Research Article

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Response of irrigation and sulphur levels on yield and economics of radish grown under drip system in arid region of Rajasthan

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ABSTRACT

Studied the effect of various treatments of drip irrigation (60% PE, 80% PE, 100% PE and 120% PE) and sulphur (Control, 15 kg S ha^{-1}, 30 kg S ha^{-1} and 45 kg S ha^{-1}) on yield and economics of radish. Among the treatments, the drip irrigation at 100% PE was comparable to 120% PE, yielding the highest root fresh weight (213.09 g), root diameter (4.12 cm), root length (30.11 cm), total fresh weight per plant (291.05 g), yield per hectare (313.93 q ha^{-1}), net returns (₹ 112,969 ha^{-1}), and B:C ratio (3.57). Application of 30 kg S ha^{-1} resulted in maximum root fresh weight (211.75 g), root length (28.94 cm), and root diameter (3.98 cm), as well as the highest total fresh weight per plant (289.87 g), yield (301.57 q ha^{-1}), and net returns (₹ 106,248 ha^{-1}). The treatment combination of 100% PE irrigation with 30 kg S ha^{-1} resulted in the highest yield per hectare (331.21 q ha^{-1}), though it was statistically comparable to the treatments of 100% PE with 45 kg S ha^{-1}, 120% PE with 30 kg S ha^{-1}, and 120% PE with 45 kg S ha^{-1}.

Introduction

Radish (*Raphanus sativus* L.) is most popular *rabi* season root crops which cultivated for its important medicinal and nutritive values. It belongs to Cruciferae family. Being a winter season crop, radish is sown in cool season from mid-September to mid-January in northern plains. Radish is the vegetable of both tropical and temperate regions of the world, widely cultivated for its root, tender leaves and green shoots (Alam *et al.,* 2010). It is rich in diverse amino acids and glucosinolate contents (Xie *et al*., 2018). Glucosinolates are associated with a reduced cancers risks of the lung, pancreas, stomach, prostate, breast, colon and rectum (Herr and Buchler, 2010). The 100 g of edible roots contain 93.7 per cent water, 1.1 per cent fat and 4.2 per cent carbohydrates. The radish leaves are rich in minerals, vitamin A (5 IU) and vitamin C (15 mg) and roots are rich in potassium (138 mg) and calcium (50 mg) (Baksh *et al.,* 2006 and Yadav *et al.*, 2019).

In recent years, the drip irrigation is mostly used to increase water use efficiency of vegetable crops. It enhances water use efficiency, alleviates moisture stress, and improves both the productivity and quality of crops. Sulphur deficiency is common in many crops, including vegetables, especially those grown in sandy soils prone to leaching. It also enhances the availability of other essential nutrients, promoting better growth and improving nutrient uptake (Nasreen *et al.*, 2007). Additionally, suphur helps lower soil pH due to its acidic nature, improves soil structure, and increases the availability of other plant nutrients. It is vital for synthesizing secondary metabolites with high nutritional value, such

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as glucosinolates, which accumulate in brassica species like radish. These compounds store sulphur, supporting normal plant metabolism, especially under sulphur-deficient conditions (Schonhof *et al.*, 2007).

In countries like India, where increasing vegetable production is a priority amidst limited irrigation resources, the role of sulphur can not be overlooked. Keeping in view, a study was undertaken to find out appropriate irrigation and sulphur level in radish.

Material and Methods

The field experiment was carried out at Instructional Farm, College of Agriculture, Bikaner (Rajasthan) during *rabi* season of 2020. The experimental site is situated at a latitude of 28° 01'N and a longitude of 73° 22'E, at an altitude of 234.70 meters above mean sea level, within Agro-climatic Zone Ic (Hyper Arid Partially Irrigated North Western Plain Zone). The soil of the experimental field was loamy sand in texture and slightly alkaline in reaction (pH 8.5), poor in organic carbon (0.12 per cent), low in available nitrogen (116 kg ha^{-1}) but medium in available phosphorus (15.3 kg ha^{-1}) and potassium (171.2 kg ha^{-1}). The experiment was laid out in split plot design and replicated thrice with combination of sixteen treatments. The treatments have four levels of irrigation (60% PE, 80% PE, 100% PE and 120% PE) and four sulphur levels (Control, 15 kg S ha^{-1}, 30 kg S ha^{-1} and 45 kg S ha^{-1}) which were randomly allotted to main plots and sub plots, respectively using random number tables of Fisher (1950).

Applied the recommended dose of N, P_2O_5 and K_2O i.e. 30:58:87 kg ha^{-1} through urea, DAP and MOP, respectively. Seeds of Pusa Reshmi variety were treated with 0.02 per cent thiram and sown on 05th November, 2020 at 1-2 cm depth. Maintained a distance of 30 cm between rows and 10 cm between plants. Applied irrigation through drip system immediately after sowing 40 mm water to ensure proper germination. The subsequent irrigations were applied at alternate days as per treatment schedule using four laterals per plot. The irrigation water was calculated by evaporation data on daily basis. The treatment wise observations were recorded on five randomly selected plants in replication. The net return and B:C ratio was calculated on the basis of prevalent market rate of radish. In order to test significance of variation, the data were statistically analyzed as per the procedure described by Panse and Sukhatme (1985).

Results and Discussion

The data presented in Table 1 showed that the yield attributes of radish increased significantly with higher irrigation levels. Irrigation at 120% PE resulted in the highest fresh weight of the root (214.15 g), root length (31.41 cm), and root diameter (4.41 cm) compared to 60% PE and 80% PE, though it was statistically similar to the 100% PE irrigation level. Higher irrigation levels (100% and 120% PE) helped alleviate stressful conditions, promoting optimal plant growth and improving yield attributes such as root fresh weight, root length, and root diameter. These findings align with the research of Saini and Brar (2018).

Radish crop irrigated at 120% PE also recorded the highest total fresh weight per plant (292.22 g) and yield per hectare (314.34 q ha^{-1}) compared to 60% PE and 80% PE, with results statistically similar to those at the 100% PE irrigation level. This supports the findings of Saxena *et al.* (2004). The increased yield per hectare of radish at higher irrigation levels is likely due to the optimal moisture content maintained in the root zone throughout the crop's growing period, which enhanced both total fresh weight and overall yield. The similar results were previously reported by Solangi *et al.* (2016).

Net returns and the B:C ratio increased significantly with different levels of irrigation (Table 1). The highest net returns (₹112,969 ha^{-1}) and B:C ratio (3.57) were observed with the 100% PE irrigation, which was comparable to the 120% PE level. Among the irrigation levels, the highest B:C ratio and net returns were achieved at the 100% PE level due to its higher yield compared to the 60% and 80% PE levels.

As the PE levels increased, the total cost of production also rose. However, the cost of irrigation included in the experiment was comparatively lower than the additional income generated, leading to higher profits. Similar results were reported by Narayanmoorthy (2004), where the initial investment in the drip irrigation system was high, but it led to increased yield, water saving, and reduced cultivation cost, which ultimately resulting in the highest benefit-cost ratio.

The data further indicated that sulphur levels significantly influenced yield attributes. The highest fresh weight of the root (212.80 g), root length (29.97 cm), and root diameter (4.17 cm) were recorded at 45 kg S ha^{-1}, compared to the control and 15 kg S ha^{-1}, though it was statistically similar to 30 kg S ha^{-1}. The highest total fresh weight per plant (290.75 g) and yield per hectare (304.72 q ha^{-1}) were also recorded at 45 kg S ha^{-1}, compared to the control and 15 kg S ha^{-1}, but were at par with the 30 kg S ha^{-1} level. The lowest yield and yield attributes were observed in the control (S_1). These findings are consistent with the results of Kumar *et al.* (2016). The increase in fresh weight of the root, root length, root diameter and total fresh weight per plant with higher sulphur levels was also reported by Yadav *et al.* (2008) and Nasreen *et al.* (2003).

The net returns and B:C ratio were significantly influenced by the application of different sulphur levels to the radish crop (Table 1). Sulphur application at 30 kg S ha^{-1} recorded the highest net returns (₹ 106,248 ha^{-1}) compared to the control (₹ 90,289 ha^{-1}), 15 kg S ha^{-1} (₹ 102,636 ha^{-1}), and 45 kg S ha^{-1} (₹ 105,273 ha^{-1}). The B:C ratio was significantly higher (3.44)

with the 15 kg S ha^{-1} treatment compared to the control and 45 kg S ha^{-1}, though it remained at par with the 30 kg S ha^{-1} treatment. The lower cost of treatment at 15 kg S ha^{-1} likely contributed to the higher B:C ratio (3.44).

The yield per hectare of radish was significantly influenced by the interaction between irrigation and sulphur levels (Table 2 & Fig. 1). The treatment combination of 100% PE irrigation with 30 kg S ha^{-1} resulted in the highest yield per hectare (331.21 q ha^{-1}), which was statistically comparable to the treatments of 100% PE with 45 kg S ha^{-1}, 120% PE with 30 kg S ha^{-1}, and 120% PE with 45 kg S ha^{-1}.

Table 1. Effect of irrigation and sulphur levels on yield attributes, yield and economics of radish

Treatments	Fresh weight of root (g)	Length of root (cm)	Diameter of root (cm)	Total fresh weight/ plant (g)	Yield/ ha (q)	Net returns (₹ ha^{-1})	B:C ratio
Irrigation levels							
60% PE	196.16	20.69	2.49	265.24	243.92	80894	2.98
80% PE	207.06	26.21	3.64	282.05	282.80	98872	3.33
100% PE	213.09	30.11	4.12	291.05	313.93	112969	3.57
120% PE	214.15	31.41	4.41	292.22	314.34	111711	3.45
SEm±	0.80	0.44	0.07	1.70	2.20	1098.7	0.03
CD at 5%	2.78	1.51	0.23	5.87	7.60	3802.10	0.09
Sulphur levels							
Control	197.90	23.42	2.90	269.26	259.45	90289	3.29
15 kg S ha^{-1}	207.92	26.07	3.60	280.68	289.25	102636	3.44
30 kg S ha^{-1}	211.75	28.94	3.98	289.87	301.57	106248	3.38
45 kg S ha^{-1}	212.88	29.97	4.17	290.75	304.72	105273	3.23
SEm±	0.85	0.40	0.09	1.21	2.55	1274.6	0.03
CD at 5%	2.47	1.16	0.26	3.54	7.44	3720.2	0.08

Table 2. Interaction effect of irrigation and sulphur levels on yield of radish (q ha^{-1})

Control	60% PE	80% PE	100% PE	120% PE	Mean
15 kg S ha^{-1}	256.67	285.64	300.97	313.71	289.25
30 kg S ha^{-1}	247.00	293.41	331.21	334.67	301.57
45 kg S ha^{-1}	245.00	294.22	336.67	343.00	304.72
Mean	243.92	282.80	313.93	314.34	
				SEm±	CD at 5%
Irrigation at same level of sulphur				4.93	4.40
Sulphur at same level of irrigation				5.10	14.88

Conclusion

The study concluded that applying drip irrigation at 100% PE provided optimal yield and economic returns for radish, performing at par with 120% PE. Similarly, the application of 30 kg S ha^{-1} resulted in the highest yield and net returns, though it was statistically similar to 45 kg S ha^{-1}. The interactive effect with application of irrigation level at 100% PE and 30 kg S ha^{-1} proved superior in terms of yield. However, the highest B:C ratio was recorded at 15 kg S ha^{-1}, making it the most cost-effective option. The results emphasize the importance of balanced irrigation and sulphur application for maximizing radish productivity and profitability in arid regions.

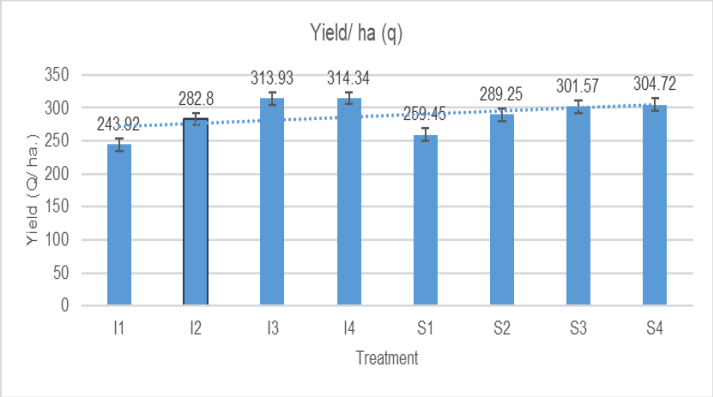

Fig. 1. Effect of irrigation and sulphur levels on yield of radish

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Conflict of Interest

The authors have no conflict of interest.

Data Sharing

All relevant data are within the manuscript

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