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Effect of different doses of nitrogen and sulphur on growth, yield and quality of onion (*Allium cepa*)

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ABSTRACT

A field experiment was conducted during the *rabi* season of 2009-10 at research farm, College of Horticulture, Mandsaur (Madhya Pradesh) to study the effect of different dose of nitrogen and sulphur on growth, yield and quality of onion. The treatments consisted of three levels of nitrogen, viz. N_1 - 80 kg N/ha, N_2 -100 kg N/ha and N_3- 120 kg N/ha and four levels of sulphur, viz. S_1-15 kg S/ha, S_2- 30 kg S/ha, S_3- 45 kg S/ha and S_4 - 60 kg S/ha. Application of nitrogen and sulphur had significant influence on the growth, yield and quality attributes of onion. Maximum plant height, number of leaves per plant, fresh weight of shoot, fresh weight of bulb, horizontal diameter, vertical diameter, bulb yield, neck diameter, total soluble solid content and pyruvic acid content were recorded with application of nitrogen 120 kg/ha. Similarly application of 60 kg S/ha resulted in highest values of growth, yield and quality attributes of onion. Combined effect of nitrogen and sulphur showed significant effect on fresh weight of shoot, fresh weight of bulb, horizontal diameter, vertical diameter, bulb yield and pyruvic acid content with maximum values under 120 kg N + 60 kg S/ha. Maximum gross income, net income and cost: benefit ratio was also found with 120 kg N + 60 kg S/ha.

Key words: Economics, Growth, Nitrogen, Onion, Quality, Sulphur, Yield

Onion (*Allium cepa* L.) is one of the most important bulb crops. It is an indispensable item in every kitchen used as salad, culinary purpose for flavoring as spice in pickles, sauce and vegetable. In India, it is cultivated as annual crop for bulb production and as biennial crop for seed production. Onion is an export-oriented crop earning valuable foreign exchange for the country. India ranks first in area and second in production of onion in the world after china. It is cultivated in an area of 1064 thousand ha with a production of 15118 thousand MT (NHB 2012). The average productivity of onion in India is 14.2 MT/ha, which is low as compared to other onion producing countries of the world. There are several factors, which influence the production of onion. Improper nutrient management is one of the main constraints. Nitrogen and sulphur are important nutrients for the crop. Recent works had showed that onion responded to nitrogen and sulphur positively in terms of yield and quality of bulbs (Nasreen *et al*. 2007). Nitrogen is a constituent of proteins, enzymes, hormones, vitamins, alkaloids, chlorophyll and photosynthesis which lead to an increment in plant metabolism and vegetative growth expressed as heights, number of leaves per plant, both length and diameter of bulb, leaf area and crop growth rate as well as dry weight of plant (El-Tantawy and El-Beik 2009). Sulphur is essential for building up of sulphur containing amino acids (cysteine, cystine and methionine), which is essential for protein synthesis. Sulphur not only increases the bulb yield but also improves its quality especially pungency and flavour. Sulphur containing secondary compounds is not only of importance for nutritive value or flavours but also for resistance against pests and diseases (Ullah *et al*. 2008). Sulphur deficiencies are widespread in Indian soil as many areas are found to be deficient in Sulphur. The current status of the extent of sulphur deficiency in soil of Balaghat, Bhind, Chhindwara, Dewas, Dhar, Gwalior, Indore, Khandwa, Mandsaur, Morena, Vidisha, Sidhi, Sehore, Seoni and Ujjain districts of Madhya Pradesh has been reported to be of more than 40% samples deficient (Tandon and Messick 2007). Sulphur deficient plants had poor utilization of nitrogen, phosphorus and potash and a significant reduction of catalase activities at all age. Severe sulphur deficiency during bulb development has detrimental effect on yield and quality of

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Table 1 Effect of different doses of nitrogen and sulphur application on growth parameters of onion

Treatment	Plant height (cm) at 90 DAT	Number of leaves per plant at 90DAT	Fresh weight of shoot (g) at 90 DAT	Fresh weight of bulb (g) at 90 DAT
Nitrogen doses (N)				
80 kg N/ha	68.92	13.27	51.40	70.12
100 kg N/ha	70.36	14.82	61.97	80.40
120 kg N/ha	74.00	15.43	81.71	95.98
SEm±	0.91	0.19	1.10	1.04
CD (P = 0.05)	2.62	0.55	3.18	3.00
Sulphur doses (S)				
15 kg S/ha	68.60	13.96	58.29	77.33
30 kg S/ha	69.23	14.20	61.28	79.73
45 kg S/ha	72.47	14.73	67.20	82.11
60 kg S/ha	74.08	15.13	73.33	89.50
SEm±	1.05	0.22	1.27	1.20
CD (P = 0.05)	3.02	0.63	3.67	3.46
Interaction (N × S)				
80 kg N+15 kg S/ha	67.57	12.08	45.94	68.18
80 kg N+30 kg S/ha	67.74	12.60	47.38	69.39
80 kg N+45 kg S/ha	69.85	14.00	52.92	69.87
80 kg N+60 kg S/ha	70.54	14.40	59.35	73.05
100 kg N+15 kg S/ha	68.04	14.60	59.47	75.66
100 kg N+30 kg S/ha	68.58	14.75	60.33	78.65
100 kg N+45 kg S/ha	71.35	15.05	63.88	82.15
100 kg N+60 kg S/ha	73.48	15.25	64.19	85.15
120 kg N+15 kg S/ha	70.18	15.20	69.48	88.15
120 kg N+30 kg S/ha	71.38	15.25	76.13	91.15
120 kg N+45 kg S/ha	76.20	15.40	84.80	94.31
120 kg N+60 kg S/ha	78.23	15.45	96.44	110.31
SEm±	1.82	0.38	2.21	2.08
CD (P = 0.05)	NS	NS	6.36	6.00

onion. Onion requires sulphur fertilization in increasing the dry matter production (Nasreen *et al*. 2003). Keeping these facts in view, the present investigation was conducted to study the effect of different dose of nitrogen and sulphur application on growth, yield, quality and economics of onion.

MATERIALS AND METHODS

The experiment was conducted at College of Horticulture, Mandsaur, Madhya Pradesh during during *rabi* season of 2009-10. Mandsaur is situated in western part of Madhya Pradesh, between latitude of 23°45' to $24^0$13' North and longitude of 74°44' to 75°18' East and at an altitude of 435.20 m above mean sea level. The average weekly minimum and maximum temperature during study period varied from 4.9° and 22.55°C to 29.21° and 41.81°C. Average weekly relative humidity varied from 10.28 to 75.42 per cent. The physical composition of soil was 50% sand, 25% both silt and clay. The electrical conductivity and pH of soil were 0.45 dS/m and 7.5, respectively. The available N, P, K and S in soil were 214 kg/ha, 12.6 kg/ha, 436.8 kg/ha and 15 kg/ha, respectively. Twelve treatment combinations comprising of three levels of nitrogen, viz. N_1 - 80 kg nitrogen/ha, N_2 -100 kg nitrogen/ha and N_3- 120 kg nitrogen/ha and four levels of sulphur, viz. S_1-15 kg sulphur/ha, S_2-30 kg sulphur/ha, S_3-45 kg sulphur/ha and S_4-60 kg sulphur/ha were tested in randomized block design with three replications. Six week old seedlings of onion variety Agrifound Light Red were transplanted on 10 December at a spacing of 20 cm between rows and 10 cm between plants. The calculated quantities of fertilizers were applied to the respective plot. The source of nutrients were DAP and Urea for nitrogen, DAP for phosphorus, muriate of potash for potassium and elemental sulphur for sulphur. Half dose of nitrogen and whole of phosphorus @60 kg/ha, potash @100 kg/ha and sulphur as per treatments were applied as basal dose prior to transplanting of onion seedlings. While the rest of nitrogen was given as top dressing in 2 equal split doses in onion crop field, first at 30 and second at 45 days of transplanting. Observation ware recorded on five randomly selected plants in each plot on plant height, number of leaves/plant, fresh weight of shoot, fresh weight of bulb, horizontal diameter, vertical diameter, bulb yield, neck diameter, total soluble solid content (with Hand refractometer) and economics of different treatments. Pyruvic acid content (µ moles/g fresh weight) was

Table 2 Effect of different doses of nitrogen and sulphur application on yield and quality parameters of onion

Treatment	Horizontal diameter (cm)	Vertical diameter (cm)	Bulb yield (q/ha)	Neck diameter (cm)	Total soluble solid content (%)	Pyruvic acid (µ mole /g)
Nitrogen doses (N)						
80 kg N/ha	4.26	4.65	381.26	1.74	13.67	1.33
100 kg N/ha	5.10	4.73	442.60	1.99	14.10	1.45
120 kg N/ha	5.99	5.60	541.42	2.17	14.34	1.59
SEm±	0.05	0.05	08.57	0.05	0.06	0.01
CD (P = 0.05)	0.14	0.15	24.66	0.15	0.17	0.03
Sulphur doses (S)						
15 kg S/ha	4.73	4.70	414.40	1.73	13.72	1.18
30 kg S/ha	4.90	4.89	433.53	1.91	13.95	1.40
45 kg S/ha	5.35	5.03	476.44	2.10	14.18	1.52
60 kg S/ha	5.47	5.36	509.31	2.12	14.31	1.72
SEm±	0.06	0.06	09.89	0.06	0.07	0.01
CD (P = 0.05)	0.17	0.18	28.48	0.17	0.20	0.04
Combined effect (N x S)						
80 kg N+15 kg S/ha	3.92	4.46	324.41	1.28	13.38	1.12
80 kg N+30 kg S/ha	4.18	4.60	366.77	1.67	13.55	1.29
80 kg N+45 kg S/ha	4.46	4.61	394.75	1.96	13.82	1.33
80 kg N+60 kg S/ha	4.49	4.92	439.10	2.04	13.95	1.59
100 kg N+15 kg S/ha	4.85	4.59	442.86	1.93	13.71	1.17
100 kg N+30 kg S/ha	4.92	4.60	446.47	1.86	14.05	1.42
100 kg N+45 kg S/ha	5.32	4.74	450.37	2.13	14.31	1.52
100 kg N+60 kg S/ha	5.31	5.00	470.70	2.03	14.35	1.70
120 kg N+15 kg S/ha	5.43	5.04	475.97	1.97	14.06	1.26
120 kg N+30 kg S/ha	5.60	5.49	487.36	2.18	14.26	1.49
120 kg N+45 kg S/ha	6.29	5.73	584.20	2.23	14.42	1.72
120 kg N+60 kg S/ha	6.62	6.17	618.14	2.30	14.63	1.88
SEm±	0.10	0.11	17.14	0.10	0.12	0.02
CD (P = 0.05)	0.29	0.31	49.33	NS	NS	0.06

determined as suggested by Anthon and Barrett (2003). The data were analysed as per standard procedure.

RESULTS AND DISCUSSION

Growth parameters

Plant height recorded at 90 days after transplanting indicated significant effect of nitrogen levels. Highest plant height was found with application of 120 kgN/ha which was significantly superior over other doses. It showed that application of nitrogen exerted the positive effect on plant height which may be due to the role of nitrogen in chlorophyll structure which is responsible for photosynthesis and manufacture of food material in the plants. These findings are in line with findings of Tiwari *et al*. (2002), Haque *et al*. (2004) and Nasreen *et al*. (2007). Application of sulphur exerted significant effect on plant height. There was an increase in plant height with increasing dose of sulphur from 15 to 60 kg/ha. But the difference between 45 and 60 kg S/ha was not remarkable. Similar findings have been reported by Jana and Kabir (1990), Joshi *et al*. (2005) and Nasreen *et al*. (2007). Combined effect of nitrogen and sulphur had not showed any significant influence on plant height. Though, there was numerical increase in plant height with increasing dose of sulphur at all the doses of nitrogen and vice-versa.

Number of leaves showed significant increase with each incremental dose of nitrogen. Highest number of leaves were observed with 120 kg N/ha followed by 100 kg N/ha and 80 kg N/ha in descending order. Higher dose of nitrogen might have stimulated the initiation of more number of leaves in the plant. Similar findings have been reported by Yadav *et al*. (2003), Haque *et al*. (2004) and El-Tantawy and El-Beik (2009).There was significant effect of sulphur on number of leaves. Maximum leaves were recorded with application of 60 kg S/ha. Though, difference between 60 kg S/ha and 45 kg S/ha was non-significant. It indicated that application of sulphur up to 45 kg S/ha had significant improvement in number of leaves and further increase in sulphur had not caused any remarkable influence. Similar findings have been reported by Jaggi and Dixit (1999) and Joshi *et al*. (2005). The combined effect of nitrogen and sulphur did not show any remarkable influence on number of leaves per plant.

Fresh weight of shoot increased with increase in nitrogen level. There was significant increase in fresh weight of shoot with each incremental dose of nitrogen. Maximum fresh weight of shoot was observed with 120 kg N/ha followed by 100 kg N/ha and 80 kg N/ha in descending

Table 3 Effect of different doses of nitrogen and sulphur application on economics of different treatments of onion

Treatment combination	Treatment cost (₹/ha)	Total cost of cultivation (₹/ha)*	Gross income (₹/ha)	Net income (₹/ha)	C:B ratio
80 kg N+15 kg S/ha	1 523	43 159	162 210	119 051	1:3.75
80 kg N+30 kg S/ha	2 073	43 709	183 395	139 686	1:4.19
80 kg N+45 kg S/ha	2 623	44 259	197 375	153 116	1:4.45
80 kg N+60 kg S/ha	3 173	44 809	219 550	174 741	1:4.89
100 kg N+15 kg S/ha	1 772	43 408	221 435	178 027	1:5.10
100 kg N+30 kg S/ha	2 322	43 958	223 235	179 277	1:5.07
100 kg N+45 kg S/ha	2 872	44 508	225 185	180 677	1:5.05
100 kg N+60 kg S/ha	3 422	45 058	235 350	190 292	1:5.22
120 kg N+15 kg S/ha	2 017	43 653	237 990	194 337	1:5.45
120 kg N+30 kg S/ha	2 567	44 203	243 685	199 482	1:5.51
120 kg N+45 kg S/ha	3 117	44 753	292 100	247 347	1:6.52
120 kg N+60 kg S/ha	3 667	45 303	309 075	263 772	1:6.82

Common expenditure (₹/ha) under all the treatments was ₹ 41 636.

order. Nitrogen play important role in synthesis of food material which might have been the reason for increased fresh weight of shoot with higher doses of nitrogen. Similar findings have been reported by Kar and Tiwari (1997). Sulphur application indicated significant effect on fresh weight of shoot. There was increase in fresh weight of shoot with increasing dose of sulphur. Each incremental dose caused significant increase in fresh weight of shoot. These findings are in line with findings of Jaggi and Dixit (1999). Combined effect of nitrogen and sulphur levels recorded significant effect on fresh weight of shoot. Highest fresh weight of shoot was observed with application of 120 kg N + 60 kg S/ha which was significantly superior over other combinations. In general, there was increase in fresh weight of shoot with increasing dose of sulphur at all the levels of nitrogen and vice-versa.

Fresh weight of bulb showed increase with increasing doses of nitrogen. Each incremental dose of nitrogen exerted significant increase in fresh weight of bulb. Highest fresh weight of bulb was observed with application of 120 kg N/ ha. Higher dose of nitrogen caused higher plant height, numbers of leaves as well as fresh weight of shoot which ultimately resulted in higher fresh weight of bulb. These findings have been corroborated by Kar and Tiwari (1997), Joshi *et al*. (2005). Sulphur application exerted significant effect on fresh weight of bulb. Increasing doses of sulphur from 15 kg S/ha to 60 kg S/ha recorded increase in fresh weight of bulb. Highest fresh weight of bulb was found with application of 60 kg S/ha which was significantly superior over rest of the doses. Combined application of nitrogen and sulphur indicated significant effect. Application of 120 kg N + 60 kg S/ha had recorded highest fresh weight of bulb. It shows that nitrogen and sulphur had synergistic effect on fresh weight of bulb. Coolong *et al*. (2004) also reported that bulb fresh weights were affected positively with nitrogen and sulphur levels.

Yield parameters and yield

The studies pertaining to yield parameters and yield were conducted on horizontal bulb diameter, vertical bulb diameter and bulb yield indicated significant influence of nitrogen and sulphur as well as their combinations in onion.

Horizontal bulb diameter revealed significant increase with incremental doses of nitrogen. Highest horizontal bulb diameter was recorded with application of 120 kg N/ha. Similar findings have been reported by Kar and Tiwari (1997) and Mohanty and Das (2001).There was positive effect of sulphur on horizontal bulb diameter. Maximum horizontal bulb diameter was measured with 60 kg S/ha. Though, it was at par to 45 kg S/ha application, but significantly higher than 30 kg S/ha and 15 kg S/ha. These findings have been corroborated by Nagaich *et al*. (1999) and Ullah *et al*. (2008). Combined effect of nitrogen and sulphur recorded significant influence on horizontal bulb diameter. Application of 120 kg N + 60 kg S/ha recorded maximum horizontal bulb diameter. Minimum horizontal bulb diameter was observed with application of 80 kg N + 15 kg S/ha. In general, increasing doses of sulphur at all the levels of nitrogen recorded increase in horizontal bulb diameter and vice-versa. Similar results have been found by Joshi *et al*. (2005) and Mozumder *et al*. (2007).

Vertical bulb diameter revealed significant effect of nitrogen and sulphur as well as their combinations. Among N doses, application of 120 kg N/ha had recorded highest vertical bulb diameter which was significantly superior over 100 kg N/ha and 80 kg N/ha. The difference between 100 kg N/ha and 80 kg N/ha was non-significant. Sulphur showed positive effect on vertical bulb diameter. There was increase in vertical bulb diameter with increasing doses of sulphur and highest vertical bulb diameter was found with application of 60 kg S/ha. It was significantly superior over other lower doses. Similar findings have been reported by Jana and Kabir (1990) and Nagaich *et al*. (1999). Combined application of nitrogen and sulphur indicated significant effect on vertical bulb diameter. Highest vertical bulb diameter was observed with application of 120 kg N + 60 kg S/ha. In general, increasing doses of sulphur enhanced vertical bulb diameter at all the levels of nitrogen and vice-

versa. Similar findings have been reported by Mozumder *et al*. (2007).

Bulb yield revealed significant effect of nitrogen levels, sulphur levels as well as their combined application. There was significant increase in bulb yield with increasing dose of nitrogen. Highest bulb yield was found with application of 120 kg N/ha which was significantly superior over 100 kg N/ha and 80 kg N/ha. Nitrogen application promoted growth parameters, chlorophyll content resulting in more accumulation of food material which was translocated to bulb as indicated with higher bulb yield under higher dose of nitrogen. These results were corroborated with the findings of El-Tantawy and El-Beik (2009) and Nasreen *et al*. (2007) who reported increment in total yields due to increment of vegetative growth and rising photosynthesis production which associated with increment in bulb size. Sulphur application exerted positive effect on bulb yield. Highest bulb yield was noticed with 60 kg S/ha which was significantly superior over 45 kg S/ha, 40 kg S/ha and 15 kg S/ha. Positive effect of sulphur doses on growth parameters and yield parameters might have ultimately resulted in higher bulb yield. Similar findings have been reported by Kar and Tiwari (1997), Jaggi and Dixit (1999), Shakirullah *et al*. (2002) and Joshi *et al*. (2005). Combined application of nitrogen and sulphur indicated significant influence on bulb yield. There was increase in onion bulb yield with increasing dose of nitrogen at all the levels of sulphur and vice-versa. Highest bulb yield was recorded with application of 120 kg N + 60 kg S/ha. Singh *et al*. (1996) and Joshi *et al*. (2005) reported that interaction of nitrogen with sulphur may cause high yield of onion.

Quality parameters

Neck diameter revealed significant influence of nitrogen and sulphur application. There was increase in neck diameter with each increasing dose of nitrogen which could be attributed to the pronounced effect of nitrogen on vegetative growth. Sulphur application enhanced neck diameter. Though, the difference between higher levels, i.e. 45 kg S/ha and 60 kg S/ha was non-significant. Similar findings have been also reported by El-Tantawy and El-Beik (2009).

Application of nitrogen had significant influence on total soluble solids. Each incremental dose of nitrogen cause significant increase in total soluble solid. Highest total soluble solids content was determined with application of 120 kg N/ha. Application of sulphur enhanced total soluble solids content in onion bulb. Highest total soluble solids were recorded with application of 60 kg S/ha followed by 45 kg S/ha, 30 kg S/ha and 15 kg S/ha. The difference between 45 kg S/ha and 30 kg S/ha were non-significant. Application of sulphur might have enhanced the availability of minerals and accumulation of soluble solids in onion bulbs which resulted in more total soluble solid. Banafar and Gupta (2005) also found that total soluble solid content in bulb were increased with the application of sulphur. Combined application of nitrogen and sulphur did not show any remarkable influence on total soluble solid content of bulb. Though, numerically higher values were observed with higher doses of sulphur at all the levels of nitrogen and vice-versa.

Pyruvic acid content showed significant effect of nitrogen, sulphur as well as their combined application. There was increase in pyruvic acid content with each increasing dose of nitrogen as well as sulphur. Highest pyruvic acid content was found with application of 120 kg N + 60 kg S/ha. Higher pyruvic acid content with increasing nitrogen and sulphur levels may be due to increased availability of sulphur which would have enhanced synthesis of volatile S compounds. Hamilton *et al*. (1997) also found increase in pyruvic acid content with sulphur levels in six clones of onion.

Economic evaluation of treatments

Economic evaluation of treatments revealed that application of nitrogen as well as sulphur enhanced the cost of cultivation, gross income, net income as well as cost benefit ratio. Highest dose of nitrogen and sulphur resulted in maximum cost of cultivation (₹ 45 303/ha), gross income (₹ 309 075/ha), net income (₹ 263 772/ha) as well as cost : benefit ratio (1:6.82). These results may be due to increase in economic yield with increasing dose of nitrogen and sulphur. More increase in economic yield as compare to increase in expenditure resulted in higher total return, net income as well as per rupee investment under 120 kg N + 60 kg S/ha application. Similar findings have been also reported by Nagaich *et al*. (1999) and Ullah *et al*. (2008).

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