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The Density Effect on the Dry Matter Production of Zea mays

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옥수수의 乾物質生産에 미치는 密度効果

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ABSTRACT

The present experiments differing from that conducted by agriculturists with the first consideration of food or seed production were performed in order to investigate the density effect on dry matter production in the artificial population of maize. Three experimental plots were established and one seed was sown in the first plot, 2 seeds in the second plot and 3 seeds in the third plot, respectively. The space of each ridge was designed with 30cm in width and 50cm in length. The space of each seed was 4cm and the growth amount by density was measured through three times. The results obtained are as follows:

1) The total growth amount per unit area was in the order of the third, second and first plots until the second sampling. At the third sampling the whole plots showed almost the same growth amount except the first plot which showed a slightly smaller amount.
2) The growth amount per individual plant was in the order of the third, second and first plots until the second sampling, while the first plot showed drastic growth compared with the other two plots at the third sampling.
3) The growth amount by each organ (leaf, stem and root) of the plant body was markedly abundant in the stem of the non-productive part compared with that in the leaf of the productive part. Especially the root was affected remarkably by density and the first plot showed an abundant growth in comparison with the other plots which were too poor to resist the ground surface.

INTRODUCTION

One of the basic problems in the plant ecology is presumed to be the relationship between the plant population density and the growth of its constructive plant; i. e. the relationship between the dry matter production and the plant population density. A good deal of agriculturists and dendrolo-

gists have ever studied merely the simple growth of plant. The relationship between the plant population density and dry matter production was once investigated by Clements (1929) in his "Classical and Comprehensive Study" and Kira (1953) on sunflower and wheat by using field crops. These studies, however, have provided nothing but some information on the actual growth process and mechanism of the plant population to various density.

It has been well known that Senda(1955) reported his study on "Young stands of Japanese red pine of various density"; plant density effect on the growth of *Vicia faba* by Hodgson and Blackman(1956) and density effect on the dry weight of *Fagopyrum esculentum* by Iwaki (1958). Romose(1940), Larsen(1941), Monsi and Saeki(1953) have been continuously engaged in this field of research, especially Iwaki reported in his thesis an effect on the plant growth in the population or the photosynthesis and respiration, the ratio to the photosynthetic and non-photosynthetic systems, and light condition to the population.

This study differing from that made by agriculturists with the first consideration of seed production was carried out in order to investigate the density effect on dry matter production in the artificial population of maize. Therefore, it is believed that the results of this study will provide the necessary data in determining the most effective density for dry matter production of crop plants.

MATERIAL AND METHODS

The variety of maize used for the experiment was flint corn, the weight of which was 0.475g per grain. The experiment was conducted from June 27 through October 1, 1969 at the experimental farm of Kon Kuk University. The seed was sown on June 27 and germinated on July 28. The pH value was 6.7 in the A layer of the experimental farm soil, containing 0.60me/100g of K which is somewhat greater than 0.32me/100g of the average content of the field soil in Korea. P_2O_5 was 298.1 ppm which is also greater than 114 ppm of the average content while N was 0.06%, smaller than 0.2% of the average content.

Three experimental plots were established and one seed was sown in the first plot, 2 seeds in second plot and 3 seeds in the third plot, respectively. The space of each ridge was designed with 30cm in width and 50cm in length. The number of seeds sown per $1m^2$ was 12 grains in the first plot, 24 grains in the second plot and 36 grains in the third plot. Sampling was carried out by leaf, stem and root through 3 times in order to measure the growth by density. The first sampling was done on July 27, 20 days after germination, the second on August 27 and the third on September 27, respectively, by picking up 6, 12 and 18 individuals per $1m^2$. The fresh weight of these samples was measured subsequently and dry weight was also measured after having dried at the temperature of 100°C for 5-6 days.

RESULTS

The density effect on the growth of maize is as presented in Tables 1 and 2. Table 3 shows dry matter production by plant layer and Table 4 illustrates the relationship between the plant height and light intensity.

Table 1. Matter production (g/1 ind.) of stem, leaf and root of *Zea mays* communites grown at various planting densities.

Plot	Each part of plant body	Jul. 27		Aug. 27		Sep. 27	
		F. W.	D. W.	F. W.	D. W.	F. W.	D. W.
1	stem	16.45	1.10	27.1	37.0	827.3	135.5
	leaf	2.21	0.21	54.7	4.5	133.7	40.7
	root	2.25	0.25	33.1	5.0	131.3	36.8
	total	20.91	1.56	114.9	46.5	1092.3	213.0
2	stem	19.35	1.55	371.5	45.8	457.0	78.0
	leaf	3.47	0.21	67.8	7.5	88.7	26.9
	root	2.85	0.40	39.2	7.5	37.7	10.7
	total	25.67	2.16	478.5	60.8	583.4	115.6
3	stem	42.60	3.65	397.2	60.7	284.0	50.0
	leaf	7.52	0.59	71.4	7.6	61.1	18.7
	root	4.20	0.50	48.9	8.1	31.0	8.7
	total	54.32	4.74	517.5	76.4	376.1	77.4

Table 2. Matter production (g/m²) of stem, leaf and root of *Zea mays* communities grown at various planting densities.

Plot	Each part of plant body	Jul. 27		Aug. 27		Sep. 27	
		F. W.	D. W.	F. W.	D. W.	F. W.	D. W.
1	stem	98.70	6.60	1510.0	175.0	4963.8	813.0
	leaf	13.26	0.72	314.2	26.0	802.3	221.3
	root	13.50	1.50	184.2	30.1	788.2	221.7
	total	125.46	8.82	2008.4	231.1	6554.3	1256.0
2	stem	232.20	18.60	3738.2	425.0	5484.0	936.2
	leaf	41.64	2.50	786.8	90.0	1064.5	293.9
	root	34.20	4.80	442.2	90.0	452.2	127.2
	total	308.04	25.90	4967.2	605.0	7000.7	1357.3
3	stem	766.80	65.70	5272.5	755.2	5124.4	898.4
	leaf	135.36	10.80	1321.5	136.0	1112.3	306.9
	root	75.60	9.00	852.4	140.8	557.2	156.1
	total	977.76	85.50	7446.4	1032.0	6793.9	1361.4

Table 3. Plant matter production of *Zea mays* (g/m²)

	1 plot							
	stem		leaf		root		stem	
each layer	F. W.	D. W.	F. W.	D. W.	F. W.	D. W.	F. W.	D. W.
20cm	444.0	85.8	1.2	0.3		100.0	537.0	103.9
40	333.9	64.6	3.2	0.8		30.0	523.0	101.0
60	367.7	71.4	26.4	7.4			490.0	94.8
80	407.2	76.5	38.2	10.5			465.0	89.8
100	375.2	67.0	53.0	14.6			609.0	107.7
120	453.4	75.8	88.2	24.3			961.0	135.9
140	420.2	69.3	111.5	30.4			1278.0	174.0
160	615.3	87.5	127.5	35.3			350.0	56.1
180	793.5	106.8	110.5	30.2			122.0	21.3
200	608.0	82.6	85.2	23.5			52.0	10.1
220	135.5	21.7	57.2	15.7			42.0	8.1
240	45.5	8.8	46.7	12.9			46.0	8.9
260	45.4	8.8	36.2	10.0			9.0	1.7
280	13.0	2.5	11.0	3.0				
300	6.0	1.2	6.0	1.7				
Total	5063.8	830.3	802.0	220.6		130.0	5484.0	913.3

2 plot				3 plot					
leaf		root		stem		leaf		root	
F. W.	D. W.	F. W.	D. W.	F. W.	D. W.	F. W.	D. W.	F.W.	D.W.
			30.7	700.0	135.0				25.0
12.9	3.6		7.7	595.0	115.1				6.0
29.0	8.0			508.0	98.1	22.0	6.0		
79.0	21.8			562.0	108.7	89.0	24.5		
126.0	34.6			805.0	121.8	160.0	44.2		
195.0	53.8			409.0	64.1	207.0	57.1		
165.0	44.2			468.0	71.6	197.0	54.4		
155.0	42.7			607.0	86.3	160.0	44.2		
150.0	41.4			124.0	23.9	124.0	34.2		
95.0	26.1			267.0	38.9	88.0	24.4		
42.0	11.5			39.0	7.5	45.2	12.4		
15.0	4.0			40.2	7.5	20.1	5.5		
1.0	0.3								
1064.9	292.0		38.4	5124.2	878.5	1112.3	306.9		31.0

Table 4. Relationship between plant height and light intensity.

plants height	1 plot	2 plot	3 plot
0 cm	30%	7%	7%
20	33	8	7
40	37	9	7
60	38	12	6
80	40	16	6
100	43	20	7
120	48	24	8
140	50	32	21
160	54	40	50
180	62	48	62
200	73	56	74
220	78	62	82
240	80	74	95
260	85	97	···
280	94	···	···

DISCUSSION

1) Growth variation of leaf, stem and root by individual plant

The measurement value of leaf, stem and root by individual plant of Table 1 is as illustrated in Figs. 1, 2 and 3 below.

The growth rate by leaf, stem and root per individual plant was almost the same in the

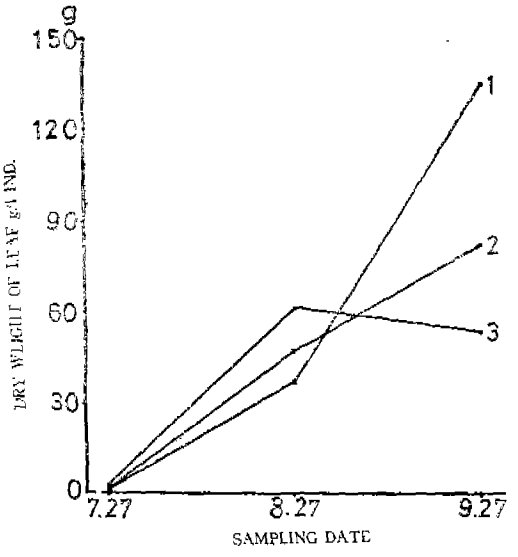

Fig. 1 Growth in leaf dry weight (g/1 ind.) of *Zea mays*.

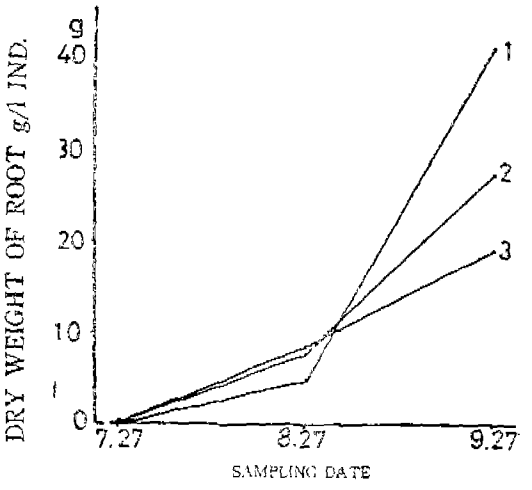

Fig. 2 Growth in stem dry weight (g/1 ind.) of *Zea mays*.

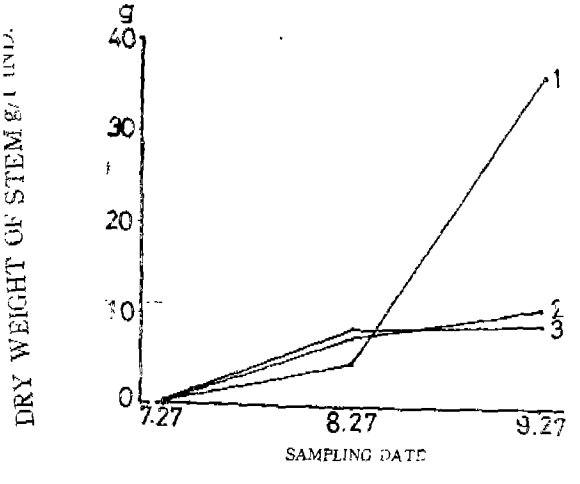

Fig. 3 Growth in root dry weight (g/1 ind.) of *Zea mays*.

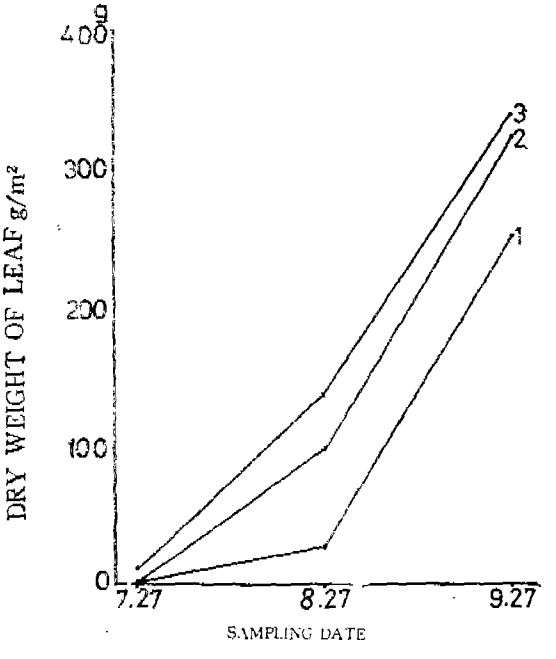

Fig. 4 Growth in leaf dry wight (g/m²) of *Zea mays*.

first, second and third plots at the first sampling, while the growth of the first plot was somewhat declined compared with that of the second and third plots at the second sampling. The second and third plots showed a similar growth of leaf and root, but a great difference in the growth of stem was observed in all plots. At the third sampling, however, the growth of leaf in the first plot was greater than the growth rate of the second and third plots as contrary to the second sampling, while the first plot showed a sharp increasing tendency in the growth of root compared with the second sampling. No particular difference was observed in both the second and third plots, however. In the case of stem a sharp increase was also observed in the first plot and the second plot showed the same growth rate as that before the second sampling, while it was declined more than that of the second sampling in the third plot.

2) Variation of leaf, stem and root of each plant body per $1m^2$

Figs. 4, 5 and 6 illustrate the measurement value of leaf, stem and root of the plant body per $1m^2$ presented in Table 2.

The growth of leaf, stem and root of the plant body per 1 m^2 was similar altogether at the early growth stage, while the growth of stem in the third plot was greater than that of the other two plots. At the second sampling it showed almost the same growth rate in each plot except leaf and root of poor growth in the first plot, especially a sharp increase was observed in the growth of stem in the third plot. The leaf at the third sampling showed almost the same growth in both the second and third plots, and the stem of the second plot showed better growth than that of the first and third plots. Although no particular difference was observed in the root of the second and third plots compared with the second sampling, it showed a sharp growth in the

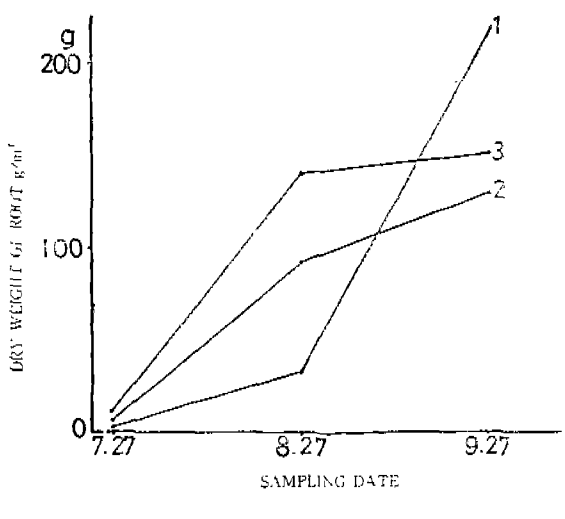

Fig. 5 Growth in stem dry weight (g/m^2) of *Zea mays*.

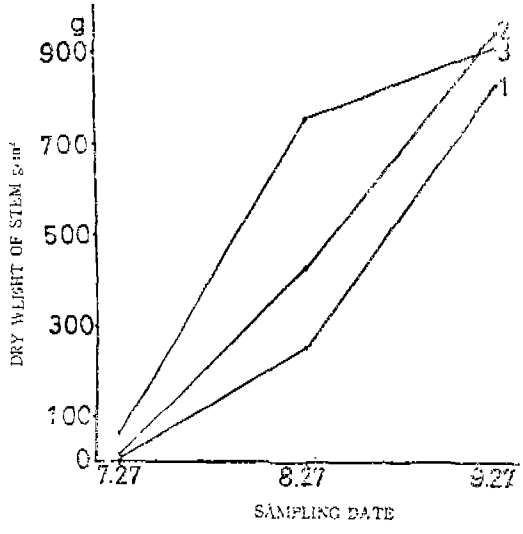

Fig. 6 Growth in root dry weight (g/m^2) of *Zea mays*.

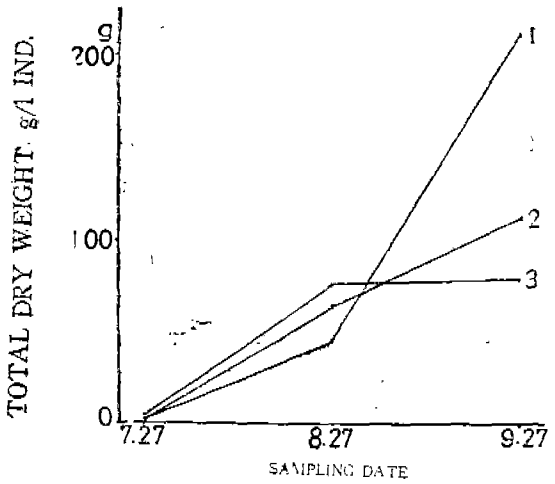

Fig. 7 Growth in dry weight(g/1 ind.)of *Zea mays*.

first plot.

Summarizing 1) and 2) above, the total dry weight (leaf, stem and root) per individual plant body, as illustrated in Fig. 7, was the same in both the first and second plots at the first sampling and the third plot showed a slight increase. The increasing ratio until the second sampling was in the order of the third, second and first plots, but it was not increased in the third plot at the third sampling compared with the second sampling. The second plot showed an increase at the same rate as at the second sampling and was greater than the third plot.

On the other hand, the first plot showed a sharp increase, greater than that of the second and third plots. When the first plot was set as 100%, the total dry weight(leaf, stem and root) was 50% in the second plot and only 30% in the third plot, respectively.

3) Variation of the total dry weight per 1 m^2

The variation of the total dry weight per 1 m^2 of Table 2 is as illustrated in Fig. 8.

There was observed no remarkable difference in the order of the third, second and first plots at the first sampling. However, when the growth rate of the third plot is set as 100% at the second sampling, the second plot is 60% and the first plot is 24%, respectively. This indicates

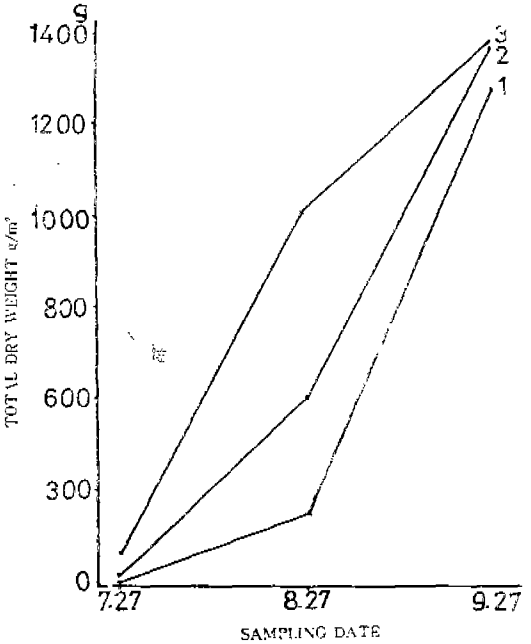

Fig. 8 Growth in dry weight (g/m^2)of *Zea mays*.

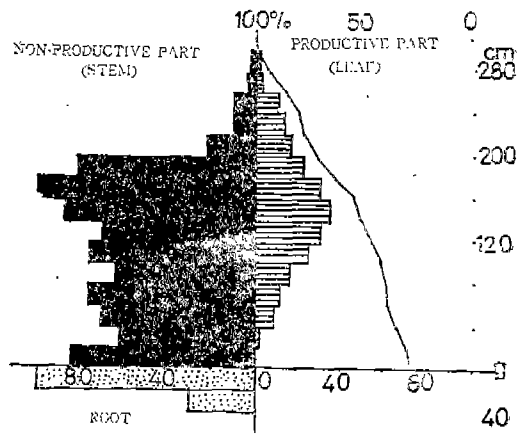

Fig. 9 Productive structure in dry weight (g/m^2) of *Zea mays* in the lst plot. Right side: plant height, Upper: light intensity(solid line).

that the third plot was the greatest all the same, and a remarkable difference was observed in the second and first plots. At the third sampling, however, the second plot was 98% and the the first plot was 90%, respectively, when the increasing rate of the third plot was set as 100%. Therefore, a sharp increase may be seen in both the first and second plots compared with the second sampling. Although the first plot showed a slight declination in the growth, almost the same level was observed in the third, second and first plots altogether.

4) Growth structure of dry weight

The diagrams of growth structure by using Tables 3 and 4 are as shown in Figs. 9, 10 and 11 below.

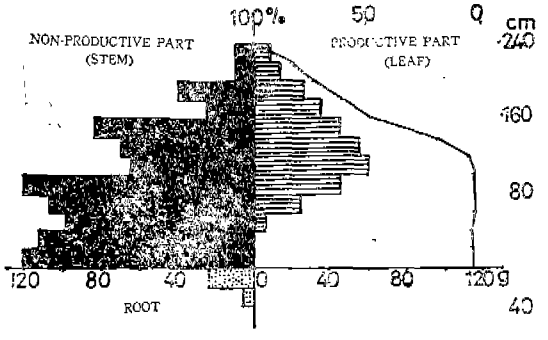

Fig. 10 Productive structure in dry weight(g/m²) of *Zea mays* in the 2nd plot. Right side: plant height, Upper: light intensity(solid line).

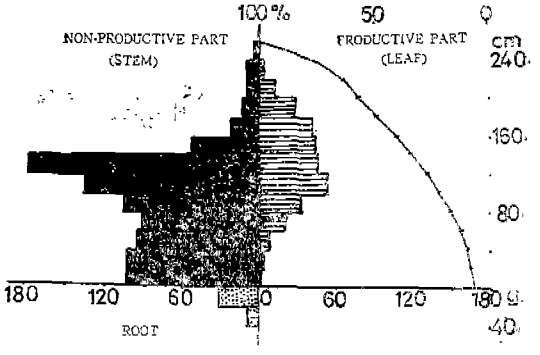

Fig. 11 Productive structure in dry weight(g/m²) of *Zea mays* in the 3rd plot. Right side: plant height, Upper: light intensity (solid line).

The diagram of productive structure per 1 m² of each plot shows that the root of the non-productive part was grown strikingly in the first plot compared with other plots. The growth of the leaf or the productive part was grown abundantly around the area of 140-160cm in plant height and the stem was markedly grown around the area of 140-200cm. Contrary to the first plot, the root growth in the second plot was very poor while the leaf was grown markedly between 100-120cm and the stem was best grown between 100-140cm but almost the same up to 100cm from the ground surface. The growth of the productive part was the greatest between 100-120cm and the stem was grown abundantly with almost the same amount between 100cm from the ground surface in comparison with the productive part. The root growth was the poorest all the same among three plots.

As seen from this structural diagram, the non-productive part was grown abundantly compared with the productive part because of such characteristic of maize as the fruit is included in the non-productive part. And also the root was grown in the order of the third, second and first plots until the second sampling, but it was very poor in the second and third plots while the first plot showed drastic growth at the third sampling. This may be considered attributable to the number of plant individuals and organic nutrient of soil per unit area. Consequently, the root of the second and third plots could not keep its resistance to the ground surface compared with the plant

body in the first plot and therefore there was observed especially a great deal of lodging by wind in the second and third plots.

CONCLUSION

The growth amount of the plant body per individual was in the order of the third, second and first plots until the second sampling, but the opposite phenomenon was observed at the third sampling. This may be considered attributable to organic nutrient of soil and light effect by density. The growth amount by organ of the plant body was in the order of the second, third and first plots in the stem; the third, second and first plots in the leaf and the first, third and second plots in the root. The poor growth of the second and third plots may be considered that the root is more affected by density than the other organs.

摘 要

本 實驗은 지금까지 農學者들에 의한 食糧, 즉 種子의 수확량을 위주로한 硏究와는 달리 옥수수의 人工群落에 있어서 그의 密度가 植物體의 物質生産에 미치는 영향을 밝히고져 이루어진 것으로 3個의 實驗區를 설치하고 1區는 種子 1個, 2區는 2個, 3區는 3個를 播種하고 이랑 간격은 가로 30 cm, 세로 50cm로 하고 各 種子間 간격을 4cm로 하여 密度에 따른 生長量을 三次에 걸쳐서 測定한 結果는 다음과 같다.

1) 二次 Sampling까지는 단위면적당 전 생장량이 3區가 제일 많았고 다음은 2區, 1區의 순서였으며 三次 Sampling에서는 3區, 2區, 1區의 順序였지만 거의 같은 生長量을 보였고 1區가 약간 적었다.
2) 植物 個體당 生長量은 二次 Sampling까지는 3區, 2區, 1區의 순서였으나 三次 Sampling에서는 1區가 2區나 3區보다도 급격한 生長을 보였다.
3) 植物體의 各 器官(잎, 줄기, 뿌리)별 生長量은 非生産部인 줄기의 生長이 生産部인 잎보다 월등히 많았으며 특히 뿌리는 密度의 영향을 많이 받아서 1區가 2區와 3區보다 많은 生長을 보였으며, 2區, 3區는 극히 빈약하여 地上部를 지탱하지 못하는 경향이 있었다.

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