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To study the effect of moisture regimes and sulphur on growth and yield of mustard (*Brassica juncea* L.) under drip environment

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Abstract

Oilseeds play crucial role in Indian agriculture economy contributing 6% in gross national product and 10% in agricultural produce value (DOAC, 2017). Indian Mustard (*Brassica juncea* L.) is one of the most important oilseed crop of *rabi* season of our country and approximately 13.2% of the annual edible oil comes from Brassica.

The field experiment was performed during *rabi* season of 2019 at the Agricultural Research Farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (Chhattisgarh). The soil of the experimental field was clay loam in texture, locally known as dorsa. The soil was neutral in reaction, medium in organic carbon, low in available nitrogen, medium in phosphorus and potash and low in sulphur. The experiment was laid out in strip plot design consisting three treatments of irrigation on strip A [irrigation at 80% PE (I_1), 60% PE (I_2) and 40% PE (I_3) through drip] with a control (farmer's practice) and four nutrient levels on strip B [75% RDF + 30 kg S through drip (F_1), 75% RDF + 20 kg S through drip (F_2), 75% RDF + 10 kg S through drip (F_3), 100% RDF through soil application (F_4)] and replicated three times.

Experimental results revealed that among the different irrigation treatments irrigation through drip at 60% PE recorded better growth in terms of plant height (197.06 cm), number of branches (10.28) and plant dry matter (21.36 g plant^{-1}), yield attributes like number of siliqua plant^{-1} (314.01), number of seeds siliqua^{-1} (16.13) and yield (grain and straw) (20.10 kg ha^{-1}and 48.76 kg ha^{-1}) of mustard. In terms of economics highest net returns was obtained from treatment I_2 (60% PE) but better B: C ratio was recorded from farmer's practice. Low water expenses (178.91 mm) and improved water expense efficiency (11.23 kg ha-mm^{-1}) was recorded for drip irrigation as compared to farmer's practice. In case of nutrient levels, significantly superior growth attributes, yield attributes, higher yield (20.44 kg ha^{-1}and 47.65 kg ha^{-1}) and net return (90624 Rs) was recorded by treatment F_1 (75% RDF + 30 kg S through drip) followed by F_2 (75% RDF + 20 kg S through drip) however, highest B: C (1.97) ratio was obtained from treatment F_4 (100% RDF through soil application). Lowest yield and economic return was recorded for treatment F_3.

Keywords: Drip environment, *Brassica juncea*, moisture regimes

1. Introduction

Oilseeds play crucial role in Indian agriculture economy contributing 6% in gross national product and 10% in agricultural produce value (DOAC, 2017) [6]. Indian mustard (*Brassica juncea* L.) is one of the most important oilseed crop in *rabi* season of our country and approximately 13.2% of the annual edible oil comes from Brassica. Due to its suitability and versatility to exploit residual soil moisture it has been proved as a potential winter crop (Mukherjee, 2010).

In India the area coverage of rapeseed and mustard is 5977.16 ('000 ha) after soybean (Anonymous, 2017-18) [1]. It holds third position in production with 8430 ('000 tonne) after soybean and groundnut and its productivity is limited upto 1410 kg ha^{-1} after soybean and groundnut (Anonymous, 2017-18) [1].

In Chhattishgarh mustard covers an acreage of 43.43('000 ha) with 18.11('000 tonnes) of production and productivity of 415 kg ha^{-1} only (Anonymous, 2017-18) [1].

By 2050, to fulfil the nutritional fat requirement of the projected 1685 million population India needs to produce 17.84 million tonnes of vegetable oil. It seems difficult to reach the estimated target with present status of resource and technology management in Indian agriculture (Hedge, 2012) [7]. When compared with other country average, per hectare productivity of mustard in India is quite low (Piri & Sharma, 2006). Low productivity of mustard is may be due to its cultivation in inherently low fertile soil, with very less or no use of additional inputs likes irrigation, nutrients etc, (Ray *et al.*, 2015) [20].

This results in big gap between requirement and production of mustard in Chhattishgarh and India.

Proper nutrient management along with 1 to 3 application of irrigation are most important factor to increase mustard yield (Piri *et al*., 2011) [18]. Nitrogen is a primary nutrient but its use efficiency is very low (30-40%) when applied through soil application. The remaining 60-70% unutilized N is not stored in the root zone but it is lost through various processes like volatilization, leaching, runoff etc. Leaching losses of N increases drastically when surface irrigation is applied where water supply is more than evapo-transpiration (Katyal *et al*., 1985) [10, 11]. Regular, uniform and timely application of N is ensured through fertigation, eliminating contamination through leaching and enhance the efficiency of N (Asad *et al*., 2002) [2].

Along with NPK addition of sulphur is very imperative for improving quality and yield of oilseeds as sulphur is a constituent of amino acids, vitamins and sulpholipids (Morris, 2007; Singh &Pal, 2011) [14, 21]. Mustard is more responsive towards sulphur as compared to other oilseed crops. Oil content of mustard increases with application of sulphur containing fertilizers (Singh *et al.*, 2015). Hence, sulphur fertilization is remarkably essential for production of oilseeds of superior nutritional quality and marketable value.

2. Materials and methods

The present investigation entitled "To study the effect of moisture regimes and sulphur on growth and yield of mustard (*Brassica juncea* L.) under drip environment" was conducted during *rabi* season of 2019-20 at the Agricultural Research Farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (Chhattisgarh) under All India Co-ordinated Project on Irrigation Water Management.

2.1 Climate of the region

Agro-climatically, the experimental site falls in dry moist, sub-humid region. During cropping period minimum and maximum temperature goes to 8.6°C and 16.0°C, respectively in the months of January and March. Total rainfall of 195.4 mm was received in 14 rainy days and minimum evaporation of 1.4 mm to maximum 2.8 mm was recorded during crop duration. The soil was neutral in reaction (7.2), medium in organic carbon (0.67%), low in available nitrogen (271.2 kg ha^{-1}), medium in phosphorus (14.58 kg ha^{-1}) and potash (269 kg ha^{-1}) and low in sulphur (11.2 kg ha^{-1}).

2.2 Experimental details

The experiment was laid out in strip plot design. Strip A consist of three irrigation levels through drip, based on different levels of PE (potential evaporation) and four nutrient levels are allocated to strip B. All the treatments are replicated three times. One treatment combination of border strip irrigation (Farmer's practice) with 100% RDF (100: 60: 40 kg N: P_2O_5: K_2O ha^{-1} through Urea, SSP and MOP) in the form of soil application was also taken as control plot.

3. Result and discussion

3.1 Growth parameters of mustard

Plant height observed at 30 DAS showed non-significant effect of treatments. However, on later stages taller plants were obtained (197.06 cm) by the treatment I_2 (60% PE) which was found significantly superior over rest, although at par with treatment I_1 (80% PE). Meanwhile, higher number of primary branches (10.28) and dry matter accumulation (21.36 g $plant^{-1}$), crop growth rate and relative growth rate was obtained from the treatment I_2. Higher plant growth parameters recorded by I_2 was may be due to continuous and adequate supply of irrigation water for cell enlargement and proliferation. Similar results were confirmed by Parihar *et al.* (2019) and Oma Shankar Bhukhar (2019) [3, 4].

Among treatments of nutrient level, treatment F_4 (100% RDF through soil application) recorded superior plant height at 30 DAS (74.24cm) in comparison with rest of the treatments. But at maturity significantly taller plants (194.31cm) were obtained by treatment F_1 (75% RDF + 30 kg S) followed by F_2 (75% RDF + 20 kg S) and F_4 (100% RDF). Similarly, higher number of primary branches (10.74), dry matter accumulation (21.00 g $plant^{-1}$), crop growth rate and relative growth rate was recorded for treatment F_1. Uninterrupted and ample supply of nutrients by treatment F_1 in the form of N, P_2O_5 and K_2O through fertigation culminate higher growth parameters during entire growth stages. This result was in accordance with findings of Rajput *et al.* (2017) and Moniruzzaman *et al*. (2010).

3.2 Yield attributes of mustard

Maximum number of siliqua per plant (314.01) and seeds $silique^{-1}$ (16.13) was obtained from treatment I_2 (60% PE) which is significantly higher than I_3 (40% PE) and was at par with treatment I_1 (80% PE). Higher number of siliqua per plant and seeds per siliqua observed in I_2 treatment might be due to extended and proportionate supply of water in root vicinity through drip irrigation. The above data is in close conformity with findings of Parihar *et al.* (2019) and Oma Shankar Bhukhar (2019) [3, 4].

Among treatments of nutrient level, highest number of siliqua per plant (313.78) and seeds $silique^{-1}$ (16.33) was obtained from the treatment F_1 (75% RDF + 30 kg S) which was found significantly superior than F_3 (75% RDF + 10 kg S) and F_4 (100% RDF through soil application), whereas found at par with treatment F_2 (75% RDF + 20 kg S). Supply of 75% RDF + 30 kg S in the form of fertigation nourished the crop of mustard very well and resulted in higher number of siliqua per plant and number of seeds per silique. Similar findings have been reported by Biswas *et al.* (2017), Jaga (2013) [9] and Yadav and Dhani (2018) [24].

No difference on test weight of mustard seeds was observed both due to treatments of irrigation and nutrient level.

3.3 Seed yield, stover yield and harvest index of mustard

Significantly higher seed (20.10 q ha^{-1}) and stover yield (48.79 q ha^{-1}) was obtained by treatment I_2 (60% PE) (20.10 q ha^{-1}) which was at par with treatment I_1 (80% PE) and lowest seed yield was recorded from the treatment I_3(40% PE). Higher harvest index (29.84) was obtained by treatment I_1 (80% PE) followed by I_2 and I_3. Higher seed yield was may be due to adequate and uninterrupted availability of moisture at root zone throughout the crop period and maintenance of suitable micro climate by frequent irrigation through drip system which produced the higher value of yield contributing characters viz. number of siliqua $plant^{-1}$, number of seeds $silique^{-1}$, test weight etc. Same research finding was mentioned by Oma Shankar (2019), Parihar *et al.* (2019) and Singh and Survyanshi (2018) [23].

Among treatments of nutrient level, treatment F_1 (75% RDF + 30 kg S) recorded significantly superior seed yield (20.48 q ha^{-1}), stover yield (47.65) and harvest index (30.06) in comparison with treatment F_3 (75% RDF + 10 kg S) and F_4 (100% RDF through soil application). However, treatment F_2 (75% RDF + 20 kg S) was at par with treatment F_1. The adequate supply of nutrients an balanced manner with sulphur at the steady rate in the form of fertigation (F_1) may be generate per plant more number of silique, per silique higher number of seeds, higher test weight resulted higher seed yield by treatment F_1. This result validates with the finding of Rajput *et al.* (2017).

3.4 Water use parameter

Highest expenses of water (276.32 mm) was recorded for the treatment I_4 (Farmer's practice) followed by I_1 (80% PE) (193.21 mm) and I_2 (60% PE) (183.99 mm). Lowest value for water expenses (174.76 mm) was documented from I_3 (40% PE).

Highest value of water expenses efficiency (10.92 kg ha-mm^{-1}) was calculated for the treatment I_2 (60% PE) followed up by treatment I_1 (80% PE) and I_3 (40% PE) however, treatment I_4 (100% RDF through soil application) (5.71 kg ha-mm^{-1}) recorded lowermost value for WEE. Among treatments of nutrient level, highest value of WEE (11.13 kg ha-mm^{-1}) was calculated for treatment F_1 (75% RDF + 30 kg S) which was followed by F_2 (75% RDF + 20 kg S) and F_4 (100% RDF through soil application). Lowermost value (7.72 kg ha-mm^{-1}) was obtained for F_3 (75% RDF + 10kg S).

3.5 Economics

Economics is the final measure to evaluate the best treatments which are cost effective and can be accepted by the farmers. Uniform cost of cultivation for mustard crop was noted for all the treatments of drip irrigation (30882 Rs ha^{-1}) except for control (border strip). Control treatment that is farmer practice I_4F_4 recorded lowest cost of cultivation among all the treatments (23489 Rs ha^{-1}). Higher gross return and net return (58061 Rs ha^{-1}) was obtained from the treatment I_2 (60% PE) (88943 Rs ha^{-1}) while better B: C ratio was recorded for farmer's practice (1.97) from the rest of the treatments.

Among the nutrient management highest cost of cultivation (33003 Rs ha^{-1}), gross return (90624 Rs ha^{-1}) and net return (56031 Rs ha^{-1}) was recorded for treatment F_1 (75% RDF + 30 kg S) while better B: C ratio was recorded for F_4 (1.97).

3.6 Interaction effect

The interaction effect of irrigation and nutrient management were found non-significant for all the growth parameters as well as for yield of mustard crop.

Table 1: Plant growth parameters

Treatment	Plant height (cm)	Number of primary branches	Dry matter (g plant^{-1})
	At maturity	At maturity	At maturity
I_1 (80% PE)	187.31	10.03	19.22
I_2 (60% PE)	197.06	10.28	21.36
I_3 (40% PE)	172.27	9.87	16.45
SEm±	3.88	0.37	0.78
CD (5%)	15.24	NS	3.09
F_1 (75% RDF + 30 kg S)	194.31	10.74	21.00
F_2 (75% RDF + 20 kg S)	189.07	10.09	19.36
F_3 (75% RDF + 10 kg S)	173.42	9.00	17.27
F_4 (100% RDF through soil application)	185.38	10.40	18.41
Sem±	4.04	0.34	0.66
CD (5%)	13.97	01.17	2.28
Interaction I×F	NS	NS	NS
I_4F_4 (Control)	181.4	10.25	18.20

Table 2: Yield attributes and yield of mustard seed

Treatment	Number of siliqua plant^{-1}	Number of seeds siliqua^{-1}	Test weight	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index	Cost of cultivation (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C Ratio
Irrigation (I)									
I_1 (80% PE)	299.33	15.25	3.85	17.58	41.35	29.84	30882	46910	1.31
I_2 (60% PE)	314.01	16.13	3.99	20.10	48.76	29.18	30882	58061	1.88
I_3 (40% PE)	278.74	13.69	3.70	14.08	37.34	27.38	30882	31422	1.01
SEm±	6.72	0.285	0.05	0.08	0.10	-	23489	46338	1.97
CD (5%)	26.93	1.11	NS	0.32	0.41	-	-	-	-
Nutrient level (F)							-	-	-
F_1 (75% RDF + 30 kg S)	313.78	16.33	4.07	20.48	47.65	30.06	1.61	1.61	1.61
F_2 (75% RDF + 20 kg S)	309.71	15.30	3.84	18.13	43.08	29.61	1.43	1.43	1.43
F_3 (75% RDF + 10 kg S)	278.32	14.09	3.70	14.22	37.87	27.29	0.99	0.99	0.99
F_4 (100%RDF through soil application)	287.63	14.88	3.77	16.17	41.34	28.11	1.97	1.97	1.97
SEm±	6.62	0.28	0.08	0.12	0.14	-	-	-	-
CD (5%)	22.89	0.95	NS	0.41	0.47	-	-	-	-
Interaction I×F	NS	NS	NS	NS	NS	-	-	-	-
I_4F_4 (Control)	283.51	14.33	3.73	15.78	39.25	28.69	-	-	-

Table 3: WE and WEE for different treatments

Treatment	Irrigation water applied (mm)	Re (mm)	WE (mm)	WEE (kg ha-mm^{-1})
I_1 (80% PE)	36.89	156.32	193.21	9.09
I_2 (60% PE)	27.67	156.32	183.99	10.92
I_3 (40% PE)	18.44	156.32	174.76	8.05
I_4 (Control)	120	156.32	276.32	5.71
F_1 (75% RDF + 30 kg S)	27.67	156.32	183.99	11.13
F_2 (75% RDF + 20 kg S)	27.67	156.32	183.99	9.85
F_3 (75% RDF + 10 kg S)	27.67	156.32	183.99	7.72
F_4 (100% RDF trough soil application)	27.67	156.32	183.99	8.78

4. Conclusion

On the basis of research findings, it can be concluded that, among the three levels of drip irrigation (irrigation at 40%, 60% and 80% PE) irrigation at 60% PE gave the higher grain and stover yield of mustard along with maximum net return and water expense efficiency. Nutrient management in the form of fertigation with 75% RDF + 30 kg S resulted maximum grain and stover yield with higher gross return and water expense efficiency of mustard than the other levels of nutrient management i.e.75% RDF + 20 kg S, 75% RDF + 10 kg S in the form of fertigation and 100% RDF through soil application.

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