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Agronomic Performance of Intercropped Wheat Cultivars

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Abstract: A field study was carried out to assess whether intercropping of three commonly used cultivars of wheat in Iran with different height may increase seed yield. Seed yield three wheat cultivars which differed in were investigated at educational field of Gonbad Agricultural Faculty in 2005-2006 (Iran). The statistical design was factorial 3 plant densities of 300, 350 and 400 seed in m^2 with 6 intercropping ratios of Kohdasht, Tajan and Zagros (3 pure stand and 3 50:50 intercropping of Kohdasht, Tajan and Zagros cultivars, respectively) in completely randomized blocks. The results showed that none of the treatments has no significant effect on yield. The results indicated that the highest seed yield was obtained from 50:50 ratios of Tajan-Zagros cultivars in density plant 400 of seed in m^2 which had Land Equivalent Ratio (LER) above 1.25 Calculation of LER revealed that seed yield in treatment TZTZTZ was 25% higher than the pure stand. Intercropping ratio showed no significant effect on any of yield components.

Key words: Intercropping, yield, wheat, LER

INTRODUCTION

Mixtures of field crops are still extensively grown in traditional agriculture, but where more mechanized methods are used, monocultures are more common. Also growing of variety mixtures instead of pure line varieties has been proposed as a means of obtaining higher and more stable yields. The suggested advantages of this cropping system include yield stability under adverse environmental conditions, efficient use of limited growth resources, biological diversity and potential control of pests and diseases. Many studies have shown that intercropping system out yielded monocultures of component crops (Baumann *et al*., 2001; Lesoing and Francis, 1999; Ghaffarzadeh *et al*., 1997; Fortin *et al*., 1994; Mandal *et al*., 1990). However, some potential disadvantages associated with intercropping often have limited its practicing to low-input and small-scale agricultural systems. The disadvantages are related mainly to use of agricultural machineries especially when the component crops have different requirements for planting pattern, fertilizer, herbicides among other factors.

A yield advantage of mixed cultivars has been observed in various crops including barley (Jokinen, 1991; Valentine, 1982), flax (Gubbles and Kenachuk, 1987), small grain cereals (Juskiw *et al*., 2000). The superiority of mixed cultivars over pure stands has been attributed generally to the significant variations of morphological characteristics including root system, plant height and leaf orientation which result in efficient exploitation of environmental resources, specifically light interception. Increased lodging resistance, improved disease resistance and weed control also have been reported by Grafius (1966), Wolfe (1985) and Jokinen (1991). Herbert *et al*. (1984), Putnam *et al*. (1985), Putnam *et al*. (1986) have concluded that the advantage of intercropping of cultivar mixtures depends on plant population density.

In some regions, such as Iran, where stressful conditions including drought and high temperature occur frequently, broad environmental tolerance associated with mixed population of wheat cultivars may play a significant role in yield stability. The main objective of this study was to evaluate the seed yield of three wheat cultivars differing in maturity as influenced by intercropping at different population ratios and densities.

MATERIALS AND METHODS

This study was conducted in 2005-2006 in at educational field of Gonbad Agricultural faculty (55°, 12' N and 37°, 16' E) Iran. In this location, the average annual temperature is 17.7°C and average annual rainfall is 487 mm. The soil of the experimental site was loam clay silty with pH 7.8. Protection operation was controlled manually.

Three cultivars of Kohdasht, Tajan and Zagros were used in this study. They were with average height of 90-100, 90-95 and 95-105 cm, respectively. The design of the experiment was a factorial 3 plant densities of 300 (D_1), 350 (D_2) and 400 (D_3) seed in m^{-2} with 6 intercropping ratios of Kohdasht, Tajan and Zagros (3 pure stand and

3, 50:50 intercropping of Kohdasht, Tajan and Zagros cultivars, respectively) in completely randomized blocks. The final harvest area for measurement of seed at maturity was 2 m^2 taken from the 4 central rows. At harvest time, 10 plants of each cultivar were harvested randomly and used for determination of yield components including plant height, number of grains in spike, number of spikelt in spike and seed weight. Land equivalent ratio (LER) was calculated (Mead and Willey, 1980) and used to evaluate the advantages in yields from intercropping of the three cultivars:

$$LER = Y_{1.2}/Y_{1.1} + Y_{2.1}/Y_{2.2}$$

where, $Y_{1.1}$ and $Y_{2.2}$ are the crop yield for cultivar 1 and cultivar 2 grown in monoculture and $Y_{1.2}$ and $Y_{2.1}$ are yield of cultivars in the mixture.

Data were analyzed using ANOVA and CASTAT. Effects were considered significant for $p = 0.05$ from the F-test. Least Significant Differences (LSD) analysis and Duncan multiple range test were conducted for mean comparison.

RESULTS AND DISCUSSION

The summary of statistical analysis of data for seed yield, yield components and Plant Height is shown in Table 1. Plant density and intercropping ratio×density had no significant effect on treatments (Table 1). Ratio showed a significant ($p<0.05$) effect on number of spikelt in spike. Expected and actual seed yields for Kohdasht, Tajan and Zagros at different planting density are shown in Table 2. In high density, actual seed yield for was more than predicted yield for intercropping ratios them. This effect also explains higher actual yield of intercropping Tajan and Zagros compared with the predicted yield for these cultivars (Table 2). The results suggest clearly that in a mixed planting system where they could have utilized

Table 1: Analysis of variance for selected morphological characteristics, seed yield and yield components

	Plant height (cm)		Seed yield (kg ha^{-1})		No. of spikelt in spike		No. of grains in spike		Seed weight (mg)	
Treatment	MS	F-value	MS	F-value	MS	F-value	MS	F-value	MS	F-value
Density (D)	76.22	1.48^{ns}	153214.61	0.28^{ns}	5.00	2.89^{ns}	210.54	1.72^{ns}	1.40	0.048^{ns}
Ratio (R)	219.75	1.70^{ns}	3215551.00	2.32^{ns}	23.99	5.55*	470.71	1.54^{ns}	59.81	0.820^{ns}
D×R	215.17	0.83^{ns}	3816615.75	1.38^{ns}	8.84	1.02^{ns}	263.38	0.43^{ns}	183.86	1.280^{ns}

*Significant at the 0.05 probability levels, ns: Not significant ($p>0.05$)

Table 2: Expected and actual yield (kg ha^{-1}) of Kohdasht, Tajan and Zagros cultivars for different densities in various intercropping ratios

Density/Intercropping	KTKT (kg ha^{-1})	KZKZ (kg ha^{-1})	TZTZ (kg ha^{-1})
Low density			
Kohdasht expected yield	2117.21	2117.21	-
Kohdasht harvested yield	3026.08	2362.88	-
Difference	-908.87	-	245.67
Tajan expected yield	2670.96	-	2670.96
Tajan harvested yield	2483.08	-	2952.88
Difference	187.88	-	267.96
Zagros expected yield	-	1496.68	1496.68
Zagros harvested yield	-	2207.20	2794.16
Difference	-	710.52	-1297.48
Medium density			
Kohdasht expected yield	2395.67	2395.67	-
Kohdasht harvested yield	3116.92	1895.98	-
Difference	-721.25	499.69	
Tajan expected yield	1726.69	-	1726.69
Tajan harvested yield	2779.84	-	3642.92
Difference	-1053.15	-	1916.23
Zagros expected yield	-	1871.23	1871.23
Zagros harvested yield	-	2892.08	2510.92
Difference		-1020.85	-639.69
High density			
Kohdasht expected yield	2035.31	2035.31	-
Kohdasht harvested yield	2130.08	3148.80	-
Difference	-94.77	-1113.49	
Tajan expected yield	2525.42	-	2525.42.
Tajan harvested yield	2372.04	-	2186.66
Difference	153.38		338.76
Zagros expected yield	-	2686.52	2686.52
Zagros harvested yield	-	3095.92	3738.30
Difference		409.40	1051.78

K, T and Z are Kohdasht, Tajan and Zagros cultivars, respectively

Table 3: Mean comparisons of selected morphological characteristics, seed yield and yield components at different intercropping ratios

Intercrop ratio	Plant height (cm)	Seed yield (kg ha^{-1})	No. of spikelt in spike	No. of grains in spike	Seed weight (mg)
KKKK†	86.56a	2104.87ba	14.16abc	43.78ab	37.66a
TTTT	81.91a	2148.89ab	14.86ab	42.14ab	38.33a
ZZZZ	87.00a	1849.33b	15.04a	38.17b	37.86a
KTKT	82.09a	2356.74ab	13.01d	46.84a	39.26a
KZKZ	83.14a	2311.51ab	14.05bc	45.26ab	35.45a
TZTZ	83.72a	2639.38a	13.89ab	46.35ab	38.11a

†K, T and Z are Kohdasht, Tajan and Zagros cultivars, respectively, Values within the same column followed by the same letter(s) are not significantly different according to the Duncan's multiple range test ($p<0.05$). Means are averaged over plant densities

Table 4: Land Equivalent Ratio (LER) for grain yield production at different plant densities and intercropping ratios for three wheat cultivars

	Intercropping ratio		
Density	KTKT†	KZKZ	TZTZ
Low (D1)			
Lk‡	0.766	0.535	-
Lt	0.470	-	0.559
Lz	-	0.630	0.560
LER	1.147	1.171	1.120
Medium (D2)			
Lk‡	0.372	0.396	-
Lt	0.511	-	0.462
Lz	-	0.550	0.690
LER	0.880	1.040	1.150
High (D3)			
Lk‡	0.540	0.570	-
Lt	0.443	-	0.410
Lz	-	0.600	0.840
LER	0.991	1.170	1.250

†K, T and Z are Kohdasht, Tajan and Zagros cultivars, respectively, ‡Lk, Lt and Lz are Land Equivalent Ratio for Kohdasht, Tajan and Zagros cultivars, respectively

Table 5: Density effect on selected morphological characteristics, seed yield and yield components of mixed wheat cultivars

Plant density	Plant height (cm)	Seed yield (kg ha^{-1})	No. of spikelt in spike	No. of grains in spike	1000-seed weight (mg)
Low (D1)	85.62a	2212.72a	14.60a	46.43a	37.29a
Medium (D2)	82.74a	2184.04a	13.98ab	41.73a	37.05a
High (D3)	83.84a	2308.61a	13.92a	43.09a	37.39a

Values within the same column followed by the same letter(s) are not significantly different according to Duncan's multiple range test ($p = 0.05$). Means are averaged over intercropping ratios

environmental resources available to both cultivars more efficiently. Therefore, in a condition like this, higher yield would be obtained from intercropping of cultivars compared with the yield from their monoculture.

The seed yields obtained from pure stands of the three cultivars were 2104.87, 2148.89 and 1849.33 kg ha^{-1} for Kohdasht, Tajan and Zagros, respectively. Replacing one row of them together that is KTKT (2356.74 kg ha^{-1}), KZKZ (2311.51 kg ha^{-1}) and TZTZ (2639.38 kg ha^{-1}) (Table 3) resulted increase in seed yield compared with their monoculture, although the difference was not statistically significant in some of comparisons. The results indicated that they could have utilized environmental resources available mixed planting system more efficiently. The LER characterizes the performance of an intercrop by giving the relative land area under sole crops, required to produce the yields achieved in intercropping (Mead and Willey, 1980). A value of greater than one for LER indicates the advantage of intercropping over monoculture cropping system. In our experiment LER values were more than 1 for almost all intercropping ratios in densities. Maximum LER value (1.25) obtained from 50:50 intercropping ratio (TZTZ) of the Tajan and Zagros cultivars (Table 4). The results indicated a 25% yield increase compared with the sole crop of the cultivars.

Among the components of seed yield, only number of spikelt in spike had response to density (Table 1) and other yield components including number of seed in spike and seed weight were not affected significantly by plant density (Table 1). Also the mean of treatments density compared by Duncans multiple range test (Table 5) only number of spikelt in spike showed a significant effect.

DISCUSSION

Creation of a broader environmental tolerance and canopy architecture associated with intercropping of wheat cultivars may enhance wheat seed yield. In the present study, intercropping of the three wheat cultivars created a wavy type canopy consisted of alternate rows of shorter and taller plants. In contrast to the monoculture of either cultivar, this canopy architecture had a greater

potential for intercepting radiation and thus dry matter production. Earlier studies have demonstrated an enhancement effect of intergenotypic competition on seed yield of wheat cultivars grown in mixed planting systems (Jokinen, 1991; Valentine, 1982; Juskiw *et al*., 2000). The results obtained in the present study are consistent with these reports. The yield advantage of the intercropping system reflected in LER value indicated an 25% increase compared with the sole crop of the these cultivars. These results were in agreement with descriptions of in the present study. Mixture of varieties benefit from the association by production of more uniform leaf distribution and also by reduction of competition among plants for using of sunlight with created a wavy canopy because of high different between cultivars which causes to intercept more sunlight.

The purpose of this study was when we use more than two cultivars for intercropping, how change yield and component yield in wheat.

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