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Professional paper

IRRIGATION-CULTIVATION INTERACTION ON YIELD AND OTHER PARAMETERS OF SOME CORN HYBRIDS (Zea Mays)

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Abstract

To select the most suitable hybrids for the climatic and soil conditions of the Pollog region during the 2024 vegetative season, a field experiment was established following a randomized block design with five replications.

The experiment investigated several production parameters for various maize hybrids, including: the number of ears per plant, the number of kernels per ear, the number of kernels per plant, ear weight, kernel weight per ear, cob weight, yield, and productivity. The hybrids involved in the experiment were from different producing companies and belonged to different FAO groups: FAO-380 (GW9003), FAO 470 (Pajdash), and FAO 400 (Kashmir).

The results of the analysis of variance showed that the model was statistically significant ($F(5,24) = 15.222$, $p < .001$), explaining 76.0% of the variance in yield ($R^2 = .760$). The effect of individual factors was as follows: Irrigation had a highly significant impact on yield ($F(1,24) = 35.430$, $p < .001$), indicating that the application of irrigation significantly improves productivity. The hybrids also showed statistically significant differences ($F(2,24) = 4.048$, $p = .031$), suggesting that genetic differences between hybrids affect yield levels. The interaction between irrigation and hybrid was particularly pronounced and meaningful: ($F(2,24) = 16.293$, $p < .001$), indicating that the effect of irrigation is not the same for all varieties benefit more from irrigation than others.

Keywords: variant, hybrid, yield, productivity, interaction, significance.

1. Introduction

Maize (*Zea mays* L.) belongs to the monocotyledonous plant family (Poaceae). It originates from Central America, from where it spread to Europe and the rest of the world. Today, maize is one of the most important cereal crops globally, along with rice and wheat. It is cultivated across various regions due to its adaptability to different climatic and soil conditions. Maize kernels contain 70–75% carbohydrates, 10% proteins, about 5% oil, 15% minerals, and 2.5% cellulose. It also contains essential amino acids such as lysine, tryptophan, and methionine, which significantly enhance its nutritional value.

In addition to its economic importance, maize has agronomic significance as it serves as an excellent preceding crop for most other plants. It leaves the soil relatively weed-free and does not typically host problematic infections for subsequent crops.

The world's largest maize producers are the USA, China, Brazil, the EU-28, and Argentina. In the EU, maize is grown on more than 15 million hectares, of which 60% (9.4 million ha) is for grain and 40% (5.9 million ha) for silage.

Maize is a highly important crop in North Macedonia. In recent years, about 70,000–80,000 hectares have been planted with maize. A primary agricultural interest in North Macedonia is the regionalization of maize hybrids, focusing on selecting those with high adaptability to local climatic and soil conditions, as well as high genetic yield potential. The regions with the highest

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maize productivity are the Pelagonia and Polog regions. In North Macedonia, the demand for maize as a primary feed for livestock is significantly higher than the domestic production.

2. Materials and Methods

The experimental material included three maize hybrids: GW9003 (FAO-380), Pajdash (FAO-470), and Kashmir (FAO-400). The experimental design was a randomized block with five replications.

The aim of the research was to determine the effect of irrigation on different maize hybrids and to assess which hybrid, depending on the FAO group, produces the highest yield under non-irrigated conditions.

3. Results and Discussion

Table 1. Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: Yield

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	122.141[a]	5	24.428	15.222	.000
Intercept	7934.880	1	7934.880	4944.621	.000
Irrigation	56.856	1	56.856	35.430	.000
The varieties	12.993	2	6.497	4.048	.031
Irrigation * The varieties	52.291	2	26.146	16.293	.000
Error	38.514	24	1.605		
Total	8095.535	30			
Corrected Total	160.655	29			

a. R Squared = .760 (Adjusted R Squared = .710)

The analysis of variance showed that the model was statistically significant ($F(5,24) = 15.222$, $p < .001$), explaining 76.0% of the variance in yield ($R^2 = .760$).

Individual factor effects were as follows:

- Irrigation had a highly significant effect on yield across hybrids ($F(1,24) = 35.430$, $p < .001$), indicating that irrigation substantially improves productivity.
- Hybrids were also statistically significant ($F(2,24) = 4.048$, $p = .031$), suggesting that genetic differences influence yield levels.
- Interaction between irrigation and hybrids was particularly notable ($F(2,24) = 16.293$, $p < .001$), meaning that the effect of irrigation varies between hybrids—some benefit more than others.

These results emphasize the importance of combining agronomic practices (such as irrigation) with appropriate hybrid selection to achieve higher yields and more efficient resource management.

General Model:

1. Corrected Model: $F(5,24) = 15.222$, $p < .001$ → Statistically significant.
2. Irrigation**:** $F(1,24) = 35.430$, $p < .001$ → Strong positive effect on yield.
3. Hybrid**:** $F(2,24) = 4.048$, $p = .031$ → Statistically significant but moderate effect.
4. Interaction (Irrigation × Hybrid): $F(2,24) = 16.293$, $p < .001$ → Significant variation in response among hybrids.

Multiple Comparisons

Dependent Variable: Yield

Tukey HSD

(I) **The varieties**	(J) **The varieties**	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
GW9003	Kashmir	1.0850	.56652	.156	-.3298	2.4998
	Pajdash	1.5750*	.56652	.027	.1602	2.9898
Kashmir	GW9003	-1.0850	.56652	.156	-2.4998	.3298
	Pajdash	.4900	.56652	.667	-.9248	1.9048
Pajdash	GW9003	-1.5750*	.56652	.027	-2.9898	-.1602
	Kashmir	-.4900	.56652	.667	-1.9048	.9248

Based on observed means.

The error term is Mean Square (Error) = 1.605.

*. The mean difference is significant at the .05 level.

Post Hoc Tests (Tukey HSD) The post hoc analysis revealed that:

Hybrid **GW9003** had a significantly higher yield than Pajdash (p = .027).

No significant differences were found between Kashmir and GW9003 (p = .156), nor between Kashmir and Pajdash (p = .667).

This suggests that GW9003 is the most promising hybrid, especially under non-irrigated conditions.

Yield

Tukey HSD[a,b]

The varieties	N	Subset 1	Subset 2
Pajdash	10	15.5750	
Kashmir	10	16.0650	16.0650
GW9003	10		17.1500
Sig.		.667	.156

Means for groups in homogeneous subsets are displayed. Based on observed means.

The error term is Mean Square (Error) = 1.605.

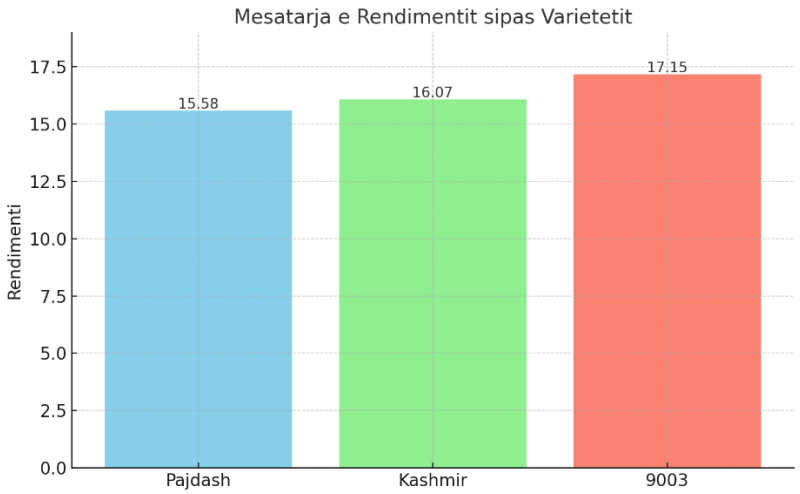
a.Uses Harmonic Mean Sample Size = 10.000.

b.Alpha = .05.

Interpretation:

- Pajdash**:** Lowest yield, forms a distinct group (Subset 1).
- Kashmir: Falls into both Subset 1 and Subset 2- moderate yield.
- GW9003**:** Highest yield, only in Subset 2 -clearly superior to Pajdash.
- **P-values summary:**Subset 1: p = .667 → no significant differences.
- Subset 2: p = .156 → also not significant within this group.
- Pajdash = low yield.
- GW9003 = high yield.
- Kashmir = "neutral" — intermediate performance.

These findings align with previous analysis: the key statistical difference is between Pajdash and GW9003**.**



This graph shows the average yield for each of the three hybrids:
Pajdash: 15.58
Kashmir: 16.07
GW9003: 17.15

1. The varieties * Irrigation

Dependent Variable: Yield

				95% Confidence Interval	
vareitetet	UJitja	Mean	Std. Error	Lower Bound	Upper Bound
GW9003	me uj	16.800	.448	15.875	17.725
	pa uj	16.800	.448	15.875	17.725
Kashmir	me uj	16.940	.448	16.015	17.865
	pa uj	15.190	.448	14.265	16.115
Pajdash	me uj	15.190	.448	14.265	16.115
	pa uj	11.340	.448	10.415	12.265

Yield Performance per Hybrid:

1. GW9003:
   - Irrigated: 16.80
   - Non-irrigated: 16.80
     → No difference; not affected by irrigation → drought-resistant.
2. Kashmir:
   - Irrigated: 16.94
   - Non-irrigated: 15.19
     → ~1.75-unit increase → Irrigation has a positive effect.
3. Pajdash:
   - Irrigated: 15.19
   - Non-irrigated: 11.34
     → ~3.85-unit increase → very sensitive to irrigation.

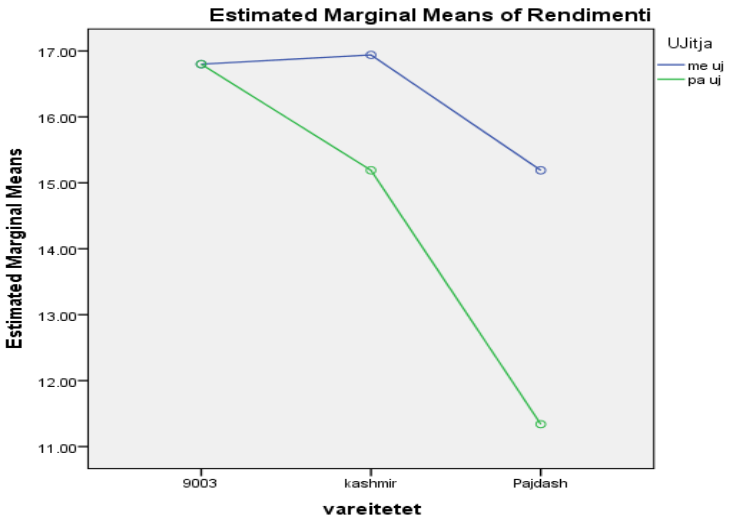


Chart 1. Impact of Irrigation on Hybrids:

- Irrigation improves yield in Kashmir and Pajdash.
- GW9003 is unaffected by irrigation – most drought-tolerant.
- Pajdash benefits the most from irrigation but is weakest without water.
- Kashmir has a higher average yield under irrigation but is more sensitive than GW9003.

Conclusion

Impact Analysis of Irrigation and Hybrid on Maize Yield

ANOVA showed that irrigation, hybrid, and their interaction significantly affect maize yield (Table 1).
Irrigation had a highly significant effect on increasing yield ($F = 35.430$, $p < .001$).
Hybrid differences were also statistically significant ($F = 4.048$, $p = .031$).
The irrigation × hybrid interaction was highly significant ($F = 16.293$, $p < .001$), indicating that irrigation effects vary by hybrid.
These results suggest that selecting the right hybrid and applying appropriate irrigation practices is crucial for yield optimization.
The strong interaction underscores the need to analyze how different hybrids respond to irrigation treatments.
According to Tukey HSD post hoc analysis, the difference between GW9003 and Pajdash was statistically significant, confirming that this yield difference is not random.
In a scientific report, this chart supports the conclusion that hybrid choice affects yield, and that GW9003 is the most productive.
A one-way ANOVA conducted to evaluate the effect of hybrid on yield showed a statistically significant effect ($F(2, 24) = 4.048$, $p = 0.031$), indicating that at least one hybrid differs significantly.

Tukey HSD results:

- GW9003 had the highest average yield (17.15 t/ha).
- Pajdash had the lowest yield (15.58 t/ha).
- The difference between GW9003 and Pajdash was statistically significant ($p = 0.027$).
- Differences between Kashmir and the other hybrids were not significant ($p > 0.05$).

The homogeneous subsets analysis supports this conclusion: Pajdash and Kashmir fall into one group, while GW9003 forms a distinct group with higher yield.

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