Shortening of the development cycle in winter rape <Brassica napus var. oleifera L.> by grafting nonvernalized scions on generative stock

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Abstract

The conditions were investigated under which the development cycle in winter rape could be markedly reduced by grafting. Scions from nonvernalized seedlings were grafted onto stock plants beginning their generative phase. Winter rape plants vernalized under natural field conditions and spring rape plants in the initial generative phase were used as stock. Best results were obtained by grafting scions from plants at the stage of 4 leaves, i.e. after 3 weeks of growth, onto winter rape stock. With such scions the effectiveness of graftings was high and seed crops were obtained 170 days earlier than under natural field conditions of growth and 80 days earlier than under artificial conditions. Scions grafted onto winter rape stock produced more siliques than those on spring rape. Grafting of scions after cutting off their apical meristems allowed formation of side shoots and consequently resulted in higher yields of siliques; the formation of siliques, however, was delayed by about 10 days as compared to grafts with apical meristems.

INTRODUCTION

A long cycle of growth is a characteristic trait of winter rape. Under Polish climatic conditions the recommended planting date is at the end of August, then flowering occurs at the beginning of May, i.e. after 240 days. In artificial conditions this period can be reduced by applying cold treatment in airconditioned cold chambers. According to Markowski and Ryka (1983a, b) the most effective induction of generative development in typical winter rape occurs in plants exposed to cold treatment in the phase of leaf rosette, i.e. after about two months of growth. The duration of cold treatment should be about 60 days. When vernalized plants are then transferred to conditions favourable for further growth their flowering occurs after four or five weeks. The minimum time of growth from planting to flowering in winter rape is thus about 150 days, if cold treatment is under artificial conditions.

Table 1

Generative development of nonvernalized winter rape scions grafted on vernalized winter rape stock (experiments 1 and 2) and on spring rape stock (experiment 3)

No. of experiment	Age of scions (days)	Number of graftings	Number of successful graftings	Percent of successful graftings	Number of grafts forming generative organs	Percent of grafts forming generative organs	Percent of grafts ending generative development on formation of			Number of days from grafting to formation of			Number of days of scion growth from planting to flowering
							buds	flowers	siliques	buds	flowers	siliques	
1	14	47	30	64	27 (100)	90	4	22	74	44.3	64.6	68.8	78.6
2		45	2	4	2 (100)	100	0	50	50	26.0	48.0	51.0	62.0
3		41	19	46	12 (100)	63	33	42	25	36.0	51.0	65.0	65.0
1	21	45	33	73	29 (100)	88	0	3	97	39.9	58.9	66.0	79.9
2		43	22	51	13 (100)	59	15	8	77	34.8	49.2	59.8	70.2
3		40	30	75	26 (100)	87	27	27	46	37.3	48.3	59.2	69.3
1	28	44	41	93	39 (100)	95	0	0	100	39.2	53.6	59.8	81.6
2		46	25	54	17 (100)	68	0	12	88	32.7	46.7	62.7	74.7
3		42	37	88	31 (100)	84	13	45	42	36.0	45.5	55.8	73.5

1		45	34	76	29 (100)	85				42.9	62.5	72.5	97.5
2	35	43	27	63	23 (100)	85	3	1	96	30.8	42.2	51.7	77.2
3		40	36	90	(29 (100)	81	22	27	61	36.0	46.2	59.0	81.0
							17	42	41				
1		45	38	84	34 (100)	89				42.7	59.9	65.5	101.9
2	42	45	30	67	26 (100)	87	6	12	82	30.0	47.0	59.9	89.0
3		41	39	95	32 (100)	82	8	19	73	36.0	43.8	54.7	85.8
							9	38	53				

The breeding and testing of new forms of rape is limited by the biological barrier preventing the acceleration of plant development even in air-conditioned growth chambers. It was reported earlier by Dubert et al. (1984) that flowering in winter rape plants could be accelerated, if grafts were made on plants already in the phase of generative development. Thus the purpose of the present experiments was to establish to what extent can grafting be used to shorten the growth phases in winter rape. This method of shortening the development cycle of plants, which was applied among other plants in the breeding of soybean (Kühl et al., 1977; Skorupska and Konieczny, 1981), seems to be well suited for experiments with winter plants, in which development must include the time necessary for vernalization.

METHODS

In four experiments scions of different age were taken from nonvernalized winter rape plants cv. 'Górczański' and grafted under natural field conditions into stock already in the generative phase of growth. The dates of grafting were as follows: experiment 1 — April 27, experiment 2 — April 28, experiment 3 — May 13, experiment 4 — May 17.

In experiments 1, 2 and 3 the stock was winter rape cv. 'Górczański' and in experiment 4 spring rape cv. 'Młochowski'. In experiments 1, 3 and 4 the grafting procedure was the same as described earlier by Dubert et al. (1984). Scions were taken from plants grown for 2, 3, 4, 5 and 6 weeks under conditions preventing vernalization, i.e. at night and day temperature of 19°C and 21°C, respectively, a 16-hour day, and relative humidity 60 per cent. In experiment 2 apical meristems and all leaves were removed from six-week-old grafts just before transplanting them onto vernalized stock.

Observations concerned the number of successful grafts, the number of grafts forming generative organs, the number of grafts ending generative development on bud, flower and silique formation, and the time in days from grafting to the formation of buds, flowers and siliques.

RESULTS

The data from experiments 1, 3 and 4 are listed in Table 1. As seen, the average time after grafting necessary for bud formation differed depending on the age of grafts and was 35 to 37 days. The average time from grafting to flowering was 50 to 54 days, and to silique formation 59 to 62 days. The rate of silique formation in grafts on spring plants (experiment 4) was much lower than in grafts on vernalized winter plants (experiments 1 and 3). A large proportion of grafts on spring stock ended generative development at flowering or even at bud formation. The number of days from planting to bud formation including the age

of scions at grafting time was recorded. The data presented in Table 2 show that maximal acceleration of generative development in winter rape is obtained with the youngest scions, e.g. scions taken from plants only two weeks old. But such plants are still very small (only developing the third leaf) which makes grafting technically very difficult. These difficulties are indicated by the very low proportion — only up to 40 per cent — of successful grafts in the youngest scion-age series, while in the next series, i.e. scions from plants three weeks old with four developed leaves, the proportion of successful grafts was more than 66 per cent. The best results — as much as 82 per cent of successful grafts — were obtained with scions from plants six weeks old and with seven developed leaves. Hence, it may be assumed that, in order to shorten most effectively the development cycle in winter rape, the best procedure will be to take grafts from plants in the phase of four leaves, i.e. after about three weeks of growth. This quarantees a high proportion of successful grafts and reduces the growth cycle of winter rape by about 170 days as compared with natural conditions and by nearly 80 days as compared with the most favourable artificial conditions (Markowski and Ryka, 1983a) of cold treatment and growth.

Table 2
Influence of the age of scions at grafting
on the time from planting to bud formation

Age of scions at grafting weeks	Time from planting to bud formation days
2	68.6
3	73.1
4	76.6
5	85.3
6	92.2

The results from experiment 2 are listed in Table 3. Grafting of scions, from which apical meristems and all leaves were removed, resulted in the same rate of generative development as in the case of the grafting procedures in experiments 1, 3 and 4. Admittedly, scions three weeks older than the recommended scion age were used in this experiment, but observations indicate that the difference need not be so wide and that the method can be applied with scions of only four weeks. The time necessary for flowering of grafts would then be only about ten days longer than in the case of grafting of scions with apical meristems and leaves, but every successful graft develops on the average two generative shoots. Moreover, grafting of scions without apical meristems and leaves proved simpler and the proportion of successful grafts was about 84 per cent.

Table 3

Generative development of nonvernalized winter rape scions grafted on vernalized stock. Scions with apical meristems and all leaves cut off

Age of scions (days)	42
Number of graftings	38 (100%)
Number of successful graftings	32 (84%)
Number of grafts forming generative organs	32
Number of generative shoots	67
Number of generative shoots per graft	2.1
Percent of shoots in generative phase of	
flowers	93
siliques	69
Number of days from grafting to formation of	
buds	36.5
flowers	49.6
siliques	55.2

DISCUSSION AND CONCLUSIONS

An earlier investigation (Dubert et al., 1984) and the present experiments indicate that grafting of nonvernalized winter rape plants into stock capable of generative development results in an effective transfer of the flowering factor from stock to grafts. This allows to limit considerably the time necessary to obtain the next generation of plants. The development cycle from planting to the beginning of flowering is then shortened by about 170 days as compared with normal growth under field conditions and by about 80 days as compared with the optimum artificial conditions of cold treatment and growth.

The method seems to be useful in experiments with breeding rape varieties: it allows to obtain as many as three generations of plants during a single year provided that "donors" of the flowering factor, i.e. rape plants beginning their generative development, are available. The difficulty lies thus in providing a sufficient number of "donor" plants, which have to be exposed to cold treatment in light. This could be circumvented, if spring rape plants were used as stock, but then a much lower rate of silique formation becomes an important consideration. In this connection worth mentioning are Chaïlakhyan's (1955) experiments with the transfer of the flowering factor in rape, in which he grafted nonvernalized winter rape scions into spring rape scions.

Nevertheless, the use of vernalized, winter rape plants as stock is more effective from the point of view of the rate of silique and seed formation.

If a high seed crop is the major consideration, then the most useful method seems to be to graft scions deprived of apical meristems and leaves, even if this retards somewhat plant development. The advantage of this procedure consists in the formation of numerous generative shoots, owing to the stimulation of

development of the meristems which allow the growth of side shoots after suppression of apical dominance.

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SKRACANIE CYKLU ROZWOJOWEGO RZEPAKU OZIMEGO <BRASSICA NAPUS VAR. OLEIFERA L.> PRZEZ SZCZEPIENIE NIEWERNALIZOWANYCH ZRAZÓW NA GENERATYWNYCH PODKŁADKACH

Streszczenie

Określono warunki umożliwiające znaczne skracanie cyklu rozwojowego rzepaku ozimego metodą szczepień. Zrazy pobrane z niewernalizowanych siewek szczepiono na podkładkach będących w początkowej fazie rozwoju generatywnego. Podkładkami były rośliny rzepaku ozimego zwernalizowane w warunkach naturalnych (w polu) oraz rośliny rzepaku jarego będące w początkowej fazie rozwoju generatywnego. Najlepsze wyniki uzyskano szczepiąc zrazy będące w fazie rozwoju 4 liści tj. po 3 tygodniach wegetacji, na podkładkach rzepaku ozimego. Użycie takich zrazów zapewniało najlepszą efektywność szczepień i pozwoliło uzyskać plon nasion o 170 dni wcześniej w porównaniu z uprawą rzepaku ozimego w warunkach naturalnych i o 80 dni wcześniej w porównaniu z uprawą w warunkach sztucznych. Zrazy szczepione na podkładkach rzepaku ozimego zawiązywały więcej łuszczyń niż zrazy szczepione na podkładkach rzepaku jarego. Szczepienie zrazów pozbawionych merystemów wierzchołkowych umożliwiało rozwój pędów bocznych, co w efekcie prowadziło do zwiększonego wytwarzania łuszczyń. Termin wytwarzania łuszczyń ulegał jednak opóźnieniu o około 10 dni w porównaniu ze zrazami posiadającymi merystemy wierzchołkowe.