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RESPONSE OF WHEAT GENOTYPES TO SEED RATES IN DIVERSE ENVIRONMENTS

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ABSTRACT

Multi-environment trials on wheat varieties of diversified origin were conducted at Sindh Agriculture University Tandojam (Sindh) and Agriculture Research Institute, Quetta (Balochistan) for two consecutive years (2008-09 and 2009-10). Six wheat varieties were included in the experiment. Three (Sarsabz, Mehran-89, and Kiran-95) were from Sindh and three (Zardana, Sariab-92 and Rasco-2005) from Balochistan. Four seed rates (100, 125, 150 and 175 kg ha^{-1}) of each variety were used at each experimental site. The randomized complete block design with split plot arrangement was used with three replications. Overall, application of 125 kg ha^{-1} seed rate showed optimistic results as compared to higher or lower seed rates. Variety Mehran performed significantly ($P< 0.05$) well than rest of the varieties with highest grain yield of 4475 kg ha^{-1}. The varieties Sarsabz, Kiran-95, Zardana, Rasco-2005 and Sariab-92 ranked 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, respectively in grain yield under Tandojam environment. On the other hand, the yield of Zardana variety was better under Quetta environment. The results showed that at Tandojam vs Quetta the seed index value was 39.84 g vs 36.68 g, grain yield 3713 kg ha^{-1} vs 3907 kg ha^{-1}, respectively. The quality response of varieties revealed that the maximum protein content was recorded in Rasco-2005 (11.35%) under Tandojam environment while the maximum protein content (11.53%) was noted in Mehran-89 under Quetta environment. Under Tandojam environment, varieties of Sindh out yielded the varieties of Balochistan while at Quetta, the Balochistan varieties surpassed in yield to the varieties from Sindh province. Therefore, site specific varieties and agricultural practices should be considered for wheat production.

Keywords: environment, grain yield and quality, seed rate, wheat varieties

INTRODUCTION

Among the cereals, wheat is the principal source of human diet, particularly in Asia and more specifically in South Asian regions which are supplying 68% of the calories and protein in the diet (FAO, 2010). Importance of wheat in Pakistan can

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be noted from the fact that agricultural policies are formulated focusing this crop. Wheat flour in Pakistan currently contributes 72 percent of daily caloric intake with per capita consumption of wheat upto 124 kg per annum (USDA, 2015). During 2014-15, wheat crop was cultivated on an area of 9180 thousand hectares, the grain production obtained was 25.478 million tonnes having 2775 kg ha^{-1} average yield (GoP, 2015). Pakistan is included in top ten wheat producing countries of the world (Khan *et al*., 2002) but unfortunately the average yield obtained is much lower than other major wheat growing countries including China, USA, and India (Arain *et al*., 2005). The major factors influencing wheat quantity are cultivar, climatic conditions, cropping system, process of harvest and storage conditions (Imran *et al.,* 2006). The lower yields are mainly caused by poor crop management practices including seed rates and site specific technology. The protein content of wheat is also influenced by the wheat cultivar (Ibrahim*,* 2004). Wheat responds differently to various agro-management practices. In crop management factors, seed rate is considered an important factor for achieving higher grain yields (Slafer and Satorre, 1999; Korres and Froud, 2002). Optimum plant density varies greatly among climatic conditions, soil, areas and genotypes. Previous research showed that seed rates significantly affected biological yield, crop stand, spike number and grain weight (Ayaz *et al.,* 1997; Ozturk *et al.,* 2006). Higher seed rates increase tiller production, promote more spikes which could be encouraging, especially for cultivars that tend to generate less tillers (Staggenborg *et al.,* 2003). Thus a close connection exists among wheat stand and yield traits (Ibrahim, 2004). If optimal seed rates exceed then yield reductions often occur. Soomro *et al*. (2009) revealed that grain yield increased upto 15% was obtained when the quantity of seeding rate was enhanced from 41 to 95 kg ha^{-1}. Moreover, it is also found that the adverse effects due to late sowing could be compensated by increasing the quantity of seed rate per unit area (Arain *et al*., 2005). It is, therefore very necessary to determine the optimum seed rate of wheat crop due to climatic change from agro-ecological and economic point of view (Kumar *et al*., 2002). Therefore, the present study was planned to investigate the growth, yield and quality of wheat varieties in response to seed rates under diverse environments.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at two locations viz. Sindh Agriculture University Tandojam, Sindh (25.4299° N, 68.5426° E) and Agriculture Research Institute, Quetta, Balochistan (30.1830° N, 66.9987° E) for two consecutive years (2008-09 and 2009-10).

Experimental design and treatments

A randomized complete block design with split plot arrangement was used in the experiment. The locations (Tandojam and Quetta) were used as main factor and six wheat varieties and seed rates were kept in sub-plots. The varieties included in the experiment were: Sarsabz, Mehran-89, Kiran-95, Zardana, Sariab-92 and Rasco-2005. Four seed rates (100, 125, 150 and 175 kg ha^{-1}) of each variety were used at the each experimental site.

Crop husbandry

At both the experimental locations, proper land preparation operations were performed for equal distribution of irrigation and fertilizers. Sowing was done in the first week of November 2008-09 and 2009-10. First irrigation was applied after 20 days of sowing and subsequent irrigations were applied as per need of the crop. Recommended rates of NPK (120-60-60 kg ha^{-1}, respectively) were applied in the form of Urea, DAP and SOP, respectively (ARI, 2014). All P, K and half of N doses were given during final land preparation. The remaining N was split into two doses, applied during 2^{nd} and 4^{th} irrigations. Weed management practices were done through hand weeding.

Yield observations

Two representative rows were selected in each experimental unit (3m×5m) for the determination of total number of tillers $plant^{-1}$. All grains were collected from each spike and weighed on top loading digital balance for determining grain weight $plant^{-1}$. A sample of thousand grains was taken from each plot and weighed on an analytical balance after sun drying. These samples were used for quality observations after drying at $70^{o}C$ for 24 hours in an oven. For the measurement of grain yield (kg ha^{-1}), the 1 m^2 row area was harvested and threshed manually.

Quality observations

Nitrogen content in wheat grain was determined by using the Kjedahl method as described by Jackson (1958). The samples were analyzed at the Lab. of Soil Chemistry Section, Agriculture Research Institute, Tandojam. The crude protein content of grain was calculated on the basis of nitrogen content of grain by multiplying a factor i.e 6.25 as crude protein content in grain = N% in grain x 6.25 (AOAC, 1984). The ash content of wheat samples was determined as: weight of 100-grains before burning ÷ burnt grain ash weight x 100 following the procedure described by AACC (2000).

Statistical analysis

The year's effect was non-significant so the data was pooled. The data was statistically analyzed to determine the effect of seed rates of different varieties. The effects on the various parameters were evaluated by ANOVA using the Version 9.1, Statistical Analysis System (SAS Institute, 2004). When P-values in ANOVA were significant, the least significant difference (LSD) test was used for comparing treatment means ($P< 0.05$).

Weather data

The weather summary of both locations is shown in Figure 1. According to weather data, less rainfall and low temperature was recorded in Quetta region as compared to Tandojam region.

RESULTS

Total number of tillers

The number of total tillers was affected significantly ($P< 0.05$) by seed rates, varieties and locations (Table 2). At Tandojam conditions, total number of tillers

plant^{-1} was highest (7.42) under seed rate of 100 kg ha^{-1}, followed by 125 kg ha^{-1} with 6.12 total number of tillers plant^{-1}. The lowest and statistically at par total number of tillers plant^{-1} (4.67 and 4.49) was recorded under seed rates of 150 and 175 kg ha^{-1}, respectively. At Quetta environment, total number of tillers plant^{-1} was maximum (7.48) when seed was used at rate of 100 kg ha^{-1}, followed by 6.73, 5.98 and 5.61 total number of tillers plant^{-1} noted in seed rate of 125, 150 and 175 kg ha^{-1}, respectively. A linear trend was observed in total number of tillers plant^{-1} where the tillering was reduced with increasing seed rate. In varieties at Tandojam, total number of tillers plant^{-1} was maximum (6.38) in Mehran-89, followed by Kiran-95 (5.83) while lowest in Sariab-95 (5.13). At Quetta, maximum and statistically equal total number of tillers plant^{-1} (7.14 and 6.99) was recorded in Sariab-92 and Zardana, respectively. The minimum and statistically similar ($P> 0.05$) number of tillers plant^{-1} (5.82 and 5.71) was noted in Sarsabz and Kiran-95, respectively. On average, the number of tillers plant^{-1} was higher (6.45) at Quetta than Tandojam (5.67).

Table 1. Physico-chemical properties of soil before experimental setup

Parameters	Tandojam		Quetta	
	Before sowing	After sowing	Before sowing	After sowing
Soil textural analysis				
Sand %	19	-	24	-
Silt %	43	-	34	-
Clay %	38	-	42	-
Textural class	Clay loam		Silty clay	
Chemical analysis				
EC (dS m^{-1})	4.42	4.30	3.93	3.89
Soil pH	7.50	7.40	7.13	7.08
O.M (%)	0.60	0.54	0.71	0.69
Total N (%)	0.026	0.022	0.034	0.031
Available P (mg kg^{-1})	4.37	4.31	4.87	4.84
Exchangeable K (mg kg^{-1})	128.31	127.20	144.36	143.19

Grain yield

Significant ($P< 0.05$) effect of varieties and seed rates was observed for grain yield plant^{-1}, while non-significant ($P> 0.05$) effect for location and treatments interaction was observed (Table 3). At Tandojam, the maximum grain yield plant^{-1} (15.18 g) was achieved when seed was used at the rate of 100 kg ha^{-1}, followed by 13.67 g with seed rate of 125 kg ha^{-1} whereas, the minimum and statistical equal grain yield plant^{-1} of 12.46 and 12.13 g was obtained under respective seed rate of 150 and 175 kg ha^{-1}. At Quetta, the grain yield was highest (16.57 g) with 100 kg ha^{-1} seed rate, followed by 125 kg ha^{-1} (13.42 g). However, minimum and non-significant to each other grain yield plant^{-1} of 11.53 and 11.32 g was recorded at 150 and 175 kg ha^{-1} seed rate, respectively. In varieties, at Tandojam, the maximum grain yield plant^{-1} (16.13 g) was observed in Mehran-89, followed by Sarsabz (14.22 g) which was statistically at par with Kiran-95 (14.15 g); while lowest (11.94, 11.86 and 11.85 g) and statistically similar ($P> 0.05$) grain yield plant^{-1} was recorded in Rasco-2005, Sariab-92 and Zardana, respectively. At Quetta for varieties, higher grain yield plant^{-1} (15.73 g) was noted

in Sariab-92, followed by Zardana (14.65 g) while minimum 10.75 and 10.92 g, and statistically similar (*P> 0.05*) grain yield plant^{-1} was recorded in Kiran-95 and Sarsabz, respectively.

Table 2. Total number of tillers plant^{-1} of wheat varieties under various seed rates and environments

Locations	Varieties	Seed rates (Kg ha^{-1})				
		100	125	150	175	Mean
Tandojam	Sarsabz	6.99	6.01	4.59	4.34	5.49 c
	Mehran-89	8.90	6.66	5.08	4.90	6.38 a
	Kiran-95	7.40	6.37	4.87	4.66	5.83 b
	Zardana	7.35	6.32	4.82	4.56	5.76 b
	Sariab-92	6.98	5.39	4.12	4.00	5.13 d
	Rasco-2005	6.90	5.94	4.54	4.44	5.45 c
	Mean	7.42a	6.12b	4.67c	4.49c	5.67 B
Quetta	Sarsabz	6.75	6.07	5.40	5.05	5.82 d
	Mehran-89	7.30	6.57	5.84	5.32	6.26 c
	Kiran-95	6.60	5.95	5.28	4.97	5.71 d
	Zardana	8.07	7.27	6.46	6.15	6.99 a
	Sariab-92	8.29	7.46	6.63	6.18	7.14 a
	Rasco-2005	7.85	7.06	6.28	5.99	6.80 b
	Mean	7.48 a	6.73 b	5.98 c	5.61 d	6.45 A

LSD: Varieties (V) = 0.20, Seed Rate (R) = 0.14, Location (L) = 0.11, V×R = 0.34, V×L = 0.28. Each value is a mean of three replications

Seed index

Significant effect (*P< 0.05*) of varieties, seed rate and location on seed index was recorded. At Tandojam, the seed index was highest (41.90 g), when seed was used at the rate of 100 kg ha^{-1}. The seed rate of 125 kg ha^{-1} and 150 kg ha^{-1}, followed in seed index with 40.63 and 39.02 g, respectively while the lowest seed index (37.79 g) was obtained when seed was used at rate of 175 kg ha^{-1} (Table 4). At Quetta, the seed index was highest (38.31 g) under the seeding rate of 100 kg ha^{-1}, followed by seeding rate of 125 and 150 kg ha^{-1} with seed index of 37.16 and 36.54 g, respectively. However, the lowest (34.71 g) seed index was recorded at seeding rate of 175 kg ha^{-1}. Linear and substantial (*P< 0.05*) differences in seed index were observed among various seeding rates and an increase in seed rate resulted in a significant reduction in the seed index value. In varieties, at Tandojam, the maximum seed index (45.63 g) was noted in Mehran-89, followed by Sarsabz (41.56 g) and Kiran-95 (40.51 g) with non statistical values. The lowest and statistically similar seed index was observed in Rasco-2005 (36.62 g) and Sariab-92 (35.78 g). At Quetta, the maximum seed index (40.04 g) was noted in Zardana, followed by Rasco-2005 (39.07 g). Sariab-92 (37.83 g) and Mehran-89 (35.53 g) ranked third with similar statistical values. However, lowest and statistically equal seed index (33.61 g and 34.00 g) was noted in Sarsabz and Kiran-95, respectively. The seed index at Tandojam was significantly higher (39.84 g) than Quetta (36.68 g). The variety Mehran-89 at 100 kg ha^{-1} seed rate in Tandojam resulted in maximum (48.88 g) seed index.

Table 3. Grain yield plant^{-1} (g) of wheat varieties under various seed rates and environments

Locations	Varieties	Seed rates (Kg ha^{-1})				
		100	125	150	175	Mean
Tandojam	Sarsabz	16.24	14.61	13.15	12.85	14.22 b
	Mehran-89	18.58	16.72	15.05	14.19	16.13 a
	Kiran-95	16.17	14.55	13.09	12.81	14.15 b
	Zardana	13.48	12.14	10.92	10.84	11.85 c
	Sariab-92	13.50	12.15	10.93	10.83	11.86 c
	Rasco-2005	13.14	11.82	11.58	11.23	11.94 c
	Mean	15.18a	13.67b	12.46c	12.13c	13.36
Quetta	Sarsabz	13.70	11.10	9.54	9.34	10.92 d
	Mehran-89	16.37	13.26	11.39	11.28	13.08 c
	Kiran-95	13.48	10.92	9.38	9.20	10.75 d
	Zardana	18.38	14.88	12.79	12.53	14.65 b
	Sariab-92	19.73	15.98	13.73	13.46	15.73 a
	Rasco-2005	17.72	14.35	12.34	12.09	14.12 b
	Mean	16.57a	13.42b	11.53c	11.32c	13.21

LSD: Varieties (V) = 0.54, Seed Rate (R) = 0.38, Location (L) = 0.31, V×R = 0.94, V×L = 0.77. Each

Table 4. Seed index (g) of wheat varieties under various seed rates and environments

Locations	Varieties	Seed rates (Kg ha^{-1})				
		100	125	150	175	Mean
Tandojam	Sarsabz	44.05	42.73	40.20	39.26	41.56 b
	Mehran-89	48.88	47.41	44.08	42.14	45.63 a
	Kiran-95	42.63	41.35	39.64	38.43	40.51 b
	Zardana	40.47	39.25	38.71	37.27	38.93 c
	Sariab-92	37.68	36.55	35.04	33.87	35.78 d
	Rasco-2005	37.66	36.53	36.50	35.79	36.62 d
	Mean	41.90a	40.63b	39.02c	37.79d	39.84 A
Quetta	Sarsabz	35.17	34.11	33.41	31.74	33.61 d
	Mehran-89	36.75	35.64	35.76	33.97	35.53 c
	Kiran-95	35.58	34.51	33.80	32.11	34.00 d
	Zardana	41.90	40.64	39.81	37.81	40.04 a
	Sariab-92	39.58	38.40	37.61	35.73	37.83 c
	Rasco-2005	40.88	39.65	38.84	36.90	39.07 b
	Mean	38.31a	37.16b	36.54c	34.71d	36.68 B

LSD: Varieties (V) = 0.98, Seed Rate (R) = 0.70, Location (L) = 0.57, V×R = 1.71, V×L = 1.39.

Grain yield

The varieties, seed rates and locations showed significant (*P< 0.05*) influence on grain yield (Table 5) of wheat. At Tandojam, the highest grain yield ha^{-1} (4150 kg) was found under the seeding rate of 125 kg ha^{-1}, followed by the seeding rate of 100 kg ha^{-1} resulting in 3617 kg ha^{-1}. The lowest and statistically similar (*P> 0.05*) grain yield (3575 and 3508 kg ha^{-1}) was noticed under the seeding rate of 175 kg ha^{-1} and 150 kg ha^{-1} seed. At Quetta, the highest (4095 kg ha^{-1}) grain yield was achieved when seed was used at rate of 125 kg ha^{-1}. Grain yield under the seeding

rate of 150 kg ha^{-1} (3957 kg) and 175 kg ha^{-1} (3917 kg) ranked 2nd and was statistically non-significant with each other. However, minimum grain yield (3660 kg ha^{-1}) was observed under the seeding rate of 100 kg ha^{-1}. Among varieties at Tandojam, the highest (4475 kg ha^{-1}) grain yield was recorded in Mehran-89. Sarsabz and Kiran-95, followed in grain yield with statistically at par values (4205 and 4199 kg ha^{-1}), respectively. However, the least (2893 kg ha^{-1}) grain yield was observed in Sariab-92. At Quetta the maximum (4368 kg ha^{-1}) grain yield was recorded by Zardana, followed by Rasco-2005 (4227 kg ha^{-1}). The lowest grain yield (3461 kg ha^{-1}) was observed in Sarsabz. Among locations, the significantly higher (3907 kg ha^{-1}) grain yield was noted under Quetta, environment compared to Tandojam (3713 kg ha^{-1}) condition. The cultivar Mehran-89 at 125 kg seed rate in Tandojam environment produced maximum (5024 kg ha^{-1}) grain yield.

Table 5. Grain yield (kg ha^{-1}) of wheat varieties under various seed rates and environments

Locations	Varieties	Seed rates (Kg ha^{-1})				
		100	**125**	**150**	**175**	**Mean**
Tandojam	Sarsabz	4109	4726	3986	4000	4205 b
	Mehran-89	4368	5024	4237	4271	4475 a
	Kiran-95	4101	4716	3978	4000	4199 b
	Zardana	3212	3693	3115	3184	3301 c
	Sariab-92	2775	3191	2692	2913	2893 e
	Rasco-2005	3135	3550	3041	3086	3203 d
	Mean	3617 b	4150 a	3508 c	3575 c	3713 B
Quetta	Sarsabz	3266	3625	3494	3459	3461 e
	Mehran-89	3503	3808	3748	3711	3692 d
	Kiran-95	3408	3783	3646	3610	3612 d
	Zardana	4040	4677	4400	4356	4368 a
	Sariab-92	3808	4227	4170	4128	4083 c
	Rasco-2005	3938	4451	4282	4239	4227 b
	Mean	3660 c	4095 a	3957 b	3917 b	3907 A

LSD: Varieties (V) = 99, Seed Rate (R) = 70, Location (L) = 57, V×R = 172, V×L = 141.

Protein content

The results showed that protein content differs significantly (*P< 0.05*) for varieties, seed rates and environmental conditions (Table 6). However, there was a non-significant effect (*P > 0.05*) of interaction on protein contents, with the exception of variety × location interaction (*P< 0.05*). At Tandojam, the highest (11.22 and 11.13%) and statistically equal grain protein content was determined in 100 and 125 kg ha^{-1} seed rate. While, lowest grain protein content (10.03%) was determined under seed rate of 175 kg ha^{-1}. Similarly, at Quetta, significantly highest (11.10%) protein content in grain was determined under the seeding rate of 125 kg ha^{-1}. For varieties at Tandojam, maximum and statistically similar grain protein content (11.35, 11.28 and 10.88%) was recorded in Rasco-2005, Sarsabz and Mehran-89, respectively. While, lowest (10.03%) grain protein content was noted in Zardana. At Quetta environment, the maximum grain protein content (11.53%) was recorded in Mehran-89. However, lowest (9.63%) grain protein content was noted in Sariab-92.

Table 6. Protein content (%) of wheat varieties under various seed rates and environments

Locations	Varieties	Seed rates (Kg ha^{-1})				
		100	125	150	175	Mean
Tandojam	Sarsabz	11.74	11.85	11.51	10.03	11.28 a
	Mehran-89	11.10	11.21	10.87	10.34	10.88 a
	Kiran-95	10.82	10.94	10.61	10.26	10.66 b
	Zardana	10.16	10.27	9.96	9.28	10.03 c
	Sariab-92	10.99	11.10	10.77	9.30	10.54 b
	Rasco-2005	12.50	11.38	11.02	10.50	11.35 a
	Mean	11.22 a	11.13 a	10.79 b	10.03 c	10.77 A
Quetta	Sarsabz	10.75	11.18	10.54	10.45	10.73 b
	Mehran-89	11.56	12.02	11.33	11.23	11.53 a
	Kiran-95	10.90	11.34	10.68	10.59	10.88 b
	Zardana	10.94	11.38	10.72	10.62	10.92 b
	Sariab-92	9.66	10.04	9.46	9.37	9.63 d
	Rasco-2005	10.22	10.62	10.01	9.92	10.19 c
	Mean	10.67 b	11.10 a	10.46 b	10.36 b	10.65 B

LSD: Varieties (V) = 0.44, Seed Rate (R) = 0.31, Location (L) = 0.10, V×R = 0.76, V×L = 0.44.

Table 7. Ash content (%) of wheat varieties under various seed rates and environments

Locations	Varieties	Seed rates (Kg ha^{-1})				
		100	125	150	175	Mean
Tandojam	Sarsabz	1.76	2.25	2.30	2.23	2.14 a
	Mehran-89	1.67	2.13	2.18	2.31	2.07 a
	Kiran-95	1.63	2.08	2.12	2.12	1.99 b
	Zardana	1.52	1.95	1.99	2.17	1.91 c
	Sariab-92	1.65	2.11	2.15	2.19	2.03 b
	Rasco-2005	1.88	2.16	2.20	2.17	2.10 a
	Mean	1.68 c	2.11 b	2.16 a	2.20 a	2.03 B
Quetta	Sarsabz	2.02	1.94	2.06	2.08	2.03 c
	Mehran-89	1.83	1.76	1.87	1.89	1.84 d
	Kiran-95	2.01	1.93	2.05	2.07	2.02 c
	Zardana	2.62	2.51	2.67	2.70	2.62 a
	Sariab-92	2.15	2.06	2.19	2.21	2.15 c
	Rasco-2005	2.34	2.25	2.39	2.32	2.33 b
	Mean	2.16 a	2.08 b	2.21 a	2.21 a	2.16 A

LSD: Varieties (V) = 0.16, Seed Rate (R) = 0.11, Location (L) = 0.08, V×R = 0.27, V×L = 0.16.

Ash content

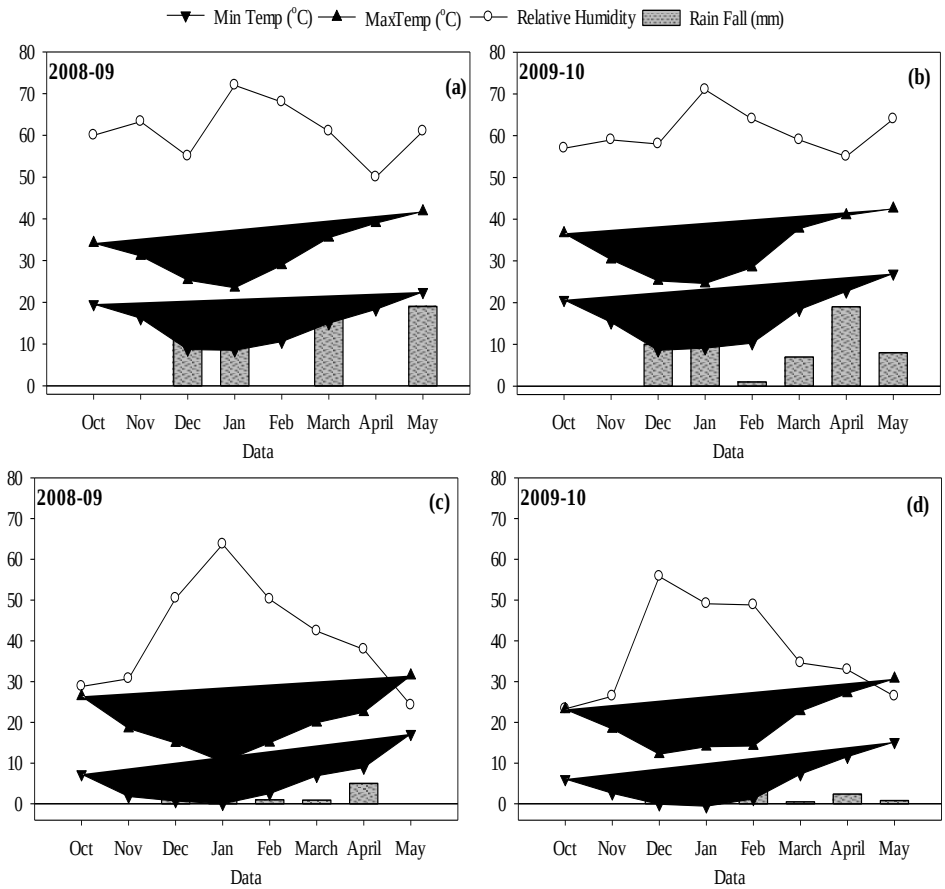
The results revealed that varieties, seed rates and environmental conditions had significant (*P< 0.05*) effect on ash content and non-significant effect (*P> 0.05*) for their interaction except variety × location and seed rate x location (*P< 0.*05). The seed rate effect on ash content indicated that at Tandojam the highest (2.20 and 2.16%) and statistically equal ash content was determined under seed rate of 175 and 150 kg ha^{-1}. The lowest (1.68%) grain ash content was recorded under lowest seed rate (100 kg ha^{-1}). At Quetta, highest ash content (2.21, 2.21 and 2.16%) was recorded under the seeding rate of 175, 150, and 100 kg ha^{-1}, respectively.

However, the least ash content of 2.08% was observed under the seeding rate of 125 kg ha^{-1}. The maximum ash content (2.62%) was observed in Zardana, followed by Rasco-2005 (2.33%) while lowest (1.84%) ash content in grain was noted in Mehran-89 at Quetta. The environmental effect on grain ash content indicated that grain ash content was higher (2.16%) under Quetta environment as compared to the crop sown at Tandojam (2.03%).

DISCUSSION

The effect of seed rates on average of two locations indicated that 125 kg ha^{-1} seed rate showed optimistic results particularly for grain yield when compared with higher or lower seed rates. The crop sown at the seeding rate of 100 kg ha^{-1} produced maximum number of total tillers $plant^{-1}$ (7.48), grain yield $plant^{-1}$ (16.57 g) and seed index (38.31 g), but higher (4095 kg ha^{-1}) grain yield was observed under the seeding rate of 125 kg ha^{-1}. It may be due to suitable environmental condition. The findings of the present study in relation to seed rate are in concurrence with Korres and Froud (2002) who found that seeding rate of 125 kg ha^{-1} resulted in highest wheat grain yield.

In present study, a close relationship exists between wheat stands and yield components. It was noted that the grain yield was improved with increasing the seeding rate upto 125 kg ha^{-1} and the increase in seed rate beyond this seed rate resulted in statistically non-significant grain yield. It may be due to limited supply of nutrient and less values for yield contributing components. The yield contributing components were higher at seeding rate of 100 kg ha^{-1} but crop stand was less as compared to 125 kg ha^{-1}. The results are partially in agreement with Ozturk *et al.* (2006) who reported that increasing seed rates resulted in increased grains $spike^{-1}$ and grain yield. Bhatti *et al.* (1990) reported higher benefit: cost ratio at 100-150 kg ha^{-1} seed rate. Sikander *et al*. (2003) reported that increased yield components of wheat were noted at lower seed rate and decreased yield components at higher seed rate but the optimum grain yield (kg ha^{-1}) was recorded at optimum seeding rate of 125 kg ha^{-1}. The effect of seed size and seed rate on wheat performance was also evaluated by Arain *et al*. (2005). They compared the effects of different seeding rates on wheat and concluded that 140 kg ha^{-1} was found as appropriate seed rates for best results. Khan *et al.* (2002) revealed that suitable seed rate for optimum grain yield of wheat could be derived from the curve of grain yield v/s plants number per unit area, which is increased to a maximum quickly and decreased slowly at higher plant density. Zewdu (2008) reported the grain yield as a function of yield components namely, the number of tillers per unit area, the number of kernels per spike, and the weight per kernel. Slafer and Satorre (1999) reported that under rain fed agriculture maximum grain yield of wheat was achieved at the seeding rate of 100 kg ha^{-1}. In another study higher wheat grain yield was recorded under the seed rate of 100 kg ha^{-1} (Soomro *et al.,* 2009). Similarly, Ayaz *et al.* (1997) reported that the interaction of seed rate and cropping year was statistically significant for 1000-grain weight, grains $spike^{-1}$ and spike m^{-2}.



Source: Regional Agromet Centers Tandojam and Quetta, Pakistan

Figure 1. Monthly climatic data of experimental location Tandojam for 2008-09 (a) and 2009-10 (b) and experimental location Quetta 2008-09 (c) and 2009-10 (d)

Growth and yield performance of varieties was also affected significantly by seed rate and locations. Performance of Tandojam origin wheat varieties was better in Tandojam as compared to their performance in Quetta environment. Similarly, the performance of Balochistan origin varieties was better in Quetta than their performance in Tandojam conditions. The overall performance of Mehran-89 was better in both experimental sites. In Tandojam environment, Mehran-89 (Tandojam origin) surpassed other varieties by producing maximum yield and poor performance of Sariab-92 (Quetta origin). In Quetta environment, the maximum grain yield was recorded in Zardana (Quetta origin). This superior and poor performance of varieties may be associated to climatic conditions change, and adoptability of variety to a particular environment. Altinbas *et al.* (2004) examined wheat cultivars under various environmental dynamics at three locations and concluded that the differences among genotype and location

means were significant for all the traits. The genotypic effect for 1000-kernel weight and location effect for the other traits notably contributed to the total variation. Baric and Pecina, (2004) reported that genotypic and environmental effects on quality of four wheat cultivars under twelve environments were significant. Suitability and stability did not significantly vary between early and optimum sowing dates.

CONCLUSION

The results concluded that seeding rate of 125 kg ha^{-1} proved to be appropriate for obtaining optimum grain yield of wheat under both Tandojam and Quetta locations. The performance of varieties was better in their native locations. Mehran-89 in Tandojam and Zardana in Quetta produced the highest grain yield as compared to other varieties. Variety Mehran-89 showed positive adaptability under agro-ecological conditions of Quetta. Similarly, variety Zardana of Balochistan showed effective adaptability under agro-climatic conditions of Tandojam. Therefore, site specific varieties should be considered for wheat production.

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