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Variations of water content in the bark and wood of various sectors of the stem in two-year-old poplars after transplantation

by

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Introduction

The Poplar Research Institute of Casale Monferrato has taken up a series of research work in order to identify the possible causes of the poor rooting success on newly transplanted 2-year-old poplars, which has been frequently observed in Northern Italy, resulting in serious economic loss, also in some clones as 'I-214', which as a rule have a high rooting capacity.

Various factors affecting the rooting success have been taken into consideration such as:

a) variation in water content in the bark and wood of the various sectors of the stem;
b) origin of the plant used in vegetative propagation;
c) soil and climatic conditions;
d) methods and time of planting;
e) cultural technics etc.

In this report the variations of the water content in the bark and wood of the various sectors of the stems have been investigated with the object of correlating them with the growth of shoots, the development of roots and the climatic conditions.

MATERIALS AND METHODS

The surveys were carried out during the period 1967-68 on three groups of 2-year-old poplars belonging to the clone 'I-214', grown in a nursery of the Poplar Research Institute, Casale Monferrato.

The first group was not removed from the nursery, on the contrary the second and the third group were transplanted, respectively in autumn 1967 and in spring 1968.

Each group of 150 trees was divided into three plots of 50 trees as replications. The lateral branches of the trees were cut according to the regular system of pruning. The trees were planted on sandy soil, with a pH value of 8, low in lime and poor in organic matter.

The variations of water content which occurred in the bark and in the wood from November 1967 to May 1968 have been determined in three plants for each group on the dates indicated in the graphs.

The water content in both the wood and bark of the stem of 2-year-old poplars was determined separately in 2-year and 1-year-old parts. Each part was cut in half, and the respective sectors were numbered as follows: 2a and 2b in the 2-year-old parts and 1a and 1b in the 1-year-old parts, the lower sectors were marked with the letter a and the apical sectors with the letter b. The water content was determined on specimens 25 centimetres long taken from the central part of each sector and was expressed on a dry-weight basis.

The development phases of the leaf buds were classified according to the differentiation scale proposed by Castellani et al.[1] The growth of shoots was estimated on the average number of the shoots and their dry-weight per tree, as indicated in table No. 2.

The dates of emergence of roots have been recorded. The growth of roots has been estimated according to the average and the total length of roots per tree, grouping them into the following classes: <1; 1-5; 6-10; 11-15; 16-20; 21-25; 26-30; 31-45 cm (table No. 3).

The average temperatures and rainfall occurring in the period from November 1967 to May 1968 are indicated in the table No. 1. Moreover, for the month of April 1968, the recordings of the temperature, rainfall, relative humidity of the air and velocity and direction of the winds and persistance of dew are given in the graph No. 4.

In each group rooting success was recorded in August.

RESULTS

Two-year-old poplars not transplanted

During the period of dormancy the water content was more or less constant both in the bark and in the wood of the 2-year-old sectors. The same occurred in the wood of the 1-year-old sectors until February when dehydration took place and persisted until sprouting began. Afterwards the water content increased, at first rapidly and later more slowly in the bark, particularly in the 2-year-old sectors. On the contrary in the wood it decreased at the outset of sprouting and then slightly rose all through the month of May, in all sectors with the exception of the apical one in which a progressive and

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(1). - CASTELLANI E., FRECCERO V. and LAPIETRA G.: "Proposte di una scala di differenziazione delle gemme fogliari del Pioppo utile per gli interventi antiparassitari" - Giorn.bot.ital. 101, 6, pp.355-360,1967.

rapid increase of the water content was observed, which may be related to the development of the buds (graph No. 1) and to the new activity of the roots.

It is interesting to note that during the leafless condition of the tree the water content is more constant in the bark than in the wood. On the other hand during the foliage season the bark contains more moisture than the wood.

Two-year-old poplars transplanted in the autumn 1967

During the leafless conditions of the tree there was no significant change in the water content either in the bark or in the wood in the 2-year-old sectors. On the contrary in the 1-year-old sectors a progressive and high loss of water occurred in the wood from the end of January in the 1b part and from the middle of February in the 1a part. This loss of water was far greater in transplanted than in not transplanted plants.

At the outset of vegetative activity the water content increased rapidly and to a great extent in the bark, whereas it slightly decreased in the wood, except in the apical sector, which was already dehydrated and where a slight increase was registered.

In the spring 1968 the growth of leaf buds took place from 18th March to 2nd April (see graph No.2). The 5th phase was prolonged to the 14th April probably due to a fall in the temperature (see graph No. 4). The shoots developed regularly (table No. 2) though,as expected, at a much slower rate than on the trees which had not been transplanted.

At the beginning of April emerging rootlets were observed and by the end of April the new root system was large enough to absorb water as rapidly as it was lost by transpiration (table No. 3). Rooting success was complete.

Two-year-old poplars transplanted in spring 1968

The 2-year-old trees transplanted in spring 1968 suffered transplantation.

In all of them, since 18th April, more or less marked wilting of the shoots took place, followed by drying up or fall, which was moderate in 30% of the trees and very serious in the remaining 70%. In the latter, in the first days of May, also drying up of the top section of the stem was observed.

In the trees of the first group (A) which lost only a part of the shoots, in the bark there was a rising water content increase, interrupted by two falls, the first and the slightest recorded on 9th April 1968 on the sectors 2b, 1a, 1b and the second and the strongest, recorded on 26th April 1968 on all four sectors. In the wood the water content of all sectors decreased from the time of sprouting to the end of April, from which time an increase was observed.

In the trees of the second group (B), which suffered because of the total loss of the shoots, the variation of the water content of the wood, as well as that of the bark, was the same as in those of the first until 17th April. From this date to the 26th April the water content in the bark of all the sectors decreased more intensely but in the following period it increased except in the apical sectors where the water content further decreased. The same phenomenon was observed in the wood but with less intensity. As concerns the development of leaf buds and the growth of the shoots differences among the trees transplanted in spring were not observed until 17th April. The leaf buds developed from 22nd March to 4th April with the chronological succession indicated in graph No. 3, and phase five lasted for at least ten days owing to the low temperature which occurred from the beginning to the middle of April. In the survey of 17th April the average number and dry weight of shoots per tree were respectively: 50.7 and 16.1. On the 18th April the shoots began to show incipient wilting followed by permanent wilting from 22nd of the same month. As above stated, it involved only a part of the shoots in some plants (group A) and practically all the shoots in the other (group B). A certain amount of the wilted shoots fell, but normally persisted on the plant even for several months, probably because the trees were not able to form the abscission layer during the short time permanent wilting occurred.

It must be emphasized that in April the root system was less developed in the plants transplanted in spring than in those planted in autumn, particularly in the plants of the group B where trees suffered transplantation more seriously. Branching and rebranching of the roots were observed in the survey of 7th May but in group A the total length of the roots per tree was twice as high as in group B.

Comparing the data given above with the meteorological conditions which occurred from 22nd March, when the growth of shoots began, to the last ten days of April, when the shoots began to wilt, the following appears:

a) From 22nd March to the 3rd-4th April there was practically no rainfall, nevertheless, the increasing temperatures made normal development of the leaf buds possible. This development coincides with an increase of the water content in the bark and a decrease in the wood.

b) The following period, including 4th to 14th April, was characterised by no rainfall, by slight winds coming chiefly from east and north-east and by a lowering of temperature which slowed down the growth of shoots and the formation of roots. The water content of the wood had further decreased to compensate the transpiration and increasing water content of the bark.

c) Finally, from 15th-16th to 23rd-24th of the same month, winds chiefly coming from the south and relatively high temperatures enhanced the growth of the shoots more than that of the roots and increased the transpiration. The increased transpiration which could not be compensated by absorption of the new root system, insufficient at that time, nor by the water reserve in the wood which was exhausted, has brought on excessive water loss of the bark, permanent wilting of the shoots and desiccation of the apical part of the stem.

As the moisture of the soil in April was, on samples taken near the young trees, sufficiently high (55.0% and 71.7% of the maximum water holding capacity respectively at 10-30 and 31-50 depth in cm), we may consider that the trees suffered transplantation as a result of excessive water loss in transpiration before an effective absorbing surface of the roots had developed. Rooting success was complete, but nevertheless the plants, in which almost all the shoots had dried up, were irremediably damaged.

CONCLUSIONS

In the 2-year-old poplar trees -which are normally used in Italy in transplantation practice from nursery to plantation- during the rest period, the water content of the bark remains almost constant, mainly to the expence of the water contained in the wood. At the outset of the growing season the water content of the bark greatly increased, mainly to the expence of the water contained in the wood, which reaches very low levels in the transplanted trees especially in those transplanted during the autumn. The development of the leaf buds precedes the emergence of the new roots, in all transplanted trees. If the absorbing surface of the roots is sufficiently developed, rapid growth of shoots, increase of water content in the bark and rehydration of wood, above all in the apical sector of the stem, take place at the same time, and consequently the plant, on reaching a good water balance, can start to grow vigorously. But if the root system is poor and the water reserve in the wood is exhausted, a dehydration in the bark occurs, the leaf transpiration is not compensated by the absorption of the few new roots and wilting and drying-up of the shoots and desiccation of the apical part of the stem takes place. On the lower part of the stem, on which shoots usually are absent, the bark dehydrates less and after some time shoots arise from dormant buds. Plants can survive but from a practical point of view they have no value and must be replaced. In poor water conditions, only a few suckers may arise from the base of the plant or the whole tree may die. In less serious cases only some of the shoots dry up and the 2-year-old poplars that have not suffered damage of relevant importance, can overcome the crisis.

The time of planting is a very important factor affecting rooting success on poplar trees. The 2-year-old poplars of the clone 'I-214' planted in autumn compared to those planted in spring, produce roots many days earlier and their absorbing root system is able to absorb water with sufficient rapidity to prevent development of serious internal water deficits during periods of rapid transpiration after transplantation.

Tab. 1

Mean temperature and precipitation occurring at Casale Monferrato from November 1967 to May 1968 (months divided into 1st, 2nd and last ten-day periods)

MONTH	Temperature °C				Precipitation							
	1st	2nd	3rd	Mean monthly	1st mm	1st days	2nd mm	2nd days	3rd mm	3rd days	Total monthly mm	Total monthly days
NOV.	8.3	8.7	4.9	7.3	86.4	5	25.4	3	18.6	2	130.4	10
DEC.	4.9	-1.0	0.8	1.5	1.6		0.8		40.2	5	42.6	5
JAN.	0.0	-0.8	2.5	0.6	0.4		1.0		0.8		2.2	
FEB.	2.5	4.1	5.5	3.9	27.0	5	5.8	1	54.2	4	87.0	10
MAR.	6.4	8.2	12.6	9.2	10.4	1	9.6	1	2.6	1	22.6	3
APR.	11.4	12.7	17.0	13.7	8.6	3	20.2	3	32.2	2	61.0	8
MAY	14.8	16.3	17.7	16.3	15.6	4	25.4	3	33.6	5	74.6	12

Tab. 2

Shoot growth in 2-year-old poplars (*P.* x *euramericana* cl. 'I-214')

	Survey date	Average No. of shoots per tree	Dry weight (gr) of shoots per tree
Not transplanted	9.IV.1968	47.3	19.9
	27.IV.1968	53.5	135.0
	7.V.1968	43.5	170.8
	25.V.1968	49.0	205.0
Transplanted in autumn 1967	17.IV.1968	52.0	19.3
	30.IV.1968	55.0	29.2
	16.V.1968	56.0	45.3
Transplanted in spring 1968			
Group A)	17.IV.1968	50.7	16.1
	7.V.1968	13.7	12.4
Group B)	17.IV.1968	50.7	16.1
	7.V.1968	0	0

Tab. 3

Root growth in 2-year-old poplars (P. x euramericana cl.'I-214') transplanted at different times

Time of transplantation	Group	Survey date	Frequency distribution of the length of the roots (cm) <1	1-5	6-10	11-15	16-20	21-25	26-30	31-45	Total No. of roots per tree	Average length of roots (cm)	Total length of roots (m)
Autumn 1967		3.IV.1968		25.0							25.0	2.5	0.62
		9.IV.1968		27.0	7.0						34.0	3.5	1.20
		17.IV.1968		15.0	13.0	15.0					43.0	7.5	3.22
		30.IV.1968		14.0	18.0	16.0	20.0				68.0	10.6	7.20
		16.V.1968				6.0	19.7	20.0	27.0	14.0	86.7	24.7	21.37
Spring 1968	A	4.IV.1968											
		9.IV.1968	21								21.0	0.5	0.10
		17.IV.1968		25.0							25.0	2.5	0.62
		26.IV.1968		10.0	8.3	8.7	13.1				40.0	10.6	4.23
		7.V.1968				13.0	21.0	19.0	20.0		73.0	20.6	15.07
	B	4.IV.1968											
		9.IV.1968	21								21.0	0.5	0.10
		17.IV.1968		25.0							25.0	2.5	0.62
		26.IV.1968		7.0	11.0	20.0					38.0	9.2	3.50
		7.V.1968		6.0	7.0	11.3	21.3	5.0			50.6	13.7	6.94

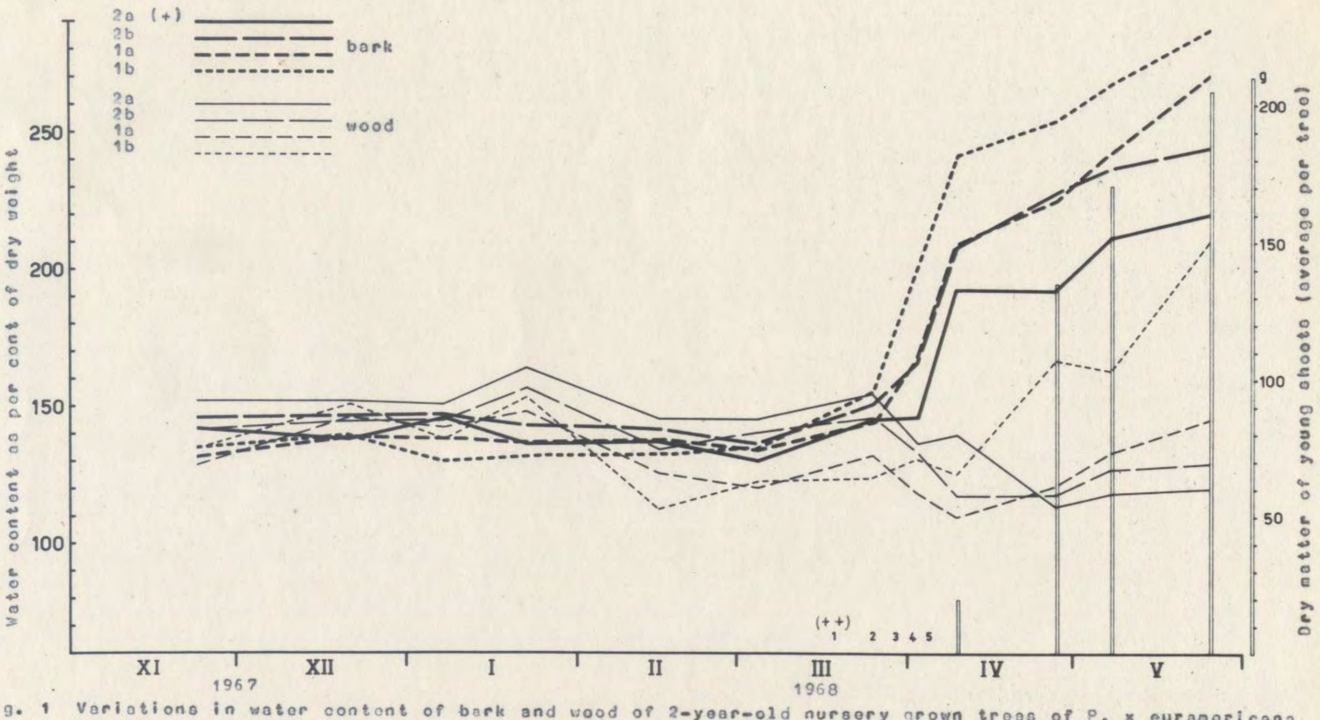

Fig. 1 Variations in water content of bark and wood of 2-year-old nursery grown trees of P. x *euramericana* cl. 'I-214' in the period between November 1967 May 1968.

(+) 2a and 2b = lower and apical 2-year-old parts; 1a and 1b = lower and apical 1-year-old parts.

(++) Numbers from 1 to 5 indicate the phases of growth in leaf buds according to the scale of Castellani et al. (1967).

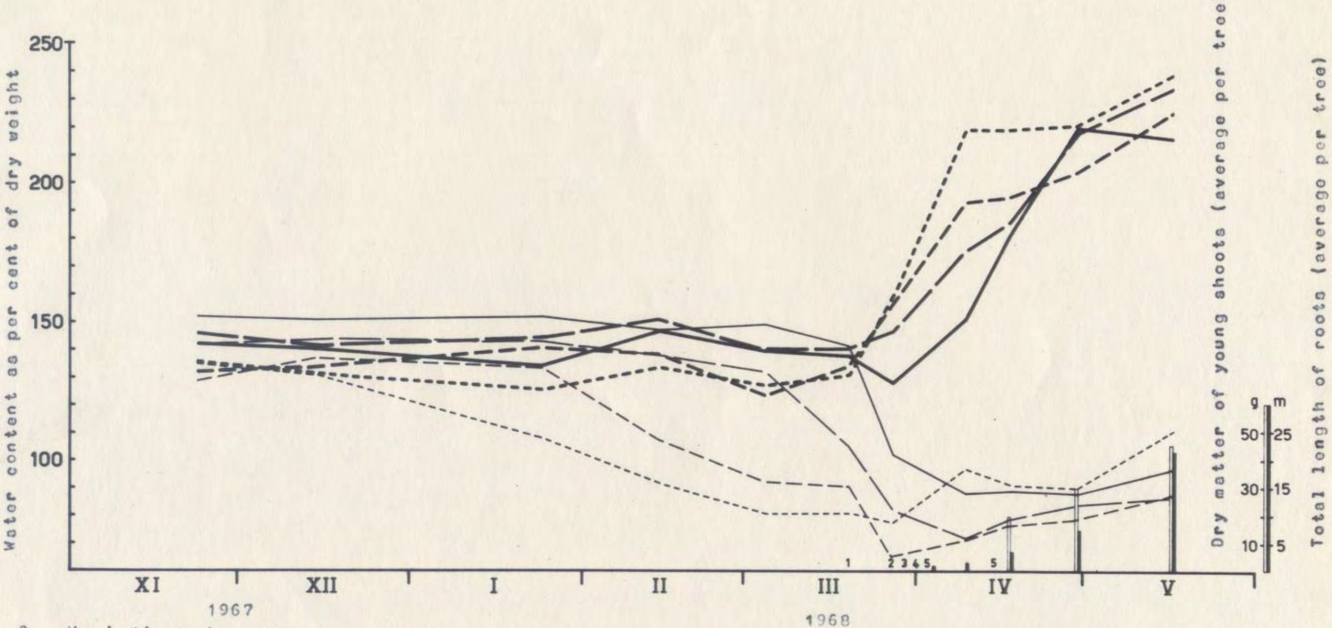

Fig. 2 Variations in water content of bark and wood of 2-year-old trees of P. x euramericana cl. 'I-214' transplanted in autumn 1967.

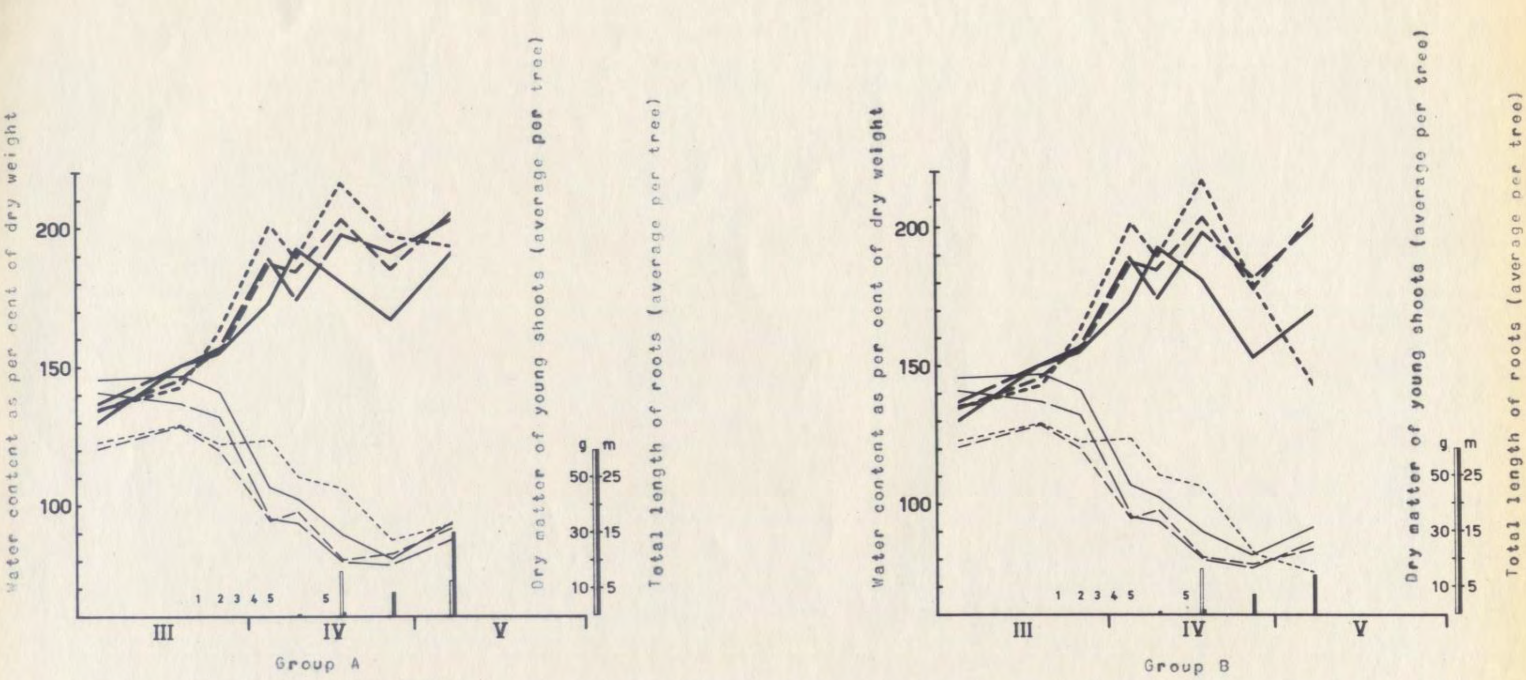

Fig.3 Variations in water content of bark and wood of 2-year-old trees of *P. x euramericana* cl. 'I-214' transplanted in spring 1968.

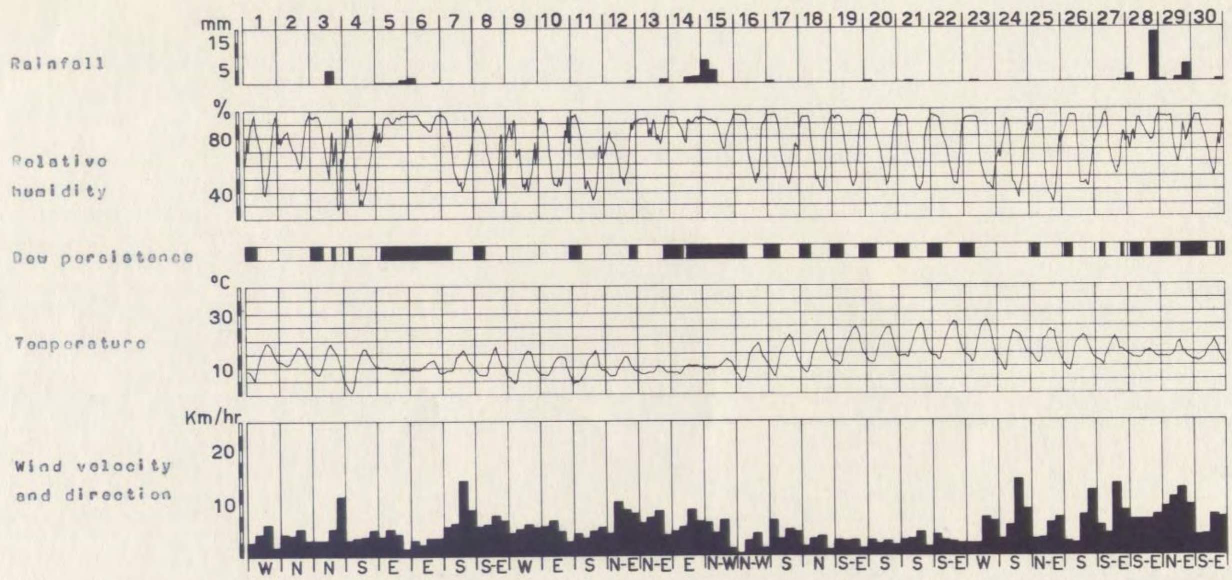

Fig. 4 Climatic elements registered in April 1968 at the meteorological station of the Poplar Research Institute, Casale Monferrato.

(The data concerning the wind have been registered by the meteorological station of Vercelli, near Casale).