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NUTRIENT UPTAKE, QUALITY AND FERTILIZER PRODUCTIVITY OF INDIAN MUSTARD (*BRASSICA JUNCEA* L.) AS INFLUENCED BY DEFICIT DRIP IRRIGATION SCHEDULING UNDER FRUIT PLANTATION

ANAMIKA BARMAN*, VK SINGH, SS RATHORE, SUBHASH BABU AND PRIYANKA SAHA

Division of Agronomy, ICAR- Indian Agricultural Research Institute, New Delhi, 110012, India

Keywords: Agri-horti system, Deficit irrigation scheduling, Fertilizer productivity, S uptake, Quality

Abstract

A field experiment was conducted to evaluate effects of deficit irrigation scheduling (DIS) and different Agri-Horti System (AHS) on nutrient uptake, quality and fertilizer productivity of Indian mustard under sandy loam soil. Results revealed that among different levels of irrigation scheduling 0.6 IW (irrigation water)/ Cumulative pan evaporation (CPE) ratio resulted in higher amount of total N, P, K and S uptake which remained significantly superior over 0.4 IW/CPE and rainfed treatments. Among different AHS, Moringa (*Moringa oleifera* L.) based AHS exhibited significantly higher nutrient uptake, quality and fertilizer productivity followed by phalsa (*Grewia asiatica* L.), karonda (*Carissa carandas* L.), Indian gooseberry (*Phyllanthus emblica* L.) and guava (*Psidium guajava* L.) based AHS. Results revealed that Indian mustard could be suitably irrigated with 0.6 IW/CPE ratio to achieve higher nutrient uptake, quality and fertilizer productivity under moringa based AHS.

Introduction

India contributes world's 28% area and 20% production of rapeseed-mustard crop (Shekhawat *et al.* 2012). Indian mustard is one of the most important winter season oilseed crops which is grown in residual soil moisture condition. Hence, the productivity of Indian mustard crop is very low. To increase the production and productivity of mustard crop, proper agronomic interventions through suitable irrigation management practices are very important. It can be achieved by proper irrigation scheduling at correct time and amount. Moreover, suitable irrigation scheduling increased the growth, quality, nutrient uptake and fertilizer productivity of Indian mustard (Ahamed *et al*. 2019 and Singh *et al*. 2021). Among different Agro-forestry system, Agri-Horti system (AHS) is highly remunerative for replacing sole cropping. Farmers can get food grains, fuel, fodder, fruit and timbers from the same piece of land. In modern agriculture high input cost, environmental degradation and climate change have generated new challenges. In view of this, AHS provided biodiversity protection, extra income to the farmers, carbon sequestration, nutrient recycling, climate change adaptation and mitigation (Lehman and Schroth 2003). Guava, karonda, aonla, phalsa, moringa are some of the important horticultural crops of tropical and subtropical region of India. They are successfully cultivated on a wide range of climatic and soil conditions due to their ability to tolerance moisture stress, heat, cold, salinity etc. Thus. the present experiment was designed with the scientific question in mind whether the deficit irrigation scheduling combined with different AHS could improve the nutrient uptake, oil content and oil yield, fertilizer productivity of mustard under sandy loam soil of semi-arid region.

*Author for correspondence: <anamikaiari123@gmail.com>.

Materials and Methods

The field experiment was conducted at Top Block Research Farm of Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi (28° 40' N latitude, 77° 12' E longitude and at 229 m above the mean sea level) during the year 2020-2021. The area was characterized as semi-arid climate with cool winter and hot summer. The soil of the experimental field was sandy loam soil with pH 7.6. Field capacity and permanent wilting point were 17.9-20 and 6.25-9%, respectively. The bulk density (BD) and EC of the soil were 1.53 $Mg/m^3$and 0.32 dS/m at 25° C. The variety was Pusa mustard 28 (crossing of SEJ 8* Pusa Jagannath). Seed rate and spacing were 5 kg/ha and 30×10 cm. Amount of irrigation water applied for 0.4 IW/CPE and 0.6 IW/CPE were 60 and 80 mm respectively. The depth of irrigation water applied for each irrigation was 20 mm. The experiment was carried out in split plot design (SPD) with 5 main-plot treatments and three sub-plot treatments and replicated thrice. In main plot five AHS were assigned *i.e.,* Moringa (*Moringa oleifera* L.), phalsa (*Grewia asiatica* L.), karonda or carandas plum (*Carissa carandas* L.), Indian gooseberry (*Phyllanthus emblica* L.) and guava (*Psidium guajava* L.). In sub plot three level of deficit irrigation scheduling were assigned *i.e.,* rainfed, 0.4 IW/CPE and 0.6 IW/CPE ratio. The following formula were used for the calculation of nutrient uptake, total nutrient uptake and partial factor productivity of N, P, K and S.

$$\text{Nutrient uptake by seed/stover (kg/ha)} = \frac{\text{Nutrient content (\%)} \times \text{Seed/stover yield (kg/ha)}}{100}$$

Total uptake= Uptake by seed (kg/ha) + Uptake by stover (kg/ha)

$$\text{Partial Factor of Productivity } (PFP_{N,\,P,\,K,\,S}) = \frac{\text{Seed yield (kg)}}{\text{Rate of fertilizer use (kg)}}$$

Results and Discussion

Different Agri-Horti system and deficit irrigation scheduling had significantly influenced the total N, P, K and S uptake (Table 1). With the increase in amount of irrigation water, increasing trend in total nutrient uptake by the mustard plant was found. The highest amount of N, P, K and S uptake were recorded with irrigation scheduling at 0.6 IW/CPE ratio and this remained significantly superior over 0.4 IW/CPE and rainfed treatments. It was also recorded that there were 13.3, 15.1, 13.6 and 16.5% increase in total N, P, K and S uptake by irrigation scheduling at 0.6 IW/CPE over 0.4 IW/CPE, respectively. Concerning various AHS, it was observed that Moringa based AHS exhibited maximum total N, P, K and S uptake. The trend for total N, P, K and S uptake for AHS were moringa, phalsa, karonda. aonla and guava based AHS. The interaction effect of deficit irrigation scheduling levels and AHS were found to be significant in case of total N and S uptake, where interaction effect of total P was found insignificant (Table 2). Significantly highest nutrient uptake with increasing in irrigation frequency might be due to better availability of moisture content throughout the growing period which attributed to better nutrient uptake by Indian mustard. As the water availability increased throughout the growing period, soluble fraction of nutrients presents in soil solution became available to plant. Singh *et al.* (2021**)** also found that uptake of total N, P, K and S was increased with the increased irrigation frequency. Similar findings were also reported by Verma *et al*. (2014). Better nutrient uptake recorded with moringa based AHS might be due to the fact that moringa was a multipurpose tree, the leaf falls and pruned biomass from moringa tree immensely contributed to soil fertility which reflected in terms of growth and yield parameters. Similarly, Barman *et al.* (2021) also reported that the highest growth and other productivity attributed under moringa based AHS.

Table 1. Effect of deficit irrigation scheduling and Agri-Horti system on total N, P, K and S uptake.

Treatments	N (kg/ha)			P (kg/ha)			K (kg/ha)			S (kg/ha)		
	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total
						Agri-Horti system						
Moringa	62.24	32.91	95.15	6.96	11.40	18.66	14.45	94.47	111.23	10.53	5.22	15.74
Phalsa	51.62	30.06	81.68	5.65	9.87	15.87	12.20	86.84	102.43	9.12	4.76	13.88
Karonda	48.46	28.79	77.26	5.24	9.06	14.64	11.16	74.32	87.80	8.77	4.48	13.25
Aonla	45.69	25.16	70.85	4.54	7.77	12.31	10.70	65.87	76.56	8.22	3.92	12.14
Guava	41.07	23.29	64.35	3.96	7.27	11.23	9.63	61.91	71.54	7.35	3.56	5.27
SEm±	2.31	0.67	2.33	0.48	0.49	0.60	0.40	3.73	3.47	0.54	0.22	0.67
CD (P=0.05)	7.53	2.19	7.59	1.58	1.59	1.97	1.31	12.16	11.30	1.76	0.72	2.20
						Deficit irrigation scheduling						
Rainfed	38.61	24.35	62.96	4.01	7.70	11.85	8.48	62.04	71.68	6.75	3.51	10.26
0.4 IW/CPE	50.87	28.33	79.19	5.42	8.99	14.58	12.14	78.20	91.84	8.83	4.46	11.79
0.6 IW/CPE	59.97	31.45	91.42	6.38	10.54	17.19	14.25	89.81	106.22	10.82	5.19	14.12
SEm±	0.92	0.81	1.06	0.18	0.33	0.27	0.27	3.48	3.48	0.66	0.24	0.63
CD (P=0.05)	2.72	2.39	3.13	0.54	0.97	0.80	0.79	10.26	10.26	1.96	0.72	1.86

Table 2. Interaction effect of deficit irrigation scheduling and Agri-horti system on N, P, and S uptake.

Agri-Horti system (AHS)	N (Kg/ha)			P (kg/ha)			S (kg/ha)		
Base	Rainfed	0.4 IW/CPE	0.6 IW/CPE	Rainfed	0.4 IW/CPE	0.6 IW/CPE	Rainfed	0.4 IW/CPE	0.6 IW/CPE
Moringa	76.7	92.5	116.2	15.1	18.2	22.5	12.1	15.9	19.1
Phalsa	66.0	83.9	95.1	12.6	16.2	18.6	10.7	14.2	16.7
Karonda	66.2	77.5	87.9	12.7	14.3	16.8	11.0	13.0	15.6
Aonla	57.2	73.6	81.6	10.2	12.2	14.4	9.29	12.11	15.0
Guava	48.6	68.3	76.1	8.4	11.8	13.4	8.0	11.8	13.4
SEm±		3.02			0.78			1.37	
(AHS*DIS) LSD (P=0.05)		9.49			2.45			4.21	

The quality parameters *i.e.*, oil content and oil yield as well as protein content and protein yield were significantly influenced by different AHS and deficit irrigation scheduling levels (Table 3). Although, there was no such significant difference in oil content between scheduling of irrigation at 0.6 IW/CPE and 0.4 IW/CPE ratio but it increased slightly with the increase in irrigation frequency. Moreover, oil content and yield varied from 38.6-40.6% and 552-787 kg/ha, respectively, among various treatments. Whereas, protein content varied from 17.3-19.9% and 257-389 kg/ha, respectively. Among different deficit irrigation scheduling levels 0.6 IW/CPE ratio recorded the maximum oil content and yield followed by 0.4 IW/CPE and rainfeed treatment. Similar trend was also observed for protein content and yield as well. Whereas, among different AHS, moringa based AHS exhibited the maximum oil content and oil yield as well as protein content and protein yield. The trend of oil content and oil yield as well as protein content and protein yield were in the following order: moringa, phalsa, karonda, aonla and guava based AHS. It was observed that with the increasing level of irrigation from 0.4 IW/CPE to 0.6 IW/CPE ratio oil and protein content, as well as oil and protein yield were also increased in a tune of 1.3, 5.5, 11and 15.2%, respectively. This result might be due to the fact that with the increase in amount of irrigation water turgidity of the cell, cell division and meristematic activity enhanced which ultimately lead to higher P and S uptake. Sulphur immensely increased the oil content of the *Brassica* species, thus oil content increased with the increasing frequency of irrigation. This finding is alignment with the findings of Yadav *et al*. (2010) and Rathore *et al.* (2019). The regression analysis of total S uptake and oil content as well as total N uptake and protein content is presented in (Figs 1 and 2). It indicated that there was a positive relationship between total S uptake and oil content as well as total N uptake and protein content. With the increased uptake of total S and N, oil and protein content were also increased linearly.

Table 3. Effect of deficit irrigation scheduling and Agri-Horti system on oil and protein content and their yields.

Treatments	Protein content (%)	Protein yield (kg/ ha)	Oil content (%)	Oil yield (kg/ha)
Agri-Horti system				
Moringa	19.86	389	40.54	787
Phalsa	18.88	323	40.02	681
Karonda	18.47	303	39.76	650
Aonla	17.71	286	39.52	634
Guava	17.36	257	38.58	566
SEm±	0.49	14.43	0.13	17.94
CD (P=0.05)	1.60	47.05	0.42	58.51
Deficit irrigation scheduling				
Rainfed	17.20	241	39.49	552
0.4 IW/CPE	18.54	318	39.51	677
0.6 IW/CPE	19.63	375	40.05	761
SEm±	0.30	5.76	0.26	11.10
CD (P=0.05)	0.87	16.99	0.77	32.75

Fertilizer productivity was calculated in terms of partial factor productivity. Partial factor productivity of N, P, K and S increased significantly with deficit irrigation scheduling and AHS (Table 4). It was observed that partial factor productivity of S (PFP_S) was higher than PFP_N and

PFP_P. Although, the highest PFP was observed for K. The maximum PFP for N, P, K and S were observed with irrigation scheduling at 0.6 IW/CPE ratio. Whereas, among different AHS, moringa based AHS recorded the highest value and guava based AHS, recorded the lowest value. This could be ascribed as the ample amount of water availability maintained during the critical stages of crop as a result seed yield increased as well as the nutrient use efficiency of the crop. This finding corroborated with findings of Ierna *et al.* (2011) and Singh *et al.* (2021).

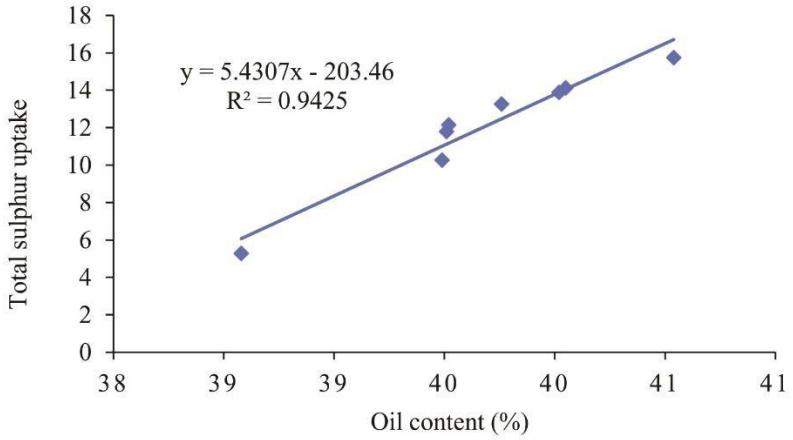

Fig. 1. Regression analysis of total sulphur uptake and oil content.

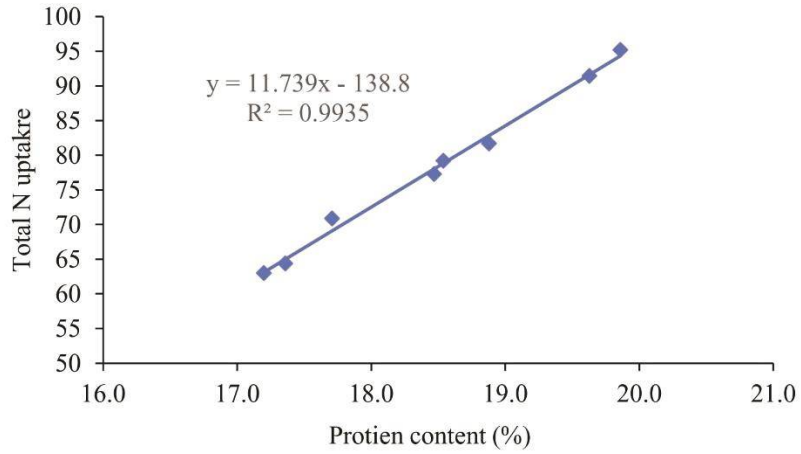

Fig. 2. Regression analysis of total nitrogen uptake and protein content.

Based on the research findings it may be concluded that deficit drip irrigation scheduling in mustard under different AHS, the nutrient uptake, fertilizer productivity and quality parameters could be improved. Concerning different Agri-Horti system, moringa based AHS showed better result compared to other horticultural crops taken. On the other hand, scheduling of irrigation at 0.6 IW/CPE ratio could be a better option in water scarce area for increasing the nutrient uptake, fertilizer productivity and quality parameters of Indian mustard under semi-arid region**.**

Table 4. Effect of deficit irrigation scheduling and Agri-Horti system on Partial factor productivity (PFP) of applied nutrients.

Treatments	PFP_N (kg/kg)	PFP_P (kg/kg)	PFP_K (kg/kg)	PFP_S (kg/kg)
Agri-Horti system				
Moringa	16.2	32.3	64.62	48.5
Phalsa	14.2	28.3	56.66	42.5
Karonda	13.6	27.2	54.46	40.8
Aonla	13.4	26.7	53.40	40.1
Guava	12.2	24.5	48.90	36.7
SEm ±	0.3	0.7	1.38	1.0
CD (P = 0.05)	1.1	2.2	4.49	3.4
Deficit irrigation scheduling				
Rainfed	11.6	23.2	46.48	34.9
0.4 IW/CPE	14.3	28.5	57.05	42.8
0.6 IW/CPE	15.8	31.6	63.29	47.5
SEm ±	0.2	0.5	0.90	0.7
CD (P = 0.05)	0.7	1.3	2.66	2.0

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