DEVELOPMENT STAGES OF WINTER OILSEED RAPE (*BRASSICA NAPUS* L) FROM SOWING TO FLOWERING

TITTONEL E.D.(i) and PALLEAU J.P. (ii)

(i) ENITA. BP 48. 21802 QUETIGNY - FRANCE.
(ii) CETIOM 8 Rue de Bastogne. 21850 St Apollinaire - FRANCE.

INTRODUCTION

Farmers and technicians regularly notice that delaying sowings has little effect on the flowering date and on the harvest. Usually, a time lag of a month at sowing shrinks to a week at floweing and to one or two days at harvesting.

For the experiment presented here, we entended to see whether this time lag reduces at particular moments or regularly during the whole period. The period looked at streches from the sowing to the beginning of flowering.

In order to keep up with the plant evolution, a development scale was needed. Therefore we completed the one of TITTONEL and al (1982). Then we recorded the dates of the floral stages of four strains, two areas and different sowing dates.

I SCALE OF DEVELOPMENT STAGES

For the first stages up to 7, we used those of TITTONEL and al (1982).

In this scale, floral initiation corresponds to stage 3. At that moment, a particular grouping (the bud-leaf couple) appears.

Until stage 5, the stage of the plant is determined by the status of the cauline apex.

Further on, from stage 6 and onwards, the stage of the plant is the one of the "reference flower", i.e. the first initiated flower on the main axis (Fig. 1).

At stage 6, this flower has turret like sepals.

At stage 7, by lenghthening, sepals completely cover the central dome of the flower. They must be taken away to keep up with the inner evolution of the flower.

At that moment, the raceme is white colored and is hardly as long as 1 mm. It can be determined directly in the field with a little hand microscope.

With a laboratory microscope, one can see the central dome divide into a new central dome (future gynoecium) surrounded by 6 other peripheral ones (future stamens).

Then, these little 7 things grow in lenghth.
Future stamens divide first into 2 lobes and later into four.

The pistil looks like an open hose, whose tip gradually closes up.

Sepals are slightly crumpled, and turn yellowish green and then green (stage 8).

At stage 9, sepals keep on crumpling. Sepals are definitively green and the serrate edge of the covering sepal turns clearly white. The inner part of the flower, under the sepals, remains uncolored or yellowish.

At this moment, in the still unclosed hose of the pistil, ovules begin to develop, looking like a double row of teeth.

Anthers still have a short filament. If squeezed no liquid appears.

During this evolution, the terminal raceme has grown bigger. It is now 2 or 3 mm high. The reference flower bud, which is approximately egg-shaped, is about 1/2 mm high, without a peduncle.

At stage 10, the raceme is clearly green and about 4 or 5 mm high. The reference flower is definitely ovoid. Sepals are streched on stamens. Beneath the sepals, intern organs which were up til now uncolored, turn yellowish green and from then onwards become more and more green.

Even though anthers have grown larger, nothing can be seen when they are squeezed.

On the other hand, the hose like pistil is now completely closed up. Ovules and the false septum can be guessed by their bending the ovary walls.

Petals look spoon shaped.

At stage 11, the anthers always have a short filament but at this stage, a white liquid appears if they are by squeezed. The flower bud without peduncle is about 2 mm high.

At stage 12, internal organs of the flower are always green. Pollen grains can be distinguished by squashing the anthers. The upper part of the pistil narrows into a style and then broadens out.

At stage 13, the petals, anthers and pollen grains inside them turn yellow meanwhile the pistil turns yellow green. The petals are as long as half the stamens. Nectaries can be distinguished.

At stage 14, the stamens are always short filamented. The petals are as long as the stamens. The pollen is like a powder. Papillae appear on the stigma.

At stage 15, the stamens now have a long filament. The style too has grown longer and the stigma looks like a half brilliant bowl. Nectaires are deep green.

Stage 16 is the anthesis.

Stage figures have been attribuated only on morphlogical modifications without knowing beforehand if they all have the same duration and what determines them.

Before our work, the development stages of the flower had already been described by FABRY (1977), CHAO DA-MING and CHANG (1980), SCARISBRICK and DANIELS (1986), POLOWICK and SAWHNEY (1986).

Our descrptions do not differ from those of these authors. They only aimed to build a scale acurate for keeping up with a laboratory work on plants.

SMITH and SCARIBRICK (1990) and BOUTTIER (1990) on the other hand, were interested in meiosis. Their work seems to allow us to link the beginning of male and female meiosis with stage 11.

The stages looked at, between sowing and anthesis, point out two particular moments i. e. the moments where new kinds of mersitem begin to work, namely,

- stage 3 or floral initiation : first signs of formation of floral meristems,
- period from stage 7 to stage 10 : from formation of the first meristems of androecium and gynoecium to the first meiosis.

II DATES OF THE DEVELOPMENT STAGES.

2 1 Materials and methods

Experiment fields are located in Eastern France, namely in DIJON region, in two different zones :

- The Plaine of Dijon, about 200 m above the sea level, with deep and rich soils
- The Plateau of Chatillonnais, towards 500 m above the sea level, colder than the Plaine, and with shallow, calcareous and stony soils.

Some of these field plots (labeled with *) are also used for a nitrogen experiment (PALLEAU and TITTONEL 1991). Others belong to farmers.

Every week, on each of these plots, 5 plants representing the average plant of the plot are dissected, their stage being recorded (Tab. 1 and Tb 2).

22 Results

As usual in our region, the first floral initiations of the various strains stretch from the end of October to the end of December. They express the needs in number of growing days, in vernalization and the sensitivity to the day length of each strain.

- repeated observations on different Winter strains indiquate that floral initiation seldom concerns plants less than 50 days old after sowing (TITTONEL unpublished data).

- During 1989-1990 Winter, maximum temperatures were regularly under 20 °C from about 20 - 25 Septembre and about Novembre the 3rd the maximum temeratures fell under to 15°C both on the Plaine de Dijon and on the Plateau du Châtillonnais (Fig. 2).

A strain such as Samourai has little need of vernalization and above all it is slightly sensitive to the day length (TITTONEL unpublished) : consequencely, they come to floral initation as soon as 50 days after sowing. The growing degree day (G D D) at this stage indicate only the climate during these 50 days.

Darmor too is slightly sensitive to the day length, but it needs more days of low temperatures. It comes into floral initiation later, when its needs of low temperatures are satisfacted and then when mild temperatures allow it to grow. On the Plateau, where the cold weather begings first, the former sowings go to initiation at the very beginning of Novembre although on the Plain, it takes place only a fortnight after. For the later ones it occurs only with the cool temperatures of December, both on the Plaine and on the Plateau.

Ceres and Corvette have a intermediate behaviour.

Since floral initition is over, floral formation and evolution comes on rapidly. Thus all the plants of a plot do not initiate at the same moment : the bigger ones are the former ones (TITTONEL 1988). So, in the same plot, plants exhibiting stages ranging from 4 to 7 are not unusual. This heterogeneity is caracteristic of this period. The transition from stage 3 to stage 7 takes place during Autumn and Winter. Because of low temperatures at this period the streching out of the stages becomes even more obvious.

Up to stage 7, the four strains do not behave differently, but from 7 and onwards to stage 10, Samourai and Ceres can be distinguished from Corvette and above all from Darmor.

For the former sowings, the floral stages of Samourai and Ceres level off between stage 7 and stage 10, whatever time is being expressed using days or GDD (baseline 0°C) (Fig. 3). The earlier stage 7 begins, the longer the duration of this period. So, stages of the later sowings do not level off.

Neither do Darmor, whenever sowing occurs (Fig. 4).
Corvette has a intermediate behaviour.
After stage 10, the curves go on paralleling or even superposing each other.

The beginning of flowering of Samourai is one of the earliest ever seen in our region : it begins at the end of March i.e. a month earlier than usual. At this moment, low temperatures are not over (7°C in average on the Plateau). So, the beginning of flowering of the other sowings spreads out over 16 days.

For the other strains, flowering begins later and is more gathered together. For instance, on the Plateau, the 22 delayed days at sowing reduce to 5 at anthesis.

23 Discussion

The period from sowing to anthesis lengthens from 1600 GDD for Samourai to 2000 GDD (baseline 0°C) for Darmor (Fig. 5).

For a given strain, the later the sowing, the shorter this period. This explains why delayed sowings gather together.

Nevertheless, all the stages do not participate equally to the shrinkage. Two of them play a particular part.

- stage 3 or floral initation :

The later the sowing, the earlier it occurs. It is the result of the interaction between the age of the plant, its sensitivity to the day length and vernalization.

However, that kind of result has already been reported elsewhere (TITTONEL 1988).

- period from stage 7 to stage 10.

On the other hand, the difference in behaviour between strains according to their sowing date and more precisely the slowing down in flower development looks more specific.

These stages taking place from November to February, one can presume various hypothesis.

- Low temperatures prevent flowers from evolving. The baseline temperature 0°C would not be acurate to fit this evolution. This hypothesis would agree with MORRISSON and al (1989) determinations on Westar summer rape grown in Western Canada. Acording to these authors, phenological development are well taken into acccount by GDD with a baseline of 5°C. If so, stage 7 to stage 10 duration using a baseline 5°C GDD, would be approximatively the same whatever the sowing dates. But it is not, even though with a baseline of 5°C, floral stages fit a better line than whith a baseline of 0°C.

- The considered period is that of the shortest days of the year. One could think that flower evolution is slowed down by day length. Nevertheless this hypothesis seems to be unacurate for strains that we know to be just slighly sensitive to the day length.

- One can also presume that during the considered period new meristems should normally begin to work. This period is therefore a development stage i.e. a period where specific needs are likely to rise.

During another experiment, plants were grown outside for various durations and then, taken in, in a growth cabinet. Some of them failed to flower. Dissections made it clear that they stopped at two particular stages : stage 2 and stage 8-9. *Geum urbanum* too, was shown (TRAN THAN VAN 1965) to be able to undergo morphological and histological modifications according to the time they were left at low temperatures.

If we take into consideration the internal status of vernalization of the plants, the expression of it and the gap that may exist between them, this could suggest the following hypothesis :

Samourai needs little exposure to low temperatures to accomplish the floral initiation.

For the first sowings, this stage occurs as early as the end of October or the very beginning of November. But then, the exposure to low temperatures is not long enough to allow the plants to go any further. Evolution slows down by lack of vernalization. The plants would have completely expressed their internal status.

Plants from the later sowings cannot enter the flowering process before they are, at least, 50 days old. During this time, and even further on, plants are sensitive to low temperatures, but these low temperatures prevent them from undergoing floral stages. There is a gap between the floral stages and the internal true status.

From mid-February onwards, mild temperatures make the expression possible and whatever the sowing dates are, the floral stage of all the plants have the same evolution.

The fact that Darmor does not level off would have the same kind of explanation. The needs of vernalization being relatively higher, floral initiation can only take place during Winter even for early sowings. So, plants react as that of the later sowings of Samourai.

CONCLUSION

Slowing down during stages 7 to 10 for early sowings of Samourai was confirmed the year after, during the 1990-1991 campaign. So this result must be taken into account if one wants to understand oil seed rape vernalization and behaviour.

REFERENCES

BOUTTIER C. (1990)
Pod and seed development in oilseed rape (*Brassica napus* L.). P.H.D. St John's College. University of Cambridge, England. 115 p.

CHAO DAMING and CHANG En-han (1980)
The sequence of the differentiation of floral primordium and the origin of the stamens in rape plants. Journal of Nanjing Agricultural College N°2 (translated by ZU XHE)

FABRY (1977)
Initiation florale du colza. Traduction CETIOM.

MORRISON M.J., McVETTY P.B.E. and SHAYKEWICH C.F. (1989)
The determination an d verification of a base line temperature for the growth of Westar summer rape. Can. J. Plant Sci. 69 : pp 455-464.

PALLEAU J.P. and TITTONEL E.D. (1991)
Effet d'un apport d'azote à un stade repère de la fleur. Répercussions sur les composantes du rendement. 8 th Oil Seed Rape Congress. Saskatoon. Canada.

POLOWICK P.L. and SAWHNEY V.K. (1986)
A scanning electron microscopic study on the initiation and development of floral organs of *Brassica napus* (cv. Westar). - Amer. J. Bot. Vol 73 (2) pp 254-263.

SCARISBRICK D.H. and DANIELS R.W.(1986)
Oilseed rape. Collins Ed. London 309 p.

SMITH L.J. and SCARISBRICK D.H. (1990)
Reproductive development in oil-seed rape (*Brassica napus* cv. Bienvenu). Annals of Botany 65, pp 205-212 .

TITTONEL E. D. DESPLANTES G., GRANGERET I., and PINOCHET X. (1982).
Modifications morphoplogiques d'un bourgeon de colza (*Brassica napus* L.) au cours de la formation des ébauches florales. Informations techniques CETIOM 78, pp.15-24.

TITTONEL E.D. (1988)
La phase automnale chez le colza d'hiver. Colza. Physiologie et élaboration du rendement. Supplément à Informations Techiques CETIOM. 158 p.

TRAN THANH VAN- LE KIEM NGOC (1965)
La vernalisation de *Geum urbanum* L.. Etude expérimentale de la mise à fleurs chez une plante exigeant du froid vernalisant pour fleurir. Annales des sciences naturelles. - Botanique, Serie 12, VI, (3) pp 373-594.

Strain	SOWING DATE	SOWING G.D.D.(1)	FLORAL INITIATION DATE	FLORAL INITIATION G.D.D. (2) Baseline 0	FLORAL INITIATION G.D.D. (2) Baseline 5	STAGE 7 DATE	STAGE 7 G.D.D.(2) Baseline 0	STAGE 7 G.D.D.(2) Baseline 5	STAGE 10 DATE	STAGE 10 G.D.D.(2) Baseline 0	STAGE 10 G.D.D.(2) Baseline 5	BEGINNING OF FLOWERING DATE	BEGINNING OF FLOWERING DURATION DAYS(2)	BEGINNING OF FLOWERING G.D.D. (2) Baseline 0	BEGINNING OF FLOWERING G.D.D. (2) Baseline 5
*SAM 1	28/08	94	18/10	716	461	08/11	959	601	07/02	1275	697	03/04	218	1722	884
SAM 2	30/08	124	21/10	727	467	08/11	929	581	20/02	1335	707	06/04	219	1710	867
SAM 3	31/08	142	21/10	709	454	08/11	911	568	06/02	1219	661	30/03	211	1635	832
*SAM 4	15/09	374	08/11	680	411	09/01	975	478	14/02	1031	520	11/04	208	1498	710
*CRS 1	28/08	94	26/10	831	536	13/12	1042	618	28/02	1441	763	11/04	226	1778	900
CRS 2	29/08	109	26/10	816	527	29/11	1014	606	18/02	1332	709	11/04	225	1763	891
CRS 3	28/08	109	23/10	775	501	16/11	974	596	18/02	1332	709	11/04	225	1763	891
*CRS 4	15/09	374	14/11	707	475	17/01	889	481	28/02	1161	573	17/04	214	1544	726
CVT 1	28/08	94	02/11	920	590	13/12	1042	618	28/02	1440	763	09/04	224	1762	895
CVT 2	15/09	374	22/11	746	425	17/01	889	481	28/03	1161	573	15/04	212	1531	723
DAR 1	24/08	40	07/11	1010	640	24/01	1241	712	27/02	1487	799	22/04	240	1910	965
*DAR 2	28/08	94	22/11	1025	615	24/01	1186	673	28/02	1441	763	22/04	237	1856	926
DAR 3	30/08	214	22/11	906	595	24/01	1067	653	01/03	1327	744	23/04	236	1746	911
*DAR 4	15/09	374	20/12	838	468	05/02	979	500	29/02	1161	573	25/04	222	1608	752

SAM : Samouraï
CRS : CERES
CVT : Corvette
DAR : Darmor

(1) from 23 august
(2) from Sowing

* : see PALLEAU and TITTONEL (1991)

Tab. 1 : Main stages on the Plaine de Dijon

Strain	SOWING		FLORAL INITIATION			STAGE 7			STAGE 10			BEGINNING OF FLOWERING			
	DATE	G.D.D.(1)	DATE	G.D.D. (2) Baseline 0	Baseline 5	DATE	G.D.D.(2) Baseline 0	Baseline 5	DATE	G.D.D.(2) Baseline 0	Baseline 5	DATE	DURATION DAYS(2)	G.D.D. (2) Baseline 0	Baseline 5
*SAM 1	28/08	84	20/10	751	486	05/11	959	658	31/01	1319	729	30/03	214	1755	906
SAM 2	01/09	143	28/10	815	530	15/11	960	636	13/02	1341	709	30/03	210	1696	867
SAM 3	02/09	157	22/10	730	460	15/11	946	627	07/02	1297	697	02/04	212	1716	877
*SAM 4	15/09	349	08/11	709	430	01/0?	755	541	21/02	1198	602	15/04	212	1607	770
*CRS 1	28/08	84	23/10	799	519	08/11	974	658	21/02	1463	777	10/04	225	1840	938
CRS 2	28/08	84	28/10	874	569	17/11	1027	690	20/02	1454	773	11/05	226	1846	939
CRS 3	28/08	84	22/10	783	508	17/11	1027	690	13/02	1400	752	11/04	226	1846	939
*CRS 4	15/09	349	27/11	814	483	24/0?	1017	546	7/02	1260	634	26/04	223	1678	791
CVT 1	28/08	84	27/10	861	658	21/11	1070	656	14/02	1409	756	08/04	223	1829	937
CVT 2	15/09	349	10/12	828	483	26/01	1030	549	10/03	1366	636	24/04	221	1663	786
DAR 1	24/08	17	06/11	1030	650	24/01	1349	768	27/02	1592	856	24/04	243	1995	1008
*DAR 2	28/08	84	09/11	980	606	17/01	1263	720	27/02	1525	809	26/04	241	1943	966
DAR 3	29/08	96	06/11	951	596	26/01	1283	717	07/02	1541	738	26/04	240	1931	959
*DAR 4	15/09	349	20/12	914	529	05/02	1088	562	10/03	1366	636	29/04	226	1714	812

SAM : Samouraï
CRS : CERES
CVT : Corvette
DAR : Darmor

(1) from 23 august
(2) from Sowing

* : see PALLEAU and TITTONEL (1991)

Tab. 2 : Main stages on the Plateau du Chatillonnais

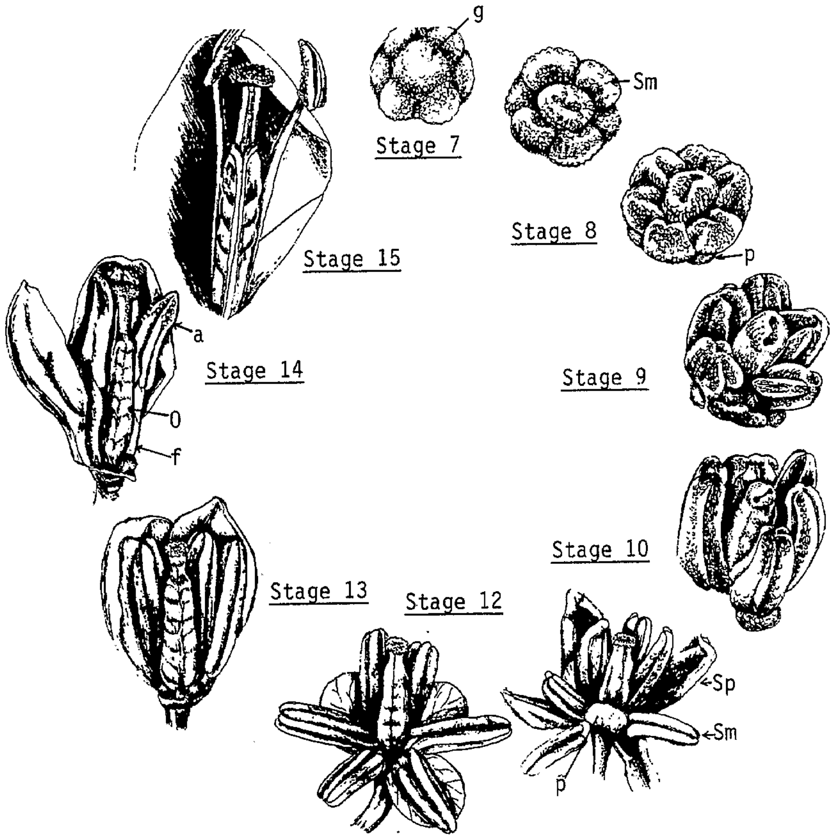


Fig. 1 : Evolution of the flower of oil seed rape.
Cv. Samouraï

a : anther
f : filament
g : gynoecium
n : nectary

0 : ovule
p : petal
Sp : sepal
Sm : stamen

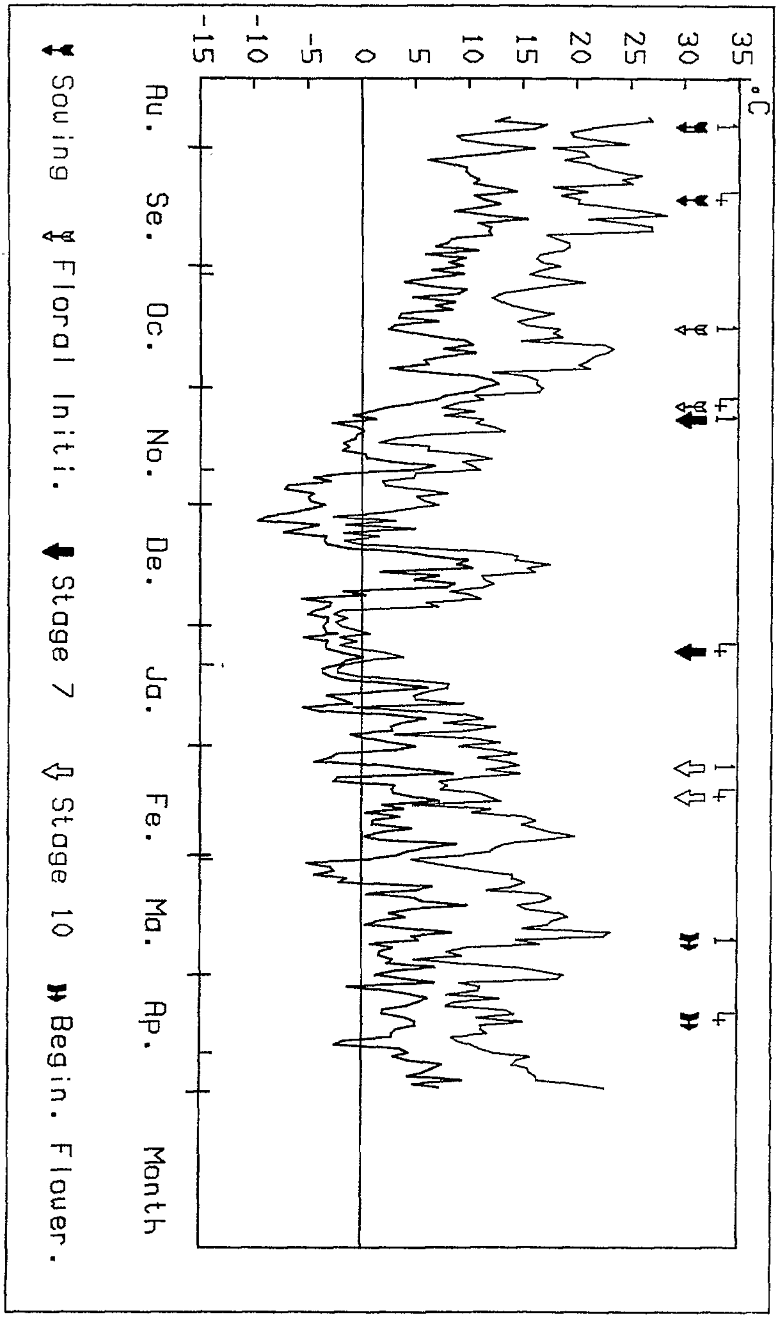


Fig. 2 : minimum and maximum temperatures on the Plaine de Dijon
Main stages for the 1st and the 4th sowing of Samouraï

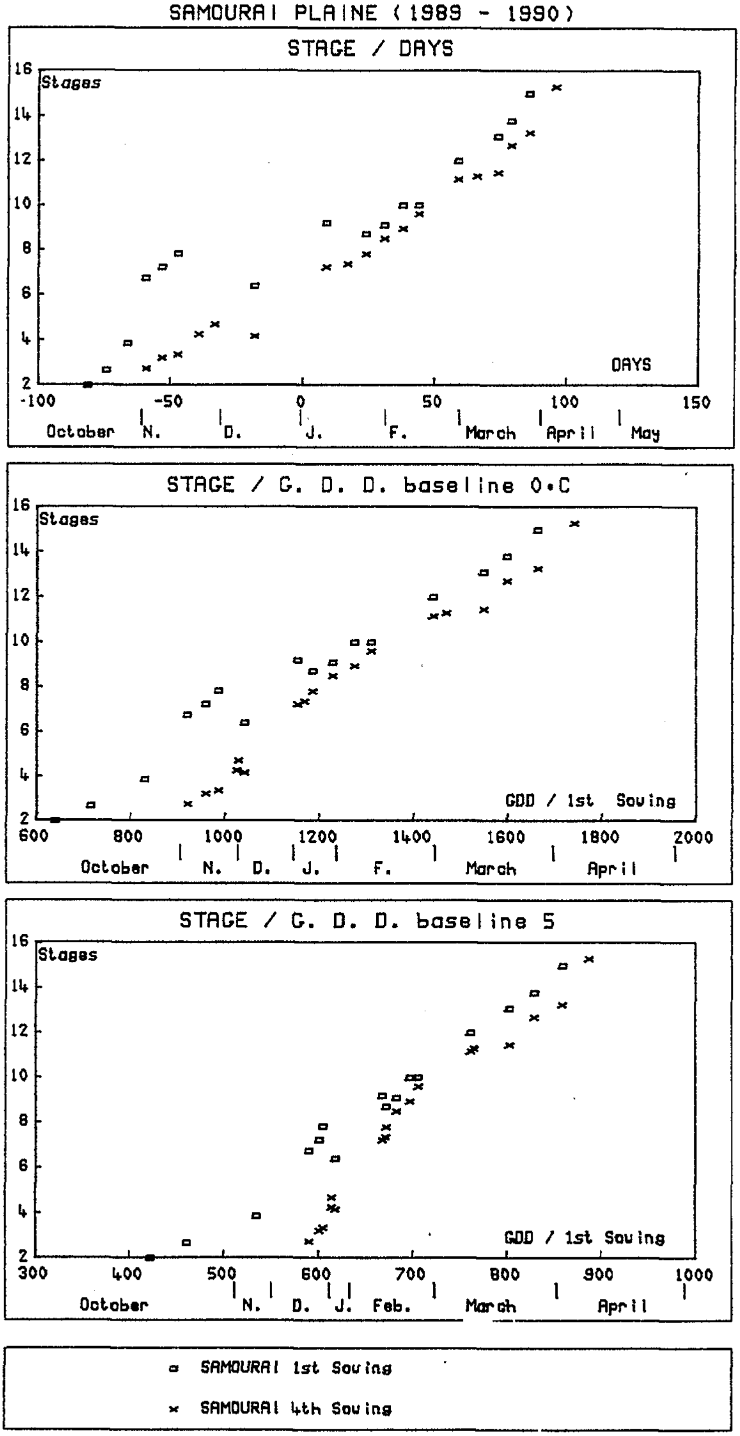


Fig. 3 : Stages of the 1st and the 4th sowing of Samouraï

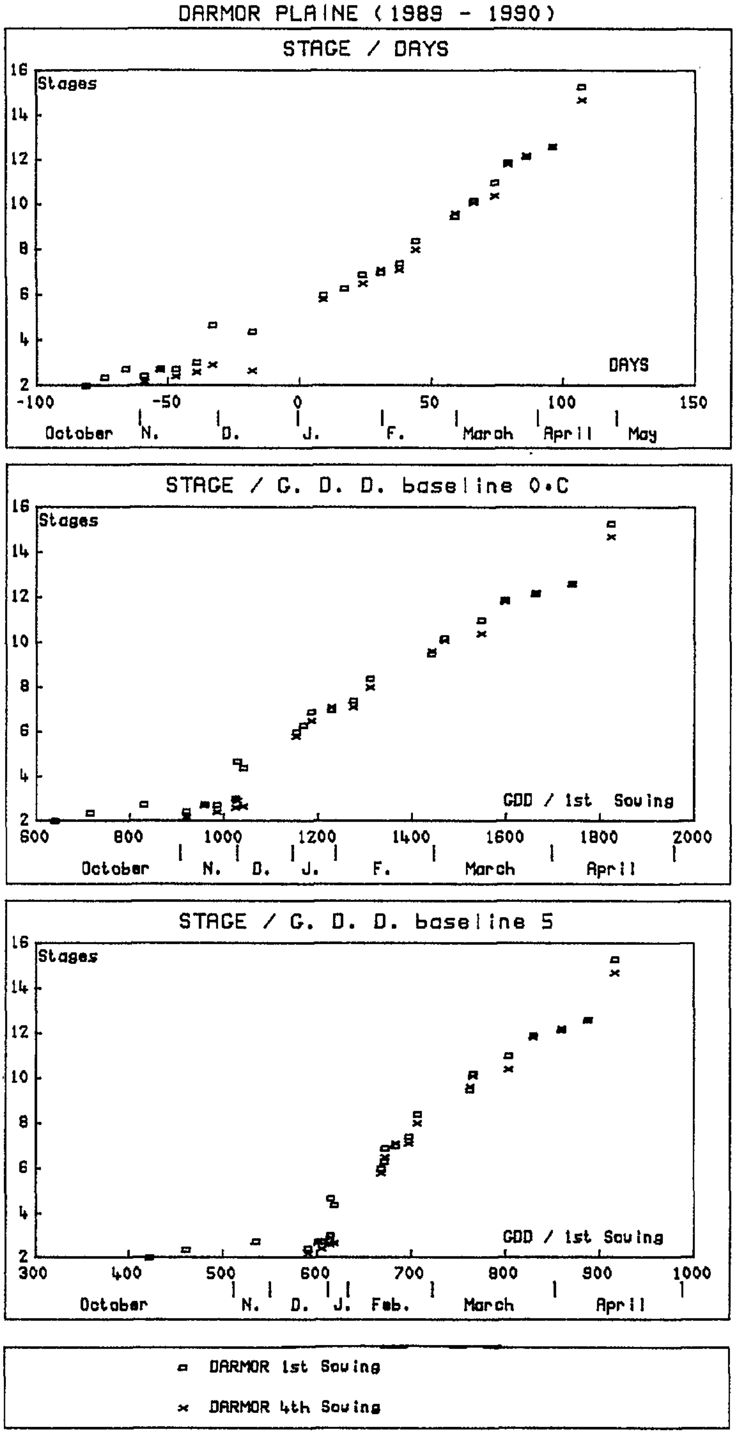
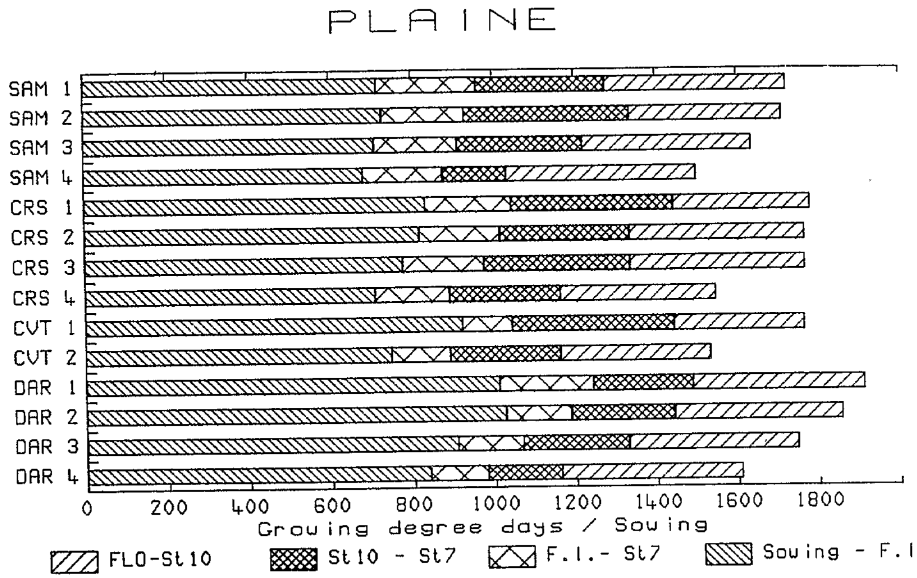


Fig. 4 : Stages of the 1st and the 4th sowing of Darmor



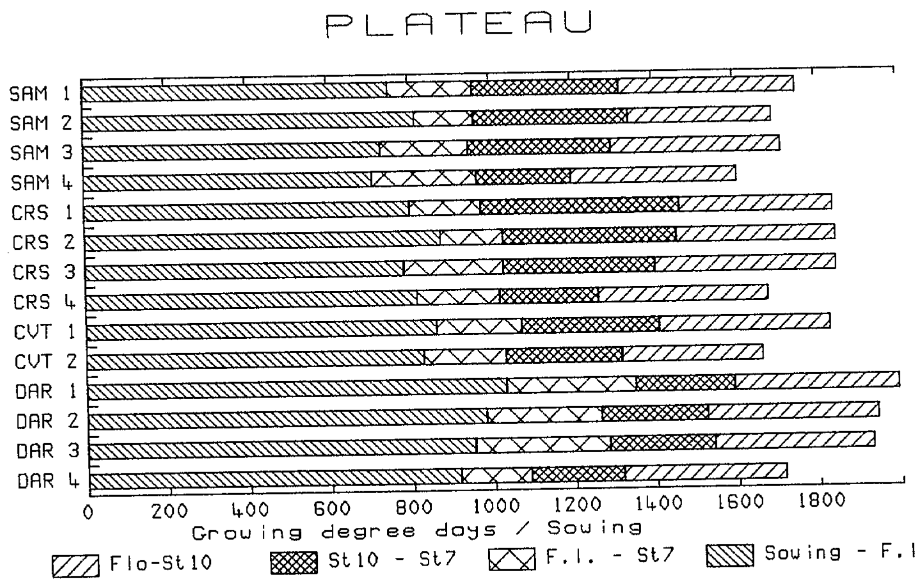


Fig. 5 : Development stages on the Plaine and on the Plateau

SAM : Samouraï
CRS : Cérès
CVT : Corvette
DAR : Darmor