of area expansion and horizontal intensification for improving oilseed production due to its short duration, high per day productivity, photoinsensitivity, wider acclimatization, and polyunsaturated fatty acids rich edible oil. Keeping in view the important role of S in oilseed crops including sunflower, increasing use of S free fertilizers, and its increasing deficiency particularly under intensive cropping systems, an attempt was made to optimize the sulphur dose for yield maximization under its adequate supply as well as the optimal allocation of sulphur particularly under its constraint availability.

2. Materials and Methods

The data were collected from the field experiments conducted during *spring* 2008 and 2009 at Punjab Agricultural University, Ludhiana (30°56′N, 75°52′E, 247 meters above mean sea level) to evaluate the productivity potential of sunflower in relation to levels and sources of sulphur application. The soil of experimental site (0–15 and 15–30 cm depth) was loamy sand in texture (77.2 ± 2.7% sand, 14.6 ± 1.5% silt, 12.6 ± 1.2% clay), slightly alkaline in nature (pH 7.9 ± 0.5), free from salts (0.20 ± 0.1 dS/m); low in organic carbon (0.19 ± 0.1%), available nitrogen (109 ± 3.5 kg/ha $KMnO_4$-N), and available sulphur (7.2 ± 2.5 ppm $CaCl_2$-S); medium in available phosphorus (11.21 ± 0.65 kg/ha Olsen's P) and potassium (155 ± 4.5 kg/ha NH_4OAC-K). After thorough seed bed preparation, sunflower hybrid PSH 569 was planted in the first fortnight of February by dibbling three seeds per hill in seven-row plots, 5.1 m long with spacing of 0.6 m between rows and 0.3 m within rows each year. After complete germination, one plant per hill was retained by thinning extra plants at the 3-4 leaf stages. The treatment combinations consisted of four sources of S, *namely*, ammonium sulphate, single super phosphate, gypsum, and elemental sulphur, were evaluated at two levels of S (20 and 40 kg/ha) along with control (no sulphur application) in randomized block design replicated thrice. All the treatment plots were uniformly fertilized with 60 kg N, 30 kg P_2O_5, and 30 kg K_2O per hectare taking into consideration the contribution of sulphur sources towards nitrogen and phosphorus nutrition. Half dose of N in the form of urea/diammonium phosphate (DAP) and full dose of P (DAP), K (muriate of potash), and S as per treatments were drilled at the time of sowing while remaining half dose of N was top dressed with first irrigation applied at 30–35 days after planting. Standard cultural practices as per state recommendations were followed till the harvest of the crop. At maturity, head samples for yield were harvested from the center rows of each plot, dried, and threshed manually to determine the seed yield which was then expressed in kg per hectare.

Significant improvement in seed yield of sunflower was observed due to sulphur application. Each incremental dose of S resulted in linear and significant increase in seed yield up to 40 kg S/ha. Though the treatment effects were similar under both of the years of the experimental study, the data thus obtained were pooled together and analyzed statistically using analysis of variance technique, and significant means were separated using least significance difference test (LSD) at 5% significance level for comparing the treatment means as per the procedure described by Cochran and Cox [9] using computer programme CPCS 1 [10]. In the test analysis, only the seed yield of sunflower has been considered as the dependent variable and the expected yields have been worked out accordingly. The sunflower byproduct has not been taken into consideration while working out the profitability in the present study. The polynomial type of production function was applied to meet the objective of the study [11]:

$$Y = b_0 + b_1 X + b_2 X^2 + b_3 X^3, \tag{1}$$

where Y = yield of oilseeds in q/ha and X = dose of sulphur in kg/ha,

$$b_1 > 0, \qquad b_2 > 0, \qquad b_3 < 0, \tag{2}$$

where b_1 is the intercept, b_2 is the slope, and b_3 is the curvature of the curve.

It is assumed that 100 kg of the sulphur fertilizer and 5 hectares of the land are available with the farmer. Depending on the conditions of resource availability, there could be an option out of any of the four methods of fertilizer application mentioned below.

(1) Fertilizer at its maximum output level: apply fertilizer at its maximum level and, thus, when the fertilizer is exhausted, leave the rest of the land uncovered by the fertilizer. The dose can be worked out as follows:

$$\begin{gathered}\frac{\delta Y}{\delta X} = b_1 + 2b_2 X + 3b_3 X^2 = 0, \\ X = \frac{-(2b_2) \pm \sqrt{(2b_2)^2 - 4(3b_3)(b_1)}}{2(3b_3)}.\end{gathered} \tag{3}$$

The positive value of X has economic significance and is considered.

(2) Fertilizer at its optimum output level: the fertilizer is applied as per optimum dose. When the fertilizer is exhausted, the rest of the land is kept without any fertilizer application. The optimum dose is worked out as follows:

$$\begin{gathered}\frac{\delta Y}{\delta X} = b_1 + 2b_2 X + 3b_3 X^2 = \frac{P_x}{P_y}, \\ X = \frac{-(2b_2) X \pm \sqrt{(2b_2)^2 - 4(3b_3)(b_1 - P_x/P_y)}}{2(3b_3)},\end{gathered} \tag{4}$$

where P_x is the price of input in Rs/kg and P_y is the price of output in Rs/kg.

(3) Fertilizer at its maximum technical efficiency: this level is calculated where the average product is maximum ignoring the value of intercept. This can be calculated as

$$\frac{Y}{X} = b_1 + b_2 X + b_3 X^2. \tag{5}$$

For its maximization, take first derivative and equate it to zero:

$$\begin{gathered}\frac{\delta AP}{\delta X} = b_2 + 2b_3 X = 0, \\ X = -\frac{b_2}{2b_3}.\end{gathered} \tag{6}$$

(4) Distribute the fertilizer equally in the whole available land. In the present study, 150 kg of sulphur and 5 hectares

Table 1: Net returns over fertilizer cost under different possibilities of fertilizer use.

Sr. no.	Particulars	Maximum yield dose	Optimum dose	Equal distribution dose	Technical efficiency dose
1	Fertilizer dose (kg S/ha)	45.21	36.70	30.00	85.75
2	Yield at fertilizer dose (t/ha)	2.62	2.61	2.60	2.63
3	Area covered (ha)	3.32	4.09	5.00	1.75
4	Total expected yield (t)	12.75	12.90	13.04	12.43
5	Total gross returns (USD)	5376	5440	5498	5240
6	Total fertilizer cost (USD)	46	46	46	46
7	Net returns over fertilizer cost (USD)	5331	5394	5452	5194
8	Net returns per hectare (USD)	1066	1079	1090	1039

USD: United States dollar, equivalent to Rs.55/dollar.

of land have been assumed to be available with the farmer. The allocation of the fertilizer has been made accordingly. The total expected yield under different situations has been worked out as follows:

$$\text{EY} = AY + (T - A)\, b_0, \tag{7}$$

where EY = expected yield, A = area covered (ha) by the respective dose of sulphur, Y = estimated yield (q/ha) at the respective dose of sulphur, T = total available land (5 ha), and b_0 = intercept of production function.

3. Results and Discussion

The estimated equation for the response of sunflower—an oilseed crop—to sulphur application is given below:

$$Y = 2406 + 12.3X - 0.225X^2 + 0.001312X^3, \quad R^2 = 0.756. \tag{8}$$

The analysis revealed that more than 75 per cent of the total variation in sunflower seed yield was caused due to sulphur application. Because of sharp increase in the prices of the fertilizers as well as lack of knowledge, the cultivators have not been using fertilizers up to the recommended level. Then the question arises at what level fertilizer application should be made to achieve the desired yield potential. There are four possibilities (maximum, optimum, equal distribution, and technical efficiency) which have been discussed in methodology. The returns obtained over fertilizer cost under all the four possibilities have been summarized in Table 1. The first two conditions exist when there is no constraint towards fertilizer availability; however, the rest of the conditions prevails under the condition of limited resource availability.

The results of the response curve presented in Table 1 elucidated that for yield maximization, the sulphur dose was estimated to be 45.21 kg S/ha. At this fertilizer dose, the yield has been calculated as 2.62 t/ha. Given the total area (5 hectares) and total sulphur available (150 kg), the area covered was 3.32 hectares and the total expected yield was found to be 12.75 t/ha giving a total returns of USD 5376 under the present situation. However, at optimum level, there was a saving of almost 8.5 kg S/ha without any reduction in seed yield compared to that obtained under maximum dose. The optimum dose was worked out to be 36.70 kg S/ha with seed yield of 2.61 t/ha giving the total expected yield of 12.90 t/ha with a coverage of larger area (4.09 ha) giving total net returns of USD 5440 as against the maximum dose. Since the cost of fertilizer was constant under both cases, the net returns over fertilizer cost were also higher under optimum dose with a net saving of USD 12.6/ha when compared with maximum dose.

In general, the farmers do not have the sufficient fertilizer to be used under the actual farm situation. Under limited availability, the option available with the farmer is either to distribute the fertilizers equally to all the fields or to use it at its maximum technical efficiency. The results revealed that equal distribution and maximum efficiency dose were worked out to be 30.00 and 85.75 kg S/ha with the corresponding yield levels of 2.60 and 2.63 t/ha, respectively. Given the total area of 5 ha and total fertilizer availability of 150 kg, the coverage area under maximum efficiency dose was found to be only 1.75 ha leading to total expected yield of only 12.43 tonnes with total returns of USD 5240 as against the total expected yield of 13.04 tonnes with total returns of USD 5498 under equal distribution dose. The net return over fertilizer cost was also higher under equal distribution dose (USD 1090/ha) compared to technical efficiency dose (USD 1039/ha).

This study indicated that the cultivators should be advised to use optimum dose of sulphur for sunflower cultivation, if it is adequately available. However, under the situation of limited fertilizer availability, it would be more beneficial to equally distribute the fertilizer dose to all the fields for yield maximization and to get maximum benefit out of it.

References

[1] H. Marschner, *Mineral Nutrition of Higher Plants*, Academic Press, London, UK, 1995.

[2] J. Roche, A. Essahat, A. Bouniols et al., "Diversified composition of sunflower (*Helianthus annuus* L.) seeds with in cultural practices and genotypes (hybrids and populations)," *HELIA*, vol. 27, pp. 73–97, 2004.

[3] S. S. Hussain, F. A. Misger, A. Kumar, and M. H. Babu, "Response of nitrogen and sulphur on biological and economic yield of sunflower (*Helianthus annuus* L.)," *Research Journal of Agricultural Sciences*, vol. 2, pp. 308–310, 2011.

[4] H. L. S. Tandon and D. L. Messick, *Practical Sulphur Guide*, The Sulphur Institute, Washington, DC, USA, 2007.

[5] M. A. Wani, F. A. Agha, M. A. Malik, and Z. A. Rather, "Response of sunflower to sulphur application under Kashmir conditions," *Applied Biological Research*, vol. 3, pp. 19–22, 2001.

[6] H. W. Scherer, "Sulphur in crop production—invited paper," *European Journal of Agronomy*, vol. 14, no. 2, pp. 81–111, 2001.

[7] S. P. McGrath and F. J. Zhao, "Sulphur uptake, yield responses and the interactions between nitrogen and sulphur in winter oilseed rape (*Brassica napus* L.)," *Journal of Agricultural Science*, vol. 126, no. 1, pp. 53–62, 1996.

[8] D. M. Hegde and S. N. Sudhakara Babu, "Declining factor productivity and improving nutrient-use efficiency in oilseeds," *Indian Journal of Agronomy*, vol. 54, no. 1, pp. 1–8, 2009.

[9] W. G. Cochran and G. M. Cox, *Experimental Designs*, John Willey and Sons, New York, NY, USA, 1967.

[10] H. S. Cheema and B. Singh, *A User's Manual to CPCS 1*, Punjab Agricultural University, Ludhiana, India, 1990.

[11] R. K. Sharma, S. C. Nayital, and J. R. Thakur, "Response of barley to nitrogenous fertilizer—a study of limited availability," *Fertilizer Marketing News*, vol. 20, pp. 11–15, 1989.