

KIELPINSKI, M & BLIXT, S.

The evaluation of the "afila" character with regard to its utility in new cultivars of dry pea.

1982. Agri Hortique Genetica XL 51-74

THE EVALUATION OF THE "AFILA" CHARACTER WITH REGARD TO ITS UTILITY IN NEW CULTIVARS OF DRY PEA.

By M. Kielpinski and S. Blixt

INTRODUCTION

The *afila* gene, *af*, converting all leaflets into tendrils, has been known in pea collections for almost thirty years. SOLOVIEVA (1955) reported a spontaneous "afila" mutant from the USSR already in 1949. After further selection this mutant was registered as a vining pea cultivar in 1965 and grown with good results. For reasons as yet unknown, breeders showed no interest in this mutation for almost fifteen years, although further induced and spontaneous mutants were found. At the end of the sixties, however, breeders at the John Innes Institute in England and in a few places in Poland, again included it in their breeding programmes. In Poland the breeding became centred upon *afila*-type cultivars of dry peas, which were expected to have a better standing ability and thus being better adapted to mechanical harvesting. The *afila* cultivars have also been called semileafless by SNOAD & GENT (1976).

This report presents the results of evaluating the *afila* character with regard to its potential for practical breeding, as well as the process leading to the first Polish *afila*-type cultivars which are also presented.

MATERIALS AND METHODS

The source of the *af* gene has been the induced mutant "Wasata", obtained by JARANOWSKI (1970) in Poland. This mutant was crossed to six commonly grown cultivars of dry peas, Porta (NL), Neuga (GDR), IP3 (H), Allround (NL), Neugatersleben (GDR) and Heros (PL), at that time the highest yielding in the Polish official trials.

The *afila* F₂ recombinants were backcrossed to the parental cultivars (Figure 1). The F₁ and sometimes the F₃ generations were planted in glasshouses to produce two generations per year. Selection was practiced to produce a so-called *afila* counterpart with a genotypic background close to the parental commercial cultivar and thus with some commercial potential for each of the six cultivars.

Figure 1 also shows how the production of *afila* counterparts was intergrated with the breeding of new *afila* cultivars. The main effort was spent on evaluating the effect of the *af* gene on yield and other characters on near-isogenic backgrounds.

In each of the years 1975 to 1977 six cultivars and six near-isogenic *afila* forms plus the origin of the *af*-gene, the cultivar Wasata, were sown. The trials were set up as split-plots in three replicates at the Plant Breeding Station Prusinowo in north western Poland. The plots, 3×6=18 m², were sown by an Öyjord plot-drill with 15

cm between rows and at a seed rate of 105 seeds/m². Two yield factors were statistically analysed: cultivar and phenotype (normal and *afila*). In order to establish the influence of lodging on yield an additional trial was set up in 1977. Lodging was eliminated by growing plants on wire trellises which were spread under the plots, and the factors analysed were phenotype (normal and *afila*) and lodging (free and eliminated).

During all three trial years the following characters were measured:

1. Number of days from sowing to flowering.
2. Number of days from sowing to harvest.
3. Number of internodes to first flower.
4. Height of mature plants.
5. Thousand seed weight.
6. Stipule and leaf area.
7. Standing ability.
8. Light penetration.
9. Yield of dry seeds.
10. Protein content in seeds.
11. Yield of protein.

The plots were harvested manually at full maturity and the seeds weighed after threshing and drying. The protein content in air-dry seeds was measured by the Kjeldahl method. The yield of protein was counted as a product of yield of seeds and protein content.

Characters no 6, 7 and 8 were measured as follows.

6. Stipule and leaf area: At the stage of flat pod, 10 plants randomly chosen from each plot were cut off. The foliage at the first flowering node was separated into leaflets and cylindrical elements, i.e., petioles and tendrils. The shade spot area of these organs was then measured by a Japanese electronical planimeter type AAC-100. The recordings of the cylindrical organs were multiplied by $0.5\pi = 1.57$, in order to obtain the area of real upper surface comparative to the area of flat organs.

7. Standing ability: The field standing ability of plants in different stages of vegetation was determined by a simple instrument made of a ruler and a tape-measure (Fig. 2). A plumb-line was attached to the ruler to keep it in a vertical position. In each plot randomly chosen plants were inserted inside the right-angled triangle as shown in Figure 2, and the readings taken from the points shown by the thin arrows. The mean $\sin \alpha = a/c$ value from 10 plants was used as a coefficient of field standing ability for a given plot a given day. These measurements were made every fifth day starting from the 70-th day of vegetation. An average standing ability coefficient was calculated for each phenotype for each day of measurement.

8. Light penetration of the canopy was determined indirectly by measuring light

intensity inside the sward using a luxometer. The measurements were made twice during the 1977 vegetation period; after 90 days of vegetation, when cultivars as well as *afila* counterparts were still standing, and after 100 days of vegetation when cultivars lodged and the *afila* counterparts still remained upright. The light intensity was measured in full sunshine at noon, at 10 points for each plot and at two levels: at the first flowering node and at the ground level. The percentage of mean light intensity at a given level in relation to the intensity of light in the open was used as a coefficient of light penetration.

RESULTS AND DISCUSSION

The results shown in Table 1 indicated that the mean values of the *afila* counterparts for the five presented characters are somewhat intermediate in relation to the parental forms but generally closer to the mean of the conventional cultivar. The results for the pure *afila* mutant also indicate that this form has little value for commercial dry seed production due to low 1000 seed weight, very high stem and too long vegetation period. The same has been noticed for several other *af* mutants induced in older varieties not adapted to mechanical harvesting (GLAZACHEVA & SIDOROVA 1973, MICHALSKI & SWIECICKI 1974, GUZHOV 1976). There seems therefore no reason to include the original Wasata mutant in the comparison of cultural value. Instead, the value of the *afila* character will be in near-isogenic forms based on shorter, more modern varieties better adapted to mechanical harvesting, produced by crossing and back-crossing the mutant with such cultivars.

For all the characters presented in Table 1 there is a significant positive correlation between the values of the cultivars and their semileafless *afila* counterparts.

The area of leaf and stipules of normally leaved cultivars and their *afila* counterparts is presented in Table 2. These results demonstrate a significant decrease in the basic leaf area in the semileafless *afila* types. The difference is slightly less when real upper surface is considered, probably due to a certain increase in stipule area in the *afila* counterparts. As a result the difference in total real upper surface does not reach statistical significance.

Considerable variation in foliage area exists among the cultivars investigated. For instance, total upper surface of foliage at the first fertile node is three times greater for the cultivar Heros (105,6 cm²) than the cultivar Porta. Similar observations were reported by VASJAKIN (1973) Also, the *afila* forms vary, though less, the difference between the extremes being about a factor two instead of three.

The effect of the decreased assimilation area has been discussed by several authors. GOTTSCHALK & KAUL (1974), GRITTON (1972) and GUSHOV (1976) maintained that the conversion of leaflets into tendrils would lead to a yield decrease. JARANOWSKI (1975), on the other hand, showed that the area of the

stipules of some *afila* genotypes was greater than the total area of stipules and leaves together in many conventional cultivars.

The results from Table 2 also indicate that the decrease of assimilation area of *afila* counterparts is fairly limited. Similar results were obtained by HARVEY (1976). Further, the total area of the *afila* forms of the cultivars Neuga, Allround, Neugatersleben and Heros is actually larger than the area of the normal Porta. In other words, assimilation area in *afila* forms can probably be considerably increased by introducing different genes for foliage and particularly stipule-size.

The increase in stipule area in the *afila* counterparts is an interesting phenomenon (exception cultivar Heros). Probably some of the assimilation ability lost as a result of converting leaflets into tendrils in the *afila* forms may be compensated for in this way. Besides, CO₂ photoassimilation per unit weight of stipules is considerably greater in *afila* types than in conventional types (VOGELSANG ET AL 1976). Thus, the slight reduction of assimilation area should not be an obstacle in using such phenotypes in plant breeding programmes; if necessary, genes for increased foliage size are available for an increase of assimilation area.

As shown in Fig. 3, 4 and 5, the *afila* counterparts had a considerably improved standing ability, remaining upright from 5 to 15 days longer in the plots than their parental normal-leaved cultivars. Also the final lodging was not so drastic as in the conventional cultivars. In 1975 the *afila* counterparts of the cultivars Allround and Porta remained standing until the plants were quite dry, which is rather unusual in peas. The lodging of the Wasata mutant (high stem, *afila* leaf) was less than in the conventional cultivars (dwarf stem, normal leaf), but it still behaved more as those than the *afila* forms. Thus dwarf stem and *afila* tendrils each by itself improve standing ability, while the effect of both together in the genotypes here investigated seems more than purely additive.

Two forces protect the *afila* forms from lodging, stem stiffness vertically and reciprocal linkage of plants by tendrils horizontally. Many years observations indicate that lodging in *afila* forms is due mainly to a breakdown of the vertical vector. Emphasis in *afila* breeding is therefore now on increasing the stem stiffness. Particularly promising is a spontaneous mutant found in a population of *afila* counterpart of the cultivar Allround with a stem morphology very similar to the mutant *ramosus* described by BLIXT (1976). The *afila* stock PRC 462, which has a dwarf *ramosus*-like stem, remained standing until fully mature in the years 1978 and 1979. In the very hard year 1980 this stock went down only six days before harvesting (unpublished data).

After 90 days of vegetation, when both the conventional cultivars and the *afila* still remained standing (Fig. 5), the first flowering node of the *afila* counterparts had on the average obtained more than twice as much light as their parental cultivars. (Tab.

3). This difference is probably entirely due to the difference in morphological structure of the leaf, the tendrils of the *afila* forms shading the lower parts of the plants less than leaflets. After 100 days of vegetation, the difference in light penetration was tenfold, because of the additional shading effects of the lodging, *afila* counterparts still standing while their normal-leaved parental cultivars had gone down (Fig. 5, photo 1, 2).

Pea plants are very sensitive to light shortage. The actual yield of a single plant in the sward is much depending on competition for light. Because of less shading, *afila* peas have a considerably better light penetration during the very important stage of pod filling which seems to have an influence on yield.

The analysis of variance of seed-yield (Tab. 6) indicates that the distribution with regard to phenotype is greater than the distribution for cultivars. The lack of significance for the interaction year x phenotype may be taken to indicate that the morphological structure of the leaf is not significantly affecting the reaction to meteorological conditions. In all years the semileafless *afila* counterparts yielded considerably higher than their parental cultivars. Mean differences amounted in 1975 to +431 kg/ha, in 1976 to +532 kg/ha and in 1977 to +236 kg/ha (Tab. 5). The mean difference for all years amounts to +400 kg/ha which is equal to a 10.2% increase over normal leaved cultivars. The correlation coefficient between the two comparative groups was significant for the years 1975 and 1977 as well as for all years together but not for the year 1976, due to small differences within both of the comparative groups this year. Similar results were obtained at the John Innes Institute in England, semileafless dry peas being reported to yield 12–17% more than the conventional variety Vedette (SNOAD & GENT 1976).

Also in the Polish official trials with dry pea cultivars *afila* material has shown high productivity. As presented in Fig. 1, three *afila* cultivars have been bred from experimental material. The cultivar Sum was included in the Register of Original Cultivars in 1979. As the best cultivar in Poland, Sum is already cultivated on a large acreage. The cultivars Gryficki and Legenda are still in official testing. As it is shown in Table 9, the *afila* cultivars as a group is the best yielding in the official trials.

In dry peas protein content is a very important character. A slight increase in protein content of the *afila* counterparts as compared with the normal-leaved cultivars was observed in all years (Tab. 4) but this increase was significant only in 1976. For the years 1974–1977 the mean difference amounted to +0.99% and was significant. Also the correlation coefficient for protein content between cultivars and their *afila* counterparts was significant for the year 1976 and for the mean values for all years together.

Many authors have observed a negative correlation between yield and protein content in peas (JERMYN & SLINKARD 1976). This negative correlation seems to have been broken by using the *af* gene (Tables 4 and 5).

It is obvious that higher yield and higher protein content in the *afila* counterparts should lead to an increase of protein yield. In every year that increase was significant (Tab. 7). The mean difference for all years together amounted to +132 kg/ha which means a 16% increase of protein yield of the *afila* counterparts as compared to their parental conventional cultivars.

Very interesting results were obtained in special field experiment set up in 1977 in order to compare the influence of lodging on yield. Under free lodging conditions the *afila* counterparts yielded on an average +335 kg/ha more than the cultivars (Tab. 8) in agreement with the result from the basic trials. Under conditions of eliminated lodging the result was the opposite – *afila* counterparts yielded considerably lower (–613 kg/ha). This should be seen against the fact that elimination of lodging caused a high and significant yield increase in the normal-leaved cultivars (+1113 kg/ha) and only a slight, statistically nonsignificant yield increase in the *afila* counterparts (+255 kg/ha). These results indicate that *afila* peas have, in fact, a lower yield potential than conventional cultivars but that under normal field conditions the real yield is normally far below the yield potential. The real yield is determined by a number of factors, among which the overall yield level is limited first of all by requirements on plants suitable for mechanical harvesting. Within this type of plants, characterized by low stem, factors connected with lodging, e.g., light penetrance, are prominent. Therefore, *afila* peas may, under conditions of 'normal' lodging, outyield normal leaved forms.

CONCLUSIONS

1. Phenological and biometrical characters were found comparable in cultivars and their *afila* counterparts.
2. The *af* gene caused a considerable reduction of leaf area. Simultaneously an increase of stipule area in the *afila* counterparts was observed. As a result total area of foliage was comparable in normal-leaved cultivars and their *afila* counterparts.
3. The *afila* peas have a greatly improved standing ability as a result of the interlocking of the branched tendrils. The plants remain upright 5–15 days longer and the final lodging is less drastic as compared with conventional cultivars. A positive interaction was observed between the *af* and the *le* genes as far as standing ability was concerned.
4. Light penetration into the sward of *afila* counterparts was several times greater as compared to a sward of conventional cultivars. This was due to the absence of leaflets (less shading) as well as to the better standing ability of the *afila* counterparts.
5. The *afila* character does not decrease the protein content in the dry pea seeds. On the contrary, *afila* counterparts each year contained slightly more protein than their conventional parental cultivars.

6. Under normal field competitive conditions, *afila* peas yielded considerably more than conventional cultivars. In a three year trial the mean yield of dry seeds of *afila* counterparts was 4318 kg/ha compared with 3918 kg/ha for the conventional cultivars.

7. In the same trial the factor 'morphological structure of leaf' influenced seed-yield more than the factor 'cultivars'.

8. Under normal competitive field conditions, *afila* peas gave considerably higher yield of protein than conventional cultivars. After three years trials the mean yield of protein of *afila* counterparts was 975 kg/ha as compared with 841 kg/ha for their conventional parental cultivars.

9. The *afila* peas do not in fact have a higher yield potential as compared with normal-leaved peas. The phenomenon of higher yielding of *afila* peas seem to result from factors connected with the improved standing ability under normal field conditions.

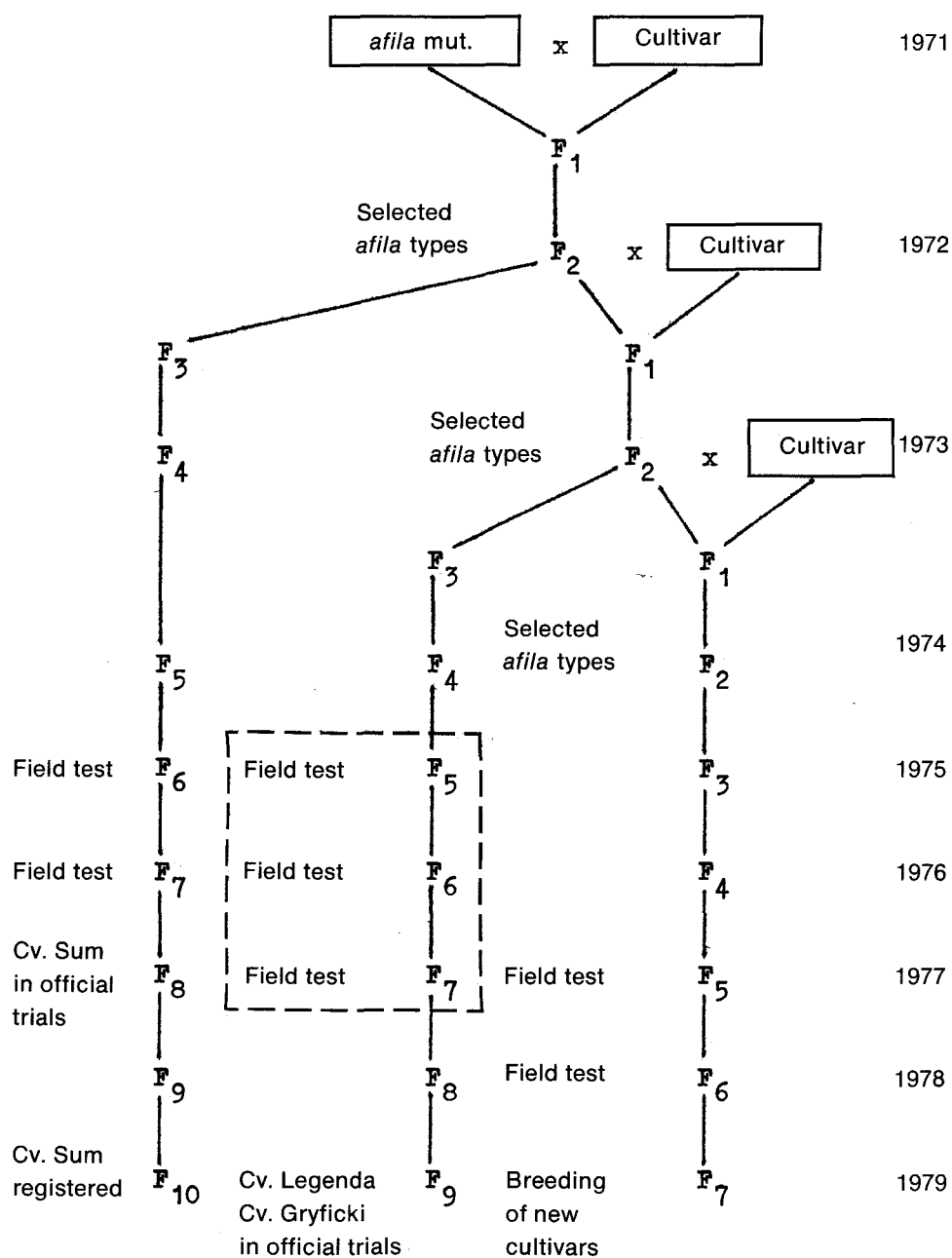
10. The *afila* character should be introduced in pea breeding programmes as soon as possible, especially in those countries where peas are grown commercially. The effect of the *af* gene for pea breeding may well prove comparable to the effect of the "Norin" genes in the wheat breeding.

LITERATURE

- BLIXT, S. 1976. Linkage studies in *Pisum* XV. Establishing the "rms"-gene and the linkage of "rms" and "fas" in chromosome 3. – *Agri Hort. Gen.* 34, 83–87.
- GLAZACHEVA, L.I. & SIDOROVA, K.K. 1973. Type of inheritance of modified characters in some mutant pea forms. – *Genetika*, 1, 46–53.
- GOTTSCHALK, W. & KAUL, M.L.H. 1974. Investigations on the cooperation of mutated genes. – *Ber. Deutsch. Bot. Ges.* 86, 513–524.
- GRITTON, E.T. 1972. Yield response to the "st", "af" and "tl" genes which modify stipules and leaves in peas. – *Pisum Newslett.* 4, 11–12.
- GUSHOV, L. 1976. The connection between yield and type of leaf in peas. – *Sel. Siemien.* 1, 22–25.
- HARVEY, D.M. 1976. The photosynthetic and respiratory potential of the fruit of leafless and semileafless mutants of *Pisum sativum*. – *J.I. Ann. Rep. Norwich*, 27–30.
- JARANOWSKI, J. 1970. Mutagenic action of gamma rays in *Pisum arvense* and *Vicia sativa*. – *Biul. IHAR*, 1, 45–49.
- 1975. Bemerkungen über genetische Grundlagen und Zuchtrichtungen bei Erbsen (*Pisum sativum* L.), *Biul. Hod. Rosl. i Nas. ZNRiO* 3, 2–5.

- JERMYN, W.A. & SLINKARD, A.E. 1976. Protein yield relationships in field peas. – *Can. J. Pl. Sci.* 56, 427–428.
- MICHALSKI, T. & SWIECICKI, W. 1974. Natural and induced variability of morphological characters in pea collection in Wiatrowo. – *Biul. Hod. Rosl. i Nas. ZNRiO* 5, 26–30.
- RYPINSKA, R. 1977, 1978, 1979. Synteza Wyników doś niadczeń. Odmianowych 1977, 1978, 1979. COBORU Słupia Wielka.
- SNOAD, B. & GENT, G.P. 1976. The evaluation of leafless and semileafless peas. – *J.I. Ann. Rep. Norwich.* 35–37.
- SOLOVIEVA, W.K. 1955. Vining Pea. Moscow.
- VASJAKIN, N. 1973. The efficiency of photosynthesis in different pea cultivars. – *Sborn. Trud. Siel. Coz. Centr. Zony* 4, 71–74.
- VOGELSANG, R.D., GRITTON, E.T. & LONG, R.C. 1976. Net photosynthesis chloropyll leaf area and leaf weights in pea near-isogenic lines for the "af", "tl" and "st" genes. – *Am. Soc. of Agr. Wisconsin University, USA.*

Fig. 1. The production and evaluation of *afila* counterparts for the dry pea cultivars Porta, Neuga, IP 3, Allround, Neugatersleben and Heros and pedigree of some Polish semileafless dry pea varieties.



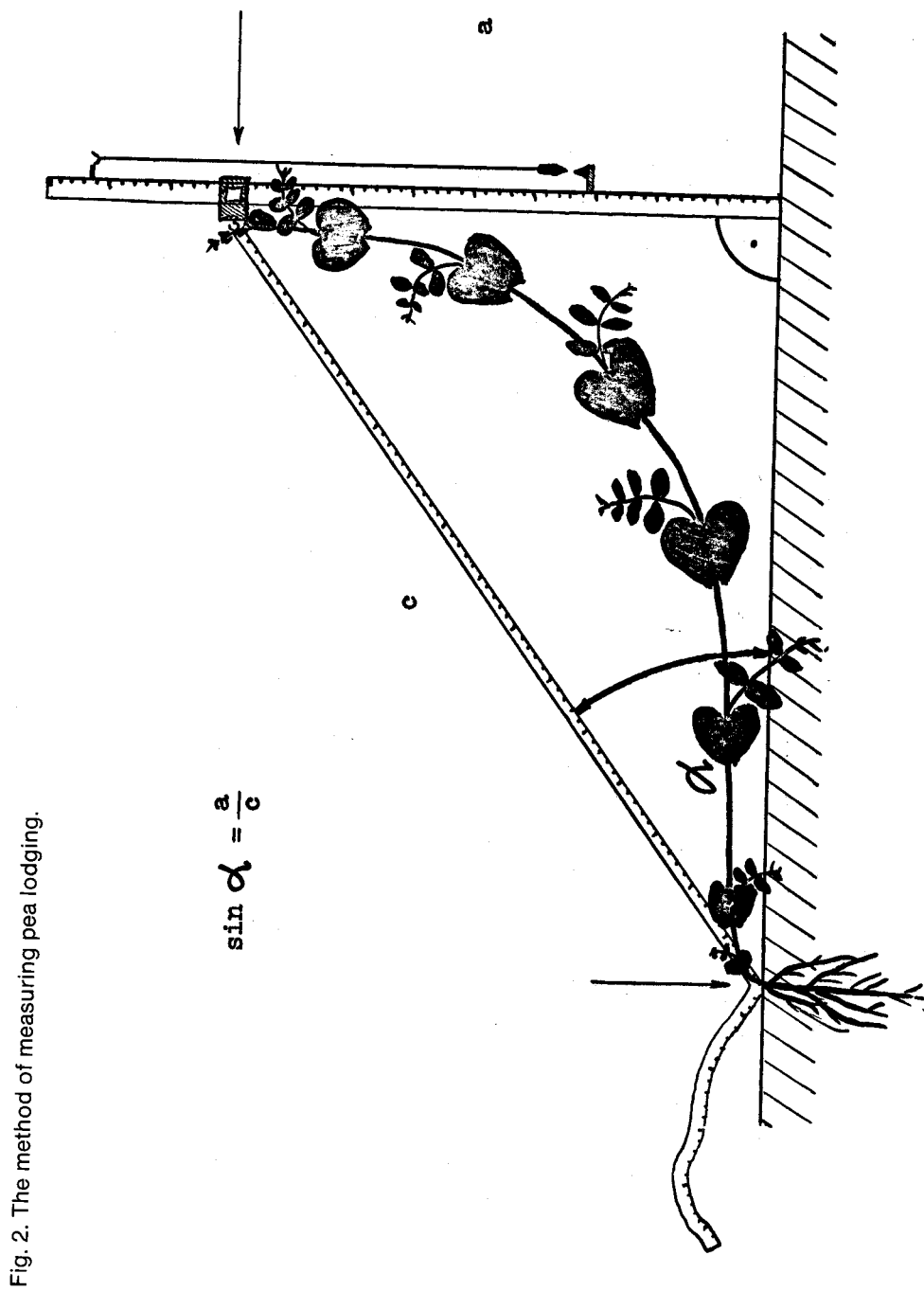


Fig. 2. The method of measuring pea lodging.

Fig. 3. Standing ability for different phenotypes of pea in 1975.

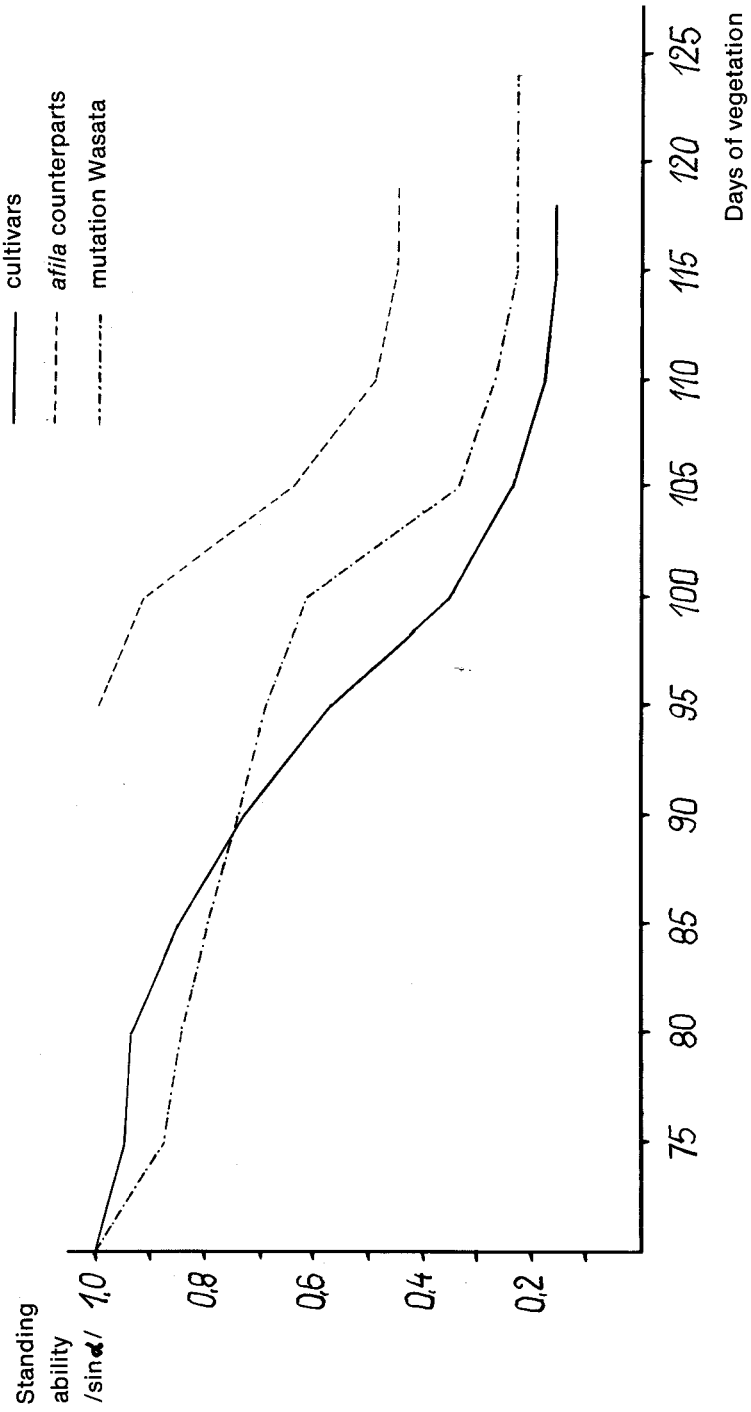


Fig. 4. Standing ability for different phenotypes of pea in 1976.

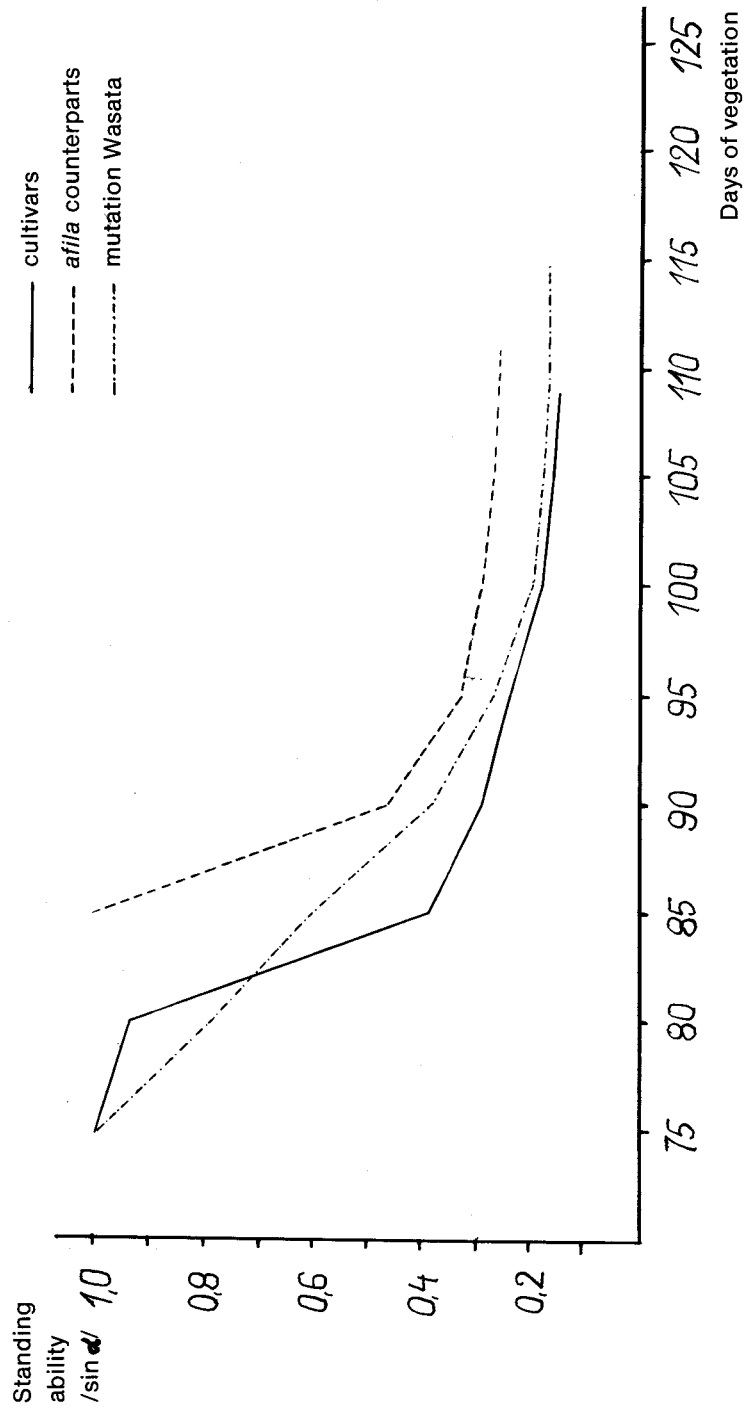


Fig. 5. Standing ability for different phenotypes of pea in 1977.

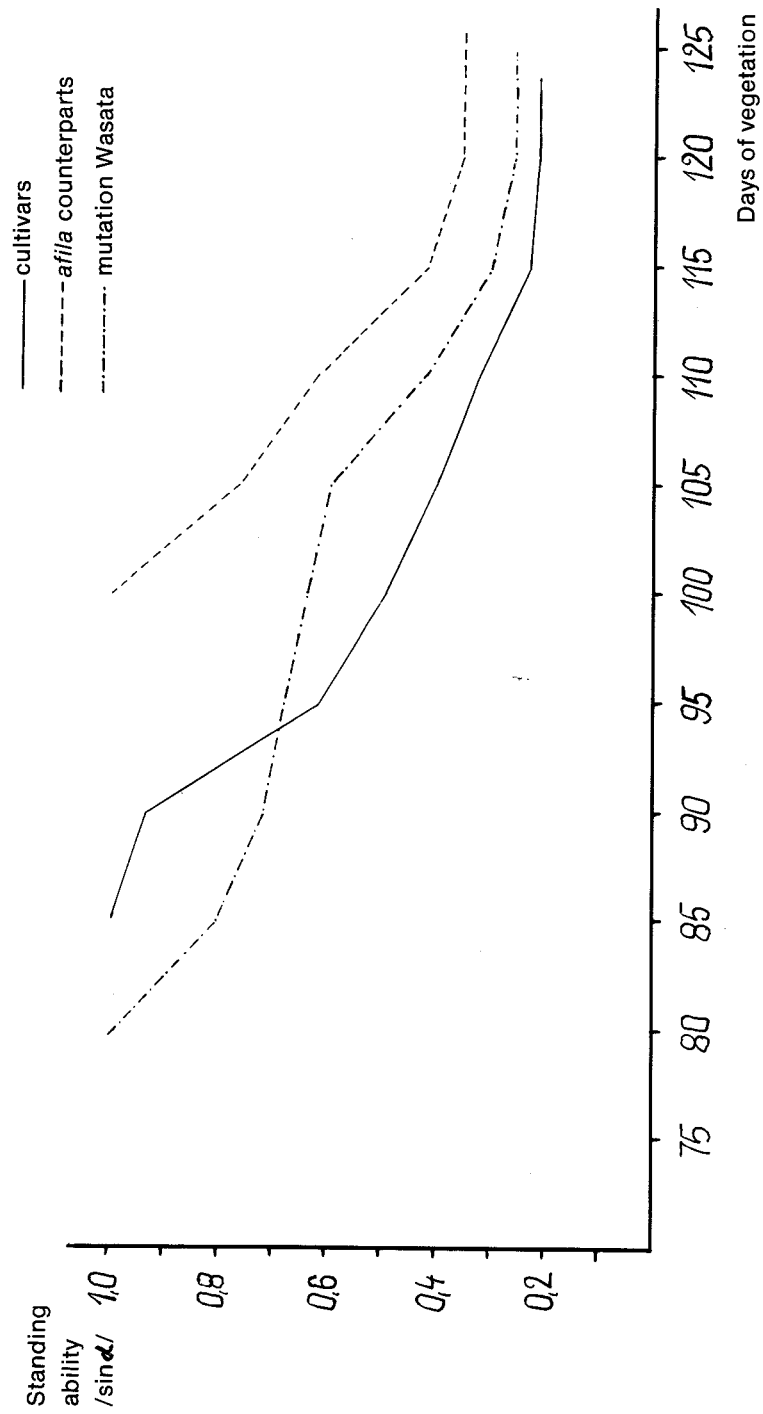


Table 1. Phenological and biometrical characters of pea cultivars and their *afila* counterparts – mean values for years 1974–77.

Cultivar	No. of days from sowing to flowering		No. of days from sowing to harvest		Mean no. of internodes to first flower		Height of mature plants (cm)		Weight of 1000 seeds (g)	
	Normal	<i>afila</i>	Normal	<i>afila</i>	Normal	<i>afila</i>	Normal	<i>afila</i>	Normal	<i>afila</i>
Porta	72,8	74,3	119,0	121,8	9,8	12,1	64,0	82,3	284	244
Neuga	72,8	74,0	121,3	120,3	10,1	10,5	77,8	77,3	243	232
IP 3	72,8	76,5	120,5	122,8	10,7	11,9	88,8	87,5	236	174
Allround	74,3	75,0	120,5	123,3	9,6	9,5	66,0	79,0	273	227
Neugatersleben	75,8	78,0	122,0	124,0	10,2	11,7	69,8	77,8	278	236
Heros	79,8	80,0	126,0	127,8	11,8	12,4	84,5	89,0	289	210
Mean	74,8	76,3	121,5	123,3	10,4	11,4	75,1	82,1	267	221
Wasata mutant		80,3		128,0		12,5		151,2		139
Correlation		0,975**		0,981**		0,616**		0,557**		0,578**

Table 2. Stipules and leaf area for normal leaved pea cultivars and their *afila* counterparts (area of shade spot in cm²).

Cultivar	Normal			<i>afila</i>			Difference		
	Leaf	Stipules	Total	Leaf	Stipules	Total	Leaf	Stipules	Total
Porta	18,3	15,2	33,5	10,8	20,0	30,8	- 7,5	+4,8	- 2,7
Neuga	22,7	18,9	41,6	11,1	23,4	34,5	-11,6	+4,5	- 7,1
IP 3	21,9	20,8	42,7	8,6	21,8	30,4	-13,3	+1,0	-12,3
Allround	22,7	17,5	40,2	7,3	27,0	34,3	-15,4	+9,5	- 5,9
Neugatersleben	29,1	24,5	53,6	12,3	32,8	45,1	-16,8	+8,3	- 8,5
Heros	51,2	54,4	105,6	16,2	52,1	68,3	-35,0	-2,3	-37,3
Mean	27,7	25,2	52,9	11,1	29,5	40,6	-16,6*	+4,3	-12,3*
Mean real upper surface	28,6	25,2	53,8	17,4	29,5	46,9	-11,2*	+4,3	- 6,9
LSD _{0,05} :							9,2	4,7	12,2

Table 3. Light penetration in the canopy of normal leaved pea cultivars and their *afila* counterparts (% of the light in the open).

Cultivar	Day of vegetation:		90		100	
	Phenotype	Level of measurement	Normal	<i>afila</i>	Normal	<i>afila</i>
Porta		1st flow. node	13,2	29,3	3,3	22,2
		Ground	3,9	6,4	3,3	4,2
Neuga		1st flow. node	11,9	35,1	2,0	27,2
		Ground	2,4	10,7	2,0	8,4
IP 3		1st flow. node	6,1	21,4	1,2	16,5
		Ground	1,6	7,1	1,2	5,3
Allround		1st flow. node	11,3	37,8	3,1	26,7
		Ground	4,2	7,7	3,1	6,7
Neugatersleben		1st flow. node	20,2	25,3	2,6	20,2
		Ground	2,6	6,2	2,6	4,3
Heros		1st flow. node	10,9	19,3	1,5	16,0
		Ground	2,2	5,2	1,5	5,3
Mean		1st flow. node	12,3	28,0	2,3	21,5
		Ground	2,8	7,2	2,3	5,7

Table 4. Protein content, (%) in seeds of pea cultivars and their *afila* counterparts for the years 1974-1977.

Cultivar	1974		1975		1976		1977		Mean	
	Normal	<i>afila</i>	Normal	<i>afila</i>	Normal	<i>afila</i>	Normal	<i>afila</i>	Normal	<i>afila</i>
Porta	20,6	22,5	20,2	22,4	21,0	21,7	20,7	21,0	20,6	21,9
Neuga	20,3	21,3	20,3	21,7	23,0	24,5	19,2	20,2	20,7	21,9
IP 3	22,4	22,7	20,0	23,0	25,8	29,0	20,6	20,9	22,2	23,9
Allround	20,9	20,6	19,3	22,4	24,3	25,0	21,7	20,6	21,6	22,2
Neugatersleben	19,7	21,1	20,2	21,6	19,9	21,1	19,7	20,7	19,9	21,1
Heros	22,1	21,2	22,1	22,9	27,2	26,1	21,3	22,1	23,2	23,1
Mean	21,00	21,56	20,35	22,33	23,53	24,56	26,53	20,91	21,36	22,35
Difference	+0,56		+1,98*		+1,03		+0,38		+0,99*	
LSD _{0,05}	1,11		0,98		1,46		0,83		0,67	
Correlation	0,386		0,301		0,882*		0,556		0,829**	
Wąsata mutant	21,7		21,5		25,8		19,9		22,2	

Table 5. Yield (100 kg/ha) of different pea cultivars and their *afila* counterparts for the years 1975-1977.

Cultivar	1975		1976		1977		Mean	
	Normal	<i>afila</i>	Normal	<i>afila</i>	Normal	<i>afila</i>	Normal	<i>afila</i>
Porta	39,0	48,3	43,9	55,5	42,9	50,1	41,93	51,30
Neuga	34,0	36,0	41,1	43,6	44,2	47,4	39,73	42,33
IP 3	17,3	20,5	42,5	44,6	32,8	33,1	30,87	32,73
Allround	44,4	44,7	36,6	46,8	47,8	52,1	42,93	47,87
Neugaterleben	35,8	40,7	44,7	45,8	53,5	51,1	44,67	45,87
Heros	28,8	35,0	38,0	42,4	38,1	39,6	34,97	39,00
Mean	33,23	37,54	41,14	46,46	43,21	45,57	39,18	43,18
Difference	+4,31*		+5,32*		+2,36*		+4,00*	
LSD _{0,05}	0,68		1,53		1,42		1,50	
Correlation	0,944*		0,417		0,899*		0,896**	
Wąsata mutant	23,7		28,5		28,1		26,8	

Table 6. Analysis of variance in the seed yield of pea cultivars and their *afila* counterparts for the years 1975-1977.

Source	1975			1976			1977			Synthesis		
	d.f.	MS	F	d.f.	MS	F	d.f.	MS	F	d.f.	MS	F
Y	5	533,82	153,82**	5	67,60	3,10	5	314,42	13,75**	2	304,70	4,02*
C												
Y x C	10	3,47		10	21,84		10	22,86		5	203,62	3,15**
E ₁	1	116,41	191,27**	1	254,40	56,79**	1	50,17	13,13**	10	50,66	
Ph	5	15,30	17,82**	5	30,06	6,71**	5	16,81	4,40*	30	16,06	
C x Ph										1	144,00	33,80**
Y x Ph										5	13,22	3,10
Y x C x Ph										2	6,70	2,19
E ₂	12	0,87		12	4,48		12	3,82		10	3,77	1,23
V ₁ (%)		5,27			10,67			10,77			9,73	
V ₂ (%)		2,64			4,83			4,40			4,24	

Y - years, C - cultivars, Ph - phenotypes, E - error, V - coefficient of variability

Table 7. Yield (100 kg/ha) of protein of pea cultivars and their *afila* counterparts for the years 1975-1977.

Cultivar	1975		1976		1977		Mean	
	Normal	<i>afila</i>	Normal	<i>afila</i>	Normal	<i>afila</i>	Normal	<i>afila</i>
Porta	7,90	10,80	9,21	12,05	8,87	10,53	8,66	11,13
Neuga	6,90	7,73	9,45	10,69	8,47	9,60	8,27	9,34
IP 3	3,47	4,70	10,97	12,93	6,77	6,90	7,07	8,18
Allround	8,63	9,97	8,90	11,69	10,37	10,70	9,30	10,79
Neugatersleben	7,23	8,73	8,90	9,67	10,53	10,60	8,89	9,67
Heros	6,30	8,03	10,34	11,07	8,07	8,73	8,24	9,28
Mean	6,74	8,33	9,63	11,35	8,84	9,51	8,41	9,75
Difference	+1,59*		+1,72*		+0,67*		+1,32*	
LSD _{0,05}	0,15		0,37		0,29		0,41	
Correlation	0,949*		0,512		0,906*		0,898**	
Wasata mutant	5,09		7,63		5,71		6,14	

Table 8. Influence of lodging on the seed-yield (100 kg/ha) of pea cultivars and their *afila* counterparts.

Cultivar	Phenotype	Type of lodging				Difference between types of lodging	
		Free		Eliminated		Normal	<i>afila</i>
		Normal	<i>afila</i>	Normal	<i>afila</i>		
Porta		37,9	50,3	60,7	51,9	+22,8	+ 1,6
Neuga		44,2	47,9	54,8	48,3	+10,6	+ 0,4
IP 3		32,9	33,1	50,1	47,0	+17,2	+13,9
Allround		47,9	52,1	58,3	56,7	+10,4	+ 4,6
Neugatersleben		59,6	57,9	60,8	52,6	+ 1,2	- 5,3
Heros		38,4	39,7	43,0	39,8	+ 4,6	+ 0,1
Mean		43,48	46,83	54,61	49,38	+11,13*	+ 2,55
Difference between phenotypes		+3,35*		-6,13*			
LSD _{0,05}		3,13		3,15		8,33	6,74

Table 9. Results of Polish official trials with dry pea cultivars – mean yields from 13 stations*.

Phenotypic group	Cultivar	Yield 100 kg/ha		
		1977	1978	1979
High stem, normal leaf	1. Kaliski	31,1	32,2	26,1
	2. Ceser	29,8	27,6	–
	3. Kujawski Wczesny	28,3	31,9	24,8
	4. R 6046	27,2	30,1	26,3
	5. R 2082/66	29,2	–	–
	6. R 195/70	29,3	–	–
	7. R 885/65	29,8	–	–
	8. R 5161/68	31,4	33,1	–
	9. R 25/76	30,7	30,9	–
	Mean:	29,6	31,0	25,7
Dwarf stem, normal leaf	10. Flavanda	33,0	36,3	–
	11. Zefir	29,1	35,5	25,7
	12. Kwartet	29,9	36,0	27,1
	13. Auralia	30,5	–	–
	14. Allround	27,6	–	–
	15. Cebeco 402 (Paloma)	–	–	30,4
	16. Borek	–	–	29,2
	17. Cebeco 102	–	–	31,2
	18. R 4017	29,5	33,7	28,6
	19. R 4006	28,4	29,4	–
	20. R 436/73	29,9	30,8	26,3
	21. R 158/71	–	34,4	28,6
	22. R 893/66/3	28,8	–	–
	23. Rwt 4025	–	–	27,2
	24. Rwt 4027	–	–	25,9
	25. R 321	–	–	27,9
26. R 434	–	–	27,2	
Mean:	29,6	33,7	27,9	
Dwarf stem, <i>afila</i> leaf	27. Sum	32,6	36,3	31,7
	28. Hamil	–	35,2	27,5
	29. Legenda	–	–	28,2
	30. Gryficki	–	–	27,8
	Mean:	32,6	35,7	28,8

*) (Rypińska R., Synteza wyników doświadczeń odmianowych 1977, 1978, 1979. COBORU Słupia Wielka).



Fig. 6



Fig. 7

The variety *Porta* (Fig. 6) and its *afila* counterpart (Fig. 7) after 100 days of vegetation in 1977. Note the difference in standing ability.



Fig. 8. A field of the *afila* cultivar "Sum" at the Plant Breeding Station Prusinowo in 1979.