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COMPARATIVE GROWTH PERFORMANCE OF RICE AND WHEAT VARIETIES AT DIFFERENT EC AND SAR RATIOS IN SOIL

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We have compared growth performance of seven rice and six wheat salt tolerant varieties at different salinity/sodicity levels in pots. Sandy clay loam soil was used to achieve various EC:SAR ratios, i.e. 3.1:8.6 (T_1), 3.9:14.3 (T_2), 6.4:15.4 (T_3), 7.6:27.8 (T_4), 10.3:25.6 (T_5) and 11.9:47.4 (T_6). Seven rice and six wheat varieties were grown and irrigated with canal water. Among the tested rice varieties, SSRI-8 gave maximum productive tillers and paddy yield. Among the tested wheat varieties, SR1-32 gave maximum plant height, productive tillers and grain and straw yields. The high EC:SAR ratios proved more hazardous for rice than that of wheat. Irrespective of the varieties tested, the highest levels of EC and SAR (T_5 and T_6) caused significant reduction in paddy yield while at the lowest levels of EC and SAR (T_1 and T_2) paddy yields were not affected significantly when compared with control. But in case of wheat crop, all the levels, i.e. lowest (T_1 and T_2), medium (T_3 and T_4), and highest (T_5 and T_6) of EC and SAR tested, affected wheat yield adversely with significant differences among EC:SAR ratios as compared to control. For both the crops, there were non-significant differences in yield for both the tested ratios (i.e. 0.50 and 0.25) at all the levels of EC and SAR. Decrease in EC_e and SAR after wheat harvest with treatments was in the decreasing order of T_6 followed by T_5, T_4, T_3, T_2 and T_1.
Keywords: Evaluation; tolerance; cultivars; salinity; sodicity

INTRODUCTION

The Indus valley of Pakistan covers an area of 21 mha and is famous for its irrigated agriculture (Ghassemi et al., 1995). This valley lies in arid and semi-arid region where formation of salt-affected soils is a natural consequence. Broadly, the Indus valley is divided into three crop ecological zones: rice-wheat belt in the northern part, mixed zone in the central part and cotton-wheat zone in the southern part. At present about 6.67 mha soils are salt-affected (Khan, 1998). The rice-wheat zone covers an area of 2.3 mha (Aslam, 1998) in which 0.8 mha soils are saline-sodic. Despite the prime position of rice and wheat in food security and economy of country, productivity of system is poor with average rice and wheat yields of 2.0 and 2.25 tons ha^{-1}, respectively although these problem soils receive all the agricultural inputs without considerable production of crops (GOP, 1999).

Rice-wheat rotation is considered as the best option for profitable use of saline-sodic soils. Both the crops have different mechanisms to cope with salinity/sodicity. Tolerance to sodicity, as well as high water requirements, makes rice a viable option for sustainable use of saline-sodic/sodic soils. High water requirement crops get the benefit of salt dilution resulting from excessive irrigations. Wheat being tolerant to salinity and rice tolerant to sodicity enjoy facility of their natural and adaptive mechanisms of resistance when grown in saline-sodic soil (Qadir et al., 2001; McNeal et al., 1966; Chhabra and Abrol, 1977). Inclusion of rice in rice-wheat rotation makes the conditions conducive for successful growth of the wheat grown after rice (Ghafoor et al., 2004).

In the past, work on comparative salt tolerance of cultivars of various crops remained a bit selective because of limited resources and less biological diversity owing to breeding species developed under and for non-saline conditions with very little, if any, to endure salt stress. Their relative tolerances to salinity are often similar and differences are difficult to measure (Epstein and Rains, 1987). Nevertheless, significant differences among varieties have been observed for some species including field crops (Shannon, 1990; Maas, 1990). Extensive work has been done by various researchers for screening wheat varieties against EC only in hydroponics (Akhtar et al., 2003; Qureshi et al., 1990) and field conditions (Malcolm, 1983). Very few studies addressed the problem of salinity along with sodicity for screening purposes which is the ground reality in rice-wheat cropping zone in the Punjab province where 84 % salt-affected soils are saline-sodic in nature (Muhammed, 1983). This screening strategy will provide information regarding tolerance to both salinity and sodicity of the existing varieties, and will help sustainable use of saline-sodic soils of Pakistan.

Keeping in view the above mentioned scenario, a pot experiment was conducted under different salinity/sodicity levels to compare the growth performance of some existing salt tolerant cultivars of rice and wheat with the objective to explore variability among them to withstand combined stress of salinity and sodicity.

MATERIALS AND METHODS

A pot experiment was conducted during 2004-05 in the Wire house, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad. A sandy clay loam soil in bulk was collected, air-dried, ground and passed through a 2 mm sieve and was analyzed for chemical properties (pH_s 7.54, EC_e 0.91 dS m^{-1}, SAR 1.52). The desired salinity/sodicity levels were developed by using different salts (NaCl, Na_2SO_4, $CaCl_2$, $MgSO_4$) as calculated with the help of quadratic equation (Ghafoor et al., 1988).

Calculated EC : SAR ratios **Observed EC : SAR ratios**

Treatment	EC_e dS m^{-1}	SAR	EC:SAR	EC_e dS m^{-1}	SAR	EC:SAR
T_0	0.9	1.5	0.9:1.5	0.9	1.5	0.9:1.5
T_1	4	8	1:2	3.1	8.6	1:2.8
T_2	4	16	1:4	3.9	14.3	1:3.7
T_3	8	16	1:2	6.4	15.4	1:2.4
T_4	8	32	1:4	7.6	27.8	1:3.7
T_5	12	24	1:2	10.3	25.6	1:2.5
T_6	12	48	1:4	11.9	47.4	1:4.0

The pots were filled with soil @ 11 kg pot^{-1}after developing desired EC:SAR levels and was arranged in completely randomized design. Twenty one days old rice nursery of seven varieties (SSRI-8, PB-95, SSRI-13, IRRI-9, IRRI-6, KS-282 and Shaheen Basmati) were transplanted into pots and two plants were maintained per hill (5 hills per pot). The pots were irrigated with canal water. Urea, di-ammonium phosphate (DAP) and sulfate of potash (SOP) were used to supply NPK @ 2.27, 0.49, 0.91 g per pot respectively. Phosphorus and K were applied in full dose at the time of transplanting while N was applied in three splits. The crop growth characteristics were recorded at physiological maturity and statistically analyzed.

After rice harvest, wheat varieties (MAW-1, Inqlab-91, Ufaq, Auqab-2000, SR1-27 and SR1-32) were sown in the same pots. Ten seeds of each cultivar were sown and 5 plants were maintained per pot. The uprooted plants were crushed and mixed in to the same pot. Urea, di-ammonium phosphate (DAP) and sulfate of potash (SOP) were used to supply the nutrients NPK @ 2.27, 1.11, 0.60 g per pot respectively. Phosphorus and K were applied in full dose at the time of sowing while N was applied in three doses. The crop growth parameters (No. of tillers, plant height, and grain and straw yields) were recorded at harvest. After the harvest of wheat crop, soil was sampled from all pots and was analyzed following the methods as described by US Salinity Lab. Staff (1954). Electrical conductivity (EC) of saturated soil paste extract was measured. Sodium (Na^+) was determined flame photometrically while Ca^{2+} and Mg^{2+} were determined titrimetrically. Sodium adsorption ratio (SAR) was determined as described by US Salinity Lab Staff, 1954 as follows:

$$SAR = Na^+/[(Ca^{2+} + Mg^{2+})/2]^{1/2}$$

Cell sap from leaves was extracted at booting stage and was analyzed for Na^+ and K^+ to determine Na^+:K^+ ratio in samples. The results obtained were subjected to statistical analysis using Duncan's Multiple Range test (Steel and Torrie, 1980) for treatment differences.

RESULTS AND DISCUSSION

Rice

The data for paddy yield and yield parameters are given in Tables 1 to 4. Maximum plant height (93 cm) was observed for Shaheen Basmati (Table 1) followed by PB-95 (92 cm), SSRI-13 (85 cm), SSRI-8 (77 cm), KS-282 (74 cm), IRRI-6 (64 cm) and IRRI-9 (60 cm). The interactive effect of the variety and EC:SAR levels was statistically significant. Maximum plant height was recorded for PB-95 with treatment T_0 while it was minimum with treatment T_5 for IRRI-9 variety. Maximum productive tillers were produced by SSRI-8 (62) followed by SSRI-13 (49), PB-95 (37), IRRI-6 (35), IRRI-9 (34) KS-282 (33) and Shaheen Basmati (32) (Table 2). There was statistically significant interaction was present for plant height between the varieties and EC:SAR levels. Maximum productive tillers were produced by SSRI-8 with T_6, while Shaheen Basmati produced minimum number of productive tillers (26) with T_6. There was statistically significant interaction was present for plant height between the varieties and EC:SAR levels. Maximum straw yield (77 g/pot) was obtained for IRRI-9 (Table 3) followed by KS-282 (74 g/pot), IRRI-6 (71 g/pot), SSRI-8 (61 g/pot), PB-95 (60 g/pot), SSRI-13 (59 g/pot) and Shaheen Basmati (56 g/pot). Maximum straw yield was recorded for KS-282 with T_0, while was minimum (40.3 g/pot) for Shaheen

Basmati with T_3. Maximum paddy yield (49 g/pot) was obtained for SSRI-8 (Table 4) followed by SSRI-13 (44 g/pot), KS-282 (42 g/pot), PB-95 (42 g/pot), Shaheen Basmati (37 g/pot), IRRI-6 (21 g/pot) and IRRI-9 (18 g/pot). The IRRI-varieties (coarse grain) gave comparatively better vegetative growth than Shaheen Basmati but less paddy yield which indicates their low tolerance to combined stress of EC:SAR ratios at both the EC levels. Interaction between the two factors statistically affected the paddy yield. Maximum paddy yield was recorded for SSRI-8 with T_0 (Table 4). On the other hand, IRRI-9 produced minimum paddy at T_5. In general, reduction in paddy yield was observed as the salinity to sodicity ratio increased at both the EC levels. The one season data on rice growth indicated varietal differences in straw and paddy yields at designed EC:SAR ratios. In general, soil EC_e (up to 8 dS m^{-1}) tended to mitigate the adverse effects of SAR on crop growth.

Wheat

The data for wheat yield and yield parameters are given in Tables 5 to 8. Maximum plant height (72 cm) was observed with SR!-32 (Table 5) followed by Auqab-2000 (71 cm), Inqlab-91 (69 cm), MAW-1 (64 cm), Ufaq (61 cm) and SR!-27 (61 cm). The interaction effect of the two factors remained significant. Maximum plant height was recorded for SR1-32 with T_0, while was minimum with T_5. With increasing salinity and/or sodicity, plant height decreased that could be attributed to low availability of water at high levels of salts, which resulted in decreased cell elongation and division, physiological drought along with specific toxicity of Na^+ ions. Maximum number of productive tillers per pot (28) were gained by SR1S-32 (Table 6) followed by Inqlab-91 (21), Auqab-2000 (21), MAW-1 (19), SR1-27 (17) and Ufaq (15). Interaction between the two factors for productive tillers was found significant. Maximum No. of productive tillers per pot were found for SR1-32 with T_0, while Ufaq produced minimum No. of productive tillers per pot (9) with T_6. Maximum straw yield (49 g/pot) was obtained for Auqab-2000 (Table 7) which was at par with SR1-32 (49 g/pot) followed by MAW-1 (47 g/pot), Inqlab-91 (44 g/pot), Ufaq (39 g/pot), and SR1-27 (37 g/pot). Interaction effects of the two factors for straw yield were significant. Maximum straw yield was recorded for Auqab-2000 at T_1. Maximum grain yield (14.88 g/pot) was recorded for SR1-32 (Table 8) whereas minimum grain yield (10.79 g/pot) was obtained for MAW-1. The interaction between the two factors was significant, maximum grain yield was produced by Inqlab-91 with T_0. On the other hand SR1-27 produced minimum grain yield with EC:SAR :: 12:48. In general, reduction in grain yield was observed as the salinity to sodicity ratio increased at all the EC or SAR levels. However, the varietal differences, in general, were conspicuous for different EC:SAR ratios. Various researchers (Ehsan and Wright, 1998; Bernstein, 1975) have already reported varietal differences for EC or SAR tolerance but such differences to EC:SAR ratios have not been available in literature.

K:Na Ratio in Plants

The K:Na ratio is considered a good indicator for salt tolerance of a crop (Pritchard et al., 2002; Palta and Fillery, 1995). Plant uptake of elements from soil depends mainly upon their concentration in soil solution, i.e. increased concentration in soil solution of an element will tend to enhance its uptake by plants, in general. Salinity and/or sodicity increased the uptake of Na^+ by crops while higher Na^+ in soil solution antagonized the uptake of K^+ (Bernstein, 1975; Gorham et al., 1985; Qadir and Shams, 1997). However, there was non-significant differences among wheat varieties regarding K:Na ratio in plants (Table 9). Regarding interaction between two factors, it was significant, K:Na ratio, being maximum for Inqlab-91 with T_1 and minimum for SR1-27 with T_6.

Soil Properties

Soil salinity (EC_e): In general, there was a decrease in EC_e (13-32 % over the initial values) after the harvest of wheat with treatments. However, after the decrease in EC_e, the EC:SAR ratios were quite similar to those achieved at the start of studies, because there was also a decrease in the SAR values. The Maximum EC_e (8.40 dS m^{-1}) was observed with T_6 followed by T_5, T_4, T_3, T_2 and T_1 (Table 10). The effect of varieties on EC_e after crop harvest was non-significant. The interaction of the two factors was significant. Maximum EC_e was observed for Auqab-2000 and MAW-1 with T_6, while it was minimum with Inqlab-91 with T_0.

Soil sodicity (SAR): Maximum SAR (19.36) was observed with T_6 followed by T_5, T_4, T_3, T_2 and T_1 (Table 11). The interaction of the two factors remained significant. Maximum soil SAR was recorded for SR1-32 with T_6, while was minimum (1.73) for Inqlab-91 with T_0.

Irrespective of the varieties tested, the highest levels of EC and SAR (T_5 and T_6) caused significant reduction in paddy yield while at the lowest levels of EC and SAR (T_1 and T_2) paddy yields were not affected significantly when compared with control. But in case of wheat crop, all the levels, i.e. lowest (T_1 and T_2), medium (T_3 and T_4) and highest (T_5 and T_6)] of EC and SAR tested, affected wheat yield adversely with significant differences among EC:SAR ratios compared to the

control. For both the crops, there were non-significant differences in yield for both the tested ratios (i.e. 0.50 and 0.25) at all the levels of EC and SAR.

CONCLUSIONS

Among tested rice varieties, SSRI-8 produced maximum productive tillers and gave maximum paddy yield. The increase in EC:SAR ratios proved more hazardous for rice even at lower EC and SAR values. Wheat varieties SR1-32 gave maximum plant height, productive tillers, straw and grain yields among the test wheat varieties at different EC:SAR ratios.

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Table 1. Response of plant height (cm) of rice varieties at different EC:SAR ratios

EC:SAR ratio	Variety							
	SSRI-8	PB-95	SSRI-13	IRRI-9	IRRI-6	KS-282	Shaheen Basmati	Mean
T_0 (0.91:1.52)	85.8c-e	102.2a	93.5a-c	62.3m-p	69.9g-m	77.6e-k	98.9ab	84.3A
T_1 (4: 8)	79.9e-h	98.08ab	92.3a-d	69.7g-m	71.1g-m	79.5e-h	97.1ab	83.9A
T_2 (4: 16)	78.9e-j	91.87a-d	90.7b-d	66.0l-p	69.2h-n	77.7e-k	98.5ab	81.8AB
T_3 (8: 16)	78.7e-k	98.73ab	84.1c-f	61.8m-p	61.7m-p	71.0g-m	96.8ab	78.9BC
T_4 (8: 32)	77.9e-k	93.13a-c	74.1f-l	57.5 pq	58.2o-q	74.3f-l	101.5a	76.6C
T_5 (12: 24)	68.3j-o	79.26e-i	82.2d-f	49.7q	59.1n-q	70.2g-m	83.9c-f	70.4D
T_6 (12: 48)	68.8i-n	83.26c-f	78.1e-k	50.9q	57.1pq	68.1k-o	80.1e-g	69.5D
Mean	76.97C	92.37A	84.98B	59.7E	63.76D	74.06C	93.83A	

Means followed by similar letter(s) in a row or column are statistically non-significant ($p \geq 0.05$). Capital letter(s) are used for comparison among overall columns or rows means and small letter(s) represent differences among interaction means. First and last letters have been used where more than two letters are required, e.g. f-k means fghijk.

Table 2. Response of productive tiller/pot of rice varieties to EC:SAR ratios

EC:SAR ratio	Variety							
	SSRI-8	PB-95	SSRI-13	IRRI-9	IRRI-6	KS-282	Shaheen Basmati	Mean
T_0 (0.91:1.52)	67ab	40f-k	56b-d	39f-k	35jk	35g-k	39f-k	44.1A
T_1 (4: 8)	58a-d	39f-k	48d-g	32h-k	29g-k	31i-k	33h-k	38.5B
T_2 (4: 16)	59a-d	37f-k	46d-h	34g-k	36g-k	33g-k	34g-k	40.1AB
T_3 (8: 16)	59a-d	33h-k	42e-j	36g-k	34g-k	28jk	27jk	36.9B
T_4 (8: 32)	55b-e	39f-k	45d-i	38f-k	38f-k	30jk	30jk	39.4AB
T_5 (12: 24)	62a-c	30jk	55b-d	33h-k	37f-k	30jk	29jk	39.3AB
T_6 (12: 48)	71a	40f-k	51c-f	30jk	33h-k	41f-k	26k	41.6AB
Mean	61.7A	36.8C	49.1B	34.3CD	34.4CD	32.5CD	31.2D	

Means followed by similar letter(s) in a row or column are statistically non-significant ($p \geq 0.05$). Capital letter(s) are used for comparison among overall columns or rows means and small letter(s) represent differences among interaction means. First and last letters have been used where more than two letters are required, e.g. f-k means fghijk.

Table 3. Response of straw yield (g/pot) of rice varieties to EC:SAR ratios

EC: SAR ratio	Variety							
	SSRI-8	PB-95	SSRI-13	IRRI-9	IRRI-6	KS-282	Shaheen Basmati	Mean
T_0(0.91:1.52)	81.2a-e	80.3a-f	74.6a-h	86.4ab	83.8a-c	88.2a	68.6a-k	80.45A
T_1 (4: 8)	54.5g-m	59.9c-m	51.6h-m	66.7a-k	66.3a-k	73.4a-i	64.8a-l	62.47BC
T_2 (4: 16)	67.7a-k	64.2a-l	64.4a-l	80.9a-e	73.1a-i	78.2a-g	63.1b-m	70.23B
T_3 (8: 16)	56.7f-m	60.5c-m	49.9i-m	82.3a-d	63.1b-m	64.1b-l	40.3m	59.58C
T_4 (8: 32)	54.1g-m	57.7e-m	58.8d-m	73.0a-e	71.3a-j	69.7a-j	54.0g-m	62.68BC
T_5 (12: 24)	48.3j-m	41.8lm	57.4e-m	76.0a-g	71.5a-j	67.7a-r	45.4k-m	58.29C
T_6 (12: 48)	63.9b-m	59.6d-m	56.3f-m	78.2a-g	65.2a-l	79.4a-f	56.5f-m	65.61BC
Mean	60.95B	60.57B	59.00B	77.66A	70.62A	74.38A	56.13B	

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Table 4. Response of paddy yield (g/pot) of rice varieties to EC:SAR ratios

EC: SAR ratio	Variety							
	SSRI-8	PB-95	SSRI-13	IRRI-9	IRRI-6	KS-282	Shaheen Basmati	Mean
T_0(0.91:1.52)	65.9a	50.9a-e	62.0ab	22.9k-s	27.9h-r	55.4a-c	36.6c-p	45.90A
T_1 (4: 8)	50.9a-e	47.7a-h	45.2b-j	24.9j-s	28.0h-r	50.1 a-e	37.1c-p	40.42AB
T_2 (4: 16)	54.6a-d	47.9a-h	40.4c-n	21.6l-s	29.3f-r	51.8a-e	43.8b-j	41.35AB
T_3 (8: 16)	47.3a-h	41.4c-m	37.2 c-p	14.7q-s	15.3q-s	38.7c-d	36.5c-p	33.02C
T_4 (8: 32)	49.0a-g	49.7a-f	32.1 e-r	13.6rs	19.5o-s	46.1a-e	34.7d-q	34.97BC
T_5 (12: 24)	34.0d-q	25.9i-s	52.6 a-e	6.2s	17.9p-s	37.3c-p	26.7e-r	28.66C
T_6 (12: 48)	44.8b-j	28.5g-r	41.6 c-l	20.7n-s	17.5p-s	20.9m-s	43.3b-r	31.05C
Mean	49.50A	41.73BC	44.30AB	17.81D	21.20D	42.90BC	36.90C	

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Table 5. Response of plant height (cm) of wheat varieties to EC:SAR ratios

EC:SAR ratio	Variety						
	MAW-1	Inqilab-91	Ufaq	Auqab-2000	SR1-27	SR1-32	Mean
T_0(0.91:1.52)	68.6 f	75.2 a-c	64.6g-j	75.3ab	65.4g-i	76.9a	71.0A
T_1 (4: 8)	65.6 g-i	73.3b-e	63.5h-k	73.5b-e	62.6j-l	75.0a-d	68.9B
T_2 (4: 16)	64.7 g-j	73.4b-e	62.4j-l	73.4b-e	61.7k-m	73.0b-e	68.1B
T_3 (8: 16)	63.2i-l	68.7f	61.8k-m	73.0b-e	60.6l-m	72.3d-e	66.6C
T_4 (8: 32)	61.3k-m	65.5g-i	59.5mn	71.1e	59.4mn	72.6c-e	64.9D
T_5 (12: 24)	61.7k-m	62.5j-l	56.4o	63.5h-k	57.4no	66.2f-h	61.3E
T_6 (12: 48)	65.4g-i	67.2fg	62.4j-l	66.8fg	61.8k-m	68.2f	65.3D
Mean	64.37D	69.40C	61.52E	70.94B	61.27E	72.03A	

Means followed by similar letter(s) in a row or column are statistically non-significant ($p \geq 0.05$). Capital letter(s) are used for comparison among overall columns or rows means and small letter(s) represent differences among interaction means. First and last letters have been used where more than two letters are required, e.g. f-k means fghijk.

Table 6. Response of productive tillers/pot of wheat varieties to EC:SAR ratios

EC:SAR ratio	Variety						
	MAW-1	Inqilab-91	Ufaq	Auqab-2000	SR1-27	SR1-32	Mean
T_0(0.91:1.52)	25bc	28a	21e-g	27a	22d-f	28a	25A
T_1 (4: 8)	23c-e	26ab	19g-i	25bc	20f-h	27a	23B
T_2 (4: 16)	21e-g	24b-d	17i-k	23c-e	18h-j	25bc	21C
T_3 (8: 16)	21e-g	20f-h	16j-l	21e-g	16j-l	23c-e	19D
T_4 (8: 32)	18h-j	20f-h	13mn	21e-g	15k-m	22d-f	18E
T_5 (12: 24)	14lm	17i-k	10pq	16j-l	19g-i	17i-k	15F
T_6 (12: 48)	11op	15k-m	9q	14lm	12no	16j-l	13G
Mean	19C	21B	15E	21B	17D	23A	

Means followed by similar letter(s) in a row or column are statistically non-significant ($p \geq 0.05$). Capital letter(s) are used for comparison among overall columns or rows means and small letter(s) represent differences among interaction means. First and last letters have been used where more than two letters are required, e.g. f-k means fghijk.

Table 7. Response of straw yield (g/pot) of wheat varieties to EC:SAR ratios

EC: SAR ratio	Variety						
	MAW-1	Inqilab-91	Ufaq	Auqab-2000	SR1-27	SR1-32	Mean
T_0(0.91:1.52)	52.1ab	46.9f-i	46.6f-i	50.8a-c	46.0g-j	52.0ab	49.50A
T_1 (4: 8)	52.3ab	47.1e-h	44.1j-m	50.9a-c	43.8j-m	53.0a	48.54A
T_2 (4: 16)	50.9a-c	47.4e-g	41.8mn	47.9d-g	39.4o	50.2b-d	46.24B
T_3 (8: 16)	48.7c-f	44.1j-m	40.0no	53.0a	37.0p	50.0b-d	45.27B
T_4 (8: 32)	44.8h-k	42.2l-n	35.1pq	50.8a-c	32.9qr	48.9c-f	42.45C
T_5 (12: 24)	43.2k-m	42.1l-n	34.7pq	49.3c-e	32.1r	48.6c-f	41.68C
T_6 (12: 48)	39.9no	36.9p	31.0r	44.5i-l	28.1s	43.6j-m	37.35D
Mean	47.42B	43.82C	39.03D	49.61A	37.03E	49.48A	

Means followed by similar letter(s) in a row or column are statistically non-significant ($p \geq 0.05$). Capital letter(s) are used for comparison among overall columns or rows means and small letter(s) represent differences among interaction means. First and last letters have been used where more than two letters are required, e.g. f-k means fghijk.

Table 8. Response of grain yield (g/pot) of wheat varieties to EC:SAR ratios

EC: SAR ratio	Variety						
	MAW-1	Inqilab-91	Ufaq	Auqab-2000	SR1-27	SR1-32	Mean
T_0(0.91:1.52)	19.4ab	20.3a	17.6a-c	19.6ab	17.2a-e	20.1a	19.03A
T_1 (4: 8)	14.2c-j	17.3a-d	15.0c-h	16.2b-g	14.3c-j	17.0a-f	15.69B
T_2 (4: 16)	12.5g-l	16.7a-f	13.4e-k	16.6a-f	13.2f-l	17.2a-e	14.93B
T_3 (8: 16)	9.6k-m	14.5c-i	10.2kl	13.5d-k	10.1kl	14.6c-h	12.10C
T_4 (8: 32)	9.4lm	13.3f-l	10.3kl	12.5g-l	10.2kl	13.4e-k	11.50C
T_5 (12: 24)	6.2mn	10.5j-l	6.4mn	10.2kl	6.2mn	10.5j-l	8.327D
T_6 (12: 48)	4.2n	11.3h-l	4.5n	10.7i-l	4.4n	11.3h-l	7.740D
Mean	10.79B	14.83A	11.07B	14.19A	10.80B	14.88A	

Means followed by similar letter(s) in a row or column are statistically non-significant ($p \geq 0.05$). Capital letter(s) are used for comparison among overall columns or rows means and small letter(s) represent differences among interaction means. First and last letters have been used where more than two letters are required, e.g. f-k means fghijk.

Table 9. Response of K^+:Na^+ in shoot of wheat varieties to EC:SAR ratios

EC: SAR ratio	Variety						
	MAW-1	Inqilab-91	Ufaq	Auqab-2000	SR1-27	SR1-32	Mean
T_0(0.91:1.52)	2.37b	1.80b	1.90b	1.93b	2.07b	1.74b	1.97AB
T_1 (4: 8)	1.82b	3.62a	2.08b	1.91b	2.05b	1.56b	2.17A
T_2 (4: 16)	1.55b	1.55b	1.68b	2.20b	2.04b	1.74b	1.79A-C
T_3 (8: 16)	1.87b	1.46b	1.75b	1.67b	1.91b	1.61b	1.71A-C
T_4 (8: 32)	1.60b	1.15b	1.80b	1.34b	1.79b	1.11b	1.47B-D
T_5 (12: 24)	1.73b	1.17b	1.52b	1.28b	1.20b	1.15b	1.34CD
T_6 (12: 48)	1.41b	1.12b	1.09b	1.13b	1.00b	1.32b	1.18D
Mean	1.77A	1.69A	1.69A	1.64A	1.72A	1.46A	

Means followed by similar letter(s) in a row or column are statistically non-significant ($p \geq 0.05$). Capital letter(s) are used for comparison among overall columns or rows means and small letter(s) represent differences among interaction means. First and last letters have been used where more than two letters are required, e.g. f-k means fghijk.

Table 10. Post harvest EC_e at different EC:SAR ratios

EC:SAR ratio	Variety						
	MAW-1	Inqilab-91	Ufaq	Auqab-2000	SR1-27	SR1-32	Mean
T_0(0.91:1.52)	2.00qr	1.83r	2.37o-r	2.07p-r	2.10p-r	2.10p-r	2.08E
T_1 (4: 8)	3.10m-r	3.10m-r	2.90n-r	3.87j-o	2.83n-r	3.57k-q	3.23D
T_2 (4: 16)	4.100i-n	3.40l-r	2.90n-r	3.20m-r	3.70k-o	2.87n-r	3.36D
T_3 (8: 16)	3.63k-p	4.60h-m	5.10g-k	5.73e-h	4.73h-l	5.13g-k	4.82C
T_4 (8: 32)	5.60f-i	4.83h-l	5.30f-j	5.03g-k	5.00h-k	5.07g-k	5.14C
T_5 (12: 24)	6.53d-g	6.63c-f	7.07b-e	7.20a-d	7.47a-d	8.00a-c	7.16B
T_6 (12: 48)	8.60a	8.50ab	8.30ab	8.63a	8.42ab	8.00a-d	8.41A
Mean	4.79A	4.70A	4.85A	5.11A	4.89A	4.97A	

Means followed by similar letter(s) in a row or column are statistically non-significant ($p \geq 0.05$). Capital letter(s) are used for comparison among overall columns or rows means and small letter(s) represent differences among interaction means. First and last letters have been used where more than two letters are required, e.g. f-k means fghijk.

Table 11. Post harvest SAR at different EC:SAR ratios

EC:SAR ratio	Variety						
	MAW-1	Inqilab-91	Ufaq	Auqab-2000	SR1-27	SR1-32	Mean
T_0(0.91:1.52)	2.27k	1.73k	2.10k	2.09k	2.20k	2.24k	2.02G
T_1 (4: 8)	5.92g-j	4.15i-k	3.88jk	6.24g-j	4.57h-k	5.65g-j	5.07F
T_2 (4: 16)	8.16d-g	6.02g-j	6.40g-j	7.70e-h	8.17d-g	5.43g-j	6.98E
T_3 (8: 16)	7.30f-i	8.40d-g	6.04g-j	8.55d-g	8.19d-g	10.73b-e	8.20D
T_4 (8: 32)	11.90bc	12.00bc	11.64bc	12.08bc	11.30b-d	10.39c-f	11.55C
T_5 (12: 24)	12.51bc	13.52bc	13.12bc	13.45bc	14.02b	13.81b	13.40B
T_6 (12: 48)	19.60a	20.11a	18.74a	18.19a	19.60a	19.93a	19.36A
Mean	9.66A	9.42A	8.85A	9.76A	9.72A	9.74A	

Means followed by similar letter(s) in a row or column are statistically non-significant ($p \geq 0.05$). Capital letter(s) are used for comparison among overall columns or rows means and small letter(s) represent differences among interaction means. First and last letters have been used where more than two letters are required, e.g. f-k means fghijk.

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