low protein contents. Similarly, the use of *L. starkeyi* as a converter of starch into SCP did not prove convenient for the same reason.

It should be recognized that SCP evaluated on the basis of N × 6.25 creates significant errors when comparisons are made with other protein sources due, primarily, to RNA contents. Also very confusing is the expression of amino acid content of SCP as grams per 16 g of nitrogen or grams per 100 g of protein, when the actual contents of total nitrogen and true protein are not given.

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Influences of Irrigation Regimens on Phytate and Mineral Contents of Wheat Grain and Estimates of Genetic Parameters

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To determine the effects of irrigation on the phytate and mineral contents of the grain and to estimate the magnitude of genotype–environment interaction, eight Iranian and two foreign wheat (*Triticum aestivum* L.) varieties were grown under dryland and irrigated conditions for 2 years. Grain yield, phytate P (PP), total P (TP), and PP as percent of TP were reduced while plant height, nonphytate P (NPP), and Ca were increased under dryland conditions. Genotypic variances were low while environmental variances comprised high proportions of total variability in the Iranian wheats. The genotype–environment interaction variance was low for plant height, Fe, TP, and yield and high for Mg and Zn.

Between 40 and 94% of the total P in wheat grain is shown to be constituted of phytic acid (O'Dell et al., 1972; Abernethy et al., 1973; Nahapetian and Bassiri, 1975, 1976; Bassiri and Nahapetian, 1977). Considerable research has been conducted to determine the relationships between phytate P (phytic acid) and other chemical constituents within the wheat grain (Reinhold, 1971, 1975a,b; Halsted et al., 1972; Berlyne et al., 1973; Reinhold et al., 1973a,b; Nahapetian and Bassiri, 1975, 1976; Bassiri and Nahapetian, 1977).

Excess phytate in the diet (predominantly bread of high phytate content) in villages of Iran decreases the availability of Ca, Zn, Fe, and Mg, thus causing deficiencies of these minerals and symptoms associated with them (Reinhold, 1971, 1972, 1975a; Reinhold et al., 1973a).

One way to decrease the amount of phytic acid in the diet is the production of wheat varieties having genetically low phytic acid content of the grain. Through breeding programs, new varieties should be made available which are as good as or better than the present varieties but with low phytate.

A breeder should know the magnitude of some genetic parameters such as genotypic, environmental, and their interaction variances and heritability of each character prior to the start of breeding for improved varieties. There are no reports on the importance of genotype–environment effects on the grain contents of phytic acid and minerals in Iranian wheat varieties. The present experiment was conducted to determine (1) the interrelationships between phytate and some mineral constituents in the wheat grain as affected by irrigation regimens in 2 years and (2) the contribution of genotype, environment, and their interaction to the total variation when each irrigation regimen in each year is considered a separate environment.

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MATERIALS AND METHODS

Two foreign (Penjamo and Tobari) and eight Iranian (Derakhshan, Harbash, Jawanjani, Jolgeh, Kalheidari, Koohrang, Ommid, and Roshan) varieties of wheat (*Triticum aestivum* L.) were grown in two adjacent experimental fields at the College of Agriculture Experiment Station, Shiraz University, Shiraz, Iran, in two successive years. The soil characteristics at the site of the experiments are previously reported (Bassiri and Nahapetian, 1977). The fields were kept fallow the year prior to plantings and were not fertilized during the course of the experiment.

Plantings were made during mid-November of each year in a randomized complete block design with four replications in each field. Within each year one field was designated as dryland (irrigated only after sowing) and the other as irrigated (irrigated after sowing and whenever necessary). The amounts and dates of natural precipitation and irrigation are reported earlier for the first year (Bassiri and Nahapetian, 1977) and shown in Figure 1 for the second year.

Each plot consisted of six 5-m rows at 50-cm distance but only the four middle rows were harvested in late May or early June. The grains were weighed and analyzed for

Table I. Grain Yield and Plant Height of Ten Wheat (*Triticum aestivum* L.) Varieties under Dryland and Irrigated Conditions during 1975-1976

	grain yield,[a] kg/ha		plant height,[a] cm	
variety (V)	dryland	irrigated	dryland	irrigated
Derakhshan	931 c	1312 cd	102.5 a	90.0 a
Harbash	1138 ab	1900 a	91.2 ab	77.5 a
Jawanjani	1112 ab	1788 ab	85.0 ab	80.0 a
Jolgeh	875 c	1388 bcd	86.2 ab	85.0 a
Kalheidari	1212 a	1218 d	80.0 ab	82.5 a
Koohrang	938 c	1648 abcd	92.5 ab	75.0 a
Ommid	938 c	1600 abcd	97.5 ab	83.8 a
Penjamo	1175 a	1385 bcd	77.5 ab	71.2 a
Roshan	1090 ab	1725 abc	88.8 ab	87.5 a
Tobari	994 b	1275 cd	73.8 b	53.8 b
av	1040	1524	87.5	78.6
CV,[b] %	9.1	17.9	13.3	11.0
irrigation (I) effect	**[c]		**	
V × I interaction	**		ns[c]	

[a]Means in each column followed by the same letter are not significantly different at the 1% probability level (Duncan's test). [b]Coefficient of variability. [c]Significant at the 1% probability level (**) or not significant (ns).

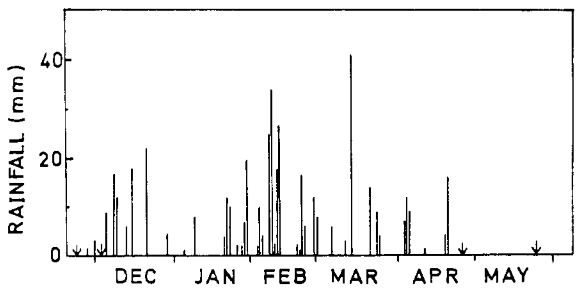

Figure 1. Distribution of rainfall at the site of experiment during the growing season of 1975–1976. Arrows indicate the date of irrigation for the irrigated treatment.

the contents of phytate P, nonphytate P, phytate P as percent of total P, and total P as described by Nahapetian and Bassiri (1975) and for the contents of Ca, Mg, Fe, and Zn determined on a Zeiss Model PMQII atomic absorption spectrophotometer, using the method of O'Dell et al. (1972).

Data of each irrigation regimen within each year (designated as data for an environment) were subjected to the analysis of variance according to a randomized complete block design. For each character, the combined data of the four environments (two irrigation regimens by 2 years) were analyzed according to the following model:

$$x_{ijk} = \mu + \text{rep}_{ij} + \text{env}_j + \text{var}_k + (\text{env} \times \text{var})_{jk} + \epsilon_{ijk}$$

where x_{ijk} indicates the observation on the ith block in the jth environment on the kth variety, μ designates the overall population mean, and the other symbols, from left to right, indicate the effects of the ith block within jth environment, jth environment, kth variety, the interaction of jth environment on the kth variety, and the pooled error. Genotypic (σ_V^2), environmental (σ_E^2), genotype–environment interaction (σ_{VE}^2), error (σ_e^2), and phenotypic (σ_A^2) variances were estimated by equating mean squares to their respective expectations and solving for the required component (Allard, 1960). Heritability (H) of each trait was estimated as

$$H = (\sigma_V^2/\sigma_A^2) \times 100$$

Simple correlation coefficients were calculated between characters using the data of both years (128 observations per character pair).

RESULTS

The results of the experiment for the first year are previously reported (Bassiri and Nahapetian, 1977), thus the data of the second year will be briefly presented first and then those of both years will be considered.

Variations and Interrelationships. There were great differences among varieties as far as yield and plant height were concerned under both irrigation conditions (Table I). Irrigation caused significantly higher yields, about 50% more as compared to dryland wheats while plant height decreased under irrigation conditions (Table I). The interaction of variety by irrigation was highly significant for yield of the grain but it was nonsignificant for plant height. The variation in yield was greater under irrigated conditions as depicted from the coefficients of variability (Table I).

Data on P constituents (phytate P, nonphytate P, phytate P as percent of total P, and total P) are shown in Table II. In general, there were differences between varieties for all the P constituents under both irrigation regimens except that under dryland conditions, all varieties had statistically similar amounts of total P (TP) in their grains. Irrigated plants had higher amounts of phytate P (PP) and TP and as a result higher amounts of PP as percent of TP (PP % TP). The case for nonphytate P (NPP) was the reverse. The differences between the overall means of varieties under the two irrigation conditions for each of the P constituents were significant. The variety by irrigation interaction effect was highly significant for PP, significant at the 5% level for NPP and PP % TP and not significant for TP. In general, the varieties with higher contents of TP also produced higher amounts of PP in their grains (Table II). For example, Derakhshan and Tobari, which had relatively very high amounts of TP in their grains under irrigated conditions, also had quite high amounts of PP under the same conditions.

With the exception of Fe, plant elemental compositions within each irrigation regimen were different from the composition for plants grown under dryland conditions (Table III). Lower Ca and higher Mg in the grains occurred under irrigation but irrigation had no effect on grain Fe and Zn contents. There was a variety by irrigation interaction for all elements except Fe.

The correlation coefficients among character pairs are reported in Table IV. Under dryland conditions, grain yield was related to only Zn (5% level), and plant height was not associated with any of the other measured characteristics. Grain yield was, however, significantly correlated with plant height, NPP, PP % TP, and TP and Zn under irrigated conditions. Plant height was associated with Ca (5% level) and Zn (1% level). Significant cor-

Table II. Concentrations of Phytate P, Nonphytate P, Phytate P as Percent of Total P, and Total P in Grains of Wheat (*Triticum Aestivum* L.) Varieties under Dryland and Irrigated Conditions during 1975-1976

variety (V)	phytate P,[a] mg/100 g		nonphytate P,[a] mg/100 g		phytate P as percent of total P[a]		total p,[a] mg/100 g	
	dryland	irrigated	dryland	irrigated	dryland	irrigated	dryland	irrigated
Derakhshan	286 a	334 ab	55 b	68 abc	84 a	83 abc	341 a	401 a
Harbash	269 ab	306 b	89 ab	36 c	75 ab	89 a	358 a	342 d
Jawanjani	240 bcd	307 b	83 ab	44 c	74 ab	88 ab	323 a	351 bcd
Jolgeh	260 abc	312 b	90 ab	61 abc	75 ab	84 abc	350 a	373 bcd
Kalheidari	245 bcd	306 b	91 ab	80 ab	73 ab	79 cd	336 a	386 ab
Koohrang	233 d	278 c	90 ab	67 abc	72 ab	81 bcd	323 a	345 cd
Ommid	270 ab	326 ab	81 ab	46 c	78 ab	88 ab	351 a	372 abcd
Penjamo	226 d	322 ab	100 ab	60 abc	70 b	84 abc	326 a	381 abc
Roshan	247 bcd	270 c	85 ab	91 a	74 ab	75 d	332 a	361 bcd
Tobari	234 cd	342 a	125 a	56 bc	66 b	86 abc	359 a	398 a
av	251	310	89	61	74	84	340	371
CV,[b] %	8.1	5.8	32.3	32.5	9.7	5.6	7.4	6.1
irrigation (I) effect	**[c]		**		**		*	
V × I interaction effect	**		*[c]		*		ns[c]	

[a]Means in each column followed by the same letter are not significantly different at the 1% probability level (Duncan's test). [b] Coefficient of variability. [c] Significant at the 1% (**) or 5% (*) probability levels or not significant (ns).

Table III. Concentrations of Ca, Mg, Fe, and Zn in Grains of Wheat (*Triticum aestivum* L.) Varieties under Dryland and Irrigated Conditions during 1975-1976

variety (V)	Ca,[a] ppm		Mg,[a] ppm		Fe,[a] ppm		Zn,[a] ppm	
	dryland	irrigated	dryland	irrigated	dryland	irrigated	dryland	irrigated
Derakhshan	405 bc	514 ab	1813 ab	1971 a	20 a	18 b	40 bc	34 bc
Harbash	496 bc	408 abcd	1860 a	1586 f	24 a	15 b	31 cd	30 cd
Jawanjani	344 c	448 abcd	1656 bc	1672 ef	20 a	40 a	34 bcd	25 d
Jolgeh	1038 a	492 abc	1774 abc	1914 ab	20 a	16 b	60 a	33 bcd
Kalheidari	449 bc	327 d	1704 abc	1883 ab	28 a	24 ab	34 bcd	41 b
Koohrang	549 b	525 a	1703 abc	1813 bcd	23 a	21 b	42 b	55 a
Ommid	466 bc	533 a	1641 c	1641 ef	21 a	14 b	30 d	33 bcd
Penjamo	378 bc	366 bcd	1680 bc	1828 bc	22 a	16 b	30 d	37 bc
Roshan	452 bc	357 cd	1766 abc	1743 cde	18 a	17 b	28 d	32 cd
Tobari	400 bc	477 abcd	1664 bc	1719 de	18 a	14 b	32 bcd	37 bc
av	498	445	1726	1777	21	20	36	36
CV,[b] %	22.1	21.3	5.7	3.9	29.7	58.1	20.0	14.8
irrigation (I) effect	*[c]		*		ns[c]		ns	
V × I interaction effect	**[c]		**		ns		**	

[a]Means in each column followed by the same letter are not significantly different at the 1% probability level (Duncan's test). [b]Coefficient of variability. [c]Significant at the 1% (**) or 5% (*) probability levels or not significant (ns).

Table IV. Correlation Coefficients[a] among Grain Yield (GY), Plant Height (PH), Concentration of Phytate P (PP), Nonphytate P (NPP), Phytate P as Percent of Total P (PP % TP), Total P (TP), Ca, Mg, Fe, and Zn of Wheat (*Triticum aestivum* L.) Grains under Dryland (Lower Diagonal) and Irrigated (Upper Diagonal) Conditions during 1975-1976

	GY	PH	PP	NPP	PP % TP	TP	Ca	Mg	Fe	Zn
GY		0.40**	0.08	-0.38*	0.37*	-0.35*	0.17	0.02	-0.11	-0.40*
PH			-0.20	-0.05	0.01	-0.16	0.33*	-0.01	0.02	-0.41**
PP	0.00	0.04		-0.36*	0.53**	0.65**	0.11	0.11	-0.03	-0.12
NPP	-0.11	-0.08	-0.51**[b]		-0.98**	0.47**	-0.20	0.31*	-0.14	0.32*
PP % TP	0.08	0.07	0.58**	-0.97**		-0.29	0.21	-0.26	0.14	-0.33*
TP	-0.20	-0.06	0.42**	0.59**	-0.36*		0.08	-0.36*	-0.14	0.11
Ca	-0.09	0.05	0.20	0.07	-0.00	0.25		-0.05	-0.11	0.10
Mg	-0.22	-0.09	0.50**	-0.23	0.32*	0.23	0.22		-0.01	0.37*
Fe	-0.23	-0.13	0.03	-0.46**	0.03	-0.02	0.11	0.17		-0.11
Zn	-0.34*[b]	-0.22	0.22	-0.17	0.21	0.03	0.58**	0.21	-0.02	

[a]Each correlation coefficient is based on 38 degrees of freedom. [b]Significant at the 1% (**) or 5% (*) probability level.

relations were obtained among all the P constituents, except for between TP and PP % TP under irrigated conditions.

Among the mineral constituents the only significant associations were those between Zn and Ca (1% level) under dryland and Mg and Zn (5% level) under irrigated conditions. Out of the 16 possible correlations among the P constituents and minerals only those between PP and Mg (1% level), NPP and Fe (1% level), and PP % TP and Mg (5% level) were significant. Under irrigated conditions, the significant correlations (5% level only) were between NPP and Mg, TP and Mg, NPP and Zn, and PP % TP and Zn.

Genetic Parameters Based on Data of Both Years. The objective of this part of study was the estimation of important genetic parameters useful to breeders in improving the Iranian varieties of wheat, thus only the data on the eight Iranian varieties are considered here.

Table V. Overall Means[a] of Grain Yield, Plant Height, Phytate P, Nonphytate P, Phytate P as Percent of Total P, Total P, Ca, Mg, Fe, and Zn in Grains of Iranian Wheat (*Triticum aestivum* L.) Varieties under Dryland and Irrigated Conditions for Two Successive Years

variety	grain yield, kg/ha	plant ht, cm	phytate P, mg/100 g	non-phytate P, mg/100 g	phytate P as % of total P	total P, mg/100 g	Ca, ppm	Mg, ppm	Fe, ppm	Zn, ppm
Derakhshan	1344 a	96 a	300 a	86 cd	78 a	385 a	664 a	1837 a	50 ab	40 ab
Harbash	1502 a	91 a	295 a	78 d	79 a	367 ab	688 a	1830 a	44 ab	36 bc
Jawanjani	1295 a	90 a	255 b	108 abc	71 bc	363 ab	384 b	1551 bc	46 ab	34 bc
Jolgeh	1224 a	89 a	267 b	120 a	69 c	387 a	699 a	1649 b	42 b	45 a
Kalheidari	1376 a	85 a	264 b	115 ab	69 c	379 a	433 b	1557 bc	58 a	44 a
Koohrang	1460 a	85 a	266 b	75 d	78 a	341 b	496 b	1559 bc	37 b	43 a
Ommid	1353 a	92 a	272 b	92 bcd	75 ab	365 ab	452 b	1473 c	37 b	34 bc
Roshan	1366 a	87 a	257 b	103 abc	71 bc	360 ab	442 b	1506 bc	38 b	33 c

[a]Each figure is the average of 16 observations. [b]Means in each column followed by the same letter are not significantly different at the 1% probability level (Duncan's test).

The overall means of the characteristics measured in both years under the two irrigation regimens are reported in Table V. In general, the varieties were not significantly different for the grain yield and plant height, while for other characteristics, highly significant differences were observed.

The breakdown of sources of variation, degrees of freedom (df) and the mean squares for the measured characteristics are shown in Table VI. The grain yield and plant height were not significant for the variety effect (V) but variety effect was significant for all other characters measured. When each irrigation regimen within each year was considered as a specific environment (E), one character (plant height) was found to be affected by environment at the 5% level and the rest at the 1% level. The effect of environment was broken down into irrigation (I), year (Y), and I × Y interaction and it was found that the effect of I was not significant for plant height, Mg, Fe, and Zn. The effect of Y was highly significant for all characteristics measured and the I × Y interaction was significant for all but plant height, Fe, and Zn. Thus the effect of year seems to be much greater than that of the irrigation regimen.

The V × E interaction was not significant for grain yield, plant height, TP, and Fe while it was highly significant for the other characters measured. The breakdown of this interaction into other specific interactions gave similar results except for Fe which showed a highly significant V × Y interaction effect.

Grain yield, plant height, and Mg had very small and negligible genotypic variances (Table VII). The genotypic variance for the grain yield was actually negative, the best estimate of which would be zero as reported here. The genotypic variances for other characters were also quite small as compared to other variances. The highest genotypic variance was that of Zn which comprised 13.8% of the total variation.

The environmental variance (σ_E^2) was rather high for all characteristics measured except for plant height and Zn. The interaction of genotype–environment variance was low for most characteristics especially for plant height, TP, Fe, and yield.

The heritability value, which is actually the ratio of genotypic to phenotypic variances, was nil for grain yield, low for Mg, plant height, NPP, and PP % TP, high for TP, Fe, and Zn, and intermediate for Ca and PP.

When the overall data of both irrigation regimens and years were considered and simple correlation coefficients were calculated for each character pair (128 observations for each character), more than two-thirds of correlations were found to be significant (Table VIII). Grain yield was highly associated with P constituents and Ca. Plant height was correlated to TP and all of the elements. All the P constituents were either significantly or highly significantly associated with each other except TP and PP % TP. Furthermore, all the mineral elements in the grain were highly significantly related to each other except Zn and Mg.

DISCUSSION

Comparison of Irrigation Regimens and Years. Irrigation, in general, significantly affected all characters except Fe and Zn (Tables I, II, and III). Similar results were also obtained for the first year of the study (Bassiri and Nahapetian, 1977).

The differences caused by the two irrigation regimens can be mainly attributed to the two irrigations at the end of April and May (Figure 1). There was a good distribution of rainfall during the growing season up to the end of April, but no precipitation occurred during the grain maturation period when it was quite dry and hot and plants were in need of water. Thus a large proportion of the differences between the characteristics of dryland and irrigated wheat could be attributed to the last two irrigations.

The frequency of rainy days and the amount of rainfall were much higher in the second year as compared to the first year. However, in spite of a good amount of precipitation during May of the first year, no rainfall occurred at the end of April up to the harvest time in the second year. These differences are probably the cause of the highly significant year effect for all the measured characteristics (Table VI).

In the second year, the grain yields, although generally less than those of the first year (Bassiri and Nahapetian, 1977), were close to the averages of the commercial farm lands of the Fars region (Bassiri, 1974). Roshan which is the predominant variety in the region was among the higher yielding varieties under both irrigation conditions. However, in the first year of study, Koohrang and Derakhshan had very high yields (Bassiri and Nahapetian, 1977) but were among the lower yielding varieties in the second year. Harbash and Jawanjani were the most productive varieties under both high and low water availability in the second year. When the overall data of both years were considered, all varieties had statistically similar grain yields (Table V). Roshan which is grown over 65% of land under wheat cultivation in the Fars region (Bassiri, 1974) could probably be replaced by other high-yielding varieties if the replacing varieties are superior in other important characteristics.

It has been previously discussed by Bassiri and Nahapetian (1977) that a good-yielding wheat variety low in phytic acid and high in minerals would be most suitable

Table VI. Breakdown of Sources of Variation with Their Respective Degrees of Freedom (df) and Mean Squares for Grain Yield, Plant Height, Phytate P, Nonphytate P, Phytate P as Percent of Total P, Ca, Mg, Fe, and Zn in Grains of Iranian Wheat (*Triticum aestivum* L.) Varieties under Dryland and Irrigated Conditions for Two Successive Years[a]

sources of variation	df	grain yield	plant ht	phytate P	nonphytate P	phytate P as % of total P	total P	Ca	Mg	Fe	Zn
variety, V	7	121 364	228	4 357**	4 541**	279**	3 701**	267 830**	317 540**	914**	409**
environment, E	3	6 933 653**	888*	112 021**	71 155**	5577**	26 896**	1 514 220**	897 773**	22 243**	301**
irrigation, I	1	18 401 211**	44	267 638**	97 627**	9505**	45 678**	2 751 565**	49 731	245	9
year, Y	1	1 042 207**	2072**	9 129**	79 152**	4290**	31 312**	254 809**	2 450 069**	66 385**	815**
I × Y	1	1 357 540**	549	59 297**	36 687**	2936**	3 698*	1 536 285**	193 520*	100	80
V × E	21	164 130	223	2 970**	4 276**	257**	930	182 014**	316 313**	298	197**
V × I	7	88 797	229	4002**	5 102**	323**	906	168 543**	462 086**	119	155**
V × Y	7	198 712	286	2 700**	4 125**	242**	1 051	214 138**	222 587**	657**	249**
V × I × Y	7	204 882	155	2 238**	3 602**	205**	833	163 361**	264 266**	119	187**
pooled error	84	99 704	263	407	624	34	705	27 742	28 728	207	41

[a] Significant at the 5% (*) and 1% (**) probability levels.

Table VII. Estimates of Genotypic (σ_V^2), Environmental (σ_E^2), Genotype-Environment Interaction (σ_{VE}^2), Error (σ_e^2), and Phenotypic (σ_A^2) Variances and Heritability (H) of Grain Yield, Plant Height, Phytate P, Nonphytate P, Phytate P as Percent of Total P, Total P, Ca, Mg, Fe, and Zn in Grains of Iranian Wheat (*Triticum aestivum* L.) Varieties under Dryland and Irrigated Conditions for Two Successive Years

genetic parameters	grain yield	plant ht	phytate P	nonphytate P	phytate P as % of total P	total P	Ca	Mg	Fe	Zn
σ_V^2	0.0 (0.0)[a]	0.3 (<0.1)	86.7 (1.9)	16.6 (0.4)	1.4 (0.5)	173.2 (9.9)	5 363.5 (4.7)	76.7 (<0.1)	38.4 (4.0)	13.2 (13.8)
σ_E^2	211 547.6 (64.6)	20.8 (7.3)	3407.9 (75.0)	2089.9 (57.4)	166.2 (64.6)	811.4 (46.5)	41 631.4 (36.7)	18 170.6 (15.3)	685.8 (71.9)	3.2 (3.4)
σ_{VE}^2	16 106.6 (4.9)	0.0 (0.0)	640.6 (14.1)	912.9 (25.1)	55.8 (21.7)	56.2 (3.2)	38 567.9 (34.0)	71 896.0 (60.5)	22.8 (2.4)	39.1 (40.6)
σ_e^2	99 703.6 (30.4)	263.3 (92.6)	407.4 (9.0)	624.5 (17.1)	33.7 (13.1)	705.1 (40.4)	27 742.4 (24.5)	28 728.5 (24.2)	207.2 (21.7)	40.6 (42.2)
σ_A^2	7 142.4	8.5	259.6	264.3	16.4	209.2	15 872.4	18 948.5	50.6	24.3
H, %	0.0	3.33	33.39	6.26	8.44	82.75	33.79	0.40	75.96	54.51

[a] Percentages are in parentheses.

Table VIII. Correlation Coefficients[a] among Grain Yield (GY), Plant Height (PH), Phytate P (PP), Nonphytate P (NPP), Phytate P as Percent of Total P (PP % TP), Total P (TP), Ca, Mg, Fe, and Zn in Grains of Iranian Wheat (*Triticum aestivum* L.) Varieties under Dryland and Irrigated Conditions for Two Successive Years

	GY	PH	PP	NPP	PP % TP	TP	Ca	Mg	Fe
PH	-0.07								
PP	0.66**[b]	-0.03							
NPP	-0.48**	-0.11	-0.78**						
PP % TP	0.55**	0.08	0.88**	-0.98**					
TP	0.35**	-0.18*[b]	0.43**	0.20**	-0.04				
Ca	-0.41**	-0.19*	-0.29**	0.25**	-0.27**	-0.13			
Mg	-0.16	0.26**	0.24**	-0.30**	0.31**	-0.12	0.42**		
Fe	0.05	-0.30**	-0.14	0.42**	-0.37**	0.34**	0.28**	-0.29**	
Zn	-0.11	-0.34**	-0.02	0.21*	-0.16	0.26**	0.24**	0.03	0.34**

[a]Each correlation coefficient is based on 126 degrees of freedom. [b]Significant at the 1% (**) or 5% (*) probability level.

for the villagers of Iran because the consumption of bread rich in phytic acid is quite high in villages and symptoms of rickets and other diseases caused by deficiencies of Fe, Zn, Mg, and Ca are frequently reported (Reinhold, 1972, 1975b).

Probably the best indication of phytic acid in the grain would be phytate P as percent of total P (PP % TP). The mean value of this characteristic was higher when wheats were irrigated (Table II). Similar results were obtained in the first year of study (Bassiri and Nahapetian, 1977). Penjamo and Tobari under dryland and Roshan under irrigation had the lowest values of PP % TP (Table II). When the overall data of both years were considered, it was observed that Kalheidari, Jolgeh, Jawanjani, and Roshan had relatively lower amounts of PP % TP (Table V). However, for a variety to be selected as a replacement for Roshan, the mineral contents of the grain should also be considered. Tobari had high contents of all minerals under both irrigation regimens in the first year and Jolgeh had high contents of Ca and Mg under both irrigation conditions and Fe and Zn under dryland in the second year. The combined data showed Derakhshan to be relatively superior to other varieties when all the four measured elements were considered (Table V). However, unfortunately Derakhshan had relatively high PP % TP.

The correlations, in general, were in agreement for both years within each irrigation regimen. Highly significant correlations existed between the P constituents under both irrigation conditions (Table IV). The relationship between phytate P (PP) and total P (TP) was significant under both irrigation conditions within each year. Similar relationships have been found between these two characteristics in beans (Lolas and Markakis, 1975) and in wheat grains (Nahapetian and Bassiri, 1976).

Genetic Parameters. When varieties obtain different ranks under different test locations or under different sets of environmental conditions, this is a possible consequence of the presence of a significant genotype–environment (V × E) interaction. Thus tests which are done in a single location under one set of conditions are valid only if the V × E effect is negligible. A major goal of a plant breeder is to produce a variety which is superior in performance in all of the environments in which it is likely to be grown. In the present study, V × E was highly significant for PP, NPP, PP % TP, Ca, Mg, and Zn and not significant for others (Table VI). Thus the average performance of these varieties with respect to these characteristics varied significantly in different environments. The contribution of σ_{VE}^2 to total variation for yield, plant height, TP, and Fe was less than 5% (Table VII). The nonsignificant V × E results in this study are in disagreement to those of Luthra and Singh (1974) for yield and plant height in eight varieties of wheat and those of Lebsock et al. (1973) for yield of a large number of durum wheat lines.

The grain yield and plant height heritabilities were nil and very low, respectively, due to the high number of genes and the complexity involved in the genetics of these characters. Among the P constituents, TP had high, PP intermediate, and others low heritabilities. Among the mineral elements, Fe had high, Zn and Ca intermediate, and Mg very low heritability estimates. This is indicative that selection by the breeder would be highly effective for TP and Fe.

If the breeder's goal is to select for a character of primary importance which has low heritability, then it would be worthwhile to consider its significant correlation with another character of high heritability. This is an indirect manner of selection. For example, in this study, if one selects for high Fe, he is automatically selecting for high values of NPP, TP, Ca, and Zn and against plant height, PP % TP and Mg (Table VIII), all of which are desirable except the lower Mg content that might be obtained in this manner.

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