

**Report about winterpea-wintertriticale-mixture-tests in
combination of three triticale-types with ten pea-types in season
2019/20 (second year of trial)**

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Abstract

Six combinations of isogenic winter peas (normal leaf type/semileafless) with different length (12 samples) were combined with three different triticale varieties. Even despite very limited precipitation during the growing season (65mm/m² from April till July 2020) satisfying yields of about 3t/ha of mixture yield could be obtained. Statistical analyses on yield showed differences between triticale varieties depending on pea varieties and pea varieties independent from triticale varieties, but no statistical interactions. On low level of significance, normal leaved peas suppressed the triticale more but led to slightly higher pea share in the yields. Ground covering was higher with normal leaved peas.

Location(s)

53°12'49.3"N, 10°50'29.2"E , DE-21371 Tosterglope-Koehlingen-Bus Stop, loamy sand

List of accessions

In 2018/19

Winterpeas (seed density 70 seeds/m²) all with white flowers

<i>DZP 11 03 b V</i>	<i>short (3), normal leaf</i>
<i>DZP 11 01 e R</i>	<i>short (3), semileafless</i>
<i>DZP 10 09 d4 V</i>	<i>short to medium (4), normal leaf</i>
<i>DZP 10 09 e1 R</i>	<i>short to medium (4), semileafless</i>
<i>DZP 08 01 f6 V</i>	<i>medium to tall (6), normal leaf</i>
<i>DZP 08 01 f6 R</i>	<i>medium to tall (6), semileafless</i>
<i>DZP 08 01 f4 V</i>	<i>tall (7), normal leaf</i>
<i>DZP 08 01 f4 R</i>	<i>tall (7), semileafless</i>
<i>Karolina</i>	<i>tall to very tall (8), normal leaf</i>
<i>Szarvasi Andrea</i>	<i>tall to very tall (8), semileafless</i>

All of them in combination with

Wintertriticale (seed density 120 seeds/m²)

<i>Agostino</i>	<i>medium after winter, late ear emergence, short</i>
<i>Vuka</i>	<i>planophile after winter, medium ear emergence, broad leaves, tall</i>
<i>Securo</i>	<i>erectophile after winter, medium ear emergence, very tall,</i>

Changes for 2019/2020

Winterpeas (seed density 75 seeds/m²)

Implemented new

DZP 08 03 c7 V	medium (5), normal leaf
DZP 08 03 c7 R	medium (5), semileafless
DZP 08 01 e V	very tall (9), normal leaf
DZP 08 01 e R	very tall (9), semileafless
Pandora V	tall (7), normal leaf
Kolinda R	tall (7), semileafless

Excluded

DZP 11 03 b V	short (3), normal leaf
DZP 11 01 e R	short (3), semileafless
DZP 08 01 f6 V	medium to tall (6), normal leaf
DZP 08 01 f6 R	medium to tall (6), semileafless

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, ...)

Trait	How it has been assessed	Type of data available
Height in April	Measure in cm	cm
Height in June	Measure in cm	cm
Ground cover of Pea	Visual notation	%
Ground cover of Triticale	Visual notation	%

Crop productive performance (yield, yield components)

Trait	How it has been assessed	Type of data available
Yield of pea samples	Weight after threshing, drying and separation	dt/ha
Yield of triticales	Weight after threshing, drying and separation	dt/ha
Yield combined	Weight after threshing and drying	dt/ha

Trial background and hypothesis

Under organic farming in the middle-north of Germany growing of winter peas can be done best in mixture with triticale, because it has a better performance and is later ripening than barley, is not as much shadowing like rye and can compensate yield, if peas are reduced by weather conditions. Peas can differ first of all in height and leaf type related to the question, which type would be best in yield to combine with triticale, but also whether there is an influence of triticale to yield. The trial shall give hints for which type of winter pea should be used in mixtures and whether height and leaf type have an influence on yield or can show interaction with different triticale.

Trial design and management

Twelve winter peas, representing 5 different types in height, each as one with normal leaf type and one with semi leaf type and where possible as isogenic lines, were combined with three different triticale varieties on plots of 3,125m² with three replications (108 plots in total as

complete randomised block design). Date of sowing was Sept. 18th, 2019. A mechanical hoeing was done on Oct. 31st, 2019. Harvested with plot combine on July 18th, 2020. Dried with cold air and separated with spiral separator. Statistical analyses were done as a multi-factorial ANOVA. Three principal factors were tested for their effects: Triticale Variety, Pea-Type (Group of similar types as one) and Pea Leaf-type.

Statistics were done with PLABSTAT, Statistical model used for 2020: $R + T + P + L + TP + LP + TL + TPL + RTPL$ the factor R was taken as random. Model for the 2-year analysis: $Y + R:Y + T + P + TP + TY + PY + PTY + L + LT + PL + TLP + LY + PLY + TLY + TPLY + RTPLY$ factors R and Y were taken as random. Y=Year; R= Repetitions; T=Triticale Variety; P=Group of Pea; L= Leaf type, last term acts as residual/error term.

In addition to the yield trial, all accessions were maintained each in five single plant descendant plots with single plant harvests and rest plot threshing.

Participatory and multi actor approaches

Due to the Corona-Virus pandemic, a possibility for contactless field visits was created during May and June. A brochure guiding through the winter-pea trials was created. Only few discussions with single visitors were possible. One discussion point was the possibility of having different maturity types of winter pea to be flexible in the choice of mixing partners. Barley and triticale are the main mixing partners used in practice, differing in their possibilities to be used as animal feed. As an outcome of this discussion winter pea types with earlier maturity, more suitable for the mixing with winter barley were identified in the breeding nursery and will in future be selected with focus on mixing-ability with winter barley additionally. The main breeding focus will stay on the mixing with triticale. But also, triticale should be looked for better total yield in combination with winter pea.

Main results

Even despite very limited precipitation during the growing season (65mm/m² from April to July 2020), satisfying yields of about 35 dt/ha of mixture yield and pea yields from 4,5 to 26 dt/ha on average could be obtained. Statistical analyses on yield showed differences between triticale varieties depending on pea varieties and pea varieties independent from triticale varieties, but no statistical interactions.

Triticale Variety VUKA showed highest yield in mixtures and on its own as triticale in 2018/19 as well as in 2019/20. VUKA in 2018/19 compensated best, with the medium type in length and a semi leafless type of pea (DZP1009e1R). Best pea yields of about 19 dt/ha in 2020 were obtained with the longer and normal leafed varieties DZP0801f4V, KAROLINA and PANDORA in mixture with Triticale VUKA.

The highest yielding triticale VUKA as broad leafed single ear type with erect overwintering gave the highest yields for pea, for mixture and, as seen in 2018/19 when necessary, a good compensation of pea losses, whilst SECURO as an ear density type with small leafes and flat overwintering, late ear emergence, produced lowest mixing yields as well as the weakest compensation in 2018/19.

As a tendency, normal leaved peas suppressed the triticale yield more but led to slightly higher pea share in the yield. Results differed only on low level of significance ($<0,1$). Longer Varieties suppressed the triticale yield most, but also led to a higher share of pea in the mixture.

Ground covering in April was significantly higher with normal leaved peas (41,5%) compared to semi-leafless types (36,2%).

In 2018/19 with an extremely dry spring in combination with stem diseases the pea yield was reduced to a low level. Nevertheless, a small dataset with three groups of peas (six varieties) could be analysed over the two trial years, the better ground cover of normal leaved pea and their stronger suppression of the triticale in yield were confirmed. The influence on total yield was mostly referring to the triticale yield and therefor on the yield performance of the triticale-variety itself.

Discussion

In season 2019/20 we saw a parallel development of pea and triticale. Yield share in average was balanced with 50% for each mixing partner. Good circumstances to detect possible interactions between pea and triticale in mixed cropping. In case of the trait yield no significant interactions between the pea and the triticale varieties were found. Together with the results from the two-year analysis the picture is getting even more clear: No statistically significant interaction between single genotypes. It means that it doesn't matter which type of triticale is used to select for best yield of pea varieties in mixture, but it is important to find the best triticale for best total yield at all.

Especially for organic farming systems, crops and varieties with a good weed suppression are crucial. The experiment could show the positive effect of a normal leaved pea to better suppress weeds from the beginning of the growing season on and there seems to be a tendency, that normal leaf type of pea can reach better yield. But normal leaf type is also more sensitive for lodging, which might limit the use related to the fertility of the soil, the location and the weather conditions. Therefor more variety trials with mixtures at different locations would be preferable.

Total yield in 2020 and in the two year analysis was influenced mainly by triticale varieties, but not pea varieties, which means that peas and triticale compensate each other, whatever the type of pea is. But the level of triticale yield brought the highest influence on total yield at all. The yield of the pea varieties was different, but not significantly influenced by triticale varieties. The shortest peas gave the lowest yield and the tallest with normal leaf type the highest. The yield of triticale itself was influenced by the type of pea. The leaf type has an influence on yield over all five length-types of pea. The very tall pea varieties KAROLINA and SZARVASI ANDREA suppressed the triticale yield significantly.

Conclusion and next steps

For more or less extensive locations like the ones available for the trials a well yielding triticale variety should be combined with more or less tall pea varieties. Normal leaved types due to

their enhanced weed suppression and their slight yield advantage should be preferred under organic farming.

To breed for better mixing ability, a medium to tall normal-leaved winter pea will be the first choice and a high yielding triticale with good compensation should be the one to combine with in yield trials for pea selection.

As triticale has such an influence on the total yield, it should be given more research on more different varieties of triticale to be combined with medium to tall peas to increase the mixed yield with a focus on the pea share and the compensation ability of the triticale. In trials for searching better triticale in mixtures a special view should be given on morphological characters like broadness of leaves, date of ear emergence and rapidness of juvenile growth, plant length and ears per square meter to develop a 'triticale mixture type'.

Supplementary material

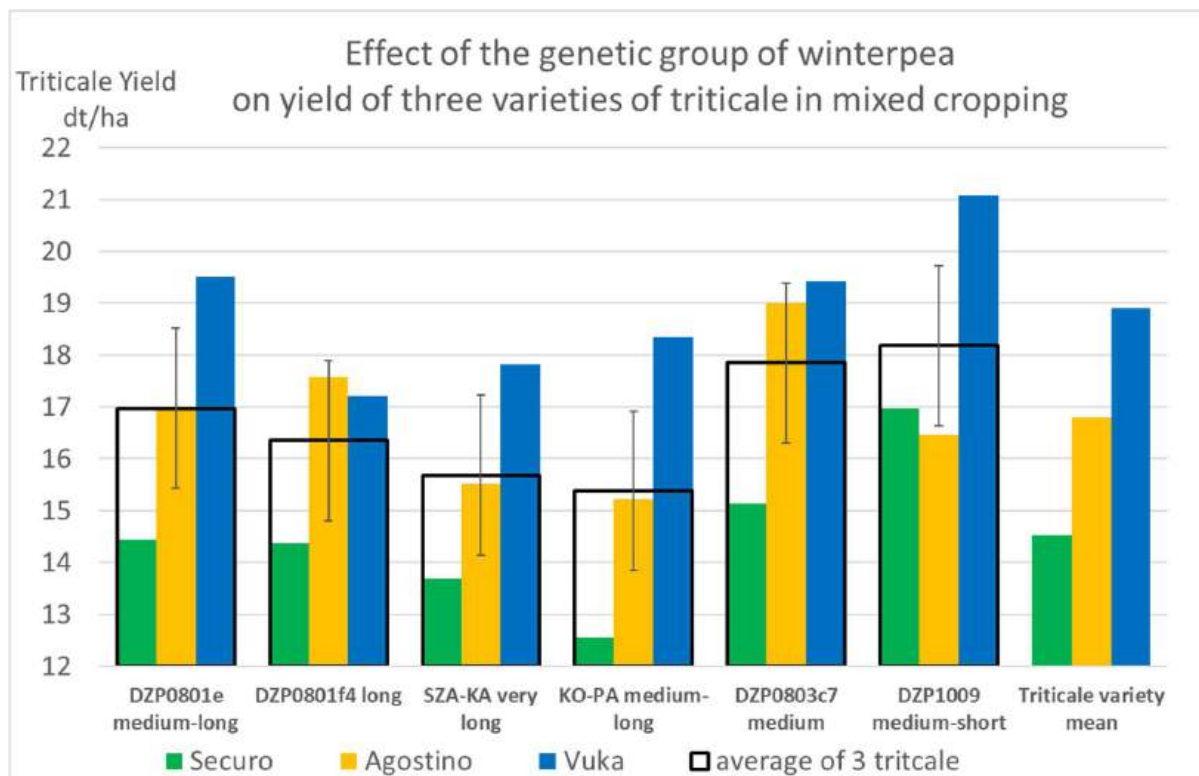


Figure 1 : Effect of the genetic group of winterpea on triticale yield of three varieties in mixed cropping. Error bars indicate LSD 5%, different letters above variety means indicate significant differences according to LSD5%.

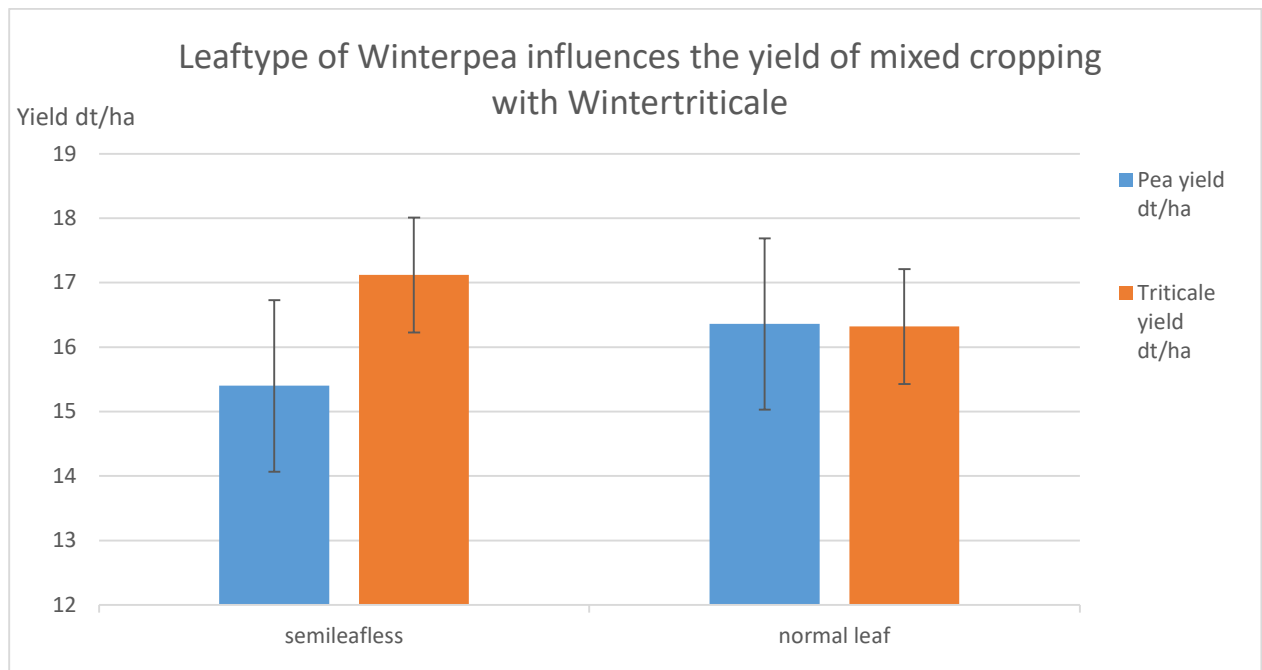


Figure 2 : Leaf-type of winterpea influences the yield of mixed cropping with wintertriticale. Means of Leaf-type of winterpea (n=12 var., 6 normal-leafed and 6 semileafless) tested. Error bars indicate LSD 5%.

Results 2020: Pea Varieties													Harvest Index Pea/Triti cale	TKM Pea (Mixed probe all REP.)
	Pea plants/2 m row	Early plant height pea (cm) 08.04.20 20	Early plant Height Triticale (cm) 08.04.2020	Ground covering pea (%) 08.04.202	Ground covering triticale (%) 08.04.202	Ground covering total (%) 08.04.202	Final plant length (cm) Triticale before Harvest 16.06.202	Final Plant length (cm) pea before Harvest 16.06.20	Lodging Index at harvest 16.06.20	Pea yield dt/ha	Triticale yield dt/ha	Total yield dt/ha		
Min	11,0	5,0	15,0	10,0	30,0	55,0	55,0	40,0	0,78	4,5	8,5	21,1	0,2	117,6
Max	33	35	30	60	70	90	105	125	1	26	27	45	2,2	215,5
Mean	21.30	15.88	21,11	38,84	45,05	83,89	97,87	90,02	0,96	15,75	16,74	32,77	0,99	153,58
LSD 0.05	n.s.	1,18**	n.s	6,85**	5,76**	n.s.	n.s.	n.s.	n.s.	3,25*	n.s.	3,91+	n.s.	Means only
DZP1009e11R	21,2	10,0	22,2	22,8	55,6	78,3	98	55,6	1	10,34	18,61	29,14	0,57	193,8
DZP1009d4V	20,2	10,6	20,6	22,2	53,3	75,6	98	55,0	1	13,04	17,74	32,26	0,73	207,8
DZP0801f4R	20,2	16,1	21,1	40,6	42,8	83,3	98	101,7	0,97	17,62	17,17	34,98	1,05	130,1
DZP0801f4V	20,4	16,7	21,1	43,9	43,9	87,8	98	105,2	0,96	19,19	15,6	34,93	1,24	131,7
DZP0803c7R	19,4	11,1	20,0	26,7	53,3	80,0	98	69,4	0,99	12,28	17,94	30,44	0,71	137,9
DZP0803c7V	20,3	11,7	20,0	31,1	50,0	81,1	98	62,2	0,99	13,69	17,76	31,58	0,8	137,3
Szarvasi Andrea	23,1	26,1	22,8	56,7	32,2	88,9	98	118,9	0,92	19,06	16,04	35,27	1,26	171,6
Karolina	19,0	20,6	21,1	50,6	38,3	88,9	98	113,3	0,89	15,62	15,32	31,08	1,04	200,9
DZP0801eR	21,3	17,8	20,0	41,7	44,4	86,1	98	98,9	0,96	16,23	17,21	33,58	0,97	121,3
DZP0801eV	23,7	18,3	20,6	46,7	38,9	85,6	98	105,6	0,95	16,88	16,72	33,77	1,08	125,6
KolindaR	23,3	13,3	21,7	28,9	52,2	81,1	98	99,4	0,97	15,33	15,76	31,32	1,06	148,2
PandoraV	23,2	18,3	22,2	54,4	35,6	90,0	93	95,0	0,94	19,73	15	34,99	1,32	136,7

Results 2020: Group of Pea, Leaf type, Triticale- Variety	Pea plants/2m row	Early plant height pea (cm) 08.04.20 20	Early plant Height Triticale (cm) 08.04.2020	Ground covering pea (%) 08.04.202	Ground covering triticale (%) 08.04.202	Ground covering total (%) 08.04.202	Final plant length (cm) Triticale before Harvest 16.06.202	Final Plant length (cm) pea before Harvest 16.06.20 20	Lodging Index at harvest 16.06.20 20	Pea yield dt/ha	Triticale yield dt/ha	Total yield dt/ha	Harvest Index Pea/Triti cale	TKM Pea (Mixed probe all REP.)
LSD 0.05	n.s.	2,36**	n.s.	4,84**	4,07**	4,44**	n.s.	7,24**	0,03**	2,3**	1,54**	2,77*	0,19**	Means only
DZP1009	20,7	10,3	21,4	22,5	54,4	76,9	98	55,3	1	11,69	18,18	30,7	0,65	200,8
DZP0801f4	20,3	16,4	21,1	42,2	43,3	85,6	98	103,4	0,96	18,41	16,35	34,96	1,14	130,9
DZP0803c7	19,9	11,4	20,0	28,9	51,7	80,6	98	65,8	0,99	12,98	17,85	31,01	0,75	137,6
SZA-KA	21,1	23,3	21,9	53,6	35,3	88,9	98	116,1	0,91	17,34	15,68	33,17	1,15	186,2
DZP0801e	22,5	18,1	20,3	44,2	41,7	85,8	98	102,2	0,95	16,56	16,97	33,67	1,03	123,5
KO-PA	23,3	15,8	21,9	41,7	43,9	85,6	96	97,2	0,96	17,53	15,38	33,11	1,19	142,4
LSD 0.05	n.s.	n.s	n.s.	2,80**	2,35**	n.s.	n.s.	n.s,	0,02+	1,33+	0,89+	n.s.	0,11+	Means only
semileafless	21,2	15,7	21,3	36,2	46,8	83,0	98	90,7	0,97	15,4	17,12	32,44	0,94	150,5
normal leaf	21,4	16,0	20,9	41,5	43,3	84,8	97	89,4	0,96	16,36	16,32	33,1	1,04	156,7
LSD 0.05	n.s.	1,67*	1,23**	3,42**	2,88**	3,14**	2,26**	n.s.	0,02**	n.s.	1,09**	1,96**	0,13*	Means only
Agostino	20,3	15,8	21,1	35,7	47,1	82,8	90	89,3	0,94	15,67	16,79	33,0	0,96	152,4
Vuka	22,3	16,9	25,4	37,8	49,6	87,4	100	91,4	0,97	16,46	18,9	35,5	0,9	156,1
Securo	21,3	14,9	16,8	43,1	38,5	81,5	104	89,3	0,97	15,13	14,52	29,8	1,1	152,3

Results 2020: Further significant Effects.														
	Pea plants/2 m row	Early plant height pea (cm) 08.04.20 20	Early plant Height Triticale (cm) 08.04.2020	Ground covering pea (%) 08.04.202 0	Ground covering triticale (%) 08.04.202 0	Ground covering total (%) 08.04.202 0	Final plant lenght (cm) Triticale before Harvest 16.06.202 0	Final Plant lenght (cm) pea before Harvest 16.06.20 20	Lodging Index at harvest 16.06.20 20	Pea yield dt/ha	Triticale yield dt/ha	Total yield dt/ha	Harvest Index Pea/Triti cale	TKM Pea (Mixed probe all REP.)
Further significant effects	none	none	Repetition s**	Repetition ns *	Repetition ns*; PEA- Group x Triticale*	Repetition ns **	none	none	none	none	none	none	Repetition ns*	

MODEL R + T + P + L + TP + LP + TL + TPL + RTPL

R= Repetitions; T=Triticale Variety; P=Group of Pea; L= Leaf type, last term acts as residual/error term.

LSD 0,05 and significance according to f-statistics.

+ = significant at level of confidence: 0,1

* = significant at level of confidence: 0,05

** = significant at level of confidence: 0,01

Means of all pea-triticale combinations for yield 2020

yield in dt/ha	yield of pea (STDDEV: 1,07 dt/ha)					yield of triticale (STDDEV: 0,54 dt/ha)					combined yield (STDDEV:1,30 dt/ha)			
Name	Agostino	Vuka	Securo	Average		Agostino	Vuka	Securo	Average		Agostino	Vuka	Securo	Average
DZP1009d4V	12,3	14,7	12,2	<u>13,0</u>		16,3	20,4	16,6	<u>17,7</u>		32,6	35,2	28,9	<u>32,2</u>
DZP1009e11R	10,8	10,5	9,8	<u>10,3</u>		16,7	21,8	17,4	<u>18,6</u>		27,8	32,5	27,2	<u>29,1</u>
DZP0801f4V	20,0	20,6	17,0	<u>19,2</u>		15,8	17,0	14,0	<u>15,6</u>		36,0	37,7	31,1	<u>34,9</u>
DZP0801f4R	17,0	19,2	16,6	<u>17,6</u>		19,4	17,4	14,8	<u>17,2</u>		36,6	36,8	31,5	<u>35,0</u>
DZP0803c7V	12,8	14,3	13,9	<u>13,7</u>		19,1	19,0	15,1	<u>17,7</u>		32,2	33,5	29,0	<u>31,6</u>
DZP0803c7R	11,3	12,6	13,0	<u>12,3</u>		18,9	19,8	15,2	<u>18,0</u>		30,5	32,5	28,3	<u>30,4</u>
Karolina	14,6	16,5	15,8	<u>15,6</u>		15,1	16,1	14,7	<u>15,3</u>		29,9	32,8	30,6	<u>31,1</u>
Szarvasi Andrea	18,2	21,5	17,5	<u>19,0</u>		15,9	19,5	12,6	<u>16,0</u>		34,4	41,2	30,2	<u>35,3</u>
DZP0801eV	20,4	12,8	17,4	<u>16,9</u>		16,6	19,6	14,0	<u>16,7</u>		37,2	32,6	31,5	<u>33,8</u>
DZP0801eR	14,7	19,4	14,6	<u>16,2</u>		17,4	19,4	14,9	<u>17,2</u>		32,3	38,8	29,6	<u>33,6</u>
PandoraV	20,4	21,2	17,6	<u>19,7</u>		14,7	17,0	13,3	<u>15,0</u>		35,6	38,3	31,0	<u>35,0</u>
KolindaR	15,6	14,2	16,2	<u>15,3</u>		15,8	19,7	11,8	<u>15,8</u>		31,6	34,1	28,1	<u>31,2</u>
Average	15,7	16,5	15,1			16,8	18,9	14,5			33,0	35,5	29,8	

Results: 2-years	Ground covering pea (%) 08.04.2020	Early plant height pea (cm) 08.04.2020	pea yield dt/ha	triticale yield dt/ha	total yield dt/ha	Harvest Index Pea/Triticale	TKM
Min	8	5	0,12	8,5	16,6	0,01	86
Max	60	38	24,1	37,5	44	2,02	215,5
Mean	31,37	20,31	8,98	20,13	29,31	0,54	142,71
LSD 0.05	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	means only
DZP1009e11R	18,67	12,11	6,31	21,69	28,1	0,34	149,25
DZP1009d4V	19,72	12,39	6,98	21,89	29,61	0,39	153,07
DZP0801f4R	32,22	20,72	9,59	20,27	29,97	0,56	115,55
DZP0801f4V	30,94	19,61	10,41	19,15	29,62	0,66	113,67
Karolina	45	30,33	10,73	18,99	29,81	0,69	162,97
Szarvasi Andrea	41,67	26,72	9,88	18,82	28,76	0,62	161,77
LSD 0.05	n.s.	9,83*	n.s.	1,23*	n.s.	n.s.	means only
DZP1009	19,19	12,25	6,65	21,79	28,85	0,36	151,16
DZP0801f4	31,58	20,17	9,68	19,71	29,79	0,61	114,61
SZA-KA	43,33	28,53	8,48	18,9	29,28	0,66	162,37
LSD 0.05	0,94+	n.s.	n.s.	n.s.	n.s.	n.s.	means only
semileafless	31,96	21,06	8,88	20,32	29,29	0,53	142,59
normal leaf	30,78	19,57	9,09	19,95	29,33	0,56	142,83
LSD 0.05	n.s.	n.s.	n.s.	2,68*	2,60*	n.s.	means only
Agostino	29,42	19,33	8,79	20,32	29,55	0,52	141,12
Vuka	28,33	21,56	9,68	22,14	31,91	0,53	147,92
Securo	36,36	20,06	8,48	17,94	26,47	0,58	139,1
Further significant effects	Year**; Triticale x years*; Pea- Group x Years **; Leaftype x Pea Group x Years+; Pea Genotype x Triticale+	Year**; Pea- Group x Years **; Pea Genotype x Year +	Years**; Repetitions : Years*; Pea-Group x Years **; Pea Genotype x Years**	Year+; Repetitions : Years**	Year*; Repetitions : Years**; Pea Group x Years **; Pea Genotype x Years*	Year**; Repetitions : Years*; Pea Group x Years **; Pea Genotype x Years**	

MODEL Y + R:Y + T + P + TP + TY + PY + PTY + L + LT + PL + TLP + LY + PLY + TLY + TPLY + RTPLY

RANDOM R Y

Y=Year; R= Repetitions; T=Triticale Variety; P=Group of Pea; L= Leaftype, last term acts as residual/error term.

LSD 0,05 and significance according to f-statistics.

+ = significant at level of confidence: 0,1

* = significant at level of confidence: 0,05

** = significant at level of confidence: 0,01