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Effect of Frequency and Salinity of Irrigation Water on Growth and Yield of Chickpea and Mustard as Inter-crops of Wheat

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ABSTRACT

A field experiment was conducted during *rabi* seasons of 1994-95 and 1995-96 on the farm of Indian Agricultural Research Institute, New Delhi to study the growth, yield and yield contributing characters of wheat inter-crops of chickpea and mustard under different frequency (IW/CPE 0.4, 0.8) and salinity levels (EC 6 and 12 dSm^{-1}) of irrigation water. Growth characters *viz.*, height, dry matter, LAI, number of branches as well as yield attributes of pod number, seeds per pod and test weight of chickpea decreased significantly with increasing salinity levels. Mustard growth characters of plant height, dry matter, number of branches and yield attributes of siliquae number, seeds per siliqua increased at EC 6 dSm^{-1} but decreased at EC 12 dSm^{-1}. However, test weight increased with salinity and decreased with irrigation frequency. The yield of chickpea decreased significantly with increasing salinity and irrigation levels. The mustard yield increased significantly at EC 6 dSm^{-1} and also at EC 12 dSm^{-1} though non-significantly in comparison to control. The yield also increased with increasing irrigation levels.

Introduction

Irrigation is essential for better crop production particularly in areas with higher evapotranspiration than precipitation and the later is seasonal and erratic. The underground water is commonly saline and it is the major source for irrigation in these areas. However, as a result of long usage of brackish water, lands tend to develop salinity and sodicity. As salt accumulation in soil is closely related to salt content of irrigation water (Lal and Singh, 1973) performance of the crops ultimately depends upon the overall salinity of the root zone and the ability of crops to tolerate this salinity. Mustard is a relatively salt tolerant crop as compared to chickpea but both have lesser water demand. Therefore, it was thought imperative to assess their relative performance as inter-row crops with wheat on using saline water at different frequencies.

Materials and Methods

Field experiments were conducted during the *rabi* season of 1994-95 and 1995-96 at experimental farm of Indian Agricultural Research Institute, New Delhi. The physical and chemical properties of the soil were : texture silt loam (sand 45.4%, silt 37.1%, clay 17.4%), bulk density 1.48 Mg m^{-3}, saturated hydraulic conductivity 1.28 cm hr^{-1}, field capacity 16.25%, permanent wilting point 6.94%, pH 7.64, EC 0.5 dSm^{-1}, organic carbon 0.40%, available N 175.4 kg ha^{-1}, P 12.3 kg ha^{-1} and K_2O 192.6 kg ha^{-1}. The experiment included the following treatments : irrigation levels : IW/CPE = 0.4 (I_1) and 0.8 (I_2); Salinity levels in irrigation water : EC = 0.4 dSm^{-1} (S_0), 6 dSm^{-1} (S_1), 12 dSm^{-1} (S_2); cropping systems : sole wheat (C_0), wheat + chickpea (C_1), wheat + mustard (C_2).

Micro-plots (2 m x 2 m) were prepared and wheat cv. (HD 2329) was sown in rows 25 cm apart on 14th November and 2nd December in consecutive years. There were 8 rows of wheat in each plot. Chickpea cv. (Pusa 372) and mustard (Pusa Bold) were seeded in rows after two rows of wheat in C_1 and C_2 crop combinations, respectively. Half of the nitrogen dose (60 kg ha^{-1}) as urea and full dose of P_2O_5 (60 kg ha^{-1}) as SSP and K_2O (40 kg ha^{-1}) as murate of potash were applied as basal dose in each plot. Remaining N was applied as top dressing during the first common irrigation. Required volume of irrigation water (50 mm) in each plot was applied from a volumetrically graduated cylindrical tank through hose pipes and flow rate was controlled by an adjustable valve. Irrigation of 50 mm at I_1

(IW/CPE = 0.4) and I_2 (IW/CPE = 0.8) treatments was applied as and when the cumulative pan evaporation totaled 125 mm and 62.5 mm, respectively. The rainfall occurring between consecutive irrigations was duly accounted to maintain required ratios. Salinity levels were imposed through irrigation water. Calculated amount of $CaCl_2$,. $MgSO_4$ and NaCl salts for treatments S1 (EC 6 dSm^{-1}) and S2 (EC 12 dSm^{-1} was dissolved in the tank. Relative proportion of different cations and anions for both salinity levels was adjusted as per the composition normally exists in this part of the country. The total rainfall received was 112 mm and 43.8 mm during 1994-95 and 1995-96 crop seasons, respectively.

Crop growth observations of plant height, dry matter and leaf area index (LAI) in all crops were periodically recorded. LAI of mustard and chickpea was measured as given by Singh and Das (1989). Crops were harvested at maturity and yield and its attributes were computed from the same plants used for growth observations.

Wheat equivalent yield of inter-crops was computed by converting the grain/seed yield onthe basis of prevailing sale prices of the commodity.

Results and Discussion

Growth characters

Values of diferent growth characteristics of chickpea and mustard as influenced by irrigation and salinity levels are given in Table 1 and 2, respectively.

Plant height

Plant height of chickpea decreased significantly with increasing salinity levels and plant height of mustard increased significantly at salinity level of EC 6 dSm^{-1} but decreased slightly at EC 12 dSm^{-1}.

Dry matter

Dry matter of chickpea decreased (74%) significantly at higher irrigation level (IW/CPE 0.8). Chickpea dry matter also decreased significantly at salinity levels of EC 6 dSm^{-1} and 12 dSm^{-1} than that at EC 0.4 dSm^{-1} of tube well (control). Dry matter of mustard increased significantly with increasing irrigation levels and EC up to 6 dSm^{-1}.

Leaf area index (LAI)

In chickpea LAI increased with time attaining

Table 1. Chickpea growth and yield characters under different cropping systems, moisture regimes and salinity levels.

Treatment	Plant height (cm)		Dry matter accumulation (g)		Leaf area index		Branches number		Pods number/ plant		Grains/pod		Test weight (g)	
	94-95	95-96	94-95	95-96	94-95	95-96	94-95	95-96	94-95	95-96	94-95	95-96	94-95	95-96
Moisture Regimes														
I_1	42.61	40.11	3.45	1.87	0.09	0.18	3.39	2.89	5.50	4.61	1.21	1.07	94.22	98.28
I_2	46.03	14.05	0.30	0.80	0.02	0.03	3.33	0.89	1.33	0.78	0.38	0.48	30.00	30.72
$CD_{(0.5)}$	0.647	0.894	0.098	0.082	0.002	0.002	NS	0.217	0.411	0.353	0.035	0.052	3.887	2.906
Salinity Levels														
S_o	55.38	43.58	2.67	2.36	0.09	0.18	3.67	2.92	5.67	3.92	1.25	1.30	100.17	107.27
S_1	49.50	19.46	1.61	1.01	0.06	0.08	3.33	1.42	2.75	2.33	0.61	0.52	46.83	48.60
S_2	43.08	18.21	1.35	0.63	0.02	0.05	3.08	1.43	1.83	1.83	0.54	0.49	39.33	37.63
$CD_{(0.5)}$	0.793	1.095	0.120	0.098	0.003	0.005	0.280	0.266	0.503	0.432	0.043	0.066	4.761	3.559
Control	46.67	29.75	1.35	0.83	0.03	0.10	3.17	2.50	7.00	3.50	1.10	1.03	103.67	123.18
Contro vs others $CD_{0.5}$	1.121	1.549	0.169	0.142	0.004	NS	NS	0.376	0.711	0.611	0.061	0.094	6.731	4.815

Table 2. Mustard growth and yield characters under different cropping systems, moisture regimes and salinity levels.

Treatment	Plant height (cm)		Dry matter accumulation (g)		Leaf area index		Branches number		Pods number/ plant		Grains/pod		Test weight (g)	
	94-95	95-96	94-95	95-96	94-95	95-96	94-95	95-96	94-95	95-96	94-95	95-96	94-95	95-96
Moisture Regimes														
I_1	131.56	134.39	42.52	60.48	1.83	3.00	6.67	6.60	214.06	178.44	12.28	13.37	5.70	5.61
I_2	158.06	139.34	60.97	92.60	2.12	4.12	7.28	6.83	305.67	220.22	11.50	13.82	5.27	5.51
$CD_{(0.5)}$	2.410	1.547	1.409	1.409	0.065	0.073	0.331	0.521	8.386	7.622	NS	0.224	0.082	NS
Salinity Levels														
S_0	140.42	134.58	54.12	62.62	1.53	3.04	6.33	6.33	265.25	214.75	11.18	13.55	5.32	5.45
S_1	154.50	148.43	58.95	88.12	2.63	4.07	7.75	7.25	332.75	236.08	13.07	14.00	5.61	5.37
S_2	139.50	127.58	42.17	78.89	1.77	3.57	6.83	5.75	181.58	147.17	11.42	13.23	5.53	5.86
$CD_{(0.5)}$	2.952	1.895	1.726	1.726	0.079	0.090	0.406	0.638	10.270	9.335	0.764	0.275	0.101	0.23
Control	151.33	144.33	47.10	34.60	1.47	1.30	6.33	6.67	238.0	139.3	11.87	12.43	4.51	5.03
Control vs others $CD_{0.5}$	4.175	2.680	2.441	2.441	0.112	0.127	0.574	NS	14.52	13.20	NS	0.389	0.142	0.327

a maximum value at 107 DAS and 84 DAS in 1994-95 and 95-96, respectively. It decreased significantly with increasing irrigation and salinity levels. Decrease in LAI was noticed to the tune of 90% at irrigation level IW/CPE 0.8 than IW/CPE 0.4 and with respect to salinity it was 25% and 62.5% at EC 6 dSm^{-1} and EC 12 dSm^{-1} respectively as compared to EC 0.4 dSm^{-1}. In mustard LAI attained a maximum value at 86 DAS and decreased thereafter. It increased with increasing irrigation levels by 19.67 and 44.22% under IW/CPE 0.4 and 0.8 than that under control Among salinity levels, it increased by 71.9 and 15.69% under salinity of EC 6 dSm^{-1} and EC 12 dSm^{-1} respectively over EC 0.4 dSm^{-1}.

Branches number

Branches number in chickpea decreased at higher IW/CPE of 0./80 and decreased significantly from 3.67 at EC 0.4 dSm^{-1} to 3.08 at EC 12 dSm^{-1}. Branches number in mustard increased up to 107 DAS during 1994-95. It increased significantly by 5.37 and 15% at IW/CPE 0.4 and 0.8, respectively over control. Branches numebr was higher by 22.43 and 7.9% under EC 6.0 and 12.0 dSm^{-1}, respectively over control.

Growth characters of chickpea *viz.* height, dry matter, LAI and branches number in chickpea decreased significantly with increasing salinity and irrigation levels. Similar results were reported by Saxena and Sheldrake (1980) and Elsheikh and Wood (1990). Mustard growth characters viz. plant height, dry matter and branch number increased at EC 6 dSm^{-1} but decreased at EC12 dSm^{-1}. However LAI increased with increasing salinity level. Similar results were reported by Boem *et al.* (1994) Growth characters were increased with increasing irrigation levels as has also been reported by Begum and Paul (1993) and Kumar *et al.* (1996).

Yield attributes

Values of different yield attributes of chickpea and mustard as influenced by irrigation and salinity levels are given in Table 1 and 2, respectively.

Pods / siliquae number

Pods per plant in chickpea ranged from 1.33 under IW/CPE 0.8 to 7.0 under control (no irrigation) and later decreased significantly by 21.43 and 81% with increasing IW/CPE to 0.4 and 0.8, respectively. Among the salinity treatments pods number was highest (5.67) under EC 0.4 dSm^{-1} followed by EC 6 dSm^{-1} (2.75) and EC 12

dSm^{-1} (1.83). Siliquae numbers per plant in mustard ranged from 181.58 to 332.75 under EC 12 dSm^{-1} and EC 6 dSm^{-1}, respectively. Siliquae number increased by 28.43% at IW/CPE of 0.80.

Grains per pod/siliqua

Average chickpea seeds per pod was lowest (0.38) under IW/CPE 0.8 and highest (1.25) under EC 0.4 dSm^{-1}. It increased by 10% under IW/CPE 0.4 but decreased by 65.45% under IW/CPE 0.8 in comparison to control. It decreased substantially by 51.2 and 56.8% under EC 6 and 12 dSm^{-1} in comparison to EC 0.4 dSm^{-1}. Average mustard seeds per siliqua was minimum (11.18) under 0.4 dSm^{-1} and maximum (13.07) under EC 6 dSm^{-1}. It increased by 3.45% under IW/CPE 0.4 but decreased by 3.12% under irrigation level IW/CPE 0.8 in comparison to control.

Test weight

Test weight of chickpea ranged from 30.0 g under IW/CPE 0.8 to 103.67 g under control treatment. It decreased significantly by 9.12 and 71.06% udner IW/CPE 0.4 and 0.8, respectively in comparison to control. Among salinity treatments, it also decreased by 53.2 and 60.79% udner EC 6 dSm^{-1} and 12 dSm^{-1}, respectively in comparison to EC 0.4 dSm^{-1}. Mustard test weight was lowest (4.51g) under control and highest (5.70 g) under IW/CPE 0.4 treatment. It increased by 26.39 and 16.85% under IW/CPE 0.4 and 0.8, respectively over the control. Among salinity treatments, it increased by 5.45 and 3.95% under EC 6 and 12 dSm^{-1}, respectively over EC 0.4 dSm^{-1}.

It is evident from the above results that pod number, seeds per pod and test weight of chickpea

Table 3. Grain yield, wheat equivalent yield under different cropping systems, moisture regimes and salinity levels

Treatment	1994-95				1995-96			
	Grain Yield qha^{-1}				Grain Yield qha^{-1}			
	Wheat	Chickpea	Mustard	Wheat equivalent yield	Wheat	Chickpea	Mustard	Wheat equivalent yield
Cropping systems								
C_o	52.26			52.26	34.38			34.38
C_1	50.04	0.39		50.71	36.08	0.38		36.77
C_2	25.44		8.696	46.51	26.70		4.023	36.20
CD (0.05)	4.67				1.368			
Moisture regimes								
I_1	39.21	0.60	8.58	46.18	29.90	0.61	3.72	33.10
I_2	45.91	0.12	9.7	53.48	34.87	0.14	4.69	34.89
CD(0.05)	2.297	0.012	0.438		0.895	0.031	0.276	
Salinity levels								
S_o	42.49	0.63	7.23	48.43	31.52	0.62	3.596	34.58
S_1	44.89	0.28	11.47	53.88	34.29	0.28	5.24	38.45
S_2	40.36	0.18	8.73	47.17	31.35	0.22	3.81	34.35
CD (0.05)	2.814	0.014	0.536		1.096	0.038	0.338	
Control	35.08	0.60	6.06	40.09	29.09	0.43	2.95	31.58
CD (0.05) control vs others	3.039	0.02	0.758		1.184	0.051	0.478	

decreased significantly with increasing salinity levels. Pods number and test weight decreased with increasing irrigation levels during 1994-95. But during 1995-96, pods number increased at IW/CPE 0.4 but decreased at IW/CPE 0.8. Grains per pod increased at IW/CPE 0.4 during both the seasons. Nanda and Saini (1992) also reported increase in pod number but decrease in grain weight with increasing irrigations.

In mustard siliquae number, seeds per siliqua increased at EC 6 dSm^{-1} but decreased at EC 12 dSm^{-1} and test weight was highest at higher salinity level of EC 12 dSm^{-1}. Similar results were also reported by Boem *et al.* (1994).

Yield of crops

Yield of chickpea (Table 3) decreased significantly with irrigation frequency during both the years. Similar observations with wheat and mustard were reported by Singh and Das (1989) and Sharma (1994). The trend of yield variability with mustard and chickpea inter-crops indicated non-compatibility of chickpea under higher moisture availability situations.

Increasing level of salinity in irrigation water from 0.4 to 6 dSm^{-1} had a favourable effect on wheat and mustard yield. Magnitude of increase was more (>50%) in mustard as compared to wheat (6-7%) during both the years. Highest level of saliity (12 dSm^{-1}) decreased the yield of wheat significantly in both the years. However, mustard yield (Table 3) was significantly higher (20%) even at this salinity particularly during 1994-95 which indicated its tolerance to highest level of salt stress. Deo and Lal (1982) also reported 5.1 percent increase in mustard yield on increasing EC_w level from 1 to 10 dSm^{-1}. Similarly wheat yield has also been reported to be unaffected with irrigation water salinity of 8-10 dSm^{-1} (Gupta and Yadav, 1986). Chickpea being sensitive to salinity and excess moisture its yield was decreased significantly even in comparison to non-irrigated inter-row crop. These results indicated that chickpea is more sensitive to salt stress and least sensitive to moisture stress. On the other hand, mustard did not show yield decrement either with moisture stress or salt stress.

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