

## CHAPTER 3

### RESULTS

#### **I. Soybean seed field characteristics under different field planting conditions**

Soybean seed field characteristics under different watering patterns (different moisture regimes), indicated in term of field emergence index, are shown in Table 2 for CM 60 variety and in Table 3 for SJ 5 variety. Thirty three field conditions were used for CM 60 variety (Table 2) and thirty one for SJ 5 variety (Table 3). Daily watering and limited watering conditions were applied in the dry season for various periods of time.

Eight treatments were applied under daily watering for CM 60 seeds (Treatment number: Trt. No 1-8). Most of them showed a field emergence index higher than 81.11%, except under very dry field condition, where the soil moisture content was lower than 6.40% (Trt. No 8) and the field emergence index was highly significantly lower, only 46.54%.

Under water-limited field conditions with scattered watering, the soybean seed field emergence was influenced by soil moisture content. The field conditions that gave the field emergence index in the range of 60-80% had to have average soil moisture content higher than 7.55, 7.30, and 7.79% during 7-day, 5-7-day, and 0-4-day periods, respectively (Trt. No 15), no matter what watering patterns they received. Fields that had an average soil moisture content lower than one of these three levels showed a field emergence index lower than 60%.

Table 2 Soil moisture content and field emergence index (FEI) of CM 60 soybean seeds planted under various watering patterns.

Trt. <sup>@</sup>	Watering at day after planting								Soil moisture (%)			FEI (%)
	0	1	2	3	4	5	6	7	0-4 dap	5-7 dap	Mean	
1	+	+h	+	+l	+l	+	++	++	9.84	9.34	9.59	95.02 A
2	+	+	++	++	+	++	m	m	11.04	11.82	11.43	89.17 AB
3	+	++	++	++	++	+	+	+	6.31	8.20	7.26	88.95 AB
4	+	+	++	++	+	++	m	m	11.93	12.37	12.15	82.74 AB
5	+h	+	+	+h	+l	+l	+l	+	11.59	11.52	11.56	89.69 AB
6	+h	+	+	+h	+l	+l	+l	+	11.59	11.52	11.56	81.48 ABC
7	++	++	++	++	++	+	++	++	8.54	10.11	9.33	81.11 ABC
8	+	+	+	++	++	++	+	+	6.33	6.40	6.37	46.54 EFG
9	++	++	++	++	++vh	-	++	++	8.62	7.98	8.30	80.46 ABC
10	++	++	++	++	++vh	-	-	-	9.05	7.06	8.06	73.16 ABCDE
11	+	+	+	+	+	-	-	-	6.33	4.30	5.32	46.27 EFG
12	+	+h	l	+	-	-	-	-	11.82	6.65	9.24	73.89 ABCDE
13	+	+h	l	+	-	-	-	-	11.82	6.65	9.24	63.98 BCDEF
14	+	+h	l	+	-	-	-	-	11.82	6.65	9.24	63.78 BCDEF
15	+	h	-	l	l	+	++	++	7.79	7.30	7.55	68.85 ABCDE
16	+	h	-	l	l	-	-	-	7.79	5.18	6.49	37.05 FG
17	++	-	++	-	++	++	++	++	7.06	9.31	8.19	62.25 BCDEF
18	+h	-	-	+h	l	l	l	-	11.78	11.45	11.62	75.54 ABCD
19	+h	-	-	+h	l	l	l	-	11.78	11.45	11.62	64.59 BCDEF
20	++	-	-	++	vh	-	-	-	7.49	6.31	6.90	48.75 DEF
21	+	-	-	++	++	+	+	+	5.25	8.20	6.73	1.64 H
22	++	-	++	-	++vh	-	++	++	7.23	7.33	7.28	48.78 DEF
23	++	-	-	++	-	++	++	++	6.76	10.00	8.38	53.01 CDEF
24	++	-	-	-	vh	-	-	-	5.86	5.23	5.55	7.79 H

Table 2 (Continued)

Trt. <sup>@</sup>	Watering at day after planting								Soil moisture (%)			FEI (%)
	0	1	2	3	4	5	6	7	0-4 dap	5-7 dap	Mean	
25	+	-	-	-	vh	-	+	+	5.75	7.07	6.41	21.61 GH
26	+	-	-	-	++	++	++	-	4.19	6.06	5.13	7.76 H
27	+	-	-	-	-	+	+	+	3.55	7.38	5.47	2.18 H
28	-	h	l	-	-	-	-	-	9.78	6.73	8.26	62.25 BCDEF
29	-	h	l	-	-	-	-	-	9.78	6.73	8.26	51.43 DEF
30	-	h	l	-	-	-	-	-	9.78	6.73	8.26	69.39 ABCDE
31	-	-	-	-	vh	-	++	++	0.67	11.66	6.17	2.25 H
32	-	-	-	-	vh	-	-	-	0.67	8.80	4.74	0.00 H
33	+1	++1	+1	++1	vh	l	+1	vh	15.58	14.18	14.88	68.97 ABCDE
F-test												**
C.V. (%)												23.93

\*\* = significant at  $P < 0.01$ .

Means not sharing the same letter in the column are statistically significantly different by DMRT.

Trt.<sup>@</sup> = treatment number ; treatment 1-8 = daily watering, treatment 9-32 = water-limited watering, and treatment 33 = rainy season planting.

-, +, ++ = no watering, watering in the morning, and watering twice-in the morning and evening, respectively.

l = little rain, m = moderate rain, h = heavy rain, vh = very heavy rain

dap = days after planting

Table 3 Soil moisture content and field emergence index of SJ 5 soybean seeds planted under various watering patterns.

Trt. <sup>@</sup>	Watering at day after planting								Soil moisture (%)			FEI (%)
	0	1	2	3	4	5	6	7	0-4 dap	5-7 dap	Mean	
1	+	+	++	++	+	++	m	m	11.04	11.82	11.43	97.47 ABC
2	+	+h	+	+l	+l	+	++	++	9.84	9.34	9.59	92.91 ABCD
3	+	++	++	++	++	+	+	+	6.31	8.20	7.26	91.42 ABCD
4	+	+	++	++	+	++	m	m	11.93	12.37	12.15	86.64 ABCDE
5	+h	+	+	+h	+l	+l	+l	+	11.59	11.52	11.56	83.28 BCDEFG
6	+h	+	+	+h	+l	+l	+l	+	11.59	11.52	11.56	84.06 ABCDEF
7	++	++	++	++	++	+	++	++	8.54	10.11	9.33	74.77 CDEFG
8	+	+	+	++	++	++	+	+	6.33	6.40	6.37	79.33 BCDEFG
9	++	++	++	++	++vh	-	++	++	8.62	7.98	8.30	106.72 A
10	++	++	++	++	++vh	-	-	-	9.05	7.06	8.06	101.27 AB
11	+	+	+	+	+	-	-	-	6.33	4.30	5.32	67.74 EFGHI
12	+	+h	l	+	-	-	-	-	11.82	6.65	9.24	63.23 EFGHI
13	+	+h	l	+	-	-	-	-	11.82	6.65	9.24	49.66 HIJ
14	+	h	-	l	l	+	++	++	7.79	7.30	7.55	85.14 ABCDEF
15	+	h	-	l	l	-	-	-	7.79	5.18	6.49	62.12 FGHI
16	++	-	++	-	++vh	-	++	++	7.23	7.33	7.28	91.81 ABCD
17	++	-	++	-	++	++	++	++	7.06	9.31	8.19	67.52 EFGHI
18	+h	-	-	+h	l	l	l	-	11.78	11.45	11.62	80.64 BCDEFG
19	++	-	-	++	vh	-	-	-	7.49	6.31	6.90	79.48 BCDEFG
20	+	-	-	++	++	+	+	+	5.25	8.20	6.73	71.85 DEFGH
21	+h	-	-	+h	l	l	l	-	11.78	11.45	11.62	70.96 DEFGH
22	++	-	-	++	-	++	++	++	6.76	10.00	8.38	45.92 IJ
23	+	-	-	-	vh	-	+	+	5.75	7.07	6.41	59.46 GHI
24	++	-	-	-	vh	-	-	-	5.86	5.23	5.55	33.62 J

Table 3 (Continued)

Trt. <sup>@</sup>	Watering at day after planting								Soil moisture (%)			FEI (%)
	0	1	2	3	4	5	6	7	0-4 dap	5-7 dap	Mean	
25	+	-	-	-	-	+	+	+	3.55	7.38	5.47	9.66 K
26	+	-	-	-	++	++	++	-	4.19	6.06	5.13	7.95 K
27	-	h	l	-	-	-	-	-	9.78	6.73	8.26	67.01 EFGHI
28	-	h	l	-	-	-	-	-	9.78	6.73	8.26	65.82 EFGHI
29	-	-	-	-	vh	-	++	++	0.67	11.66	6.17	37.02 J
30	-	-	-	-	vh	-	-	-	0.67	8.80	4.74	1.73 K
31	+l	++l	+l	++l	vh	l	+l	vh	15.58	14.18	14.88	72.71 DEFGH
F-test												**
C.V. (%)												16.07

\*\* = significant at  $P < 0.01$ .

Means not sharing the same letter in the column are statistically significantly different by DMRT.

Trt.<sup>@</sup> = treatment number ; treatment 1-8 = daily watering, treatment 9-30 = water-limited watering, and treatment 31 = rainy season planting.

-, +, ++ = no watering, watering in the morning, and watering twice-in the morning and evening, respectively.

l = little rain, m = moderate rain, h = heavy rain, vh = very heavy rain

dap = days after planting

In rainy season planting (Trt. No 33), CM 60 soybean seeds had a field emergence index of 68.97% in the field that had soil moisture content of 14.88, 14.18, and 15.58% during 7-day, 5-7-day and 0-4-day periods, respectively.

For SJ 5 soybean seeds planted under daily watering (Trt. No 1-8), most of them showed field emergence index higher than 80% (6 of 8 treatments) (Table 3).

SJ 5 seed field emergence mostly depended on soil moisture content uniformity, especially in the average of 7-9% soil moisture content, which had field emergence index higher than 100% (Trt. No 9 and 10). Non-uniform soil moisture content gave seed germination lower than 80% under very dry conditions that had the average soil moisture content lower than 7%. The field condition that had the early dry at the first 4 days with the soil moisture content lower than 6% showed a very low field emergence of lower than 60%.

Under rainy season planting (Trt. No 31), SJ 5 soybean seeds had a field emergence index the same as under dry field condition of 72.71% and the average soil moisture content was 14.88, 14.18, and 15.58% during 7-day, 5-7-day and 0-4- day periods, respectively.

## **II. Field emergence of soybean seeds planted under different field conditions**

### **2.1 Daily watering**

Ten lots of CM 60 seeds (Table 4) and eleven lots of SJ 5 seeds (Table 5) were planted under daily watering. The seeds had three statistically different qualities in terms of standard germination. Soybean seed field emergence under daily watering decreased according to their quality. The high quality seeds of CM 60 and SJ 5 varieties had field emergence of 79.50-86.00% and 72.00-91.00%, the medium quality seeds had field emergence of 63.50-69.50% and 61.00-74.00%, and the low quality seeds had field emergence of 45.50 and 59.50%, respectively.

Soybean seed emergence performance in terms of speed of emergence index, seedling height, and seedling shoot dry weight showed nearly the same trend as in field emergence but some showed a lower speed of emergence index. The seedling height and shoot

Table 4 Standard germination, field emergence, speed of emergence index, seedling height, seedling shoot dry weight and field emergence index of CM 60 soybean seeds of different qualities planted under daily watering field condition.

Seed lot number	Standard germination (%)	Field emergence (%)	Speed of emergence index	Seedling height (cm)	Seedling shoot dry weight (mg/seedling)	Field emergence index (%)
1	98.00 A	79.50 AB	7.79 BC	7.72 AB	63.00 A	81.11
2	98.00 A	81.00 AB	10.13 A	9.28 A	61.50 A	82.74
3	98.00 A	79.50 AB	9.37 AB	8.05 AB	66.75 A	81.48
4	95.25 A	85.50 A	10.21 A	7.95 AB	63.00 A	89.69
5	95.25 A	85.00 A	10.81 A	8.90 AB	60.50 A	89.17
6	90.50 A	86.00 A	9.29 AB	8.26 AB	66.75 A	95.02
7	90.50 A	80.50 AB	7.39 C	4.68 C	44.00 B	88.95
8	75.00 B	63.50 B	6.93 C	9.15 A	71.00 A	85.30
9	74.25 B	69.50 AB	8.23 BC	7.48 B	58.75 AB	98.87
10	54.00 C	45.50 C	4.29 D	7.53 B	56.50 AB	84.29
F-test	**	**	**	**	**	ns
C.V. (%)	7.37	10.97	10.29	9.34	12.12	17.07

ns, \*\* = non significant and significant at  $P < 0.01$ , respectively.

Means not sharing the same letter in each column are statistically significantly different by DMRT.

Table 5 Standard germination, field emergence, speed of emergence index, seedling height, seedling shoot dry weight and field emergence index of SJ 5 soybean seeds of different qualities planted under daily watering field condition.

Seed lot number	Standard germination (%)	Field emergence (%)	Speed of emergence index	Seedling height (cm)	Seedling shoot dry weight (mg/seedling)	Field emergence index (%)
1	96.25 A	72.00 BCD	7.49 CD	7.68 BC	54.25 AB	74.77
2	95.25 A	88.50 AB	10.11 AB	8.74 AB	60.00 AB	92.91
3	95.25 A	87.00 AB	9.69 AB	6.75 CD	53.50 AB	91.42
4	95.25 A	75.50 ABCD	6.47 DE	5.77 DE	37.25 C	79.33
5	93.50 AB	91.00 A	11.28 A	9.83 A	65.00 A	97.47
6	93.50 AB	78.00 ABCD	9.50 ABC	8.58 AB	65.00 A	83.28
7	91.25 AB	79.00 ABC	9.90 AB	9.88 A	62.75 A	86.64
8	91.25 AB	76.50 ABCD	9.04 BC	7.83 BC	55.75 AB	84.06
9	83.75 BC	61.00 CD	4.87 E	4.87 E	32.50 C	72.25
10	78.25 C	74.00 ABCD	8.99 BC	9.55 A	59.75 AB	94.44
11	63.75 D	59.50 D	5.38 E	7.19 BCD	45.50 BC	98.50
F-test	**	**	**	**	**	ns
C.V. (%)	5.82	11.15	11.64	9.62	14.15	16.12

ns, \*\* = non significant and significant at  $P < 0.01$ , respectively.

Means not sharing the same letter in each column are statistically significantly different by DMRT.



dry weight were not much different among seed qualities. Most of the CM 60 seeds had the seedling height and shoot dry weight of 7.48-9.15 cm and 56.50-71.00 mg, while SJ 5 seeds had the seedling height of 5.77-9.88 cm and shoot dry weight of 53.50-65.00 mg.

All soybean seed lots of both varieties planted under daily watering had the same high field emergence indexes, mostly higher than 81.11%. This indicated that in the field under daily watering, soybean seeds of all qualities had the ability to germinate of 80% or higher of their standard germination percentages.

## 2.2 Water-limited field planting condition

Seventeen seed lots of CM 60 (Table 6) and fourteen seed lots of SJ 5 (Table 7) were planted under drought condition. The high quality seeds with the standard germination of 86.50% and higher of CM 60 and SJ 5 varieties had the field emergence of 60.00-75.00% under drought planting condition (Tables 6 and 7). The medium and low quality seeds had a field emergence of lower than 60.00%.

CM 60 seeds showed uncertain speed of emergence index; however, medium and low quality seeds had a lower speed of emergence index. The high quality seeds of SJ 5 had speed of emergence indexes of 4.98-7.70 which were not statistically significantly different but were statistically higher than those of medium and low quality seeds. Seeds of both varieties showed uncertain seedling height and shoot dry weight. The medium and low quality seeds of CM 60 had a significantly higher seedling height and shoot dry weight. However, most of the SJ 5 seeds had a significant lower seedling height and shoot dry weight than high quality seeds.

CM 60 seeds of all qualities showed non statistically significant differences in field emergence index and most of them (15 in 17 lots) had a field emergence index of between 62.25-82.39%. Nearly the same trend was found in SJ 5 seeds that had a field emergence index of 62.12-80.64%, but the medium and low quality seeds gave a lower field emergence index of lower than 34.41%.

Table 6 Standard germination, field emergence, speed of emergence index, seedling height, seedling shoot dry weight and field emergence index of CM 60 soybean seeds of different qualities planted under water-limited condition.

Seed lot number	Standard germination (%)	Field emergence (%)	Speed of emergence index	Seedling height (cm)	Seedling shoot dry weight (mg/seedling)	Field emergence index (%)
1	99.50 A	73.50 A	8.54 A	6.85 BC	57.75 BCD	73.89
2	99.50 A	69.00 AB	5.48 ABCDE	4.66 FG	32.75 FG	69.39
3	98.50 A	63.00 ABC	6.55 ABCD	6.43 BCDE	56.25 CD	63.98
4	98.50 A	61.50 ABC	5.10 BCDE	4.51 G	31.25 FG	62.25
5	98.00 A	63.50 ABC	6.06 ABCD	6.23 BCDEF	44.25 DEFG	64.59
6	98.00 A	61.00 ABC	4.66 CDE	5.88 CDEFG	35.00 EFG	62.25
7	95.25 A	72.00 AB	7.39 ABC	6.63 BCD	46.00 DEF	75.54
8	94.25 A	60.00 ABC	6.42 ABCD	6.16 BCDEFG	51.75 CD	63.78
9	90.50 AB	62.00 ABC	5.14 BCDE	4.85 EFG	34.00 EFG	68.85
10	90.25 AB	72.50 AB	8.13 AB	7.72 AB	72.75 AB	80.46
11	90.25 AB	66.00 AB	7.38 ABC	6.95 BC	65.00 ABC	73.16
12	83.00 BC	43.00 BCD	4.15 DE	6.66 BCD	53.50 CD	51.77
13	83.00 BC	26.50 D	2.49 E	5.36 CDEFG	50.50 CDE	32.12
14	74.25 CD	59.50 ABC	4.45 CDE	5.04 DEFG	28.75 G	82.39
15	67.25 D	48.50 ABCD	5.37 BCDE	8.87 A	79.25 A	72.99
16	67.25 D	47.00 ABCD	5.14 BCDE	7.82 AB	80.25 A	71.13
17	54.00 E	35.00 CD	2.63 E	5.48 CDEFG	29.25 FG	65.96
F-test	**	**	**	**	**	ns
C.V. (%)	5.83	23.37	26.04	12.43	16.06	25.79

ns, \*\* = non significant and significant at  $P < 0.01$ , respectively.

Means not sharing the same letter in each column are statistically significantly different by DMRT.

Table 7 Standard germination, field emergence, speed of emergence index, seedling height, seedling shoot dry weight and field emergence index of SJ 5 soybean seeds of different qualities planted under water-limited condition.

Seed lot number	Standard germination (%)	Field emergence (%)	Speed of emergence index	Seedling height (cm)	Seedling shoot dry weight (mg/seedling)	Field emergence index (%)
1	96.50 A	63.50 AB	5.22 AB	4.81 CDE	32.25 BCDEF	65.82 A
2	96.50 A	61.00 AB	6.63 A	6.71 AB	53.50 A	63.23 A
3	96.25 A	65.00 AB	4.98 AB	6.22 ABC	35.75 BCDE	67.52 A
4	95.25 A	68.50 AB	5.20 AB	5.45 ABCD	42.25 ABCD	71.85 A
5	95.25 A	64.50 AB	6.58 A	4.79 CDE	37.00 BCDE	67.74 A
6	95.25 A	59.00 AB	5.40 AB	5.01 BCD	40.00 ABCD	62.12 A
7	94.75 A	63.50 AB	5.45 AB	5.15 BCD	33.00 BCDE	67.01 A
8	93.50 A	75.00 A	7.70 A	6.58 ABC	44.00 ABC	80.64 A
9	91.25 AB	64.50 AB	6.39 A	6.33 ABC	42.25 ABCD	70.96 A
10	86.50 AB	68.50 AB	7.10 A	7.00 A	45.75 AB	79.48 A
11	83.75 B	20.50 CD	1.63 CD	3.11 E	23.42 EF	23.88 B
12	74.00 C	25.50 CD	2.23 CD	4.82 CDE	27.88 CDEF	34.41 B
13	65.00 D	7.50 D	0.54 D	3.72 DE	16.85 F	11.45 B
14	63.75 D	44.50 BC	3.35 BC	5.20 ABCD	27.50 DEF	70.91 A
F-test	**	**	**	**	**	**
C.V. (%)	5.28	22.48	25.84	15.92	20.83	23.11

\*\* = significant at  $P < 0.01$ .

Means not sharing the same letter in each column are statistically significantly different by DMRT.

### 2.3 Rainy season

The soybean seeds had field emergence according to their seed quality when planted in rainy season. High quality seeds with the germination of 98.00-96.25% had field emergence of 67.50 and 70.00% for CM 60 and SJ 5 varieties, respectively (Table 8). The medium and low quality seeds of CM 60 variety had a very low field emergence of 38.50-26.50%, while the SJ 5 seeds had the field emergence of 53.00-50.00%.

Seeds of both varieties had speed of emergence index with the same pattern as their field emergence. The seedling growth in terms of height and shoot dry weight showed statistically significant differences between seed qualities.

Only high quality seeds of CM 60 had field emergence index of 68.97% but medium and low quality seeds had a very low field emergence index of 45.08 and 36.56%, respectively. SJ 5 seeds had a better field emergence ability under rainy season planting. The high and low quality seeds had a field emergence index of 72.71 and 72.00%, respectively, and medium quality seeds had a field emergence index of 57.98%.

Table 8 Standard germination, field emergence, speed of emergence index, seedling height, seedling shoot dry weight, and field emergence index of CM 60 and SJ 5 soybean seeds of different qualities planted in rainy season.

Variety	Seed lot number	Standard germination (%)	Field emergence (%)	Speed of emergence index	Seedling height (cm)	Seedling shoot dry weight (mg/seedling)	Field emergence index (%)
CM 60	1	98.00 A	67.50 A	8.45 A	9.73 A	61.25 AB	68.97 A
	2	87.25 A	38.50 B	5.25 B	9.95 A	69.50 A	45.08 B
	3	75.00 B	26.50 B	3.03 C	8.63 B	53.75 B	36.56 B
F-test		*	**	**	*	**	*
C.V. (%)		8.62	17.62	13.03	7.07	6.99	26.59
SJ 5	1	96.25 A	70.00 A	8.61 A	10.15 A	65.00 A	72.71 A
	2	86.25 B	50.00 B	6.06 B	8.75 B	50.00 B	57.98 B
	3	73.75 C	53.00 B	6.56 B	9.50 AB	55.17 B	72.00 A
F-test		*	**	*	**	**	*
C.V. (%)		6.98	12.72	15.62	4.23	6.79	10.81

\*, \*\* = significant at  $P < 0.05$  and  $P < 0.01$ , respectively.

Means not sharing the same letter in each column of each variety are statistically significantly different by DMRT.

### **III. Response of soybean seed quality to the field planting conditions**

The high and medium quality seeds of both varieties showed the same statistical responses to planting conditions under daily watering, drought and rainy season (Table 9). Under drought and rainy planting, the high quality seeds had a field emergence of 65.30-70.00%, while the medium quality seeds had 23.00-50.00% field emergence for both varieties. For the low quality seeds, CM 60 seeds had the same level of field emergence of 43.50-45.50% under drought condition as daily watering planting but had a very low field emergence of 26.50% in rainy season planting. While the low quality seeds of SJ 5 variety had the same level of field emergence of 53.00-59.50% under the daily watering planting and in rainy season, they had very low field emergence of 26.00% under drought condition. The results indicated that high quality seeds gave the same field emergence level under both drought and rainy season plantings. Both of them showed the potential to emerge under the stress conditions. However, the medium and low quality seeds of both varieties had low potential to emerge in drought and rainy season plantings.

Table 9 Field emergence of CM 60 and SJ 5 soybean seeds of different qualities planted under various field conditions.

Variety	Field condition	Seed quality		
		High	Medium	Low
Field emergence (%)				
<b>CM 60</b>	Daily watering	82.43 A	66.50 A	45.50 A
	Drought	65.82 B	43.00 B	43.50 A
	Rainy season	67.50 B	38.50 B	26.50 B
F-test		**	**	*
C.V. (%)		7.56	11.51	22.56
Field emergence (%)				
<b>SJ 5</b>	Daily watering	80.94 A	67.50 A	59.50 A
	Drought	65.30 B	23.00 B	26.00 B
	Rainy season	70.00 AB	50.00 A	53.00 A
F-test		**	**	**
C.V. (%)		7.13	24.08	16.06

\*, \*\* = significant at  $P < 0.05$  and  $P < 0.01$ , respectively.

Means not sharing the same capital letter in each column of each variety are statistically significantly different by DMRT.

#### IV. Water-limited germination test

The three statistically different qualities of seeds, in terms of standard germination, from both varieties are shown in Table 10.

Table 10 Standard germination of CM 60 and SJ 5 soybean seeds used in the water-limited germination test.

Variety	Germination (%)			F-test	C.V. (%)
	High	Medium	Low		
CM 60	98.75 a	83.00 b	67.25 c	**	5.29
SJ 5	96.00 a	75.50 b	65.00 c	**	9.08

\*\* = significant at  $P < 0.01$ .

Means not sharing the same letter in each row are statistically significantly different by DMRT.

Soybean seeds germinated in soil in baskets showed a sensitive response to water-limited conditions or limited water supply, in terms of both amount of water and watering frequency. At 50%PAW daily watering, high, medium and low quality of CM 60 seeds had germination of 80.00, 54.50 and 56.50%, respectively (Table 11), whereas SJ 5 had germination of 83.50, 79.00 and 49.00% for high, medium and low quality seeds, respectively. Germination decreased dramatically when they were watered at 50%PAW every 3 days and under every watering frequency at 40%PAW. At 50%PAW every 2 days watering, high quality seeds of CM 60 and SJ 5 varieties had germination of 66.00 and 70.00%, respectively. However, medium quality seeds of SJ 5 variety showed quite a good germination under the condition. At 50%PAW every 3 days watering and at 40%PAW every watering frequency, most seed quality levels of both varieties had germination lower than of 56.00%.

Seedling growth in terms of speed of emergence index, seedling height and seedling shoot dry weight had the same pattern as germination when seeds were germinated in the soil under the water-limited conditions (Tables 12, 13 and 14).



Table 11 Germination of CM 60 and SJ 5 soybean seeds of three different qualities planted in the soil in basket with different amounts of water and watering frequencies.

Amount of water and watering frequencies	Germination (%)		
	High	Medium	Low
<b>CM 60</b>			
50%PAW daily	80.00 A	54.50 A	56.50 A
50%PAW every 2 days	66.00 B	33.00 B	14.00 B
50%PAW every 3 days	15.50 D	0.00 C	0.00 C
40%PAW daily	41.00 C	26.50 B	17.00 B
40%PAW every 2 days	20.50 D	3.50 C	0.00 C
40%PAW every 3 days	0.00 E	0.00 C	0.00 C
F-test	**	**	**
C.V. (%)	17.96	21.43	27.76
<b>SJ 5</b>			
50%PAW daily	83.50 A	79.00 A	49.00 A
50%PAW every 2 days	70.00 B	61.00 B	31.00 B
50%PAW every 3 days	22.00 D	47.00 BC	0.00 E
40%PAW daily	39.50 C	56.00 B	20.50 C
40%PAW every 2 days	32.00 CD	36.00 C	6.50 D
40%PAW every 3 days	0.00 E	8.00 D	0.00 E
F-test	**	**	**
C.V. (%)	14.64	15.68	15.75

\*\* = significant at  $P < 0.01$ .

Means not sharing the same letter in each column of each variety are statistically significantly different by DMRT.

Table 12 Speed of emergence index of CM 60 and SJ 5 soybean seeds of three different qualities planted in the soil in basket with different amounts of water and watering frequencies.

Amount of water and watering frequencies	Speed of emergence index		
	High	Medium	Low
<b>CM 60</b>			
50%PAW daily	12.49 A	7.29 A	9.53 A
50%PAW every 2 days	9.30 B	4.05 B	1.80 B
50%PAW every 3 days	1.75 DE	0.00 C	0.00 C
40%PAW daily	6.01 C	3.20 B	2.13 B
40%PAW every 2 days	2.37 D	0.35 C	0.00 C
40%PAW every 3 days	0.00 E	0.00 C	0.00 C
F-test	**	**	**
C.V. (%)	16.61	22.73	28.74
<b>SJ 5</b>			
50%PAW daily	13.17 A	11.41 A	6.18 A
50%PAW every 2 days	10.36 B	8.91 B	3.46 B
50%PAW every 3 days	2.70 D	6.08 CD	0.00 D
40%PAW daily	5.72 C	7.50 BC	2.47 C
40%PAW every 2 days	4.18 CD	4.61 D	0.74 D
40%PAW every 3 days	0.00 E	1.20 E	0.00 D
F-test	**	**	**
C.V. (%)	15.01	18.18	18.26

\*\* = significant at P < 0.01.

Means not sharing the same letter in each column of each variety are statistically significantly different by DMRT.

Table 13 Seedling height of CM 60 and SJ 5 soybean seeds of three different qualities planted in the soil in basket with different amounts of water and watering frequencies.

Amount of water and watering frequencies	Seedling height (cm)		
	High	Medium	Low
<b>CM 60</b>			
50%PAW daily	9.08 A	7.33 A	11.90 A
50%PAW every 2 days	5.36 C	4.27 B	3.32 C
50%PAW every 3 days	2.09 D	0.00 C	0.00 D
40%PAW daily	6.62 B	4.35 B	5.12 B
40%PAW every 2 days	2.24 D	1.11 C	0.00 D
40%PAW every 3 days	0.00 E	0.00 C	0.00 D
F-test	**	**	**
C.V. (%)	13.06	31.72	20.35
<b>SJ 5</b>			
50%PAW daily	10.47 A	10.46 A	8.52 A
50%PAW every 2 days	6.10 B	6.58 B	4.52 B
50%PAW every 3 days	2.62 C	4.60 C	0.00 D
40%PAW daily	5.92 B	7.08 B	5.82 B
40%PAW every 2 days	3.63 C	3.28 C	2.48 C
40%PAW every 3 days	0.00 D	1.65 D	0.00 D
F-test	**	**	**
C.V. (%)	17.85	13.50	21.67

\*\* = significant at  $P < 0.01$ .

Means not sharing the same letter in each column of each variety are statistically significantly different by DMRT.

Table 14 Seedling shoot dry weight of CM 60 and SJ 5 soybean seeds of three different qualities planted in the soil in basket with different amounts of water and watering frequencies.

Amount of water and watering frequencies	Seedling shoot dry weight (mg/seedling)		
	High	Medium	Low
<b>CM 60</b>			
50%PAW daily	27.25 A	18.75 A	28.50 A
50%PAW every 2 days	15.25 C	11.75 B	13.44 C
50%PAW every 3 days	10.92 D	0.00 C	0.00 D
40%PAW daily	19.50 B	13.25 B	17.00 B
40%PAW every 2 days	10.81 D	3.75 C	0.00 D
40%PAW every 3 day	0.00 E	0.00 C	0.00 D
F-test	**	**	**
C.V. (%)	8.42	33.02	12.95
<b>SJ 5</b>			
50%PAW daily	29.00 A	20.00 A	19.75 A
50%PAW every 2 days	16.25 B	15.25 AB	12.75 B
50%PAW every 3 days	11.00 C	13.50 BC	0.00 D
40%PAW daily	19.50 B	16.25 AB	13.97 B
40%PAW every 2 days	11.00 C	10.14 CD	9.50 C
40%PAW every 3 days	0.00 D	7.50 D	0.00 D
F-test	**	**	**
C.V. (%)	11.73	16.72	10.96

\*\* = significant at P <0.01.

Means not sharing the same letter in each column of each variety are statistically significantly different by DMRT.

### V. Soybean seed germination under flooding condition

Soybean seeds showed a very low tolerance to flooding. High quality seeds of CM 60 and SJ 5 varieties treated with captan had only 4.00 and 3.00% germination when they were flooded for only four hours (Table 15). The seeds flooded for 48 hours had no germination at all.

Table 15 Germination of CM 60 and SJ 5 soybean seeds under different flooding periods.

Flooding periods (hours)	Germination (%)	
	CM 60	SJ 5
0	85.50 A	88.50 A
4	4.00 B	3.00 B
6	0.50 B	5.00 B
12	0.50 B	4.50 B
24	0.50 B	3.00 B
48	0.00 B	0.00 B
F-test	**	**
C.V. (%)	12.04	15.02

\*\* = significant at  $P < 0.01$ .

Means not sharing the same letter in each column are statistically significantly different by DMRT.

## **VI. Soybean seed germination test for evaluating field emergence under drought condition and in rainy season**

Analysis of variance of the soybean seed germination among the watering daily at 40%PAW, daily and every 2 days at 50%PAW, and under drought, and rainy season field planting conditions was undertaken (Table 16). The high quality seeds of CM 60 and SJ 5 varieties receiving daily watering at 40%PAW showed lower germination percentages than field emergence both under drought field condition and in the rainy season planting. The same statistical germination percentages were found in medium quality seeds. But the low quality seeds under stress planting field condition had field emergence higher than the germination percentage in 50%PAW every 2 days watering test.

The seeds germinated in soil in baskets at 50%PAW every 2 days watering gave statistically the same germination percentage as in drought field condition and in rainy season planting for almost seed qualities of both CM 60 and SJ 5 varieties.

Table 16 Germination of CM 60 and SJ 5 soybean seeds of three qualities tested in three water-limited methods, drought field condition, and in rainy season.

Test methods and field conditions	Germination (%)		
	High	Medium	Low
<b>CM 60</b>			
40%PAW daily	41.00 C	26.50 C	17.00 C
50%PAW daily	80.00 A	54.50 A	56.50 A
50%PAW every 2 days	66.00 B	33.00 BC	14.00 C
Drought field condition	65.82 B	43.00 AB	43.50 B
Rainy season	67.50 B	38.50 BC	26.50 C
F-test	*	**	**
C.V.(%)	9.49	14.70	19.59
<b>SJ 5</b>			
40%PAW daily	39.50 C	56.00 B	20.50 B
50%PAW daily	83.50 A	79.00 A	49.00 A
50%PAW every 2 days	70.00 B	61.00 B	31.00 B
Drought field condition	65.30 B	23.00 C	26.00 B
Rainy season	70.00 B	50.00 B	53.00 A
F-test	**	**	**
C.V.(%)	9.12	14.75	14.37

\*, \*\* = significant at  $P < 0.05$  and  $P < 0.01$ , respectively.

Means not sharing the same letter in each column of each variety are statistically significantly different by DMRT.

## VII. Effect of soil series on water-limited germination test in soybean seeds

CM 60 and SJ 5 seeds of three quality levels (Table 17) were used in water-limited germination test in three soil series. The high quality seeds had a very high germination of 85.50-96.50% in Ko Yai (silt loam) and Tha Khwang (clay) soil series. In Ranong/Phato association (sandy loam) soil, they had only 58.50 and 55.00% germination of CM 60 and SJ 5 seeds, respectively (Table 18). Medium and low quality seeds showed not much different germination in the test among three soil series. The differences in germination percentage were in high quality seeds tested in the Ranong/Phato association soil. These differences mainly depended on the soil water holding capacity. Figure 1 shows the soil moisture content of three soil series. Silt loam and clay soils had nearly the same moisture content which was higher than the sandy loam soil during the test.

Table 17 Standard germination of CM 60 and SJ 5 soybean seeds of different qualities used in the tests.

Variety	Germination (%)			F-test	C.V. (%)
	High	Medium	Low		
CM 60	98.25 a	75.25 b	14.25 c	**	9.85
SJ 5	95.50 a	70.75 b	51.25 c	**	5.86

\*\* = significant at  $P < 0.01$ .

Means not sharing the same letter in each row are statistically significantly different by DMRT.



Table 18 Germination of CM 60 and SJ 5 soybean seeds of three different qualities in water-limited germination tested in three soil series.

Soil series/ Texture	Germination (%)		
	High	Medium	Low
<b>CM 60</b>			
Rg/Pto / Sandy loam	58.50 B	35.50 B	22.00
Koy / Silt loam	96.50 A	55.50 A	21.50
Tq / Clay	95.50 A	46.00 AB	18.00
F-test	**	*	ns
C.V. (%)	12.58	19.78	27.74
<b>SJ 5</b>			
Rg/Pto / Sandy loam	55.00 B	43.50	31.00
Koy / Silt loam	85.50 A	56.00	19.50
Tq / Clay	92.50 A	57.00	23.50
F-test	**	ns	ns
C.V. (%)	16.96	23.14	23.64

ns, \*, \*\* = non significant, significant at  $P < 0.05$ , and  $P < 0.01$ , respectively.

Means not sharing the same letter in each column of each variety are statistically significantly different by DMRT.

Rg/Pto = Ranong/Phato association

Koy = Ko Yai

Tq = Tha Khwang

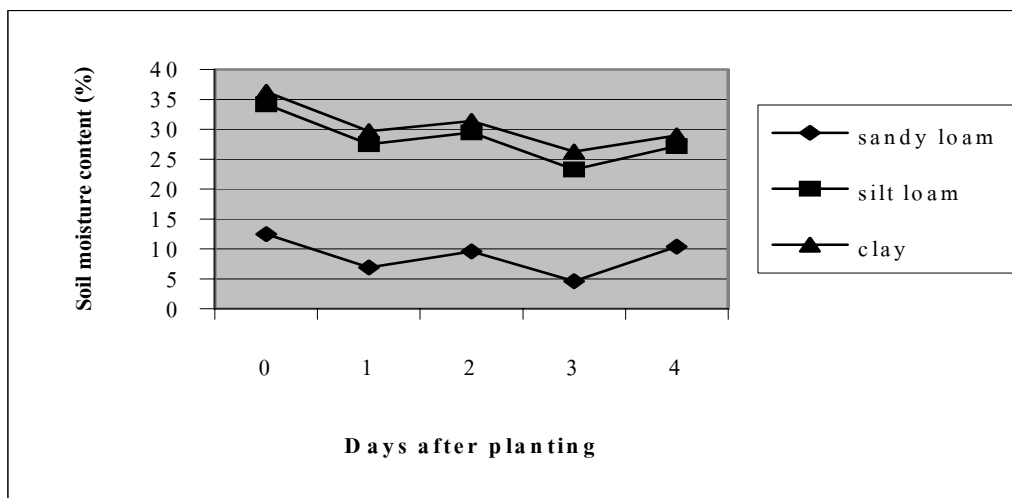


Figure 1 Soil moisture contents at 0-4 days after planting of sandy loam (Ranong/Phato association), silt loam (Ko Yai) and clay (Tha Khwang) soil watered at 50%PAW every 2 days.