Environment and Ecology 42 (3A) : 1212—1218, July—September 2024
Article DOI: https://doi.org/10.60151/envec/YDQV2430
ISSN 0970-0420

Effect of Irrigation Scheduling and Thiourea on Nutrient Concentration, Uptake and Water Use Efficiency of Mustard

Santosh Meena, A. C. Shivran, Devi Lal Dhaker, Rayapati Karthik, B. R. Meena

Received 19 December 2023, Accepted 7 June 2024, Published on 5 August 2024

ABSTRACT

To know the effect of irrigation scheduling and foliar application of thiourea on nutrient concentration, uptake and water use efficiency of mustard, an experiment was conducted at Agronomy Farm, SKN College of Agriculture, Jobner during winter season of 2019-20. The experiment consisted five treatments of scheduling of irrigation (Surface irrigation, sprinkler, drip irrigation at 0.4 IW/CPE ratio, 0.6 IW/CPW ratio and 0.8 IW/CPE ratio, respectively) and three levels of foliar application of thiourea (Control, thiourea @ 500 ppm and thiourea @ 750 ppm). The experiment was laid out in split plot design with three replications. The results revealed that drip irrigation at 0.6 IW/CPE ratio recorded significantly higher nitrogen, phosphorus, sulfur concentration and their uptake in mustard, water use efficiency as well as protein content as compared to surface irrigation, sprinkler and drip irrigation at 0.4 IW/CPE ratio. The thiourea @ 500 ppm recorded significantly higher nitrogen, phosphorus and sulfur concentration and their uptake in mustard, protein and oil yield of mustard, water use efficiency. Based on the above findings, drip irrigation at 0.6 IW/CPE ratio with foliar application of thiourea @ 500 ppm could be recommended to farmers of mustard in Rajasthan.

Keywords Nutrient uptake, Thiourea, Protein, Mustard.

INTRODUCTION

Rapeseed-mustard is an important group of oilseed crops in the world. India ranks 2nd in area and 3rd in production with contribution of 21.7 and 10.7% to the estimated global area (33.83 mha), production (71.28 million tonnes) and productivity (2.11 tonnes/ha), respectively of rapeseed-mustard (Anonymous 2018-19). Despite its substantial contribution to human nourishment and the national economy, mustard productivity in the state has nearly stagnated, which is cause for concern. At the expense of food grain crops, there is no way to expand the area under this

Santosh Meena[1], A. C. Shivran[2], Devi Lal Dhaker[3]*, Rayapati Karthik[4], B. R. Meena[5]

[2]Professor, [3,4]PhD Student, [5]Assistant Professor
[1,2,3,5] Department of Agronomy, Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan 303328, India

[4]Department of Agronomy, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana 500030, India

Email: devilal.dhaker09gmail.com
*Corresponding author

crop. As a result, new crop production technology is the only method to boost production and productivity. Oil content in mustard varies from 30 to 48% and oil content of white mustard varies from 25 to 33%. Mustard oil extracted from mustard seeds is a good source of vitamin E. Mustard seeds also contain protein, calcium, vitamin A, omega-3 and omega-6 fatty acids. Mustard seeds are used in prevention of cancer, helpful for contact dermatitis, faster hair growth, prevent cardiovascular problems and relieve respiratory ailments.

The contemporary methods of production have had adverse effects on both nutrient equilibrium and soil fertility (Karthik *et al.* 2021). Mustard is mainly cultivated in poor and marginal soils in our country which is the main reason for low productivity. Oil quality as well as content of mustard depends upon sulfur content and farmers should focus on its uptake. Nutrient uptake of mustard is also very low in poor and marginal soils as there is a water deficit. These problems can be overcome by practicing proper irrigation scheduling. It is essential to develop irrigation strategies under local climate condition to utilize scarce water resources efficiently and effectively. Irrigation in short defines as artificially supply of water to irrigate field for good germination establishment and growth of crop so that we can obtain high quality produce of crops. There are many methods available for irrigation, like smart irrigation, surface irrigation, sprinkler irrigation, drip irrigation. Smart irrigation is the latest technique which consist of automated and cost-effective sensors helps to conserve and proper use of water. Different types of crop require different quantity of water for their growth.

In the IW/CPE approach, a specific quantity of irrigation water is administered once cumulative pan evaporation hits a predetermined threshold. For practicality, irrigation initiation should coincide with the allowable depletion of available moisture in the root zone, which lies between field capacity and permanent wilting point. Consequently, irrigation scheduling offers guidance to managers in formulating irrigation strategies for individual plots within the farm. Simply extending the irrigation interval does not consistently conserve water; rather, optimization of the interval is contingent upon the agro-climatic conditions. On the other hand, the poor irrigation scheduling can lead to the development of crop water deficit and result in a reduced yield due to water and nutrient deficiency.

Thiourea is a stress mitigating chemical which is highly beneficial in rainfed and arid areas. Due to the presence of the S-H group as an important ingredient of these thiols, foliar sprays of thiourea boost plant photosynthetic efficiency and canopy photosynthesis. Because thiourea exhibits cytokinin-like activity, it appears to have a positive effect by delaying the senescence of both vegetative and reproductive organs (Halmann 1980). Present investigation was carried out to study the impact of irrigation scheduling and thiourea on nutrient concentration, uptake, protein, oil content and water use efficiency of mustard.

MATERIALS AND METHODS

This study was carried out at SKN College of Agriculture, Jobner, District Jaipur (Rajasthan). Geographically, Jobner is situated 45 km away from Jaipur in western side at $75^0 28'$ East longitude and $26^0 05'$ North latitude. The region fall under agro climatic zone IIIA of Rajasthan state named as semi-arid eastern plains. The climate of this region is a typically semi-arid, specially characterized by extremes of temperature during both summer and winters. The average annual rainfall of this region varies from 350 to 400 mm, most of which is contributed by the south-west monsoon between July and September months. The soil of the experimental plot was loamy sand in texture (82.9% sand, 9.8% silt and 7.3% clay) and low in fertility status (0.19% O.C, 130.2 kg available N ha^{-1}, 17.5 kg available P ha^{-1} and 7.89 kg available S mg kg^{-1}) and neutral condition in nature (pH = 7.92).

The seed of mustard variety RH-406 @ 5 kg ha^{-1} was used for sowing in the experiment. The sowing was done in rows at 30 cm apart behind the plough. The experimental mustard crop was fertilized uniformly with 45 kg ha^{-1} of N and 30 kg ha^{-1} P_2O_5 through urea and DAP, respectively. Half dose of the N as well as full dose of P_2O_5 were applied at the time of sowing as basal. The remaining dose of nitrogen was top dressed in two equal splits after irrigation at 30 and 40 days after sowing of the crop.

The experiment was laid out in split plot design with three replications. The main plot constituted of five irrigation scheduling treatments i.e., Surface irrigation. Sprinkler irrigation, Drip irrigation at 0.4 IW/CPE ratio, Drip irrigation at 0.6 IW/CPE ratio and Drip irrigation at 0.8 IW/CPE ratio. The each main plot was further divided into sub plots viz. control, Thiourea @ 500 ppm and Thiourea @ 750 ppm. Thiourea is a sulphydral compound and its empirical formula is CH_4N_2S. It is applied as foliar spray in the plots as per the treatments at pre flowering and pod formation stage.

Statistical analysis

The experimental data recorded were subjected to statistical analysis using analysis of variance technique suggested by Panse and Sukhatme (1985). The critical difference (CD) was worked out to assess the significance of treatments mean wherever the 'F' test was found significant at 5% level of probability. To elucidate the nature and magnitude of treatments effects, summary tables along with SEm± and CD at 5% are given in the text of the chapter "Experimental Results" and their analysis of variance are given in annexure at the end. All these statistical estimates were computed by standard statistical procedures (Panse and Sukhatme 1985).

RESULTS AND DISCUSSION

Nitrogen concentration and uptake

Drip irrigation at 0.6 IW/CPE ratio, being at par with 0.8 IW/CPE ratio, significantly enhanced the nitrogen concentration in seed by 13.0, 7.8 and 6.9% over surface irrigation, sprinkler and drip irrigation at 0.4 IW/CPE ratio, respectively (Table 1). The foliar application of thiourea @ 750 ppm recorded significantly highest nitrogen concentration in seed by 24.2 and 3.9% over control and 500 ppm, respectively. Sprinkler and drip irrigation at different levels significantly increased the nitrogen concentration in straw of mustard crop over surface irrigation. Drip irrigation at 0.6 IW/CPE ratio, being at par with 0.8 IW/CPE ratio, significantly enhanced the nitrogen concentration in straw by 12.7, 6.7 and 8.1% over surface irrigation, sprinkler and drip irrigation at 0.4 IW/CPE ratio, respectively. Thiourea when applied as foliar spray @ 750 ppm acheived significantly highest nitrogen concentration in straw by 11.1 and 3.4% over control and 500 ppm, respectively.

Table 1. Effect of irrigation scheduling and thiourea on nitrogen concentration in seed and straw and its uptake by mustard.

Treatments	N concentration (%) Seed	Straw	Total N uptake (kg/ha)
Irrigation scheduling			
Surface irrigation	3.30	0.71	91.5
Sprinkler	3.46	0.75	109.7
Drip irrigation at 0.4 IW/CPE ratio	3.49	0.74	109.1
Drip irrigation at 0.6 IW/CPE ratio	3.73	0.80	133.1
Drip irrigation at 0.8 IW/CPE ratio	3.81	0.81	139.6
SEm+	0.05	0.01	3.4
CD (p=0.05)	0.17	0.03	11.2
CV (%)	5.14	4.09	10.2
Thiourea			
Control	3.10	0.72	89.4
Thiourea @ 500 ppm	3.73	0.77	124.3
Thiourea @ 750 ppm	3.85	0.80	136.0
SEm±	0.04	0.01	2.4
CD (p=0.05)	0.11	0.02	7.0
CV (%)	4.79	4.08	7.8

Drip irrigation at 0.6 IW/CPE ratio, which is at par with drip irrigation at 0.8 IW/CPE ratio, significantly increased the total nitrogen uptake by 45.4, 21.3 and 22.0% over surface irrigation, sprinkler and drip irrigation at 0.4 IW/CPE ratio, respectively. Foliar application of thiourea @ 500 ppm significantly increased the total nitrogen uptake by 39.1 over control. Foliar application of thiourea @ 750 ppm also significantly increased the total nitrogen uptake by 52.1 and 9.4% over control and thiourea when applied as foliar spray @ 500 ppm, respectively

Phosphorus concentration and uptake

Drip irrigation at 0.6 IW/CPE ratio and 0.8 IW/CPE ratio, significantly increased the phosphorus concentration in seed by 14.0, 5.2 and 5.7% over surface irrigation, sprinkler and drip irrigation at 0.4 IW/CPE ratio, respectively(Table 2). Thiourea when applied as foliar spray @ 750 ppm recorded significantly highest phosphorus concentration in seed by 13.4

Table 2. Impact of irrigation methods and thiourea on phosphorus concentration in seed and straw and its uptake by mustard.

Treatments	P concentration (%) Seed	Straw	Total P uptake (kg/ha)
Irrigation scheduling			
Surface irrigation	0.71	0.41	33.8
Sprinkler	0.77	0.42	39.7
Drip irrigation @ 0.4 IW/CPE ratio	0.76	0.41	39.2
Drip irrigation @ 0.6 IW/CPE ratio	0.81	0.42	45.5
Drip irrigation @ 0.8 IW/CPE ratio	0.81	0.42	47.4
SEm±	0.01	0.04	1.0
CD (p=0.05)	0.03	NS	3.3
CV (%)	5.22	3.04	8.6
Thiourea			
Control	0.72	0.39	32.5
Thiourea @ 500 ppm	0.79	0.42	43.6
Thiourea @ 750 ppm	0.81	0.43	47.2
SEm±	0.01	0.01	0.6
CD (p=0.05)	0.02	0.07	1.9
CV (%)	4.76	2.52	6.0

Table 3. Impact of irrigation methods and thiourea on sulphur concentration in seed and straw and its uptake by mustard.

Treatments	S concentration (%) Seed	Straw	Total S uptake (kg/ha)
Irrigation scheduling			
Surface irrigation	0.63	0.244	23.3
Sprinkler irrigation	0.67	0.277	29.2
Drip irrigation @ 0.4 IW/CPE ratio	0.64	0.272	28.3
Drip irrigation @ 0.6 IW/CPE ratio	0.68	0.297	34.4
Drip irrigation @ 0.8 IW/CPE ratio	0.69	0.301	36.0
SEm±	0.07	0.003	0.5
CD (p=0.05)	0.024	0.009	1.6
CV (%)	3.79	3.42	5.6
Thiourea			
Control	0.62	0.249	23.3
Thiourea @ 500 ppm	0.67	0.288	32.3
Thiourea @ 750 ppm	0.69	0.298	35.1
SEm±	0.05	0.002	0.5
CD (p=0.05)	0.01	0.006	1.4
CV (%)	2.65	3.06	6.1

and 3.1% over control and 500 ppm, respectively. Thiourea and drip irrigation treatments could not significantly influence the phosphorus concentration in straw of mustard.

Total phosphorus uptake of mustard crop was significantly improved with sprinkler and drip irrigation at different IW/CPE ratios over surface irrigation. Drip irrigation at 0.6 and 0.8 IW/CPE ratio, recorded significantly increased total phosphorus uptake by 34.7, 14.7 and 16.2% over surface irrigation, sprinkler and drip irrigation at 0.4 IW/CPE ratio, respectively. Total phosphorus uptake of mustard crop significantly improved by 34.03 over control with the spraying of thiourea @ 500 ppm. Application of thiourea @ 750 ppm significantly increased the total phosphorus uptake by 45.0 and 8.2% over control and thiourea @ 500 ppm, respectively.

Sulfur concentration and uptake

Sulfur concentration in seed of mustard at drip irrigation at 0.6 IW/CPE ratio recorded significantly increased as compared to surface irrigation and drip irrigation at 0.4 IW/CPE ratio and remained statistical at par with sprinkler and drip irrigation at 0.8 IW/CPE ratio (Table 3). The drip irrigation at 0.6 IW/CPE ratio, recorded significantly increased sulfur concentration by 7.4 and 5.7% in seed over surface irrigation and drip irrigation at 0.4 IW/CPE ratio.

Foliar application of thiourea significantly increased the sulfur concentration in seed of mustard over control. Application of thiourea @ 500 ppm increased the sulfur concentration in seed over control by 8.99%. Application at thiourea @ 750 ppm recorded significantly increased sulphur concentration in seed over control and application of thiourea @ 500 ppm. The per cent increased in sulfur concentration in seed of mustard was 12.0 and 19.7% over control and spraying of thiourea @ 500 ppm, respectively. Sulfur concentration in straw of mustard at drip system @ 0.6 IW/CPE ratio recorded significantly increased over surface, sprinkler and drip method @ 0.4 IW/CPE ratio but remained statistical at par with drip system @ 0.8 IW/CPE ratio. The drip irrigation at 0.6 IW/CPE ratio recorded significantly increased sulfur concentration by 21.7, 7.2 and 9.2% in straw over surface irrigation, sprinkler and drip system @ 0.4 IW/CPE ratio.

Foliar application of thiourea significantly increased the sulfur concentration in seed of mustard over control. Application of thiourea @ 500 ppm increased the sulfur concentration in seed of crop as compared to control by 15.66%. Application at thiourea @ 750 ppm recorded significantly increased sulfur concentration in seed over control and application of thiourea @ 500 ppm. The per cent increase in sulfur concentration in seed of mustard was 19.7 and 3.5% over control and thiourea @ 500 ppm, respectively.

Drip irrigation @ 0.6 IW/CPE ratio significantly recorded higher sulfur uptake of mustard over surface, sprinkler and drip system @ 0.4 IW/CPE ratio and remained at par with drip system @ 0.8 IW/CPE ratio. The drip system @ 0.6 IW/CPE ratio, significantly increased sulfur uptake by 47.4, 18.0 and 21.7% in mustard over surface irrigation, sprinkler and drip system @ 0.4 IW/CPE, respectively.

Thiourea significantly increased total sulfur uptake in seed of mustard over control. Application at thiourea @ 750 ppm led to significantly increased total sulfur uptake over control and thiourea @ 500 ppm. The per cent increased in total sulfur uptake under thiourea @ 750 ppm was 50.8 and 8.9% over control, thiourea @ 500 ppm, respectively. Phosphorus concentration in straw as well as oil content of mustard seed was not improved significantly by different level of irrigation scheduling.

This is attributed to improved nutritional environment in the rhizosphere as well as in the plant system leading to higher nutrients translocation in plant parts along with irrigation water. Since the nutrient uptake depends upon its content in crop plant, seed and straw yield of the crop (Malve 2015). The increased nitrogen, phosphorus and sulfur contents in mustard is due to availability of moisture in rhizosphere which solubilized the nutrients and ultimately the plants exploited more nutrients from soil through their root proliferation (Lakpale *et al.* 2007). Under sufficient soil moisture, the transpiration flow gets increased owing to full stomata opening which intends to higher content of nutrients (Singh *et al.* 2013).

Protein content

Irrigation scheduled at 0.6 IW/CPE ratio significantly enhanced protein content over surface, sprinkler and drip irrigation @ 0.4 IW/CPE ratio and remained at par with 0.8 IW/CPE ratio of drip irrigation (Table 4). 0.6 IW/CPE ratio of drip irrigation significantly enhanced protein content by 13.0, 7.8 and 6.9% over surface irrigation, sprinkler and drip irrigation at 0.4 IW/CPE, respectively.

Table 4. Impact of irrigation methods and thiourea on protein as well as oil content in seed of mustard.

Treatments	Protein content (%)	Oil content (%)
Irrigation scheduling		
Surface irrigation	20.6	36.8
Sprinkler	21.6	38.7
Drip irrigation @ 0.4 IW/CPE ratio	21.8	38.3
Drip irrigation @ 0.6 IW/CPE ratio	23.3	41.2
Drip irrigation @ 0.8 IW/CPE ratio	23.8	41.4
SEm±	0.4	0.9
CD (p=0.05)	1.4	NS
CV (%)	6.6	8.3
Thiourea		
Control	19.4	37.3
Thiourea @ 500 ppm	23.3	39.9
Thiourea @ 750 ppm	24.1	40.6
SEm±	0.4	0.8
CD (p=0.05)	1.1	2.4
CV (%)	6.2	7.9

Foliar spray of thiourea significantly increased the protein content in mustard seed. Foliar spray of thiourea @ 500 ppm, being at par with spraying of thiourea @ 750 ppm, significantly increased mustard seed protein by 20.3% over control.

Oil content

Oil content in seed of mustard was not improved significantly by different level of irrigation scheduling (Table 4). Foliar spray of thiourea significantly increased the oil content in seed of mustard. Foliar application of thiourea @ 500 ppm, being at par with spraying of thiourea @ 750 ppm, significantly enhanced oil content to the extent of 7.19% over control.

Soil moisture studies

Consumptive use of water

Significantly highest consumptive use of water obtained with drip irrigation @ 0.8 IW/CPE ratio over rest of the irrigation scheduling treatments. The drip irrigation @ 0.8 IW/CPE consumed higher water by 9.40, 15.39, 57.97, 29.18 mm compared to surface, sprinkler, drip system @ 0.4 IW/CPE and drip system @ 0.6 IW/CPE.

Foliar spray of thiourea did not significantly influenced the consumptive use of water.

Water use efficiency

Irrigation scheduled at 0.6 IW/CPE ratio (13.3 kg/ha-mm), and 0.4 IW/CPE ratio (14.10 kg/ha-mm), recorded significantly higher water use efficiency over surface irrigation (8.99 kg/ha-mm), sprinkler (10.71 kg/ha-mm), drip irrigation @ 0.8 IW/CPE ratio (11.58 kg/ha-mm). The drip irrigation @ 0.6 IW/CPE ratio recorded significantly higher water use efficiency by 47.7, 24.0 and 14.68% over surface irrigation, sprinkler and drip irrigation at 0.8 IW/CPE ratio, respectively.

These results are in agreement with Pramanik *et al.* (2008) and Ray *et al.* (2015).This increase in consumptive use of water with level of irrigation scheduling was attributed to more plant height as well as dry matter accumulation, which in turn might have utilized more water to fulfill evapotranspiration and metabolic requirement of plants.

Foliar spray of thiourea significantly increased the water use efficiency. The thiourea @ 500 ppm (12.1 kg/ha-mm), and thiourea @ 750 ppm (12.8 kg/ha-mm), recorded significantly higher water use efficiency over control (10.3 kg/ha-mm). Spraying of thiourea @ 500 ppm increased water use efficiency by 17.1% over control.

Relative water saving

Per cent water saving by sprinkler and drip irrigation at, 0.4, 0.6 and 0.8 IW/CPE ratio was 12.2, 43.1, 24.3 and 7.7%, respectively over surface irrigation (Table 5).

Irrigation scheduled at 0.6 IW/CPE ratio (13.3 kg/ha-mm), and 0.4 IW/CPE ratio (14.1 kg/ha-mm), recorded significantly higher water use efficiency over surface (9.0 kg/ha-mm), sprinkler (10.7 kg/ha-mm), drip irrigation at 0.8 IW/CPE ratio (11.6 kg/ha-mm).

The findings suggest that drip irrigation at a ratio of 0.4 IW/CPE recorded the highest water saving, with similar results reported in previous studies conducted by Pramanik *et al.* (2008) and Ray *et al.*

Table 5. Impact of irrigation methods and thiourea on consumptive use of water, water use efficiency and relative water saving in mustard.

Treatments	Consumptive use of water (mm)	Water use efficiency (kg/ha-mm)	Relative water saving (%)
Irrigation scheduling			
Surface irrigation	179.2	9.0	0
Sprinkler	173.2	10.7	12.2
Drip irrigation @ 0.4 IW/CPE ratio	130.7	14.1	43.1
Drip irrigation @ 0.6 IW/CPE ratio	159.5	13.3	24.3
Drip irrigation @ 0.8 IW/CPE ratio	188.6	11.6	7.7
SEm±	1.9	0.3	-
CD (p=0.05)	6.3	1.0	-
CV (%)	4.0	9.9	-
Thiourea			
Control	166.2	10.3	-
Thiourea @ 500 ppm	166.2	12.1	-
Thiourea @ 750 ppm	166.2	12.8	-
SEm±	1.7	0.3	-
CD (p=0.05)	NS	0.8	-

(2015). This saving could be attributed to factors such as increased plant height and dry matter accumulation, leading to more efficient water use to fulfill plant needs. Moreover, drip irrigation at a 0.6 IW/CPE ratio resulted in the highest water use efficiency, likely due to a more pronounced increase in yield compared to water used for biomass production. This increase in efficiency might stem from the optimal use of water to maintain appropriate soil moisture levels, ensuring maximum yield with minimal water input. Overall, these findings underscore the advantages of drip irrigation, particularly at certain ratios of IW/CPE, in achieving significant water savings and enhancing water use efficiency compared to traditional surface irrigation methods and hence the net quantity of water applied was nearly equal to the moisture depleted by the crop.

CONCLUSION

Productivity of any crop is mainly correlated with nutrient concentration and uptake. As mustard is mainly cultivated in marginal lands, efforts should be on enhancing nutrient uptake and water use efficiency. There is a scope for improvement in mustard productivity through agronomic interventions particularly in Rajasthan where moisture deficit and abiotic stress conditions prevail. We have tried to find out the suitable irrigation schedule and thiourea concentration to enhance nutrient uptake, quality and water use efficiency through this study. Scheduling of irrigation at 0.6 IW/CPE ratio along with foliar spray of thiourea @ 500 ppm was found most suitable for obtaining higher nutrient uptake, protein, oil content and water use efficiency in mustard.

REFERENCES

Anonymous (2018-19) Ministry of agriculture and farmer welfare. www. *Agriculture.gov. in.*

Halmann M (1980) Synthetic plant growth regulators. *Advances in Agronomy* 43: 47-105.

Karthik R, Dhaker D, Raising LP (2021) Performance of Cereals under Need based Nitrogen Management Strategies: A Review. *Agricultural Reviews*.

Lakpale R, Shrivastava GK, Tripathi RS (2007) Effect of irrigation schedule on growth, yield and economics of spice crops. *Indian Journal of Agricultural Sciences* 77(3): 170-173.

Malve SH (2015) Performance of wheat under drip irrigation and fertigation scheduling at 0.4, 0.6, 0.8.and 1.0 IW/CPE ratio. PhD thesis. TNAU, Rajendranagar, Telengana.

Panse VG, Sukhatme PV (1985) Statistical methods for Agricultural workers.

Pramanik SC, Singh KK, Singh NB (2008) Irrigation scheduling in chickpea under raised bed planting system. *Journal of Food Legumes* 21(1): 67-68.

Ray K, Sengupta K, Pal AK, Banerjee H (2015) Effects of sulfur fertilization on yield, S uptake and quality of Indian mustard under varied irrigation regimes. *Plant Soil and Environment* 61(1): 6–10.

Singh AS, Pandey N, Ahmad A, Verma N (2013) Nutrient uptake and economics of rice under aerobic condition in CPE based irrigation schedules and nutrient level in Raipur, India. Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur. *Research Journal* 47(1): 42-44.