

Relation between leaf number and final leaf area of rye

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Summary

In the two varieties concerned in this research, the emergence date of all last leaves appeared to be *almost the same and independent of the serial number of the leaves*. In general the total leaf surface area increased as the leaf number was higher. There is no reliable correlation between leaf number and size of the last leaf. There is, however, a positive correlation between total leaf area and number of spikelets.

1. Introduction

It has been proved that the final number of leaves in rye plants is also dependent on hereditary properties (HOOGLAND, 1961, 1962). In order to investigate whether this has any effect on the productivity of the plants it was desirable to obtain some information about the relation between leaf number and leaf surface area. For instance, it might be possible that a greater leaf number is compensated by each leaf being proportionally smaller. The investigation described below treats of this subject. At the same time it deals with the surface area relations of the subsequent leaves as well as the relation with the number of spikelets initiated in the ear.

As for the leaf number influencing seed production, this problem can only be solved when different populations, each consisting of plants with the same leaf number, have been obtained. A small selection program has been started for this purpose. In the present investigation, plants with many leaves and plants with few leaves have been used indiscriminately, so that differences in productivity may be partly or completely due to unequal competitive relations.

2. Method of research

Observations on leaf number and leaf area in the field are rather difficult. It is hard to determine the serial number of leaves due to the early dying and decomposition of the oldest leaves, while establishing the size of leaves is most inconvenient as well. If a part of the plants is periodically harvested for observation in the laboratory, the uncertainty of sampling errors will be introduced. This may be of considerable influence due to the heterogeneous nature of rye.

Growing the rye in eternite containers of 70 by 90 cm on lorries, so that the plants were on the correct height for observation, largely improved conditions for research. In poor weather, the lorries could be pushed into a greenhouse along a rail. In these

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containers 4 rows of rye were sown at regular depth and distance. Only the two centre rows were used for observation. One of these rows consisted of the variety *Petkuser*, the other of the variety *Zelder*. Each row comprised 29 plants. On 27th October 5 containers were sown in this way, each plant being numbered. When two leaves had developed, the measuring of the full-grown leaves on the main axis was started. The frequency of measuring was limited by the necessity to prevent bringing any damage on the plants. For our purpose the leaves were considered to be full grown when the leaf sheath began to emerge. For easy determination of the serial number the 5th and 8th leaves on the main axis were marked with a painted dot on the leaf tip.

Per variety 145 grains were sown of which 142 and 141 remained for the complete observation of the varieties *Petkuser* and *Zelder* respectively.

3. Results

TABLE 1 reflects data on leaf surface area, number of spikelets and the average data on which the leaves of a certain serial number were full grown for 4 groups of plants, viz. the groups which finally had 10, 11, 12 or 13 leaves respectively. The date figures are averages of the dates on which the concerning leaves were observed to be full grown for the first time. As observations have not been carried out daily, the actual dates usually are somewhat advanced, the more so as the time interval between two observations is larger.

3.1. The rhythm of emergence

The date of emergence is almost the same for all last leaves, independent of the serial number of those leaves. Accordingly, the rate of emergence is higher in plants with many leaves. Thus, the group with 13 leaves already had 2 fully developed leaves on 12th December, while the group with 10 leaves had only one. Evidently, the group with the greatest leaf number was much in advance at the time that the fifth leaf had emerged, these leaves being already present at the beginning of March, while in the group with the smallest leaf number this was only the case at the end of March.

In FIG. 1 an attempt has been made to represent in the best possible way the date at which the leaves of various serial numbers were full grown. The observation dates have been reflected on the abscissa. From this it will be evident that the results have been influenced somewhat by the chosen observation dates.

The average trend of leaf emergence per group does not hold good for all plants of the group. Indeed, a plant with finally 13 leaves may start slowly and, by rapid emergence later on, it may yet form a great number of leaves. Reversely, a plant with only 10 leaves may start at a relatively rapid rate, after that slowing down to a very low emergence rate of the last few leaves. These two rather striking emergence rhythms, however, are an exception in the populations we used so far. Nevertheless, selection experiments have proved that such rhythms are hereditary and can be fixed as constant factors in certain populations.

It should be mentioned here that the rhythm of emergence in the varieties *Petkuser* and *Zelder* hardly differs. As to the classes of different final leaf number in both varieties, these are also represented in the population to almost the same extent.

3.2. Leaf surface area

From TABLE 1 it is evident that the total leaf area distinctly increases as the leaf

TABLE 1. Average leaf surface area in mm², leaf number and dates of measuring, and average number of spikelets; average dates of measuring ()

Varieties	Number of plants	Average leaf area in mm ² (leaf sequence 1—13)											Number of spikelets				
		1	2	3	4	5	6	7	8	9	10	11	12	13	total	initiated	full-grown
10-leaves group																	
<i>Petkuser</i>	12	388 (12/12)	267 (31/12)	322 (22/21)	497 (4/3)	708 (31/3)	928 (9/4)	1549 (20/4)	2334 (28/4)	2774 (5/5)	1445 (11/5)			11 212	28,2	26,0	
<i>Zelder</i>	9	345 (12/12)	279 (2,1)	344 (22/21)	505 (8/3)	636 (31/3)	883 (13/4)	1460 (24/4)	2197 (31/5)	2435 (6/5)	1055 (12/5)			10 139	26,8	24,8	
11-leaves group																	
<i>Petkuser</i>	73	376 (12/12)	308 (27/12)	365 (22/21)	520 (28/2)	733 (24/3)	1024 (9/4)	1543 (16/4)	2210 (23/4)	2940 (30/4)	2960 (6/5)	1221 (12/5)		14 200	32,3	31,5	
<i>Zelder</i>	75	363 (12/12)	305 (20/12)	340 (22/21)	469 (26/2)	653 (24/3)	902 (10/4)	1289 (17/4)	1980 (24/4)	2674 (1/5)	2768 (6/5)	1158 (12/5)		12 901	31,8	31,3	
12-leaves group																	
<i>Petkuser</i>	50	376 (12/12)	312 (22/12)	315 (22/21)	449 (27/2)	638 (19/3)	911 (8/4)	1378 (13/4)	1946 (20/4)	2529 (25/4)	2971 (2/5)	2715 (7/5)	1066 (11/5)	15 606	33,2	30,6	
<i>Zelder</i>	50	383 (12/12)	339 (14/12)	348 (22/21)	435 (22/2)	636 (16/3)	867 (7/4)	1263 (12/4)	1799 (23/4)	2447 (25/4)	3005 (2/5)	2779 (7/5)	1104 (12/5)	15 405	36	35,5	
13-leaves group																	
<i>Petkuser</i>	7	384 (12/12)	342 (12/12)	360 (22/21)	367 (28/2)	547 (7/3)	773 (3/4)	1199 (11/4)	1926 (17/4)	2521 (20/4)	2703 (25/4)	3053 (4/5)	2357 (9/5)	852 (12/5)	17 384	36	35,4
<i>Zelder</i>	7	369 (12/12)	333 (12/12)	341 (22/21)	391 (24/2)	538 (7/3)	744 (6/4)	1068 (10/4)	1410 (15/4)	1855 (21/4)	2387 (26/4)	2537 (3/5)	2088 (9/5)	665 (13/5)	14 726	34	33,7

1 The reason that this date is the same in all groups, is a result of the fact that the interval between this and the preceding date was rather great, due to influences of winter and poor weather.

RELATION BETWEEN LEAF NUMBER AND FINAL LEAF AREA OF RYE

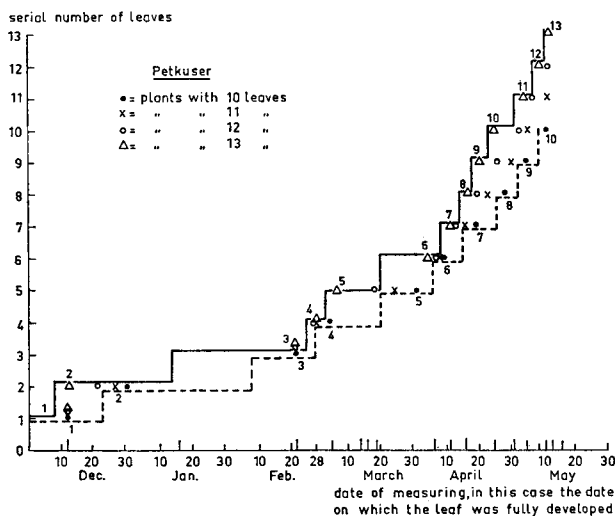
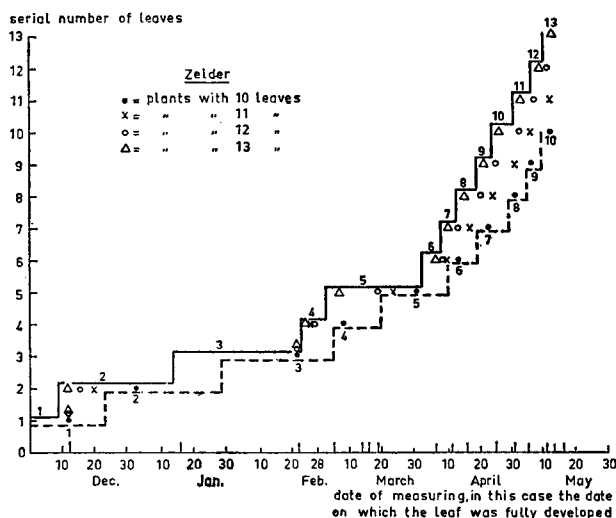


FIG. 1.
Rhythm of leaf formation
in the varieties *Petkuser* and
Zelder



number rises (also see FIG. 2). Only the variety *Zelder* does not show an increase when the leaf number grows from 12 to 13, but this figure is based on observations of only 7 plants. A correlation coefficient of + 0,45 in *Petkuser* and one of + 0,44 in *Zelder* was found between leaf number and total leaf surface area.

TABLE 2 proves that a larger total leaf area is not only due to a larger leaf number, but also to a larger average leaf area in the plants with many leaves (also see FIG. 3). Anyway, it has been proved that leaf size does not decrease as leaf number rises. This only holds good for the average surface area of all stem leaves.

In comparing the leaves of both groups — few leaves and many leaves — in TABLE 1, it is evident that the first leaves show little variation, the second and third leaves being larger in the group with many leaves, while the fourth to ninth leaves win in the group with few leaves and the higher-numbered leaves are also larger in the

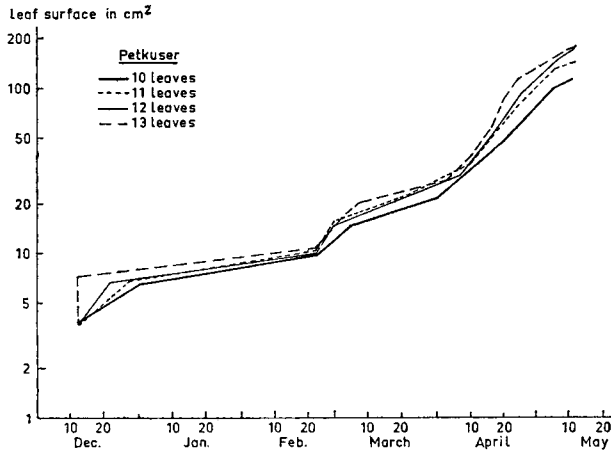


FIG. 2.
Sum total (summation) of
leaf surface of the varieties
Petkuser and *Zelder* (ordi-
nate on log. scale)

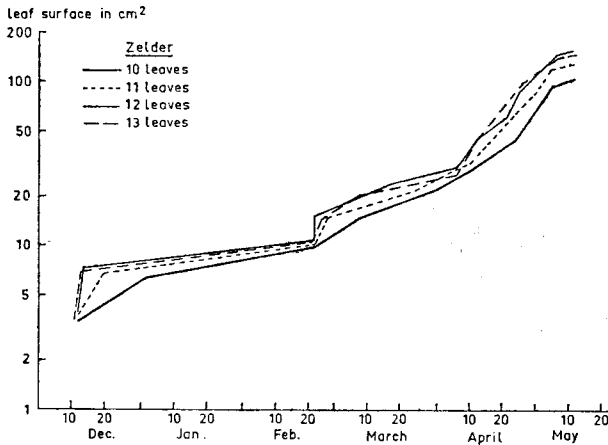


TABLE 2. Average surface area per leaf in mm² of plants with 10, 11, 12 and 13 leaves respectively

Variety	Leaf number (%)				Average p. plant
	10	11	12	13	
<i>Petkuser</i>	1121 = 100	1290 = 115	1300 = 116	1337 = 120	14.600
<i>Zelder</i>	1014 = 100	1173 = 116	1284 = 127	1133 = 112	13.700

group with many leaves. These facts may be related to the trend of temperature in winter and spring (FIG. 3). Earlier research has proved that obviously a positive relation exists between temperature and leaf size (VAN DOBBEN en HOOGLAND, 1954). At falling temperatures in autumn early formation of a certain leaf leads to a larger surface area, at increasing temperatures in spring it results in a reduced leaf area. Thus, it stands to reason that the eighth leaf in *Petkuser* with 10 full-grown leaves on 28th April (2334 mm²) will be much larger than the eighth leaf in *Petkuser* with

RELATION BETWEEN LEAF NUMBER AND FINAL LEAF AREA OF RYE

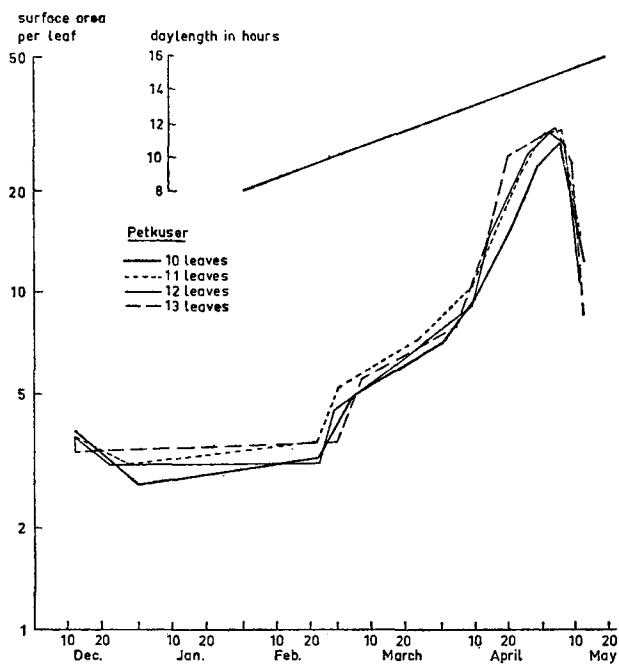
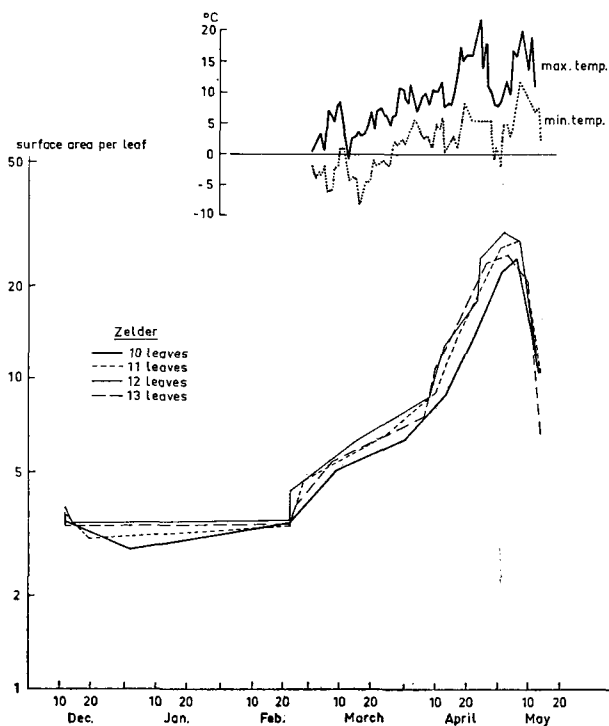


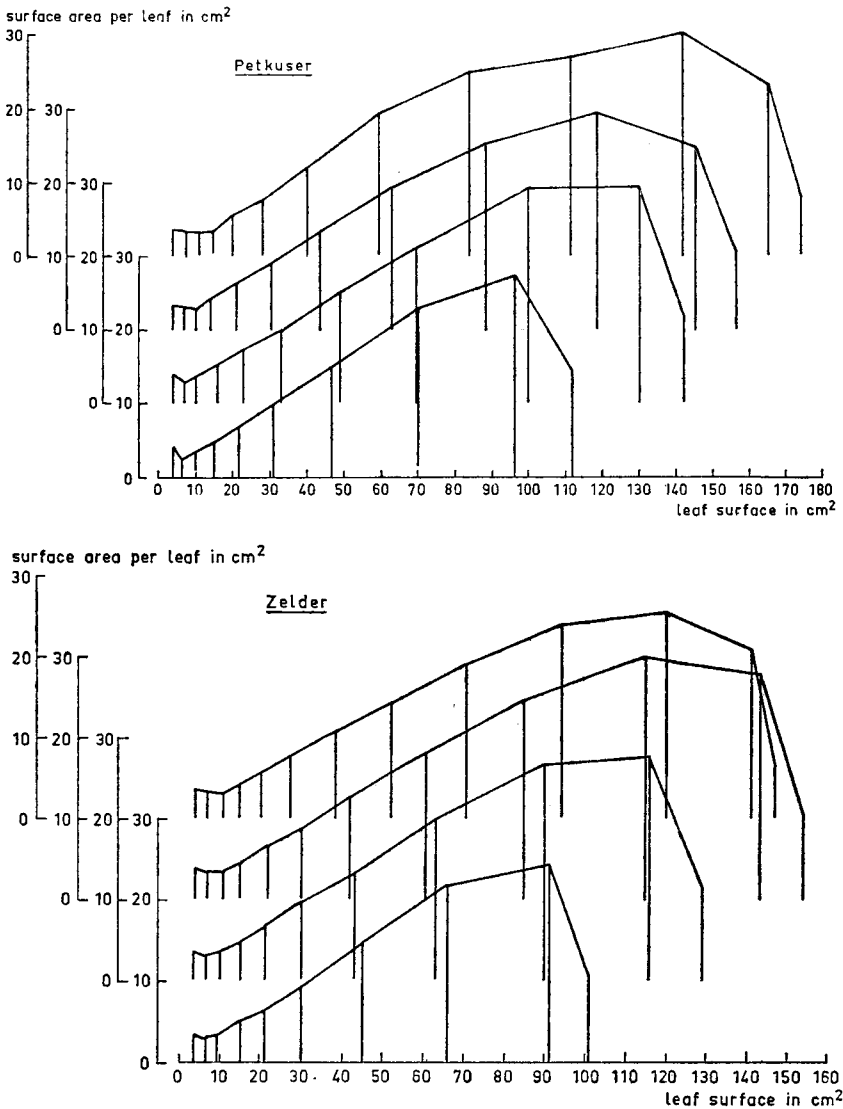
FIG. 3.
Surface area per leaf of the
varieties *Petkuser* and *Zel-*
der during growth (ordinate
on log. scale)



13 full-grown leaves on 17th April (1926 mm²). This, however, does not alter the fact that the last-mentioned group of plants has the lead in total leaf surface area on 28th April because in this group a ninth and tenth leaf have been formed, which surpass by far the size of the eighth leaf emerging at the same time in the group with few leaves.

The development of leaf area may be examined with the aid of FIG. 4. In this

FIG. 4. Surface area per leaf plotted against the total leaf surface for the groups with 10, 11, 12 and 13 leaves of the varieties *Petkuser* and *Zelder*



figure, the area of each separate leaf indicated by a vertical line has been plotted against the total leaf area at the moment that each leaf was full grown. It follows from these series that the surface area of a certain leaf is proportional to the total surface area of all leaves formed so far. The proportionality factor is shown by the slope of the line drawn over the apices of the vertical lines which indicate the leaf areas. The slopes may be less steep for plants with many leaves than for those with few leaves.

The relation can obviously be explained by the part played by the leaf area present in supplying the growing leaves with nutrients. The somewhat reduced proportionality factor in plants with many leaves may be due to the fact that each new leaf has to share the available nutrients with a greater number of younger leaves than is the case in plants with few leaves. The relation is completely lost when the last leaves emerge. This is partly due to the fact that the function of the oldest leaves comes to an end and, partly because the reproductive parts of the plant need a larger portion of the nutrients.

The proportion is also disturbed when the first leaves are initiated. A detailed analysis of this phenomenon, as well as a further scrutiny of leaf development will be given in a subsequent paper (WITTENROOD and HOOGLAND, 1964).

The rather advanced lead in surface area of plants with many leaves increases due to the cumulative effect of the assimilating surface area. At the time of heading, the lead in surface area of the plants with 12 to 13 leaves will amount to about 50 % in comparison with that of plants having 10 leaves. This does not straight away mean that the leaf area of a rye crop consisting solely of plants with many leaves will surpass that of a crop with less leaves. Probably the difference between plants with many and those with few leaves found in this investigation have also been influenced by a difference in competitive power after the plants with many leaves have obtained a small lead in leaf area.

The average total leaf area per plant appears to differ slightly per variety. It was observed that the difference was reversed in the previous season (1960/61). Furthermore, the size of the last leaf decreases as the leaf number increases. The reliability of the decrease, however, is doubtful as is confirmed by the correlation found (*Petkuser* — 0,26 and *Zelder* — 0,11).

3.3. The number of spikelets per ear

TABLE 1 also proves that the number of initiated spikelets per ear increases as the leaf number is greater. It is not evident from the data whether a direct relation between leaf number and number of spikelets initiated exists or the greater number of spikelets is due to the larger leaf area inherent to the greater leaf number.

FIG. 5 proves that the leaf area is closely related indeed to the number of spikelets, also within the groups. Here, the leaf area has been plotted against the number of spikelets in individual plants. From this material correlation coefficients of + 0,61 and + 0,69 could be calculated for *Petkuser* and *Zelder* respectively.

Evidently, a number of 40 spikelets represents a certain maximum. There is a slight difference between the number of spikelets initiated and the number of full-grown ones, as is shown in TABLE 3.

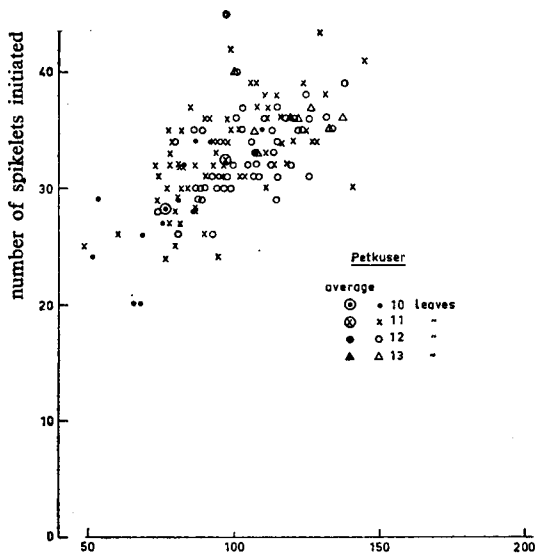


FIG. 5.
Relation between total leaf surface and number of spikelets initiated in the varieties *Petkuser* and *Zelder*

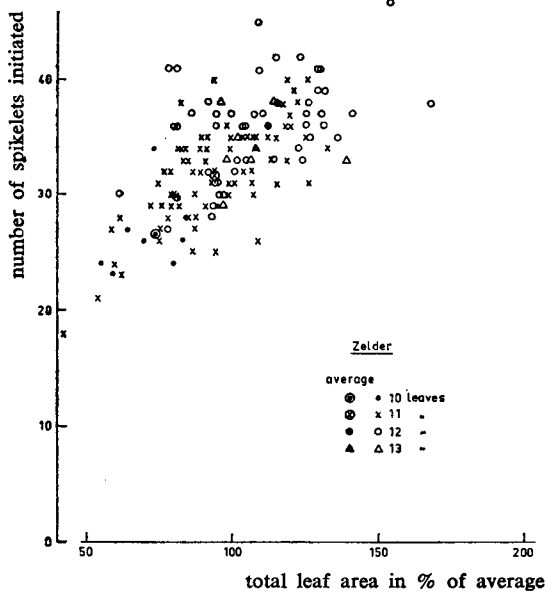


TABLE 3. Average number of spikelets initiated and full-grown per ear

Variety	Number of spikelets per ear on main axis	
	initiated	full-grown
<i>Petkuser</i>	32,4	30,8
<i>Zelder</i>	33,1	32,5

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