Indian J. Plant Physiol., Vol. 1, No. 2, pp.88-92 (April- June, 1996)

EFFECT OF FLOWERING TIME ON RATE OF DRY MATTER ACCUMULATION, DURATION OF FILLING PERIOD AND TOTAL OIL CONTENT IN *BRASSICA* SEEDS

NANDA, R.., BHARGAVA, S.C. AND MAMTA GAUTAM*

Division of Plant Physiology, Indian Agricultural Research Institute, New Delhi-110012

Received on 25 Aug. 1995, Revised on 20 Oct. 1995

SUMMARY

Development of seeds/siliqua originating from early and late flowers on main raceme was studied in two Brassica speceis sown on different dates in field for two seasons. The rate of dry matter accumulation in both seasons and through all sowings remained higher in late formed pods. This higher rate is due to higher temperature and longer photoperiod that existed during their development. Since seeds from late formed pods appeared at a faster rate, so had lesser degree days. The mean degree days were 728 and 851°Cd for late and early formed pods respectively. Linear regression showed a positive correlation between duration for seed filling period and degree days. The development span decrease by one day for decrease of every 11 and 8° Cd in early and late siliqua respectively. Duration of filling period from flower opening to maximum seed weight was more in early than late formed pods. This period was longer for early sown crops. Mean maximum dry weight of seeds through all planting dates and cultivars were 61.0 and 56.5 mg/siliqua for early and late formed pods respectively. Seeds in upper positioned pods on the main raceme had invariably low per cent oil content than lower positioned pods.

INTRODUCTION

In olieferous crop Brassica, studies on pod and seed development have been largely restricted to the measurement of dry matter and oil accumulation (Norton and Harris, 1975). The vegetative growth in this crop is determinate while the reproductive phase is indererminate. Pods originating from early flowers begin filling earlier than pods originating from late flowers; the duration of vegetative phase and the time of season at which seed development commenced were both found to be important determinats of seed yield (Thurling and Das, 1980) Therefore, for optimum yield in oil yielding *Brassica*, flowering should be at a time which enables seed development to be completed before the onset of unfavourable conditions, like high temperature, without significantly reducing the vegetative growth. However, there is little information available for rapeseed and mustard cultivars on how different components of the pod such as its weight, seed weight rate and duration of seed development and seed oil content change according to their position on the terminal raceme under different environments, an experiment was conducted to study the effect of sowing dates on grain filling duration and oil content of seeds in early and late formed pods.

MATERIALS AND METHODS

Seeds of cv. 'Varuna' Indian mustard (*Brassica juncea* (L) (Czernj and Cosson) and cv. 'Pusa Kalyani' brown sarson (*B. campestris*) were sown sequentially on 29 October, 8, 18 and 28 November and 9 Decmember

* Division of Biochamistary Indian Agricultural Research Institute New Delhi-110012

and on 16 October, 3,24 November and 8 December in 1992 and 1993, respectively. Plot size was 4mx7m. All plots received 87 Kg/ha urea, 250kg/h. single super phosphate and 66 kg/ha muriate of potash i.e. P, K @ 40,40 Kg/ha. Seeds were sown in rows 45 cm apart and thinned to 15 plants/m^2 two weeks after germination maintaining plant to plant spacing of 15 cm. Irrigation was given as and when necesssary.

During the 1st week of flowering, 250 flowers were tagged in each cultivar (early tagging) and most of these flowers were on the lower part of the main raceme. After 10-12 days, more flowers were tagged (late tagging). These flowers were largely on the upper portion of the main raceme. 4 days after tagging,10 pods were collected from each of the 3 replicates and sampling continued there after on alternate days till maturity. Samples were dried to constant weight at 80°C and then seeds were weighed, seed oil content was determined by the cold percolation technique (Kartha and Sethi, 1957).

The two species flowered in 45-58 and 50-55 days respectively after sowing under normal date of sowing (Table I). Record of daily maximum and minimum temperature were obtained from the Indian Agricultural Research Institute Meteorological Station, New Delhi located less than 100 m away from the experimental site. Degree days with units of °Cd were calculated by accumulating the mean of these maximum and minimum temperature. Growing degree days (GDD) were calculated by using the formula:

$$GDD = \Sigma \frac{Sn}{S_1} (Tm-b_o)$$

Where Tm is mean daily temperature, S_1 and Sn are growth stages of siliquae and seed/siliqua, b_0 is the base line temperature as calculated by Morrison *et al* 1989 for summer rape development. These degree days were accumulated for each sowing and cultivar.

Least square regression (Y=a+bx) was used to calculate the rate of dry matter accumulation in seeds/ siliqua (b values)/day as well as total duration from onset of podding to its maximum weight from early and late flowering pods of each species and sowing dates.

RESULTS AND DISCUSSION

Time of flowering (or pod position on the raceme) had a marked and consistent effect on the rate and duration of dry matter accumulation in *Brassica* seed.

The rate of dry matter accumulation in both seasons and through all sowing dates remained higher in late than those of early formed pods. It rangerd from 0.85-1.53 and from 0.65-1.44 mg/siliqua in late and early formed seeds respectively in *Brassica campestris* (mean 1.32 and 1.19). Similarly it ranged from 1.00 to 1.49 and 0.77 to 1.33 mg/ siliqua/day in late and early developed siliqua respectively in *B. Juncea* (mean 1.14 and 1.28). Between the two cultivars, it remained higher in Pusa kalyani. In both the seasons. the growth rate of seeds in the basal pods was significantly lower (10%) than that of seeds in the apical position. Fig. 1 (a and b) shows that higher rate of seed development in late formed pods through all sowings due to higher temperature and longer photoperiod that existed during later part of floral axis development.

Table I. Days to 50% flowering after emergence in two *Brassica* species under different sowing dates

Date of Sowing	*B. campestris* Cv. Pusa Kalyani	*B. juncea* Cv. Varuna
1992		
Oct.29	48	55
Nov.08	47	56
Nov.18	47	55
Nov.28	45	53
Dec.09	43	42
1993		
Oct.16	49	59
Nov.03	48	57
Nov.24	45	54
Dec.08	42	50

Late pods appeared at a faster rate and so had less degree days than the early one. The mean degree days were 728 and 851 °Cd for late and early pods respectively. Table II indicates that it is the late sowings that shows the greatest reduction in degree days. Fig. 2 indicated that linear regression between durtion for seed filling period and degree days are positively correlated in pods located

Fig. 1(a)

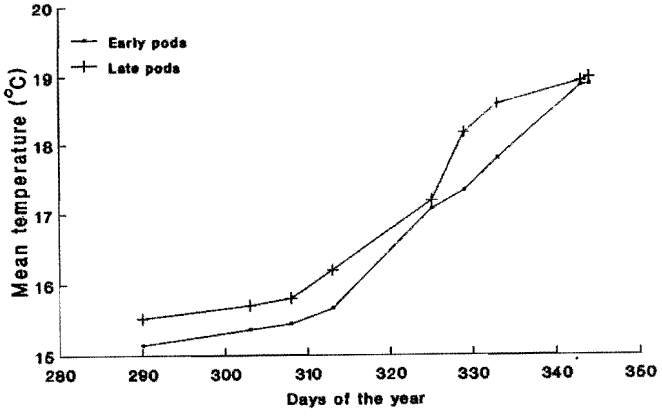

Fig. 2(a)

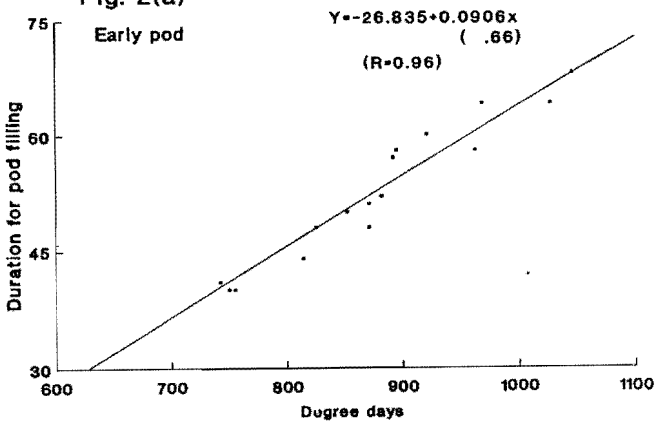

Fig. 1(b)

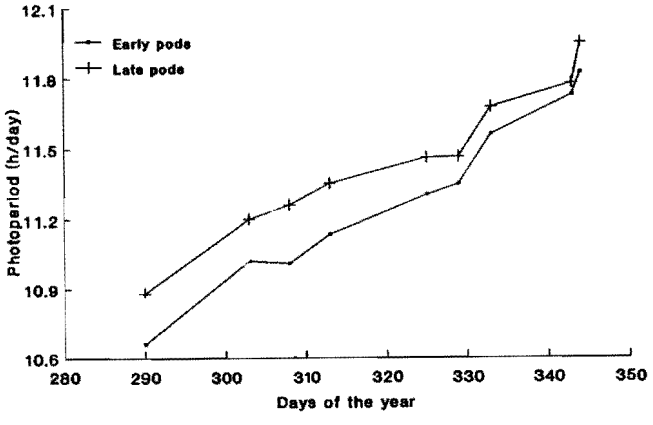

Fig. 2(b)

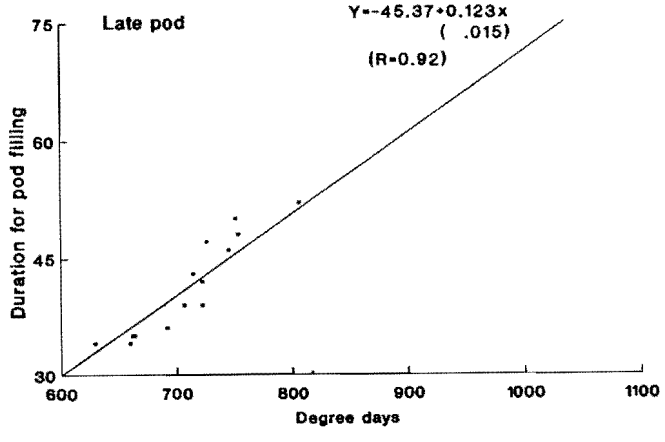

Fig.1 Effect of mean temperature and photoperiod on rate of seed development in early and late formed pods of two *Brassica* species.

Fig.2 Relationship between the duration of pod filling period and degree days (°Cd) in early and late fromed pods of two *Brassica species.*

at both the position. Developmental span decreases by one day for decreases of every 11 and 8°Cd in early and late seed/sliqua respectively.

Duration of filling period from flower opening to maximum seed weight was 34 to 54 and 40 to 68 days for late and early seeds/siliqua respectively. Since the early formed pods develop comparatively at low temperature than late pods, therefore they took longer duration for completion of seed filling. This period was longer in early sown crops in both the species, Varuna took longer period at both the positions. The shorter developmental span for late pods could be due to rise in environmental temperature and photoperiod (Fig.1).

Nanda *et al.*, (1994) have reported in four *Brassica species* sown on different dates that duration of actual filling period was 39-79 and that of effective filling period was 30-68 day in siliquae and 24-56 days in seeds/ siliqua (The effective filling period was obtained by dividing the rate of dry matter accumulation i.e. b value to the final dry weight).

Gbikapi and Crookston (1981) reported that later developing seeds in pods on upper nodes had significantly faster rate of dry matter accumulation and short effective filling period than the seeds in early developing lower pods in soybean.

Mean maximum dry weight of seeds through all sowing dates and cultivars were 61.0 and 56.5 mg/siliqua for early and late formed pods respectively. It ranged

from 26.3 to 92.0 (mean 62.0) and 28.8-76.4 (mean 56.5) for early and late pods respectively in *B. campestris*. Similarly it varied from 31.6 to 73.7 (mean 59.1) and 34.2 to 67.9 (mean 54.5) mg/siliqua in *B. juncea*.

The siliqua located in position 5-27 from base were healthier and longer in comparison with 29-49. There was a 66% decrease in dry weight and seed weight per siliqua for position 27 to 49 siliqua (Munshi and Kumari, 1994). They indicated that higher temperature, longer photoperiod and sunny days for position 35 and above were not favourable to the siliqua and seed development. Kumari (1992) indicated that the enhanced sink capacity of seeds in position 5-27 also reduced the availability of metabolities to the growth and development of seeds in position 35 and above.

The negative relationship between pod position, pod weight and seed weight/ pod in yellow sarson and mustard cultivars have been shown by Chauhan and Bhargava, (1986). Relatively poor development of pods on more apically positioned nodes appeared to be mainly due to

Table II. Effect of time of *Brassica* pod set on rate of seed dry matter accumulation (b-values), duration of seed growth, seed size, heat unit and total oil content for crops sown on different dates during two seasons.

Date of Sowing	b-values of seed/pod (mg/pod/day)		Duration for seed filling of		Maximum dry weight (mg) seeds/pod		heat units (Degree days)		Per cent oil content of seeds from	
	Early pods	Late pods	Early pods	Late pods	Early pods	Late pods	Early pods	Late pods	Early pods	Late pods
					B. campestris cv. Pusa kalyani					
1992										
Oct 29	1.120	1.439	60	48	67.2	69.1	921	753	38	35
Nov.08	1.262	1.323	57	46	71.9	60.8	892	745	38	35
Nov.18	1.222	1.293	51	42	62.3	54.3	871	722	39	35
Nov.28	1.312	1.475	44	36	57.7	53.1	764	670	39	35
Dec.09	0.652	0.846	41	34	26.3	28.8	742	629	39	34
1993										
Oct.16	1.438	1.529	64	50	92.0	76.4	969	751	39	34
Nov. 03	1.376	1.515	58	47	79.6	71.2	895	726	41	35
Nov. 24	1.223	1.318	47	41	57.5	54.0	871	722	40	36
Dec. 08	1.088	1.161	40	35	43.3	40.6	755	663	40	34
Mean	1.188	1.322	51.3	42.1	62.0	56.5	851	728	39	35
CV	19.5	16.3	17.1	14.3	31.2	26.8	9.4	9.5	2.5	1.9
					B. juncea cv. Varuna					
Oct. 29	1.152	1.305	64	52	73.7	67.9	1027	806	41	36
Nov. 08	1.328	1.488	52	44	69.5	65.5	882	714	42	36
Nov. 18	1.177	1.328	50	42	58.8	55.8	852	722	42	34
Nov. 28	1.186	1.237	44	36	52.2	44.7	814	691	42	35
Dec. 09	0.771	1.007	41	34	31.6	34.2	716	659	42	35
1993										
Oct. 16	1.o49	1.249	68	54	71.3	67.4	1046	873	40	35
Nov.03	1.256	1.494	58	47	72.8	65.5	963	726	41	35
Nov. 24	1.154	1.178	48	42	55.4	49.5	825	706	42	35
Dec. 08	1.178	1.272	40	35	43,5	44.5	750	659	44	36
Mean	1.14	1.28	51.6	42.9	59.1	54.9	875	707	41	35
CV	14.7	11.7	19.2	16.8	24.1	22.5	13.2	6.2	2.7	1.5

diminishing assimilate supply. It has been found that depodding of 15 basally positioned pods in *B. napus* cv. Zollergold on the terminal raceme resulted in more pods developing in apical regions on raceme. These pods were heavier, had larger seeds and sometimes more seeds (Tayo and Morgan, 1979).

Although seeds in the late pods started their increase in dry weight approximately 9-10 days later than in early flowered pods but seed in the late formed pods reached physiological maturity from 1-4 days later than the seed in the early pods. Thus, there was a greater delay between early and late pods in the initiation of seed growth than those of reaching physiological maturity.

Time of flowering (or pod position on raceme) had a significant effect on percent oil content. Late developing seeds on upper nodes always had lower per cent oil content than the early developing seeds on lower pods. (Table II). The differences were significant in all sowing dates in both seasons. It varied from 34-36 and 38-44 per cent in late and early flowered pods respectively. Thus in early developed seeds it was 13% more than late formed seeds. It has been demonstrated that total maximum oil content in four species of *Brassica* varied from 40-45 per cent (Neeta and Bhargava., 1983). The present result are in confirmity with their findings.

The siliqua in position 5-27 on the mustard (*Brassica juncea* L.) inflorscence has higher oil content per seed than those in position 29-49 at maturity. The per cent oil content did not change in different sowing dates. It has been reported by Agrawal (1971) that optimal photoperiod caused a perferential utilization of carbon skeleton for fat synthesis over the low and high photoperiod regime.

Present data suggest that oil filling, total dry weight of seeds/siliqua were significantly higher in early pods. The lower values of the seeds in the late formed pods result from unfavourable environmental conditions that limit the availiability of metabolites. A meaningful strategy is required to enhance the sink capacity of seeds in the late formed pods of *Brassica* inflorescence.

REFERENCES

Agrawal. P.K. (1971). Effect of photoperiod on oil content, falty acid composition and protein content of rape (*Brassica napus* L.) and flax (*Linum usitatissimum* L.) seeds. *Ind. J. Exp. Biol.*, **2**: 252-254.

Chauhan, Y.S. and Bhargava, S.C. (1986). Composition of pods of the terminal raceme of rapeseed (*Brassica campestris* var. Yellow sarson) and mustard (*Brassica juncea*) cultivers. *J. Agric. Sci., Camp.*, **107**, 469-473.

Gbikapi, P.J., Crookston, R.K. (1981). Effect of flowering date on accumulation of dry matter and protein in soybean seeds. *Crop Science.*, **21**,1981.

Kartha, A.R.S. and Sethi, A.S. (1957). A cold percolation method for rapid gravimatric estimation of oil in small quantities of oilseeds. *Indian J. Agric. Sci.*, **27**: 211-218.

Kumari A. (1992). Synthesis of lipids in mustard seed as influenced by siliqua position on the inflorescence axis. M. Sc. thesis. PAU, Ludhiana, India.

Morrison, M.J.; Mc Vetty, P.B.E. and Shaykewich, C.F. (1989). The determination and verification of a base line temperature for the growth of western summer rape. *Can. J. Plant. Sci.*, **69**: 455-464.

Munshi, S.K.; Kumari, A. (1994). Physical characteristics of siliqua and lipid composition seeds located at different positions in mature mustard inflorescence. *J. Sci. Food Agric.*, **64**, 289-293.

Nanda R. and Bhragava S.C. and Tomar, D.P.S (1994). Rate and duration of siliqua and seed filling period and the relation to seed yield in Brassica species. *Ind. J. Agric. Sci.*, **64**: 227-32.

Neeta, S. and Bhargava. S.C. (1988). Pod growth and development of *Brassica species*. Dry matter accumulation in the pod wall and seeds. *Plant. Physiol. Biochem*, **15**: 123-129,

Norton, G. and Harris J.F. (1975). Compositionl changes in developing rapeseed (*Brassica napus* L.), *Planta.*, **123**: 163-174.

Tayo, T.O. and Morgan, D.G. (1979). Factors influencing flower and pod development in oil-seed rape (*Brassica napus* L.). *J. Agr. Sci., Camb.*, 363-373.

Thurling, N and Das, LDV. (1980). The Relationship between pre-anthesis development and seed yield of spring rape (*Brassica napus*). *Aust. J. Agric. Res.*, **31**: 25-36.