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# GENETIC BASE OF DURABLE RESISTANCE TO *Puccinia triticina* OF TWO SERBIAN VARIETIES

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The aim of the study was to differentiate the two long term incomplete resistant varieties according to Lr genes and compare the effects of some in the accumulation. The investigated varieties were developed more than 15 years ago. Basis of the trait was investigated according to reaction type (RT) 10 days after spores of the race 2 were trashed at seedlings of $F_2$ generations of varieties *Anastasia* or *Selekta* x Lr 1, Lr 2a, Lr 3, Lr 13, Lr 14a, Lr 16 or Lr 26 grown at air temperatures 20-25$^{o}$C. The presence of single resistant genes Lr 1 and Lr 2a in the varieties was excluded by presence of susceptible plants in F2 progenies of adequate crosses. The RT decreaseable combinations were Lr 3+B as Lr3+C in *Selekta* and Lr26+E, Lr26+C as EC in *Anastasia*. According to lower infection efficiency and yellowing of the above tip top part the C was similar or Lr 34. The Lr 13 and 14a were near the same effective at seedlings when were added to

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proposed combinations in parents. According to F1 results in field the most effective over season combination was achieved in progeny of the investigated varieties because of two LP prolong able complementary genes and accumulation of three infection severity responsible ones.

*Key words:* durable resistance, latent period*, Puccinia triticina,* wheat

## INTRODUCTION

The most common diseases of wheat in world are rusts (ROELFS *et al.* 1992). Leaf rust, caused by *Puccinia triticina,* was most widespread (BOLTON *et al*, 2008). Growing of resistant varieties was the only way for high yield and safe food production in semiarid region because of short time between fungus significant development in May followed by optimal in environment conditions in June and harvesting. So, the allowed fungicide treatments were not economical payable.The breeding program with mentioned character achievement aim in Serbia exists for more than half of a century (MOMČILOVIĆ, 1969). As durable resistant, genotypes were pronounced according lower infection efficiencies as lower reaction types at higher temperatures (BROWDER, 1985; VAN SILFHOUT, 1993). The genes expressed throw prolonged latency period and high reaction type, were also treated as to parasite non specific (PARLEVLIET, 1979). Created genotypes in Serbia were tested in field and greenhouse conditions for many years according to resistance characters expressions simultaneous with LR NILs (single resistance genes to *Puccinia triticina* were transferred in variety Thatcher) (BOŠKOVIĆ and BROWDER, 1976; JERKOVIĆ and JEVTIĆ, 2002; JERKOVIĆ *et al*., 2002).Linkage between nowadays involved characters as adult growth ratios (AGRs) and adult plants lower maximal *Puccinia triticina* severities (JERKOVIĆ and PUTNIK-DELIĆ, 2010), oppened the oportunity for the new deffinition of durable resistance as all different from controlled by single to parasite isolate specific reacting gene (always followed by prolonged LP) in AGR intermediate background and defined the LP prolongable genes as parasite specific (JERKOVIĆ and PUTNIK-DELIĆ, 2010). The resistance genes identification in Serbia was performed mostly using genotypes with high level of the resistance (complete) predicted for sources of resistance in breeding program The criterium was also the diference in genetic basis and the larger number of involved genes with complementary effect linked with durability of the trait (JERKOVIĆ, 1992). The main reason for the luck of investigations directed to resistance genes identification of the varieties were the parasite isolates for lower RT achievement. They appaired again after many years (BOŠKOVIĆ, 1965; JERKOVIĆ et al., 2003). The aim of the study was to differentiate the two long term incomplete resistant varieties according to Lr genes and compare the effects of some in the accumulation.

## MATERIALS AND METHODS

Winter wheat varieties *Anastasia* and *Selekta* were hypersensitive incomplete resistant at the seedling stage to the race 2 of *Puccinia triticina* (JOHANSON and BROWDER,1966) when reaction types (STAKMAN *et al*., 1962) were estimated after 10 days from incubation and growth in the greenhouse at air temperature between $20^{o}$ and $25^{o}$C greenhouse at the Institute of Field and Vegetable Crops in Novi Sad. Single-pustule isolate developed from the variety *Pesma* was thrashed on the seven

days old seedlings (STAKMAN, 1954). Incubation in high moisture lasted for 24 hours. The reaction types (RT) estimated after ten days from incubation according to the scale 0—4 (STAKMAN *et al.,* 1962). Lr 1 and Lr 2a were involved as so single effective. F2 progenies of the varieties crossed with Lr 1, Lr 2a, Lr 3, Lr 13, Lr 14a, Lr 16 or Lr 26 were tested simultaneously. Data were processed as in JERKOVIĆ *et al.* (2003), so as resistant were recognized plants with any sign of hypersensitivity. $\chi^2$ test was used for statistical analyses. F1 generations were grown in rust nursery and differentiated according percentage of last two leaves area coverage by *Puccinia triticina.*

## RESULTS AND DISCUSSION

The presence of single resistant genes Lr 1 and Lr 2a in the varieties was excluded by frequency of resistant plants (Fr=0,95-0,97 but not 1) (tab. 2,3). Such frequencies statistically not fitted segregation ratio 57 R: 7 S suggesting complementary effect of two genes plus one single effective. The frequencies of resistant plants from other crossings, except with Lr 26 (0, 94), were from 0.83-0.89 indicated interalellic interaction of two of three completely dominant genes in cultivar *Anastasia.* Much higher frequencies of the resistant plants (Fr) fited to segregation ratio 60R:4S proved the presence of Lr 26. By previous studies *Anastasia* had the same resistance gene like one single not expressible in variety *Renesansa.* In the progenies of Selekta and Pesma was no segregation according to resistance (JERKOVIĆ *et al*. 2003). Similar, the highest frequencies (Fr) of resistant plants (0.96 and 0.94) were in $F_2$ progenies from crosses of variety *Selekta* and Lr 1 and Lr 2. The lowest were from crosses with Lr 16 and Lr 10 (FR=0.69 and 0.76). $F_1$ progenies were different according to infection severities (tab.1).

*Table 1. The infection severity of $F_1$ progenies*

| **F 1** | **Inf. Sever.** | **F 1** | **Inf. sever** |
|---|---|---|---|
| Anastasija x Lr 1 | **10** | Selekta x Lr 1 | 5 |
| Anastasija x Lr 2a | T | Selekta x Lr 2a | T |
| Anastasija x Lr 10 | T | Selekta x Lr 3 | 10 |
| Anastasija x Lr 13 | 10 | Selekta x Lr 10 | 10 |
| Anastasija x Lr 14a | T | Selekta x Lr 13 | 20 |
| Anastasija x Lr 26 | T | Selekta x Lr 14a | 20 |
| Anastasija x NS 40/93 | T | Selekta x Lr 16 (Lr22b) | 20 |
| **Anastasija x Selekta** | **0** | Selekta x Lr 26 | **5** |
| | | Selekta x NS 40/93 | 5 |

Complete resistant was progeny from cross of the varieties Anastasia with Selekta because of two different complementary resistance genes latency period prolong able inherited from both sides**.** Lr3, Lr 13, Lr 14a and Lr 26 decreased the FR**.** The Lr 26 was defined as gene for adult plant resistance also with similar effect as all involved genes beside Lr 1 and Lr 2a. The low stem was characteristic of both varieties as of Lr 10 line. The responsible for the trait in *Anastasia* was to in Lr 10 line similar one. In $F_2$ of *Anastasia* x Lr 10 line the Fr 6% less than nearest expected was explainable by Rht genes accumulation (JERKOVIĆ and PRIJIĆ, 2010).

The resistant combinations were AB and AC in *Selekta* as DE, DC and EC in *Anastasia*. The gene A in *Selekta* was Lr 3, D in Anastasia Lr 26 (FR =0,94) as B and E were unknown.

*Table 2. The segregation in F2 generation of crossings variety Anastasia with some of Lr lines*

| Variety | R* | S* | T* | f(R)* | Seg. Ratio | $\chi 2$ | P |
|---|---|---|---|---|---|---|---|
| Anastasija x Lr1 | 303 | 15 | 318 | 0.95 | 57:7 | 12.639 | ‹0.01 |
| Anastasija x Lr2a | 275 | 8 | 283 | 0.97 | 57:7 | 19.298 | ‹0.01 |
| Anastasija x Lr10 | 269 | 40 | 309 | 0.87 | 54:10 | 1.6747 | 0.2 |
| Anastasija x Lr13 | 256 | 33 | 289 | 0.89 | 54:10 | 1.102 | 0.3 |
| Anastasija x Lr14a | 278 | 44 | 322 | 0.86 | 54:10 | 0.939 | 0.3 |
| Anastasija x Lr26 | 282 | 19 | 301 | 0.94 | 60:4 | 0.002 | 0.95 |
| Anastasija x NS40/93 | 241 | 49 | 290 | 0.83 | 54:10 | 0.356 | 0.5 |

R-*resistant* S-*susceptible* T-*total*

*Table 3. The segregation in F2 generation of crossings variety Selekta with some of Lr lines*

| Variety | R* | S* | T* | F(R)* | Seg. ratio | X2 | P |
|---|---|---|---|---|---|---|---|
| Selekta x Lr1 | 218 | 10 | 228 | 0.96 | 57:7 | 10.046 | ‹0.01 |
| Selekta x Lr2a | 333 | 12 | 345 | 0.96 | 57:7 | 19.705 | ‹0.01 |
| Selekta x Lr3 | 314 | 22 | 336 | 0.94 | 60:4 | 0.051 | 0.8 |
| Selekta x Lr10 | 227 | 73 | 300 | 0.76 | 45:19 | 0.071 | 0.8 |
| Selekta x Lr13 | 302 | 40 | 342 | 0.88 | 54:10 | 4.005 | 0.05 |
| Selekta x Lr14a | 270 | 61 | 331 | 0.82 | 54:10 | 1.974 | 0.2 |
| Selekta x Lr16 | 225 | 104 | 329 | 0.69 | 45:19 | 0.583 | 0.5 |
| Selekta x Lr26 | 261 | 56 | 317 | 0.82 | 54:10 | 1.001 | 0.3 |
| Selekta x NS40/93 | 231 | 79 | 310 | 0.75 | 45:19 | 2.642 | 0.1 |

Lr 2a, Lr 9 and Lr 26 combinated with adult plant resistance genes were highly resistant to leaf rust *(*KOLMER, 2003). The Lr 16 was transfered in Thatcher bacground carrying Lr 22b for the difference of other used Lr lines (Thatcher with LrTc or Lr 2c) (JERKOVIĆ and PUTNIK-DELIĆ, 2010). The presented combination was of different SAGR (staem adult growth ratio= maximal lenght of last two internodia devided by stem lenght) influental genes. The lower reactioin types at $20^{O}$C were related to et least one gene for prolonging the latency period particulary Lr 2a (JERKOVIĆ and PRIJIĆ, 2010). According to low infection efficiency and yellowing of the above tip top part the C was similar or Lr 34 (DYCK, 1991; MCINTOSH, 1992; SINGH, 1992a, 1992b). The Lr 3, Lr 14a, Lr 13, Lr 26 effect was SAGR increseable conected with low infection severity in field so effective as well as Lr 34 in combinations with LP prolongable SAGR low decreseable genes.According to these studies the genes for leaf rust resistance were effective parasite presence independently. Lr 16 (in Thatcher with Lr 22b) was different according to previous studies (JERKOVIĆ and PRIJIĆ, 2010), but not complementary or identical with Lp prolongable gene from Selecta. Even in case of using such combinations durability of resistance had to be increased in comparison to single Lp prolonging gene (ROELFS, 1985).

## CONCLUSION

The durability of investigated varieties resistance was mostly based on IF decreseable stres tolerance genes accumulation. Enhanced resistance to parasite population in field was not achieved by involved Lr lines than identified in the progeny of Anastasia x Selekta because of two complementary Lp prolongable genes and three IF dicreseable. Even one of two Lp prolong able (specific) genes to whole parasite population Lr1 or Lr 2a were added, the IF decrese able genes accumulation was not enough for achieving complete resistance in field because of incomplementarity of genes with those from the varieties as Lr Tc presence with lower AGR values increasing effect than Lr 3, Lr 34 or Lr 26. Lr 16 was also confirmed as incomplementary specific gene SAGR decreseable. B and E genes were LP prolong able or parasite specific genes because of hypersensitive resistance of both investigated varieties.

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## GENETSKA OSNOVA TRAJNE OTPORNOSTI PREMA *Puccinia triticina* U DVE SRBIJANSKE SORTE

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I z v o d

Istraživanje se vršilo sa ciljem utvrđivanja razlike između dve dugotrajno otporne sorte na osnovu prisutnosti određenih Lr gena i da se uporedi njihov efekat u akumulaciji. Sorte su razvijene pre više od 15 godina. Osnova otpornosti je istraživana u stadijumu sejanaca na osnovu reakcionog tipa pri temperaturi vazduha od oko 25$^{o}$C. Testiranje $F_2$ generacije sorti Anastasija i Selekta x Lr 1, Lr 2a, Lr 3, Lr 13, Lr 14a, Lr 16 ili Lr 26, izvršeno je izolatom avirulentnim prema prvim dvema pomenutim Lr linijama (rasa 2) i virulentnim prema ostalim. Prisustvo tih gena u sortama bilo je isključeno na osnovu visokih frekvencija otpornih biljaka (Fr je bila 0,95-0,97 ali ne 1) te nižih (0,70 i 0,83) kod potomstava ukrštanih sa osetljivom linijom NS 40/93. Otporne kombinacije su bile Lr 3+B kao i Lr 3 +Cu Selekti i Lr 26+E i Lr 26 +C iz Anastazije. Na osnovu žućenja i niske uspešnosti infekcije na vrhovima listova C je sličan Lr-u 34. Niska stabljika vezana uz Lr 10 liniju je bila prisutna kod obe sorte kao i gen za pprodu\eni latentni period.. Lr 13 i Lr 14a bili su komplementarni sa Lr 26 i Lr 34. Na osnovu rezultata F1 generacije u polju najbolja kombinacija je postignuta međusobnim ukrštanjem ispitivanih sorti.

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