PHOTOPERIODIC EFFECT ON SESAMUM IN RELATION TO THE VARIATIONS OF THE ENVIRONMENTAL FACTORS OF THE DIFFERENT SEASONS.

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INTRODUCTION.

Sesamum is one of the most ancient crops in India which can be traced in the Vedic literature, supposed to have been written between 1500 and 800 B.C. (Majumdar, 1946). Its importance is mainly for the oil contained in its seeds, commercially known as gingelly oil or til-oil. The varieties of Indian Sesamum have been studied in detail by Kashi Ram (1930). Twenty-nine types have been described and these are classified as early, medium and late, based on the length of their vegetative periods. The seed colour varies from white, black, grey to dark-brown. The oil content varies from 37–51%. The black variety is largely grown in India as a heavy yielder. Sesamum is grown all over India as a pure crop and in certain areas, such as in the United Provinces and in Bengal, as a mixed crop. Winter varieties are generally sown in September-October and harvested in January-February while summer varieties are sown in June-July and harvested in October-November.

Sesamum flowers earlier when exposed to shorter days. Rhind (1935) exposed late maturing Burmese Sesamum to short days in July, covering the 25 days' old plants in the field with large earthenware pots for 4 hrs. per day for 10 days, which induced early flowering, but later the plants reverted to vegetative growth. In a second experiment with Boktaung variety in which the plants were darkened for total periods of 10–70 hrs. in a similar way, those darkened for 50–70 hrs. produced flowers and fruits. When pot plants were exposed to long photoperiods, i.e. for 2, 4, or 6 hrs. more than normal day length, plants of the Boktaung variety remained vegetative, while about half the plants of the Thadunbyu variety flowered irregularly.

Adams (1925) showed that the vegetative period and the nature of response to the same photoperiod in different seasons of the year vary a great deal. The length of the day as also the other environmental factors, viz., temperature, rainfall, and humidity, vary considerably during the year. It is difficult to determine the effect of the environmental factors separately under natural conditions due to their simultaneous variation and to the carry-over effects which continue to be manifested under changed environments. Temperature is undoubtedly the most important environmental factor in relation to the action of light period on plant growth and it can either substitute or nullify its effects. Gilbert (1926), working with xanthium, found that temperature and photoperiod jointly influenced the time of flowering. Chroboczek (1934), working with beet, showed that photoperiodic requirement for floral initiation was completely changed with temperature. There are also records that day lengths independent of temperature will control the type of growth in winter wheat and that heading can be controlled irrespective of the season (Wanser, 1922). Sen Gupta and Sen (1946) observed that under short day conditions jute flowered in about 30 days irrespective of the season, though the growth was influenced by the seasonal changes.

Apart from its effect on photosynthesis, photoperiod influences the course of growth and development of plants in two ways: (1) by its direct effect on growth, and (2) by accelerating the onset of the reproductive phase, thus reducing the vegetative period. Tincker (1928) observed with a large number of plants that those exposed to the action of light for the longest period gave the greatest dry weight and average height. Singh, Kapoor and Chowdhury (1941), by exposing *Triticum vulgare, Linum usitatissimum* and *Crotalaria Juncea* to different photoperiods ranging from 2–24 hrs. per day with light intensity near plants at 80,000 m.c., which is above the limiting value of photosynthesis, found that the magnitude of growth rate is directly proportional to the increase of photoperiods. The sigmoid form is maintained and the growth rate curves are characterized by a maximum at the approach of flowering and seeding. Bonner (1940) observed that vegetative growth as measured by shoot elongation, leaf size, accumulation of dry matter and root growth is generally greater in long days than in short ones irrespective of reproductive behaviour of plants.

The present investigation was undertaken with a view to find out the effect of varying environmental factors during different seasons on the photoperiodic effect in Sesamum.

Experimental Procedure.

Experiments were conducted with two varieties of Sesamum, I.P. 7 and I.P. 29, in the experimental garden of Presidency College, Calcutta. I.P. 7 is an early maturing variety with white seeds, while I.P. 29 is a late maturing variety with black seeds.

The seeds were selected for uniformity of size and colour by sight alone and sown in earthenware pots (12″×12″) containing soil manured with well-rotted cow-dung. Seeds were sown in four spaces in each pot and as the seedlings emerged, they were gradually thinned out leaving only four plants of uniform size, equidistant from each other as far as possible. There were five pots for each treatment. The pots were watered regularly in the afternoon. Whenever a pest appeared a soap-nicotine solution was sprayed twice a week. Both the varieties were sown in the different seasons in the year 1945 at the interval of 3 months; there being four sowings; 1st January (winter); 1st April (summer); 4th July (monsoon), and 1st October (autumn). In each sowing there were three treatments; the control, the short and the long photoperiods. The control set was left to grow in natural conditions with the usual variations in the four sowings. The plants of the short photoperiodic set were removed to a specially constructed dark chamber sometime before sunset after exposing them for 10 hrs. from sunrise, and then brought back to the field after sunset. The plants of the long photoperiodic sets were taken to light room just before sunset and were exposed to light from a 200 c.p. electric lamp, placed at a distance of about 1·5 metres till they received 14 hours photoperiod from sunrise (Natural + Artificial), and then brought back to the field. Treatment was begun immediately after germination and the time of exposure for the definite photoperiods were adjusted twice a month nearest to minute.

As the plants developed, the following measurements were taken once in a fortnight:—

(1) *Height of stem.*—Height was measured with a millimetre scale from the base to the stem tip.

(2) *Total number of nodes.*—Nodes were counted including the node of the cotyledonary leaves. During counting, nodes with two leaves and nodes with one leaf were separately recorded. Slight separation of the two successive leaves has been included in the nodes with one leaf.

(3) *Number of branches.*—The number of primary branches more than 4 cms. in length was taken as the number of branches.

As the plants matured and flower-buds began to appear the following changes were recorded separately for each plants:—

(4) The time of initiation of the first flower-bud was taken as the *time of budding.*

(5) The time of opening of the first flower was taken as the *time of flowering.*

(6) The time of formation of the first fruit was taken as the *time of fruiting.*

All results have been expressed as the mean of the total number of plants in each treatment which was generally twenty, but in some cases, less, as a few plants did not develop well or died. The measurements were continued till the fruit formation in all the plants of a treatment. Growth, however, continued slowly for some time after this.

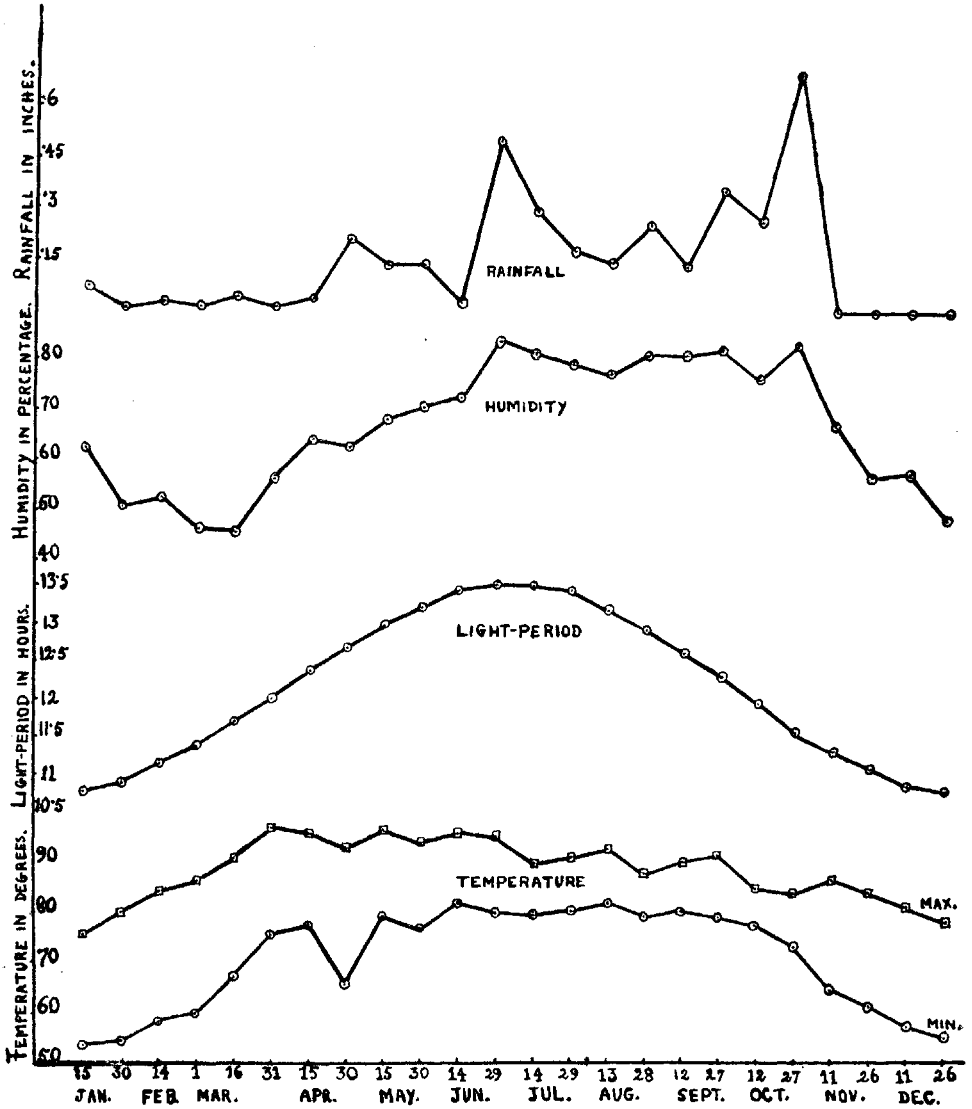

FIG. 1. Meteorological Data for 1945: showing fortnightly means of rainfall, humidity, lightperiod and maximum and minimum temperature.

To understand the nature of variation of the environmental factors for the different treatments, daily records of maximum and minimum temperature, relative humidity and rainfall were taken from the India Meteorological Department, Alipore, and light periods were adjusted from the Nautical Almanac of the current year. The fortnightly averages of meteorological records are graphically represented in Fig. 1.

It is seen that there was considerable variation in all the environmental factors in different seasons. The daily light period increased from 10 hrs. 47 min. in January to 13 hrs. 30 min. by the end of June and then gradually decreased to the original level by the end of December. The minimum temperature was lowest in December and January being about 53° F. which increased to about 80° F. in May and varied around that level till to the end of September. The maximum temperature followed almost the same course being about 75° F. in December and January reaching the highest level of about 97° F. earlier in May and then decreasing to about 90° F. in July. This level was maintained till September after which the maximum temperature decreased. There was practically no rainfall from November to March, the first noteworthy shower being 0·22 inches towards the end of April and then 0·5 inches by the end of June, the first half of June being practically dry. During July to first half of October, the rainfall varied between 0·14–0·35 inches while the heaviest shower of 0·74 inches occurred by the second-half of October. Relative humidity roughly followed the course of rainfall, the lowest level reached being 46% in February–March and highest of 84% in June and October.

Experimental Results.

The variation of the climatic factors in the different seasons of the year considerably influenced the course of growth and development of both varieties of Sesamum. In all the sowings I.P. 7 had a comparatively shorter vegetative period than that of I.P. 29. Environmental factors also influenced the effect of photoperiod in both the varieties and in some cases even masked it to a certain extent. Insect pests caused considerable damage at the onset of monsoon. I.P. 7, the early variety, was more susceptible and the monsoon crop of this variety was completely destroyed.

Initiation of buds, flowers and fruits.—The time of initiation of flower buds, flowers and fruits in the different sowings of all the sets receiving long, normal and short photoperiods for I.P. 29 are given in Table IA, for I.P. 7 in Table IB, and these are graphically represented in Fig. 2. In the control sets of I.P. 29 the time taken for the initiation of flower buds was 30·6 days in autumn, 39·1 days in summer, 53·6 days in winter and 66·2 days during the monsoon season. The time required from budding to flowering varied greatly with the season being 9·7 days in winter and 53·8 days in summer. But once the flower buds opened the period to set the first visible fruit was very slightly affected being 2·8 days in winter and 5·9 days in monsoon and 3·1 days in summer and autumn. Exposure to short days induced early flowering, the vegetative period being about 25 days in all the sowings except in that of winter, consequently the difference in earliness due to short photoperiodic treatment was mainly due to the variation in the vegetative period of the controls and the effect was most prominent in the monsoon sowing being 41·2 days and least in autumn being 7·2 days. The reproductive phase was delayed when the plants were exposed to long photoperiod, the length of vegetative period was more influenced by season being 108·5 days in summer, 90·5 days in monsoon, 59·6 days in winter and 44·7 days in autumn. The lateness from control was least in winter being six days and greatest in summer being 69·4 days. If the vegetative periods of plants exposed to 10 hrs. and 14 hrs. in different seasons are compared it is seen that the difference was least in winter being 6·0 days and greatest in summer

TABLE IA.—(*Time of Budding, flowering and fruiting I.P. 29*).

Time in days after sowing.

Time of flowering.	Treatment.	Initiation of flower buds.	Variation from control.	Opening of flowers.	Variation from control.	Time taken after budding till flowering.	Time taken for initiation of fruits.	Variation from control.	Time taken from flowering to fruiting.
WINTER (January, 1945) ..	Long light (14 hrs.)	59·6	+6	81·2	+17·9	21·6	89·0	+22·9	7·8
	Control 10·47 hrs. to 11·59 hrs.	53·6	..	63·3	..	9·7	66·1	..	2·8
	Short light (10 hrs.)	53·6	±0	62·8	−0·5	9·2	65·3	−0·8	2·5
SUMMER (April, 1945) ..	Long light (14 hrs.)	108·5	+69·4	150·3	+57·4	41·8	159·4	+63·4	9·1
	Control 12·21 to 13·30 hrs.	39·1	..	92·9	..	53·8	96·0	..	3·1
	Short light (10 hrs.)	26·4	−12·7	34·9	−58·0	8·5	36·6	−59·4	1·7
MONSOON (July, 1945) ..	Long light (14 hrs.)	90·5	+24·3	121·7	+26·6	31·2	127·4	+26·4	5·7
	Control 13·29 to 11·56 hrs.	66·2	..	95·1	..	28·9	101·0	..	5·9
	Short light (10 hrs.)	25·0	−41·2	50·0	−45·1	25·0	52·4	−48·6	2·4
AUTUMN (October, 1945) ..	Long light (14 hrs.)	44·7	+14·1	*	*	*	*	*	*
	Control 11·56 to 11·4 hrs.	30·6	..	44·2	..	13·6	47·3	..	3·1
	Short light (10 hrs.)	23·4	−7·2	38·6	−5·6	15·2	41·8	−5·5	3·2

* Experiments discontinued due to the failure of the arrangements for long light.

TABLE IB. (*Time of budding, flowering and fruiting I.P. 7.*)

Time in days after sowing.

Time of sowing.	Treatment.	Initiation of flower buds.	Variation from control.	Opening of flowers.	Variation from control.	Time taken after budding till flowering.	Time taken for initiation of fruits.	Variation from control.	Time taken from flowering to fruiting.
WINTER (January, 1945) . .	Long light (14 hrs.)	50·7	+1·2	66·0	+1·9	15·3	69·7	+3·6	3·7
	Control . .	49·5	. .	64·1	. .	14·6	66·1	. .	2·0
	Short light (10 hrs.)	48·5	−1·0	64·0	−0·1	15·5	65·6	−0·5	1·6
SUMMER (April, 1945) . .	Long light (14 hrs.)	41·2	+15·5	71·5	+37·3	30·3	88·5	+52·3	17·0
	Control . .	25·7	. .	34+·2	. .	8·5	36·2	. .	2·0
	Short light (10 hrs.)	24·0	−1·7	31·1	−3·1	7·1	33·2	−3·0	2·1
MONSOON (July, 1945) . .	Crop completely destroyed.								
AUTUMN (October, 1945) . .	Long light (14 hrs.)	32·9	+7·4	46·1	+7·0	13·2	51·2	+9·3	5·1
	Control . .	25·5	. .	39·1	. .	13·6	41·9	. .	2·8
	Short light (10 hrs.)	23·4	−2·1	38·7	−0·4	15·3	43·7	+1·8	5·0

being 82·1 days. Variations due to treatments are more marked at the time of initiation of fruits than that at the time of bud initiation in all the sowings.

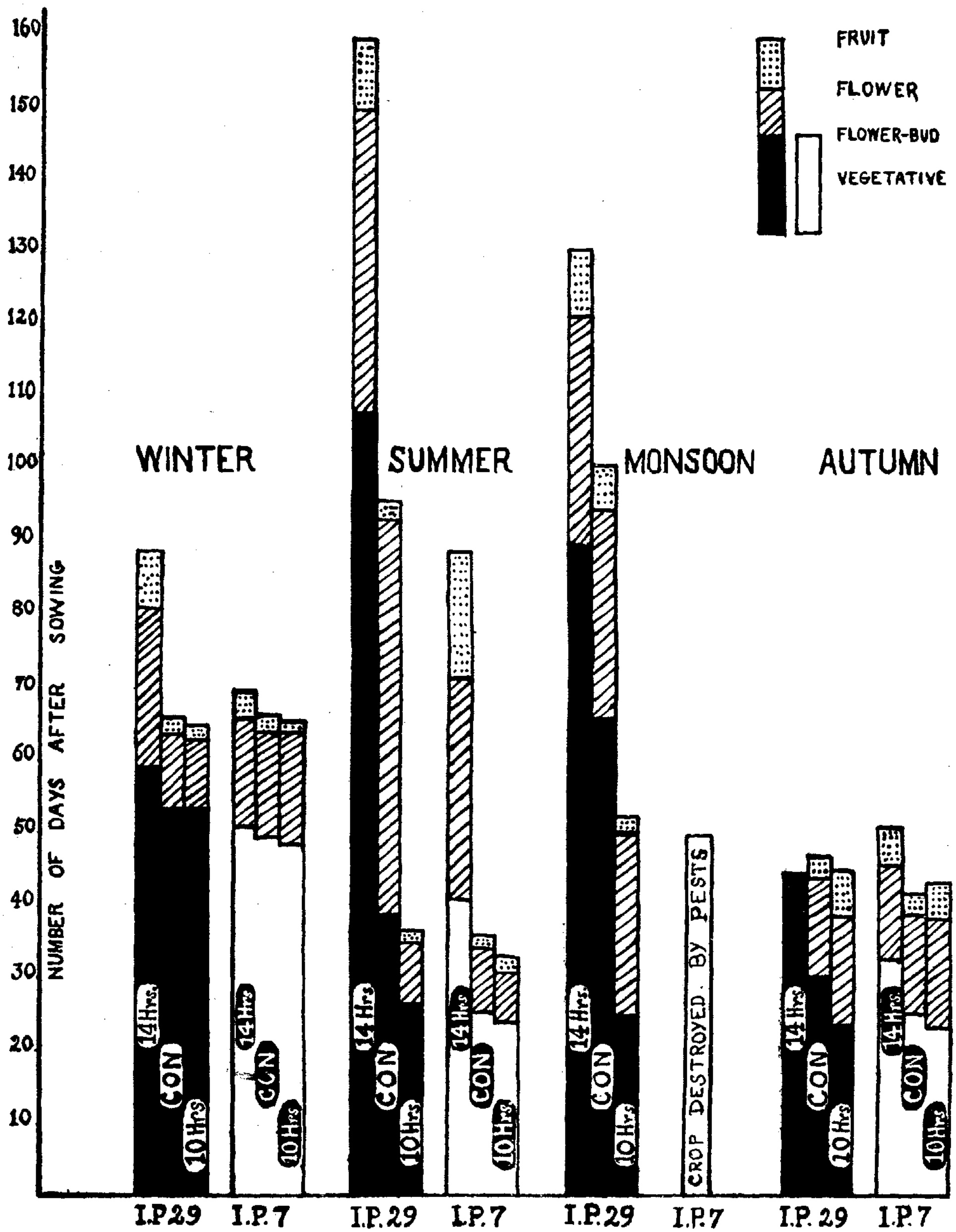

FIG. 2. The time required for the initiation of flower buds, flowers and fruits under different photoperiods in different season.

In I.P. 7 the time taken for the initiation of flower buds was practically the same in summer and autumn being about 25 days but this period was almost doubled in winter being 49·5 days. Exposure to short photoperiod induced slight earliness in flowering of 1-2 days from control and flowering was retarded when exposed to long photoperiod, the treatment being most effective in summer.

The plants of the long photoperiods of both the varieties were always characterized by the shedding of the first formed flower buds and the first formed flowers. The periods from the initiation of the flower buds to flowering and from flowering to fruiting were in general comparatively higher for this treatment.

Height: The growth in height in both the types was greatly influenced by the time of sowing and exposure to photoperiods in the same way as flowering and fruiting. Records of height taken fortnightly from the date of sowing till fruit formation of I.P. 29 are given in the Table IIA and those for I.P. 7 are given in Table IIB.

Both the species grew very slowly in the winter season. Amongst the plants of control sets of I.P. 29 those of the monsoon sowing were tallest at all stages of growth. There was little difference between the heights at different stages, in autumn and winter sowings. In I.P. 7 the autumn sown plants were tallest at budding and flowering time but at the fruiting stage highest level was reached in summer. When exposed to long photoperiod growth in height was generally checked in I.P. 29, but with longer vegetative period these plants became taller than the controls except in the monsoon sown ones. Behaviour of I.P. 7 was similar and in both the varieties the difference from control was most striking in summer sowings. The response of exposure to short photoperiod on growth was anomalous. Having flowered earlier the plants were exhausted and the plants of all the sowings had lesser height than the control ones. Exposed to short photoperiod the plants of I.P. 29 sown in summer and monsoon maintained higher levels and those in autumn and winter lower levels than the control sets at all stages of growth. Summer and winter sown plants of I.P. 7 also were higher in the early stage when exposed to short photoperiod.

In I.P. 29 among the controls, the rate of growth in stem elongation was found to be highest in monsoon and lowest in winter, while that of the summer and autumn, it was nearly the same at the same age of the plants. The rate of growth in height increased up to the time of flowering in both winter and autumn, and up to the initiation of flower buds in summer and monsoon sowings. In the long photoperiod, however, the growth rate became slower long before the initiation of flower buds in monsoon, from the time of budding in summer, a fortnight after budding in autumn and after the time of flowering in winter. Except in the monsoon, the growth rate in the long photoperiodic set showed an irregular rise and fall, this being most marked in summer. In I.P. 7 the increase in growth rate is maintained in all the treatments of all the sowings till fruit-formation, except in plants growing in long light in summer where it falls after the initiation of flower buds.

Number of nodes: In both the varieties of Sesamum two types of nodes were observed, some bearing opposite leaves and others alternate leaves. In general, all the nodes during the vegetative period had two leaves in each node but with the initiation of the reproductive phase, gradual transition from nodes with two leaves to nodes with one leaf were seen. The upper internodes were also comparatively smaller than the lower ones, while the internodes of the middle region of the stem were longest.

In I.P. 29, the total number of nodes formed was largest in the monsoon sowing and least in the winter sowing being 61·7, and 19·1 respectively at the close of fruiting, while the total number of nodes for summer was 45·9 and autumn 20·5. The number of nodes with two leaves was also largest in the monsoon, being 25·7, while in summer the number was 24·7, in autumn 9·1 and in winter only 6. The nodes with one leaf began to appear about 30 days after sowing in summer and autumn and 45 days after sowing in winter and monsoon. In all the sowings, the nodes with one leaf were produced after the initiation of flower-buds.

TABLE IIA. (*Height in cms. I.P. 29.*)

Time of Sowing.	Treatment.	Time in days after sowing. 15	30	45	60	75	90	105	120	130	150	165
WINTER (1st Jan., 1945).	Long light ..	*	1·4	3·8	10·6	21·4	31·2	41·7	..	..	..	..
	Control ..	*	0·7	2·5	15·6	34·1	..	..	..	..	..	..
	Short light ..	*	0·7	2·5	10·4	23·5	..	..	..	..	..	..
SUMMER (1st April, 1945).	Long light ..	2·8	9·8	21·8	37·4	48·7	64·8	80·6	97·1	105·9	113·7	121·6
	Control ..	2·2	9·9	29·8	47·6	61·6	71·4	84·9	..	..	..	..
	Short light ..	2·3	12·9	34·9	..	..	..	..	..	..	..	..
MONSOON (4th July, 1945).	Long light ..	5·7	19·9	45·9	69·0	85·1	97·8	†	111·4	..	..	..
	Control ..	4·2	15·5	38·8	67·6	104·7	132·0	†	..	..	..	..
	Short light ..	4·3	23·0	45·7	59·7	..	..	..	..	..	..	..
AUTUMN (1st October, 1945).	Long light ..	5·2	10·3	18·3	31·6	41·2	..	..	..	..	..	..
	Control ..	3·9	11·2	30·1	35·6	..	..	..	..	..	..	..
	Short light ..	3·8	10·7	27·3	..	..	..	..	..	..	..	..

* As the plants were too small no measurement was taken.
† No measurement was possible due to continuous heavy rains for three days.

TABLE IIB. (*Height in cms. I.P. 7.*).

Time of Sowing.	Treatment.	15	30	45	60	75	90	105
WINTER (1st Jan., 1945) ..	Long light ..	*	1·12	3·9	13·1	27·6	..	..
	Control ..	*	0·7	2·7	12·3	25·7	..	..
	Short light ..	*	0·9	3·4	11·6	23·6	..	..
SUMMER (1st April, 1945) ..	Long light ..	2·1	11·3	31·2	47·8	62·0	75·7	89·3
	Control ..	2·2	16·3	41·8	..	..	..	..
	Short light ..	2·4	20·1	39·0	..	..	..	..
MONSOON (4th July, 1945)	Plants destroyed by pests.							
AUTUMN (1st October, 1945)	Long light ..	5·7	12·4	29·4	38·4	..	..	..
	Control ..	4·5	16·9	32·6	..	..	..	..
	Short light ..	3·6	12·6	30·7	..	..	..	..

* As the plants were too small no measurement was taken.

In I.P. 7 smaller number of nodes were produced than in I.P. 29 in all the sowings. In the different sowing times, largest number of nodes were produced in summer being 26·3, and least in autumn with 14·4 only. In contrast to I.P. 29 there was hardly any difference in number of total nodes with two leaves in any of the sowings, which was between 7 and 8.

In I.P. 29 exposed to long photoperiods, the number of nodes at the close of fruiting was 56·7 in summer, 34·3 in monsoon, 33·1 in winter and 15·6 in autumn, while the number of nodes with two leaves, for these sowings was 35·6, 31·9, 10·1 and 12·9 respectively. In winter more nodes were produced in long light period up to the 45th day, after which due to the production of more nodes with one leaf in the control, the total number became greater in the control set for the 60th, and 75th day after sowing. In summer the nodes were produced at a slower rate than the control set but due to prolonged vegetative period the number exceeded, that of the control. In monsoon very little difference was observed up to the 60th day, but later the control plants produced larger number of nodes which at the close of fruiting became almost double that of the long photoperiodic set. In autumn there was little difference between the two sets up to the 30th day, then the number slightly increased in the control set.

In I.P. 7 plants growing in long photoperiod produced 53·4 nodes in summer, 18·7 in winter and 15·4 in autumn of which the number of nodes with 2 leaves were 30·2, 7·4 and 3·5 respectively for those seasons. Compared with the control ones there was little difference in the production of nodes in the long photoperiodic set in winter and autumn. In summer, nodes were produced at a greater rate in the control set; but due to a longer vegetative period in the long photoperiod the total number at the close of fruiting was fairly higher.

In the short photoperiod I.P. 29 had the largest number of nodes in monsoon (32·8) and least in winter (6·9) while in summer and autumn they were 14·7 and 12·2 respectively. The number of nodes with two leaves, however, showed little difference, but a great variation was observed in the total number of nodes with one leaf. In winter, the plants of the short photoperiodic set showed little difference in the total number of nodes up to the 45th day and then more nodes were produced in the control. In summer also there was little difference up to the close of fruiting between the two sets except that larger number of nodes with one leaf were produced in short photoperiod. In monsoon, however, the total number of nodes as well as the number of nodes with one leaf was much higher in the short photoperiodic treatment from the 30th to the 60th day when the plants of this set were all in fruits. After this the plant of the control set continued producing nodes, the number of which became almost double that of the short photoperiodic set at the close of fruiting. In autumn, the number of nodes was slightly higher in the control up to the close of fruiting.

In I.P. 7 plants of the short photoperiod produced largest number of nodes in summer with 21·8 at the close of fruiting, while in winter and autumn the number was the same being only 13·7. Little difference was observed in the production of nodes with two leaves, thus the number of nodes with one leaf was much higher in summer than in the two other sowings. In comparison with the controls the total number of nodes as well as those with two leaves in the short photoperiodic set showed very little difference in all the sowings.

Branches: In pot culture Sesamum did not produce many branches, and the development of branches was closely associated with the beginning of the reproductive phase. In I.P. 29 branches were generally produced between 45–60th day in monsoon and winter sowings and between 30–45th day in summer and autumn sowings. The total number of branches produced at the close of fruiting was 2·3 in autumn, 3·2 in winter, 5·1 in summer, and 11 in monsoon. In I.P. 7 branches were initiated after the 45th day of sowing in winter, while in the summer these appeared between 30–45th day. The total number of branches produced were 0·4 in autumn, 3·3 in winter and 2·8 in summer. In the long photoperiodic sets of I.P. 29 the total number of branches recorded was 11·5 in summer, 5·4 in monsoon, 4·1 in winter, and 0·8 in autumn. The number of branches in summer was more than twice that of the control while in monsoon this condition was reversed. In the short light treatment of I.P. 29 the total number of branches produced were 3·5 in summer, 2·5 in monsoon, 2·4 in winter and only 0·8 in autumn. In I.P. 7 difference due to long and short light period from the control sets was negligible.

Leaf heteromorphism : In all sowings of Sesamum it was observed that the leaf forms in both the varieties were extremely variable. Generally the lower leaves were ovate lanceolate which gradually passed through a large number of leaves of different shapes with serration and various degrees of incised margins depending upon the sowing time and photoperiod to small linear lanceolate leaves in the apical region.

In all the sowings the plants receiving 14 hrs. light period showed larger and more variable leaf forms than those of all other treatments of the same sowing. The leaf heteromorphism was only seen in the controls of the monsoon sowing when the normal light period of the season was high from the beginning, while plants growing in short photoperiod had little variation in leaf shape.

DISCUSSION.

Both the early and late varieties of Indian Sesamum flower earlier when exposed to shortened photoperiods irrespective of seasons, in conformity with the observations of Rhind (1935) on Burmese Sesamum and according to Garner and Allard's (1920) terminology they should be classified as short day plants. Irrespective of the time of sowings both the varieties flowered when exposed to photoperiods between 10 and 14 hrs. When exposed to short photoperiod of 10 hours, the vegetative periods in both the early and late varieties were almost the same for all the seasons; being about 25 days, except in winter, when it was about double this period. It thus becomes clear that the low temperature of winter retards the initiation of the reproductive phase. The reaction of the two varieties to long photoperiodic treatment, however, was different, the vegetative period in all the sowings being distinctly greater in I.P. 29. In untreated plants the natural variations of light period in the different seasons associated with other environmental factors considerably modified the time of flowering, the effect being more pronounced in the late variety. The time of initiation of flower buds was progressively delayed with increase in photoperiod from 10–16 hrs. in both the varieties as is seen in the autumn sowing.

The onset of the reproductive phase from the vegetative is now ascribed by some to the production of certain substances of the nature of enzymes or hormones which are supposed to be formed in the plants and influence the production of flowers. Hypotheses have been advanced by Cajlachjan (1936), Kuijper and Wiersum (1936), Moshkov (1937), Hamner and Bonner (1938) that such a specific flower producing hormone is formed in the plants under certain photoperiods, resulting in the floral initiation and subsequent development. In the case of Sesamum, therefore, it seems that the production of the hypothetical flower producing substance is controlled by the photoperiod and temperature, the formation of this substance being delayed by long photoperiods. In winter when the temperature was low even in short photoperiod flowering was much delayed.

In summer flower buds were initiated in a short time but flowering was considerably delayed due to the shedding of a large number of early formed buds. Compared with the monsoon sowing, the control plants of the summer sowing were exposed to shorter photoperiod in the early stage which may be responsible for this early induction of flower buds and the gradually increasing photoperiod retarded flower formation, the time required being almost the same in summer and monsoon sowings. Rhind observed that if after exposing the plants to short photoperiod for some time, Sesamum were grown in long photoperiod, linear lanceolate leaves associated with flower buds originate but later the plants again become vegetative. Thus Sesamum completes its development earlier in short photoperiod but the effect is not carried over in long days. The induction effect due to short photoperiod in these experiments, however, cannot be definitely traced as undoubtedly other factors like rainfall, humidity, temperature, etc., may also have been operative. The long vegetative period in winter seems to be due to the influence of low temperature as the short photoperiod of those months and exposure to 10 hours photoperiod did not induce earliness in flowering.

Late variety of Sesamum has the best vegetative growth in summer and monsoon. High temperature, relative humidity, and rainfall seem to be favourable factors associated with long photoperiod which prolong the vegetative phase. Irrespective of sowing time, plants growing in short photoperiod had lesser vegetative growth, height and branches, and those in long photoperiod produced more vegetative matter mainly due to prolonged vegetative phase. The growth rate in height in long photoperiod was low except in the monsoon sowing of I.P. 29. This is probably due to the fact that plants generally grow more in height in darkness than in light and the plants in long photoperiod receives much less daily dark period. From the standpoint of cultivation it seems that both the varieties can be grown with success in summer and autumn, the early one should be preferred for summer and the late one for autumn sowing.

SUMMARY.

(1) Two varieties of Indian Sesamum I.P. 29 (late) and I.P. 7 (early) were grown in pots in four seasons, Winter (January), Summer (April), Monsoon (July) and Autumn (October). In all the sowings different sets were exposed to short photoperiod of 10 hrs., long photoperiod of 14 hrs. and in natural photoperiod of the season which varied between 10 hrs. 47 mins. to 13 hrs. 30 mins.

(2) In all the sowings I.P. 29 had greater vegetative growth flowering later than I.P. 7 and the effect on growth and development due to variation in climatic conditions and different photoperiods were more pronounced in the former. I.P. 7 is more susceptible to pests and in monsoon majority of the plants were killed.

(3) In all the sowings short photoperiod induced early flowering and long photoperiod delayed it. The effects were greatly influenced by season, photoperiod and the variety of the Sesamum.

(4) Exposed to short photoperiod of 10 hrs. the vegetative period of both the types was almost similar being about 25 days except in winter when it was about double that period.

(5) In I.P. 29 flowering was much delayed in summer and monsoon, both in normal and long photoperiods as compared to autumn and winter sowings.

(6) Plants in short photoperiod grew less and in long photoperiod more in height than those of the control set. The growth rate, however, varied with the season and the variety.

(7) Number of nodes varied with height of the plants. The formation of nodes with one leaf was closely associated with the onset of reproductive phase.

(8) The form of the leaves and their size were greatly affected due to sowing time and photoperiod. Long photoperiod induced leaf heteromorphism—the proportion of different types of leaves being directly influenced by length of the photoperiod.

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