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Sulphur management in onion (*Allium cepa*) cultivation in hills of Himachal Pradesh

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Abstract: *Field experiment were conducted at CSK HPKV Research Farm, Palampur during Rabi seasons of 2000-01 and 2001-02, to study the response of onion (Allium cepa var. Patna red) at four sulphur levels (0, 15, 30 and 60 kg ha^{-1}) applied through Gypsum and S^{95}. The analysis was done to allocate the limited availability of sulphur for maximizing net profit over fertilizer cost. The results show that the dose of sulphur under its full availability is 43.02 kg ha^{-1}. But under its scarce availability, the maximum benefit would occur when it is applied upto 32.11 kg ha^{-1} followed by even distribution of fertilizer i.e. 20 kg ha^{-1}. The returns following sulphur application at these rates, would be Rs 69340, 73092 and 68700 ha^{-1} respectively.*

Key words: *Gypsum, S^{95}, Sulphur, Onion, Management*
PDF of full length paper is available online

Introduction

In recent years the cultivation of onion (*Allium cepa* L.) has picked up in Himachal Pradesh because of shrinking size of holding, thus, forcing the farmers to opt for high value crops. Onion is rich condiment besides its medicinal properties. Liliac plants (onion and garlic) are known for their affinity to sulphur because sulphur is a constituent of secondary compounds, *i.e.* allin, cycloallin and thiopropanol (Schnug, 1993; Raina and Jaggi, 2008) therein. These secondary compounds not only govern the taste, pungency and medicinal properties of onion but are also important for resistance against pests and diseases (Brown and Morra, 1997). Frequent sulphur responses in onion and garlic have been observed in Himachal Pradesh (Jaggi and Raina, 2008; Jaggi, 2009; Jaggi and Raina, 2008). As such sulphur is a key nutrient in onion production. But because of high cost, it is not within the reach of small and marginal farmers. Thus, there is a need to find out (i) the optimum dose of sulphur and also the (ii) equal distribution and (iii) maximum efficiency dose to achieve highest returns when either its availability is scarce or the farmers are unable to buy it.

Materials and Methods

The data were collected from the field experiments conducted during Rabi seasons of 2000-01 and 2001-02 at CSKHPKV, Research Farm, Palampur. Acid Alfisols (Typic Hapludalf) of the experimental site had the following characteristics : Silty clay loam texture, pH 5.2, O.C 1.35% , and available N, P,K and sulphur were : 251, 36, 220 and 35 kg ha^{-1}, respectively. The treatments consisted of one control and three level of sulphur (15, 30 and 60 kg ha^{-1}) applied through Gypsum and S^{95} in four replicates in a Randomized Block Design having a plot size of 2.25 x2.00 m^2.

Nitrogen, P_2O_5 and K_2O were applied basally @ 125 (50% at transplanting time), 76 and 60 kg ha^{-1} respectively through IFFCO (12:32:16). Additional nitrogen and K_2O were applied through urea and murate of potash respectively. Farm Yard Manure @ 25 t ha^{-1} was also worked basally in the soil with these fertilizers. Remaining nitrogen was split in two halves to be added approximately at 8 and 12 weeks intervals after transplanting onion seedlings depending upon the moisture conditions of the soil and plant growth. Transplantation of onion seedlings was done in the second and fourth week of January in two years in respective manner. Standard cultural package of practices were followed till the harvest of crop done in the second week of June. Fresh weights of onion bulbs and foliage were taken separately and their samples were dried in oven at 65±5°C for moisture determination. The data were analyzed statistically on pooled basis for the two years of study. The method outlined by Hicks (1977) was followed for the statistical analysis.

The polynomial type of production function was applied (Sharma *et al.*, 1989).

$$Y = b_1 + b_2X + b_3X^2 + e$$

Y = Yield of onion in tonnes; X = dose of sulphur in kg ha^{-1}; e = error term; $b_1 > O$; $b_2 > 0$ and b3 < O where b_1 is the intercept, b_2 is the slope of curve and b_3 is the curvature of the curve.

100 kg of sulphur fertilizer and 5 ha of land has been assumed to be available. Under their limited availability, four methods of application of input (sulphur) can be used.

1. Fertilize at maximum output level. Leave the rest of the land without fertilizer when the fertilizer is exhausted. The dose can be worked out as follows:

$$\frac{\delta Y}{\delta X} = b_1 + 2b_2X + 3b_3X^2 = 0$$

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$$X = \frac{-(2b_2) \pm [2b_2)^2 - 4(3b_3)\ (b_1)]^{1/2}}{2(3\ b_3)}$$

The positive value of X_1 has economic significance and is considered.

2. Fertilize at optimum dose. The fertilizer is applied as per optimum dose per ha when the fertilizer is exhausted the rest of land is kept without any fertilizer application. The optimum dose is worked out as follows:

$$\frac{\delta Y}{\delta X} = b_1 + 2b_2X + 3b_3X^2 = P_X / P_Y$$

$$X = \frac{(2b_2)\ X \pm [2b_2)^2 - 4(3b_3)\ (b_1) - P_x / P_Y)]^{1/2}}{2\ (3b_3)}$$

Where, P_x = Price of sulphur (Rs 45 kg^{-1}); P_Y = Price of onion (Rs 4,000 $tonne^{-1}$)

3. Fertilize at maximum technical efficiency level. This level is calculated where the average product is maximum, ignoring the value b_1 (intercept).

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

For its maximization, take first derivative and equate this to zero.

$$\delta AP/ \delta X = b_2 + 2b_3 X = 0$$

$$X = \frac{b_3}{(2)\ b_3}$$

Distribute the fertilizer equally in all the available land at 20 $kg\ ha^{-1}$.

4. Total expected yield = AY + (T-A) b_1

Where, A = Area covered (hectares) by the respective dose of sulphur; Y = Estimated yield (tonnes) at the respective dose of sulphur; T = total available land (5 ha) and b_1 = Intercept of production (tonnes) function.

Results and Discussion

The estimated production function is given below:

$$Y = 6.5 + 0.2091X + 0.0244X^2 - 0.00038X^3\ R^2 = 0.3594$$
$$(\pm 0.0543) \qquad (\pm 0.0116) \quad (\pm 0.00013)$$

Values in parentheses are standard error.

The results of the response curve are presented in Table 1. The table revealed that for maximization of yield, sulphur dose was estimated at 43.25 $kg\ ha^{-1}$. At this dose of sulphur, the yield has been calculated as 30.44 tonnes ha^{-1}. Given the total area (5 ha) and total sulphur available (100 kg), the area covered was 2.31 hectares and the total yield was estimated to be 87.80 tonnes giving a total returns of Rs. 3,51,200. At optimum level, sulphur dose was marginally decreased to 43.02 $kg\ ha^{-1}$. However, it covered larger area (2.32 ha) and the total returns were found to be Rs 3,51,800. The returns over fertilizer cost were estimated to be Rs 3,46,700 and Rs 3,47,300 for maximum and optimum yields levels in respective manner. The corresponding per hectare returns have been calculated to be Rs 69,340 and Rs 69,460. For optimum dose of fertilizer, the farmer would require 215.10 kg of fertilizer. At this level, total yield would be 152 tonnes and total returns would be Rs 6,08,000 giving Rs. 5,98,329 returns over the fertilizer cost. The per hectare net returns would be Rs.1,19,664. But the farmers, in general, do not have sufficient fertilizer to be used upto optimum level. The farmers have limited fertilizers and in actual practice they distribute equally to all the fields. There is other alternative dose, maximum efficiency dose, which gives higher returns. The returns obtained under these two methods have been shown in the Table 1. The results revealed equal distribution dose and maximum efficiency dose to be 20.00 and 32.11 $kg\ ha^{-1}$, respectively. The corresponding yield levels were worked out as 17.40 and 25.79 tonnes ha^{-1} giving total yields of 87.00 and 92.49 tonnes. Table 1 revealed highest net returns ha^{-1} under maximum efficiency dose amongst all the four doses of sulphur. Jaggi and Sharma (1996) have used similar model to manage sulphur application under its limited availability in Raya (*Brassica juncea*); another sulphur loving crop. There

Table - 1: Net returns under different methods of fertilizer application

S.N.	Particulars	Maximum yield dose	Optimum yield dose	Equal distribution dose	Maximum efficiency dose
1	Fertilizer dose ($kg\ ha^{-1}$)	43.25	43.02	20.00	32.11
2	Yield at fertilizer dose (Tonnes ha^{-1})	30.44	30.40	17.40	25.79
3	Area covered (ha) [100 kg/S.N.1]	2.31	2.32	5.00	3.11
4	Total yield (Tonnes) [substituting the value of S.N.1 in the equation]	87.80	87.95	87.00	92.49
5	Total returns (Rs) [S.N. 4* P_Y]	3,51,200	3,51,800	3,48,000	3,69,960
6	Total cost of fertilizer (Rs) [P_X]	4,500	4,500	4,500	4,500
7	Return over fertilizer cost (Rs) [S.N.5 – S.N.6]	3,46,700	3,47,300	3,43,500	3,65,460
8	Returns per ha (Rs) [S.N.7/ total available land *i.e.* 5 ha]	69,340	69,340	68,700	73,092

also the results revealed that the dose of sulphur under its full availability was 110.3 kg ha^{-1}, but under its limited availability, the maximum benefit would occur when the sulphur was supplied upto 69.7 kg ha^{-1} (maximum efficiency dose) followed by S dose of 40 kg ha^{-1} under even distribution. The net returns over fertilizer cost under these three situations were Rs 23356, 27815 and 25715 ha^{-1}, respectively.

Hence, the study recommends optimum dose of sulphur, if it is adequately available; whereas under limited availability it would be more economical to use fertilizer at maximum efficiency level. Needless to repeat that sulphur is a key element for the production of oilseeds, onion and garlic; and if its full use is not within the reach of the average or marginal farmers; present study suggests the dose adjustment (maximum technical efficiency dose) to get maximum benefits out of it.

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