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Agro-physiological Studies on the Yield Performance of Mungbean

I. Cultivaral differences in earliness in flowering and their relationships with growth and seed yield*

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Abstract : The growth and yield performance of 24 mungbean cultivars selected from initial 83 introductions based on 1987 trials, were evaluated in field experiments to identify the cultivars suited for cultivation in warm temperate environment and to examine the basis of high yield. Relationships among earliness in flowering, growth, and seed yield were examined. The number of days to first flower (DFF) was positively correlated with plant height, number of primary branches, and vegetative, reproductive, and total main-stem nodes. However, DFF was negatively correlated with the percentage of reproductive nodes to total number of main-stem nodes, number of days to first mature pod, reproductive stage duration, and seed yield. Thus, the early flowering cultivars had limited vegetative growth, but had a long reproductive growth duration and produced high seed yield. Late flowering cultivars had significantly more vegetative and reproductive main-stem nodes but very low seed yield. Yield was negatively correlated with all vegetative parameters. However, some high yielders, including the top yielding KUS, the Indian origin check, had a high degree of vegetative growth. The generally lower yield of some cultivars in 1988 was partly due to the attack of spider mite (*Tetranychus* sp.). The KUS check cultivar which flowered relatively early, had a long reproductive growth duration, and the highest 2-year mean seed yield of 191 g m^{-2}, appears to be the "Ideo-type" for warm temperate environments.
Key words : Earliness in flowering, Ideo-type, Mungbean, Reproductive growth, Vegetative growth, *Vigna radiata* (L.) Wilczek, Seed yield.

リョクトウの収量成立に関する栽培生理学的研究　第1報　開花の早晩性における品種間差異とその生育及び子実収量との関係：フランシスコ，P.B., Jr.・前田和美［愛媛大学大学院連合農学研究科・(高知大学農学部)］

要　旨：リョクトウの"Ideo-type"の特性を知るためにインド産1を含むアジア各地域産の在来及び育成品種計83を5月中旬に播種し，開花の早晩により I～III の3群に分け，高知での採種が可能な弱感光性品種群（II）の24品種について2ヵ年にわたり圃場条件で栄養生長，生殖生長諸特性，子実収量などと開花の早晩性との関係を調べた．播種後開花始迄日数（DFF）は，両年で46～63，43～65日，平均約52日で変異係数は約10%と小さく，草丈，1次分枝数，主茎の栄養節数，生殖節数及び総節数とは高い有意な正の相関を示した．DFFはまた生殖節数/主茎総節数割合，莢実成熟始迄日数（播種後），生殖生長期間および子実収量とは負の相関を示し，開花の早い品種では栄養生長の期間が抑えられて生殖生長期間が長くなり，子実収量が増加したが，開花の遅い品種では栄養節と生殖節数の増加が多収化に寄与しなかった．子実収量は多くの栄養生長指標形質とは負の相関を示したが，両年とも最高収量（平均191 g m^{-2}）を示したインドの在来品種起源の系統KUS（高知大学選抜系1-19）を含む開花の早い高収量の数品種は概して栄養生長量が優れた．この系統KUSは温暖な温帯地域の環境条件に適したリョクトウの"Ideo-type"の特性を具えていることが示唆された．
キーワード：Ideo-type，栄養生長，開花の早晩性，子実収量，生殖生長，リョクトウ．

In spite of the long history of cultivation of mungbean, *Vigna radiata* (L.) Wilczek, it remains as one of the least-researched legume crops. Its agricultural potential which remains substantially under-exploited, and the increasing demand for additional sources of protein, have stimulated great interest in the crop. This is because mungbean is a high quality protein source, and a short-duration crop with good adaptability to diverse cropping systems and to a wide range of environmental conditions.

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Mungbean exhibits high plasticity in phenology and morphology depending upon the genotype, growing season, and place of sowing[4,6]. Mungbean, therefore, is notorious for its low and unpredictable yield and its high yield potential is seldom realized. Analysis of the data obtained from the series of International Mungbean Nursery (IMN) Yield Trials indicated that 60 to 80% of the variation in yield is due to the environment alone, while genotype and genotype x environment (G×E) interaction account for 3 to 6% and 17 to 32%, respectively[4,5]. Cultivar performance is therefore expected to vary in different environments, and the identification of genotypes that produce the highest yield in a particular environment should then be a primary concern.

Studies were initiated to evaluate the agronomic performance and to examine the agro-physiological basis of high yield in some mungbean cultivars in a warm temperate environment in Japan. This paper describes the relationships among earliness in flowering, vegetative and reproductive growth characteristics, and seed yield of some mungbean cultivars.

Materials and Methods

The experiments were conducted at The Farm of the Faculty of Agriculture, Kochi University, Nankoku, Kochi (33°33'N, 133°40'E) which is a warm temperate, subhumid, coastal environment. Mean minimum and maximum temperature, and accumulated solar radiation and rainfall for the duration of the experiment were summarized in Table 1. The soil was sandy-loam and well-structured with a pH of 6.7. Two weeks before sowing, 3 kg N, 10 kg P_2O_5, and 10 kg K_2O $10a^{-1}$, were applied as a compound fertilizer. Pre-emergence herbicide was mixed with the soil just before sowing.

In 1987, hand-picked seeds of 83 cultivars (cvs.) consisting of the introductions from the Asian Vegetable Research and Development Center (AVRDC), Taiwan (20 cvs.), and from the Institute of Plant Breeding (IPB), University of the Philippines at Los Baños (62 cvs.), and one Indian local Kochi University Selection (KUS) as the check cv., were coated with fungicide and sown in May 7 in 1.2×3.0 m field plots with 3 rows spaced 35 cm apart. The rows were thinned at the second trifoliate leaf stage to a final intra-row mean distance of 12.5 cm, resulting into a final density of 22,857 plants $10a^{-1}$. The experimental design used was randomized complete block with 2 replications. Weeding and pesticide application were done as needed.

In 1988, the cultural practices and experimental design used were basically the same as in 1987 but only 24 cvs. which were selected for their ability to produce mature seeds in the preceeding year, were sown in May 9, in 1.5× 5 m plots with 4 rows 30 cm apart. Rows were also thinned to a final average distance of 12.5 cm or a final density of 26,667 plants $10a^{-1}$. The cultivars used are listed in Table 2.

The dates of the first flower opening and first pod maturation were recorded for each cultivar. At maturity, plants in 1 m of the central row in 1987 and in the 2 central rows in 1988 were harvested. Plant height, number of primary branches, and reproductive and total main-stem nodes were determined. The pods were air-dried for 1 month and then hand-threshed for seed yield estimation.

Table 1. Climatogical data for the Faculty of Agriculture, Nankoku, Kochi during the period of the experiments in 1987 and 1988.

Climatic factor	1987 (May 7～July 30)		1988 (May 9～August 22)	
	Mean±S.D.	Range	Mean±S.D.	Range
Maximum temperature (°C)	26.2±2.9	20.7−31.7	27.4±3.1	19.1−32.0
Minimum temperature (°C)	19.5±3.6	11.2−26.0	20.6±3.6	9.7−25.4
Average temperature (°C)	23.6±3.0	17.8−29.4	25.4±3.2	15.5−29.9
Rainfall (mm day^{-1})	945.0[1)]	0−164.0	1,124.5[1)]	0−225.0
Solar radiation (MJ day^{-1})	1,414.0[1)]	2.1−27.2	1,713.8[1)]	2.9−26.9

1) Accumulated amount.

Table 2. Materials and their origins.

	Cultivar[1)]	Source or origin of introductions
1	KUS	India
2	V 1387	Philippines
3	V 2010	China
4	V 2773	India
5	V 2984	Korea
6	V 3476	Philippines
7	V 3686	USA
8	V 3726	India
9	V 6083	USA
10	VC 1482E	Taiwan
11	VC 2719A	Taiwan
12	VC 1177B	Taiwan
13	VC 1973A	Taiwan
14	VC 2768A	Taiwan
15	Pag-asa 4	Philippines
16	A 3	Philippines
17	A 16	Philippines
18	A 41	Philippines
19	A 102	Philippines
20	A 105	Philippines
21	A 176	Philippines
22	IPB M 79-13-45	Philippines
23	IPB M 79-22-117	Philippines
24	IPB M 82-42-21	Philippines

1) KUS : Kochi Univ. Selection 1—91. Indian local origin, collected in Raipur, Madhya Pradesh, India, by, Tottori Univ. Expedition Team in 1971 and selected and grown since 1971 in Kochi by K. Maeda (see references No. 11 ~12 for description) ; V and VC lines : AVRDC collection and breeding lines, respectively ; A, IPB and Pag-asa lines : Inst. Plant Breeding, Univ. of the Philippines at Los Baños.

Results and Discussion

1. Grouping of cultivars in 1987

The 83 cvs. were classified into 3 groups based on earliness in flowering in 1987. Group I which flowered at 39 days after planting (DAP) is composed only of the small-seeded, early and uniform maturing V 6037 from the USSR. Group II which flowered from 46—71 DAP, is composed of 77 cvs. with varying morphological characteristics. Cvs. from the Philippines generally were taller and produced more primary branches and total nodes than the potential high yielding cvs. from AVRDC. The KUS check which flowered at 49 DAP was intermediate in the above characters. Group III which flowered late from 85—95 DAP is made up of 5 cvs. from the Philippines. Even at flowering period, these cvs. continued growing vegetatively. Since most of their flowers abscissed at various stages of development, these cvs. failed to produce well-filled mature seeds such that their yield was practically zero. Group I, in spite of having many but small pods, yielded low (98 g m^{-2}) probably bacause of its very limited vegetative growth and small seeds. Seed yield of Group II was highly variable: KUS produced the highest (184 g m^{-2}), while many IPB beeding lines from the Philippines had less than 50 g m^{-2} and some even failed to produce mature seeds. Most AVRDC materials had a medium yield of about 100 g m^{-2}.

Attempts were made to classify each flowering group based on the duration of the reproductive growth, i. e., from flowering to matu-

Table 3. Grouping of mungbean cultivars according to number of days to first flower and duration of the reproductive phase (means of 2 replicates).

Reproductive duration group	Parameter	Flowering group I (39 DAP[1)])	Flowering group II (46~71 DAP)	Flowering group III (85~95 DAP)
A (30~35 days)[2)]	No. of cvs.		7	No. of cvs. : 5
	Yield (g m^{-2})		9.93±10.28	
	Harvest index (%)		5.72±8.95	
B (36~40 days)	No. of cvs.	1	42	Reproductive duration not determined since it did not appear normal (most flowers and pods were aborted)
	Yield (g m^{-2})	94.70	50.10±36.28	
	Harvest index (%)	31.82	13.53±11.20	
C (41~46 days)	No. of cvs.		28	
	Yield (g m^{-2})		104.68±15.96	
	Harvest index (%)		23.20±10.79	

1) DAP : Days after planting.
2) Values in parentheses represent ranges for the groups.

Table 4. Number of days to first flower (DFF), days to first mature pod (DFMP), days from first flower to first mature pod (DFF-DFMP) and duration of the reproductive stage (RD) (24 cultivars and means of two replicates).

	DFF		DFMP		DFF-DFMP		RD[1]	
	1987	1988	1987	1988	1987	1988	1987	1988
Maximum, days	63.0	66.5	81.5	82.0	22.0	20.5	45.5	59.0
Minimum, days	47.0	42.5	64.5	62.0	13.0	13.5	32.5	31.5
Mean, days	52.8	52.1	71.8	69.5	18.9	17.3	40.2	41.2
S.E.	4.4	6.8	5.3	5.7	2.2	1.8	3.3	8.4
CV (%)	8.4	13.0	7.4	8.2	11.4	10.4	8.2	20.5
LSD (5%)	4.8	5.2	3.8	5.2	ns	ns	4.7	6.8
r value between years	0.84***		0.85***		-0.07^{ns}		0.69***	

1) Number of days from first flowering to full pod maturity.
ns, *** : Not significant and significant at 0.1%, respectively.

rity, as done in soybeans[3]. Three groups were made, namely Groups A, B, and C with reproductive growth duration ranges of 30—35, 36—40, and 41—48 days, respectively (Table 3). Cv. V 6037 which is the only member of Group I, belongs to Group B, while cvs. of Group III were not assigned to any of the above group since their reproductive growth was not normal. Among the Group II cvs., 7, 42, and 28 were placed in Group A, B, and C, respectively. It was difficult to morphologically characterize the cultivars belonging to any of the reproductive duration groups though it was noted that all Group A cvs. and many Group B cvs. tended to be tall with many primary branches and main-stem-nodes, but had low percentages of reproductive main-stem nodes. Cvs. of Group C (long reproductive duration group) had the highest mean seed yield and harvest index, while Group A (short reproductive duration group) had the lowest values for both parameters. As in the case of the flowering groups, it was also difficult to determine the relationship of reproductive duration with latitude of origin since the exact origin of the cultivars used cannot be established. When the approximate latitude of origin were used, no pattern can be discerned since cvs. from the Philippines were represented in all groups and cvs. from India and the AVRDC breeding lines were likewise scattered in Groups B and C. Thus, mungbean ecotypes, if they exist in the cvs. used, cannot be determined in this experiment.

In the case of the flowering groups, the extremely early and late flowering dates of Groups I and III cvs., respectively, might indicate that these groups are probably more photosensitive than Group II, and are not fitted for cultivation in warm temperate environments. Thus, the materials used in 1988 all belong to the probably relatively less photosensitive Group II.

2. Cultivaral differences in earliness

In both years, differences in the number of days to first flower (DFF) among cvs. were significant (Table 4). In 1987, cvs. V 2984 and IPB M82-42-21 flowered earliest and latest, respectively. The KUS check which flowered at 48.5 days after planting (DAP) in 1987 was the earliest in 1988 at 42 DAP while A 41 which flowered only slightly earlier than IPB M82-42-21 in 1987, was the latest at 66.5 DAP. The onset of flowering for the other cvs. slightly varied between years. Nevertheless, the high positive correlation between years (r=0.84***) indicated that the relative performance of the cvs. in terms of flowering earliness were similar in both years.

The number of days to first mature pod (DFMP) was also significantly different among cvs. in both years (Table 4). Except A 3 and A 41, all cvs. produced their first mature pod earlier in 1988. Nevertheless, as the significant correlation coefficient between years (r=0.85***) suggests, the cvs. showed relatively the same performance for this character across years. Relationship of DFMP with DFF was likewise positive and highly significant in both years (Table 6). Thus, the onset of pod maturation was earlier in early flowering cvs. than in later flowering ones.

The number of days from first flower to first mature pod (DFF to DFMP), was not significantly different among cultivars in both years (Table 4) and was shorter in 1988 for all

Table 5. Vegetative and reproductive growth characters at maturity and seed yield (24 cultivars and means of two replicates).

	Plant height (cm)		Primary branches (/pl.)		Main-Stem nodes Veg.[1] (/pl.)		Rep.[2] (/pl.)		Total (/pl.)		Rep./Total (%)		Seed yield (g m^{-2})	
	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988
Max.	84.3	122.4	4.6	5.8	8.7	13.6	9.1	9.8	18.4	22.8	62.7	66.0	184.3	198.5
Min.	26.7	22.9	0.4	0.0	4.0	4.0	5.4	5.2	10.2	9.8	46.6	38.5	16.3	3.6
Mean	50.4	52.5	2.3	1.3	5.8	6.5	7.2	7.1	13.0	13.6	54.9	52.8	95.2	74.7
SD	15.6	37.1	1.4	1.5	1.4	2.7	1.2	1.3	2.3	3.6	4.5	7.4	50.1	54.4
CV (%)	30.9	70.9	60.2	117.1	24.4	41.4	16.4	19.0	17.7	26.3	8.1	14.0	95.2	72.7
LSD (5%)	9.4	16.2	1.0	0.9	0.8	1.9	0.8	2.1	1.2	2.0	4.1	13.9	48.2	48.3
r value[3]	0.74***		0.60**		0.78***		0.42*		0.79***		0.42*		0.82***	

1) Vegetative ; 2) Reproductive ; 3) Correlation coefficient between years.
*, **, *** : Significant at 5.0, 1.0 and 0.1%, respectively.

cultivars except KUS, VC 2719A, and A 16. The period from the initiation of flowering to the onset of pod maturation were variable across cvs. and years as indicated by the very low correlation coefficient value between years ($r=-0.07^{ns}$).

The shorter period from DFF to DFMP in 1988 could be partly attributed to the meager and scatterred 19 mm rainfall from 52 DAP, when more than 50% of cvs. have initiated flowering, until 71 DAP when 50% of the cvs. have initiated pod maturation, and the only 67.5 mm from 71 DAP to 82 DAP when all cvs. have produced their first mature pod. At the same growth stages in 1987, accumulated rainfall were 316 and 113 mm, respectively, which were both clearly much more than in 1988. The period from flowering to pod maturity in mungbean is sensitive to water stress and the crop escapes drought through faster development[8].

Reproductive growth duration, i.e., number of days from first flower to final pod maturation (DFF to about full pod maturity), was significantly different among cvs. in both years (Table 4). However, relative cv. ranking across years was similar ($r=0.69$***) in spite of the higher rainfall from 71 to 76 DAP in 1987 probably because at this period, many of the pods were at the late maturation stage. Lawn[8] observed that rain at late pod filling stage does not significantly affect mungbean crop duration because of its determinate habit and hence, cannot exhibit renewed vegetative growth and extended flowering in response to late season rain.

3. Cultivaral differences in vegetative and reproductive growth

For all vegetative and reproductive growth parameters, the differences among cvs. in both years were significant (Table 5). A high positive correlation between 1987 and 1988 was recognized for plant height. Less than 50% of the total cvs. were taller in 1988. Cvs. A3 and IPB M82-42-21 doubled their height in 1987 while VC 1177B and Pag-asa 4 were only half as tall as they were in 1987.

The average across cvs. for the number of vegetative, reproductive and total main-stem nodes, and the percentage of reproductive main-stem node to total main-stem nodes were comparable between years. The correlation between years was high for the number of vegetative and total main-stem nodes but was low for reproductive main-stem nodes and its percentage to total main-stem nodes. Correlation analysis also indicated that plant height in both years was highly positively associated with vegetative, reproductive, and total main-stem nodes ($r=0.64$***, 0.70***, and 0.81***, respectively, in 1987, and 0.92***, 0.63***, and 0.93***, respectively, in 1988), but negatively correlated with the percentage of reproductive main-stem nodes to total main-stem nodes ($r=-0.67$*** and -0.63*** in 1987 and 1988, respectively).

The correlations of number of days to first flower with all growth parameters examined were positive and highly significant in both years except for the number of primary branches in 1988 and reproductive main-stem nodes in both years which were insignificant, and the percentage of reproductive main-stem nodes to total main-stem nodes which was

Table 6. Correlation coefficient (r) values among some parameters of earliness, vegetative and reproductive growth and seed yield (n=24).

Parameters	Days to first flower		Reprod. duration[1)]		Seed yield	
	1987	1988	1987	1988	1987	1988
Days to first flower	–	–	−0.64***	−0.72***	−0.76***	−0.81***
Days to first mature pod	0.91***	0.97***	−0.51*	−0.72***	−0.70***	−0.82***
Pod maturation period[2)]	0.19^{ns}	−0.64***	0.08^{ns}	0.40^{ns}	-0.13^{ns}	0.42*
Plant height	0.60**	0.57**	-0.22^{ns}	-0.29^{ns}	−0.44*	−0.47*
Primary branch no.	0.56**	0.31^{ns}	-0.07^{ns}	0.02^{ns}	-0.36^{ns}	-0.15^{ns}
Vegetative MS[3)] node no.	0.73***	0.78***	-0.33^{ns}	−0.51*	−0.72***	−0.66***
Reproductive MS node no.	0.48*	0.34^{ns}	-0.10^{ns}	0.04^{ns}	-0.28^{ns}	-0.21^{ns}
Total MS node no.	0.70***	0.72***	-0.26^{ns}	-0.36^{ns}	−0.59**	−0.57**
% Reproductive MS node	0.54**	−0.78**	0.36^{ns}	0.67***	0.02^{ns}	0.12^{ns}
Seed yield	−0.76***	−0.81***	0.68***	0.85***	–	–

1) Reproductive duration : days from first flower to full pod maturity ; 2) Days from first flower to first mature pod ; 3) Main-stem.
ns, *, **, *** : Not significant and significant at 5%, 1% and 0.1%, respectively.

negative in both years (Table 6). Thus, the early flowering cultivars were smaller with fewer vegetative nodes (Fig. 1) and total main-stem nodes, and tended to produce fewer primary branches and reproductive main-stem nodes, but had a greater percentage reproductive main-stem nodes than later flowering ones. The lesser vegetative development in early flowering cvs. may be attributed to the determinate habit of the cvs. used where vegetative growth effectively ceases at the onset of flowering.

4. Cultivaral differences in seed yield

Seed yield significantly differed among cvs. in both years, and when averaged across cvs., it was generally higher in 1987 (Table 5). The KUS check was consistently the highest yielder, producing 184 and 198 g m^{-2} in 1987 and 1988, respectively. These yield levels are about five times higher than the world average (0.38 t ha^{-1}) but still low compared to the more than 3 t ha^{-1} reported in other yield trials[9)]. Nevertheless, Maeda et al.[13)] who first cultivated the KUS cv. in Japan in 1971, reported a yield of 278 g m^{-2} from 3 harvest dates. The Philippine cvs. A 16 and A 105 ranked 2nd and 3rd, respectively, in 1987, but were 5th and 6th in 1988. Cv. V 2984 from Korea, which was among the consistently high yielding genotypes in the 3rd and 4th International Mungbean Nursery (IMN) Yield Trials[4)], likewise yielded over 150 g m^{-2} in 1987. Cv. V 1387 from the Philippines, the AVRDC breeding line VC 2768A, one of the highest yielders in the 9th to 12th IMN[5,10)], and V 2984, also exceeded 150 g m^{-2} in 1988. Averaged across years, the top 4 yielders which produced over 150 g m^{-2} were KUS, V 2984, A 16, and A 105, in that order. Cvs. V 1387 and VC 2768A yielded slightly lower. The Philippine cv. V 3476 which was among the high yielders in the 6th to 10th IMN trials[5)], had a poor average of 47 g m^{-2} and had an overall 19th ranking out of 24 cvs. in the present experiment. Although yield differences between years were noted in all cvs., and coefficients of variation were relatively high in both years, the coefficient of correlation for yield between years was very high (r=0.84***) indicating that the relative yield performance of the cvs. were similar across years.

The decrease in mean seed yield in 1988 in spite of the abundant rainfall during the reproductive stage, might have been partly caused by the attack of spider mite (*Tetranychus* sp.) on some cvs., particularly A 176, V 3726, V 6083, and IPB M79-13-45 during pod filling period. It was noted that the top yielding cvs. exhibited negligible damage and apparent resistance to this pest. Yield reduction in the series of IMN were often attributed not only to drought but also to disease occurrence[4,6,15)]. However, disease was not a very important constraint in the present experiment.

5. Relationships of seed yield with earliness and reproductive growth duration

Seed yield showed a highly negative correlation with the number of days to first flower (DFF) (Fig. 2) and days to first mature pod

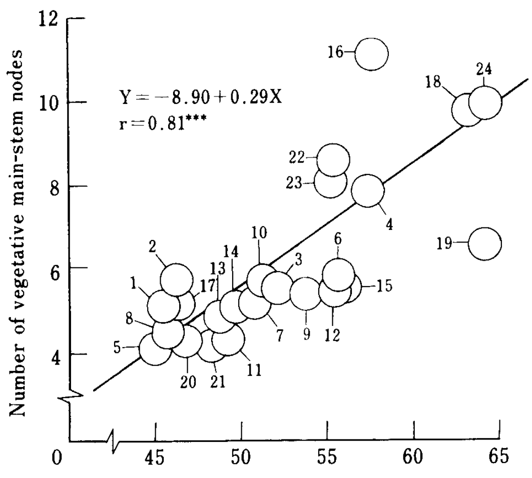

Fig. 1. Relationship between number of days to first flower after planting and number of vegetative main-stem nodes at harvest.
Plotted data are means of 2 years. Number for each circle is cultivar number in Table 2.

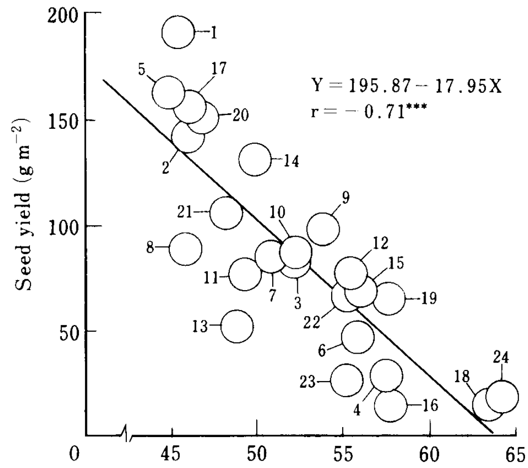

Fig. 2. Relationship between number of days to first flower after planting and seed yield.
Plotted data are means of 2 years. Number for each circle is cultivar number in Table 2.

(DFMP), but was highly and positively correlated with reproductive growth duration in both years (Table 6). Cvs. that flower early, and therefore have an early onset of pod maturity, and those with long reproductive growth are likely to produce high seed yield. Data obtained from the 3rd and 4th IMN trials also showed that the highest yielding cv. groups were the earliest to flower[4] indicating that short vegetative growth duration does not necessarily limit yield potential. DFF was positively and highly correlated with DFMP, (Table 6), and the time elapsed from the appearance of first flower to the first mature pod (DFF to DFMP), was not significantly different among cvs. in any year. Apparently, the strong positive relationship of yield with the reproductive period in early flowering cvs. is more likely the consequence of extended flowering period through the occurrence of a second flowering and fruiting flush which accounts for as much as 25% of the total yield of KUS in 1988. The strong correlation of seed yield with the duration of the reproductive growth and pod filling has long been recognized in soybeans[1].

6. Relationships of seed yield with vegetative and reproductive growth

Seed yield was negatively correlated with all the vegetative growth parameters examined (Table 6). The correlation with the number of primary branches was low, slightly significant with plant height and total main-stem nodes, and was very significant with the number of vegetative main-stem nodes. Correlations of yield with the number of reproductive main-stem nodes and its percentage to total main-stem nodes were both insignificant although it was negative for the former and positive for the latter.

Analysis of the data obtained from the 7th to the 10th IMN yield trials indicated that yield was positively correlated with plant height which, in turn, was strongly associated with foliage yield[4]. While seed yield was negatively correlated with plant height in this experiment, the 5 top yielders notably KUS, V 1387, V 2984, and VC 2768A, as will be discussed later in another paper[2], had high leaf dry matter which were exceeded only by the late flowering and low yielding IPB breeding lines and cv. A 16.

Accumulation of vegetative main-stem nodes in late flowering cvs. did not increase yield in agreement with the data obtained by Lawn[6]. Apparently, it is the percentage of reproductive nodes to total plant nodes that affects yield. Summerfield et al.[17] considered the percentage of total plant nodes that becomes reproductive, as one of the components of yield in determinate legumes.

In the present experiment, cvs. having higher number of reproductive main-stem nodes from which racemes originate, had lower seed yield, since most of the flower buds on these racemes abscissed before opening and open flowers aborted notably in the lowest yielding cvs. A 41, IPB M79-22-117, and IPB M82-42-21. The loss of flower buds and open flowers is a common characteristic of legumes and appears to be a kind of "insurance" for pod and seed production with a negligible dry matter loss. Flower shedding reaches about 50 to 80% for leguminous crops in general[16)], and up to about 90% for mungbean[9)]. In the present experiment, the massive flower shedding in the late flowering cvs. may be partly explained by the competition between the developing reproductive and the vegetative organs. Muchow et al.[14)] reported that as much as one third of the total dry matter accumulated during the reproductive stage may still be partitioned into the vegetative organs.

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* In Japanese.

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