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Effects of levels of sulphur on soil properties, growth, yield and economics of onion

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Abstract
The experiment entitled "Effect of levels of sulphur on soil properties, growth, yield and economics of onion" was carried out during *rabi* season in the year 2013-2014 at Main Garden, Department of Horticulture, Dr. PDKV, Akola. The experiment was laid out in RBD with nine levels of sulphur *viz.* (0, 10, 20, 30, 40, 50, 60, 70 and 80 kg S ha^{-1}) which was replicated three times. Out of nine treatments the sulphur application @ 40 kg ha^{-1} is the best in respect of growth and yield parameter as it recorded the maximum plant height (39.98, 60.92 and 70.56 cm at 30, 60 and 90 DAT respectively), maximum number of leaves at 30 DAT (6.70), 60 DAT (9.44) and 90 DAT (12.46), maximum neck thickness 1.50 cm as well as highest yield/ plot (5.81 Kg) and yield/ ha (215.18 q). This treatment also recorded maximum B:C ratio (1:3.75). The available nitrogen, phosphorus and potassium and sulphur were recorded higher in treatment of soil application of sulphur @ 80 kg ha^{-1}.

Keywords: Growth, yield, B:C ratio, nitrogen, phosphorus, potassium, sulphur

Introduction
As a protective food, vegetables occupy an estimable portion in the nutritive menu of the most Indian peoples. They are very common in human diet that a meal without a vegetable is supposed to be incomplete in any part of the world. Vegetables play important role in diet by providing proteins, carbohydrates, minerals, vitamins and roughages, which constitute essential part of balanced diet. Onion *(Allium cepa* L.) belongs to the family Amaryllidaceae which having chromosome no. 2n=16 and originated from Central Asia. Onion is also known to possess several medicinal and therapeutic properties, its effectiveness range against common cold to diabetes, heart diseases, osteoporosis and other diseases. Onion is known for antiplatelet aggregation, anti-rheumatic, diuretic and fibrinolyctic effects as well as it lowers the blood sugar. Onion contains a chemical compound quercetin believed to have anti-inflammatory, anti-cholesterol, anticancer and antioxidant properties. Bulb juice is also used as smelling agent against hysterical convulsions and faintness. Besides fresh consumption, onion used as raw material for processing industry for dehydration as processed the various dehydrated products like dehydrated powder, rings, shreds, flour, flakes, paste etc.
In India it is grown in an area of 11.73 lakh hectare with production of 187.77 lakh metric tons and productivity of 16 metric tons/ha (Anon, 2014) [1]. Thus, India tops second in both area and production next only to China, in the world. Among fresh vegetables, onion is a pride item of agricultural export, earning valuable foreign exchange to the country. Indian onion is being exported to Malaysia, Singapore, Gulf Countries, Sri Lanka, Bangladesh, Pakistan and Nepal. India exported nearly 1.5 lakh tons onion this year (Anonymous, 2014) [1]. In India onion is mainly grown in the state of Maharashtra, Karnataka, Gujarat, Bihar, Andhra Pradesh, Uttar Pradesh, Orissa and Madhya Pradesh. Maharashtra is the leading state in area and production. Area under cultivation is 4.68 lakh hectare with production of 58.67 lakh metric tons and 14.3 metric tons/ha productivity (Anon, 2014) [1]. In Maharashtra, Nasik, Ahmednagar, Pune and Satara are the major onion producing districts. Onion is one of the important commercial vegetable that used in every kitchen as condiments and vegetable. Hence, extensive demand in internal and external market. The onion crop is grown with application of N, P, K fertilizers only. Thus, possess the problems of sulphur deficiency in soil and creating imbalance in nutrients availability. The sulphur is removed by the field crop, leached in ground water, lost by soil erosion due to runoff. The deficiency of sulphur is increasing now a days due to decreased application of organic matter in soil and not addition of sulphur. Onion is a sulphur loving plant and is required much for proper growth and yield (Kumar and Singh, 1995) [6].

Sulphur is essential for building up sulphur containing amino acids and also for a good vegetative growth and bulb development in onion. The availability of sulphur in the soil and its effects on crop productivity need to be studied for its efficiency in balance nutrient management. Application of sulphur helps in the availability of other nutrients resulting in better growth and increased uptake of all the nutrients at higher levels of sulphur. (Dabhi *et al.* 2004 and Nasreen *et al.* 2007) [3, 8]. The favorable effect of sulphur on reducing soil pH, increasing soil particles flocculation, thereby improving soil structure and increasing the availability of certain plant nutrients in the soil. Sulphur requirement of crops is almost similar to that of phosphorus. The efficient utilization of N, P, K fertilizer and secondary nutrients is obtained only in presence of adequate quantities of available micronutrients in soil. The approach of general fertilizer recommendation related to soil test ratio was in common use. Because of changing trend in agricultural, yield target concept and fertilizer recommendation for maximum profit per hectare become more promising. Yield target concept has the added advantage in which target can be fixed by taking into consideration the resources available. To facilitate the desire increase in productivity the plants need adequate quantities of essential nutrients in readily available forms. These comes mainly from three sources (1) nutrient reserve in soil (2) organic sources such as FYM, crop residues, biofertilizers, green manures and (3) chemical fertilizers. Since the chemical fertilizers are not enough to meet the requirement of onion crop for higher yield. The judicious application of sulphur in different levels is beneficial in order to provide required nutrients recover the different deficiencies as well as disorder and increased the yield or production of onion.

Material and Methods

The experiment was conducted at Main Garden, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *rabi* season of 2013-14. Akola comes under tropical belt and is situated at 307.4 meters above mean sea level. The geographical situation is 20.42°N latitude and 77.02°E longitude. The experiment consists with nine different doses of sulphur which was replicated thrice under RBD. The land used under the experimental layout was fairly uniform with gentle slope. The soil was medium black with uniform in texture, colour and having good drainage. Before laying out the experiment, Initial soil samples were drawn at five randomly selected spots at a depth of 0-30 cm from the field and the composite samples were analyzed for chemical characteristics as per the methods suggested against each parameter.

Transplanting of seedlings was done when the seedlings reached height of 15 cm in flat beds at a distance of 15 cm x 10 cm. The crop was fertilized with recommended nitrogen, phosphorus and potassium @ 100:50:50 kg per hectare in the form of urea, single superphosphate and muriate of potash, respectively. Out of recommended dose, 50 per cent of N and full dose of P and K was applied as a basal dose and remaining 50 per cent of N was applied after one month of transplanting as top dressing. Whereas sulphur was applied in the soil as basal dose through gromer.

The treatments were allotted randomly into blocks. The different doses of sulphur was used in experiment as, T_1 (0 kg/ ha, Control), T_2 (10 kg/ ha) T_3 (20 kg/ ha), T_4 (30 kg/ ha), T_5 (40 kg/ ha), T_6 (50 kg/ ha), T_7 (60 kg/ ha), T_8 (70 kg/ ha), T_9 (80 kg/ ha) respectively.

The land used under the experimental layout was fairly uniform with gentle slope. The soil was medium black with uniform in texture, colour and having good drainage. Before laying out the experiment, Initial soil samples were drawn at five randomly selected spots at a depth of 0-30 cm from the field and the composite samples were analyzed for chemical characteristics as per the methods suggested against each parameter in table 1. Methods and materials applied in investigation are headed below.

Growth and yield parameters

For recording growth observations, five plants were selected randomly from each plot.

Height of plant (cm)

The height of the plant was recorded from ground level to the top of all leaves. The height of the plant was noted in centimeter. It was measured at interval from 30, 60 and 90 days of transplanting.

Number of leaves per plant

The number of fully grown, green and photo-synthetically active leaves were recorded and average number of leaves per plant was worked out from the five randomly selected plants at 30 days interval from transplanting date i.e., 30, 60, and 90 DAT.

Neck thickness of bulb (cm)

The neck thickness below the joint of leaf lamina was measured with the help of vernier caliper after curing of bulbs and the measurements were expressed in cm.

Yield per plot (kg)

The total bulb yield was obtained after harvest of the crop. The bulbs were separating from the top from each plot individual treatment. Then yield per plot was computed and expressed in kilograms.

Yield per hectare (q/ha)

From the total plot yield of bulb, yield per hectare was computed and recorded accordingly in quintals.

Soil analysis

Initial nutrient status of the soil

Common composite soil samples were taken at random at 0-30 cm depth and analyzed in the laboratory to know the initial nutrient status of the experimental site.

Final nutrient status of the soil

After the crop was harvested soil samples were taken at random at 0-30 cm depth after harvest and analysed for NPK and Sulphur status in the soil.

Table 1: Methods and Chemical properties of soil before harvest of the onion crop

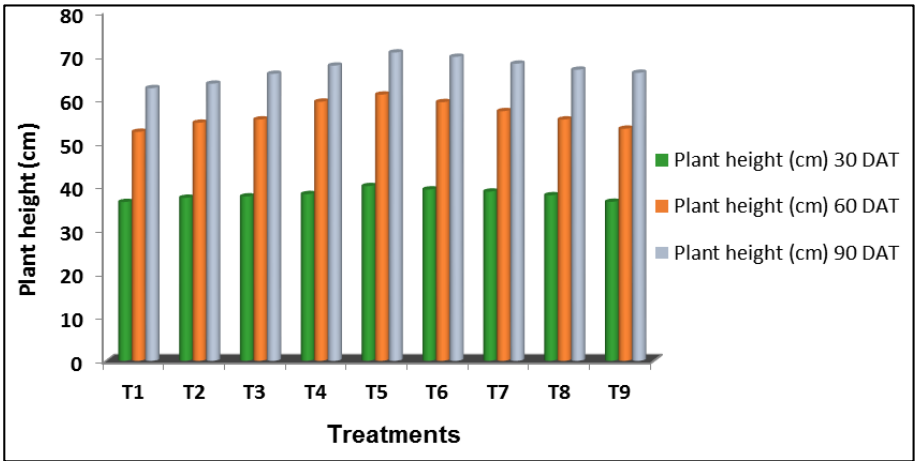
Chemical properties of soil	Initial status of soil	Method adopted	Reference
p^H	7.74	Potentiometric Method	Jackson (1973) [5]
EC (dS m^{-1})	0.15	Conductivity Bridge	Jackson (1967) [4]
Organic carbon g /kg	4.45	Walkley and Black's wet oxidation method	Nelson and Sommers (1982 [9]
Available nitrogen (kg/ha)	236	Alkaline permanganate method	Subbaiah and Asija (1956) [12]
Available phosphorous (kg/ha)	8.98	Olsen method	Nelson and Sommers (1982) [9]
Available potassium (kg/ha)	325	Flame photometer method	Piper (1966) [10]
Available sulphur (mg/g)	10.51	Turbidimetric method using Spectrophotometer	Sparks (1996) [11]

Table 2: (Graph 1, 2 and 3) Growth and yield characters influenced by application of different levels of Sulphur

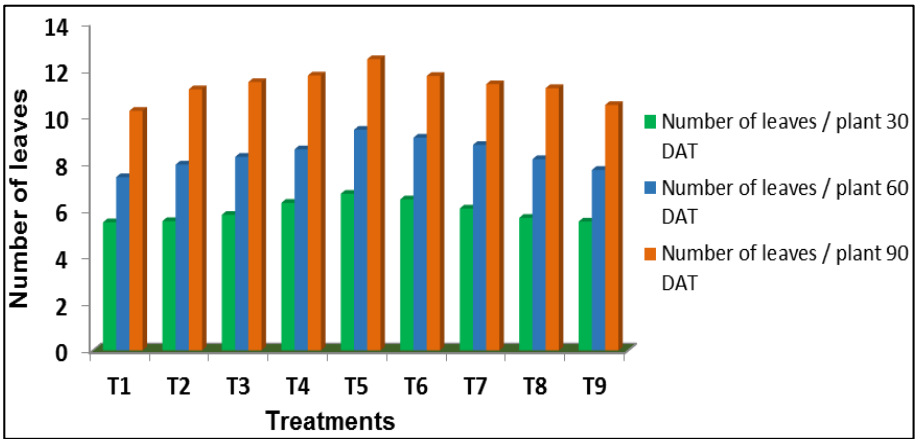
Treatments	Plant height (cm)			Number of leaves / plant			Neck thickness (cm)	Yield/plot (kg)	Yield/ha (q)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT			
T_1 - 0 kg ha^{-1} (Control)	36.34	52.40	62.40	5.48	7.41	10.25	1.34	5.27	195.18
T_2 - 10 kg ha^{-1} S	37.30	54.48	63.42	5.53	7.95	11.17	1.37	5.48	202.96
T_3 - 20 kg ha^{-1} S	37.61	55.23	65.68	5.80	8.28	11.48	1.38	5.59	207.03
T_4 - 30 kg ha^{-1} S	38.15	59.30	67.55	6.31	8.60	11.76	1.45	5.67	210.00
T_5 - 40 kg ha^{-1} S	39.98	60.92	70.56	6.70	9.44	12.46	1.50	5.81	215.18
T_6 - 50 kg ha^{-1} S	39.21	59.20	69.57	6.46	9.10	11.74	1.49	5.74	212.59
T_7 - 60 kg ha^{-1} S	38.72	57.13	68.00	6.07	8.79	11.39	1.42	5.56	205.92
T_8 - 70 kg ha^{-1} S	37.88	55.23	66.62	5.67	8.18	11.22	1.40	5.46	202.22
T_9 - 80 kg ha^{-1} S	36.38	53.11	65.91	5.51	7.72	10.50	1.39	5.33	197.40
'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m)±	0.31	0.34	0.34	0.09	0.03	0.05	0.02	0.03	0.87
C.D.at 5%	0.92	1.01	1.02	0.27	0.10	0.15	0.06	0.08	2.61

Table 3: (Graph 4 and 5)-Fertility status of soil after harvest of onion as influenced by application of different levels of sulphur

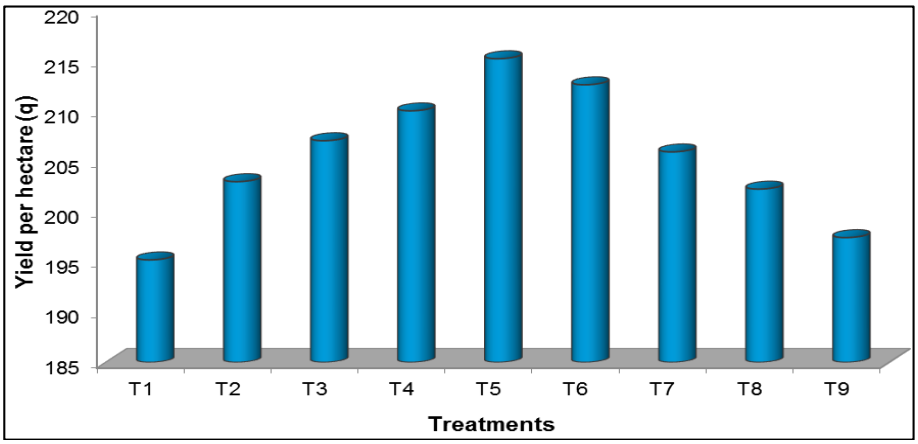
Treatments	N	P	K	S	P^H (1:2.5)	EC (dS m^{-1})	Organic carbon (g /kg)
	(kg ha^{-1})			(mg kg^{-1})			
T_1 - 0 kg ha^{-1} (Control)	236.10	9.87	327.30	10.75	7.74	0.16	4.46
T_2 - 10 kg ha^{-1} Sulphur	237.00	10.25	327.81	11.31	7.73	0.17	4.47
T_3 - 20 kg ha^{-1} Sulphur	237.98	10.54	328.06	11.56	7.72	0.17	4.49
T_4 - 30 kg ha^{-1} Sulphur	238.07	10.83	328.63	11.91	7.72	0.18	4.50
T_5 - 40 kg ha^{-1} Sulphur	238.43	11.25	329.05	12.49	7.71	0.18	4.52
T_6 - 50 kg ha^{-1} Sulphur	238.98	11.49	329.84	12.78	7.70	0.19	4.52
T_7 - 60 kg ha^{-1} Sulphur	239.23	11.56	330.02	12.96	7.70	0.19	4.54
T_8 - 70 kg ha^{-1} Sulphur	239.83	11.72	330.53	13.12	7.69	0.20	4.55
T_9 - 80 kg ha^{-1} Sulphur	240.01	11.97	330.95	13.45	7.69	0.21	4.57
'F' test	Sig	Sig	Sig	Sig	NS	NS	NS
SE (m)±	0.35	0.22	0.41	0.29	0.29	0.02	0.17
C.D.at 5%	1.04	0.65	1.22	0.88	0.89	0.05	0.52



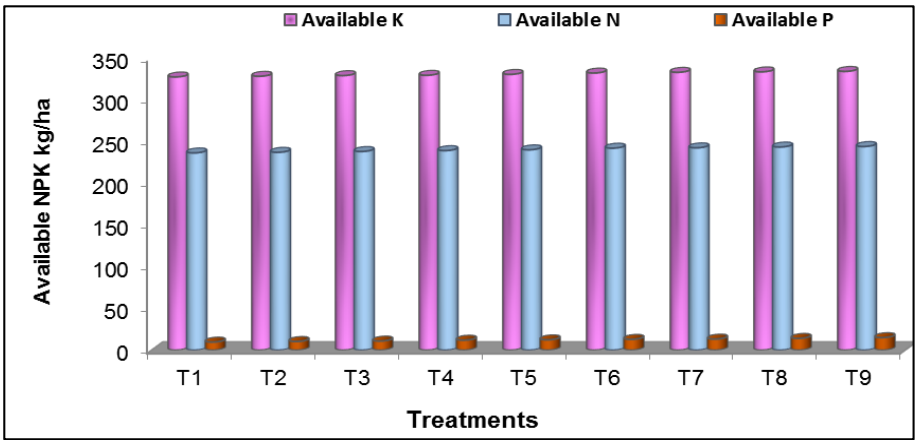
Graph 1: Height of plant influenced by application of different levels of sulphur



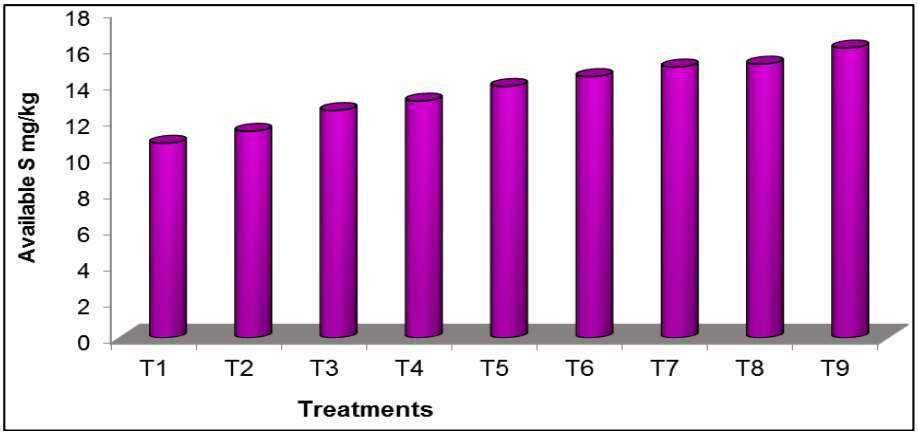
Graph 2: Number of leaves influenced by application of different levels of sulphur



Graph 3: Yield per hectare (q influenced by application of different levels of sulphur



Graph 4: Available NPK status of soil after harvest of onion as influenced by application of different levels of sulphur



Graph 5: Available sulphur status of soil after harvest of onion as influenced by application of different levels of sulphur

Table 4: Economics as influenced by influenced by application of different levels of Sulphur

Treatments	Gross returns	Cost of cultivation	Net monitor Returns	B:C ratio
T_1 - 0 kg ha^{-1} (Control)	201430	57120.00	144310.00	1 : 3.53
T_2 - 10 kg ha^{-1} Sulphur	205019	57508.85	147510.15	1 : 3.56
T_3 - 20 kg ha^{-1} Sulphur	206934	57897.70	149036.30	1 : 3.57
T_4 - 30 kg ha^{-1} Sulphur	208873	58286.55	150586.45	1 : 3.58
T_5 - 40 kg ha^{-1} Sulphur	219909	58675.40	161233.60	1 : 3.75
T_6 - 50 kg ha^{-1} Sulphur	217817	59064.25	158752.75	1 : 3.69
T_7 - 60 kg ha^{-1} Sulphur	214625	59453.10	155171.90	1 : 3.61
T_8 - 70 kg ha^{-1} Sulphur	212817	59841.95	152975.05	1 : 3.56
T_9 - 80 kg ha^{-1} Sulphur	212589	60130.80	152458.20	1 : 3.54

Result and discussion

The data on growth parameters as influenced by different levels of sulphur indicated significant variations among them. In all the case, application of sulphur @ 40 kg ha^{-1} significantly increased the plant height at 30, 60 and 90 DAT (39.98, 60.92, 70.56 cm respectively), number of leaves per plant at 30, 60 and 90 DAT (6.70, 9.44, 12.46 cm respectively) and neck thickness (1.50 cm) than control. However, statistical parity was recorded with application of sulphur @ 50 or 60 kg ha^{-1} (Table 2). The significantly higher bulb yield per plot (5.81 kg) and yield per hectare (215.18 q ha^{-1}) was observed with @ 40 kg ha^{-1} followed by 50 and 60 kg S ha^{-1} with same statistical rank (Table 2). However, the lowest bulb yield/ plot (5.27 kg) and yield (195.18 q ha^{-1}) was reported in T_1 control. The enhancement of yield of onion due to sulphur application in addition to recommended dose of fertilizer *i.e.* NPK may be attributed to the fact that sulphur play a vital role in plant nutrition uptake and use These results confirm the earlier result of Narseen *et al.* (2007), Ullah *et al.* (2008) [13] and Bharti and Ram (2014) [2] in onion.

The available nitrogen, phosphorus and potassium were recorded higher in treatment of soil application of sulphur @ 80 kg ha^{-1} which was found to be at par with T_8 (70 kg S ha^{-1}), T_7 (60 kg Sha^{-1}) and T_6 (50 kg S ha^{-1}). Available sulphur in soil after harvest of onion was highest (13.45 mg kg^{-1}) in treatment of sulphur application @ 80 kg ha^{-1} which was at par with T_8 (13.12 mg kg^{-1}), T_7 (12.96 mg kg^{-1}) and T_6 (12.78 mg kg^{-1}). These results are in close conformity with the findings of Narwal *et al.* (1991) [7] and Sreemannarayan *et al.* (1993). The p^H, electrical conductivity and organic carbon were not influenced significantly by various levels of sulphur.

In relation of economics treatment T_5 (40 kg S ha^{-1}) recorded maximum B: C ratio (1:3.75) by giving maximum gross returns (219909 Rs.) and net monitor returns (161233.6 Rs.) whereas treatment T_1 (control) recorded minimum B:C ratio of 1: 3.53.

Conclusion

The results can be concluded that, application of sulphur @ 40 kg ha^{-1} was found to be effective in improving the vegetative growth and yield of onion crop which was ultimately increased the economics in onion. However, sulphur application @ 80 kg ha^{-1} recorded the highest nutrient content in soil. Hence, application of sulphur @ 40 kg ha^{-1} and 80 kg ha^{-1} was found to be the most appropriate treatments of sulphur levels during *rabi* season under Akola condition.

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