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# The Role of Wheat Cultivars Blend on Grain Yield and Backing Quality

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## Abstract
Wheat cultivar Divana was released in 1995 as the result of wheat breeding program on premium bread-making quality. According to quality data, Divana is the best quality wheat grown in this region. However, due to its low lodging resistance linked to low grain yield, this valuable cultivar has not improved the quality of the milling and baking industry in the region. With the mixture of two cultivars: 1) cv. Koleda - high yielding, above average quality, resistant to lodging and 2) cv. Divana - excellent quality, prone to lodging – this problem could be solved, and wheat producers, millers and bakers could be satisfied. Preliminary results have shown that when growing the blend of these two wheat cultivars, both grain yield and bread-making quality could be maintained at a high level and price of premium quality class (improver) could be achieved on the market. On the basis of achieved results, the proportion 1:1 of cvs. Divana and Koleda is recommended.

## 1. Introduction

Growing cultivar mixtures had been common throughout agriculture until roughly one hundred years ago. In the past, wheat was frequently grown in mixtures even with other cereal species such as rye or oats. Even Charles Darwin, in his famous work "On the Origin of Species", noted how farmers had commonly grown variety mixtures because they had better performances than single varieties (Wolfe, 2006).

Not so long ago, growing cultivar blends was still a rather common practice.

According to Faraji (2011) there are three advantages that cultivar mixtures can provide:

1) Stabilization of yield due to larger genetic diversity - genotype by environment interaction.
2) Compensation effects - a stronger variety compensates for a weak or injured variety, and
3) Better disease control due to more different resistance genes involved.

In recent time interest for improving yield stability and management of multiple disease tolerance by growing more agrobiodiverse crops has been tremendously increasing. General reasons for this interest are:

a) better protection from airborne diseases (Cox et all., 2004; Dai et all., 2012; Gigot et all., 2012; Huang et all., 2012; Mille et all., 2006),
b) protection from cold injuries (Cowger and Weisz, 2008),
c) protection from insect attacks (Tooker and Frank, 2012),
d) achievement of better quality (Zhoua et all., 2014) and as a final result
e) achievement of higher yield stability (Asghar et all. 2011; Mengistu et all., 2010; Smith et all., 2014; Zhoua et all., 2014).

From 1984 to 1990, in German Democratic Republic (DDR), cultivar mixtures

comprised up to 92% of the barley acreage. Barley mixtures had been planted until the political reunification of East and West Germany when government supports for the project stopped. Under the influence of country's strong chemical industry, barley mono-culture has been reestablished in Germany and the use of fungicides has been increased.

In 1996, around 62.000 ha of barley (9.7% of the total) were sown to variety mixtures in Denmark. For the 1997 growing season, 49 different mixtures were marketed, involving 20 different varieties from six resistance groups to powdery mildew. Variety mixtures yield better than their components (Ø stergård and Jensen, 2005).

The data for period 2003 to 2007 shows: in the wheat growing states of USA cultivars mixtures were grown on over 10 % of wheat growing area. Six to 17 % of the wheat production area in the states of Washington, Oregon, and Kansas is planted to blends every year. Cox et all. (2004) provide evidence that cultivar mixtures can increase yield and reduce yield variability.

In Poland the use of barley cultivar mixtures for disease suppression was initiated in the early 1990's and it has reached about 90,000 ha per year. In Switzerland, 10 percent of bread wheat acreage is currently sown by cultivar blends (reviewed by Faraji, 2011).

However, south east wheat growing regions of EU has no experience with growing cultivar mixtures in spite of fact that wheat cultivar blends can be used as a measure of disease control and for improving grain yield stability and end-product quality.

In order to achieve the best balance between grain yield potential and lodging resistance, wheat breeders give great attention to the final plant height. It has been found that higher wheat genotypes, have better resistance to *Fusarium* (Španić et all. 2013.), but usually they are prone to lodging.

Based on mentioned data, we decided to combine 110 cm tall, excellent bread making quality (17 % grain protein) but lodging susceptible cv. Divana, with high grain yield, average quality and lodging resistant of cvs. Sloboda and Cerera (Jost et all., 1997) and Koleda. In blends, we expect to improved resistance to lodging, and consequently to improve grain yield, while retaining excellent end-product quality.

## 2. Material and Methods

From 1993 to 2013, at the Agricultural College Križevci, Croatia ($46^0$1' N, $16^0$33' E, elevation 150 m, average annual rainfall 786 mm), on hydromorphic pseudogley, slightly acid soil (pH ≥ 6), low in organic matter (≥ 1, 5 %), and rich in nutrients, several yield and quality tests of winter wheat blends were performed:

- *Experiment 1:* In 1993, cv. Divana and its blends of 15, 10 and 5 % with high yielding cv. Sloboda.
- *Experiment 2:* In 1997, cv. Divana and its blends of 40, 30, 20 and 10 % with high yielding cv. Cerera
- *Experiment 3:* In 2013, cv. Divana and its blends of 75, 50 and 25 % with high yielding cv. Koleda

As the results of cvs. blends with Sloboda and Cerera was published earlier (*Jošt et all. 1997)*, only the third experiment will be presented in this paper: The replicated randomized block design (5x5 Latin-square) were used. An excellent soil with green manure (oil rape), very rich in phosphorus and potassium was used for the micro-trial, and there was no need for the before sowing fertilization. The proportion of seed blends was determined on weight basis before planting. 220 kg/ha of wheat seed was sown on October 19, 2012 and all plots were sprouting uniformly around November 3. Additional nitrogen (KAN 27 %) was added in tillering (200 kg/ha) and steam elongation (150 kg/ha). Methods of quality testing: The analytic procedures by ISO Standards were performed, and besides, the standard quality and rheology tests, the baking test of wheat flours by ICC Standard 131 were done.

## 3. Results and Discussion

In an earlier test the cultivar Divana showed the highest resistance levels against initial infection to *Fusarium* head blight (Španić et all., 2013). So, beside excellent bread quality parameters, cv. Divana could improve resistance of blend to *Fusarium*, one of the most important wheat diseases in Croatia. However, due to favorable weather conditions in 2013, the disease infection had minor effects on yield and quality.

***Table 1.*** *Grain yield and quality parameters for cv. Divana, and its blends of 75 %, 50 % and 25 % in cv. Koleda. Križevci, 2013.*

| No. | Quality parameters | Divana | 75 % | 50 % | 25% | Koleda |
|---|---|---|---|---|---|---|
| 1 | Grain yield - t/ha* | 6.27 a | 7.67 b | 8.92 c | 9.77 d | 9.94 d |
| 2 | TKW - g | 46.86 | 48.23 | 48.84 | 47.76 | 46.04 |
| 3 | Test weight - kg/hl | 79.52 | 80.28 | 80.80 | 80.64 | 82.10 |
| 4 | Grain protein on D.M. -% | 17.72 | 16.69 | 15.38 | 14.01 | 13.85 |
| 5 | Total protein yield -kg/ha | 1111 | 1280 | 1371 | 1368 | 1376 |
| 6 | Wet gluten - % | 40.5 | 37.6 | 34.5 | 33.0 | 31.5 |
| 7 | Sedimentation value - ml | 70.0 | 60.5 | 57.5 | 50.1 | 46.5 |
| 8 | Falling number | 292 | 301 | 344 | 346 | 366 |
| 9 | Milling - % | 72.2 | 71.1 | 70.4 | 70.0 | 70.0 |

* Mean values with different letters are significantly different at P=0.01 level.

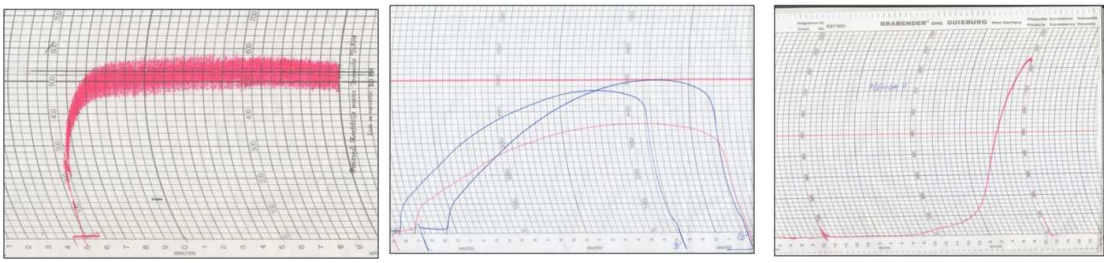
In 2012/13 growing season, the environmental conditions for wheat growth were favorable, and the better yielding cultivar Koleda obtained exceptional high grain yield (nearly ten tons per hectare). The other cultivar Divana also obtained grain yield over half a ton higher than is many years average. In grain yield the three blends were

distributed between the poor yielding cultivar Divana and high yielding cultivar Koleda with the 1:1 blend for 9,2 % higher in yield than the mean-value of cultivars included (Smithson and Lenné reported 5,4 %) and improved quality parameters (Tab. 1).

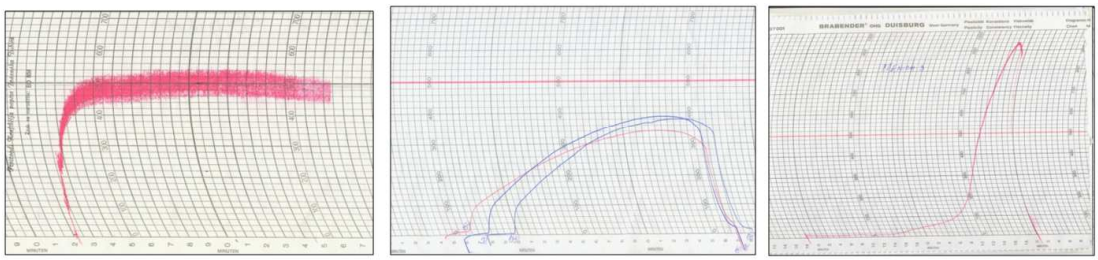
However, because of negative relations between grain yield and grain protein concentration, there is an opinion that we should look at the total yield of protein per unit area, rather than in percentage terms as we have always tended to do.

Beside grain yield, the bread making quality parameters were also regularly distributed in blends between both cultivars - grain protein content between 13.85 and 17.72%, and wet gluten between 31.5 % and 40.5 %. In favorable 2013 harvest, blend with 50% of cv. Divana obtained yield nearly nine tons per hectare of premium quality grains – an excellent result not reported in early studies. In experiment 3, we have proved the statement made by Faraji (2011): "by choosing cultivars that complement each other for performance of important traits, mixtures could be formulated to meet specific production requirements". The high yield, and additional premium for quality can provide good income for farmers. (In Croatia, premium quality wheat has 30% higher selling price.)

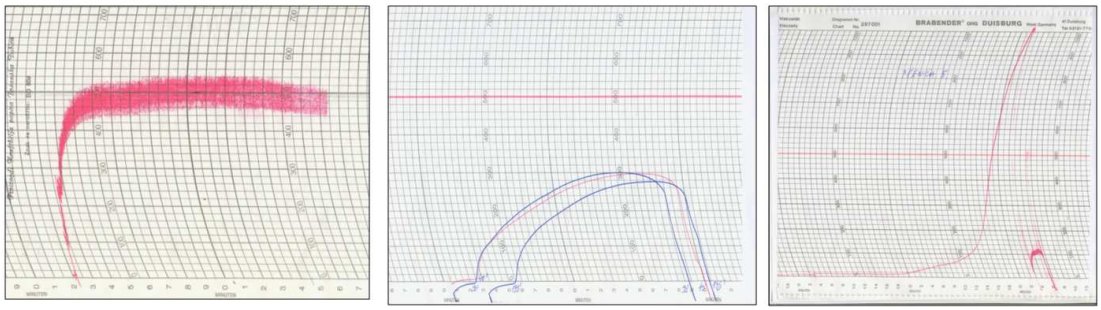
DIVANA



Blend 1:1 (50 %)



KOLEDA



***Graf. 1.*** *Farinograms, extensograms and amylograms of two cultivars DIVANA, KOLEDA and their blend 1:1.*

***Table 2.*** *Rheological parameters for cv. Divana, and its blends of 75 %, 50 % and 25 % in cv. Koleda. Križevci, 2013.*

| Quality parameters | Cultivars / blends | | | | |
|---|---|---|---|---|---|
| | DIVANA | 75 % | 50 % | 25 % | KOLEDA |
| FARINOGRAPH | | | | | |
| Water absorption (%) | 60.2 | 61.6 | 60.5 | 60.7 | 60.5 |
| Development time (min) | 9.0 | 8.5 | 8.5 | 10.0 | 8.0 |
| Stability (min) | 4.0 | 3.5 | 4.0 | 3.5 | 3.5 |
| Resistance (min) | 12.5 | 11.5 | 12.5 | 11.0 | 10.5 |
| Degree of softening (BU) | 5.0 | 10.0 | 20.0 | 30.0 | 30.0 |
| Quality number | 94.5 | 92.1 | 90.3 | 85.9 | 75.4 |
| Quality group | A1 | A1 | A1 | A1 | A2 |

| Quality parameters | Cultivars / blends | | | | |
|---|---|---|---|---|---|
| | DIVANA | 75 % | 50 % | 25 % | KOLEDA |
| EXTENSOGRAPH (135 min) | | | | | |
| A Energy (sq cm) | 150 | 113.9 | 87.1 | 66.9 | 54.2 |
| B Extensibility (mm) | 230 | 204 | 177 | 156 | 151 |
| C Resistance (EU) | 250 | 230 | 230 | 210 | 200 |
| D Max. resistance (EU) | 500 | 440 | 380 | 325 | 280 |
| Proportion C/B | 1.09 | 1.13 | 1.30 | 1.44 | 1.32 |
| Proportion D/B | 2.17 | 2.16 | 2.15 | 2.23 | 1.85 |
| AMYLOGRAPH | | | | | |
| Max. viscosity (AU) | 850 | 900 | 940 | 960 | 1120 |

The rheological parameters (farinograms, extensograms and amilograms) for both cultivars and their blends are presented in Tab. 2 and Graph. 1. As expected, the grain yield of blends proportionally increased with the amount (participation) of high yielding cultivar Koleda in the blend, while the quality parameters are decreasing, but still they belong to A1 quality group.

In the earlier published data for Argentina, different blends of cultivars Buck Pronto and Klein Escudo of (100:0, 75:25, 50:50, 25:75, and 0:100) were analyzed to relate composition of blends to the characteristics of dough and breads obtained from them (Ponzio et all., 2008). As expected, bread quality of Buck Pronto was superior to that of Klein Escudo and all their blends.

The main goal of this paper is to emphasize the well-known, but in commercial production not enough used agrotechnical procedure, which have a number of advantages. In this example we successfully solved the problem of low yield, as the result of lodging susceptibility of the premium quality cultivar. The mixture had increased yield, but it has stayed in A1 quality class. With proper combination cultivars in mixtures many other disadvantages could be solved**.**

The significant dependence of Divana bread making quality upon the climate conditions has been proven. (Ćurić et all. 2009). Based on these findings we assume that proportion of each cultivar in blend should be experimentally determined for each growing region.

## 4. Conclusion

From the results of the three different experiments in different years (1993, 1997 and 2013) with premium quality cultivar Divana and its different blends (5 to 75 %) with three different high yielding, lodging resistant, standard bread quality cultivars (Sloboda, Cerera, Koleda) we can conclude:

1. Winter wheat variety blends are promising in enhancing competitive ability and may provide greater yield stability.
2. In different blends it is possible to increase grain yield and keep premium bread making quality of cv. Divana (A1 quality group).
3. The proportion of cv. Divana in blend will depend upon the other component and upon the climate which is not predictable.
4. If the proportion of cv. Divana is larger, security of obtaining premium quality is greater, but expected grain yield would be lower.
5. Beside characteristics of other component (cultivar) in blend, grain yield, and especially baking quality will greatly depend upon environmental factors.
6. The 2013 harvest season was exceptional and 15 – 30 % higher grain yield than many years average for cultivars included were obtained.
7. As cvs. Sloboda and Cerera are not on variety list anymore, more attention should be put to blends with cv. Koleda, the cultivars that complement well with cv. Divana.
8. With rather good security for improved grain yield and quality parameters, the proportion of 1:1 (50 % blend) is recommended.

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