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Research Article

Influence of Sulphur Dose and Spacing on Quality Attributes and Economics of Knol-Khol (*Brassica oleracea* var. *gongylodes* L.) Variety Early White Vienna

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Abstract

A field experiment was conducted to study the effect of sulphur and spacing on quality attributes and economics of knol-khol (Brassica oleracea var. gongylodes L.) at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Jaipur) during *Rabi* season 2014-15 on loamy sand soil with consisting four levels of each sulphur (0 kg, 20 kg, 40 kg and 60 kg sulphur ha^{-1}) and spacing (30x20 cm, 30x30 cm, 45x30 cm and 45x45 cm). The Results revealed that application of 60 kg sulphur ha^{-1} to the knol-khol crop significantly increased the sulphur content in knob, protein content (%), ascorbic acid content in knob (mg/100g), net returns and B: C ratio as compared to control and 20 kg sulphur ha^{-1} but statistically at par with 40 kg sulphur ha^{-1}. The level of spacing 45x45 cm significantly increased the sulphur content in knob, protein content (%) and ascorbic acid content in knob (mg/100g) as compared to 30x20 cm spacing and 30x30 cm spacing, but statistically at par with 45x30 cm spacing. The net returns and B:C ratio were found significantly maximum at 30x30 cm spacing as compared to 45x45 cm and 30x20 cm spacing which was found statistically at par with 45x30 cm spacing. The combined application of 40 kg sulphur ha^{-1} with 45x30 cm spacing proved to be most superior treatment combination in terms of sulphur content in knob and 40 kg sulphur ha^{-1} with 30x30 cm spacing in terms of net returns and B:C ratio. In case of T.S.S. content in knob, maximum value of sulphur and spacing were found to be non significant over preceding levels of the treatments.

Keywords: Knol-khol, Sulphur, spacing, interaction effect, quality and economics

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Introduction

Knol-khol (*Brassica oleracea* var. *gongylodes*) is a winter season crop and is originated from the coastal countries of Mediterranean region [1]. It is commonly grown in Northern India and also in some parts of Rajasthan. The stem swells and stores edible food material specially starch and sugars. When consumed as raw it gives sweetish taste with slight aroma. The stem develops entirely above ground, which is edible and vary delicate in flavour and texture [2]. Knol-khol is characterized by formation of knob (tuber) which arises from thickening of the stem tissue above the cotyledon. The knob is harvested for human consumption either as raw or cooked. It is also utilized for making salad and pickles. Knol-khol contain protein 1.1 g, calcium 20 mg, iron 0.4 mg, vitamin A 36 IU and other minerals 0.7 mg per 100 g of edible portion. It also contains thiamin, riboflavin, nicotinic acid and ascorbic acid [3]. Sulphur appears to be essential for the formation of chlorophyll and protein in plants and effects the assimilation of carbohydrates [4]. Sulphur also has a number of important functions in plant nutrition. It is required for synthesis of certain amino acids, which are essential component of protein and also help in synthesis of biotin, thiamin, glutathione and co-enzyme-A and formation of chlorophyll and nitrogenase enzyme [5]. The spacing of crop may be varied according to climatic condition, soil fertility and cultivars adaptation to particular region. Under the wider spacing, the plant was more vigorous in terms of leaf size, which might be due to less competition for light, nutrients and moisture as compared' to closer spacing [6]. Among the various cultural practices, proper spacing & application of different dose of fertilizer at appropriate time are of great importance especially for semi-arid conditions of Rajasthan keeping adequate plant population per unit area.

Materials and Methods

The experiment was laid out at Horticulture farm, S.K.N. College of Agriculture, Jobner, Distict Jaipur (Rajasthan) during *Rabi* season 2014-15. The climate of Jobner is typically semi-arid characterized by extremes of temperature both in summer and winter, low rainfall and moderate relative humidity. Maximum temperature in summer ranges between 30 to 48^0C whereas, in winter, temperature falls down to as low as -1^0C. The average rainfall varies between 250 to 500 mm. The crop was transplanted on 18/10/2014 and harvested as last picking on 12/12/2014. The mean daily temperature maximum and minimum during the growing season of knol-khol fluctuated 35.0 and 2.0^0C, relative humidity ranged from 52 to 70 per cent. The soil was loamy sand in texture, slightly alkaline in reaction, poor in organic carbon (0.15 %) with low available nitrogen (128 kg ha^{-1}), phosphorus (16.63 kg ha^{-1}) and sulphur (8.40 mg kg^{-1}) and medium in potassium content (154.1 kg ha^{-1}). The experiment was comprised of 16 treatment combination will be carried out in Randomized Block Design (RBD) with four levels of each Sulphur (0, 20, 40 and 60 kg ha^{-1}) and spacing (30x20, 30x30, 45x30 and 45x45 cm). Two raised nursery beds of dimensions of 3 m x 1 m x 0.15 m (Length x Width x Height) were prepared by mixing well rotten FYM in soil @ 15 kg m^{-2}. Seeds of knol-khol *cv.* Early White Vienna obtained from National Seed Corporation was treated with 0.02 percent thiram to save the seedlings from damping off disease. Five weeks old seedlings were transplanted on 18th October 2014, when average height of seedlings was about 5-7 cm. The distance between row to row and plant to plant was kept at four levels of spacing (30x20, 30x30, 45x30 and 45x45 cm).

Treatment application

Sulphur and spacing

Sulphur was applied as per treatment through agriculture grade elemental sulphur and was broadcasted uniformly before transplanting and incorporated in the soil. The agricultural grade of elemental sulphur (100 % S) was applied as per treatment before 20 days of transplanting. Sowing of the seedlings was carried out as per the scheduled levels of spacing viz. 30x20 cm, 30x30 cm, 45x30 cm and 45x45 cm.

Nutrient content and quality parameters

Nutrient content	Estimating method
Sulphur content in knob (%)	turbidometric method by Tabutabi and Bermner, 1970 [7].
Nitrogen content in knob (%)	Nessler's reagent with colorimetric method by Snell and Snell, 1939 [8].
Protein content in knob (%)	multiplying nitrogen per cent in knob by the factor 6.25 by A.O.A.C., 1980 [9]
Ascorbic acid content in knob (mg/100g)	determined by diluting the known volume of juice with 3% metaphosphoric acid and titrating it with 2,6-dicholorophenol-indophenol solution by A.O.A.C.,1960 [10]

Results and Discussion

Effect of sulphur and spacings on quality attributes

Data presented in **Table 1** indicated that increasing levels of sulphur significantly increased the sulphur, protein and ascorbic acid content in knob upto 40 kg sulphur per ha. The maximum sulphur content (0.736 per cent), protein content (4.39 %) and ascorbic acid content (53.40 mg/100g) was recorded in application of 60 kg sulphur per ha whereas minimum was recorded in control being at par with 40 kg sulphur.. Application of 60 kg sulphur being at par with 40 kg sulphur indicated an increase of 17.76 and 7.60 per cent in case of sulphur content, 66.13 and 17.71 per cent in case of protein content and 15.26 and 6.67 per cent in case of ascorbic acid content over control and 20 kg sulphur per ha, respectively. A perusal of data in the same table explains that different levels of sulphur and spacing did not preciptible variation in the TSS content of knob. The results of present investigation revealed that increasing levels of sulphur significantly increased the sulphur content in knob (Table 1). Increased accumulation of nutrients especially N, P and S in vegetative plant parts concomitant with improved metabolism led to greater translocation of these nutrients to reproductive structure of crops. The results are in conformity with the findings of [11], [12], [13] and [14]. From the experiment, protein and ascorbic acid content in knol-khol increased significantly with the increasing levels of sulphur (Table 1). The results may be due to the fact that nitrogen and sulphur are the main ingredients of protein and increase in their availability increase the utilization of nitrogen for the synthesis of protein. Sulphur synthesized some sulphur containing amino acids like cysteine and methionine and resulted in increased protein content, which is in accordance with the findings of [15], [16] and [17].

Table 1 Effect of sulphur and spacing on quality attributes and economics of knol-khol

Treatments	Sulphur content in knob (%)	T.S.S. content (%)	Protein content (%)	Ascorbic acid content	Net returns (Rs/ha)	B:C ratio
Sulphur level						
S_0 (0 kg/ha)	0.625	7.01	2.48	46.33	196634	2.30
S_1 (20 kg/ha)	0.684	7.51	3.50	50.06	258281	3.01
S_2 (40 kg/ha)	0.723	7.92	4.12	52.51	303293	3.50
S_3 (60 kg/ha)	0.736	8.21	4.39	53.40	315103	3.60
SEm±	0.012	0.19	0.10	0.73	6206	0.07
CD at 0.05%	0.035	0.56	0.30	2.12	17922	0.22
Spacing						
D_0 (30x20 cm)	0.639	7.12	2.71	47.36	263111	3.03
D_1 (30x30 cm)	0.682	7.48	3.49	49.77	308026	3.55
D_2 (45x30 cm)	0.718	7.87	4.01	52.17	290822	3.36
D_3 (45x45 cm)	0.729	8.18	4.28	52.99	211352	2.46
SEm±	0.012	0.19	0.10	0.73	6206	0.07
CD at 0.05%	0.035	0.56	0.30	2.12	17922	0.22

A perusal of data (Table 1) explains that levels of spacing significantly increased the sulphur, protein and ascorbic acid content in knol-khol knob. The Spacing 45x45 cm recorded significantly maximum sulphur content (0.729 per cent), protein content (4.28%) and ascorbic acid content (52.99 mg/100g) in knob which was found to be at par with 45x30 cm spacing. Spacing 45x45 cm remained at par with 45x30 cm spacing indicated an increase of 14.08 and 6.89 per cent in case of sulphur content and 11.89 and 6.46 per cent more ascorbic acid content but spacing 45x30 cm registered an increase of 47.97 and 14.90 per cent more protein content over 30x20 cm and 30x30 cm spacing, respectively. Data given in same Table further exhibited that different levels of sulphur and spacing did not preciptible variation in the TSS content of knob. Sulphur content in knob was maximum in wider spacing and minimum in closer spacing. It plays an important part in protein synthesis and the functioning of several enzyme systems. The synthesis of chlorophyll and the activity of nitrate reductase are dependent on sulphur. It enhances oil formation in crops. Increased accumulation of nutrients especially N, P and S in vegetative plant parts concominant with improved metabolism led to greater translocation of these nutrients to reproductive structure of crops. The results are in conformity with the findings of [18], [19] and [20].

Protein content is directly related to nitrogen content present in the edible parts of knol-khol. Since protein content of grain is essentially a manifestation of N content. Increased N content due to wider spacing resulted in higher protein content because of their beneficial role in enhancing N content in knob. Protein content at closer spacing decreased due decrease in nitrogen content because timely space, fertilization and sunlight are not or less available at proper time to crop but in case of wider spacing crop generally used space and sunlight so physiological and morphological activities of crop including activity of tissues of leaves or other plant part occurs more rapidly. Finding of [21], [22] and [23] also provide support to the results of present investigation.

The TSS content in knob of knol-khol was found non-significant at the levels of spacing (Table 1). T.S.S. increased due to nitrogen fertilization. Application of nitrogen helps in vigorous vegetative growth and imparted deep green colour to the foliage, which favoured photosynthetic activity of the plants, resulting in greater accumulation of food material i.e. carbohydrates due to more synthesis of ascorbic acid, T.S.S. and moisture contents. These results are in close conformity with the findings of [24], [25], [26] who reported that TSS content in knob of knol-khol were non-significant at spacing levels.

Effect of sulphur and spacings on economics of the treatment

Data represented in Table 1 revealed that different sulphur levels significantly increased the net returns (Rs ha^{-1}) and B:C ratio over control and 20 kg sulphur per ha. The maximum net returns (3,15,103) and B:C ratio of 3.60 was obtained under 60 kg sulphur per ha while minimum was recorded in control. Application of 60 kg sulphur remained statistically at par with 40 kg sulphur representing a significant increase of Rs 118469 and Rs 56822 ha^{-1} in case of net

returns and 56.52 and 19.60 per cent in case of B:C ratio, respectively over control and 20 kg sulphur per ha. Data represented in same Table exhibited that net returns of knol-khol was significantly influenced by different spacing levels over 45x45 cm spacing. The spacing 30x30 cm was recorded significantly higher net returns (3,08,026) and fetched maximum B: C ratio (3.55) over 45x45 cm and 30x20 cm spacing which was found statistically at par with 45x30 cm spacing. The mean increase in net returns due to 30x30 cm spacing over 45x45 cm and 30x20 cm spacing were Rs 96674 and Rs 44915 ha^{-1} and 44.31 and 17.16 per cent increase in case of B:C ratio, respectively.

Interactive effect of sulphur and spacing on sulphur content (%) in knob of knol-khol

Data in **Table 2** showed that the combined effect of different levels of sulphur and spacing on sulphur content in knob were found to be significant. The application of 40 kg sulphur along with 45x30cm spacing recorded the sulphur content of knob (0.800 %) but found statistically at par with 60 kg sulphur per ha with 45x45 cm spacing, 60 kg sulphur per ha with 45x30 cm spacing and 40 kg sulphur per ha with 45x45 cm spacing. The treatment combination of 60 kg sulphur with 45x30 cm spacing proved as good as 60 kg sulphur along with 45x45 cm spacing and 40 kg sulphur with 45x45 cm spacing found significantly superior to rest of the treatment combinations. Application of 40 kg sulphur with 45x30 cm spacing registered an increase of 50.09 per cent in sulphur content of knob over control with 30x20 cm spacing.

Table 2 Interactive effect of sulphur and spacing on sulphur content, net returns and B:C ratio of knol-khol

Spacings	Sulphur levels											
	Sulphur content (%)				**Net return (Rs ha^{-1})**				**B:C ratio**			
	0 kg/ ha	**20 kg/ ha**	**40 kg/ ha**	**60 kg/ ha**	**0 kg/ ha**	**20 kg/ ha**	**40 kg/ ha**	**60 kg/ ha**	**0 kg/ ha**	**20 kg/ ha**	**40 kg/ ha**	**60 kg/ ha**
30x20 cm	0.533	0.652	0.652	0.719	190388	253417	311375	297265	2.22	2.93	3.59	3.39
30x30 cm	0.641	0.694	0.692	0.702	226694	297625	342569	365215	2.65	3.44	3.95	4.17
45x30 cm	0.659	0.682	0.800	0.730	220124	278671	321473	343021	2.57	3.22	3.71	3.92
45x45 cm	0.666	0.708	0.749	0.791	149330	203413	237755	254911	1.74	2.44	2.74	2.91
S.Em.±	0.014				12412.31				0.15			
C.D. (P = 0.05)	0.041				35844.57				0.43			

Interactive effect of sulphur levels and spacing on net returns (Rs ha^{-1}) and B:C ratio

Data in Table 2 showed that the combined effect of sulphur levels with spacings on net returns and B:C ratio of knol-khol was found to be significant. Application of 60 kg sulphur with 30x30 cm spacings gave highest net return (365215 Rs /ha) and B:C ratio (4.17) being at par with 60 kg sulphur with 45x30 cm spacings and 40 kg sulphur with 30x30 cm spacings. The combination of 40 kg sulphur with 30x30 cm spacings proved as good as 60 kg sulphur with 45x30 cm spacings and significantly superior to rest of the treatment combinations. Application of 40 kg sulphur with 30x30 cm spacings registered an increase of 193239 (Rs ha^{-1}) net returns and 2.21 B:C ratio over control with 45x45 cm spacing. Combined application of 40 kg sulphur ha^{-1} with 45x30 cm spacing found most efficacious in enhancing the sulphur content in knob and combined application of 40 kg sulphur ha^{-1} with 30x30 cm spacing found most efficacious in enhancing the knob yield ha^{-1}, net return and B: C ratio. The significant increase in yield under the application of sulphur levels as basal dose and spacing levels was largely a function of improved growth and subsequent increase in diameter of knob (cm) and other yield attributes as described above. The interactive advantages of combining sulphur levels and spacing generally proved superior to the use of each component separately.

Conclusion

The combined application of 40 kg sulphur ha^{-1} and 30 x 30 cm spacing was found suitable in terms of yield, net return 1,93,239 (Rs ha^{-1}) and B:C ratio (2.21) over control with 45 x 45 cm spacing, respectively and resulted in saving of 20 kg sulphur ha^{-1}. Thus, application of sulphur 40 kg ha^{-1} along with 45 x 30 cm spacing recommended for knol-khol crop.

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