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NEW RESULTS IN THE BREEDING OF PEAS IN THE RESEARCH CENTRE OF CENTRE FOR AGRICULTURAL SCIENCES AND ENGINEERING OF UNIVERSITY OF DEBRECEN IN NYÍREGYHÁZA

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1. THE AIM OF THE RESEARCH

The leguminous plants –like the green peas- are necessary and valuable sorts in the human society feeding. After the soybeans the beans and the peas are the most important from this family. The pea seed as a food has been consumed for a very long time past. The demand for the peas started to increase from the 19th century.

The green peas have a short growing season; it can be well fitted in the crop rotation. The realization of crop can be covered available. Moreover, it is environment friendly, because the soil is left over in a good stage after the green peas. The nitrogen content of the soil has been increased.

The ripe seed of *Pisum sativum* is the one of the most important nutrition goods nowadays.

In Hungary the assignment of the grower of the green peas to produce good quality raw materials constantly 30-35 days long with good choice of the varieties and periodic sows for the processing industry.

The demand against the varieties is other for the processing industry, the grower and the customer.

The judgments of the difference maturity groups are diverse. The potential productivity of earlier varieties is the lowest, nevertheless we have to grow these varieties, because the processing season can be prolongated with them. The other reason is that the growing of the green peas is relatively safe in our weather relation.

The potential productivity of the latest varieties is more than 30%. This power of productivity shows up only in wet and not too hot summers.

In our environment the varieties of the middle majority group gives the squarest yield.

To consider the domestical range of varieties we can determine, that in the middle-early and the latest majority group has high yielding capacity, there are excellent varieties, but the supply from the group of early majority types is rather poor. Because of these reasons our aim is to produce green pea varieties belonging to the early majority group, but we are focusing on production of varieties from other promising lines in other majority group.

The most important characteristics of peas required by the processing industry and the freezer industry are the productivity, tenderness, steady seed colour and seed size. Nowadays the smaller seed size and the darker green color are the preferred, because these peas won't became grey before the cold storage.

The suitability for automated harvest is important from the aspect of the efficiency. The ideal plant height at green harvest is 60-80 cm, where the pods nestle are at the top third of the stem.

It is a good possibility to elevate the fitness to produce half leafless or tendril varieties. These varieties can keep each other. We made some population like this in 2001, and our cross-bred plants are very promising.

One of the most important aspects is the resistance against diseases. The recognized green pea varieties are resistant to *Fusarium oxysporum f. sp. pisi* I. race, without this resistance it is impossible to receive state qualification. There is an increasing problem with the presence and infection of *Fusarium solani.* Therefore our aim was to test the resistance to the starting varieties, other varieties and the breeding populations to *Fusarium solani.* In the last years the resistance against abiotic stress came to the focus of the breeders. The extreme environmental circumstances can cause huge damage in the pea crop, like it happened with the crop of 2007 (drought after sowing, freeze at flowering, and drought again). These extreme weather conditions have a lot of influence on the crop results, therefore our goal is to breed forward the drought and freeze tolerant varieties.

Eventually, it is very important to extend the Hungarian list of varieties with powerful varieties that can successfully compete against the foreigner varieties, and can adapt themselves to the special circumstances of the Karpathian region.

2. THE HISTORY OF THE RESEARCH

All the abilities and possibilities in Hungary are optimal for pea growing. These good circumstances have been realized at the early 20th century, when foreign companies started the seed production. This tendency has being developed continuously, goes on even today, except the period between the two world wars.

The history of pea breeding in Hungary started in the early 1940's, and the development was not so significant. At the early 1940's there were results and

experiments, but the first varieties were produced with simple selection. These varieties were *Diószegi*, *Monori*, *Montenuovo*, *Mauthner Express* types, the types of *Victoria* and *Record*. Nowadays one variety originated from those times: the Express variety. After the 2nd world war the breeding work started in state owned institutes under state control. Three basements were established.

The first was established in Iregszemcse immediately after the war by Ernő Kurnik and Anna Oberritter. They focused on mainly feed pea breeding.

The second basement was organized by Antal Ács at the region of Hatvan in Fenyőharaszt that after a short time was removed to Újmajor in Nógrád county. In 1957, partially this institute was moved to Debrecen, led still by Antal Ács. In Újmajor Antal Lászlóffy and László Csizmadia was working on the breeding of peas.

The third basement started in Budatétény led by Kálmán Csatári-Szüts and Ágnes Harsányiné Baranyai.

The Research Centre of Nyíregyháza joined to the pea breeding work in 1978, led by József Bukai, with the participation of Veronika Deák, they were followed by Mrs. Lajosné Mándi. Their achievements resulted a lot of powerful variety in all maturity groups.

All the varieties in the National List of Varieties – included all the domestic and foreign types – can match to those requirements, which could come from the agricultural, the industrial, or the sales sector. In Hungary – based on the European List of Varieties - 700 pea varieties can be used legally for growing. In this amount there are 500 types of wrinkle-seeded pea, 130 types of smooth-seeded pea, and 70 types of sugar pea. Varieties that were bred by our Institute (Léda, Margó, Lora, Zeusz, Zita, Zsuzsi) and the foreigner varieties that are maintained by us (Avola, Talbot, Combi, Durango, Hailey, Milor, Resal, Tristar, Twin) are all in the European List of Varieties.

The powerful development of the food industry and the increasing protein demand in the animal breeding sector generated the development of the pea breeding. Nowadays we need varieties in every maturity groups, and the quick exchange of different varieties. Very important aim is to have as much domestical varieties in the agriculture as possible. In our Institute the breeding on disease- resistance and the methodology of resistance tests have the highest priorities.

In the past couple years the rate and the severity of infestation of *Fusarium* in the peas increased. This fact brought the conclusion, that a new *Fusarium sp*. is spreading, that could infect the resistant varieties. These serious symptoms are caused by the *Fusarium solani* with common name the fusarial root and stem rot. The causative agent was already known. It was reasonable to establish a provocation garden, where the resistance of the pea varieties could and can be tested to *Fusarium solani*.

We started the resistance test in 2000. From 2001 the Ministry of Agriculture subsidized and supported our experiments (ID num.: 116-a1/2001).

3. THE METHOD OF THE RESEARCH

The experiments took place in the Research Centre of Centre for Agricultural Sciences and Engineering of University of Debrecen in Nyíregyháza in humous sand soil.

3.1. Breeding to create a new variety

The parent-partners used for crossing were chosen according to the observation of our variety collection in previous years' (1: Léda, 2: Margó, 3: Foremos, 4: Presto, 5: Mariza, 6: Early sweet, 7: Debreceni korai velő 8: Horymir, 9: Kijevszkij korai, 10: Early snap). The aim of the breeding work was to create a new, extra early variety and an early variety with a high yielding productivity.

We made the crossings in 2002 beside a net with as much repetition as much flower was on one variety. It is important, to have enough pollen or optimal amount of flowers from one variety, which we could put the pollen on because we used the non-reciprocal method,

The parental partners and the progenies generations until F_3 were planted beside net, and were being examined. We kept until generation F_4 in Ramsch. The F_4 and F_5 generations were planted randomly in on the field in 1,6 x 2 m small parcels.

The way of crossing:

The crossing of the peas can happen in planthouse, in plastic house, in climate box, or outside on the field, etc. The partners must flower synchronic, the anther of mother partner's should not be opened, but the father partner must have enough matured pollen. This is the basic criteria of the crossing. Knowing the heat units, the in synchronic flowering can be achievable, but it is a simpler way to have multiple sowing of the

partners. With this method, from one sowing the flowering would be in synchronic. We used cooling and freezing techniques to avoid the differences in flowering times.

One way of the crossing is the castration, when the closed anther is eliminated from the opened flower with a pike.

We have to put the pike in alcohol after every flower, to avoid the unwanted crosses by chance with the falling pollen of the opened anther.

In the course of the crossing we put the mature pollen on the pistil with pike, paint brush or along with the flower.

The most suitable time is the morning for the crossing, when the temperature is not too high, and the relative moisture is good.

We can isolate the pollinated flowers, but –if the destruction not so high- the flowers close, there is no need for the isolation.

We have to put a label on the pollinated flowers, for mark the number of crosses.

We 60-80 % fertilization can be reached in the field depending on the weather.

The progenies have been further multiplied in F_1, F_2, F_x populations. The selection can be started in F_2 depending on the aim of the breeding, but it is practical if we started it in the F_4 or F_5, because the numbers of the homozygous plants increase, so we can select more promising plants. The progenies of the selected plants can be treated as lines.

3.2. The calculations applied in the course of the analysis

The quarter diallel-system was analyzed with the Diallel Analysis and Simulation Software by Burrow and Coors based on the Model I. Method II of Griffing in F1 generation. The program used the next model for the analysis:

$$x_{ijk}=\mu+g_i+g_j+s_{ij}+r_{ij}+b_k+e_{ijk}$$

where: μ= population means,

g_i= GCA effect for parent i,

g_j= GCA effect for parent j,

s_{ij}= SCA effect for parents i and j,

r_{ij}= reciprocal effect

b_k= block effect for block k,

e_{ijk}= error.

We analyzed the general combining ability (GCA) and the specific combining ability (SCA), and the variance of the variance components.

I made the calculations of standard deviation, the variance and the correlation with Windows XP. Microsoft Office Excel. I used this scheme $CV = \frac{s \times 100}{\bar{x}}$ to determine the coefficient of the variation, where s = standard deviation, x= average.

I calculated the variations of GCA and SCA, the additive genetic variance, the dominance variance with the help of the diallel-program.

I got the rate of dominance (DF) from this scheme: $DF = \frac{V_D}{V_A}$, where V_D= dominance variance, V_A= additive variance.

The calculation of h^2 value in a narrower meaning was made to the next formula: $h^2 = \frac{V_P}{V_A}$, where V_P= phenotypical variance, V_A= additive variance.

The significance review in F_2 generation was valued by SPSS 13.0 for Windows software package. I tested the treatment effects with a Tukey test on a $p<0.05$ significance level.

3.3. Study of the resistance to *Fusarium solani*

The experiments were carried out in a provocation garden of the Research Centre infected with *Fusarium solani.* We used more varieties, which are resistance to *Fusarium oxysporum*.

In our experiment infectious potato root was mashed worked into the soil in the provocation garden after 1 week time of incubation.

24 varieties and breeding lines were selected including one sensitive variety to *Fusarium oxysporum* (*Margit*), and the parents of the diallel cross.

These varieties and breeding lines were sowed in 4 repetition and 40 seed in one repetition in 2000, 2001 and 2002.

4. THE MOST IMPORTANT STATEMENTS OF THE DISSERTATION

4.1. Results of the crossing

Ten almost similar parents were selected to our crossings. We made the crosses in every flower (min. 20). We got a small amount of pods, because the plants were under the effect of outside environmental circumstances, because we had pollinated the plants out on the field beside net. We obtained defects in seed setting, immature, deformed seeds, which could not germinate. The crossing were not successful with 3 varieties (*Kijevszkij, Horymir, Early snap*), because of the lack of pods. The following combinations were reproduced, but for our experiments were not used at all: *Léda* x *Early snap*, *Léda* x *Horymir*, *Margó* x *Horymir*, *Horymir* x *Debreceni korai velő.*

4.2. Testing the combining ability in generation F_1

We studied four quantitative parameters, that affects the yield directly: pods per plant, seeds per pod, lenght of pod, and the height of the plant.

Parents that were used for the research:

1. Léda
2. Margó
3. Foremos
4. Presto
5. Mariza
6. Early sweet
7. Debreceni korai velő.

4.2.1. The estimated phenotypical values of the parents based on the generation F_1:

We studied every parameter value separately. The average seed in one pod is 5.34 pieces. The biggest amount of seed was found in *Foremos* (5.73 pieces), the least amount was found in *Early sweet* (4.96 pieces).

In comparison of the combinations we found the biggest amount of seeds per pod in progeny of *Foremos* x *Presto* parents (6.45 pieces), the least amount was found in the generation F_1 of *Presto* x *Early sweet* parents (4.56 pieces). The average amount of seed per pod in the three best combinations exceeded the average seed amount of the best parent. The values of the worst three combinations were lower than the values of the worst parent *Early sweet.*

The average **length of the pods** in the population was 5.35 cm. We noticed the longest pods at the Foremos parents (5.70 cm), the shortest ones at the *Margó* (4.95 cm). From the group of combinations the population of *Presto* x *Debreceni korai velő*

had the best result (6.25 cm), the *Early sweet* x *Debreceni korai velő* combined population had the worst result (4.21 cm).

The average **pod length** in the three best combinations exceeded average length of the best parent, but in this case the results of the next four combinations (*Léda* x *Early sweet*, *Léda* x *Foremos*, *Margó* x *Foremos*, *Foremos* x *Mariza*) exceeded this value, too. The values of the worst three combinations were lower than the values of the worst parent, *Margó*.

The third evaluated parameter was the **pods per plant**. The total average was 4.8 pieces of pods on one plant. Léda produced the biggest amount of pods per plant (5.5 pieces), and *Debreceni korai velő* produced the smallest amount (4.3 pieces). From the combinations the best results were brought by *Léda* x *Early sweet* F_1 (7 pieces per plant), and the *Margó* x *Presto* was the least successful combination (3 pieces per plant).

At this parameter we could find the same conclusion as we had found in the previous two. This means*, that the averages of the best combinations exceeded the results of the best parent. The results of the three worst combinations were below the worst parental values.*

When we measured the plant height at the stage of the green ripening, we found that the estimated phenotypical value based on generation F_1 was the highest at *Foremos* (48.22 cm). This exceeds the average of the total population (35.24 cm). *Debreceni korai velő* was the smallest (30.21 cm). From the combinations the *Margó* x *Foremos* had the highest phenotypical value (67 cm), and the combination of *Léda* x *Debreceni korai velő* had the smallest.

At this parameter only the results of two combinations exceeded the best parental values, and values of ten combinations were lower than the smallest *Debreceni korai velő* parent.

4.2.2. The comparison of the realized average values of the parents and the estimated values based on the phenotypical values of the generation F_1

We found bigger deviations in the height, there were relevant differences between the values. Smaller differences were measured in the pods per plant. The estimated values of variety *Foremos, Presto and Debreceni korai velő* were lower; in the rest of the varieties these numbers were almost equal. Regarding the lenght of the pod we found big deviations only in variety *Foremos.* If we see all the parameters we found similar average values compared to the parents in their combinations.

4.2.3. General Combining Ability (GCA)

The estimated values of the general combining ability based on the parents are in the Table 1.

Table 1. Values of the general combining ability (GCA)

Parents	Parameters			
	Pod/plant	Pod lenght	Seed/pod	Height
1. Léda	**0.771**	0.362	-0.001	1.521
2. Margó	-0.161	**-0.489**	0.021	-1.651
3. Foremos	-0.095	**0.415**	**0.466**	**15.575**
4. Presto	-0.228	0.027	0.099	-1.298
5. Mariza	0.104	-0.148	-0.068	-5.458
6. Early sweet	0.304	-0.354	**-0.464**	-2.651
7. Debreceni korai velő	**-0.695**	0.186	-0.052	**-6.038**
se [g(i)]	0.260	0.124	0.157	1.836
se [g(i)-g(j)]	0.397	0.190	0.240	2.805

We did not find big deviations in the values of the general combining ability in the amount of pods per plant, the lenght of the pods and the seeds per pods, because the chosen parents had similar parameters except *Foremos*. Regarding the height of the plant the values are varying on a wider range. The value of combining ability in *Foremos* is 15.575. The value of CGA is positive at variety *Léda* (1.521), but lower compared to *Foremos*. The value of combining ability at the rest of the parents are

negative, we can not expect any progress from their combinations. We detected an extremely negative number at the variety *Debreceni korai velő* (-6.038) and the *Mariza* (-5.458).

The value of GCA at the lenght of the pod (0.415) comes together with a higher GCA value of the seed per pod parameter.

4.2.4. Special combining ability (SCA)

Examining the values of the special combining ability we can draw the same conclusion as with the GCA values. There was no extremely positive or negative value, because of the similarity of the parents. The exception here was the height, too.

We got relatively higher values at the **amount of pods per plant** parameter in the:

- Margó x Foremos (1.40),
- Presto x Mariza (1.60),
- Early sweet x Debreceni korai velő (1.20) combinations,

At the lenght of the pod in the:

- Léda x Early sweet (0.714),
- Presto x Debreceni korai velő (0.685),
- Margó x Foremos (0.546) combinations,

At the seeds per plant parameter in the:

- Margó x Debreceni korai velő (0.632),
- Foremos x Presto (0.535),
- Foremos x Mariza (0.537) combination.

Considering the height separately, the values are remarkable at the *Léda* x *Foremos* (1x3), *Margó* x *Foremos* (2x3), and *Foremos* x *Presto* (3x4), *Foremos* x *Mariza* (3x5), *Foremos* x *Early sweet* (3x6), *Foremos* x *Debreceni korai velő* (3x7), *and Presto* x *Early sweet* (4x6) combinations. We have to attract the attention on the results of those combinations where *Foremos* (3) was the mother line, because in these cases *Foremos* was extremely improver. As a father line it brought negative results, so in this variation we can not expect any corrective effect in the next generation.

4.3. The analysis of the correlation between the phenotypical values and the value of the GCA

Analyzing the phenotypical values and the general combining values we can conclude the conclusion, that with the relatively higher phenotypical value we could find a higher GCA value (Table 2.)

The GCA values are similar; we could not find any extreme result, because the chosen parental lines were similar to each other in almost all parameters we tested. The exception is the height parameter, from the varieties the *Foremos* is the exception. We wanted to see, if the results of the new generation would be better, than the parental values.

If we study our varieties, it can be seen that the *Foremos* has the best phenotypical values and the highest general combining ability values in all three parameters tested, except the pods per plant value. By our results all the parameters have improving effects in the new generation. These improving effects have not so large rate, that we can stabilize the trait in the combination, although *Foremos* is an early, tall, light green colored, long podded (8-10 cm), midsized seeded variety, that has high amount of seeds per pod.

Table 2. The correlation between the phenotypical values and the value of the GCA

	Pod length	GCA	Seed/pod	GCA	Pod/ plant	GCA	Plant height	GCA
Léda	6,4	0,3623	5,7	-0,0013	7,8	0,7714	48,4	1,5219
Margó	5,6	-0,4896	5,1	0,0213	6,7	-0,1619	47,5	-1,6514
Foremos	8,8	0,5147	8,2	0,4660	5,5	-0,0952	108,9	15,5752
Presto	6,5	0,0277	7,8	0,0993	12,4	-0,2285	56,2	-1,2980
Mariza	5,6	-0,1482	5,7	-0,0686	8,4	0,1047	50,6	-5,4580
E. sweet	5,8	-0,3542	5,9	-0,4640	5,2	0,3047	48,6	-2,6514
Dkv.	7,9	0,1863	7,05	-0,0526	10,6	-0,6952	50,5	-6,0380
átlag	6,66		6,49		8,09		58,67	
szórás	1,15		1,1		2,45		20,68	
variancia	1,53		1,41		7,01		498,78	
CV%	17,22		16,95		30,31		35,24	
R2	0,81		0,61		-0,46		0,92	

Pod lenght: *Foremos* has the highest phenotypical value: 8.8 cm, together with this we found a higher GCA value: 0.51. The correlation coefficient is 0.81. The *Margó* and the *Mariza* have the least phenotypical values: 5.6 cm. It can be not expected better population than the parents in this parameter, because the GCA values are too low. From the low variation coefficient (17.22%) it can be seen that the parents are square to the pod length.

Seed per pod: The *Foremos* has the highest phenotypical value: 8.2 cm, and the highest general combining ability value (0.46). This GCA value is low like all the general combining ability values, thus we can not calculate that we get populations with better phenotypical values than the parents. The coefficient of the variation is 16.57%, and the correlation coefficient is 0.61.

Pod per plant: The *Presto* had the most pods in one plant (12.4 pieces), but negative general combining ability value (-0.23) belong to this value. The *Debreceni korai velő* has 10.6 pieces pod number, but it has negative GCA value (-0.69), too. We may not make the conclusions like the other varieties, that the varieties with highest and lowest phenotypical values have highest and lowest general combining ability values, therefore we may get negative correlation in this parameter (-0.46).

The *Léda* (7.8 pieces) has the highest GCA values (0.77).

Plant height: The correlation between the phenotypical value and the GCA is the strongest in this parameter (0.92). The *Foremos* has the highest phenotypical value (108.9 cm), where the general combining ability is 15.57. The other parents have average plant height, but the GCA values are negative (except the *Léda*, 1.52).

The coefficient of the variation is 35.24%. We may wait for progress those lines, to which one of the parents is the *Foremos*.

The received correlations do not indicate the measure of the studied values; it is only representing the tightness of phenotypical values and the general combining ability values. We may not wait for progress in the characteristics despite the tight correlations, because the general combining ability values are low, and this indicates that they equalize onto these characteristic, and presumably their genetic background are similar.

4.4. Evaluation in the F_3 generation

Plant height: There are lines with lower and higher values then the parental average values in the population. In the F_3 generation there are transgress segregation was obtained. We can determine from the genotype variance, that the value of the additive variance significantly exceeds the value of the dominance variance.

The heritability of the characteristic is high; therefore the individual selection from F_2 generation could have been successful, if we would have already started the selection in this early stage. But we applied the Ramsch-method till the F_4 generation, so we did not make individual selection. The value of the variation coefficient is high, that does not relate the squared of the characteristic, which can not be expected in the F_3 generation yet.

The predominance of the additive effects is considerable, so the breeding methods can be used successful in this character, which increase the predominance of additive genetic effects

Pod per plant: There are lines with lower and higher values at the parental average values in the population. The dominance variance makes the bigger proportion of the genotype variance. If this value exceeds the value of the additive variance, it refer positive transgress epistatic interaction. The heritability is medium. This is detectable to the lower V_A value. Starting the selection in early generations would not have been advisable.

The dominant alleles in pod per plant must be brought in homozygous by selection through more generations. This induces slow genetic progress.

The high CV% refers to the variability of the character.

Seed per pod: We received diverse values at this characteristic. This is a variable characteristic with high heritability. The additive genetic variance is the higher, so the additive genetic effects prevail in the characteristic.

Pod length: The inheritance of the characteristic is additive, the h^2 value is medium.

The typical is in every character that lines should be further multiplicated, which show positive transgress.

4.5. Evaluation in the F_5 generation

- There are some plants and full populations which are promising despite the received statistical results, since the parental characteristics are significantly exceeded.
- The growth of lines in the early maturity group was affected by the frost in the middle of the season in 2007. From those populations no any plants were regenerated after the cold effect.
- The considerable parts of the combinations are suitable for a mechanical harvest.
- The selected plants in 2007 (according to the yearly observation) are fit for our breeding plans. However other observations are necessary in the future.
- The promising lines and the selected plants will be tested to *Fusarium solani* in the provocation garden.
- The results of the shooting, the pod fertility, and the genetic of the combinations were affected by the weather. We cultivate some intensive variety between intensive circumstances, for example in irritated area. However the farmers are generally not able to inisate because of the geographical position or economic reasons.
- More observation will be needed in the future; that the well adapting lines and plants how can adapt to the extreme ecological conditions, and how can enforce their good characteristics in other years.
- Anyway it is necessary to breed new varieties, which can be grown satisfactory under water shortage or frost effects (have good ecological plasticity).

4.6. Study of the resistance to *Fusarium solani*

4.6.1. Results of shooting

To study the results of shooting we got nearly the same results in every repetition. These results are satisfying if the water supply was suitable. Prominently negative result was obtained in the *Vica* (20) in the third repetition in 2002, in the second repetition at the *8607/75-3*-2 (16), and the *8611/3* (20); and the *Zsuzsi* in the second repetition in 2001. The reason was probably the margin effect, and the seeds were hosed down by the fall.

We could not find significant differences between the years, but there were significant differences between the genotypes (error=1.063). The averages were between 24.75-35.75 hatched seed when we study the years together.

4.6.2. The level of infection, results of the study of resistance

The 70-80% of the pea varieties that are commonly used in the agricultural techniques are resistant to *Fusarium oxysporum*, the varieties that we examined reacted very sensitively on *Fusarium solani.*

We generated four experimental groups based on the level of infection, and the differences in the averages from the three experimental years.

- 1. group: the level of infection is below 25% (good resistance). The differences among the varieties were not significant.
- 2. group: the level of infection is between 26-30% (medium resistance),
- 3. group: the level of infection is between 31-37% (medium sensitivity,
- 4. group: the infection is more than 37% (sensitive).

There is no significant difference between group 2. and 3.

UM korai and the *Margit* in group 4. are not different significantly, but on the level of P=5% the are different from the variety *8607/75-3-2* and the *Margit*.

1. Group: We got the best result in the *Lora* (17.21%), but all the varieties in this group (*UM 1096, Léda, Zita, Early sweet, 8616/25-3-2, Mariza*) developed tolerances to *Fusarium solani*.

2. and 3. Group: These groups include all the parents what we can used in the diallel crosses, and include varieties bred in the Research Center in Nyíregyháza (*Lora, Léda, Zita, Zeusz, Ave*). The *Zsuzsi* and *Vica* belong to the third group (where the infection is between 30-40%), but the range of the infection is respectable (31.2%, 31.18%).

4. Group: One sensitive variety to *Fusarium oxysporum* was sowed in the provocation garden in every year. This variety is the *Margit*. The *Margit* gave expected because 89.94% of the plants were infectious. We can say that the *Margit* is a sensitive variety to *Fusarium solani*, too.

We got the same result in the 8607/75-3-2 breeding line, where the infection was 69.89%, *so we can use this line in experiments like a sensitive variety in the future.*

If we sow those varieties which were resistance to *Fusarium solani* in the provocation garden in every year, we can stabilize the resistance in the varieties.

We could not find any variety with 0% and 100% infections.

5. New scientific results

1. To determine for the breeding value of 7 varieties with their general (GCA) and specific (SCA) combining ability with diallel analysis and with studies of the progenies generations, which give us more information about the varieties, and it can be used in other breeding programs.

2. Production of 24 new, early, perspective, homogenous populations and lines, with the application of combination and positive selection methods, from which after the necessary breeding works may be new kinds then.

3. Selection of the 0222/4 line, which has good qualitative traits, because it keeps their tenderly for several days. This line may have an important part of the growing in the future since in case of the overdue harvest gives a good quality for the processing industry.

4. We selected the 0108/4-5 line, which is perspective because it has triple pods position, and it has good fitness.

5. Selection of tolerant and sensitive varieties to *Fusarium solani*, and use the Lora and Margit as tolerant and as sensitive standard in the provocation experiments in the future.

6. Results with practical application

1. The growing of the green pea is necessary for the human consumption and for animal feeding, and from growing considerations (necessary in the crop rotation). The soil is left over in a good state after the pea. The pea does not extort the soil, its nitrogen content is getting richer (120-140 kg/ha). The growing time is short and after it second crop can be cultivated. The pea straw can be use for fodder. It is benefit furthermore, that growing can be well mechanized.

2. Intrinsically factors of the qualitative product production are the variety, which is the most important factor of success of the growing.

3. Use the varieties in the early maturity group, which have high yielding capacity and resistance to *Fusarium* species.

4. Use of the breeding lines, and later the varieties as a crossing partner or as breeding stock for the plant breeders.

5. Our results can be usable for the other resistance studies, for the development of the method for the breeding institutions, and other institutes. The results are realized in the production of the new resistant varieties, which entails economic profit.

6. We can produce new, drought-resistant, early line or variety with high yielding capacity, and we can explain the inheritance of the characteristics.

7. Scientific reports published in the field of the dissertation

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