International Journal of Agriculture, Environment and Bioresearch

Vol. 08, No. 01; 2023

ISSN: 2456-8643

HYBRID CORN SEED PRODUCTION WITH STRAIGHT AND RECIPROCAL CROSSING COMBINATION FORMS IN CASE OF SOME MV HYBRIDS

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https://doi.org/10.35410/IJAEB.2023.5806

ABSTRACT

The selection of optimal parental lines are very important – at hybrid corn seed production.
Correlation between the seedling length, high seed vigour ratio, and emergence during suboptimal environmental conditions are high.
The higher-yielding ability is the most important thing, point of view as a financial factor.
After examination, the seed biological value (germination, and vigour laboratory tests) the seed lots of 21 maize genotypes, with different straight and reciprocal combinations were studied at field experiments, between 2020-2022.
We can emphasize: there are differences between the different crossing combinations.
The fresh shoot weight of maize seedlings developing in a cold, oxygen poor environmental conditions was greater than the fresh root weight for the genotypes, regardless of the crossing methode. The plants developing from seeds with greater seed vigour; exhibited better emergence, faster ripening and lower grain moisture at harvest (H 05 x RPK, H 70 x RPK, H 06 x US, H 06 x H 44, H 06 x TG, H 72 x H 29, H 06 x H 49, GS 21 x H 35, GS 22 x H 35).
Correlation between the high vigour seedlings - for plants developing from seed lots from reciprocal crossing combinations-and fresh shoot weight of the seedlings and the kernel yield, were obvious – Marco, Kadricorn, Ghurkan, Koramag, Marfi, Mv 633, Mv Exp 21, and Mv 401-21 hybrids.
Importance of selection the best crossing (yielding ability) combinations as the same – like importance of seed biological value.

Keywords: Seed Vigour, Reciprocal Crossing Combination, Yielding Ability.

1. INTRODUCTION

Creating the best seed emergence in field (stress conditions) – in case of early sowing corn hybrids- could be using only high vigour seedlings, and seed amounts. Which quality parameters could correlat , with seed emergence, plant densities, and kernel yield ? Germination, vigour, seedling fresh weight, seedling root weight, seedling length ?

Sowing the seeds at cold and oxygen defficiency content soil, only possible with the best cold tolerant and healthy seed amounts – from different crossing combinations. These seed amounts are able to create high vigouros seedlings during uncomfortable circumstances.

One of our main task, to eliminate the outfield stress factors point of view to different crossing hybrid corn genotypes.

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The cold tolerance at germination is not obvious, depending from the crossing type, and mainly – the maternal genotypes. The germination vigour declines while the germination time is lengthened (*Blacklow* ,1972;*Christeller* 1984). Correlation between the maize seedlings length – during suboptimal emergence temperature are high (*Burris* 1975; *Perry*, 1981;*Lovato et al*. 2001,*George et al.* 2003; *TeKrony*,2003; *Marcos-Filho*,2015; *Berzy et* al.2020).

The cold test without soil method (Complex Stressing Vigour Test) is reproductive, easy method and could be more suitable for cold tolerance imitation – during early sowing circumstances (*Záborszky and Berzy* 2016).

The location of production and maternal parentage on seedling vigour can be different (*Espinosa-Calderon et al.* 2007.)

The physiological seed vigour of self pollinated lines could inherit at simple maternal crossing progeny, ore F1 hybrid ? (*Záborszky and Berzy* 2016*)*

This phenomenon could be genetically determined, or depending on the agro –ecologically parameters ? Seed vigour, and kernel yielding ability could be different ; depending of the genetic bacground. Selecting the best combinations could be more efficient- point of view the corn breeding. We can emphasize the importance of maternal effects of reciprocal crossing combination forms.

2.MATERIAL AND METHODS

In 2020-2022 , the seed lots of 21 maize gnotypes (Table 1,2,3), with different normal and reciprocal crossing combination were studied in the laboratory and filed experiments (Ireg, Kaba, Keszthely, Martonvasar).

The seed biological value of normal and reciprocal crossing combinations were examined at laboratory of Agr. Res.Center.

The germination ability and field emergence could be different –(depending of weather conditions and years, (*Martin et al*. 1988). Point of view of this phenomenon ; more important the seedling vigour during abiotic stress factors (*TeKrony* 2003, *Matsushima and Sakagami*, 2013).

Complex Stressing Vigour Test (CSVT, High vigour seedlings)

During the first 96 hours of the test the seeds (8x25) were exposed to a combination of stress factors that may occur in nature in the case of unfavourable weather conditions (*Berzy et al*. 2020). The stress period was folowed by 96 hours germination. The developing seedlings were divided on the basis of shoot length into high- and low vigour groups, or classified as abnormal or non-germinated(rotten seeds). The weight of eight days old seedlings (GW) and roots (RW) were measured also.

The hypothesis : the stress tolerance some of the different maternal crossing combinations can be different – depending from the physiological seed vigour ; in case of single cross type crossing combinations (new candidate, or qualified corn hybrids).

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The Hybrids: **Marco** (RPK x H 05 ; H 05 x RPK)

Kadricorn (RPK x H 70; H 70 x RPK), **Millacorn** (H 68 x RPK; RPK x H 68) , **Ivanka** (H72 x H 71; H 71 x H 72), **Lenacorn** (H 68 x H 88; H 88 x H 68), **Gürkán** (H49 x H 06; H 06 x H 49), **Mv 633** (US x H 06; H 06 x US), **Mv 204** (H 29 x H 72; H 72 x H 29), **Koramag** (H 35 x GS 21; GS 21 x H 35), **Mv 220** (H 35 x GS 22; GS 22 x H 35), **Mv 350** (H 68 x H 29; H 29 x H 68), **Mv 260** (H 72 x H 35; H 35 x H 72), **Marfi**(H 06 x H 44; H 44 x H 06),**Megasil** (H 35 x GL; GL x H 35),**Mv Exp 21** (TG x H 06; H 06 x TG), **Duca**t (H 88 x H 72; H 72 x H 88),**Mv Exp 22** (H 88 x H 48; H 48 x H 88), **Benede**k (H 85 x H 96; H 96 x H 85), **Mv 401-21**(H 72 x H 48; H 48 x H 72), **Mv 402-21** (H 22 x H 48; H 48 x H 22), **Mv 501-21** (H 06 x H 48; H 48 x H 06).

Field experiments

The experiments were carried out in the nursery of MATE, Georgikon Faculty, Martonvasar, Ireg, and Kaba .

The seed lots were sown in random block design with four replications. The plots measured 2,25 x 6 m, with two rows of 30 plants per rows (*Zaborszky and Berzy*, 2016) .

Records were made of the plants emerging, the seed moisture content at harvest, and kernel yield.

The plants were harvested by machine (Kaba, Ireg,Martonvasar), and manually(MATE, Keszthely). Due to reverse grain moisture contents of the straight and reciprocal crossing genotypes, the results were converted to 14% seed moisture content and the data were evaluated using single and two factor analysis of varíance (*Sváb*, 1981).

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3.RESULT AND DISCUSSION

Table 1 Reciprocal crossing effect to the hybrid corn seed biological value and kernel yield (Kaba-Keszthely-Martonvásár, 2020)

Hybrid	Crossing	G%	CSVT	GW	RW	GL	RL	Yield 1	Yield 2	Yield 3
Marco	H 05 x RPK	96	**88***	**2,8***	1,81	4,93	**9,05***	**16,86****	**12,69***	8,96
	RPK x H 05	90	64	0,9	0,63	2,07	4,57	13,92	10,81	7,91
LSD *,**		NS	22,7	1,84	NS	NS	3,37	2,54	1,85	NS
Lenacorn	H 68 x H 88	92	78	3,28	2,07	5,9	9,47	14,35	11,32	7,97
	H 88 x H 68	92	84	4,31	3,02	6,7	11,02	13,3	11,39	8,74
		NS						NS	NS	NS
Mv 204	H 29 x H 72	90	**87***	3,87	1,93	5,76	8,88	**14,38***	10,65	8,32
	H 72 x H 29	93	54	1,7	0,67	4,63	6,02	12,47	10,62	8,34
LSD *		NS	25,3	NS	NS	NS	NS	1,84	NS	NS
Gürkán	H 49 x H 06	**100**	98	4,2	2,98	6	9,22	**14,25***		8,16
	H 06 x H 49	91	77	2,68	2,11	5,01	9,23	12,13		7,97
LSD *,		8,4	NS	NS	NS	NS	NS	1,87		NS
Kadricorn	H 70 x RPK	95	**81***	**3,47***	2,09	**5,72**	8,42	**13,25***		**7,9***
	RPK x H 70	90	57	1,42	1,11	3,48	8,15	11,18		6,53
LSD *		NS	23,9	1,82	NS	2,22	NS	1,92		
Mv 633	H 06 x US	95	**91***	4,22	4,08	7,33	11,7	**14,86****	**14,23***	7,35
	US x H 06	93	67	3,38	3,12	6,52	10,77	12,27	12,22	6,37
LSD *,**		NS	23,8	NS	NS	Ns	Ns	2,52	1,88	Ns

G %: Germination %
CSVT: Complex stressing vigour test (high vigour seedlings %)
GW: 8 days old seedlings germ fresh weight(g/ 25 sedlings)
RW: 8 days old seedlings root fresh weight (g/ 25 seedlings)
GL: 8 days old seedlings germ length (cm)
RL: 8 days old seedlings root length (cm)
Yield 1: kernel yield weight (kg/parcel) Kaba
Yield 2: kernel yield weight(kg/parcel) Keszthely
Yield 3: kernel yield weight (kg/parcel) Martonvásár

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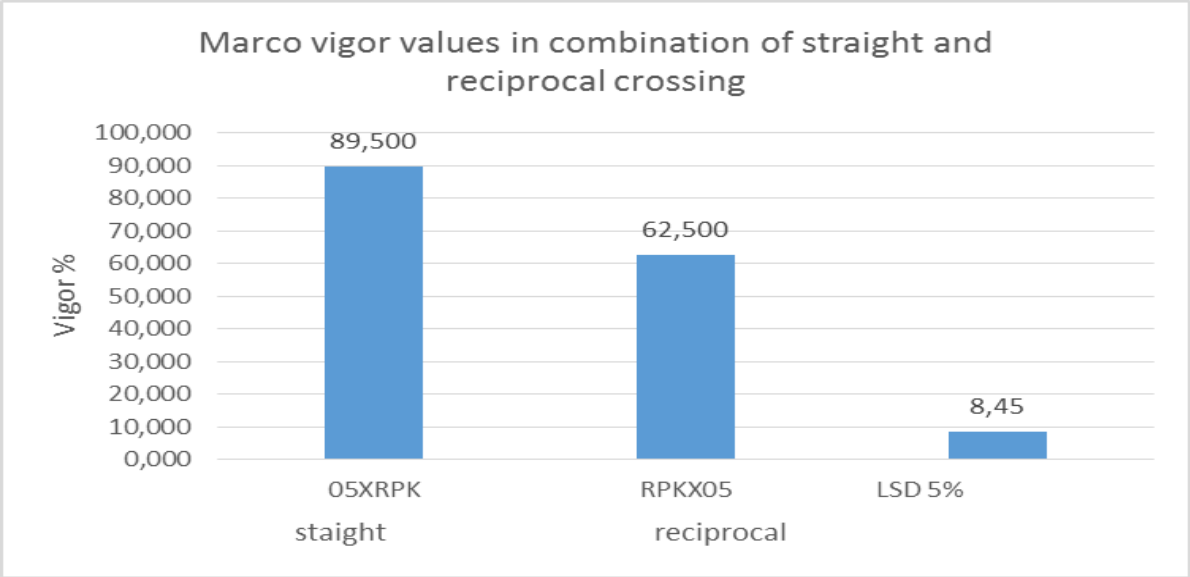
Figure 1



The vigour of the seed lots resulting retarded germination and the development of significant smaller, shorter seedlings under stress conditions (RPK x H 05).

The plants developing from the seeds with greater vigour exhibited better emergence, faster ripening and lower grain moisture at harvest (H 05 x RPK) **Table 1**

Despite ; the RPK female genotype more stress sensitive , but hybrid corn seed production (Marco), less complicate, than, using H 05 female genotype. The higher – and significant- _ density, and kernel yielding ability (H 05 x RPK; Keszthely, Martonvasar) correlate strong(LSD 5%). It is useful to select the better crossing combination form , point of view optimal kernel yield plant production**. Figure 1.**

The biotic stress sensibility of this line(H 05 ,) can eliminate with spraying fungicides (*Fusarium sp)*, and insecticides at flowering period.

The RPK x H 70 crossing form – Kadricorn hybrid – resulted higher stress sensibility (CSVT -24%, GW -2,1 g/seedling) – and less (9-10%) density, and kernel yield (2-2,4 kg/parcel) than the more stress tolerant, and better seed biological value of **H 70 x RPK** reciprocal crossing combination.

A **H 06 x US** crossing combination (Mv 633 hybrid) results: : better high vigour seedlings ratio (CSVT +24%)- and significantly higher kernel yield - during well wet soil conditions (Keszthely (+1,97 kg/parcel). The opposite side experimental filed conditions (higher heat and drought stress conditions) could eliminate the seed moisture content at harvest (SMC, Kaba - 5,53%!), and earlier and less wast of energy drying process than US x H 06 reciprocal crossing combination!

Germination ability and early seedling vigour, could more important than the crossing combination forms at hybrid Mv 204, and Ghurkan (2020.year)

Table 2 Reciprocal crossing effect to the hybrid corn seed biological value, and yield parameters *(Keszthely, Martonvásár, Kaba, Iregszemcse) 2021*

Hybrid	Crossing	G%	CSVT	GW	RW	D1	D 2	D 3	D 4	Y 1	Y 2	Y 3	Y 4
Koramag	H 35 x GS 21	94	71	3	2,68	139	184	178	193	5,14	7,2	5,46	8,48
	GS 21 x H 35	95	67	2,69	2,12	**151***	**196***	182	200	6,48	7,86	6,19	9,25
LSD *						11,4	10,8						
Mv 220	H 35 x GS22	88	78	3,75	3,96		176	192	186		7,38	5,2	7,86
	GS22 x H 35	94	77	4,83	2,41		**191***	190	189		7,93	5,56	8,32
LSD*							12,4						
Mv 350	H 68 x H 29	**98***	**91****	**6,25***	**4,36***		**198***	172	**189***		11,16	11,23	10,48
	H 29 x H 68	87	62	3,2	1,86		176	171	168		10,07	10,06	9,76
LSD *, **		10,6	24,7	2,72	2,44		14,4		13,8				
Ivanka	H 72 x H 71	96	88	5,31	4,43	161	188	189	174	7,86	9,52	10,5	8,87
	H 71 x H 72	93	82	5,07	2,92	155	193	186	168	7,96	9,11	9,36	8,62
Ducat	H 88 x H 72	94	92	6,1	5,63	**170***	196	174	192	7,84	8,57	9,88	7,84
	H 72 x H 88	92	80	4,57	3,92	149	184	177	189	7,89	8,32	10,2	7,89
LSD *						16,7							
Mv 260	H 72 x H 35	90	**69****	3,27	1,67		**180****	165	177		**9,22***	9,31	8,11
	H 35 x H 72	88	36	1,68	1,02		157	175	177		7,51	8,27	8,13
LSD *, **			28,2				22,5				1,57		
Marco	H 05 x RPK	96	**88***	3,82	2,67	165	**197****	189	165	9,29	**11,63***	11,4	11,29
	RPK x H 05	92	62	2,63	1,83	156	173	188	164	8,69	10,11	10,5	10,43
LSD *			8,45				23,6				1,48		
Mv 204	H 29 x H 72	97	56	2,23	0,92		182	189	171		10,12	10,31	11,06
	H 72 x H 29	93	**92****	**5,13***	**4,06****		195	192	**189***		10,29	9,49	10,53
LSD *			28,3	2,85	3,11				14,4				
Kadricorn	H 70 x RPK	90	47	1,93	1,17		145	180	177		9,17	10,22	10,24
	RPK x H 70	87	51	2,25	1,73		155	169	180		9,44	9,81	8,82
Millacorn	H 68 x RPK	98	67	5	4,23		159	167	154		10,21	11,41	10,12
	RPK x H 68	97	77	5,11	5,17		151	161	151		9,96	10,92	10,07
Marfi	H 06 x H 44	93	**91***	5,42	2,73	189	161	189	174	9,33	10,22	**12,68***	10,75
	H 44 x H 06	96	68	3,2	2,13	196	149	199	180	9,49	9,98	11,17	10,86
LSD *			6,67									1,45	
Megasil	H 35 x GL	95	83	3,93	4,66	152	186	192	168	7,76	7,92	8,21	8,03
	GL x H 35	94	89	5,25	5,05	165	194	188	178	7,34	9,28	9,96	8,43

G%: Germination %
CSVT: Complex stressing vigour test (high vigour seedlings%)
GW: 8 days old seedlings germ fresh weight (g/25 seedlings)
RW: 8 days old seedlings root fresh weight (g/25 seedlings)
D 1: Total plant number at Keszthely
D2: Total plant number at Martonvasar

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D3: Total plant number at Kaba
D4: Total plant number at Ireg
Y 1: kernel yield weight (kg/parcel) Keszthely
Y 2: kernel yield weight(kg/parcel) Martonvasar
Y 3: kernel yield weight(kg/parcel) Kaba
Y 4: kernel yield weight(kg/parcel) Ireg

Despite the similar germination ability, the higher vigour seedling ratio (CSVT) coud result higher seedling germ weight (GW) , better field emergence and density in case of straight crossing form H 05 x RPK.; (Hybrid Marco). (**Table 2**) This crossing combination resulted higher kernel yield (1,1 kg/parcel, Mvasar) , and lower seed moisture content at harvest(Keszthely), than the stress sensitive RPK x H 05 reciprocal crossing form.

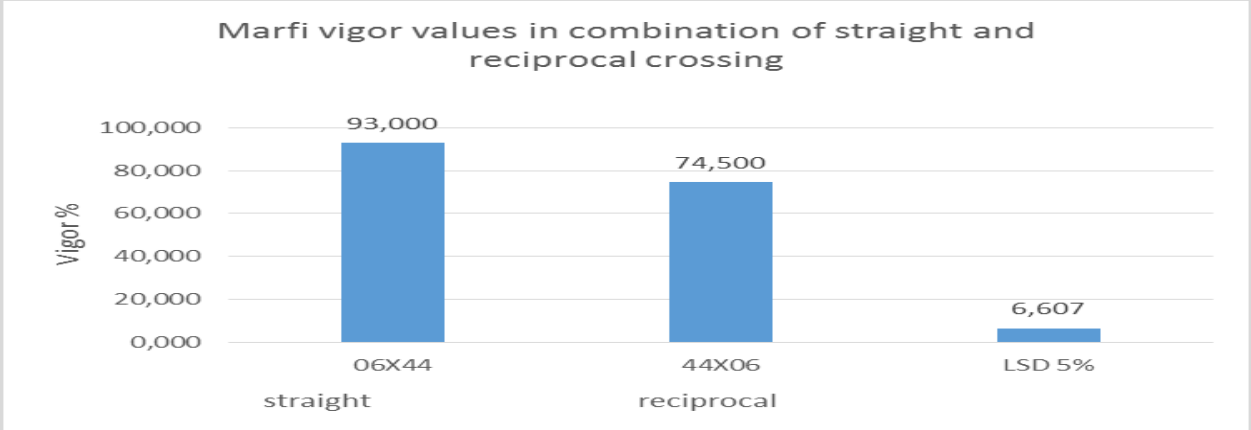
Despite the late flowering and difficult seed processing of H 05 - seed production proposed at this tolerant genotype maternal form.

Seed biological value and abiotic stress tolerance of normal and reciprocal crossing forms of **GS 21, GS22** maternal combinations, and H35 genotypes are similar.

Biotic stress sesibility of H35 x GS21 reciproc maternal crossing combinations are obvious (Koramag, Mv 220 hybrid). This phenomenon could result moderate surplus kernel yield weight – in case of GS 21 x H 35, and GS 22 x H 35 hybrids (every experimental fields).

H 06 x H 44 (Marfi hybrid) and reciprocal crossing form germinations are equivalent. The better high vigour seedling ratio (+23%) in case of H 06 maternal form – **(Figure 2)-** results stress tolerant, and greater fresh seedling germ weight (GW) , and significant surplus kernel yield weight than (H 44 X H 06) reciprocal crossing combination (experiment at Kaba).

Figure 2



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H68, and H 72 maternal genetic forms resulted better germination and seed biologic value(CSVT,GW,RW), emergence and yield ; despite the H 29 maternal crossing forms. Storability, and seed deterioration - reciprocal crossing combinations H29x H 68 ,and H 29 x H 72 - could be more damaging factor in these crossing forms.(Hybrid, Mv 204 , Mv 350).

Stress sensibility of H 35x H 72 crossing combination (Mv 260 hibrid) similar to Koramag, and Mv 220. The more stress tolerant crossing combination(**H 72 x H 35)** resulted significant better field emergence, density, and higher kernel yield (Martonvasar), than the reciprocal (H 35 x H 72) crossing form.

Table 3 Reciprocal crossing effect to the hybrid corn seed biological value, and yield parameters (Keszthely, Kaba 2022)

Hybrid	Crossing	G%	CSVT	GW	RW	SMC 1	SMC2	D1	D2	Y1	Y2
MvExp 21	TGxH 06	91	43	1,73	2,08	25,35	34,56	198	174	4,43	3,41
	H 06 x TG	93	**86****	2,92	2,36	24,15	32,41	196	**189***	5,21	**5,17***
LSD *, **			38						14.3		1,74
Ducat	H72 x H 88	93	70	3,33	2,62	19,15	17,42	193	176	5,1	8,08
	H 88x H 72	91	80	3,53	2,66	19,08	16,44	191	163	4,78	6,13
MvExp22	H 88xH 48	94	66	2,57	2,67		**18,92***		161		5,45
	H48 x H 88	86	56	2,36	2,48		21,43		170		5,88
LSD *							2,46				
Mv501-21	H06 x H 48	99	86	5,03	4,66	19,06	28,44	202	184	6,76	7,36
	H 48 xH 06	96	64	3,66	2,93	21,26	30,12	208	188	6,56	8,05
Mv 633	US xH06	92	25	1,26	0,77		29,22		162		4,58
	H 06 x US	91	**53***	1,95	1,16		29,65		177		5,13
LSD *			22,2								
Benedek	H85 xH 96	96	**86****	3,05	1,27		17,45		177		8,19
	H 96x H85	88	42	1,92	0,97		17,84		180		7,03
LSD **			41								
Ghurkán	H 49 x H06	89	27	0,63	0,1		22,63		147		7,04
	H 06 x H 49	91	**49***	1,87	**1,45***		22,79		**184****		**9,69****
LSD *, **			21,6		1,3				36		2,61
Mv 401-21	H 72 xH 48	99	**96****	**5,51***	**3,02***	18,65	23,67	201	**191****	6,11	**8,84***
	H48 x H 72	95	52	1,68	1,27	17,41	24,35	188	158	5,33	6,63
LSD *, **			43	2,77	1,66				24,9		1,88
Mv 402-21	H 22 x H 48	93	**91***	2,3	1,73		26,26		**189****		7,75
	H 48 x H 22	91	59	2,11	2,16		25,36		143		6,22
LSD *			24,4						32		NS

G%: germination %
CSVT: Complex stressing vigour test (high vigour seedlings %)
GW: 8 days old seedlings germ fresh weight (g/ 25 seedlings)
RW: 8 days old seedlings root fresh weight (g/25 seedlings)
D 1: density Total plant number at Keszthely

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D2: density Total plant number at Kaba
SMC1: Seed moisture content % at Keszthely
SMC 2: Seed moisture content % at Kaba

A TG x H 06 (Hybrid ,Mv Exp 21) crossing combination excellent germination ability with high cold stress, and abiotic stress sensibility . The reciproc crossing combination form – **H 06 x TG** - results more high vigour (CSVT, GW) seedlings, , and because this phenomenon, significant higher kernel yield. (**Table 3**)

This abiotic stress resistance – at maternal line **H 06** - inherited in normal crossing combination forms ; **H 06 x US** (Mv 633 hybrid), and in case **H 06 x H 49** (Hybrid Gurkhán) too. Stress sensibility had greater importance in case of these hybrids because of the worst, and unfavourable climate factors(rain defficiency, and high temperature at flowering period) in this year. H 06 x H 49 (Ghurkan hybrid) resulted significant higher kernel yield.!

H 72 x H 48 (Mv 401-21 hybrid) crossing combination form is better, than the reciprocal form. The moderate germination value difference will be higher during unvaourable stress conditions. (enormous high vigour seedlings ratio).

H 48 line – member of Lancaster group - characterize with excellent genetic crossing combination ability. The maternal form is more sensible to biotic and abiotic stress factors.
A **H 22 x H 48 (Hybrid Mv 402-21)** crossing combination form has the same results.
Bigger plant number /parcel and higher kernel yield - against the reciprocal form.
Hybrid seed corn production is better using stress tolerant H 22, H 72 female and H 48 male parents!
H 85 and H 96 are new genetic sources (hybrid Benedek), with less results.

3.CONCLUSION

Importance of early seed vigour could be determined considering of the different maternal crossing type. Close correlation was found the vigour of stressed seedlings(CSVT) and emergence, with r2 value of 0,89 (H 05 x RPK), and kernel yield (Y') with an r2 value of 0,96.

In 2020- the correlation values between seedling shoot weight (GW) and kernel yield (- are:

H 05 x RPK; Y'= 14,68 + 0,75 GW , r2 = 0,92

H 70 x RPK ; Y'= 11,05 + 0,65 GW r2= 0,75

corelation values between high vigour seedling ratio (CSVT) an kernel yield(Y'):

H 05 x RPK r2 = 0,96

H 70 x RPK r2 = 0,88

H 06 x US r2 = 0,91

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The importance of early seed vigour parameters could be determined (*TeKrony* 2003., *Záborszky and Berzy,*2016), considering, the seed biological value ,and maternal effect of the kind of crossing combination forms. Germination ability and early seed vigour could be as important as crossing combination (straight and reciprocal) forms too.

4.SUMMARY

The selections of optimal parental lines are very important at hybrid seed corn production. The hybrid seed corn factories used to select maternal, and paternal genotypes on the basis of flowering time, seed biological value, and kernel yielding ability(as the main important genetic factor) . The higher yielding ability is the most important thing ; point of view as a financial factor.

Selections of yielding ability of the best seed corn fractions (-after the seed processing)- were not form the basis of yielding ability of F1 progeny .

One of our main task, to select the optimal crossing type,- depending on stress factors (cold tolerance at sowing, heat and drought tolerance at flowering time). We can change the maternal, and parental lines , normal and reciprocal crossing combinations . Which combination form will be the best ?

After the seed biological value - germination, and vigour laboratory tests - the seed lots of 21 maize genotypes (Marco, Kadricorn, Lenacorn, Millacorn, Ghurkán, Mv 633, Mv 204,Koramag, Mv 220, Mv 350, Ivanka, Mv 260, Marfi, Megasil, MvExp 21, Mv Exp 22, Ducat, Benedek, Mv 401-21, Mv 402-21, Mv 501-21) with different normal and reciprocal combinations were studied at filed experiments (in Kaba, Mvásár, Ireg and Keszthely) between 2020-2022.

After three year experimentation and different environmental conditions – we can emphasize : there are differences between the different crossing combinations !

The vigour of the seed lots resulting in retarded germination and the development of significantly smaller, shorter seedlings under cold stress conditions **(RPK x H 05 ; RPK x H 70; US x H 06; TG x H 06; H 35 x H 72, H 48 x H 22, H 49 x H 06).**

The fresh shoot weight of seedlings developing in a cold, oxygen poor environment was greater than the fresh root weight for all the genotypes, regardless of the crossing method.

In the filed experiment, the plants developing from seeds with greater vigour exhibited better emergence, faster ripening and lower grain moisture at harvest **(H 05 x RPK, H 70 x RPK, H 06 x US, H06 x H 44, H 06 x TG, H 72 x H 29, H 06 x H 49, GS 21 x H 35, GS 22 x H 35).**

Correlation between the high vigour seedlings for plants developing from seed lots from reciprocal crossing combinations and fresh shoot weight of the seedlings and the kernel yield were obvious **– Marco, Kadricorn, Ghurkan, Koramag, Marfi, Mv 633, Mv Exp 21, Mv 401-21 hybrids.**

Importance of selection the best crossing (yielding ability) combinations as the same – like importance of seed biological value.

Before the qualification (registration) of the new hybrid, we need to take a notice for selection the best seed production (crossing combination) forms.

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