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Effect of Defoliation on the Grain Yield of Two Soybean Cultivars Grown under Different Population Densities

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摘葉處理가 栽植密度를 달리한 大豆品種의 收量 및 收量構成要素에 미치는 影響

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Abstract

Defoliation effect of two soybean cultivars on the grain yield was studied under different planting densities planted at two different planting date.

Leaf removal caused a linear decrease of grain yield with increased amounts of defoliation in the case of lower population densities, while in the case of higher population densities over 40 plants per sqare meter, the slight removal of lower leaves indicated increased grain yields by 13% to 35% compared with control depending on the cultivar and planting time.

The pod number per plant was the most effective factor influencing grain yield. The grain weight and the percent of matured grain become more important components for higher yield with decreased population densities depending on cultivar.

Introduction

Soybean is an important crop, not only for its broad uses in animal and human foods, but also for its cultural properties as a favorable crop in rotation systems, and as an inter-or mix-crop in different cropping sequences in Korea. One of the more widely cropping systems used in Korea is the double cropping of soybeans after barley. In this case, the grain yield of soybeans are adversely affected because of the shorter duration available for growth. Under these conditions, it is necessary to understand the relationship between population density and canopy in order to compensate for yield loss due to the shorter growth duration.

Reports on population density in relation to soybean canopy and its response to grain yields have been variable. Shibles, R.M. and C.R. Weber,[12] H.S. Lee,[7] K.Y. Park,[11] and Atsuhiko Kumura[6] reported that the response of grain yield to various planting densities is quite different depending on cultivars, weather, soil conditions, and cultural practices such as planting time, fertilization, planting pattern, and postulated optimum leaf area for the maximum yield.

Den F. McAlister and Orland A. Krober[8] reported that seed yield was lowered significantly by 40% and 80% leaf removal and that leaf removal caused a definite and similar decrease in number of mature pods. They also observed that seed weight expressed as grams per 100 seeds was the most sensitive measurement of response to leaf and pod removal.

Beuerlein et al[1] reported that at the highest population density debranched plants produced 10% greater yields than normal plants and the difference of the yield between normal and debranched plants at the high population was due to greater pod set per node, greater seed weight, and less structural material being produced in the debranched plants.

The light intensity and degeneration or falling of lower leaves vary greatly depending on the population density of the soybean cultivar and to a considerable extent on the degree of leave damage caused by insect feeding or disease occurance.

The object of this study is to determine the effect on grain yield from different degrees defoliation of two soybean cultivars grown under different population densities and planting times.

Materials and Methods

Two cultivars Kwangkyo and SRF-300 were planted in 50cm spacings on June 1st and June 20th, respectively. The variety Kwangkyo is a Korean bred cultivar and determinate in growth type, while SRF-300 is a USA cultivar, indeterminte in growth type with small and somewhat narrow leaves. The population densities and planting pattern for each population are as follows;

plants per square meter		80	40	27	20
planting pattern	within rows	1 2	1 2 1	1	1
	plants per hill	1 1	1 1 2	1	1

Defoliation treatments were carried out on 20 plants of each treatment at initial flowering stage by removal of leaves from the lower part of each plant. The remaining number of leaves were 1, 2, 3, 5, and 7 as counted from the top plus an untreated control. From the control plots of each population, leaf area was measured at initial flowering stage and 30 days after flowering stage. In the discussion of experimental results for defoliation treatments, the average value for all planting patterns in the same population density treatment were used, since there were no great differences between planting patterns within population density for the response of grain yield.

Results and Discussion

From the control plot of four different population densities, LAI was measured, and the relationship between LAI and grain yield in both optimum and late planting of the two cultivars were studied respetively. The results are shown in figure 1 and 2.

According to second degree polynomial, there were significant quadratic effects in the relation between grain yield and LAI in Kwangkyo. The maximum yield of this cultivar occured at an LAI of around 4 at the initial flowering stage and at an LAI of 5-6 at 30 days after initial flowering stage in case of optimum date planting. For the late planting the maximum yield occured at an LAI of 4-5 at the initial flowering stage and also 30 days at the post initial flowering stage.

In cultivar SRF-300, there were also significant quadratic effects in the response of grain yield to LAI except that in this case late planting showed a linear response. The maximum yield occured at an

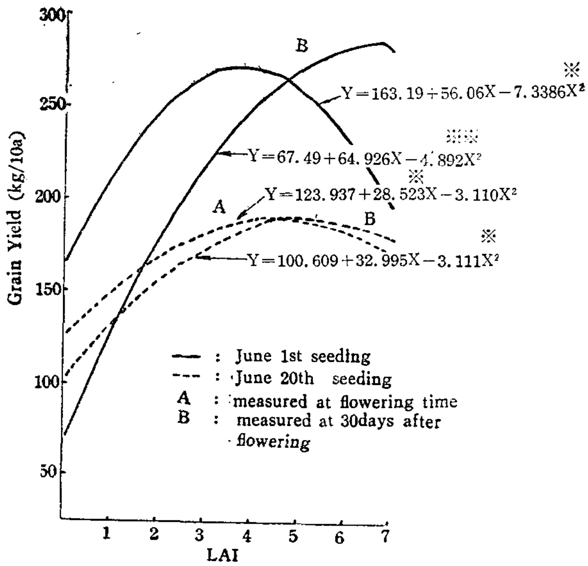

Fig. 1. Relationship between LAI and grain yield (Kwangkyo)

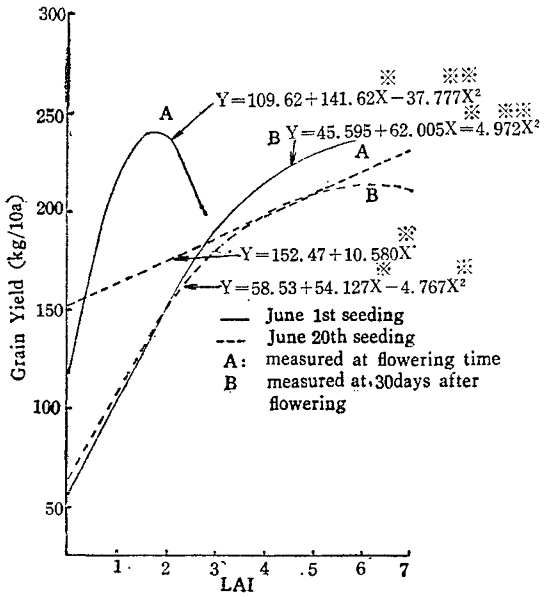

Fig. 2. Relationship between LAI and grain yield (SRF—300)

LAI of around 2.5 at the initial flowering stage and at an LAI of about 6 in case of 30 days after initial flowering stage for the optimum date of planting.

Defoliation effects on the grain yield were quite different with population densities, cultivars, and planting time. In the case of the optimum planting time for Kwangkyo, there were significant quadratic effects on yield response to the number of remaining leaves in the highest population denstiy, which indicated considerable increase of grain yield by slight defoliation. The grain yield of the slight defoliation plot under the highest population density (7 leaves from the top were left) was as much as 35% higher as compared with the control.

On the other hand, plots under the population densities of 20, 27 and 40 plants per square meter showed linear decreases of grain yield with increased amounts of defoliation.

In case of late planting of Kwangkyo, there were significant quadratic effects in the response of grain yield to defoliation in both populations of 40 and 80

Table I. Defoliation effect of soybean plants to grain yield under different populiation density. (Kwangkyo)

Seeding time	Plants/m² / Planting patterns / No. of remained leaves	80		40			27	20
		1—1	1—2	1—1	1—2	2—1	1—1	1—1
1st June	1	177.0	177.7	91.3	102.7	84.0	78.3	75.3
	2	220.7	222.0	206.3	192.7	201.7	162.7	121.3
	3	226.7	226.0	215.7	219.3	200.7	173.3	137.7
	5	274.3	265.0	229.3	236.7	234.3	166.0	154.7
	7	302.0	296.7	293.7	289.0	285.7	235.0	246.0
	Control	217.8	223.7	286.9	298.9	268.1	265.4	234.8
20th June	1	96.3	88.3	60.3	66.0	53.3	39.0	35.7
	2	131.7	131.3	107.3	120.0	114.0	94.0	85.3
	3	180.3	184.3	156.0	160.0	159.3	107.7	101.7
	5	194.0	196.0	179.3	180.3	177.0	129.0	148.0
	7	200.7	203.7	196.3	198.0	181.3	148.3	142.3
	Control	158.0	165.7	184.6	212.8	173.0	177.0	174.0

※ 1—1 indicate 1 within row and 1 plant per hill

plants per square meter. Slight defoliation showed an increase of grain yield as much as about 1% and 25% for population densities of 40 and 80 plants per square meter as compared with the control, respectively. On the other hand, grain yield of lower population dentities showed linear decreases in yield with increased amounts of defoliation. Different responses of grain yield to the amount of defoliation between optimum and late planting were observed in the population desnity of 40 plants per square

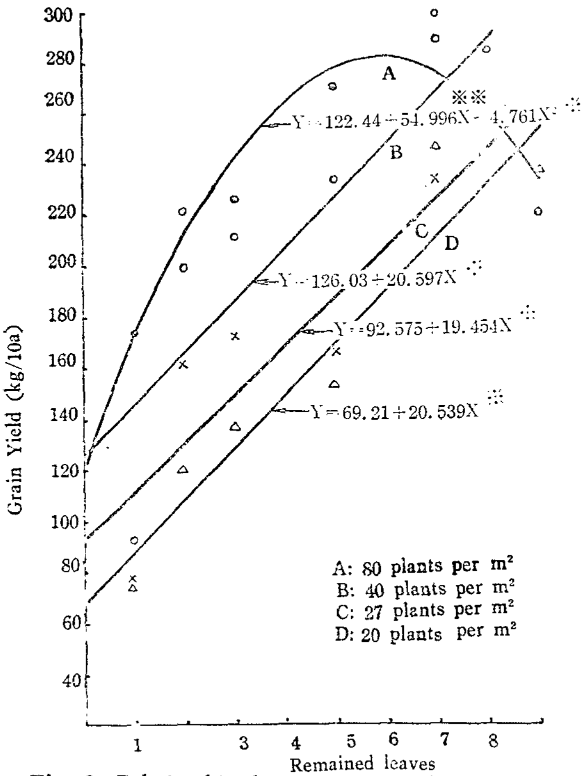

Fig. 3. Relationship between remained leaves and grain yield (Kwangkyo, 1st June)

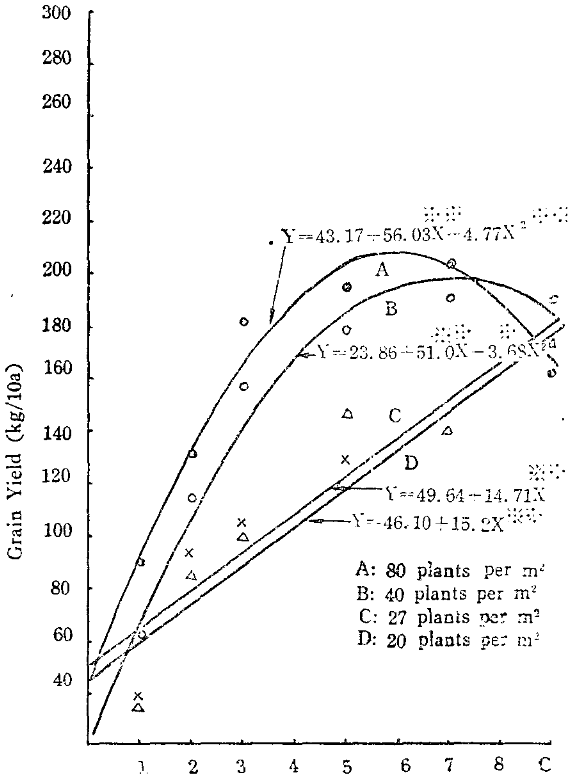

Fig. 4. Relationship between remained leaves and grain yield (Kwangkyo, 20th June)

meter, but the grain yields of the optimum planting date were always higher than late planting in any of the treatments.

In the case of the optimum planting date of SRF-300, the response of grain yield to the amount of remaining leaves showed significant quadratic effects in the population density of 40 and 80 plants per square meter, but the increase of grain yield by the slight removal of lower leaves were smaller than that of late planting. The grain yield of slight defotiation (7 leaves remaining from the top) increased as much 13% compared with the control under the highest population density, while there were no significant differences between these two treatments in the population density of 40 plants per square meter.

On the other hand, in the population densities of 27 and 20 plants per square meter, grain yields were linearly decreased by increased amounts of defoliation.

Under late plantings, the relationship between grain yield and remaining numbers of leaves were quite similar to the same relationship within the optimum planting date except quite large difference of grain yield responding to the amount of leaves remained between different population densities.

The minimum defoliation plot indicated increase grain yield of 32% over the control under the highest population density, while there were no significant differences between these two treatments in the population density of 40 plants per square meter.

The decrease in grain yield by increasing amounts of defoliation under lower population densities were larger than that of the optimum planting date. These different responses of grain yield to the defoliation account for the fact that some reports indicate decreases or little effect on grain yield while others indicate increase in grain yields.

According to the above results, it is concluded

Table II. Defoliation effect of soybean plants to grain yield under different population density. (SRF—300)

Seeding time	Plants/m² / Planting patterns / No. of remained leaves	80		40			27	20
		1—1	1—2	1—1	1—2	2—1	1—1	1—1
1st June	1	164.7	166.0	152.0	147.7	144.7	120.0	105.3
	2	209.0	206.3	171.3	167.3	186.7	165.3	136.7
	3	216.3	218.3	190.0	194.3	201.3	175.7	145.3
	5	224.7	232.0	213.0	210.0	213.3	186.0	166.0
	7	232.0	233.3	227.0	231.7	227.3	214.3	181.7
	Control	202.8	206.7	236.1	241.2	229.4	224.8	209.1
20th June	1	89.3	99.7	50.0	56.3	45.3	40.3	38.0
	2	152.3	160.7	104.0	100.3	103.3	86.7	74.7
	3	196.7	202.0	164.7	168.0	167.3	141.7	121.7
	5	219.0	237.3	171.3	178.3	174.3	165.7	136.3
	7	240.3	251.3	199.0	209.7	202.7	169.7	147.0
	Control	184.1	188.7	189.0	217.5	192.0	174.9	167.3

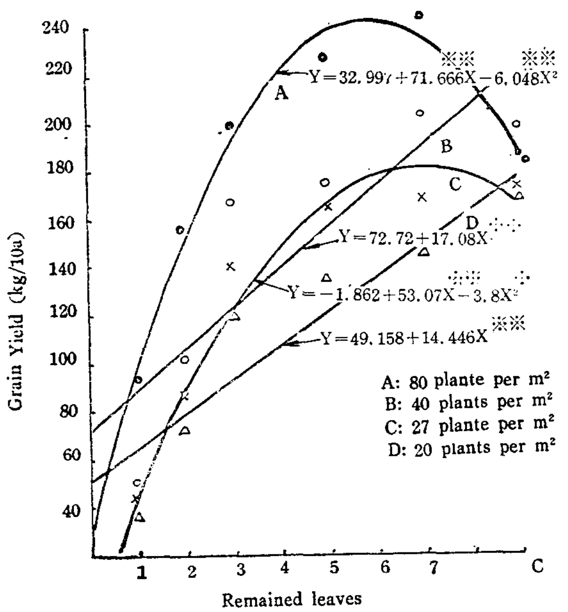

Fig. 5. Relationship between remained leaves and grain yield (SRF—300, 1st June)

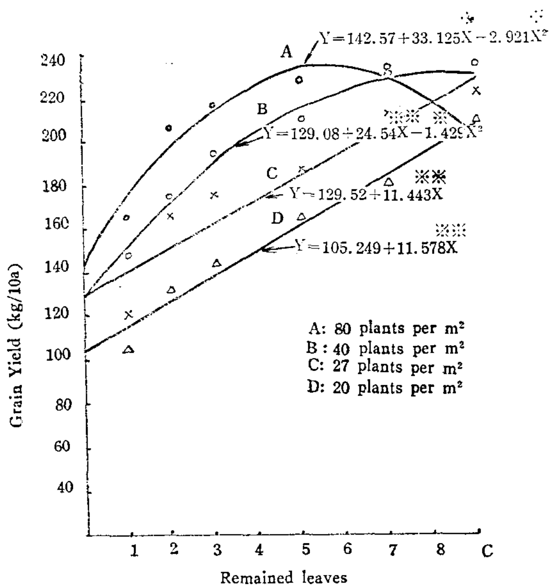

Fig. 6. Relationship between remained leaves and grain yield (SRF—300, 20th June)

that a population density of over 40 plants per square meter will not be economically adequate in terms of dry matter production due to over vegetation, and thus a little removal of lower leaves would be an efficient practice for the increase of grain yield in cases of over vegetation.

In order to find out the effects of yield components to grain yield under the condition of various defoliation treatments in each population density, the results were analysed by the method of path coefficient analysis for both cultivars and planting times.

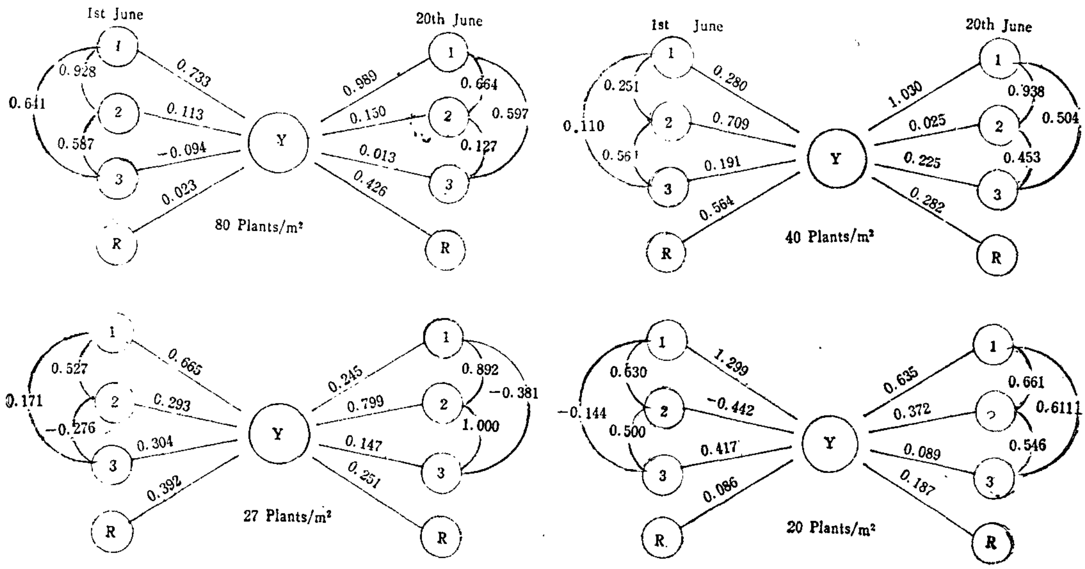

Fig. 7. Path coefficient of yield components for grain yield and correlation coefficients between yield components under different population density and planting time. (Kwangkyo)
1) No. of pods, 2) Matured grain percentage, 3) 100 grain weight, 4) Residual effect, Y) Grain yield

For the cultivar Kwangkyo, the most effective factor for grain yield among yield components was the number of pods per plant. The percentage of matured grain was also effective in some cases.

Under the higher population densities of 40 and 80 plants per square meter, pod number per plant was more critical in late planting than optimum planting. On the other hand, in lower population densities pod number per plant was more critical to the grain yield for the optimum planting date as compared to the late planting date. In lower population densities within the optimum planting date, grain weight was a significant factor for increased grain yield. The above results indicated that in the

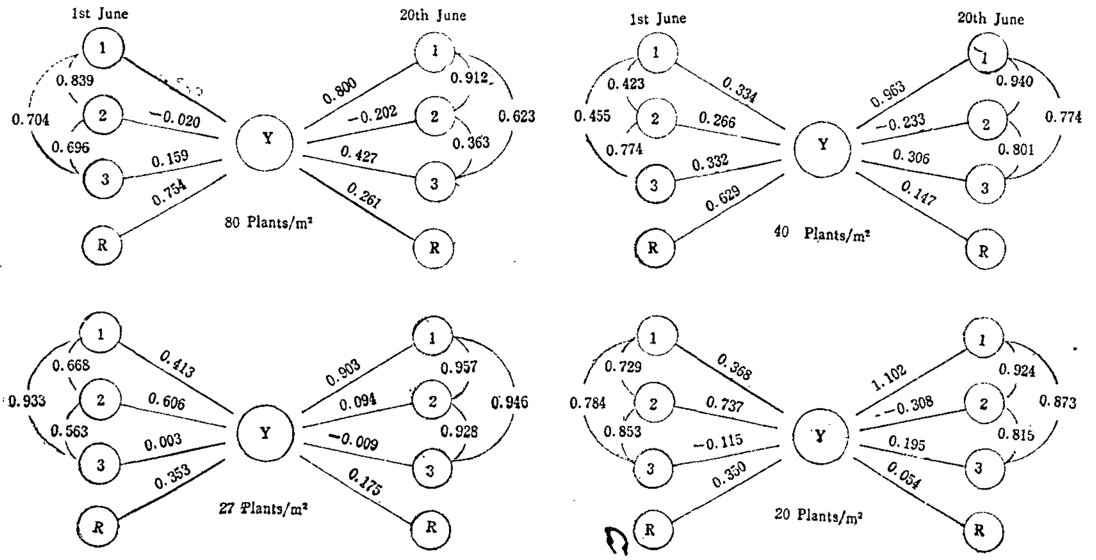

Fig. 8. Path coefficient of yield components for grain yield and correlation coefficients between yield components under different population density and planting time. (SRF-300)

response of grain yield to the defoliation, pod number per plant is the more important factor for higher yield in late planting as compared to optimum planting and the effect of grain weight became more important with decreasing population densities within the optimum date of planting.

For the cultivar SRF-300, pod number per plant was also the most effective factor, particulary in case of late planting for each population density. However, as the population density decreased, the percent of matured grain became more critical in its effect on grain yield within the optimum planting date. This was not observed for the late planting of the cultivar SRF-300.

Residual effects in the conventional planting date, particulary under higher population densities were condiserably large. The source of residual effects is not clear in this case but the seed number per pod and some disease damage is considered as a possible source. According to McAlister[8] leaf removal caused a definite decrease in number of matured pods, but seed weight was the most sensitive measurement of response to leaf and pod removal.

In this experiment, the results suggest that in the response of grain yield to leaf removal, the pod number per plant is the most important factor, particulary in late planting and the percentage matured grain becomes more important with decreasing population densities within the optimum date of planting of cultivar SRF-300.

SUMMARY

The optimum LAI was observed to be 4—5 at the initial flowering stage and 5—6 at 30 days after flowering, depending upon the date of planting for the cultivar Kwangkyo.

For the cultivar SRF-300, the optimum LAI were 2.5—6 at the initial flowering stage and 6—7 at 30 days after the initial flowering stage, depending on planting date.

Leaf removal caused a linear decrease of grain yield with increased amounts of defoliation in the case of lower population desities, while in the higher population densities, quadratic effects were statistically significant.

The slight removal of lower leaves indicated increased grain yields by 25% to 35% in Kwangkyo and 13% to 32% in SRF-300 compared with the control in the case of the highest population density for the optimum and late planting dates, respectively.

According to path coefficient analysis, the pod number per plant was the most effective factor influencing grain yield in both cultivars, particulary in late planting. The effect of grain weight become more important for higher yield with decreased population densities within the optimum planting date for Kwangkyo.

In case of SRF-300, as the population density decreased the percent of matured grain become more of an effective component of grain yield within the optimum planting date.

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摘　　要

栽植密度를 달리한 條件에서 摘葉處理가 大豆品種의 收量 및 收量構成要素에 미치는 影響을 알고저 6月1日과 6月20日에 m^2當 80本, 40本, 27本 및 20本이 되도록 栽植密度를 調節 播種하고 開花始期에 殘餘葉數가 上部로부터 各各 1,2,3,5,7葉이 되도록 下位葉을 摘葉處理하고 無摘葉의 標準區를 包含하는 6處理로 하여 試驗을 實施하였는데 그 結果를 要約하면 다음과 같다.

1. 標準區에서의 最適葉面積指數는 播種期에 따라다르며 光敎에 있어서는 開花始에 LAI가 4~5이고 開花後 30日에는 5~6이었으며 SRF-300에 있어서는 開花始에 2.5~6.0이고 開花 30日後에는 6~7이었다.

2. 種實收量은 栽植密度가 낮은 境遇에는 摘葉處理에 依하여 直線的으로 減少되었으나 栽植密度가 m^2當 40本以上으로 높은 境遇에는 收量과 着葉數사이에 有意的인 曲線効果가 認定되어 下位部의 輕微한 摘葉處理를 하므로서 標準에 比하여 光敎에서는 25~35%, SRF-300에서는 13~32%의 增收를 보였다.

3. 摘葉處理時에 收量에 가장 크게 影響하는 收量構成要素는 全體的으로 볼때 植物體當 莢數이며 다음으로 6月1日 播種區에서 栽植密度가 減少됨에 따라서 光敎에서는 粒重의 効果가 增大되었고 SRF-300에서는 收量에 影響하는 稔實率의 比重이 顯著히 增大되었다.