



# The Effect of Mungbean Seed Size on Germinating Ability, Bean Sprout Production and Agronomic Characters

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## Abstract

The purpose of this study was to determine the effect of seed size on the speed of emergence in the field conditions, which included the efficiency of germination and sprout production in laboratory test. The experiment was conducted in a split-plot design using varieties/lines as the main plot and seed size as the sub-plot. The results showed no effect of seed sizes on speed of emergence in field setting both in rainy and dry season. Nevertheless, the speed of emergence in rainy season was higher than that of the dry season. Correlation among agronomic characters revealed that seed size was the character which may compensate to the other yield components. The result of the field testings both in rainy and in dry seasons was similar. The experiments also showed that large seeds had higher germination percentage than that of small seeds. In general, mungbean sprouts from large seeds were heavier and had bigger head and stem but was shorter than the sprouts from small seeds. Therefore, the results from this study suggested that the large seeds would be advantageous only for sprout production but small seeds are also suitable for planting without any effect on early stage of plant growth such as speed of emergence.

**Keywords :** Seed size, mungbean, emergence, germination, sprout

## Introduction

In principle, seed size has effects on many characters both in the field and laboratory tests. The storage and handle of different seed size varieties are similar in many countries. Although genetic background of seeds in individual lines or cultivars is similar, seed sizes in individual lines or cultivars may affect other agronomic characters. Different seed sizes of a cultivar having different levels of starch and other food storage may be one factor which influences the expression of physiological-dependent character. Percent of seed emergence and speed of seedling emergence are the characteristics that could be observed in the field and could be used as an indicator of seed vigor. These characters usually differ under field stresses such as low temperature, wet or crusted soil in which small seeds of soybean and common bean perform better than large seeds due to seedling from small seeds were less damaged than large seeds (Hoy and Gamble, 1987; Sexton et al., 1994). While winter wheat (Chastain et al., 1995) and mungbean (Amin, 1999) are in the field with no stress, large seed size of these plants tend to do better in germination than small seed size. However, several reports showed that spring wheat (Lafond and Baker, 1986), and soybean (Edwards and Hartwig, 1971) emerged faster from small seeds than the large seed size for hybrid. Moreover, many studies indicated that germination percentage of winter wheat (Mian and Nafziger, 1994), seedling emergence of soybean (Johnson and Luedders, 1974; TeKrony et al., 1987) and barley (Demirlicakmak et al., 1963) were not affected by seed size.

Singh et al. (1972) reported that large seeds of soybean had greater supply of stored energy to support early seedling growth and subsequently affected plant growth and development. However, seed size has been considered to be a significant factor only during the early stage of plant growth. Nevertheless, Amin (1999) reported that 50% of large-seeded mungbean matured earlier than that of small-seeded type. Although large seed has an advantage of having higher stored energy supply but not all reports

demonstrated the effects of seed size on yield. Although the largest seed sizes have the largest cotyledonary area, the higher photosynthetic rate from smaller seed size could compensate and support seedling growth (Burris et al., 1973). Several studies reported that seed size of difference of sorghum (Suh et al., 1974), soybean (Sexton et al., 1994) did not affect yield of these crops. Suh et al. (1974) explained that the source of the different in seed size and seed weight on the resulting crop was not affected by genetic and quality difference. The results imply that seed weight per se would have little influence on yield of the resulting crop. White et al., (1992) found that small-seeded genotypes are probably physiologically most efficient over large-seeded genotypes in common bean at warmer areas and higher latitudes.

One observation on the effect of agronomic characteristics such as seed size and seed number was that both characteristics affected yield. However, the characteristics such as seed number and seed size may both affect and compensate each other in determining yield (Spaeth and Sinclair, 1984; Board et al., 1999) and the main factor which directly contributed to yield was dependent upon plant species and plant varieties. The component compensation may be the reason that seed size did not affect yield in soybean (Hoy and Gamble, 1987; Singh et al., 1972), mungbean (Amin, 1999) and common bean (Perin et al., 2002). The correlation between yield and yield component characters with seed size has been estimated in different varieties and crop plants but not all reports presented the same conclusions. Length and width of soybean seeds were positively correlated with final seed size (Fraser et al., 1982) but 1,000-kernel weight of seeds harvested and the seeds per head of spring wheat were not significantly correlated with initial seed size (Austenson and Walton, 1970).

This study is aimed to study the effects of mungbean seed size on agronomic characters, study germination test and sprout production.

## Materials and Methods

### *Study the effect of seed size on coefficient of emergence in field conditions.*

Coefficient of emergence that calculated from speed of emergence and correlation of field performance characters was evaluated in the 2003 at the Suranaree University of Technology Experimental Farm (SUT farm), Nakhon Ratchasima, Thailand. Seed sizes of seven varieties/lines of mungbean (SUT1, SUT2, PSU1, CN36, CN60, VC3781A and KPS2) were classified by using the screen of mesh number 20, 3.175 mm in diameter (mesh of Seed Buro Equipment Company, Chicago, IL, USA). The experiments were conducted twice, in the rainy and dry seasons representing non-stress and stress conditions by using a split plot in randomized complete block design with three replications. Main plots were varieties and subplots were seed sizes. Each plot consisted of four 5 m rows, spaced 50 cm apart. Three-four seeds per hill were planted at a distance of 20 cm between hills. Plots were kept weed-free throughout the season by spraying alachlor at rate of 3.125 liters/ha herbicide as well as hand weeding. After emergence, the seedlings were thinned to desired stand density and the fertilizer N-P-K (12-24-12) at rate of 312.5 kg/ha was side-dressed and covered by handler. Fungicides and insecticides were applied as needed.

The field performance was recorded on the speed of emergence, which was presented as coefficient of emergence (CE) that was derived from the coefficient of velocity of germination as proposed by Kotowski (1926). Days to first flowering and to pod maturing were observed. Yield and yield component characters such as the number of pods per plant, number of seeds per pod, number of seeds per plant, 100-seed weight and length of pod were recorded at harvest. The length of pod and number of seeds per pod were measured from the same pods. Twenty pods taken at random were measured for pod length and number of seeds per pod. The data for yield and yield component characters were based

on the plot means. The yield per plant and 100-seed weight were measured at 12% moisture content by using Dole Model 400 B Moisture tester.

#### ***Standard germination test***

Five varieties (KPS2, CN36, CN60, PSU1 and VC3751A) were used in the study of the effect of seed size on seed germination which was tested twice in the laboratory using between-paper method. The first test was made after seed size classification before storage (0 month storage). After which times the seeds of different sizes were stored at room temperature and in a cold room. The second set of seeds were kept for 4 months to compare the effect of seed size after storage in different conditions. Each germination test was replicated done 3 times with 100 seeds per replication. The rolls of seeds were incubated in illumination chamber with the light intensity of 2,200 lux at 20°C/30°C which was set for 16 hr dark and 8 hr light. After one week, germinating seeds were counted in each roll and were presented as percent seed germination.

#### ***Study on the efficiency of sprout production.***

In each seed size group of five varieties (SUT1, SUT2, PSU1, CN36 and CN60), the seeds were weighed out 100 grams. They were filled in a plastic basket and covered with nylon net and damp cloth overtop. The water was then filled into the basket to reach the cloth and left for 5-10 minutes, then the water was decanted off and the basket kept in the dark. This process was routinely done three times a day (morning, afternoon and evening). After three days the bean sprouts were weighed and the sprout production efficiency could be estimated.

## Results

### *The effect of seed size on coefficient of emergence in field conditions.*

The combined analysis of variance of speed of emergence (Table 1) showed highly significant difference due to season. But seed size did not affect on the character under studied. This indicated that large and small seed of a given variety would have the same effect on coefficient of emergence. The speed of emergence of two seed sizes as measured by the differences in the coefficient of emergence did show large variation as previously observed by Hoy and Gamble (1987). They found in some experiments in soybean that seed size did not significantly affect CE. Although large seeds were emerging more slowly than small seeds in some plantings. The present study showed similar CE of both large and small seeds and even in wet and dry seasons (Table 2).

CE showed an advantage on field performance in rainy season and would decrease in dry season which was the result of water shortage (Table 2).

The correlation coefficient in rainy season and dry season was presented in Table 3 and Table 4, respectively. Under non-stress condition, seed size and yield has less correlation coefficient value (-0.07) than seed size and other characters (Table 3). Moreover, seed size was negative correlated with other yield components although there was no statistical significant difference. The result indicated that seed size was the character which had compensated other yield components and had no effect on yield. The result was similar in dry season (Table 4).

### *Seed germination*

The analysis and mean values of the germination test of the seed at 0 month (before storage) and 4 months after storage in different conditions are present in Table 5 and Table 6-7, respectively. At 0 month the seeds of both sizes showed no difference in germination. However, significant differences were found among varieties and there was an interaction effect between variety and seed size. CN36,

KPS2 and VC3751A and CN60 showed highest percentage of seed germination (96.33%, 95.5% 94%, and 93%, respectively) while PSU1 was lowest (87%) (Table 6).

After 4 months of storage in two conditions, all varieties showed highly significant differences in germination (Table 6). Seed size also had an effect on germination. However, only CN60 and PSU1 showed differences at all storage conditions. Large seeds always germinated better than small seeds irrespective of storage conditions. Nevertheless, the other three varieties kept in the same condition showed no difference in germination. It must be noted that varieties were different in seed germination, particularly the small seeds of PSU1 which had quite low germination percentage even when they were kept in a cold room for 4 months (Table 7). It seemed that CN36 and VC3751A retained exceptionally high germination at all storage conditions, while CN60 had very poor seed quality when kept at room temperature even only for 4 months.

#### ***The efficiency of sprout production.***

Seed size and variety had highly significant difference on sprout production (Table 8). In addition, the size of the sprouts was also highly significantly different. No interaction between variety and seed size was observed on the size or the weight of the sprouts produced excepting stem diameter.

On average, SUT1 and SUT2 produced highest weight of sprouts (g/100 seeds) (42.31 g and 41.67 g, respectively) (Table 9). Large seeds gave higher sprouts production than small seeds in all varieties. The same was true for head diameter of the sprouts. In all varieties, large seed size always gave larger sprout head than the small seed size. SUT1 with larger seed size produced larger sprout head than other varieties. However, CN36 gave thicker stem (2.64 mm) than other but had rather shorter (3.56 cm) stem than other varieties (Table 10). It must be noted that CN60 was inferior to other varieties in all other characters. Stem length was the only character that showed a reverse effect of seed size while small seeds produced longer sprouts than large seeds. Therefore, it could be

concluded that SUT1 and SUT2 were suitable for sprout production due to their ability to produce highest weight.

## Discussion

In the field, seed size had no effect on speed of emergence. Although previous study showed that large seed size of wheat and mungbean did germinate better in winter (Chastain et al., 1995; Amin, 1999). These reports explained that larger endosperm enhanced emergence ability and large seeds of soybean had greater supply of stored energy to support early seedling growth and consequently its plant status (Singh et al., 1972). However, not all reports demonstrated the positive effect of large seed size, on the speed of seed emergence in small seeds such as spring wheat (Lafond and Baker, 1986) and soybean (Edwards and Hartwig, 1971). Small-seeded genotypes are probably physiologically most efficient, especially at warmer sites and higher latitudes (White et al., 1992). An alternative explanation that seed size influenced growth and yield was that there may be a correlation between cell size in the seed and the cell size in the rest of the plant tissue (White and Gonzalez, 1990). Smaller cell size may have greater photosynthetic rates which result in greater yield than large seed size in some studies. Moreover, small cell size has been associated with increased specific leaf nitrogen and greater rate of photosynthesis as found in wheat (Morgan et al., 1990).

In this study, the genetic background of mungbean varieties influenced the emergence of seeds in the field condition. Under dry season and inadequate water condition, seed sizes was affected and speed of seed emergence decreased. This may be because water are required for many reactions of enzymes, and it could affect pH level in the soil. The correlation coefficient of seed size and yield has less value than other characters in both seasons. This can be assumed that seed size was a character which contributed to yield components but had no effect on seed yield performance. Many reports also showed low genetic correlation between yield and seed



size of soybean (Anand and Torrie, 1963; Kwon and Torrie, 1964) both in early generation as in  $F_3$  lines (Johnson et al., 1955) and in later generations as in  $F_6$  and  $F_7$  generations (Byth et al., 1969a, b). This may be because seed size was one of the factors which indirectly affected yield. It was reported that both characteristics conversely compensated each other in determining yield of the plant (Spaeth and Sinclair, 1984; Board et al., 1999). Although genetic background of each variety was the main factor which influenced seed vigor in the field, seed size was a major factor which played an important role in affecting seed vigor in the laboratory. Three out of five varieties had the value of seed germination percentage between large and small seeds, which the larger seeds of CN60 and PSU1 varieties had higher germination at all keeping conditions. However, these two varieties quickly deteriorated in term of germination capability especially when they were kept at room temperature for 4 months.

Apart from seed size variation among varieties, each variety may have unique features in which it can adapt to a specific condition (Amin, 1999). Large seeds could produce larger bean sprouts including sprout weight, head diameter, and stem diameter characters. This can be explained that larger cotyledons had produced larger hypocotyls (Black, 1956; Burriss et al., 1971). Large sprout character seem to have an advantage over small seed when they will be used as food, but under field condition (such as crusted soil), small seedling from small seed showed less damaged than large seedling from large seeds (Hoy and Gamble, 1987; Sexton et al., 1994).

## Conclusion

Under both rainy season and dry season, seed size did not affect speed of seed emergence. This characteristic is beneficial for mungbean production under dry season or inadequate water condition. Seed size slightly affected the speed of seed emergence among the mungbean varieties, probably due to their genetic backgrounds difference and its interaction with field conditions. Three out of five varieties had the same seed germination percentage between large and small seeds, while CN60 and PSU1 which had larger seeds had higher germination in two storage conditions. These two varieties appeared to deteriorate quickly and affected their germination ability especially when were kept at room temperature for 4 months. Large seeds of mungbean could produce larger bean sprouts.

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**Table 1** Combining analysis of variance on speed of emergence in two seasons in 2003.

Source	df	Mean squares
Season (D)	1	116.27**
Reps/season	2	0.09
Variety/line (V/L)	6	0.06ns
D x V/L	6	0.09ns
Error (a)	12	0.12
Seed size (S)	1	0.002ns
D x S	1	0.02ns
V/L x S	6	0.13ns
D x V/L x S	6	0.14ns
Error (b)	14	0.07
CV (a) (%)		1.7
CV (b) (%)		1.3

\*\* Significantly different at 0.01 levels of probability.

ns = not significant.

**Table 2** Effect of seed size on coefficient of emergence on seven varieties/lines in field evaluation averaged in two seasons in 2003.

Variety/line	Coefficient of emergence			
	Rainy		Dry	
	Large	Small	Large	Small
	..... % .....			
SUT1	21.99	21.95	19.14	19.21
SUT2	22.10	22.10	19.27	18.63
PSU1	22.00	22.14	19.36	19.50
CN36	22.15	22.16	18.60	19.50
CN60	22.17	21.89	18.94	19.33
KPS2	22.14	22.06	19.30	18.92
VC3781A	22.02	22.08	19.51	19.38
Mean	22.08	22.06	19.16	19.21
LSD 0.05		0.23		0.84
CV (b) (%)		0.4		1.8

**Table 3** Correlation coefficients among characters as effect by seed size in rainy season, 2003.

Character	Biomass	*TDM	Pods/ plant	Seeds/ pod	Seeds/ plant	Seed weight	Yield/ plant	Pod length
Height	0.707**	0.788**	0.513**	0.159ns	0.525**	-0.108ns	0.518**	-0.076ns
Biomass		0.922**	0.555**	0.020ns	0.560**	0.146ns	0.581**	-0.010ns
TDM			0.485**	0.055ns	0.509**	0.137ns	0.539**	0.001ns
Pods/plant				0.028ns	0.815**	-0.081ns	0.670**	-0.003ns
Seeds/pod					0.397**	-0.245ns	-0.005ns	0.563**
Seeds/plant						-0.219ns	0.608**	0.161ns
Seed weight							-0.070ns	0.328*
Yield/plant								0.070ns

\*, \*\*Significantly different at 0.05 and 0.01 levels of probability, respectively.

ns = not significant.

\*TDM = total dry matter

**Table 4** Correlation coefficients among characters as effect by seed size in dry season, 2003.

Character	Biomass	*TDM	Pods/ plant	Seeds/ pod	Seeds/ plant	Seed weight	Yield/ plant	Pod length
Height	0.468**	0.389**	0.456**	0.253ns	0.543**	0.072ns	0.617**	0.010ns
Biomass		0.953**	0.401**	0.105ns	0.329**	0.252ns	0.511**	0.003ns
TDM			0.402**	0.039ns	0.325**	0.240ns	0.458**	0.040ns
Pods/plant				0.059ns	0.949**	-0.053ns	0.640**	-0.268*
Seeds/pod					0.140ns	-0.102ns	0.276*	0.329*
Seeds/plant						-0.171ns	0.653**	-0.299*
Seed weight							-0.010ns	0.462**
Yield/plant								-0.163ns

\*, \*\* Significantly different at 0.05 and 0.01 levels of probability, respectively.

ns = not significant.

\*TDM = total dry matter

**Table 5** Analysis of variance of seed germination percentage at 0 and 4 months of storage in two conditions.

Source	df	0 month	4 months	
			Cold room	Room temperature
Varieties/lines (V/L)	4	81.33*	359.87**	1087.37**
Error (a)	8	17.18	24.14	17.97
Seed size	1	36.30ns	192.53**	240.83**
V/L x Seed size	4	52.47*	38.20*	87.67**
Error (b)	10	11.23	7.07	9.80
CV (a) (%)		4.4	5.4	5.0
CV (b) (%)		3.6	2.9	3.7

\*,\*\* Significantly different at 0.05 and 0.01 levels of probability, respectively.

ns = not significant

**Table 6** Means of seed germination percentage at 0 and 4 months of storage in room temperature.

Variety /line	0 month				4 months (Room temperature)			
	Large	Smal	Mean	Difference	Large	Small	Mean	Difference
KPS2	97.33	93.67	95.50ab	3.67ns	89.67	89.67	89.67ab	0.00ns
CN36	94.67	98.00	96.33a	-3.33ns	97.33	94.67	96.00ab	2.67ns
CN60	69.67	89.33	93.00abc	7.33*	75.33	59.33	67.33c	16.00**
PSU1	91.00	83.00	87.00c	8.00*	80.00	68.67	74.33c	11.33**
VC3751A	91.67	96.33	94.00abc	-4.67ns	96.67	98.33	97.50a	-1.67ns
Mean	94.27a	92.07b	93.17		87.80a	82.13b	84.97	

In column, means followed by a common letter are not significantly different at 0.05 level by DMRT.

\*,\*\* Significantly different at 0.05 and 0.01 levels of probability, respectively.

ns = not significant.

**Table 7** Means of seed germination percentage at 0 and 4 months of storage in cold room.

Variety /line	0 month				4 months (cold room)			
	Large	Smal	Mean	Difference	Large	Small	Mean	Difference
KPS2	97.33	93.67	95.50ab	3.67ns	91.67	88.67	90.17abc	3.00ns
CN36	94.67	98.00	96.33a	-3.33ns	97.67	94.67	96.17ab	3.00ns
CN60	69.67	89.33	93.00abc	7.33*	95.33	90.33	92.83abc	5.00*
PSU1	91.00	83.00	87.00c	8.00*	84.67	71.00	77.83d	13.67**
VC3751A	91.67	96.33	94.00abc	-4.67ns	97.33	96.67	97.00a	0.70ns
Mean	94.27a	92.07b	93.17		93.33a	88.27b	90.80	

In column, means followed by a common letter are not significantly different at 0.05 level by DMRT.

\*,\*\* Significantly different at 0.05 and 0.01 levels of probability, respectively.

ns = not significant.

**Table 8** Means square of four characters as affected by seed size on sprout production.

Source	df	Sprout weight	Head diameter	Stem diameter	Stem length
Varieties/Lines	4	254.02 **	0.0033 **	0.0019 **	5.662 **
Error (a)	8	3.61	0.0003	0.0001	0.185
Seed sizes	1	365.54 **	0.0753 **	0.0056 **	1.221 **
Varieties x Sizes	4	4.92 ns	0.0005 ns	0.0002*	0.069 ns
Error (b)	10	6.03	0.0004	0.00004	0.035
CV (a) %		5.1	3.3	3.1	10.1
CV (b) %		6.6	3.7	2.8	4.4

\*,\*\* Significantly different at 0.05 and 0.01 levels of probability, respectively.

ns = not significant

**Table 9** Means of two characters as affected by seed size on sprout production.

Variety	Weight (g/100 seeds)			Head diameter (mm)		
	Large	Small	Mean	Large	Small	Mean
SUT1	45.89	37.46	41.67 ab	6.29	5.25	5.77 a
SUT2	46.68	37.95	42.31 a	5.84	4.66	5.25 bc
PSU1	39.53	34.50	37.02 c	5.82	4.66	5.24 bc
CN36	43.28	35.63	39.46 bc	5.88	5.06	5.47 b
CN60	28.86	23.80	26.33 d	5.62	4.89	5.21 c
Mean	40.85 a	33.87 b	39.36	5.89 a	4.89 b	5.39

In column, means followed by a common letter are not significantly different at 0.05 level by DMRT.

**Table 10** Means of two characters as affected by seed size on sprout production.

Variety	Stem diameter (mm)				Stem length (cm)		
	Large	Small	Mean	Difference	Large	Small	Mean
SUT1	2.46	2.17	2.32b	0.29**	4.82	4.86	4.84ab
SUT2	2.44	2.17	2.30b	0.26**	5.05	5.63	5.34a
PSU1	2.45	2.24	2.35b	0.21**	4.36	4.77	4.56b
CN36	2.87	2.42	2.64a	0.45**	3.32	3.81	3.56c
CN60	2.24	2.09	2.16c	0.15*	2.71	3.21	2.96d
Mean	2.49a	2.12b	2.35	0.27	4.05b	4.46a	4.25

In column, means followed by a common letter are not significantly different at 0.05 level by DMRT.

\*, \*\* Significantly different at 0.05 and 0.01 levels of probability, respectively.

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