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Variation in dry matter accumulation and growth indices of mustard as influenced by irrigation regimes and fertilizer levels

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Abstract
A field experiment was carried out to assess the variation brought out by irrigation regimes and fertilizer levels on the dry matter accumulation and growth indices of mustard during 2020-21. The experiment was laid out in factorial randomized block design with three irrigation scheduling regimes (1.0, 0.8 and 0.6 IW/CPE) and four levels of fertilizer application *viz.*, F_1 – control, F_2 – 75% RDF (Recommended dose of fertilizer) (60-30-30 kg N- P_2O_5-K_2O ha^{-1}), F_3 – 100% RDF (80-40-40 kg N- P_2O_5-K_2O ha^{-1}) and F_4 – 125% RDF (100-50-50 kg N- P_2O_5-K_2O ha^{-1}). Results showed that application of irrigation at 1.0 IW/CPE along with 125% RDF resulted in increment in dry matter accumulation at different growth stages as well as harvest. Further, these treatments were also adjudged superior in terms of growth indices *viz*., leaf area index (LAI), crop growth rate (CGR) and leaf area duration (LAD) in comparison to other treatments during the course of the trial. Interactional effect of irrigation regimes and fertilizer levels on different treatments was found to be non- significant.

Keywords: Mustard, irrigation regimes, growth indices, fertilizer levels

Introduction

India stands among the largest vegetable oil economies across the world accounting for about 14% of the world's oilseed area and 8% of oilseed production and ranks second in rapeseed-mustard production. Oilseeds play pivotal role in Indian economy contributing 6% in gross national product and 10% in agricultural produce value (DOAC, 2017) [3]. Rapeseed-mustard is the key oilseed crop that can help in addressing the challenge of demand-supply gap of edible oil in India. Among the oilseeds, rapeseed mustard is the third largest oilseed after groundnut and soybean (Jat *et al*., 2019) [5]. This crop accounts for nearly one-third of the oil produced in India, making it India's key edible oilseed crop. The major mustard growing states in India are Rajasthan, Uttar Pradesh and Madhya Pradesh. In the state of Telangana, mustard is cultivated in an area of 3000 ha with a production of 5000 tonnes (Agriculture statistics at a glance, 2018-19). The oil contains 80 to 94% carbohydrates and 2.2 to 4.4% protein (Prasad, 2018) [11]. Traditionally in India, mustard is raised under rainfed conditions on marginal soils with low productivity. Raising mustard during *rabi* (winter) season using high yielding varieties and hybrids with proper resource management is a new dimension in mustard production for higher productivity. However, both water stress and excess water leads to problems of cessation of growth, raising water table, soil salinity and alkalinity consequently affecting yield attributes and yield. Amongst the various agronomic factors known to augment crop production, the application of fertilizer has an important role in getting high yield in mustard. growing mustard during *rabi* (winter) season using varieties and hybrids with proper genetic potential along with proper resource management is a new dimension in mustard production for higher productivity (Rana *et al*., 2020) [12]. The present study was therefore conducted to study the effect of irrigation regimes and fertilizer levels on dry matter and growth indices of mustard in semi arid tropics.

2. Materials and Methods

The field experiment was conducted at college farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana (17º 32' N, 78º 41' E and 541.6 altitude) during *rabi* season of 2020-21 on sandy clay soils. The soil was low in N, medium in P and high in K status and neutral in reaction (pH 7.11). The soil water retention capacity at -0.03 and 1.5 Mpa was 0.246 and 0.127 cm^3 cm^{-3}.

The available water was 11.7 cm m^{-1} depth of soil. Bulk density of the soil was 1.62 g cm^{-3}. The treatments were laid out in Randomized Block Design with Factorial concept and replicated thrice. The treatments consisted of three irrigation regimes *viz.*, I_1 – IW/CPE = 1.0, I_2 – IW/CPE = 0.8, I_3 – IW/CPE = 0.6 and four levels of fertilizer application *viz.*, F_1 – control, F_2 – 75% RDF (Recommended dose of fertilizer) (60-30-30 kg N- P_2O_5-K_2O ha^{-1}), F_3 – 100% RDF (80-40-40 kg N- P_2O_5-K_2O ha^{-1}) and F_4 – 125% RDF (100-50-50 kg N- P_2O_5-K_2O ha^{-1}). Buffer channels of width 1.5 m and 2 m were laid between treatments and replications respectively to avoid the influence of one treatment on the other. Variety Pusa Agrani was used in the study. Field was prepared after harvest of kharif crop and pre sowing irrigation was applied uniformly to the experimental field. Afterwards furrows were opened at a spacing of 40 cm between rows and seeds were sown on 17th November in 2020 with seed rate of 5 kg ha^{-1}. Half dose of nitrogen and full dose of phosphorous and potassium were applied as basal in the form of urea (46% N), single super phosphate (20% P and 12% S) and murate of potash (60% K_2O), respectively. At pre flowering stage (40-50 days after sowing) top dressing of the remaining half dose of nitrogen was done. Hand weeding was done at period of critical weed crop competition (15-35 days after sowing). A plant to plant spacing of 10 cm was maintained and thinning was done after 15- 20 days after sowing. All the standard package of practices except irrigation scheduling and fertilizer application were followed uniformly in the entire plots. Irrigation of 5cm depth were provided as per the IW/CPE ratio which came out as one, two and three irrigations in 0.6, 0.8 and 1.0 IW/CPE, respectively. Dry matter accumulation (kg ha^{-1}) and growth indices such as leaf area index (LAI), crop growth rate (CGR) and leaf area duration (LAD) were calculated and recorded as per standard procedure. Leaf area index (LAI) was measured at 30, 60 and 90 days after sowing (DAS) with the help of plant canopy analyzer model no. LP-80 Accu PAR. The total leaf area was measured first followed by recording land area. Leaves of five plants taken from net plot as treatment wise for dry matter observation were removed for leaf area estimation which was recorded with leaf area meter. The average of leaves area was multiplied with a total number of leaves. The leaf area index was calculated using the formula suggested by Watson (1952) [16].

LAI = Total leaf area $plant^{-1}$ (cm^2)/ Land area $plant^{-1}$ (cm^2)

Crop growth rate (CGR) indicates the rate of increase of dry weight per unit land area per unit time and calculated using the formula given below

$$CGR = W_2 – W_1/ t_2 – t_1 \ (g\ m^{-2}\ day^{-1})$$

Where, W_1 and W_2 are whole plant dry weight at time t_1 and t_2 respectively.

Leaf area duration (LAD) Leaf area duration (LAD) was calculated using the formula given below

$$LAD\ (days) = ((LAI_1 + LAI_2)/2)*(t_2 – t_1)$$

Where, LAI_1 and LAI_2 are the leaf area indices at first and second stage taken at time t_1 and t_2, respectively. Recorded data was analyzed using appropriate method of 'Analysis of Variance (ANOVA)' given by Panse and Sukhatme (1978) [9].

3. Results and Discussion

3.1 Dry matter accumulation

The variation in dry matter accumulation (Table 1) of mustard crop as influenced by irrigation regimes and fertilizer levels at different growth stages reported significantly different during the course of trial. Among the irrigation regimes, highest dry matter accumulation was recorded with 1.0 IW/CPE (125 kg ha^{-1} at 30 DAS, 2634.21 kg ha^{-1} at 60 DAS and 5181.89 kg ha^{-1} at harvest) which was observed significantly superior to 0.8 (112 kg ha^{-1} at 30 DAS, 2353 kg ha^{-1} at 60 DAS and 4280 kg ha^{-1} at harvest) and 0.6 IW/CPE (97 kg ha^{-1} at 30 DAS, 2035 kg ha^{-1} at 60 DAS and 3317 kg ha^{-1} at harvest) at all stages of crop growth. More dry matter accumulation in treatments in which irrigation scheduled at 1.0 IW/CPE might be due to adequate and timely water supply to plants through irrigation which enhanced cell turgidity and cell enlargement as well as meristamatic activity resulting in greater photosynthesis and build up of greater bio mass. These results were in agreement with experimental findings of Mishra *et al.* (2019) [8] who stated that among varied irrigation regimes, significantly highest plant dry matter production was observed in three irrigations treatment plot followed by two and single irrigations treatment. Dry matter production $plant^{-1}$ was found to improve with increasing irrigation frequency at all the stages of crop growth. These findings were also in concurrence with Piri *et al.* (2011) [10] Verma *et al.* (2018) [15] and Rana *et al.* (2020) [12] also. Among the fertilizer levels, dry matter accumulation at different growth stages of mustard showed successive increment with increase in fertilizer level. Application of 125% recommended dose of fertilizer recorded significantly highest dry matter accumulation (154 kg ha^{-1} at 30 DAS, 3367 kg ha^{-1} at 60 DAS and 6265 kg ha^{-1} at harvest) as compared with rest of the treatments *viz.*, F_3 – 100% RDF (125 kg ha^{-1} at 30 DAS, 2809 kg ha^{-1} at 60 DAS and 5290 kg ha^{-1} at harvest), F_2 – 75% RDF (100 kg ha^{-1} at 30 DAS, 2383 kg ha^{-1} at 60 DAS and 4308 kg ha^{-1} at harvest) and F_1 – control (67 kg ha^{-1} at 30 DAS, 803 kg ha^{-1} at 60 DAS and 1175 kg ha^{-1} at harvest). The successive increase in the dry matter accumulation in higher dose of fertilizer treatment plot might be due to availability of more nutrients for proper growth of plants at different stages of mustard crop. These results are also validated with the findings of Yogesh *et al.* (2009) [17], Keerthi *et al.* (2017) [6] and Shorna *et al.* (2020) [13].

Table 1: Dry matter production (kg ha^{-1}) of mustard as influenced by Irrigation regimes and fertilizer levels

Treatment	Dry matter production (kg ha^{-1})		
	30 DAS	60 DAS	At harvest
Factor 1: Irrigation regimes			
I_1 - IW/CPE=1.0	125	2634	5181
I_2 - IW/CPE=0.8	112	2353	4280
I_3 - IW/CPE=0.6	97	2035	3317
SEm ±	0.98	13.69	36.97
CD (P=0.05)	2.91	40.43	109.14
Factor 2: Fertilizer levels			
F_1 - Control	67	803	1175
F_2 - 75%RDF	100	2383	4308
F_3 - 100% RDF	125	2809	5290
F_4 - 125%RDF	154	3367	6265
SEm ±	1.14	15.81	42.69
CD (P=0.05)	3.36	46.68	126.03
Interaction (I x F)			
SEm ±	1.97	27.39	73.95
CD (P=0.05)	NS	NS	NS

3.2 Growth Indices

The effect of irrigation regimes and fertilizer application on growth indices of mustard was noted significant during the period of experimentation (Table 2). Irrigation scheduling had significant effect on leaf area index of mustard crop at all stages of crop growth. Crop irrigated at 1.0 IW/CPE (0.35 at 30 DAS, 1.99 at 60 DAS, 1.08 at harvest) found significantly superior to that of 0.8 (0.33 at 30 DAS, 1.92 at 60 DAS, 0.97 at harvest) and 0.6 IW/CPE (0.29 at 30 DAS, 1.87 at 60 DAS, 0.88 at harvest). The highest LAI was recorded with 1.0 IW/CPE while lowest values were observed with 0.6 IW/CPE. Similarly, growth indices namely, leaf area duration (Table 3) and crop growth rate (Table 4) were also observed significantly superior with 1.0 IW/CPE followed by 0.8 IW/CPE and lower in 0.6 IW/CPE. More soil moisture in the crop root zone due to more quantity of irrigation in I_1 - IW/CPE=1.0 irrigated plot, might have led to better nutrient uptake, cell growth and division, higher photosynthetic activity and thus resulted in superior growth indices. These results were also reported by Somayeh *et al.* (2011) [14] and Hossain *et al.* (2013) [4]. Significant effect of fertilization was noted in leaf area index of mustard crop and increase in levels of fertilizer registered successive increase in LAI at all stages of crop growth and among fertilizer levels, application of 125% RDF recorded maximum LAI (0.39 at 30 DAS, 2.43 at 60 DAS, 1.20 at harvest) followed by 100% RDF (0.36 at 30 DAS, 2.23 at 60 DAS, 1.02 at harvest), 75% RDF (0.31 at 30 DAS, 1.90 at 60 DAS, 0.95 at harvest) and control (0.23 at 30 DAS, 1.15 at 60 DAS, 0.74 at harvest). Similar observations were noted with leaf area duration and crop growth rate of mustard crop. Lower growth indices in F_1 - control treatment plot might be due to low availability of plant nutrients which are necessary for the normal growth. These findings were in close accordance with those reported by Achin *et al.* (2016) [1], Krishna *et al.* (2018) [7] and Shorna *et al.* (2020) [13].

Table 2: Leaf area index of mustard as influenced by Irrigation regimes and fertilizer levels

Treatment	Leaf Area Index		
	30 DAS	60 DAS	At harvest
Factor 1: Irrigation regimes			
I_1 - IW/CPE=1.0	0.35	1.99	1.08
I_2 - IW/CPE=0.8	0.33	1.92	0.97
I_3 - IW/CPE=0.6	0.29	1.87	0.88
SEm ±	0.002	0.016	0.008
CD (P=0.05)	0.007	0.04	0.024
Factor 2: Fertilizer levels			
F_1 - Control	0.23	1.15	0.74
F_2 - 75%RDF	0.31	1.90	0.95
F_3 - 100% RDF	0.36	2.23	1.02
F_4 - 125%RDF	0.39	2.43	1.20
SEm ±	0.002	0.018	0.009
CD (P=0.05)	0.008	0.05	0.027
Interaction (I x F)			
SEm ±	0.004	0.032	0.016
CD (P=0.05)	NS	NS	NS

Table 3: Leaf area duration (days) of mustard as influenced by Irrigation regimes and fertilizer levels

Treatment	Leaf Area Duration (Days)		
	30 DAS	60 DAS	At harvest
Factor 1: Irrigation regimes			
I_1 - IW/CPE=1.0	5.39	35.39	46.22
I_2 - IW/CPE=0.8	5.06	33.97	43.60
I_3 - IW/CPE=0.6	4.43	32.62	41.51
SEm ±	0.046	0.22	0.29
CD (P=0.05)	0.13	0.65	0.87
Factor 2: Fertilizer levels			
F_1 - Control	3.62	20.96	28.60
F_2 - 75%RDF	4.76	33.73	42.91
F_3 - 100% RDF	5.47	39.45	48.91
F_4 - 125%RDF	5.98	42.60	54.75
SEm ±	0.053	0.25	0.34
CD (P=0.05)	0.15	0.76	1.01
Interaction (I x F)			
SEm ±	0.09	0.44	0.59
CD (P=0.05)	NS	NS	NS

Table 4: Crop growth rate ($g\ m^{-2}\ day^{-1}$) of mustard as influenced by Irrigation regimes and fertilizer levels

Treatment	Crop Growth Rate ($g\ m^{-2}\ day^{-1}$)		
	30 DAS	60 DAS	At harvest
Factor 1: Irrigation regimes			
I_1 - IW/CPE=1.0	0.41	8.36	7.80
I_2 - IW/CPE=0.8	0.37	7.46	6.29
I_3 - IW/CPE=0.6	0.32	6.46	4.27
SEm ±	0.002	0.05	0.05
CD (P=0.05)	0.008	0.15	0.14
Factor 2: Fertilizer levels			
F_1 - Control	0.22	2.45	1.24
F_2 - 75%RDF	0.33	7.60	6.41
F_3 - 100% RDF	0.41	8.94	7.74
F_4 - 125%RDF	0.51	10.71	9.10
SEm ±	0.003	0.06	0.10
CD (P=0.05)	0.009	0.18	0.29
Interaction (I x F)			

SEm ±	0.005	0.09	0.39
CD (P=0.05)	NS	NS	NS

Interactional effect

Interactional effect of irrigation regimes and fertilizer levels was found to be non-significant at all stages of crop growth. Similarly, interactional effect of irrigation regimes and fertilizer levels on growth indices *viz*., crop growth rate, and leaf area duration and leaf area index was also found to be non-significant.

Conclusion

On the basis of experimentation, it was revealed that irrigation at 1.0 IW/CPE in mustard produced maximum dry matter accumulation as well as improved growth indices in comparison with 0.8 and 0.6 IW/CPE. Among fertilizer levels, 125% recommended dose of fertilizer recorded highest dry matter accumulation and growth indices. Thus, it is concluded that Indian mustard variety Pusa Agrani may be irrigated at 1.0 IW/CPE and fertilized with 125% recommended dose of fertilizer.

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