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Impact of different doses of sulphur and boron application in onion (*Allium Cepa* L.) under semi-arid condition of north Madhya Pradesh

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Abstract
The research experiment was conducted during *rabi* seasons of 2017-18 at the horticulture farm nursery, College of Agriculture, Gwalior. The study material consist Sixteen treatment combinations consisting of four sulphur levels viz. S_0: Control, S_1: 20 kg S ha^{-1}, S_2: 40 kg S ha^{-1}, S_3: 60 kg S ha^{-1} and four doses of Boron, i.e. B_0: Control, B_1: 0.5 kg B ha^{-1}, B_2: 1.0 kg B ha^{-1} and B_3: 2.0 kg B ha^{-1} in factorial randomized block design with three replications. The recommended dose of fertilizer (RDF) adopted was 100:60: 80 kg of N: P: K ha^{-1}. The maximum net return Rs. 259485, 259860 and 283163 ha^{-1} was obtained from S_2 (40 kg ha^{-1}),B_2 (1.0 kg ha^{-1}) treatments and S_3 x B_2 combination and it was higher than all other treatments. Minimum net income (Rs 202520 ha^{-1}) was recorded under control S_0 x B_0. Under different levels of sulphur, maximum B: C ratio (4.69) was obtained from S_2 (40 kg ha^{-1}) and B_2 (1.0 kg ha^{-1}). Under different treatment combination (interactions) of sulphur and boron, maximum B: C ratio (4.91) was obtained from S_3 x B_2.

Keywords: Net return, benefit cost ratio, sulphur and boron

Introduction
The growing of vegetable is the most intensive, profitable and remunerative hence it may be adopted with small holders with profitable and gaining business. Apart from this, vegetables have an excellent dietary value and may be known as protective foods.

Onion (*Allium cepa* L.) is one of the oldest bulb crop consumed worldwide. It is one of the most important commercial vegetable crop grown in India and believed to be originated in Central Asia. It is valued for its distinct pungent flavour and is an essential ingredient for the cuisine of many regions. Onion is the queen of the kitchen (Selvaraj, 1976) [7]. The onion is preferred mainly because of its green leaves, immature and mature bulbs are either eaten raw or cooked as a vegetable. Mild flavoured and low pungent bulbs are often chosen for salads. The bulbs are used in soups, sauces, condiments, spices, medicines, seasoning of many foods and for the preparation of value added edible products like powder and flakes. A distinct characteristic of onion is its alliaceous odour, which accounts for their use as food. The pungency in onion is due to a volatile compound allyl propyl disulphide.

Onion has many uses as folk medicine and recent reports suggest that onion plays an important role in preventing heart diseases and other ailments. It is one of the richest sources of flavonoids which reduce risk of cancer, heart disease and diabetes. Flavonoids are not only anti-cancer but also known anti-bacterial, antiviral and anti-allergenic. Onion contains 11 amino acids. Hundred gram of raw onion bulb contains about moisture 86.8 g, carbohydrate 11.0 g, protein 1.2g, fibre 0.6g, minerals 0.4 g, thiamine 0.08 mg, vitamin c 1mg, calcium 180 mg, phosphorus 50 mg and riboflavin 0.01 mg which make up the dry matter of the bulb (Boss *et al.*,2003) [2].

The area under onion cultivation in India is a about 1263 thousand hectares which gives a total production of 23485 thousand tonnes (Anon., 2018-19 NHB estimated). In Madhya Pradesh, it is grown in an area of 145 thousand hectares with the production of 3672 thousand tonnes (NHRDF data base., 2019) [4, 5]. India exports onion mainly to other countries like Malaysia, Russia, Kuwait, Sri Lanka, Singapore, Germany, Japan, Iran, Myanmar and UK *etc*. (Shinde and Sontake, 1993) [8].

The pungency in the onion bulb is due to a volatile oil known as allyl-propyl – disulphide ($C_6H_{12}S_2$) and the red colour is because of the pigment “anthocyanin” and yellow colour because of “quercetin”. The nutritive value of onion varies from variety to variety. Nutritionally, fresh onion contains about 86.6 per cent moisture, 11.6 per cent carbohydrates, 0.2 to 0.5 per cent calcium, 0.05 per cent phosphorus and traces of iron and ascorbic acid **(**Dev Raj *et al.*, 2004) [3].

Boron is one of the important micro-nutrients having different function in plants. It is one of the most widely applied micro-elements though required in small quantity (Rao and Deshpande, 1971) [6]. Its shortage in soil may hamper crop yield to a great extent. Boron is known to play many important functions in plant metabolism.

Materials and methods

An appropriate research design and methods are the backbone of any research project. The experiment entitled "Impact of Different Doses of sulphur and boron Application in Onion (*Allium Cepa* L.) under semi-arid condition of north Madhya Pradesh" was carried out, during *Rabi* season of 2017-18 at the horticulture nursery, College of Agriculture, Gwalior. The soil of the experimental field was alluvial, sandy clay loam in texture. The field of research farm having homogenous fertility and uniform textural make up was selected for the field experimentation.

The region comes under semi-arid and sub-tropical climate with extreme weather condition having hot and dry summer and cold winter. Generally, monsoon sets in the last week of June. Annual rainfall ranges from 700 to 800 mm, most of which falls during last week of June to the middle of September. Winter rains are occasional and uncertain. The maximum temperature goes up to 47 ºC during summer and minimum as low as 2.8 ºC during winter. Frost also expected from the last week of December to the first week of February. Usually the monsoon arrives in the second fortnight in June and lasts till September. Occasionally, light rains are expected during winter. An average precipitation of 700 mm is usually received from July to September with few showers during winter.

The experiment was conducted with 16 treatments (Combination of 4 levels of each S and B). During the research Agri Found Light Red variety was transplanted with the spacing of 15cm row to row and 10 cm plant to plant.

The treatments included in the investigation comprised of the sixteen combinations of 4 doses of sulphur with four doses of boron. A recommended nursery beds (2.0 m x 1.0 m) were raised 15 cm above the soil surface in the departmental nursery field at the end of November of 2017. Then the prepared bedding mixture was evenly spread in the form of 5.0 cm thick layer over the nursery. Rows were made 1.5 to 2.0 cm deep at 10.0 cm apart and seeds sown, covered and watered. The seedlings became ready for transplanting at 45 Days after Sowing (DAS).

Table 1: Treatments detail

Factor		Notation
A.	Sulphur Doses	
	Control	S_0
	20 kg ha^{-1}	S_1
	40 kg ha^{-1}	S_2
	60 kg ha^{-1}	S_3
B.	Boron Doses	
	Control	B_0
	0.5 kg ha^{-1}	B_1
	1.0 kg ha^{-1}	B_2
	2.0 kg ha^{-1}	B_3

Table 2: Treatment combination

T_1: S_0B_0	T_5: S_1B_0	T_9: S_2B_0	T_{13}: S_3B_0
T_2: S_0B_1	T_6: S_1B_1	T_{10}: S_2B_1	T_{14}: S_3B_1
T_3: S_0B_2	T_7: S_1B_2	T_{11}: S_2B_2	T_{15}: S_3B_2
T_4: S_0B_3	T_8: S_1B_3	T_{12}: S_2B_3	T_{16}: S_3B_3

Result and discussion of economics of onion experiment

Economics of onion as affected by different doses of S and B is given in table 4.10.

The maximum gross income Rs. 331100, 330300 and 355600 ha^{-1} in onion crop was recorded under S_3 (60 kg ha^{-1}), B_3 (2.0 kg ha^{-1}) and S_3 x B_2 was higher than all other treatments. Whereas minimum gross income of was recorded under control of respective nutrients.

The maximum net return Rs. 259485, 259860 and 283163 ha^{-1} was obtained from S_2 (40 kg ha^{-1}),B_2 (1.0 kg ha^{-1}) treatments and S_3 x B_2 combination and it was higher than all other treatments. Minimum net income (Rs 202520 ha^{-1}) was recorded under control S_0 x B_0.

Under different levels of sulphur, maximum B:C ratio (4.69) was obtained from S_2 (40 kg ha^{-1}), followed by S_3 (60 kg ha^{-1}), with 4.64 B:C ratio. Whereas minimum B:C ratio (4.22) under control treatment.

Under different levels of boron, maximum B:C ratio (4.73) was obtained from B_2 (1.0 kg ha^{-1}), followed by B_3 (2.0 kg ha^{-1}) with 4.67 B:C ratio. Whereas minimum B:C ratio (4.27) was recorded under control.

Under different treatment combination (interactions) of sulphur and boron, maximum B:C ratio (4.91) was obtained from S_3 x B_2 followed by S_2 x B_3 and S_2 x B_2 with 4.88 and 4.84 B:C ratio. Whereas minimum B:C ratio (3.95) under control of both nutrients (S_0 x B_0).

Table 3: Economics of different treatments of S and B under onion crop

Treatments	Cost of cultivation excluding treatments (Rs. ha^{-1})	Treatment cost (Rs. ha^{-1})	Total Cost of cultivation (Rs. ha^{-1})	Bulb yield (q ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B : C ratio
Sulphur levels (S)							
S_0: 0 kg ha^{-1}	68550	0	68550	289.0	289000	220450	4.22
S_1: 20 kg ha^{-1}	68550	932	69482	308.8	308800	239318	4.44
S_2: 40 kg ha^{-1}	68550	1865	70415	329.9	329900	259485	4.69
S_3: 60 kg ha^{-1}	68550	2797	71347	331.1	331100	259353	4.64
Boron levels (B)							
B_0: (Control)	68550	0	68550	292.4	292400	223850	4.27
B_1 : 0.5 kg ha^{-1}	68550	545	69095	306.5	306500	237405	4.44
B_2 : 1.0 kg ha^{-1}	68550	1090	69640	329.5	329500	259860	4.73
B_3 : 2.0 kg ha^{-1}	68550	2180	70730	330.3	330300	259570	4.67
Treatment combination							
T_1-S0B0	68550	0	68550	271.07	271070	202520	3.95
T_2-S0B1	68550	545	69095	285.50	285500	216405	4.13
T_3-S0B2	68550	1090	69640	298.47	298470	228830	4.29
T_4-S0B3	68550	2180	70730	300.83	300830	230100	4.25

T_5-S1B0	68550	932	69482	293.40	293400	223918	4.22
T_6-S1B1	68550	1477	70027	299.90	299900	229873	4.28
T_7-S1B2	68550	2022	70572	317.50	317500	246928	4.50
T_8-S1B3	68550	3112	71662	324.37	324370	252708	4.53
T_9-S2B0	68550	1865	70415	299.73	299730	229315	4.26
T_{10}-S2B1	68550	2410	70960	319.60	319600	248640	4.50
T_{11}-S2B2	68550	2955	71505	346.23	346230	274725	4.84
T_{12}-S2B3	68550	4045	72595	353.97	353970	281375	4.88
T_{13}-S3B0	68550	2797	71347	305.57	305570	234223	4.28
T_{14}-S3B1	68550	3342	71892	320.93	320930	249038	4.46
T_{15}-S3B2	68550	3887	72437	355.60	355600	283163	4.91
T_{16}-S3B3	68550	4977	73527	342.10	342100	268573	4.65

Sale price of onion bulb seed = (Rs. 1000 q^{-1})

The results reported in foregoing pages, revealed the maximum gross and net return obtained under 40 kg S ha^{-1} followed by 60 kg S ha^{-1} whereas, maximum B:C ratio (3.58) was obtained under (40 kg S ha^{-1}) followed by 60 kg S ha^{-1} treatment. This may be because of the difference in yield between 40 and 60 kg S ha^{-1} was at par and cost of cultivation was lesser with 40 kg S ha^{-1}.

The results reported in foregoing pages, revealed the maximum net return and B:C ratio obtained under 1.0 kg B ha^{-1} followed by 2.0 kg B ha^{-1}. This may be because of the difference in yield between 1.0 and 2.0 kg B/ha was non-significantly differ from each other.

Under different treatment combination (interactions) of sulphur and boron, maximum B:C ratio (4.91) was obtained from S_3 x B_2 followed by S_2 x B_3 and S_2 x B_2 with 4.88 and 4.84 B:C ratio. Whereas minimum B:C ratio (3.95) under control of both nutrients (S_0 x B_0). Similar findings were also reported by Smriti *et al.* (2002) [9].

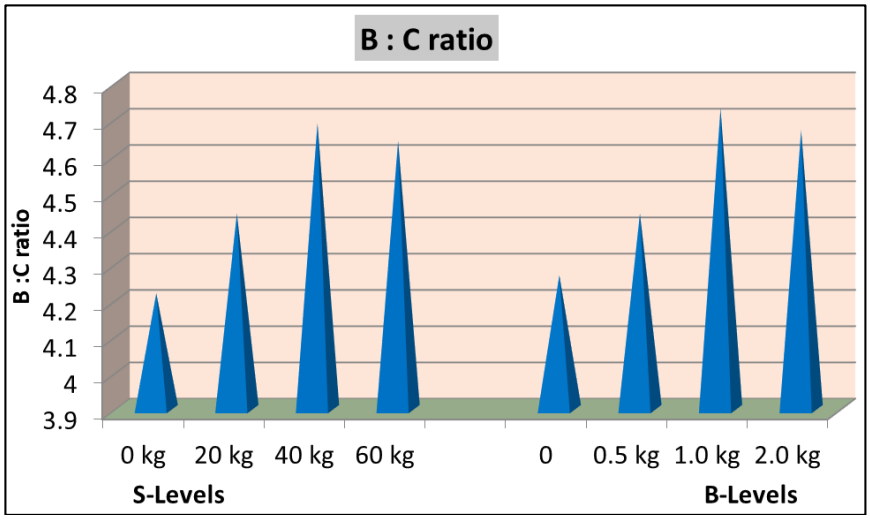

Fig 1: Effect of sulphur and boron on B: C ratio in onion

Conclusion

Under different treatment combination (interactions) of sulphur and boron, maximum B: C ratio (4.91) was obtained from S_3 x B_2 followed by S_2 x B_3 and S_2 x B_2 with 4.88 and 4.84 B: C ratio. Whereas minimum B: C ratio (3.95) under control of both nutrients (S_0 x B_0).

The above experiment concluded that that the maximum benefit cost ration is found in treatment 15 that is 60 kg/ha sulphur and 1.0kg/ha boron and it is recommended to farmers for better return in onion cultivation.

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