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Effect of Irrigation Frequencies and Foliar Application of Zinc and Boron on Growth and Yield of Yellow Sarson (*Brassica rapa)*

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out during the winter (*Rabi*) season of 2021-22 on sandy loam soil at C.S. Azad University of Agriculture & Technology, Kanpur (U.P.) to study the Growth, yield of Yellow Sarson (*Brassica rapa*) influenced by different irrigation frequencies and foliar application of micronutrients (Zinc and Boron). Three irrigation (main plot) and four micronutrients level (sub plot) treatments were tested with "Split Plot Design" to know the influence of irrigation frequencies and micronutrients level on Yellow Sarson. To assess the effect of irrigation frequencies on yellow

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sarson, the treatment included IR_1(one irrigation at 30 DAS), IR_2(two irrigations at 30 and 55 DAS) and IR_3 (three irrigations at 30 DAS, 55 DAS and 90 DAS) and to assess the effect of micronutrients level, the treatments were F_0 (control), F_1(0.5% zinc at 30-35 and 40-45 DAS) and F_2(0.2% boron at 30-35 and 40-45 DAS) and F_3(0.5% zinc+0.2% boron at 30-35 and 40-45 DAS). Treatment IR_3 was found to be significantly superior to IR_2 and IR_1 treatments. The maximum seed yield was with the three irrigation frequencies IR_3 (30+55+90 DAS) which were higher by 10.56 and 37.23 per cent than IR_2 and IR_1 treatments respectively. Regarding micronutrients the maximum seed yield was obtained in F_3 treatment which was higher by 8.21, 14.42 and 21.78 percent than F_2, F_1 and F_0 treatments in a relative manner. The maximum seed yield was obtained with IR_3 X F_3 interaction which was higher by 21.70, 13.20 and 7.92 per cent than then IR_3F_0, IR_3F_1, and IR_3F_2 treatment combination.

Keywords: Foliar; micronutrients; irrigation frequencies.

1. INTRODUCTION

Rapeseeds and Mustard are important *rabi* season oilseed crop in India which belongs to the family Cruciferae. Rapeseed and Mustard is a prominent Oil seed crop being next to Soyabean. India is one of the top countries in the world for producing oilseeds, accounting for 10% of global production and 16.2% of the world's total area. Within the category of field crops, oilseed is India's second-largest agricultural product after cereals. It significantly affects the value of all agricultural commodities in India. In addition to being a fundamental component of the human diet, oils and fats are important raw materials used to make a variety of products, including soap, paint, hair oils, lubricants, varnishes, pharmaceuticals, auxiliaries, textiles, etc. It contributes significantly to the Indian economy, making up 12 percent of the value of all agricultural commodities, around 3.0 percent of the gross national production, and 27 percent of the gross cultivated area (rapeseed and mustard). Only seven of these oilseed crops groundnut, rapeseed, and mustard; soybean, sesame, sunflower, safflower, and Niger are suitable for human consumption. Linseed and castor are not suitable for human consumption. (DAC&FW, Annual Report 2020-21).

Mustard contains 37-49% oil, 25-32% protein, 7% ash, 0.6% calcium, 1.45% phosphorus, 0.6% magnesium, 0.05% manganese and good source of vitamins, thiamine 5.2 (mg g^{-1}), niacin 160 (mg g^{-1}), riboflavin 3.7 (mg g^{-1}), pantothenic acid 9.5 (mg g^{-1}), folic acid 2.3 (mg g^{-1}), chlorine 6.7 (mg g^{-1}), and tocopherols 1.5 (mg g^{-1}). The cake contains 42% crude proteins and 7% ash [1].

Zinc is an important constituent of several enzymes which regulate various metabolic processes in plants and also influences the formation of several growth hormones like IAA in plants. Zinc stimulates the pod setting, seed formation and oil synthesis in the seeds of mustard and it increases the biological seed and stover yield of mustard [2]. Mustard is quite responsive to micronutrients zinc (Zn) and boron (B), which play an important role in the growth and development of this crop. Availability of boron to plants is affected by a variety of soil factors including soil pH, texture, moisture, temperature, oxide content, carbonate content, organic matter content and clay mineralogy [3]. Its deficiency has been realized as the second most important micronutrient constraint in crops after that of zinc on the global scale [4]. Boron also helps in flowers and pollen grain formation. Boron application produced the best quality seeds with respect to the protein content of mustard. Boron deficiency in mustard may cause sterility e.g., fewer pods and fewer seeds pod^{-1}, attributing low seed yield [5].

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at SIF, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The City Kanpur Nagar is situated in the alluvial tract of Gangetic plains in the Central part of Uttar Pradesh between $25^0$56’ to $28^0$58’ North latitude and $79^0$31’ to 80^0 East longitudes and at an elevation of 125.9 meters from sea level. It is situated in the alluvial belt of the Gangetic plain of central U.P. India.

2.2 Edaphic Condition

The soil of the experimental field was sandy loam in texture and slightly alkaline in pH (7.3). Organic carbon in the soil was 0.4% which was estimated by the rapid titration method given by Walkley and Black, [6]. The available Nitrogen in

Table 1. Treatment combinations

Symbol	Treatments
IR_1F_0	One irrigation (30DAS) + control
IR_1F_1	One irrigation (30DAS) + Zn @ 0.5% at 30-35 DAS and 40-45 DAS
IR_1F_2	One irrigation (30DAS) + B @ 0.2% at 30-35 DAS and 40-45 DAS
IR_1F_3	One irrigation (30DAS) + Zn @ 0.5% and B @ 0.2% at 30-35 DAS and 40-45 DAS
IR_2F_0	Two irrigations (30DAS+55DAS) + Control
IR_2F_1	Two irrigations (30DAS+55DAS) + Zn @ 0.5% at 30-35 DAS and 40-45 DAS
IR_2F_2	Two irrigations (30DAS+55DAS) + B @ 0.2% at 30-35 DAS and 40-45 DAS
IR_2F_3	Two irrigations (30DAS+55DAS) + Zn @ 0.5% and B @ 0.2% at 30-35 DAS and 40-45 DAS
IR_3F_0	Three irrigations (30DAS+55DAS+90DAS) + Control
IR_3F_1	Three irrigations (30DAS+55DAS+90DAS) + Zn @ 0.5% at 30-35 DAS and 40-45 DAS
IF_3F_2	Three irrigations (30DAS+55DAS+90DAS) + B @ 0.2% at 30-35 DAS and 40-45 DAS
IR_3F_3	Three irrigations (30DAS+55DAS+90DAS) + Zn @ 0.5% and B @ 0.2% at 30-35 DAS and 40-45 DAS

the soil was 217.0 kg ha^{-1}, which was estimated by the Alkaline permanganate method given by Subbiah and Asija, [7]. The available Phosphorus was 17.0 kg ha^{-1} estimated by Olsen's method given by Jackson, 1967. The available K was 145.0 kg ha^{-1} which was estimated by the Flame photometer method given by Jackson, 1967.

2.3 Experimental Details

The experiment was laid out in a split-plot design with three replications. The main plot treatment consisted of three levels of irrigation viz. IR_1 (one irrigation at 30 DAS), IR_2 (two irrigations at 30 DAS and 55 DAS), IR_3 (three irrigations at 30 DAS, 55 DAS and 90 DAS), whereas four levels of (micronutrients Zinc & Boron) i.e., F_0 (control), F_1 (0.5% Zinc), F_2 (0.2% Boron) and F_3 (0.5% zinc + 0.2% boron) were applied to sub-plots. So, the total number of treatment combinations was twelve. The treatments were replicated thrice to avoid any effect of heterogeneity. The treatments within main plots and sub-plots were allocated randomly in each replication as per the standard procedure. The treatment details with symbolic representation are given in Table 1.

2.4 Land preparation

Land preparation was started after harvesting of *kharif* crop, and pre-sowing irrigation was given to the field for proper germination of seed. One ploughing was done by disc plough followed by two cross ploughing by tractor-drawn cultivator and each ploughing was followed by planking so that the soil was done properly to make the soil firm, friable and level to ensure proper germination of seed.

2.5 Nutrient Application

The fertilizers were applied at the rate of 120kg N, 60kg P_2O_5, and 60kg K_2O ha^{-1}. A full amount of phosphorus and potash and 75% nitrogen was applied as basal at the time of sowing in the form of Urea, DAP and MOP while the remaining amount of nitrogen was applied after first irrigation as a top dressing. The requirement of Zn at the rate of 0.5% was applied as spray as per treatment from Zinc sulphate. And for the requirement of Boron the rate of 0.2% was applied as a spray as per treatment from Borax.

2.6 Sowing

After the final field preparation, the seed of Pitambari Yellow sarson was sown at the rate of 5 kg ha^{-1} at a row distance of 45 cm. The variety is an early maturing variety. It takes 110-115 days to mature in Rabi season. It is suitable for growing in whole Uttar Pradesh. The height of the plant is 135-145 cm. The potential yield of this variety is 22.38 q ha^{-1}.

3. RESULTS AND DISCUSSION

3.1 Effect of Irrigation Frequencies and Micronutrients Spray on Growth Characters of Mustard

An explicit effect of irrigation frequencies was observed on growth attributing characters of rapeseed plant viz., plant height, primary and secondary branches $plant^{-1}$ of the crop during the experimentation. Application of three irrigations at 30 DAS, 55 DAS and 90 DAS (IR_3)

significantly enhanced the growth attributing characters followed by two irrigations at 30 DAS and 55 DAS. Plant height in treatment IR_1 (30 DAS) was not significantly influenced due to different irrigation frequencies. Data about plant height is given in Table 2.

The highest plant height was recorded with treatment F_3 (RDF + foliar spray of Zn @ 0.5% and B @ 0.2% at 30-35 DAS and 40-45 DAS). Which proved significantly superior over all other treatments like F_0 (RDF + control), F_1 (RDF + Zn @ 0.5% at 30-35 DAS and 40-45 DAS) and F_2 (RDF + foliar spray of B_0 @ 0.2% at 30-35 DAS and 40-45 DAS) at all the dates of observation (Table 2). The research also confirms the findings of Hamouda et al. [8] and Karimunnisa et al. [9]. Application of treatment F_3(RDF + foliar spray of Zn @ 0.5% and B @ 0.2% at 30-35 DAS and 40-45 DAS) significantly produced a greater number of secondary branches plant^{-1} than control (Table 3). Similar results were also reported by Verma et al. [10] and Karimunnisa et al. [11].

Three irrigations produced the tallest plant height at the harvest stage over other treatments. A significant improvement in the plant height was observed with increasing the irrigation frequencies i.e., one irrigation to three irrigation in treatments (Table 2). Water is the chief metabolic constituent of the plant body and increasing the irrigation frequencies increases the plant's metabolic activity which significantly affects the plant's height. The more water availability with three irrigations enabled the plants to grow taller than other irrigation frequencies at all stages. A similar result was also reported by Tyagi and Upadhyay [11], Barick et al. [12] and Yadav et al. [13].

Three irrigations significantly increased the number of secondary branches per plant as compared to other irrigation frequencies (Table 3) The increased growth as a result of high water potential in plants produces a higher number of branches. Similar results were also reported by Dudwal et al. [14] and Yadav et al. [13].

The days taken 50% siliqua initiation was significantly influenced by irrigation treatments. The maximum number of days counted was recorded with treatment IR_3 which was followed by treatment IR_2 and treatment IR_1 (Table 4).

Table 2. Effect of irrigation frequencies and micronutrients spray on Plant height (cm) of yellow sarson at different stages of crop growth

Treatment	**Plant height (cm)**				
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**
Irrigation frequency					
IR_1	6.388	35.336	96.912	102.505	107.058
IR_2	6.412	35.305	101.628	106.210	113.508
IR_3	6.435	35.343	101.727	106.658	118.950
S.E. (d)±	0.160	0.607	1.178	1.735	1.886
C.D. (5%)	N.S.	N.S.	3.253	4.791	5.376
Micronutrient levels (Zn & Bo)					
F_0	6.367	32.187	96.167	100.94	106.517
F_1	6.400	34.170	98.677	103.99	111.073
F_2	6.440	36.550	101.643	106.72	115.267
F_3	6.463	38.404	103.870	108.84	119.830
S.E. (d)±	0.264	0.984	1.178	1.851	2.362
C.D. (5%)	N.S.	2.068	2.985	3.890	5.000
F(IR)					
S.E.(d)±	0.394	1.480	2.409	3.341	4.090
C.D. (5%)	N.S.	N.S.	N.S.	N.S.	N.S.
IR(F)					
S.E.(d)±	0.458	1.705	2.461	3.206	4.013
C.D. (5%)	N.S.	N.S.	N.S.	N.S.	N.S.

Table 3. Effect of irrigation frequencies and micronutrient spray on Number of secondary branches plant^{-1} of yellow sarson crop at different crop growth stages

Treatment	Number of secondary branch plant^{-1}		
	60 DAS	**80 DAS**	**100 DAS**
Irrigation frequency			
IR_1	8.405	9.557	9.608
IR_2	9.065	10.44	10.558
IR_3	9.093	10.833	10.928
S.E.(d)±	0.205	0.279	0.172
C.D. (5%)	0.567	0.769	0.489
Micronutrients levels (Zn & B)			
F_0	8.383	9.433	9.517
F_1	8.760	10.210	10.363
F_2	8.790	10.600	10.673
F_3	9.030	10.863	10.903
S.E. (d)±	0.181	0.262	0.216
C.D. (5%)	0.379	0550	0.458
F(IR)			
S.E. (d)±	0.365	0.508	0.375
C.D. (5%)	N.S.	N.S.	N.S.
IR(F)			
S.E. (d)±	0.313	0.453	0.367
C.D. (5%)	N.S.	N.S.	N.S.

Table 4. Effect of irrigation frequencies and micronutrient spray on Days taken 50% siliqua initiation of yellow sarson

Treatment	Days taken 50% siliqua initiation
Irrigation frequency	
IR_1	74.430
IR_2	80.510
IR_3	81.065
S.E.(d) ±	1.261
C.D (5%)	3.595
Micronutrients levels	
F_0	81.440
F_1	79.350
F_2	77.697
F_3	76.187
S.E.(d) ±	1.623
C.D. (5%)	3.436
F(IR)	
S.E.(d)±	2.811
C.D. (5%)	N.S.
IR(F)	
S.E.(d)±	2.742
C.D. (5%)	N.S.

3.2 Effect of Irrigation Frequencies and Micronutrients Spray on Yield of Mustard

The maximum number of siliqua plant^{-1} increased significantly with treatment F_3 (RDF + foliar spray of Zn @ 0.5% and B @ 0.2% at 30-35 DAS and 40-45 DAS). These results confirm the findings of Rao et al. [15] and Karimunnisa et al. [9]. Application of micronutrient also significantly increased the number of seeds siliqua^{-1} up to application of F_3 (RDF + foliar spray of Zn @ 0.5% and B @ 0.2% at 30-35 DAS and 40-45 DAS) which was significantly superior to F_0 (RDF + control), F_1(RDF + Zn @ 0.5% at 30-35 DAS and 40-45 DAS) but

Table 5. Yield attributes of yellow sarson as influenced by irrigation frequencies and micronutrients spray

Treatment	Siliquae plant^{-1}	Siliqua length (cm)	Seed Siliqua^{-1}	Test weight (g)
Irrigation frequency				
IR_1	294.045	6.695	35.707	3.808
IR_2	302.888	6.877	37.992	4.052
IR_3	309.015	7.032	41.865	4.225
S.E.(d)$\pm$	3.700	0.057	0.658	0.056
C.D. (5%)	10.214	0.158	1.876	0.155
Micronutrient level				
F_0	287.657	6.543	35.280	3.863
F_1	300.347	6.813	37.110	3.983
F_2	307.793	7.000	39.560	4.083
F_3	312.133	7.117	42.126	4.183
S.E.(d)$\pm$	4.512	0.072	0.805	0.082
C.D. (5%)	9.482	0.151	1.704	0.172
F(IR)				
S.E.(d)$\pm$	7.609	0.120	1.394	0.128
C.D. (5%)	N.S.	N.S.	N.S.	N.s.
IR(F)				
S.E.(d)$\pm$	7.816	0.125	1.375	0.141
C.D. (5%)	N.S.	N.S.	N.S.	N.S.

remain at par with and F_2 (RDF + foliar spray of B @ 0.2% at 30-35 DAS and 40-45 DAS). The maximum value of test weight was also obtained with the application of treatment F_3 (RDF + foliar spray of Zn @ 0.5% and Bo @ 0.2% at 30-35 DAS and 40-45 DAS) which is significantly superior over F_0 (RDF + control) and F_1(RDF + Zn @ 0.5% at 30-35 DAS and 40-45 DAS) but at par with F_2 (RDF + foliar spray of B @ 0.2% at 30-35 DAS and 40-45 DAS). This might be attributed to the increased translocation of photosynthates towards the seed resulting in the formation of bold seeds [9].

Application of treatment F_3 (RDF + foliar spray of Zn @ 0.5% and B @ 0.2% at 30-35 DAS and 40-45 DAS) significantly increased the number of siliqua plant^{-1}, length of siliqua, number of seeds siliqua^{-1} and 1000 seed weight (Table 5), over treatment F_0 (RDF + control), treatment F_1 (RDF + Zn @ 0.5% at 30-35 DAS and 40-45 DAS) and treatment F_2 (RDF + foliar spray of B @ 0.2% at 30-35 DAS and 40-45 DAS).

The length of siliqua (cm) was significantly influenced by irrigation treatments. The highest length of siliqua was recorded with treatment IR_3 (7.03) which was found significantly higher over treatment IR_1 (6.69) but remained at par with the treatment IR_2 (6.87). The effect of micronutrients on siliqua length (cm) was significant. The highest siliqua length was recorded with treatment F3 (7.11) which was significantly higher over control (6.54) and treatment F_1 (6.81) but remained at par with treatment F_2 (7.00). The interaction effect of irrigation X micronutrient was found non-significant but the interaction of IR_3 X F_3 produced the highest siliqua length.

4. CONCLUSION

Based upon the results of the present investigation the following conclusions are drawn: it may be concluded that the highest seed yield, water use and economics were obtained with three irrigations and Zn @ 0.5% and B @ 0.2% at 30-35 DAS and 45-50 DAS. It may be advised that the application of irrigations to yellow sarson (*Brassica rapa*) at 30 DAS, 55 DAS and 90 DAS were found best for getting maximum yield. If two irrigations are available, they should be applied at 30 DAS and 55 DAS to obtain higher yields and water use efficiency. According to the results obtained from this research, it can be recommended that the application of micronutrient F_3 (Zn @ 0.5% and B @ 0.2% at 30-35 DAS and 45-50 DAS) is best for getting maximum yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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