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STUDIES ON PHOTOPERIODIC RESPONSES OF MUNGBEAN,
VIGNA RADIATA (L.) WILCZEK, VARIETIES

presented by Moheb Moh. H. Bashandi

a candidate for the degree of Master of Science

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STUDIES ON PHOTOPERIODIC RESPONSES OF MUNGBEAN, VIGNA RADIATA (L.) WILCZEK, VARIETIES

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ABSTRACT

This study was initiated to obtain information concerning the response of selected varieties of mungbean in different photoperiods, and to identify the critical photoperiod for individual varieties.

Eight varieties of mungbean were grown in environment controlled growth chambers at 8-, 12-, and 16-hour photoperiods. There was no appreciable difference in days to flower among varieties at the 8- and 12-hour photoperiods, or in days to flower of the individual varieties. With the 16-hour photoperiod, days to flower for one variety was not different from days to flower with 8- and 12-hours indicating that this variety is less sensitive to photoperiod than the other varieties. Two varieties flowered with the 16-hour photoperiod but required a greater number of days than with 8 or 12 hours. Five varieties did not flower with the 16-hour photoperiod within a period of 180 days at which time the experiment

was discontinued. Plants from the latter five varieties transferred to 8- and 12-hour photoperiods after 80 days flowered within a 10 to 41 day period. Results were confirmed by repeating the experiment.

Since the initial experiments indicated that the critical photoperiod for the varieties studied to be between 12 and 16 hours, an experiment was conducted using 13-, 14-, and 15-hour photoperiods. All varieties flowered in each photoperiod. Varieties could be classified into five groups according to days to flower in the three photoperiods.

Plant height increased as flowering was delayed by lengthening the photoperiod. The increase in plant height resulted from an increase in internode length with no appreciable increase in the internode number.

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CHAPTER I

INTRODUCTION

The mungbean (*Vigna radiata* (L.) Wilczek.) is a short duration grain legume crop which originated in Southern Asia. It is widely grown in Pakistan, India, Burma, Thailand, and the Philippines. Protein content of the mungbean seed averages about 22 to 24 percent. For this reason it provides an important protein supplement in the diets of many people in that area when eaten in combination with cereals.

Mungbean is known to have been grown in the United States prior to 1835, mainly as a forage and green manure crop. Interest in it as a grain crop developed during World War II when imports from the Southern Asia area were reduced. Currently, several million pounds of mungbean are used annually in the United States as bean sprouts, mainly in oriental foods. About 30,000 acres are grown annually in Oklahoma and Texas. Over fourteen million pounds were imported into the United States in 1971.

The mungbean is currently being utilized for thesis research by students in International Agriculture at UMC. Several hundred varieties were grown in 1970 and 1971 at Columbia, Missouri, which is located about 39° N. latitude.

These varieties originated from India, Iran, Afghanistan and other parts of the world. No information was available on their characteristics. When grown at Columbia they varied widely in a large number of characters including days to flower.

Seed of high yielding varieties at Columbia were distributed to mungbean breeders in several South Asia Countries. Preliminary reports from several of these locations indicated that these varieties were relatively short and early in maturity when grown with the short photoperiods of the low latitudes. This reaction to photoperiod is similar to that obtained when varieties of soybean adapted to a northern area in the United States are moved southward and grown in an area with shorter photoperiods.

Very little information on photoperiod response of the mungbean is known. Knowledge of response of mungbeans to photoperiod would be useful in identifying where specific varieties of mungbean may be adapted with respect to latitude. This study was initiated to obtain information on the problem.

CHAPTER II

LITERATURE REVIEW

Early Studies of Photoperiodism

The effects of day-length upon growth, flowering, and fruiting of plants was demonstrated by Garner and Allard (1920a). In 1906 it had been observed that a giant plant of tobacco which did not flower in the field in Maryland before frost blossomed and produced seed when transplanted to the greenhouse. In a later experiment in which soybeans were grown in the greenhouse in winter, it was observed that blossoms were set before the plants had made their normal growth. This led to a study of why the plants behaved so differently in fall and winter months. After eliminating temperature, intensity of light, and quality of light as major factors influencing time of flowering, attention was turned to the length of daily exposure to light. The length of the daily period of exposure was varied from a minimum of 5 hours to a maximum of 12 hours by placing the plants in a dark chamber for the remainder of the 24-hour period. On the basis of observations of a large number of species they concluded that: (1) the relative length of day is a factor of the first importance in the growth and development of plants particularly with respect to sexual reproduction; (2) in

the absence of a favorable length of day for flowering in certain species, vegetative development may continue more or less indefinitely; (3) in certain species, when exposed to a length of day distinctly favorable to both vegetative growth and flowering, the two processes tended to proceed hand in hand for an indefinite period; and (4) the annual cycle of plant life is primarily due to the seasonal change in length of day, and the destructive effects of winter temperature are largely incidental rather than fundamental. They suggested the term "photoperiod" to designate the favorable length of day for an organism to flower, and "photoperiodism" to designate the response of the organism to the relative length of day and night. They also used the expression "short-day" for exposures of 12 hours or less and "long-day" for exposures of more than 12 hours. Subsequently a wide variety of field, garden and ornamental plants were studied for response to photoperiod (Garner and Allard, 1920b, 1923, 1930, 1940). Garner and Allard (1920b) demonstrated that similar effects could be obtained either from shortening the long days of summer by placing plants in a dark chamber for portions of each 24-hour period, or from increasing the short winter days by lengthening the duration of the light period with illumination from electric light bulbs.

By the simple means of exposing only parts of a plant to definite photoperiods, Garner and Allard (1923, 1925) were able to demonstrate with *Cosmos sulphureus*

(typical short-day plant) that: (1) each branch responds in a characteristic manner to its particular light period more or less independently of the other branches; (2) the localized responses might continue for several months under favorable conditions; (3) continuous darkness does not definitely initiate flowering, but neither does it necessarily inhibit formation of flower buds in response to the action of a short-day light period on another part of the plant.

Borthwick and Parker (1940) found that the most effective leaf in inducing floral initiation is the one which has most recently attained its full size. It is the physiological age of the leaf and not its position on the plant which determines its effectiveness.

Hamner (1940) reported that exposure to both light and darkness was necessary for photoperiodic induction of Biloxi soybean. The plants failed to initiate flower primordia in any photoperiodic cycle which did not include a dark period longer than 10 hours. The optimum photoperiod was between 10 and 12 hours at 1200 f.c. and 23° to 26° C.

Prior to the research of Garner and Allard several workers had made observations on photoperiod behavior in plants but in most cases probably did not grasp the significance of their observations. According to Allard (1944), an interesting reference to the photoperiod as affecting plants is given by A. Henfrey in his book,

The Vegetation of Europe (1852), wherein a theorem is proposed that the length of day is a factor in the natural distribution of plants. Mooers (1908) recognized a difference in flowering date and seed production in soybeans and cowpeas as an effect of delayed planting. He stated that"(1) the variation in length of season takes place almost entirely previous to flowering, and (2) the factors which control these peculiarities are not apparent." According to Murneek (1948), Klebs, as early as 1913, seemed to have had a fairly definite idea that the time of flowering of some of his experimental plants (*Sempervivum funkii*) was determined by the length of day.

After the general principles of the influence of the duration of light on plants was pointed out by Garner and Allard, photoperiodism became a favorite topic for research and numerous reviews concerning the phenomena and its relation to the physiology of flowering have been published (Murneek and Whyte, 1948; Parker and Borthwick, 1950; Lang, 1952; Liverman, 1955; Salisbury, 1961; Evans, 1971.)

Nature of Photoperiodic Response

The real understanding of the role or roles of light in the flowering process is still not fully understood. It is generally believed that during the period of photoperiodic induction substances are formed in the leaves, which are translocated to the growing point where flower

primordias are initiated. Tracer studies have revealed that in leaves fed radioactive carbon (C^{14}) in CO_2 under various conditions of photoperiodic treatment, a number of compounds experience marked quantitative changes, but which of these compounds is specifically concerned with flowering could not be established.

Once the mature or newly expanded leaves have received the proper photoperiod, they produce a substance, or precursor of hypothetical substance called florigen. Unfortunately, however, florigen remains only a name, for it has proven to be one of the most elusive of all plant-growth substances. Its transport from the leaves to the growing point can be demonstrated indirectly up and down stems, across graft unions, and from one plant to another, but the substance has not been isolated. The term florigen was used at the California Institute of Technology to designate a plant hormone thought to stimulate the flowering of plants.

Work over the last 35 years, has established that a photoreversible protein "Phytochrome" (P) controls a wide spectrum of physiological display in plants including germination, stem elongation, flower initiation and development, sex expression, and others. Phytochrome is a blue or bluish-green protein, that exists in two interconvertable forms with maximum absorption in the red (R) part of the spectrum at 660 nm and near the limit of vision at 730 nm (far red (F.R.)). The conversion reaction

can be simplified as follows:

$$P_R \underset{\text{far red light}}{\overset{\text{red light}}{\rightleftharpoons}} P_{FR} \xrightarrow{\text{darkness}} P_R$$

It has been found that P_{FR} "excited form" has three important distinctions: (1) a low electric excitation level, (2) serves as a major factor in the interaction of plants with the environment, and (3) dark conversion to P_R is the control factor in time measurement in photoperiodism. The dependence upon phytochrome conversion from P_R to P_{FR} and vice-versa is the reason for the universality of its action. This reversal character is independent of temperature differences maintained during the time of irradiation.

Hendricks and Borthwick (1963) indicated that the control of growth and development probably arises from action of P_{FR} as an enzyme. Zeevaart (1963) believes that phytochrome acts as a flowering hormone since leaves perceive the relative length of day and night, whereas the axillary or apical meristems differentiate into flower primordia. A floral stimulus moving from leaf to bud is definitely implied in the photoperiodic control of flower formation. Certainly, this material meets all the requirement of a flower hormone. It is an organic compound other than a nutrient. It regulates the initiation of flower primordia. It is produced by plants and there is a site of production, the leaf, and a site of action, the bud. According to Zeevaart, (1963) "Nothing

is yet known about the nature of flower inhibiting reaction in which P_{FR} participates, but it seems that in order to suppress flowering it has to operate for different periods in different short-day plants."

According to Evans (1971), "More evidence is needed before we discard the attractive concept of a single florigen, but the case for doing so is already strong. If there are at least two primary photoperiodic stimuli, and if they act in balance like cytokinin and auxin in shoot and root formation, the inhibitory effects of non-inductive photoperiods are readily explained."

Photoperiod sensitive plants respond primarily to the length of the dark period. Long nights induce flowering in short-day plants and prevent it in long-day plants. Brief irradiation close to the middle of the long night will result in the opposite response; short-day plants remain vegetative and long-day plants flower. A brief illumination during a long night with red light is again most effective in reversing the effect of a long night on short-day plants, but in long-day plants it induces flowering.

These facts lead to the conclusion that the essential difference between short-day plants and long-day plants lies in the fact that P_{FR} catalyzes a flower inhibiting reaction in the former group but participates in a flower promoting reaction in the latter group (Zeevaart, 1963).

The classification of plants as short-day, long-day, and day-neutral is largely simplified. Short-day plants will flower earlier whenever the length of the light period is shorter than a critical period. Long-day plants will flower earlier whenever the length of the light period is longer than a critical period. Day-neutral plants will flower regardless of day length. Flowering induction may be affected by several other factors so that the three major groups may be divided again into subclasses. Also, the optimum length of the light period varies between varieties within species.

Thermoperiodicity

There have been numerous reports indicating that low temperature, particularly during the dark period greatly reduces the response of soybean to inductive photoperiod. Steinberg and Garner (1936) found that low temperature delayed the development of flowers in early, medium, and late varieties of soybeans, but that the critical daylength was altered only to a limited degree.

Parker and Borthwick (1939) found that initiation of flower primordia in Biloxi soybeans was influenced to a much greater extent by variation in temperature during the dark period than during the light period. Blaney and Hamner (1957) found clear indications that some of the effects produced by low temperature treatment influences the endogenous rhythm and thereby the flowering

response. For example, they found that 4 hours of low temperature (4° C) given during the dark period of a normal day (8 hours light and 16 hours darkness) reduced the flowering response. On the other hand, on a 28-hour cycle (8 hours light and 20 hours darkness), 4 hours of low temperature (4° C) during the dark period stimulated flowering. At normal temperature a 28-hour cycle is much less effective in inducing flowering than is a 24-hour cycle. Many studies on the effect of temperature on endogenous rhythms indicate that a change in temperature produces a phase shift in the rhythm (Cumming and Wagner, 1968).

Van Schaik and Probst (1958) studied several varieties of soybeans to evaluate the effect of temperature and photoperiods on flower production and reproductive efficiency. They concluded that both high temperature and long photoperiod increases the percent of flowers and podshedding. They found that shedding was not a result of lack of viable pollen grains. The increase in shedding was observed both in plants grown under controlled conditions and in the field. Under controlled conditions raising temperature appeared to increase shedding.

Garner and Allard (1930) conducted a very complete study to measure the photoperiodic response of soybeans in relation to temperature and other environmental factors. They concluded that sustained temperature below an average of 75 to 77° F would tend to cause a slight delay in

flowering. Roberts and Struckmeyer (1938) reported that the photoperiod response of plants were altered by temperature above or below those usually used in the greenhouse. Soybeans were among the plants affected. According to Johnson et al. (1960), only when temperature drops below an optimum value does it begin to play a major role in photoperiod of soybeans.

Coyne (1969) reported that there is an interaction between temperature (degree and diurnal) and photoperiodic response (the degree and absolute response) in varieties of Phaseolus vulgaris L. Coyne (1970) indicated that varieties of the same species (Phaseolus) respond differently to photoperiod under different temperatures.

Sandhu and Hodges (1971) reported, in an evaluation of the effects of photoperiod, light intensity, and temperature on growth and reproduction of Cicer arietinum, that the combination of long photoperiod (16-hour), high light intensity (28 kilolux), and medium and high temperatures (22.5^{o} and 30° C), resulted in the earliest flowering. None of the strains studied flowered when exposed to 8- and 12-hour photoperiods of low light intensity (about 16 Kilolux at 15° or 30° C temperature).

Photoperiod Studies of the Grain Legumes

The soybean has played a prominent role in basic studies of photoperiodism in plants due to the fact that early observations and studies were made on this crop

plant (Mooers, 1908; Garner and Allard, 1920a and b) and to the responsiveness of different varieties of the soybean to variations in the photoperiod. This knowledge has been used by soybean breeders to develop varieties adapted to different latitudes. Some of this research will be briefly reviewed as well as research on beans (*Phaseolus vulgaris*), chick pea (*Cicer arietinum*), and mungbean (*Vigna radiata*).

Soybeans (Soya max (L.) Merril)

Mooers (1908) observed that when the planting date of soybeans was delayed from May 15 to July 15, the maturity of the late Mammoth Yellow variety was delayed only 19 days but the maturity of an early variety, Ito-san, was delayed 60 days. Garner and Allard (1920a) noted that soybeans planted in the greenhouse in short winter days flowered early before making normal growth. When the daily light exposure was increased from 5 hours to full natural day light (12½ to 15 hours) the number of days from germination to maturity was increased by 3, 39, 49, and 83 days for the varieties Mandarin, Peking, Tokyo, and Biloxi, respectively. Height and vegetative growth was also increased reflecting the increase in the length of the period to maturity. The relation of length of day to adaptation for a particular latitude and to correct season for planting was pointed out by Garner and Allard (1920b).

The knowledge that soybean varieties differ in response to photoperiod has led to the classification of the varieties in the United States and Canada into ten maturity groups, 00 through VIII (Morse, Cartter and Williams, 1949). Varieties in any particular maturity group are grown in a zone with a narrow range in latitude, roughly 75 to 125 miles in width. Varieties in Group 00 are the earliest in maturity and are adapted to the long days of southern Canada; varieties in Group VIII are the latest in maturity and are adapted to the relatively shorter days in the southern United States. Varieties moved southward into a shorter daylight period reach flowering in a shorter period of time than in their area of adaptation; varieties moved northward into a longer day light period require a longer period of time to reach flowering than in their area of adaptation (Johnson and Bernard, 1963). Figure 1 shows the daylength in different latitudes at different times of the year (constructed after data from Allard and Zaumeyer, 1944). Francis (1970) reported that the number of hours with light intensity above the critical level for photoperiod sensitive reactions in plants is greater than the number of sunlight hours. In temperate latitudes, the dark period calculated from time of sunset to time of sunrise is nearly one hour longer than the effective dark period as measured by light intensity of less than one f.c. Conversely, the effective photoperiod is longer by one hour.

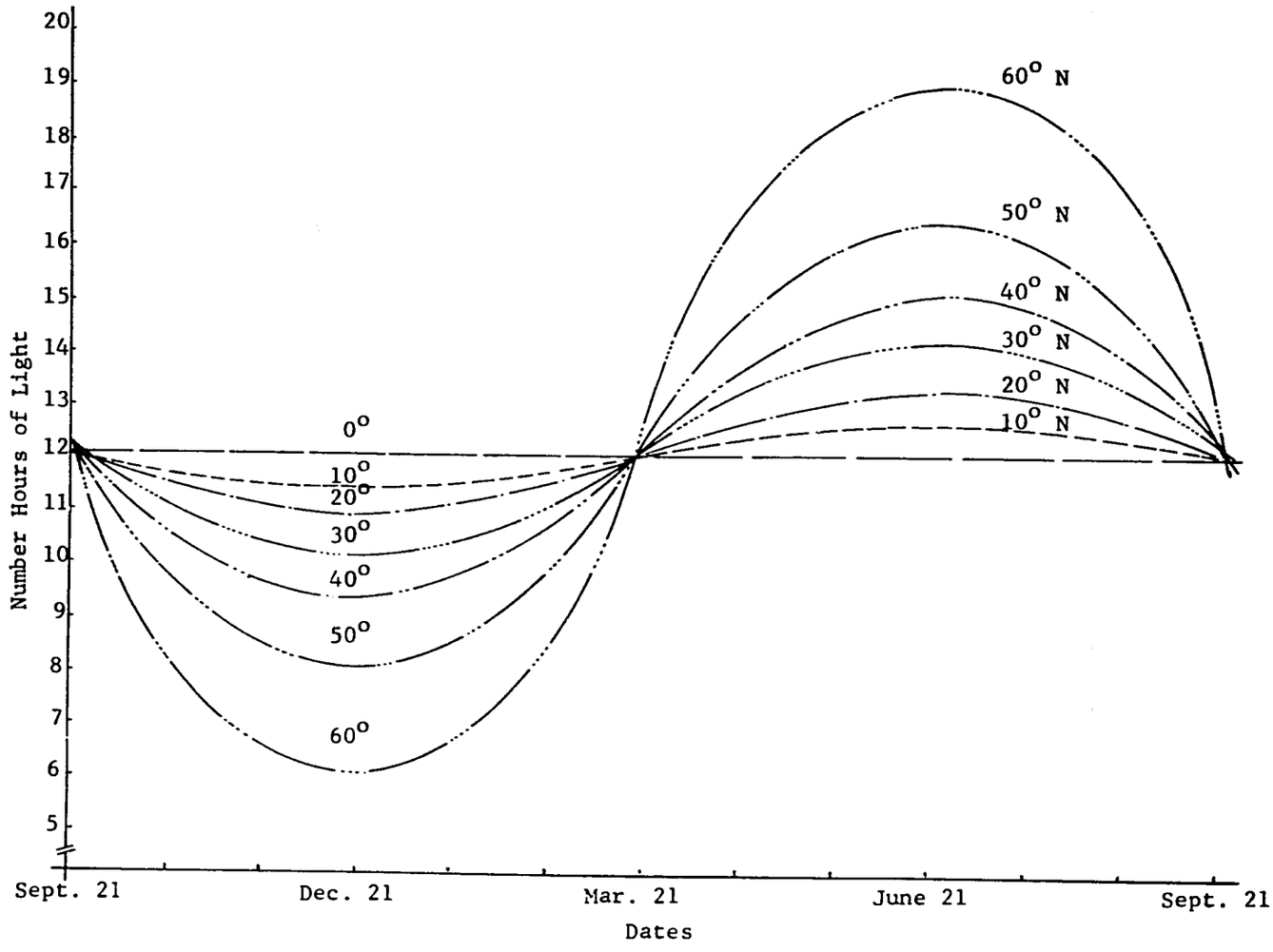

Figure 1. Hours from Sunrise to Sunset for Monthly Intervals at Varying Latitudes. (Adapted from Allard and Zaumeyer, 1944.)

Byth (1968) grew several varieties of soybeans at photoperiods of 8, 10, 12, 14, and 16 hours. No differential responses for days to flowering among varieties were obtained at photoperiods of less than 12 hours. With photoperiods of 12 and 14 hours the number of days to flower for the tropical varieties, Mamloxi and Aroyelles, was greater than for the temperate variety, Bienville. In general, Mamloxi and Aroyelles had greater growth and development in the short and moderate photoperiods, while Bienville had greater growth in the longer photoperiods.

Abel (1970) reported a decrease in plant height and a delay in flowering of soybean plants grown in mid-December and mid-February as compared to May and June plantings. He states, "this effect is due mainly to the low temperature in the field during the growing period." Extending the photoperiod increased the yield in the December planting and decreased the yield in the February planting, the latter due to reinducted vegetative stage and the resultant competition.

Criswell and Hume (1972) evaluated a large number of soybean strains of maturity group 00 for sensitivity to change in photoperiod. They reported that in approximately 70 percent of the 111 strains studied the length of time from planting to flowering was unaffected by photoperiod.

Garden Beans (*Phaseolus vulgaris* L.)

Allard and Zaumeyer (1944) reported that many varieties of the species *P. vulgaris* are day neutral which permits them to be grown over a wide range of latitudes. However, with respect to 86 individual varieties, they classified 28 as short-day varieties and 58 as day-neutral varieties.

Coyne (1966), in a study of constant and diurnal changes in temperature under different photoperiods on time of flowering, reported that both degree of temperature and diurnal change affected the photoperiodic response and the degree of response in the variety OSU 949. White Seeded Tendergreen was day-neutral but time of flowering was markedly affected by temperature. In a later experiment Coyne (1970) reported a differential response for date of flowering in a 14-hour photoperiod with increases in temperature. The days to flowering of variety G. N. 1140 were not increased by an increase in temperature in a 14-hour photoperiod, but were increased when the photoperiod was extended to 16 hours at the higher temperature. The days to flower of variety P. I. 65078 was increased with an increase in temperature in a 14-hour photoperiod and further increased when the photoperiod was extended to 16 hours at the higher temperature.

Chick Pea (Cicer arietinum L.)

Allard and Zaumeyer (1944) classifies the chickpea as a day-neutral species. Sandhu and Hodges (1971) grew eight strains of chickpeas at three photoperiods, two light intensities, and three temperatures. In general, all of the chickpea strains flowered in the 16-hour photoperiod and high light intensity in each temperature regime. With high light intensity and an intermediate temperature regime, flowering was delayed in the shorter photoperiods. It is suggested that the strains that flowered and set seed under the shorter photoperiod may have potential for breeding chickpeas with wider environmental adaptability.

Mungbean (Vigna radiata (L.) Wilczek)

Allard and Zaumeyer (1944) classified mungbean as a short-day crop because long photoperiods delayed flowering. Number of days to flowering averaged 30 at photoperiods of 10 through 13.5 hours, 35 at photoperiods of 14 and 14.5 hours, and 77 days at photoperiods of 18 hours. The height of the plants was also increased in the longer photoperiods.

Mendiola and Mercado (1933) studied 13 local Philippine varieties of mungbeans and concluded that duration of flowering and maturity of seed varied according to season of planting. They also reported the possibility of isolation of an early strain from a late variety.

Hartmann (1969) reported that a single line of *P. radiatus*, P.I. 291,366 from China, was day-neutral.

Yohe and Poehlman (1972), in an evaluation of several characters in over three hundred strains of mungbeans originating from a wide range of latitudes, reported that days to first ripe pod varied from 57 to 117 with an overall mean of 81 days at Columbia, Missouri, in 1970.

CHAPTER III

EXPERIMENTS

The response of selected varieties of mungbeans to different photoperiods was studied in three experiments conducted in controlled-environment growth chambers. In Experiment A, two soybean varieties from maturity groups I and V and eight mungbean varieties were grown with photoperiods of 8-, 12-, and 16-hours. Experiment B, conducted to confirm the results of Experiment A, included the same eight mungbean varieties grown with photoperiods of 8, 12, and 16 hours. Experiment C was conducted with 12 varieties of mungbeans using photoperiods of 13, 14, and 15 hours.

Experiment A

Materials and Methods

Eight varieties of mungbeans (*Vigna radiata* (L.) Wilczek), chosen to represent a wide range in maturity as measured by "days to first flower" in the field at Columbia, Missouri, and two varieties of soybeans were grown in Experiment A. The Missouri accession number, USDA Plant Introduction (P.I.) number, name, origin, and source of seed of the varieties used in Experiment A are given in Table 1. While a wide range in maturity was the

Table 1. Accession Number, Name, Origin, and Source of Seed of Mungbean and Soybean Varieties Grown in Experiment A

Missouri Accession Number	USDA P.I. Number	Name of Variety	Origin	Source of Seed
Mungbean Varieties:				
M028	368,291	Bhatili 2-3-7	India	UMC 1971
M140	31,290		USDA	UMC 1971
M101	271,401		India	UMC 1971
M90	223,711		India	UMC 1971
M118	180,311		India	UMC 1971
M287	255,825		Afghanistan	UMC 1970
M328	317,465		Afghanistan	UMC 1971
M370	374,150	Chunbuki-jaerae--18	Korea	R.D.D. Korea
Soybean Varieties:				
		Chippewa 64	Illinois, 1964	UMC 1971
		Dare	N. Carolina, 1965	UMC 1971

major criterion for choosing the mungbean varieties in this experiment, it was also deemed desirable to choose varieties that had yielded well and were relatively free of virus in the field in order to have vigorous and disease free plants. In Table 2 are listed the mean days to first flower, height, yield, 1000-seed weight, and percent virus infection at Columbia for the two-year period, 1970 and 1971, for the varieties, except for the variety M370 for which only 1971 data were available. Also, growth type is given for 1971 only.

Two varieties of soybeans (Glycine max (L.) Merrill) were included in Experiment A since information on their photoperiod response and the range in latitude in which they are adapted is widely known. The varieties were Chippewa 64, group I maturity range, and Dare, group V maturity range.

Three model 25-7-HL SHERER growth chambers were used for this experiment, one being maintained with a daily 8-hour photoperiod, one with a daily 12-hour photoperiod, and one with a daily 16-hour photoperiod. The light sources in each growth chamber were a combination of ten 40-watt fluorescent bulbs (Sylvania, cool white, VHO, reflectorized) and twelve 25-watt incandescent bulbs. The light intensity of the combined fluorescent and incandescent bulbs measured approximately 3200 f.c. at one-foot below the light source. The combined fluorescent and incandescent bulbs burned for a period of 8 hours in

Table 2. Two-year Average at Columbia, Missouri, (1970, 1971) for Growth Type, Days to First Flower, Height, Yield, 1,000-Seed Weight, and Percent Virus Infection of Mungbean Varieties Grown in Experiment A

Mo. Acc. No.	Growth Type (1-5)[2]	Days to First Flower	Length cm	Yield kg/ha	1,000-Seed Weight gm	Virus Infection %
M028	3.0	67	41	294	24	22
M140	3.3	46	48	1429	47	9
M101	1.0	62	45	1987	75	1
M090	1.3	59	77	2336	63	2
M118	1.7	60	71	2418	55	3
M287[3]		85	64	605	20	20
M328	2.3	79	72	594	34	39
M370[1]	2.0	59	75	1453	35	8

[1]Data for 1971 only.

[2]1=prostrate; 2=semiprostrate; 3=intermediate; 4=semierect; 5=erect.

[3]Data for 1970 only.

each growth chamber. In the growth chamber with the 12-hour photoperiod, the light period was extended by burning only the incandescent bulbs for two hours preceding and two hours after the 8-hour period of full light. In the growth chamber with the 16-hour photoperiod, the incandescent bulbs were burned for four hours preceding and four hours after the 8-hour period of full light.

Similar temperature regimes were maintained in all growth chambers. For the first 8 days after planting the seeds, a temperature of 27.8 ($\pm$ 1.7)$^{\circ}$ C was maintained for 13 hours and alternated with a temperature of 23.9 ($\pm$ 1.7)$^{\circ}$ C for 11 hours. After 8 days, the temperatures were programmed to increase gradually from a minimum of 18.3 ($\pm$ 1.7)$^{\circ}$ C at the midpoint of the dark period to a maximum of 27.8 ($\pm$ 1.7)$^{\circ}$ C at the midpoint of the light period and then decrease gradually to the 18.3° C minimum. The synchronization of the light and temperature regimes in each of the three growth chambers is shown in Figure 2. The humidity in each growth chamber was maintained at 75% $\pm$ 5%.

Seeds of each variety of soybeans and mungbeans were cleaned, treated in 1.5% Clorox (sodium hypochlorite) solution for 2 minutes, washed in running water, and soaked over night in petri dishes at 27.8° C. The fully imbibed seeds were then inoculated with Nitragin, inoculant strain EL (*Rhizobium* spp.) before planting. A planting media was prepared by mixing soil, agricultural

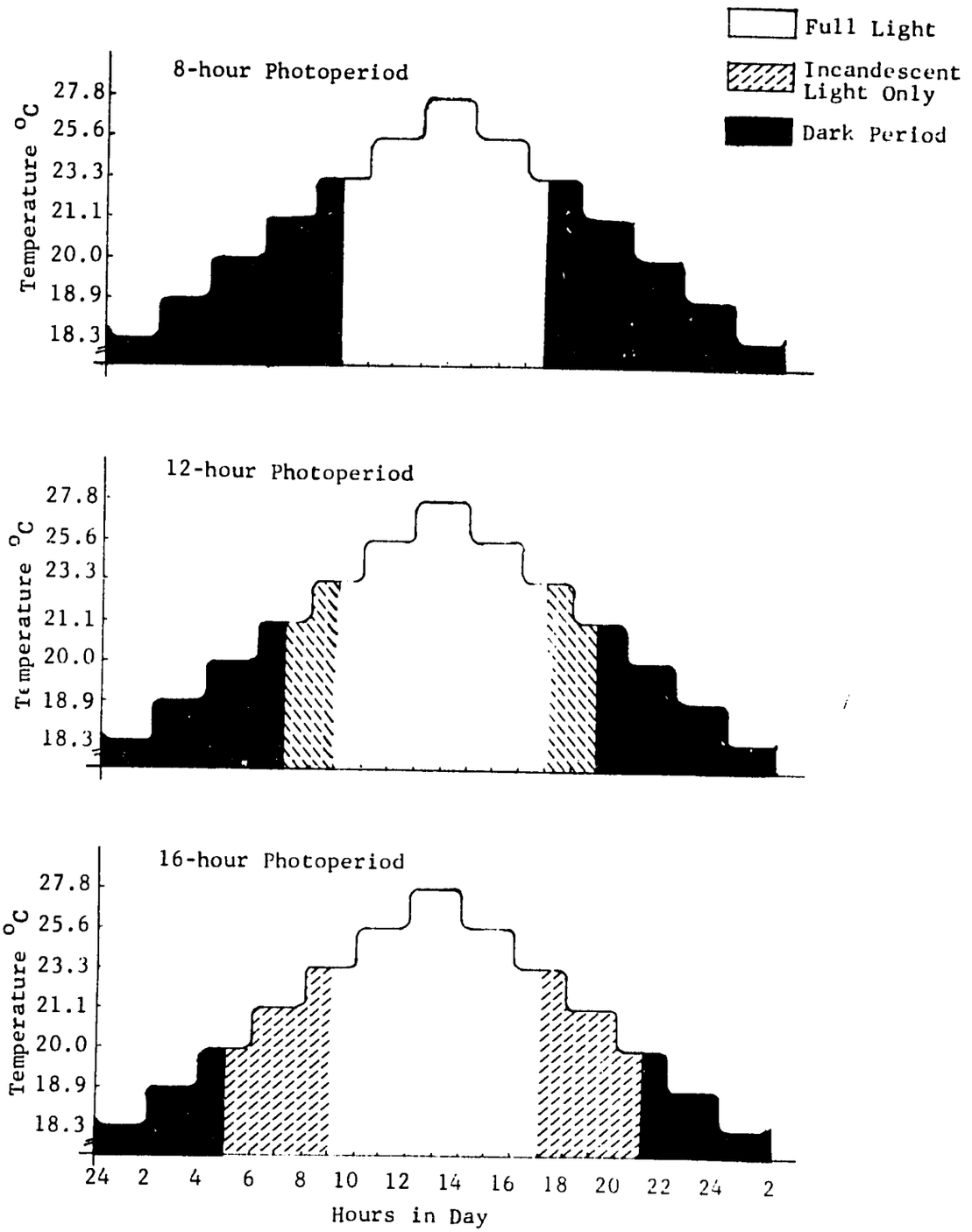

Figure 2. Light and Temperature Regimes Used in Growth Chambers to Provide 8-, 12-, and 16-hour Photoperiods.

vermiculite, and peat in equal proportions. The pH of the media was tested and raised to 7.5 by adding hydrated lime.

Experiment A was planted on February 24, 1972. Four seeds of a variety were planted in a 15 cm plastic pot containing the planting media. Four pots of each variety were placed in each growth chamber. Germination was relatively uniform with emergence on the 6th to 7th days after planting the imbibed seeds. After the seedlings were established they were thinned to two plants per pot, except for the soybeans which were thinned to one plant per pot. Moisture content of the pots was maintained by adding distilled water as needed. A nutritive solution containing (NH_4, P_2O_5, and K_2O) in a ratio of 25:5:20 with a concentration of 100 ppm was supplied once each week.

Measurements that were made included days from planting to opening of the first flower, and plant height and number of internodes at 80 days.

After 80 days, the plants of the varieties which had not flowered in the 16-hour photoperiod were divided into three groups as follows: (a) Four plants (two pots) remained in the 16-hour photoperiod growth chamber; (b) two plants (one pot) were transferred to the 8-hour photoperiod growth chamber; (c) two plants (one pot) were transferred to the 12-hour photoperiod growth chamber. Plants which had flowered were discarded after 150 days.

Observations were continued on plants which did not flower up to 180 days at which time they were discarded.

An analysis of variance was calculated for days to flower for all varieties using individual plant measurement for each of the 8- and 12-hour photoperiods, and for the varieties M028, M140, and M101 for the 16-hour photoperiod. Also, an analysis of variance was calculated for plant height for all varieties using variety means for each of the 8-, 12-, and 16-hour photoperiods. An L.S.D. test was used to identify significant differences among means.

Results and Discussion

Soybeans. The number of days to flower for the soybean varieties Chippewa 64 (maturity group I) and Dare (maturity group V) when grown at 8-, 12-, and 16-hour photoperiods is given in Table 3. The data show that Chippewa 64 and Dare each required 38 days to flower at the 8-hour photoperiod. When the photoperiod was increased to 12 hours, Chippewa 64 still flowered in 38 days, but Dare required 48 days, a 10-day longer period. In a 16-hour photoperiod, flowering of Chippewa 64 was delayed to 50 days but flowering of Dare required 72 days, a difference of 22 days. The comparative days to flowering at the three photoperiods is illustrated graphically in Figure 3. These results suggest that the critical photoperiod to induce flowering in Chippewa 64 is between 12

Table 3. Number Days to First Flower of the Soybean Varieties Chippewa 64 (Group I) and Dare (Group V) Grown at 8-, 12-, and 16-hour Photoperiods

Variety	Plant Number 1	2	3	4	Mean	Difference D-C	F	L.S.D. 5%
8-hour Photoperiod:							0	n.s.
Chippewa 64	37	38	39	39	38			
Dare	37	38	39	39	38	0		
12-hour Photoperiod:							240.54	4.1
Chippewa 64	37	37	38	39	38			
Dare	47	48	49	49	48	+10*		
16-hour Photoperiod:							32.34	9.3
Chippewa 64	48	50	50	53	50			
Dare	61	74	75	77	72	+22*		

* Significant at 1% level of probability.

F value for differences among photoperiods = 18.23**

L.S.D. at 5% level of probability = 8.3

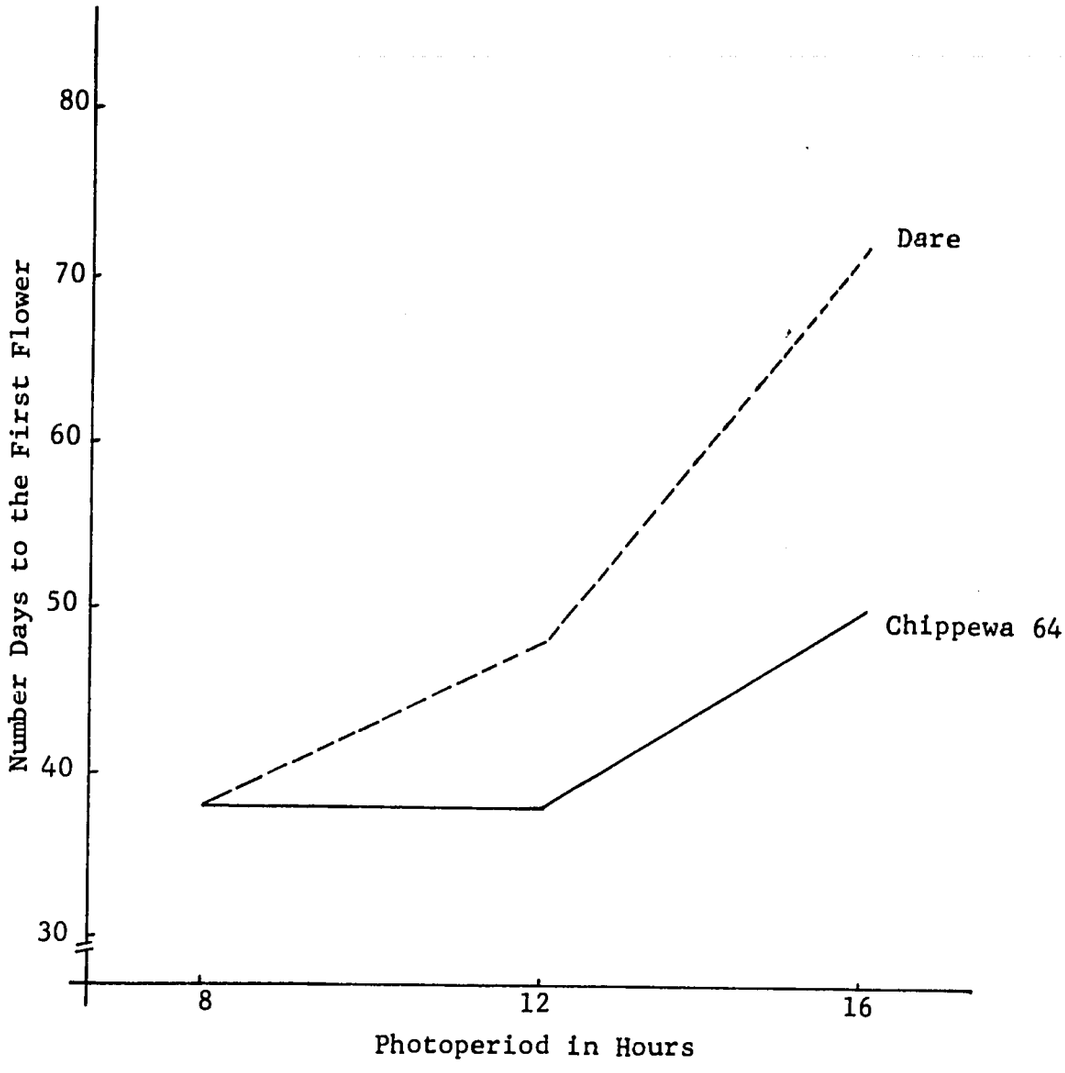

Figure 3. Days to First Flower for Dare and Chippewa 64 Varieties of Soybeans at 8-, 12-, and 16-hour Photoperiods.

and 16 hours but in Dare to be less than 12 hours.

Chippewa 64 is classified as being in maturity Group I. Soybean varieties in Group I are adapted roughly in the USA between latitudes of 44° and 46° N. The effective day length at 45° N. on June 20 is 17 hours and 3 minutes. Dare is classified in maturity Group V. Soybean varieties in Group V are adapted roughly between latitudes of 36° and 38° N. The effective day length on June 20 at 37° N. is 15 hours and 54 minutes. The performance of these two varieties in the growth chambers at different photoperiods is similar to the performance which has been observed for the soybean varieties in the field. Both varieties flower more quickly under shorter photoperiods which are characteristic of the southern latitudes. However, the critical daylength for Chippewa 64 is longer than that of Dare which means Chippewa 64 is more adapted to the northern latitudes. Byth (1968) did not obtain a differential response for days to flower in soybeans with photoperiods under 12 hours which is comparable to results obtained here with Chippewa 64 but not with Dare.

These two soybean varieties were included in this experiment because the effect of photoperiod on soybeans has been studied extensively and the general performance in the field of varieties such as these is known. Since little is known in general regarding the photoperiod response of mungbeans, and no information is available

on the photoperiod response of the varieties used in this experiment, the data from the soybean varieties obtained here will serve as a reference with which the response of the mungbean varieties may be compared.

Mungbeans.

1. Days to First Flower. The mean number of days from planting to first flower for eight varieties of mungbeans grown in 8-, 12-, and 16-hour photoperiods is given in Table 4. All eight varieties flowered in the 8- and 12-hour photoperiods but only three varieties flowered in the 16-hour photoperiod. In the 8-hour photoperiod, the range in the number of days to flower was from 49 days for M328 to 60 days for M101. Differences among varieties, although small, were significant (Table 5). In the 12-hour photoperiod the range in number of days to flower was from 48 days for M028 to 55 days for M140, M118, M287, and M370. These differences were not significant (Table 5). In the 16-hour photoperiod M028 flowered in 53 days, M140 in 66 days, and M101 in 111 days. Each variety differed significantly from the other varieties (Table 5). Except for one plant of each M090, M287, and M370, none of the other varieties flowered in the 16-hour photoperiod within a 180-day period.

The three varieties which flowered in 8-, 12-, and 16-hour photoperiods were M028, M140, and M101. In the case of M028, the number of days to flower did not differ significantly among the three photoperiods (Table 5)

Table 4. Number Days to First Flower of Mungbean Varieties Grown at 8-, 12-, and 16-hour Photoperiods In Experiment A

Mo. Acc. No.	Days to First Flower at Photoperiod of				
	8-hours	12-hours	16-hours	16-hours[1] to 8-hours	16-hours[2] to 12-hours
M028	52 a[3]	48 a	53 a		
M140	54 a	55 a	66 b		
M101	60 a	54 a	111 b	91	90
M090	56	52	*	101	112
M118	52	55	**	119	112
M287	51	55	*	119	120
M328	49	52	**	115	120
M370	56	55	*	121	117
Mean (M028, M140, and M101):[4]					
	55.3 a	52.3 a	76.7 b		
Mean (All Varieties):					
	53.8 a	53.3 a			

[1]Two plants transferred to 8-hour photoperiod after 80 days.

[2]Two plants transferred to 12-hour photoperiod after 80 days.

[3]Number days to flower followed by the same letter for a variety (among photoperiods) are not significantly different at the 5% level of probability.

[4]Means with same letter (among photoperiods) not significantly different at the 5% level of probability.

*M090, one out of four plants remaining at 16-hours flowered in 118 days; M287, one out of four plants remaining at 16-hours flowered in 148 days; M370, one out of four plants remaining at 16-hours flowered in 139 days.

**M118, none flowered up to 180 days; M328, none flowered up to 180 days.

Table 5. Analyses of Variance for Days to First Flower of Mungbean Varieties Grown in Experiment A

Source of Variance	D.F.	M.S.	F.	L.S.D.
Within Photoperiods:				
Among Varieties (8-hour Photoperiod)	7	147.93	3.54*	6.5
Among Varieties (12-hour Photoperiod)	7	50.77	0.60	n.s.
Among Varieties (16-hour Photoperiod)[1]	2	4593.34	103.57**	11.3
Within Varieties:				
Among Photoperiods (Variety M028)	2	53.37	3.13	n.s.
Among Photoperiods (Variety M140)	2	295.79	11.64**	5.9
Among Photoperiods (Variety M101)	2	4245.44	38.2**	15.9
Between Photoperiods:				
8-hour vs 12-hour Photoperiod (8 Varieties)	1	80.25	0.12	n.s.

[1]Three varieties only (M028, M140, and M101).
*Significant at 1% level.
**Significant at 5% level.

suggesting that this variety may be insensitive within the range of photoperiods studied. In the case of M140 the days to flower in the 8- and 12-hour photoperiods were 55 and 56 days, respectively, but 66 days were required in the 16-hour photoperiod. The 66 days to flower in the 16-hour photoperiod differs significantly from the number of days to flower in the 8- and 12-hour photoperiods (Table 5). In the case of M101 the days to flower in the 12-hour photoperiod were less than in the 8-hour photoperiod but the difference was not statistically significant. In the 16-hour photoperiod M101 required 111 days which differs significantly from the number of days to flower in the 8- and 12-hour photoperiods (Table 5). A comparison of the flowering of these three varieties at 8-, 12-, and 16-hour photoperiods is illustrated graphically in Figure 4. The means of the three varieties did not differ between the 8-hour and 12-hour photoperiods, but in the 16-hour photoperiod the mean number of days to flower was greater than in either the 8- or 12-hour photoperiods.

After 80 days two plants of each M101, M090, M118, M287, M328, and M370 were transferred to an 8-hour and two plants to a 12-hour photoperiod. M101 flowered within 11 days after being transferred to the 8-hour photoperiod, and within 10 days after being transferred to the 12-hour photoperiod. With the exception of the M090 plants that were transferred to the 8-hour

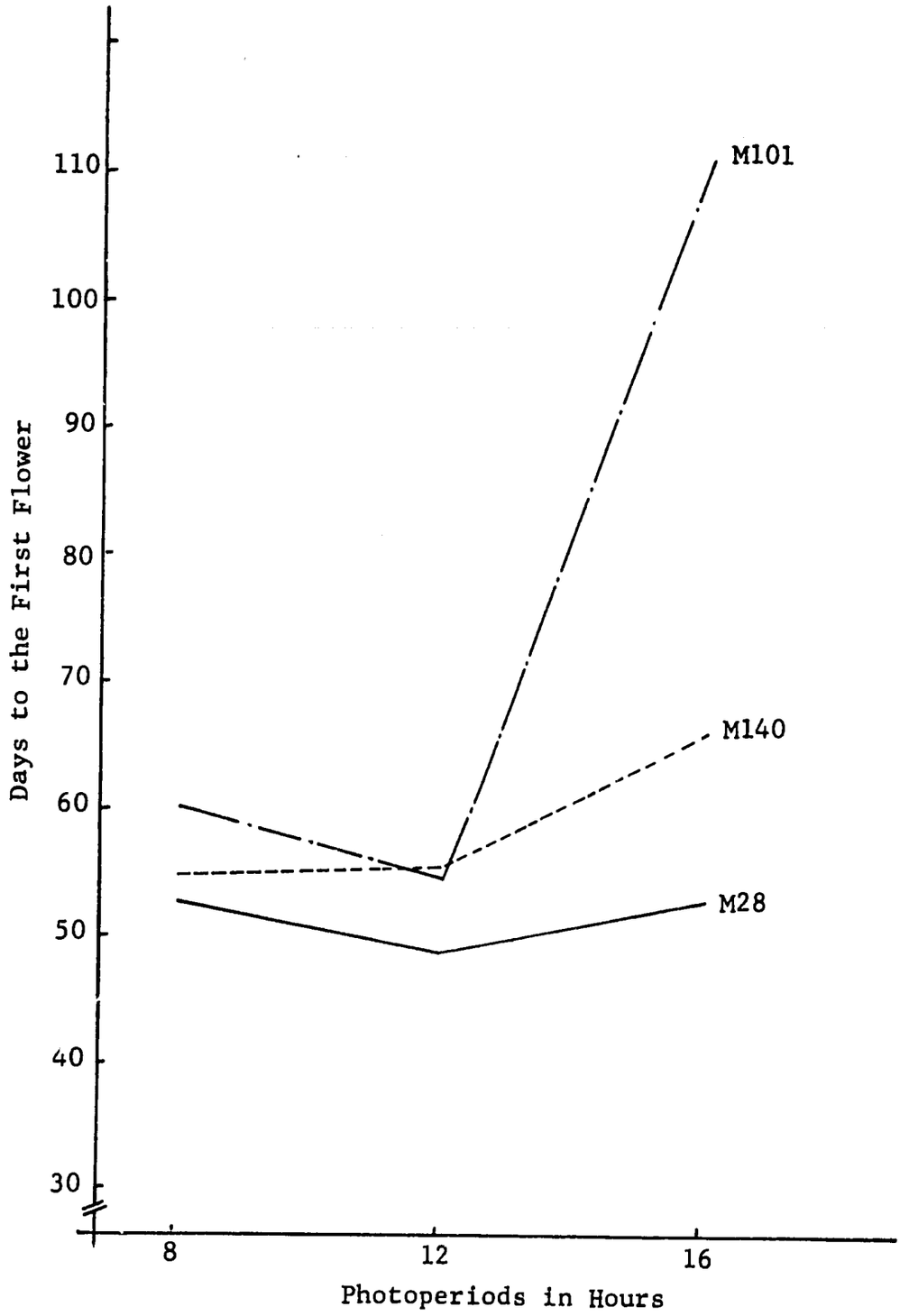

Figure 4. Days to First Flower of Mungbean Varieties Grown at 8-, 12-, and 16-hour Photoperiods.

photoperiod, from 32 to 41 days were required for the other varieties to flower. This suggests that flowering in M101 had been initiated when the plants of this variety were transferred to the shorter photoperiods but flowering in the other varieties was not initiated until after the transfer to the shorter photoperiods. This is supported by the fact that the plants of M101 remaining in the 16-hour photoperiod all flowered. The data suggest, also, that flowering in the remaining varieties was not initiated until they were transferred to the shorter photoperiods. This is supported by the fact that, except for a single plant of each M090, M287, and M370, none of the plants remaining in the 16-hour photoperiod flowered within a period up to 180 days. For these varieties a photoperiod of 16-hours did not initiate flowering under the conditions of this experiment.

Although there were significant differences among varieties for days to flower in the 8-hour photoperiod, the overall mean of 53.8 days for the eight varieties did not differ significantly from the mean of 53.3 days for the corresponding varieties growing at the 12-hour photoperiod (Table 5). This suggests that reducing the photoperiod below 12-hours will not accelerate flowering in the mungbean varieties grown here.

2. Plant Height and Number of Internodes. The mean plant height after 80 days in cm for the eight varieties at each of the three photoperiods in Experiment A

is given in Table 6. The height among varieties varied from 12.0 to 22.5 cm with an overall mean of 17.1 cm in the 8-hour photoperiod. In the 12-hour photoperiod the range in height among varieties was from 13.0 to 24.0 cm with an overall mean of 18.6 cm. In the 16-hour photoperiod, the range in height among varieties was from 19.5 to 51.0 cm with an overall mean of 41.6 cm. In general, these data show that there was a small but nonsignificant overall increase in plant height in the 12-hour as compared to the 8-hour photoperiod and a significant increase in height in the 16-hour as compared to the 8-hour and the 12-hour photoperiods (Table 7). With respect to the individual varieties, the M028 variety which had similar flowering dates in the three photoperiods reached only a maximum height of 19.5 cm in the 16-hour photoperiod. M328 was the tallest variety in all photoperiods and reached a height of 51 cm in the 16-hour photoperiod. In general, in varieties in which flowering was delayed or which did not flower, the plant height in the 16-hour photoperiod was greatly increased over that of the other two photoperiods.

The increase in height at the 16-hour photoperiod resulted from an increase in the internode length and not from an increase in the number of internodes as may be observed from the data on number of internodes in Table 8. A comparison of height of plants grown at the three photoperiods for M028 is shown in Figure 5, and for M328 in

Table 6. Plant Height after 80 Days for Mungbean Varieties Grown at 8-, 12-, and 16-hour Photoperiods in Experiment A

Mo. Acc. No.	Plant Height in cm at Photoperiod of		
	8-hours	12-hours	16-hours
M028	13.0	13.0	19.5
M140	21.0	20.0	48.0
M101	19.0	19.5	45.0
M090	13.0	18.5	37.5
M118	15.0	19.0	36.0
M287	12.0	18.0	48.0
M328	22.5	24.0	51.0
M370	21.0	18.0	48.0
Mean	17.1 a[1]	18.6 a	41.6 b

[1]Means followed by the same letter are not significantly different at the 5% level of probability.

Table 7. Analysis of Variance for Plant Height of Mungbean Varieties Grown at 8-, 12-, and 16-hour Photoperiods in Experiment A

Source of Variance	D.F.	M.S.	F	L.S.D. (5%)
Among Photoperiods	2	1506.25	34.8**	6.75
Error	21	43.27		
Total	23	1549.52		

**Significant at 5% level of probability.

Table 8. Number of Internodes of Mungbean Varieties Grown at 8-, 12-, and 16-hour Photoperiods in Experiment A

Mo. Acc. No.	Number of Internodes at Photoperiod of		
	8-hours	12-hours	16-hours
M028	5.25	5.00	5.25
M140	6.00	5.25	5.25
M101	6.00	5.50	5.25
M090	5.50	5.25	5.50
M118	5.50	5.25	5.25
M287	5.50	5.00	5.50
M328	5.50	5.00	5.00
M370	5.75	5.50	5.50
Mean	5.63	5.23	5.31

Figure 5. Comparison of Plant Height of M028 in 8-, 12-, and 16-hour Photoperiods.

Figure 6. The comparative height of varieties M090, M118, M287, M328, and M370, after 180 days in the 16-hour photoperiod is shown in Figure 7.

3. Comparison of Photoperiod Response of Mungbeans and Soybeans. Results of this experiment indicate that the mungbean like the soybean is a short-day crop. Flowering is hastened by reducing and delayed by extending the photoperiod. The critical photoperiod above which flowering is delayed for mungbeans under the conditions of this experiment appears to be between 12- and 16-hours for all but M028 which was either day neutral or had a critical daylength above 16 hours. The overall mean for days to first flower was not changed when the photoperiod was reduced below 12-hours. Flowering was delayed, with the possible exception of M028, when the photoperiod was extended to 16-hours. The varieties M140 and M101 flowered in the 16-hour photoperiod although M101 required a longer period of time than M140. The flowering pattern of M101 and M140 is similar to that of Chippewa 64 in that the critical photoperiod which delayed flowering was greater than 12 hours but flowering was not inhibited in the 16-hour photoperiod. In the case of the other five mungbean varieties flowering was inhibited with the 16-hour photoperiod, up to the 180 day period that the experiment was maintained. Dare differed in that flowering was earlier in the 8-hour than in the 12-hour photoperiod, indicating that the minimum photoperiod which will delay flowering

Figure 6. Comparison of Plant Height of M328 in 8-, 12-, and 16-hour Photoperiods.

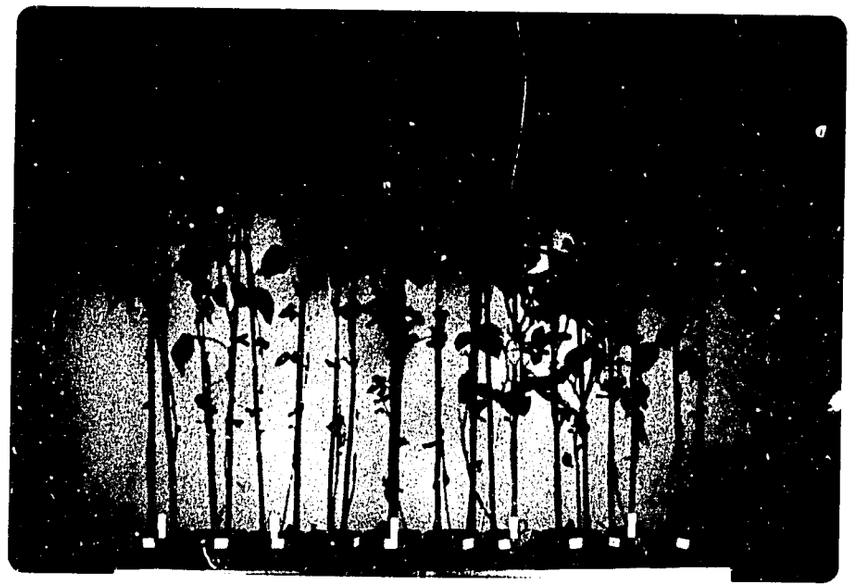

Figure 7. Plants of M090, M118, M287, M328, and M370 after 180 Days in a 16-hour Photoperiod.

is shorter for this variety than for Chippewa 64 or for the mungbean varieties studied. The mungbean varieties M090, M118, M287, M328, and M370 did not flower in the 16-hour photoperiod up to 180 days. This indicates that the maximum photoperiod which will initiate flowering in these varieties to be less than 16-hours under the conditions of this experiment.

Experiment B

Materials and Methods

Experiment B was conducted to verify the results obtained with mungbeans in Experiment A. Four pots of each of the eight varieties grown in Experiment A were included in the growth chambers with 8- and 12-hour photoperiods. In the growth chamber with the 16-hour photoperiod only three pots of each variety could be included since some of the plants from Experiment A which had not flowered were still being grown. Eight seeds were planted in each pot and after germination the pots were thinned to four seedlings each.

The three growth chambers were maintained with the same photoperiod and temperature regimes as in Experiment A. All other factors including light sources, light intensity, humidity, planting media, soil pH, seed treatment, and inoculation were kept similar to those used in Experiment A. Plants were watered as necessary to prevent water stress. Since four plants were included in each pot

instead of two, nutrient solution was supplied twice instead of once a week.

Observations were recorded for days to the first flower, plant height, and number of internodes for each plant. The observations were continued for 96 days at which time all plants of all varieties in the 8- and 12-hour photoperiods had flowered, and all plants of M028, M140, and M101 varieties in the 16-hour photoperiod had flowered. None of the plants of the other varieties in the 16-hour photoperiod had flowered at 96 days and the experiment was discontinued.

The data were analyzed as in Experiment A.

Results and Discussion

Days to First Flower. The mean number of days from planting to the first flower for eight varieties of mungbeans grown at 8-, 12-, and 16-hour photoperiods is given in Table 9. The results, except for M028, are similar to those obtained for the same varieties in Experiment A. As in Experiment A all plants of all varieties flowered in the 8- and 12-hour photoperiods and only three varieties, M028, M140, and M101, flowered in the 16-hour photoperiod. In the 8-hour photoperiod the range in the number of days to flower was from 49 days for M028 to 58 days for M101. The overall mean of 54.0 days differs from that of Experiment A by only 0.2 days. Differences among varieties for days to flower were significant (Table 10). In the 12-hour

Table 9. Number of Days to First Flower of Mungbean Varieties Grown at 8-, 12-, and 16-hour Photoperiods in Experiment B

Mo. Acc. No.	Days to First Flower at Photoperiod of		
	8-hours	12-hours	16-hours
M028	49 a[1]	52 a	63 b
M140	56 a	55 a	70 b
M101	58 a	56 a	86 b
M090	56	54	*
M118	55	51	*
M287	53	53	*
M328	50	48	*
M370	55	53	*
Mean (3 Varieties)	54.3 a[2]	54.3 a	73.0 b
Mean (8 Varieties)	54.0 a	52.8 a	

[1]Number of days to flower for a variety followed by the same letter (among photoperiods) not significantly different at the 5% level of probability.

[2]Means with same letter (among photoperiods) not significantly different at the 5% level of probability according to an L.S.D. test.

*None of the plants flowered within 96 days.

Table 10. Analyses of Variance for Days to First Flower for Mungbean Varieties Grown in Experiment B

Source of Variance	D.F.	M.S.	F.	L.S.D.
Among Varieties (8-hour Photoperiod)	7	138.87	7.12*	3.0
Among Varieties (12-hour Photoperiod)	7	94.89	1.39	n.s.
Among Varieties (16-hour Photoperiod)[1]	2	1433.29	49.44**	4.7
Among Photoperiods (Variety M028)	2	554.41	39.24**	3.2
Among Photoperiods (Variety M140)	2	965.18	53.86**	3.3
Among Photoperiods (Variety M101)	2	3304.21	157.89**	3.5
8-hour vs 12-hour Photoperiod (8 Varieties)	1	6.20	.078	n.s.

[1]Three varieties only (M028, M140, and M101).

*Significant at 1% level of probability.

**Significant at 5% level of probability.

photoperiod the range in number of days to flower was from 48 days for M328 to 56 days for M101. The overall mean of 52.8 days differs from that of Experiment A by only 0.5 days. The differences among varieties for days to flower were not significant (Table 10). In the 16-hour photoperiod M028 flowered in 63 days, M140 in 70 days, and M101 in 86 days, the differences being significant (Table 10). None of the plants of the other five varieties flowered in the 16-hour photoperiod within 96 days from planting at which time the experiment was discontinued.

The three varieties which flowered at 8-, 12-, and 16-hour photoperiods were M028, M140, and M101 as in Experiment A. As may be observed from Table 10 differences among photoperiods were significant within each of the three varieties. In this experiment M028 increased slightly with each increase in photoperiod in contrast to Experiment A in which there were no significant differences among photoperiods. Flowering of M140 was similar to the previous experiment. M101 flowered earlier in the 12-hour than in the 8-hour photoperiod as in Experiment A.

The means of the three varieties, M028, M140, and M101, did not differ in days to flower in the 8-hour and 12-hour photoperiods, but in the 16-hour photoperiod the mean days to flower was 18.7 days longer. Over all varieties, there was no significant difference in the number of days to flower between the 8-hour and 12-hour

photoperiods (Table 10).

The days to flower for M028, M140, and M101 at the 8-, 12-, and 16-hour photoperiods are compared graphically in Figure 8.

Plant Height and Number of Internodes. The mean plant height in cm for the eight varieties in each of the three photoperiods in Experiment B is given in Table 11. The height among varieties varied from 11.5 to 23.5 cm with an overall mean of 17.2 cm in the 8-hour photoperiod. In the 12-hour photoperiod the range in height among varieties varied from 14.0 to 27.0 cm with an overall mean of 20.6 cm. In the 16-hour photoperiod, the range in height among varieties varied from 21.5 to 53.0 cm with an overall mean of 42.7 cm. In general these data show that there was no significant increase in plant height in the 12-hour as compared to the 8-hour photoperiod but a significant increase in height in the 16-hour as compared to the 8- and the 12-hour photoperiods (Table 12).

In this experiment M028 was the shortest variety in each photoperiod. M028 increased in height with each increase in photoperiod with the largest increase coming in the 16-hour photoperiod. M328 was the tallest variety in the 12- and 16-hour photoperiods. Increases in height may be noted for the other varieties with the increases being much larger than for M028, particularly at the 16-hour photoperiod. No significant increase in number of internodes was obtained with increase in photoperiod

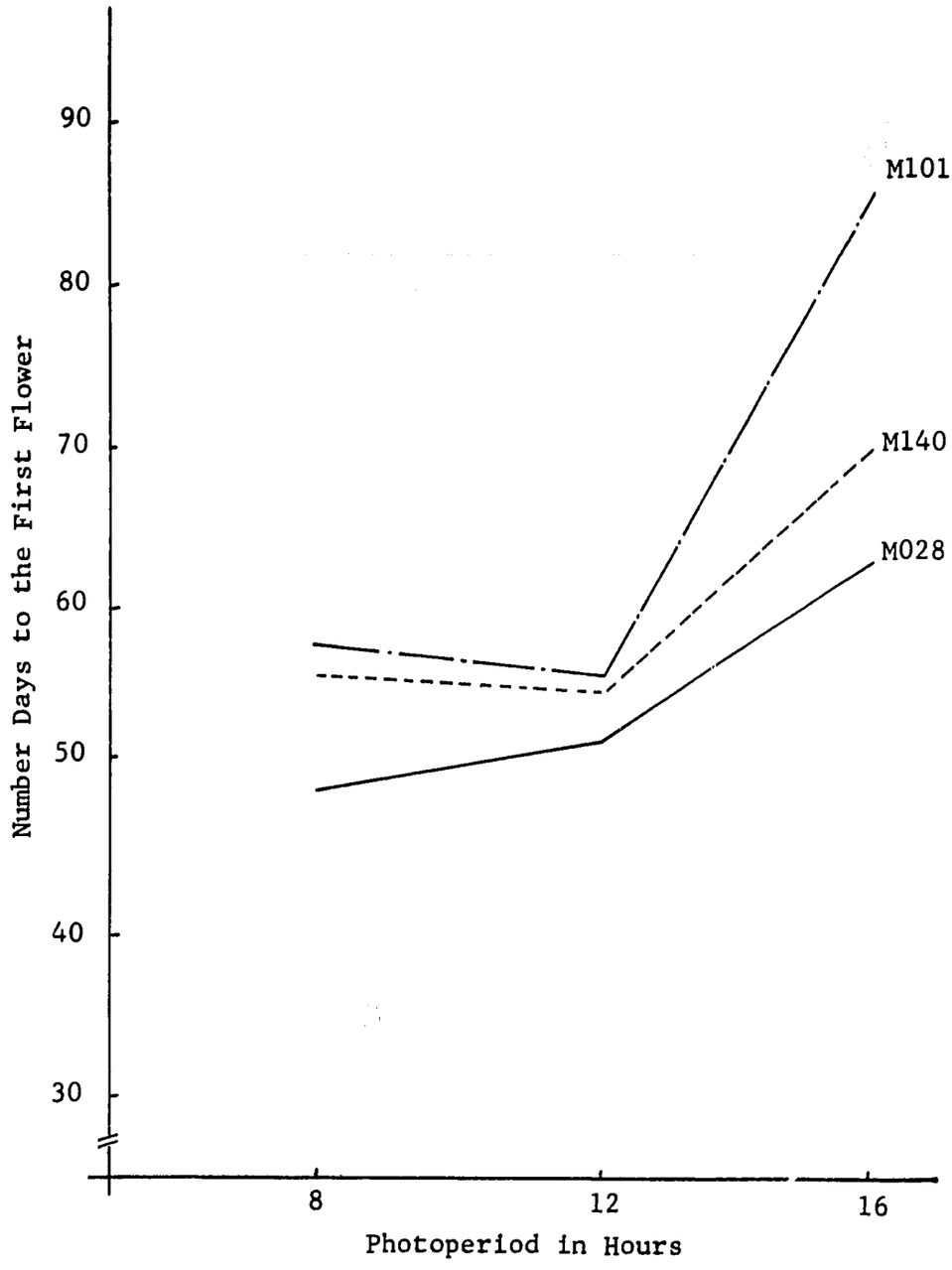

Figure 8. Days to the First Flower of Mungbean Varieties Grown at 8-, 12-, and 16-hour Photoperiods.

Table 11. Plant Height After 96 Days of Mungbean Varieties Grown at 8-, 12-, and 16-hour Photoperiods in Experiment B

Mo. Acc. No.	Plant Height in cm at Photoperiod of		
	8-hours	12-hours	16-hours
M028	11.5	14.0	21.5
M140	19.0	23.5	51.0
M101	19.0	21.0	44.0
M090	13.0	19.5	40.0
M118	14.0	18.0	38.0
M287	16.5	21.0	44.5
M328	21.0	27.0	53.0
M370	23.5	20.5	49.5
Mean	17.2 a[1]	20.6 a	42.7 b

[1]Means followed by the same letter are not significantly different at the 5% level of probability.

Table 12. Analysis of Variance for Plant Height of Mungbean Varieties Grown at 8-, 12-, and 16-hour Photoperiods in Experiment B

Source of Variance	D.F.	M.S.	F.	L.S.D.
Among Photoperiods	2	1534.88	34.15**	5.1
Error	21	44.17		
Total	23	1579.05		

**Significant at 5% level of probability.

(Table 13) indicating that the increase in height resulted from increases in internode length as in Experiment A.

Results of Experiments A and B Combined

Experiment B was conducted to confirm the results of Experiment A. Since the results from Experiment B appeared to be similar to the results from Experiment A, it appeared desirable to combine the data from the two experiments and analyze the combined data statistically.

Days to First Flower. Using the combined data from Experiments A and B, a separate analysis of variance was calculated for each photoperiod with experiments as replicates. Only three varieties flowered with the 16-hour photoperiod so a separate analysis of variance was calculated for each of these varieties within photoperiods. Also, a comparison was made for the performance in the 8-hour vs the 12-hour photoperiod. Summaries of these analyses are given in Table 14.

Consideration will be given first to the results of the analyses within photoperiods. The differences among varieties in the 8-hour photoperiod were statistically significant according to the F test, differences among varieties in the 12-hour photoperiod were not significant. These differences are comparable to those obtained in each Experiment A and Experiment B when the two experiments were analyzed separately. It is of interest that the varieties differed at the 8-hour

Table 13. Number of Internodes of Mungbean Varieties Grown at 8-, 12-, and 16-hour Photoperiods in Experiment B

Mo. Acc. No.	Number of Internodes at Photoperiod of		
	8-hours	12-hours	16-hours
M028	5.25	5.06	5.33
M140	4.81	5.13	5.25
M101	5.19	5.06	5.25
M090	5.38	5.19	5.75
M118	5.19	5.25	5.42
M287	5.44	5.06	6.33
M328	5.50	5.63	6.25
M370	5.38	5.13	6.00
Mean	5.26	5.19	5.70

Table 14. Analyses of Variance for Days to Flower of Mungbean Varieties in Experiments A and B Combined

Source of Variance	D.F.	M.S.	F.	L.S.D.
Within Photoperiods:				
Among Varieties (8-hour Photoperiod)	7	19.68	9.84**	1.4
Among Varieties (12-hour Photoperiod)	7	8.00	2.00	n.s.
Among Varieties (16-hour Photoperiod)[1]	2	4943.87	61.45**	6.2
Between Experiments (8-hour Photoperiod)	1	0.25	0.02	n.s.
Between Experiments (12-hour Photoperiod)	1	1.00	0.16	n.s.
Between Experiments (16-hour Photoperiod)[1]	1	79.48	0.29	n.s.
Within Varieties:				
Among Photoperiods (Variety M028)	2	40.16	1.93	n.s.
Among Photoperiods (Variety M140)	2	112.67	33.80**	2.5
Among Photoperiods (Variety M101)	2	1156.17	10.96*	14.2
Between Experiments (Variety M028)	1	20.16	0.66	n.s.
Between Experiments (Variety M140)	1	6.00	0.11	n.s.
Between Experiments (Variety M101)	1	104.17	0.17	n.s.
Between Photoperiods:				
8-hour vs 12-hour Photoperiod	1	5.062	0.780	n.s.

[1]Only three varieties flowered in the 16-hour photoperiod.

*Significant at 1% level. **Significant at 5% level.

photoperiod in both experiments, and overall, but not at the 12-hour photoperiod. Most of the varieties originated in areas at low latitudes where effective day lengths did not greatly exceed the 12-hour period. It may be that exposing them to 8-hour photoperiods subjects them to a selection pressure to which they are responding differently.

Only three varieties could be included in the analyses of the days to flowering for the 16-hour photoperiod since only three of the eight varieties flowered. Actually, the differences among varieties at the 16-hour photoperiod is much greater than signified by the F value in this analysis since five of the varieties failed to flower and therefore could not be included in the analysis. Differences between experiments were not significant either at the 8-, 12-, or 16-hour photoperiods, indicating that the results from the two experiments are similar with respect to overall performance of the varieties in each of the three photoperiods.

If we examine the analyses of variance for individual varieties among the different photoperiods, it may be noted that variety M028 did not differ significantly in days to flower among photoperiods. Variety M028 did not differ in days to flower in the different photoperiods in Experiment A but increased in days to flower as the photoperiod was increased in Experiment B. For the two experiments the days to flower for M028 was 50.5, 50.0, and 58.0,

respectively. Height of plant of M028 increased with increase in length of photoperiod. From the two experiments it appears that M028 may not be completely insensitive to increases in photoperiod as suggested from the data in Experiment A but it certainly is less sensitive than the other varieties. M028 originated in Orissa State, India, where mungbeans are usually planted in short days of winter (with an effective photoperiod between 11 and 12 hours).

M140 and M101 differed significantly among photoperiods. The differences resulted from an increase in days to flowering for both M140 and M101 as the photoperiods were increased. Neither M028, M140, nor M101 differ significantly for days to flower between the two experiments. This lack of significant differences between experiments for the varieties and for the photoperiods indicates that the results of Experiment B confirm those previously obtained in Experiment A. The results here further confirm those previously obtained in each Experiment A and B that, overall varieties, days to flower at the 8-hour photoperiod does not differ significantly from days to flower at the 12-hour photoperiod.

Plant Height. Analyses of plant height data for Experiments A and B are given in Table 15. These analyses show that the varieties differ significantly within photoperiods but that there are no significant differences between experiments with respect to either of the three

Table 15. Analyses of Variance for Plant Height of Mungbean Varieties in Experiments A and B Combined

Source of Variance	D.F.	M.S.	F.	L.S.D.
Within Photoperiods:				
Among Varieties (8-hour Photoperiod)	7	32.96	14.64**	4.2
Among Varieties (12-hour Photoperiod)	7	22.50	8.62**	1.1
Among Varieties (16-hour Photoperiod)	7	206.78	77.44**	1.6
Between Experiments (8-hour Photoperiod)	1	0.06	0.0034	n.s.
Between Experiments (12-hour Photoperiod)	1	13.14	1.11	n.s.
Between Experiments (16-hour Photoperiod)	1	4.52	0.04	n.s.
Within Varieties:				
Among Photoperiods (Variety M028)	2	39.85	39.85**	1.4
Among Photoperiods (Variety M140)	2	547.79	125.35**	2.9
Among Photoperiods (Variety M101)	2	413.11	619.63**	1.1
Among Photoperiods (Variety M190)	2	351.25	290.29**	1.5
Among Photoperiods (Variety M118)	2	288.16	288.16**	1.4
Among Photoperiods (Variety M287)	2	589.04	85.12**	3.6
Among Photoperiods (Variety M328)	2	543.79	214.04**	2.2
Among Photoperiods (Variety M370)	2	527.17	214.30**	2.2

photoperiods. These data further confirm that the responses of the varieties were similar in the two experiments. In general, as the number of days to flower increases, the height of the plant increases due to elongation of the internodes.

Experiment C

Results of Experiments A and B indicated, (1) that critical photoperiods for initiating flowering for most of the mungbean varieties studied under the conditions of these experiments were between 12 and 16 hours, and (2) that results obtained could be repeated with a high degree of accuracy. It appeared desirable to grow the same varieties in photoperiods of 13, 14, and 15 hours to learn whether the critical photoperiods for individual varieties could be pinpointed more specifically. Some other varieties which were being studied in the field were included also.

Materials and Methods

Experiment C was conducted using seven of the varieties of mungbeans grown in Experiments A and B and five new varieties and photoperiods of 13, 14, and 15 hours. The Missouri accession number, USDA Plant Introduction (P.I.) number, name, origin, and source of seed of the 12 varieties are given in Table 16. A comparison of the performance of these varieties in the field at

Table 16. Accession Numbers, Name, Origin, and Source of Seed of Mungbean Varieties Growing in Experiment C

Mo. Acc. No.	USDA P.I. No.	Name of Variety	Origin	Source of Seed
M025	368,288	Bhatili 3-4	India	UMC 1971
M028	368,291	Bhatili 2-3-7	India	UMC 1971
M038	368,299	Kusumi 1-10	India	UMC 1971
M047	368,307	Angul 3-6 (A)	India	UMC 1970
M090	223,711		India	UMC 1971
M101	271,401		India	UMC 1971
M118	180,311		India	UMC 1971
M140	31.290		USDA	UMC 1971
M299	271,405		India	UMC 1971
M328	317,465		Afghanistan	UMC 1971
M370	374,150	Chunbukjaerae	Korea	UMC 1971
M408		Morden	Canada	Morden, Manitoba, 1971

Columbia, Missouri, for the two-year period, 1970 and 1971, is given in Table 17.

Three photoperiods of 13, 14, and 15 hours were used with light sources as in Experiments A and B except that both fluorescent and incandescent bulbs were burned for 12 hours daily instead of 8 hours. The light period was extended by burning the incandescent bulbs only for 30 minutes before and after the full light period in the 13-hour growth chamber, for 60 minutes before and after in the 14-hour growth chamber, and for 90 minutes before and after in the 15-hour growth chamber. The light and temperature regimes are illustrated in Figure 9. The temperature regime and humidity were the same as in the preceding experiments. All other factors were kept as similar as possible.

Four pots containing four plants each were grown of all varieties except M025, M028, M038, and M047 for which only two pots containing four plants each were grown.

Observations were recorded for days to flower, plant height, and number of internodes. The experiment was terminated after 120 days.

The data were analyzed as in Experiments A and B.

Results and Discussion

Days to Flower. The mean number of days to the first flower for twelve varieties of mungbeans grown in 13-, 14-, and 15-hour photoperiods is given in Table 18.

Table 17. Two-year Average at Columbia, Missouri, (1970, 1971) for Growth Type, Days to First Flower, Height, Yield, 1000-Seed Weight, and Percent Virus Infection of Mungbean Varieties Grown in Experiment C

Mo. Acc. No.	Growth[1] Type (1-5)[2]	Days to First Flower	Length cm	Yield kg/ha	1000-seed Weight gm	Virus Infection %
M025	3.0	60	49	608	22	24
M028	3.0	67	41	294	24	22
M038	3.0	65	36	200	24	44
M047[3]		67	42	187	15	50
M090	1.3	59	77	2336	63	2
M101	1.0	62	45	1987	75	1
M118	1.7	60	71	2418	55	3
M140	3.3	46	48	1429	47	9
M299	3.0	42	38	482	40	8
M328	2.3	79	72	594	34	39
M370	2.0	59	75	1453	35	8
M408	Not grown in either 1970 or 1971					

[1]Data for 1971 only.

[2]1=prostrate; 2=semiprostrate; 3=intermediate; 4=semierect; 5=erect.

[3]Data for 1970 only.

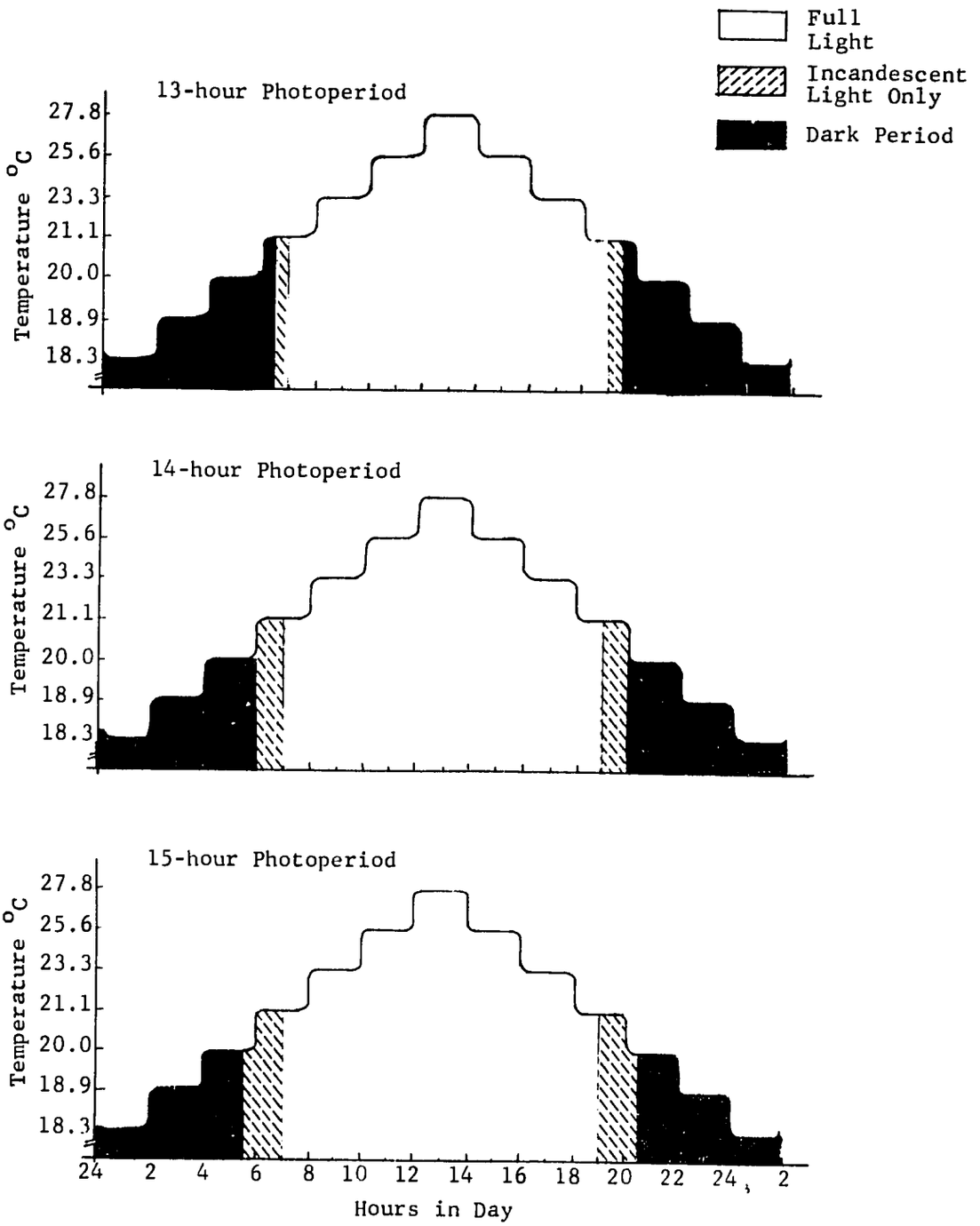

Figure 9. Light and Temperature Regimes Used in Growth Chambers to Provide 13-, 14-, and 15-hour Photoperiods.

Table 18. Number Days to First Flower of Mungbean Varieties Grown at 13-, 14-, and 15-hour Photoperiods in Experiment C

Mo. Acc. No.	Days to the First Flower at Photoperiods of[1]		
	13-hours	14-hours	15-hours
M028	42 a[1]	47 b[1]	54 c[1]
M025	42 a	47 b	54 c
M038	45 a	46 a	51 a
M047	42 a	45 a	52 b
M140	51 a	53 a	52 a
M299	52 a	60 b	51 a
M370	49 a	55 a	81 b
M408	62 a	68 b	71 b
M101	80 a	85 b	91 c
M090	85 a	90 b	91 b
M118	83 a	89 b	100 c
M328	80 a	97 b	95 b
Mean[2]	59.4 a	65.1 b	70.3 c

[1]Number of days to flower followed by the same letter for a variety (among photoperiods) are not significantly different at 5% level of probability.

[2]Means for photoperiods followed by the same letter are not significantly different at the 5% level of probability.

All plants of all varieties flowered in the 13-, 14-, and 15-hour photoperiods except for three plants which were lost from an apparent root rot disorder. The mean number of days to flower for the 12 varieties with the 13-hour photoperiod was 59.4 days; with the 14-hour photoperiod, 65.1 days; and with the 15-hour photoperiod, 70.3 days. The differences among the means were significant at the 5% level of probability (Tables 18 and 19).

Experiments A and B demonstrated that individual varieties differed in response to photoperiod. It appeared desirable, therefore, to examine the response of each variety separately. The analyses of variance for individual varieties for days to flower among photoperiods is shown in Table 19.

Inspection of the data for individual varieties suggests that they may be divided into five groups with respect to response in the three photoperiods. The varieties M028, M025, M038, and M047 appear to show similar responses to photoperiod being the earliest varieties to flower at the 13-hour photoperiod and increasing in days to flower as the photoperiods were increased in length. The mean for the four varieties were 42.75 days at the 13-hour, 46.25 at the 14-hour, and 52.75 days at the 15-hour photoperiods. Direct comparisons with Experiments A and B may not be fully valid since the plants in Experiment C were given 12 hours full light as compared to 8 hours in Experiments A and B. However, variety M028 as an

Table 19. Analyses of Variance for Days to Flower of Mungbean Varieties Grown in Experiment C

Source of Variance	D.F.	M.S.	F.	L.S.D.
Within Photoperiods:				
Among Varieties (13-hour Photoperiod)	11	3987.34	234.99*	3.5
Among Varieties (14-hour Photoperiod)	11	4896.81	286.01**	3.5
Among Varieties (15-hour Photoperiod)	11	5307.68	153.65**	5.0
Among Light Periods	2	5015.09	14.30**	4.1
Within Varieties:				
Among Photoperiods (M028)	2	367.792	28.633**	3.7
Among Photoperiods (M025)	2	283.792	52.168**	2.4
Among Photoperiods (M038)	2	67.792	4.620	n.s.
Among Photoperiods (M047)	2	196.125	9.107**	4.8
Among Photoperiods (M090)	2	143.409	12.405**	2.5
Among Photoperiods (M101)	2	506.271	33.729**	2.8
Among Photoperiods (M118)	2	1222.858	53.973**	3.5
Among Photoperiods (M140)	2	28.146	2.317	n.s.
Among Photoperiods (M299)	2	326.438	11.163**	3.9
Among Photoperiods (M328)	2	1333.000	16.204**	7.0
Among Photoperiods (M370)	2	3186.311	42.644*	6.3
Among Photoperiods (M408)	2	361.521	19.165*	3.1

average over Experiments A and B flowered in 50 days with the 12-hour and 58 days at the 16-hour photoperiods. In Experiment C it flowered in 42, 47, and 54 days at the 13-, 14-, and 15-hour photoperiods, respectively. These results are quite similar to those of Experiments A and B. It is not known why the flowering at 13 hours in Experiment C was earlier than in the 12-hours in Experiments A and B. However, the overall tendency to increase in days to flower with increased length of photoperiod is a similar trend. The data from Experiment C further suggests that M028 may not be photoinsensitive but that M028, along with M025, M038, and M047, may be less sensitive than the other varieties. The four varieties are of similar origin, all having been collected from cultivator's fields in Orissa State, India.

The second earliest group in flowering would include M140 and M299. M140 in Experiments A and B averaged 55 days at the 12-hour and 68 days at the 16-hour photoperiod. In Experiment C, M140, like M028, flowered earlier in the 13-hour photoperiod than in the 12-hour photoperiod in Experiments A and B. No increase in days to flower among photoperiods was noted in Experiment C, but in Experiments A and B the days to flower increased to 68 days at the 16-hour photoperiod. The origin of M140 is unknown. M299 flowered significantly later in the 14- than in the 13- and the 15-hour photoperiod. Additional trials should be made with this variety to determine the validity of this

observation. M299 originated in India and is the earliest variety to flower in the field at Columbia.

M370 flowered in 49 days with a photoperiod of 13 hours and in 55 days with 14 hours, but required 81 days at 15 hours. In Experiments A and B it flowered at 54 days in a photoperiod of 12 hours but did not flower at 16 hours. M370 originated in Korea.

M408 required 62 days to flower with a 13-hour photoperiod, 68 days with 14 hours, and 71 days at 15 hours. M408 came to us from Morden, Manitoba, Canada, where it flowers in the field with the long summer days at that latitude.

In the last group are placed M101, M090, M118, and M328. The mean days to flower for these four varieties with a photoperiod of 13 hours is 82 days, 90.25 days with a 14-hour photoperiod, and 94.25 days with a 15-hour photoperiod. In Experiments A and B, M101 flowered at 55 days in a 12-hour photoperiod and 99 days at 16 hours. M090, M118, and M328 flowered in 53, 53, and 50 days, respectively, at 12 hours, but none of them flowered at 16 hours in Experiments A and B indicating that the critical photoperiod for these varieties is between 12 and 16 hours.

Plant Height and Number of Internodes. The mean plant height in cm for the twelve varieties at the three photoperiods is given in Table 20. The height varied among varieties from 10 to 29 cm with an overall mean of 15.5 cm

Table 20. Plant Height after 100 Days of Mungbean Varieties Grown in 13-, 14-, and 15-hour Photoperiods in Experiment C

Mo. Acc. No.	Plant Height in cm at Photoperiod of		
	13-hours	14-hours	15-hours
M028	10	11	20
M025	11	10	19
M038	11	12	21
M047	11	11	21
M140	16	21	35
M299	14	13	22
M370	18	22	41
M408	14	17	27
M101	16	28	47
M090	19	22	41
M118	17	21	35
M328	29	39	59
Mean[1]	15.5 a	18.9 a	32.3 b

[1]Means for photoperiods followed by the same letter are not significantly different at the 5% level of probability.

in the 13-hour photoperiod. In the 14-hour photoperiod the range in plant height among varieties varied from 10 to 39 cm with an overall mean of 18.9 cm. In the 15-hour photoperiod, the range in plant height among varieties varied from 19 to 59 cm with an overall mean of 32.3 cm. In general these data show that there was a small but non-significant overall increase in plant height in the 14-hour as compared to the 13-hour photoperiod, and a significant increase in height in the 15-hour as compared to the 14-hour photoperiod (Table 21).

If response of individual varieties is examined it may be seen that they may be grouped for height in a similar manner as for days to flower. As flowering was delayed by extending the photoperiod the height of the plant was increased. One exception to the grouping may be noted in M328 which was 10 cm taller than any of the other varieties in the 13- and 14-hour photoperiods and 12 cm taller than any of the other varieties in the 15-hour photoperiod even though the days to flower were about the same as the other varieties in its group.

No significant increase in number of internodes was obtained with increase in photoperiod (Table 22). The data obtained in this experiment, as in the previous two experiments, suggest that the increase in plant height resulted from increases in internode length and not in internode number.

Plants of M028 grown at 13-, 14-, and 15-hour

Table 21. Analysis of Variance for Plant Height of Mungbean Varieties Grown in 13-, 14-, and 15-hour Photoperiods in Experiment C

Source of Variance	D.F.	M.S.	F.	L.S.D.
Between Photoperiods	2	950.08	10.75	8.3
Error	33	88.38		
Total	35	1038.46		

*Significant at 1% level of probability.

Table 22. Number of Internodes of Mungbean Varieties Grown at 13-, 14-, and 15-hour Photoperiods in Experiment C

Mo. Acc. No.	Number of Internodes at Photoperiod of		
	13-hours	14-hours	15-hours
M028	6	6	7
M025	5	6	7
M038	7	7	7
M047	7	7	6
M140	5	6	7
M299	6	6	6
M370	9	9	10
M408	7	8	8
M101	8	8	9
M090	9	8	9
M118	9	9	9
M328	11	10	10
Mean	7.42	7.50	7.92

photoperiods are shown in Figure 10 and plants of M328 are shown in Figure 11.

Field Observations

Genetic Variability within Varieties for Date of Flowering

The mungbean varieties used in this thesis study originally came to the University of Missouri from the U.S. Department of Agriculture. No information was available on the genetic purity of the varieties. This study was designed to evaluate the extent to which the variability in days to flower within a variety observed in the growth chamber was due to genetic variability. Seed was harvested separately from the earliest and the latest plant to flower for each variety at each the 8-hour and the 12-hour photoperiod in Experiment A. Progenies were grown in plant rows in the field at the UMC Bradford Farm, Columbia, Missouri, in 1972. Observations were made on days to first flower on five plants in each row. The data are recorded in Table 23. An analysis of variance calculated among the four seed sources, viz. early and late plants from each 8-hour and 12-hour photoperiods shows that days to flower among the four seed sources were not significantly different. This indicates that there was no measurable genetic variability within the strains for days to flower, and that the differences in days to flower among plants within a variety at a particu-

Figure 10. Comparison of Plant Height of M028 at 13-, 14-, and 15-hour Photoperiods.

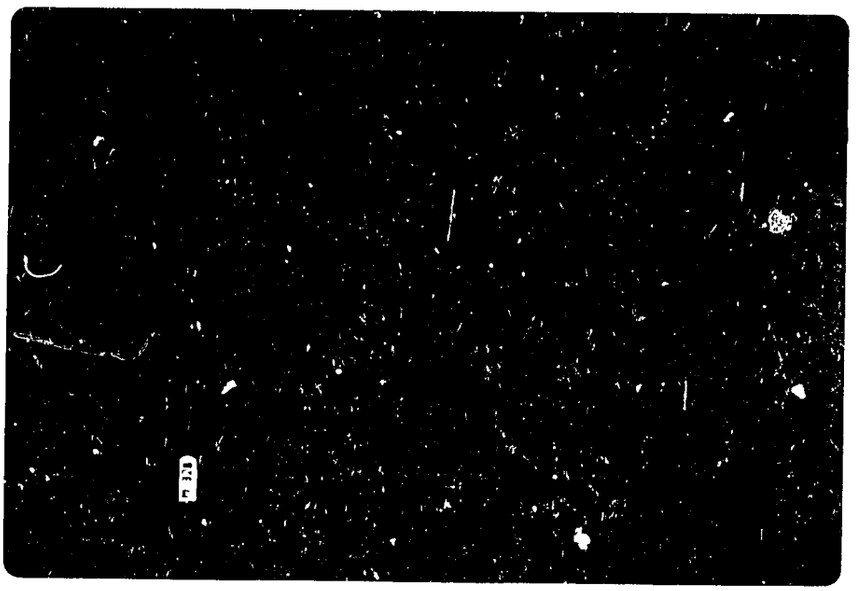

Figure 11. Comparison of Plant Height of M328 at 13-, 14-, and 15-hour Photoperiods.

Table 23. Number Days to First Flower for Progenies of the Earliest and Latest Plants from Each Variety in the 8-hour and 12-hour Photoperiods in Experiment A

Mo. Acc. No.	Mean Number Days to Flower for Progenies of: 8-hour Photoperiod		12-hour Photoperiod	
	Early Plant	Late Plant	Early Plant	Late Plant
M028	62	65	60	66
M090	70	68	71	70
M101	52	51	56	57
M118	71	75	69	74
M140	47	49	47	52
M287	72	73	74	76
M328	77	80	81	79
M370	69	69	71	64
Mean	65	66.25	66.13	67.75

F value for differences among means of seed sources = 0.062 (n.s.).

lar photoperiod in the growth chambers were due to micro-environmental influences.

CHAPTER IV

SUMMARY AND CONCLUSIONS

1. Two varieties of soybeans and eight varieties of mungbeans were grown at photoperiods of 8, 12, and 16 hours in Experiment A.
2. Fluorescent and incandescent bulbs were burned for a period of 8 hours in each growth chamber, and the light period was extended in the 12- and 16-hour photoperiod chambers by burning the incandescent bulbs only. Temperature and humidity in all growth chambers were similar.
3. The soybean variety, Chippewa 64 (maturity group I), flowered in 38 days in the 8- and 12-hour photoperiods but 50 days were required with the 16-hour photoperiod. The soybean variety Dare (maturity group V) flowered in 38, 48, and 72 days in the 8-, 12-, and 16-hour photoperiods, respectively.
4. All varieties of mungbeans flowered in the 8- and 12-hour photoperiods but only three varieties flowered in the 16-hour photoperiod within the 180 day period of the experiment. Variety M028 appeared to be relatively insensitive to photoperiod in Experiment A as number of days to flower for this variety did not differ significantly among photoperiods.

5. The mean number of days to flower at the 8-hour photoperiod did not differ significantly from that at the 12-hour photoperiod. Five varieties did not flower at the 16-hour photoperiod so the critical photoperiod to initiate flowering in these varieties was between 12 and 16 hours under the conditions of this experiment.
6. There was a significant increase in plant height at 16 hours in comparison to plant height at 12 hours. An exception may be noted for M028 in which the difference in day to flower was relatively small.
7. Increase in height was the result of longer internodes rather than increase in internode number.
8. In general, there was an increase in plant height corresponding to increases in days to flower.
9. Experiment B confirmed the results obtained in Experiment A except for M028 in which there were significant differences among photoperiods for number days to flower.
10. Experiment C was carried out with photoperiods of 13, 14, and 15 hours to see if the critical photoperiod for the varieties studied could be identified more accurately. Except that the full light period was extended to 12 hours all conditions were kept similar to those of Experiments A and B. Five additional varieties were included in Experiment C.

11. The varieties could be divided into five groups on the basis of response to photoperiod.
12. Height of plants increased in the longer photoperiods corresponding to increases in days to flower as in Experiments A and B.
13. Varieties which did not flower in Experiments A and B with a 16-hour photoperiod flowered in Experiment C in all photoperiods.
14. Progeny in the field of early and late plants from the growth chamber indicate that the variability in days to flower within varieties is due to environmental rather than genetic variations.
15. The mungbean may be classified as a short-day plant with a critical photoperiod between 12 and 16 hours.

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Appendix Table 1. Days to Flower of Mungbean Plants in Experiment A

Mo. Acc. No.	Rep. 1 Plant No. 1	Rep. 1 Plant No. 2	Rep. 1 Rep. av.	Rep. 2 Plant No. 1	Rep. 2 Plant No. 2	Rep. 2 Rep. av.	Rep. 3 Plant No. 1	Rep. 3 Plant No. 2	Rep. 3 Rep. av.	Rep. 4 Plant No. 1	Rep. 4 Plant No. 2	Rep. 4 Rep. av.	Expt. av.
8-hour Photoperiod													
M028	50	53	51.5	48	49	48.5	48	67	57.5	47	51	49.0	52
M090	50	54	52.0	51	55	53.0	61	68	64.5	51	57	54.0	56
M101	56	57	56.5	59	72	65.5	57	61	59.0	55	62	58.5	60
M118	50	53	51.5	50	52	51.0	52	54	53.0	50	58	54.0	52
M140	49	50	49.5	57	59	58.0	50	57	53.5	52	61	56.5	54
M287	52	52	52.0	48	49	48.5	48	49	48.5	53	56	54.5	51
M328	51	53	52.0	43	44	43.5	49	52	50.5	44	53	49.5	49
M370	54	59	56.5	56	59	57.5	50	51	50.5	51	71	61.0	56
Dare	37		37.0	38		38.0	39		39.0	40		40.0	38
Chippewa 64	37		37.0	38		38.0	39		39.0	39		39.0	38
12-hour Photoperiod													
M028	46	52	49.0	50	50	50.0	46	49	47.5	45	46	45.5	48
M090	49	52	53.5	49	54	51.5	52	56	54.0	52	54	53.0	52
M101	51	53	52.0	59		59.0	49	45	47.0	56	64	60.0	54
M118	55	59	57.0	52	54	53.0	56	58	57.0	51	57	54.0	55
M140	51	62	56.5	57	59	58.0	55	55	55.0	50	54	52.0	55
M287	55	67	60.5	49	61	55.0	50	54	52.0	50	52	51.0	55
M328	50	54	52.0	50	50	50.0	50	54	52.0	54	55	54.5	52
M370	50	55	52.5	49	52	50.5	59	64	61.5	48	64	56.0	55
Dare	47		47.0	48		48.0	49		49.0	49		49.0	48
Chippewa 64	37		37.0	37		37.0	38		38.0	39		39.0	38
16-hour Photoperiod													
M028	53	55	54.0	51	54	52.5	54	54	54.0	51	52	51.5	53
M090	118	N.F.	118.0	99*	103*	101.0	N.F.	N.F.		105**	119**	112.0	
M101	87*	94*	90.5	97	105	101.0	86**	94**	90.0	120	122	121.0	111
M118	117*	121*	119.0	102**	122**	112.0	N.F.	N.F.		N.F.	N.F.		
M140	71	74	72.5	57	60	58.5	59	71	65.0	63	70	66.5	66
M287	N.F.	N.F.		118*	120*	119.0	148	N.F.	148.0	118**	120**	119.0	
M328	113*	116	114.5	N.F.	N.F.		N.F.	N.F.		119**	120**	119.5	
M370	139	N.F.	139.0	N.F.	N.F.		120*	122*	121.0	117**	N.F.	117.0	
Dare	61		61.0	74		74.0	75		75.0	77		77.0	72
Chippewa 64	48		48.0	50		50.0	50		50.0	53		53.0	50

**16- and 12-hour Photoperiod.

*16- and 8-hour Photoperiod.

N.F. = never flowered.

Appendix Table 2. Plant Height in cm of Mungbean Plants in Experiment A

Mo. Acc. No.	Rep. 1 Plant No. 1	Rep. 1 Plant No. 2	Rep. 1 Rep. av.	Rep. 2 Plant No. 1	Rep. 2 Plant No. 2	Rep. 2 Rep. av.	Rep. 3 Plant No. 1	Rep. 3 Plant No. 2	Rep. 3 Rep. av.	Rep. 4 Plant No. 1	Rep. 4 Plant No. 2	Rep. 4 Rep. av.	Expt. av.
8-hour Photoperiod													
M028	12	13	12.5	13	14	13.5	12	13	12.5	13	14	13.5	13.0
M090	13	14	13.5	12	13	12.5	17	9	13.0	14	12	13.0	13.0
M101	21	20	20.5	18	18	18.0	20	19	19.5	21	15	18.0	19.0
M118	17	15	16.0	16	12	14.0	18	16	17.0	15	11	13.0	15.0
M140	25	23	24.0	23	20	21.5	19	19	19.0	21	18	19.5	21.0
M287	14	12	13.0	11	9	10.0	13	8	10.5	15	14	14.5	12.0
M328	27	23	25.0	26	20	23.0	21	19	20.0	22	22	22.0	22.5
M370	24	20	22.0	20	19	19.5	23	18	20.5	24	20	22.0	21.0
12-hour Photoperiod													
M028	12	13	12.5	11	12	11.5	14	15	14.5	13	14	13.5	13.0
M090	21	17	19.0	24	20	22.0	17	12	14.5	15	13	14.0	18.5
M101	23	19	21.0	20		20.0	20	15	17.5	22	19	20.5	19.5
M118	23	19	21.0	19	18	18.5	22	19	20.5	18	14	16.0	19.0
M140	21	17	19.0	25	19	22.0	20	14	17.0	24	20	22.0	20.0
M287	19	16	17.5	20	19	19.5	18	16	17.0	19	17	18.0	18.0
M328	28	24	26.0	26	15	20.5	28	27	27.5	25	19	22.0	24.0
M370	23	18	20.5	18	15	16.5	19	17	18.0	20	14	17.0	18.0
16-hour Photoperiod													
M028	15	18	16.5	20	20	20.0	21	23	22.0	18	19	19.5	19.5
M090	41	30	35.5	38	36	37.0	40	38	39.0	43	35	39.0	37.5
M101	53	47	50.0	48	43	45.5	40	35	37.5	49	45	47.0	45.0
M118	40	35	37.5	39	37	38.0	37	33	35.0	36	31	33.5	36.0
M140	53	40	47.5	54	46	50.0	48	46	47.0	49	48	48.5	48.0
M287	49	41	45.0	48	48	48.0	53	48	50.5	54	43	48.5	48.0
M328	58	44	51.0	53	49	51.0	58	49	53.5	49	48	48.5	51.0
M370	53	46	49.5	54	40	47.0	48	48	48.0	49	46	47.5	48.0

Appendix Table 4. Days to Flower of Mungbean Plants in Experiment B

Mo. Acc. No.	Rep. 1 Plant No. 1	2	3	4	Rep. av.	Rep. 2 Plant No. 1	2	3	4	Rep. av.	Rep. 3 Plant No. 1	2	3	4	Rep. av.	Rep. 4 Plant No. 1	2	3	4	Rep. av.	Expt. av.
8-hour Photoperiod																					
M028	46	48	49		47.67	48	48	49	52	49.25	46	48	50	52	49.00	49	49	51	52	52.25	49.13
M090	55	57	57	62	57.75	51	51	53	58	53.25	51	52	68	75	61.50	52	53	53	54	53.00	56.38
M101	53	59	59		57.00	56	58	63		59.00	56	58	61		58.33	56	57	58	62	58.25	58.15
M118	48	53	53	58	53.00	48	51	56		51.67	51	53	57	57	54.50	50	52	53	82	59.25	54.80
M140	52	53	53	59	54.25	53	55	56	58	55.50	51	55	56	58	55.00	56	57	58	63	58.50	55.81
M287	48	53	53	54	52.00	50	54	54	62	55.00	49	52	54	55	52.50	49	51	55	56	52.75	53.06
M328	47	55	55	63	55.00	45	45	47	48	46.25	45	46	51	52	48.50	49	51	53	54	51.75	50.38
M370	51	52	53	58	53.50	50	51	54	57	53.00	52	52	53	56	53.25	51	54	55	81	60.25	55.00
M221	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF											NF
12-hour Photoperiod																					
M028	48	49	50	53	50.00	50	51	52		51.00	49	53	54	56	53.00	49	53	53	55	52.50	51.62
M090	50				50.00	52	53	58	60	55.75	51	51	53	58	53.25	50	51	58	58	54.25	54.08
M101	49	53	55	70	56.75	50	52	54	62	54.50	54	54	57	63	57.00	51	53	61	64	57.25	56.38
M118	50	51	53	54	52.00	48	49	51	53	50.25	48	51	53	56	52.00	46	49	51	53	49.75	51.00
M140	48	55	57	60	55.00	55	56	57	60	57.00	48	52	57	63	55.00	50	51	52	54	51.75	54.69
M287	49	50	53	59	52.75	50	51	53	56	52.50	50	52	53	61	54.00	51	52	53	61	54.25	53.38
M328	48	49	51	53	50.25	45	46	47	47	46.25	48	48	50	51	49.25	47	48	48	49	48.00	48.44
M370	50	51	51	53	51.25	52	54	55	63	56.00	50	52	54	54	52.50	49	51	53	56	52.25	53.00
M221	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF											
16-hour Photoperiod																					
M028	59	59	68		62.00	53	62			57.50	59	61	68	76	66.0						62.78
M090	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF						NF
M101	82	82	84	90	84.50	82	84	88	91	86.25	83	86	93		87.33						85.91
M118	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF						NF
M140	64	66	69	81	70.00	64	68	71	73	69.00	65	69	75	76	71.25						70.08
M287	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF						NF
M328	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF						NF
M370	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF						NF
M221	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF		NF

NF = never flowered.

Appendix Table 3. Number of Internodes of Mungbean Plants in Experiment A

Mo. Acc. No.	Rep. 1 Plant No. 1	Rep. 1 Plant No. 2	Rep. av.	Rep. 2 Plant No. 1	Rep. 2 Plant No. 2	Rep. av.	Rep. 3 Plant No. 1	Rep. 3 Plant No. 2	Rep. av.	Rep. 4 Plant No. 1	Rep. 4 Plant No. 2	Rep. av.	Expt. av.
8-hour Photoperiod													
M028	5	5	5	5	5	5	6	6	6	5	5	5	5.25
M090	5	5	5	6	6	6	5	5	5	6	6	6	5.50
M101	6	6	6	6	6	6	6	6	6	6	6	6	6.00
M118	5	5	5	5	5	5	6	6	6	6	6	6	5.50
M140	6	6	6	6	6	6	6	6	6	6	6	6	6.00
M287	5	5	5	6	6	6	6	6	6	5	5	5	5.50
M328	5	5	5	6	6	6	5	5	5	6	6	6	5.50
M370	5	5	5	6	6	6	6	6	6	6	6	6	5.75
12-hour Photoperiod													
M028	5	5	5	5	5	5	5	5	5	5	5	5	5.00
M090	6	6	6	5	5	5	5	5	5	5	5	5	5.25
M101	6	6	6	6		6	5	5	5	5	5	5	5.50
M118	5	5	5	6	6	6	5	5	5	5	5	5	5.25
M140	6	6	6	5	5	5	5	5	5	5	5	5	5.25
M287	5	5	5	5	5	5	5	5	5	5	5	5	5.00
M328	5	5	5	5	5	5	5	5	5	5	5	5	5.00
M370	6	6	6	5	5	5	5	5	5	6	6	6	5.50
16-hour Photoperiod													
M028	5	5	5	6	6	6	5	5	5	5	5	5	5.25
M090	6	6	6	5	5	5	6	6	6	5	5	5	5.50
M101	6	6	6	5	5	5	5	5	5	5	5	5	5.25
M118	5	5	5	6	6	6	5	5	5	5	5	5	5.25
M140	6	6	6	5	5	5	5	5	5	5	5	5	5.25
M287	6	6	6	6	6	6	5	5	5	5	5	5	5.50
M328	5	5	5	5	5	5	5	5	5	5	5	5	5.00
M370	6	6	6	5	5	5	5	5	5	6	6	6	5.50

Appendix Table 5. Plant Height in cm of Mungbean Plants in Experiment B

Mo. Acc. No.	Rep. 1 Plant No. 1	2	3	4	Rep. av.	Rep. 2 Plant No. 1	2	3	4	Rep. av.	Rep. 3 Plant No. 1	2	3	4	Rep. av.	Rep. 4 Plant No. 1	2	3	4	Rep. av.	Expt. av.
8-hour Photoperiod																					
M028	14	10	12		12.00	13	12	11	10	11.50	14	12	12	10	12.00	12	10	10	9	10.25	11.50
M090	15	14	13	12	13.50	16	14	14	14	14.50	15	12	12	10	12.25	13	13	11	11	12.00	13.00
M101	21	17	18		18.75	23	19	19		10.25	25	19	17		20.33	20	23	19	14	19.00	19.00
M118	17	15	14	10	14.00	14	14	11		13.00	17	15	13	12	14.25	18	17	14	13	15.50	14.00
M140	23	22	20	19	21.00	19	19	18	18	18.50	23	22	19	18	20.50	18	18	14	14	16.00	19.00
M287	19	18	16	15	17.00	20	18	19	16	18.25	19	16	15	12	15.50	17	15	15	14	15.25	16.50
M328	25	24	20	19	22.00	21	20	19	18	19.50	24	23	18	17	20.50	25	24	20	19	22.00	21.00
M370	28	27	22	21	24.50	24	23	21	20	22.00	27	25	20	20	23.00	27	26	23	22	24.50	23.50
12-hour Photoperiod																					
M028	16	16	14	13	14.75	17	16	15		16.00	16	14	12	10	13.00	15	13	12	11	12.75	14.00
M090	24				24.00	21	20	18	17	19.00	21	19	15	14	19.25	23	21	19	18	20.25	19.50
M101	24	23	18	17	20.50	25	24	20	19	22.00	21	20	19	18	19.50	24	22	22	20	22.00	21.00
M118	22	21	19	18	20.00	18	18	17	17	17.50	22	21	18	17	19.50	17	17	13	13	15.00	18.00
M140	27	26	23	22	24.50	24	23	21	20	22.00	28	27	22	21	24.50	27	25	20	20	23.00	23.50
M287	23	20	18	17	20.00	24	22	22	20	22.00	25	23	21	19	22.00	24	23	20	15	20.50	21.00
M328	29	26	24	23	25.50	30	28	28	26	28.00	31	29	27	25	28.00	30	29	26	21	26.50	27.00
M370	24	23	20	19	21.50	20	19	19	18	19.00	23	22	18	17	20.00	24	23	20	19	21.50	20.50
16-hour Photoperiod																					
M028	24	21	17		19.75	25	23			22.50	25	23	21	20	22.25						21.50
M090	48	48	44	40	45.00	43	41	40	38	40.50	35	34	32	30	32.75						40.00
M101	51	49	48	46	48.50	44	41	37	35	39.00	47	45	44		44.50						44.00
M118	42	41	35	34	38.00	39	38	37	36	37.50	41	39	38	36	38.50						38.00
M140	59	58	43	44	51.00	54	53	50	49	51.50	53	50	50	49	50.50						51.00
M287	53	52	47	46	49.50	47	43	41	39	42.50	46	41	40	39	41.50						44.50
M328	59	58	47	48	53.00	54	43	54	53	53.50	55	52	51	51	52.50						53.00
M370	58	57	52	51	54.50	53	52	48	47	50.00	47	45	43	40	43.75						49.50

Appendix Table 6. Number of Internodes of Mungbean Plants in Experiment B

Mo. Acc. No.	Rep. 1 Plant No. 1	2	3	4	Rep. av.	Rep. 2 Plant No. 1	2	3	4	Rep. av.	Rep. 3 Plant No. 1	2	3	4	Rep. av.	Rep. 4 Plant No. 1	2	3	4	Rep. av.	Expt. av.
8-hour Photoperiod																					
M028	6	5	5		5.33	6	5	5	5	5.25	6	5	5	4	5.00	6	6	5	5	5.50	5.25
M090	6	5	5	5	5.25	6	6	5	5	5.50	6	6	5	5	5.50	6	5	5	5	5.25	5.38
M101	5	5	5		5.00	6	5	5		5.33	6	6	5		5.66	6	5	5	5	5.25	5.19
M118	5	5	5	5	5.00	6	5	5		5.33	6	5	5	5	5.25	6	5	5	5	5.25	5.19
M140	5	5	4	4	4.50	5	5	5	5	5.00	5	5	5	4	4.75	5	5	5	5	5.00	4.81
M287	6	6	5	5	5.50	6	6	6	5	5.75	6	5	5	5	5.25	6	5	5	5	5.25	5.44
M328	6	6	5	5	5.50	6	6	5	5	5.50	6	6	5	5	5.50	6	6	5	5	5.50	5.50
M370	6	5	5	5	5.25	6	6	5	5	5.50	6	6	5	5	5.50	6	5	5	5	5.25	5.38
12-hour Photoperiod																					
M028	5	5	5	5	5.00	5	5	5		5.00	6	5	5	5	5.25	5	5	5	5	5.00	5.06
M090	6				6.00	5	5	5	4	4.75	5	5	5	5	5.00	5	5	5	5	5.00	5.19
M101	6	5	5	5	5.25	5	5	5	5	5.00	5	5	5	5	5.00	5	5	5	5	5.00	5.06
M118	6	5	5	5	5.25	6	5	5	5	5.25	6	5	5	5	5.25	6	5	5	5	5.25	5.25
M140	6	6	5	5	5.50	5	5	4	4	4.50	5	5	5	5	5.00	6	6	5	5	5.50	5.13
M287	6	6	5	5	5.50	5	5	5	5	5.00	5	5	5	4	4.75	5	5	5	5	5.00	5.06
M328	6	5	5	5	5.25	6	6	5	5	5.50	7	6	5	5	5.75	6	6	6	6	6.00	5.63
M370	6	5	5	5	5.25	6	5	5	5	5.25	5	5	5	5	5.00	5	5	5	5	5.00	5.13
16-hour Photoperiod																					
M028	6	6	5		5.66	6	5			5.50	6	5	5	5	5.25						5.33
M090	7	6	5	5	5.75	7	6	5	5	5.75	7	6	5	5	5.75						5.75
M101	6	5	5	5	5.25	6	5	5	5	5.25	6	5	5		5.33						5.25
M118	6	6	5	5	5.50	6	5	5	5	5.25	6	6	5	5	5.50						5.42
M140	6	5	5	5	5.25	6	5	5	5	5.25	6	5	5	5	5.25						5.25
M287	7	7	6	5	6.25	7	6	5	5	5.75	7	6	5	5	5.75						6.33
M328	8	7	7	6	7.00	7	7	5	5	6.00	7	6	5	5	5.75						6.25
M370	6	6	5	5	5.50	7	7	6	5	6.25	7	7	6	5	6.25						6.00

Appendix Table 7. Days to Flower of Mungbean Plants in Experiment C

Mo. Acc. No.	Rep. 1 Plant No. 1	2	3	4	Rep. av.	Rep. 2 Plant No. 1	2	3	4	Rep. av.	Rep. 3 Plant No. 1	2	3	4	Rep. av.	Rep. 4 Plant No. 1	2	3	4	Rep. av.	Expt. av.
13-hour Photoperiod																					
M025	39	40	41	44	41.00	42	42	43	43	42.50											41.75
M028	39	41	43	45	42.00	42	42	43	44	42.75											42.38
M038	44	46	47	53	47.50	38	41	45	48	43.00											45.25
M047	42	42	44	45	43.25	38	40	42	42	40.50											41.88
M090	78	84	85	89	84.00	84	86	88	90	87.00	79	84	91	91	86.25	80	84	86	88	84.50	85.44
M101	65	77	78	81	75.25	77	80	82	83	80.50	81	82	83	88	83.50	77	78	80	80	78.75	79.50
M118	77	79	86	94	84.00	75	83	86	92	84.00	80	83	86	90	84.75	73	77	78	83	77.75	82.63
M140	47	48	52	56	50.75	47	48	51	52	49.50	44	48	56	59	51.75	46	47	53	54	50.00	50.50
M299	46	47	54	54	50.25	52	53	54	57	54.00	51	54	56	57	54.50	42	46	54	54	49.00	51.94
M328	76	77	80	83	79.00	81	83	84	85	83.25	79	81	83	83	81.50	71	72	80	81	76.00	79.94
M370	47	48	51	51	49.25	47	49	49	50	48.75	46	48	50	50	48.50	48	48	51	51	49.50	49.00
M408	56	64	67	67	63.75	60	62	64	67	63.75	54	60	62	67	60.75	57	59	59	67	60.50	62.00
14-hour Photoperiod																					
M025	45	46	49	50	47.50	44	46	46	49	46.25											46.88
M028	44	45	48	50	46.75	41	45	49	50	46.25											46.50
M038	42	43	45	49	44.75	45	45	46	53	47.25											46.00
M047	39	42	45	45	42.75	46	47	47	51	47.75											45.25
M090	85	91	92	94	90.50	86	91	94	91	90.50	90	91	94	86	90.25	86	88	92	92	89.50	90.19
M101	81	85	87	93	86.50	82	85	86	87	85.00	84	84	85	86	84.75	83	83	85	87	84.50	85.19
M118	86	87	91	92	89.00	85	86	87	88	86.50	87	88	96		90.33	85	86	90	92	88.25	88.40
M140	54	54	55	56	54.75	48	49	51	57	51.25	48	54	54	55	52.75	51	52	54	57	53.50	53.06
M299	47	51	51	60	52.25	50	64	67	71	63.00	57	64	65	68	63.50	52	54	62	66	58.25	59.25
M328	86	93	96	100	93.75	89	96	98	103	96.50	90	96	104		96.66	96	100	101	103	100.00	96.73
M370	51	53	57	60	55.25	53	54	55	57	54.75	52	54	56		54.00	52	53	56	66	56.75	55.27
M408	59	60	66	67	63.00	71	71	71	73	71.50	69	69	74	76	72.00	63	64	65	75	66.75	68.31
15-hour Photoperiod																					
M025	49	54	56	57	54.00	50	52	55	56	53.25											53.63
M028	52	53	55	57	54.25	52	53	56	67	57.00											55.63
M038	48	49	51	53	50.25	47	48	52	57	51.00											50.63
M047	43	50	51	52	49.00	48	50	52	67	54.25											51.63
M090	92	93	94	97	94.00	88	92	92	92	91.00	87	88	91	93	89.75	85	89	90	91	88.75	90.88
M101	79	92	93	94	89.50	88	91	91	93	90.75	88	88	94	94	91.00	90	91	93	93	91.75	90.75
M118	93	98	102	108	100.25	98	100	102	103	100.75	94	103	105	100	100.50	96	98	100	103	99.25	100.19
M140	49	51	54	54	52.00	53	54	54	55	54.00	49	50	54	55	52.00	46	48	56	56	51.50	52.38
M299	50	50	56	57	53.25	46	50	50	55	50.25	48	51	52	56	51.75	47	48	50	50	48.75	51.00
M328	89	95	100	101	96.25	102	108	109	109	107.00	92	94	94	100	95.00	48	93	108	79	82.00	95.06
M370	79	80	80	83	80.50	81	81	81	83	81.50	80	81	83	83	81.75	79	80	81	83	80.75	81.13
M408	68	71	75	77	72.75	68	69	72	73	70.50	69	69	75	77	72.50	67	68	71	72	69.50	71.31

Appendix Table 8. Plant Height in cm of Mungbean Plants in Experiment C

Mo. Acc. No.	Rep. 1 Plant No. 1	2	3	4	Rep. av.	Rep. 2 Plant No. 1	2	3	4	Rep. av.	Rep. 3 Plant No. 1	2	3	4	Rep. av.	Rep. 4 Plant No. 1	2	3	4	Rep. av.	Expt. av.
13-hour Photoperiod																					
M025	12	11	11	10	11.00	12	11	10	10	10.75											10.87
M028	12	10	9	9	10.00	11	11	10	9	10.25											10.13
M038	12	12	12	11	11.75	12	11	11	10	11.00											11.38
M047	13	12	10	10	11.25	12	12	11	9	11.00											11.13
M090	19	19	18	18	18.50	21	18	19	19	19.25	19	19	19	17	18.50	20	19	19	18	19.00	18.81
M101	18	16	15	15	16.00	18	17	16	15	16.50	18	16	15	14	15.75	18	16	15	14	15.75	16.00
M118	13	17	17	16	15.75	16	15	21	16	17.00	17	17	15	16	16.25	17	21	17	20	18.75	16.93
M140	17	16	16	16	16.25	17	17	16	16	16.50	18	16	16	14	16.00	19	15	15	14	15.75	16.13
M299	15	13	13	11	13.00	17	15	14	11	14.25	14	13	12	11	12.50	16	16	14	13	14.75	13.63
M328	30	30	28	26	28.50	33	29	27	24	28.25	31	30	29	27	29.25	33	29	29	27	29.50	28.88
M370	21	21	20	19	20.25	19	19	18	16	18.00	18	18	18	18	18.00	17	17	18	17	17.25	18.38
M408	17	15	13	13	14.50	16	14	15	15	15.00	16	13	13	12	13.50	17	15	12	11	13.75	14.19
14-hour Photoperiod																					
M025	11	10	10	10	10.25	9	11	10	10	10.00											10.13
M028	13	11	11	11	11.50	12	12	12	9	11.25											11.38
M038	11	11	10	10	10.50	10	16	12	12	12.50											11.50
M047	13	12	11	11	11.75	9	12	11	10	10.50											11.13
M090	22	22	21	21	21.50	19	22	22	21	21.00	26	25	21		24.00	24	22	21	20	21.75	22.06
M101	30	29	26	26	27.75	24	32	30	29	28.75	32	31	31	27	30.25	31	30	30	24	28.75	27.63
M118	20	20	19	19	19.50	19	23	20	21	20.67	21	21	20		20.67	26	23	21	18	22.00	20.71
M140	24	24	24	24	24.00	22	23	22	20	21.75	24	23	22	20	22.25	27	24	23	23	24.25	20.56
M299	13	13	12	12	12.50	12	15	15	13	13.75	17	14	13	12	14.00	14	14	13	11	13.00	13.31
M328	42	37	35	35	37.25	35	43	40	39	39.25	43	42	40		41.67	41	40	40	37	39.50	39.42
M370	26	24	22	22	23.50	22	20	20	19	20.25	27	22	19		22.67	24	20	18	18	20.00	21.61
M408	17	16	16	15	16.00	15	20	18	17	17.50	21	19	17	15	18.00	19	19	17	16	17.75	17.31
15-hour Photoperiod																					
M025	21	20	19	19	19.75	21	20	18	17	19.00											19.38
M028	23	21	21	16	20.25	22	21	18	16	19.25											19.75
M038	22	20	20	18	20.00	23	22	22	21	22.00											21.00
M047	24	23	20	20	21.75	22	20	19	18	19.75											20.75
M090	45	43	42	42	43.00	45	41	38	36	40.00	44	43	43	38	42.00	38	42	39	38	39.25	41.06
M101	50	49	48	48	48.75	48	46	46	45	46.25	49	47	46	46	47.00	45	47	47	46	46.25	47.06
M118	35	34	29	27	31.25	38	38	35	43	38.50	38	35	35	35	35.75	36	36	34	31	34.33	34.96
M140	39	39	35	35	37.00	39	35	35	33	35.50	40	36	34	31	35.25	30	39	34	30	33.25	35.25
M299	22	22	21	18	20.75	24	23	21	20	22.00	24	26	24	23	24.25	22	24	23	21	22.50	22.38
M328	63	59	57	49	57.00	59	56	52	56	55.67	58	61	60	58	59.25	55	55	38		49.33	58.79
M370	48	45	43	43	44.75	46	38	37	34	38.75	45	43	40	38	41.50	37	43	40	40	40.00	41.25
M408	28	27	26	25	26.50	29	26	25	24	26.00	24	30	30	27	27.75	24	29	29	28	27.50	26.94

Appendix Table 9. Number of Internodes of Mungbean Plants in Experiment C

Mo. Acc. No.	Rep. 1 Plant No. 1	2	3	4	Rep. av.	Rep. 2 Plant No. 1	2	3	4	Rep. av.	Rep. 3 Plant No. 1	2	3	4	Rep. av.	Rep. 4 Plant No. 1	2	3	4	Rep. av.	Expt. av.
13-hour Photoperiod																					
M025	5	5	5	5	5.00	6	6	6	5	5.75											5.38
M028	7	7	6	6	6.50	7	6	6	6	6.25											6.38
M038	8	7	7	6	7.00	7	6	6	5	6.00											6.50
M047	7	6	6	6	6.25	7	7	7	7	6.75											6.50
M090	9	9	9	9	9.00	10	9	9	8	9.00	10	8	8	10	9.00	9	9	9	9	9.00	9.00
M101	8	7	7	7	7.25	8	8	8	8	8.00	9	8	8	7	8.00	10	8	8	8	8.50	7.94
M118	9	9	9	9	9.00	8	7	10	9	8.50	9	9	9	10	9.25	10	10	9	9	9.50	9.06
M140	6	6	5	5	5.50	6	6	5	5	5.50	6	5	5	5	5.25	6	6	5	5	5.50	5.44
M299	5	5	5	5	5.00	6	6	6	6	6.00	7	8	6	5	6.00	7	7	7	6	6.75	5.94
M328	11	10	11	11	10.75	11	11	12	10	11.00	11	10	11	11	10.75	12	9	9	9	9.75	10.56
M370	9	10	9	9	9.25	9	9	9	10	9.25	9	8	8	9	8.50	8	9	7	9	8.25	8.81
M408	8	7	7	7	7.25	7	9	5	5	6.50	7	7	7	7	7.00	8	8	8	7	7.75	7.13
14-hour Photoperiod																					
M025	7	7	6	5	6.25	7	6	6	6	6.25											6.25
M028	6	6	6	6	6.00	6	6	6	6	6.00											6.00
M038	7	7	7	6	6.75	7	7	7	6	6.75											6.75
M047	7	7	6	6	6.50	7	7	7	6	6.75											6.63
M090	9	9	8	9	8.75	9	8	8	8	8.25	8	9	9	9	8.75	9	8	8	7	8.00	8.44
M101	9	8	8	7	8.00	9	9	8	8	8.50	9	9	9	8	8.75	9	8	8	7	8.00	8.31
M118	9	9	9	9	9.00	10	10	9	9	9.50	9	9	8		8.66	10	9	9	8	9.00	9.04
M140	7	7	6	5	6.25	6	6	6	6	6.00	6	6	6	6	6.00	7	6	6	6	6.25	6.13
M299	6	6	6	5	5.75	7	6	6	5	6.00	8	7	7	7	7.25	8	7	6	6	6.75	6.44
M328	11	9	9	11	10.00	10	10	9	9	9.50	11	10	10		10.25	11	10	9	9	9.75	9.88
M370	9	10	9	9	9.25	9	8	8	7	8.00	11	8	8		9.00	9	8	8	7	8.00	8.50
M408	9	8	8	7	8.00	9	8	8	7	8.00	9	8	8	8	8.25	9	8	8	8	8.25	8.13
15-hour Photoperiod																					
M025	7	7	6	6	6.50	8	8	8	8	8.00											7.25
M028	9	8	6	6	7.25	8	8	7	6	7.25											7.25
M038	7	7	7	6	6.75	8	7	7	7	7.25											7.00
M047	6	6	6	6	6.00	8	6	6	6	6.50											6.25
M090	9	9	8	7	8.25	10	9	9	8	9.00	9	9	9	8	8.75	10	9	9	9	9.25	8.81
M101	11	10	8	8	9.25	10	9	10	8	9.25	10	8	9	9	9.00	10	9	9	9	9.25	9.19
M118	9	9	9	8	8.75	10	8	8	7	8.25	9	9	8	8	8.50	9	9	9	8	8.75	8.60
M140	8	7	6	6	6.75	7	6	6	6	6.25	6	6	6	6	6.00	8	7	7	7	7.25	6.81
M299	6	6	6	5	5.75	6	6	6	6	6.00	7	7	6	6	6.50	7	7	6	5	6.25	6.13
M328	12	11	9	10	10.50	13	11	11	9	11.00	11	11	11	10	10.75	11	9	8	10	9.50	10.40
M370	11	11	9	10	10.25	11	10	10	9	10.00	11	10	10	10	10.25	11	11	10	10	10.50	10.25
M408	8	8	8	8	8.00	9	8	8	8	8.25	9	8	8	7	8.00	9	7	7	7	7.50	7.94