Influence of Shade Treatment on Leaf and Branch Emergence, and Dry Matter Production of Kudzu Vine Seedlings (Pueraria lobata Ohwi)

Tsugawa, Hyoe

Tange, Munetoshi

Mizuta, Yasunori

(Citation)
神戸大学農学部研究報告,16(2):359-367

(Issue Date)
1985-01-31

(Resource Type)
departmental bulletin paper

(Version)
Version of Record

(JaLCDOI)
https://doi.org/10.24546/00225553

(URL)
https://hdl.handle.net/20.500.14094/00225553

神大農研報 (Sci. Rept. Agr. Kobe Univ.) 16 : 359—367, 1985

INFLUENCE OF SHADE TREATMENT ON LEAF AND BRANCH EMERGENCE, AND DRY MATTER PRODUCTION OF KUDZU VINE SEEDLINGS (*Pueraria lobata* Ohwi)

Hyoe TSUGAWA*, Munetoshi TANGE* and Yasunori MIZUTA**

(Received for publication on August 10, 1984)

Abstract

During the period from May to August 1980, potted seedlings of kudzu vine were grown at four levels of shade (0, 35, 66, and 83% shade) under a glasshouse condition to evaluate their growth responses to reduced light. Leaf emergence of the main stem was delayed, and emergence and growth of branches tended to be suppressed as the degree of shade increased. Decrease in dry weight of plant tops with increasing amount of shade was dependent more largely on decrease in dry weight of the primary branches than that of the main stems and the secondary branches. Out of total dry weight of the plant top, the percentage of leaflet dry weight was higher in lower light intensities and that of the stem dry weight had a reverse relationship. Root dry weight and diameter at the base of the main root decreased with incraesing shade, and shade reduced main root weights more remarkably than latreals. Under the deepest shade (83%), root growth was affected to a greater extent than top growth.

Introduction

In high-rain areas of the tropics and subtropics, a large variety of crops can be cultivated by making use of abundant sunlight and water. A number of workers, however, have pointed out that too much solar energy and water have been a dangerous power destroying arable land. In fact, there are many tragic examples in many places with respect to the soil erosion in upland fields. Planting of cover crops which develop their leaf canopies rapidly and cover the ground surface completely is desirable for the purpose of preventing soil erosion. Tropical kudzu (*Pueraria phaseoloides* Benth.), a close relative of kudzu vine (*P. lobata* Ohwi), has given excellent results as a cover crop in rubber, oil palm, citrus and clove plantations in many parts of the tropics.

Kudzu vine is considered to be very suitable for soil cover and erosion control in humid tropics and subtropics beause it can grow in these climates, having a wide range in soil adaptability and vigorous propagating power, improving the nitrogen status of soil, and covering the soil surface rapidly by means of expanding their broad leaves. However, solar radiation in the tropics may be quite low due to a dense cloud cover during the wet season and may be intercepted by the partial shade of tree crops in many areas where these crops are grown. For these reasons, influence of shade on the growth characteristics of kudzu vine seedlings was examined in this study.

Materials and Methods

Seeds of kudzu vine were collected from wild plants in a campus of Kobe University in early December, 1979. Mature and large-size seeds were selected. Scarification for hastening germination of the seeds were conducted according to the procedure described in previous peper[14]. On 10 May 1980, six germinated seeds were sown in a 1/5,000 are Wagner pot filled with 4 kg of sandy loam soil which had been screened

*Laboratory of Crop Science
**Hyogo Agricultural Research Center (Awaji)

through a 5-mm sieve. The amount of applied fertilizers was 0.16 g N, 0.66 g P_2O_5 and 0.38 g K_2O per pot. Pots were placed in a glasshouse of the faculty of agriculture, Kobe University. Shade was imposed by steel frames of 1-m height, which were covered with one layer of a white cheese cloth (35% shade), two layers of a white cheese cloth and a black one (66% shade) and two layers of a white cheese cloth and a baron screen (The Koizumi Jute Mills Ltd.) (83% shade). While full light intensity inside the glasshouse averaged 79% of full sunlight outside the glasshouse, it was used as a control (0 % shade) for comparing all other treatment. Fifteen pots were alloted for each treament. All pots were watered with 300 ml of tap water at 2 to 4 day-intervals until early July and were watered daily thereafter.

Emergence dates of the leaves on main stems and of primary branches were recorded. We considered that a new leaf had appeared on a stem when the tip became visible outsible the stipules and that the primary branch had emerged when the first leaf to appear on the branch became visible. Plants were thinned to one on June 10 (32 days after seeding). For each shade treatment, plants were harvested about 7 days after ceasing to produce leaves on the main stem, namely on August the 14th (96 th day after seeding) for 0 %, 18th for 35%, 21st for 66% and 25th for 83% shade. Stem length, leaf area and dry weight of each organ in plant tops were measured separately for the main stems, the primary and the secondary branches. Dry weight of plant roots was determined separately for the main roots and laterals, and diameter at the base of the main roots was measured.

Results

1. Weather conditions

Mean daily temperature inside the glasshouse and outdoor level of solar radiation during the experimental period are given in Fig. 1. The data on the solar radiation used for drawing the Fig. 1 and on sunshine hours were cited from the observations of Osaka District Meteorological Observatory situated about 25 km east of Kobe University. The sunshine hours of 1980 were 12% longer than normal for May and were 20, 29 and 50% shorter for June, July and August, respectively. The solar radiation was 14% and 2% higher for May and June when compared with normal and was 5% and 17% lower for July and August. As shown in Fig. 2, mean daily temperature tended to become slightly lower with increasing amounts of shade.

2. Leaf emergence of the main stem

As seen in Fig. 3, the differences in leaf emergence interval started occuring among treatments around 7 days after the onset of shade (20 days after seeding), and leaf emergence tended to be delayed as the amount of shade increased. It was diagnosed from Fig. 3 that a turning of leaf emergence rate occured at the 9th leaf in 83 % shade. However, the turning point was not so obvious in 0, 35, and 66% shade as that in 83% shade. Average leaf emergence interval between the 3rd leaf at which the difference in the interval began to appear and the 9th leaf was 3.8, 4.4, 4.9 and 7.1 days for 0, 35, 66 and 83% shade, respectively. The differences in average leaf-emergence interval disappeared among four shade treatments in the latter half.

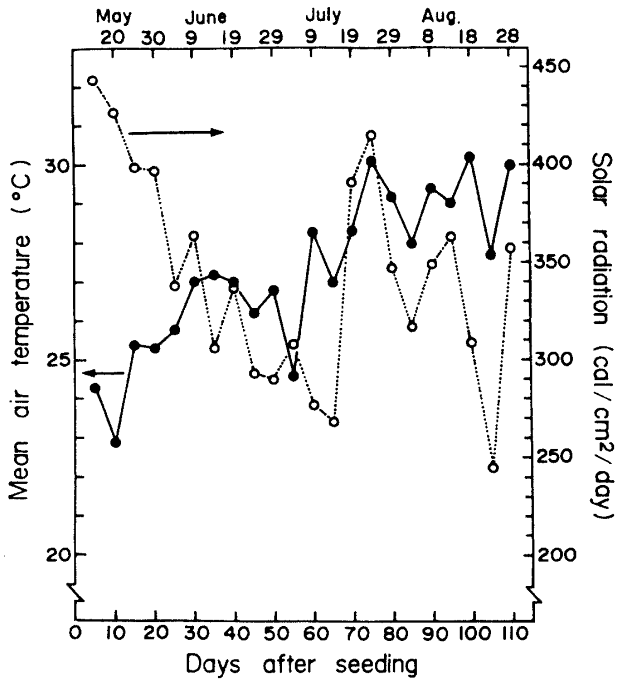

Fig. 1. Mean air temperature inside glasshouse and outdoor level of solar radiation during growing period.
Solar radiation was drawn from the data in the monthly original record of Osaka District Meteorological Observatory.

The main stems had 15 to 20, 17 to 23, 16 to 24 and 15 to 23 leaves with the averages of 18.3, 19.5, 20.0 and 18.6 leaves for 0, 35, 66 and 83% shade, respectively. Thus, the number of leaves on the main stems tended to increase slightly under intermediate shades.

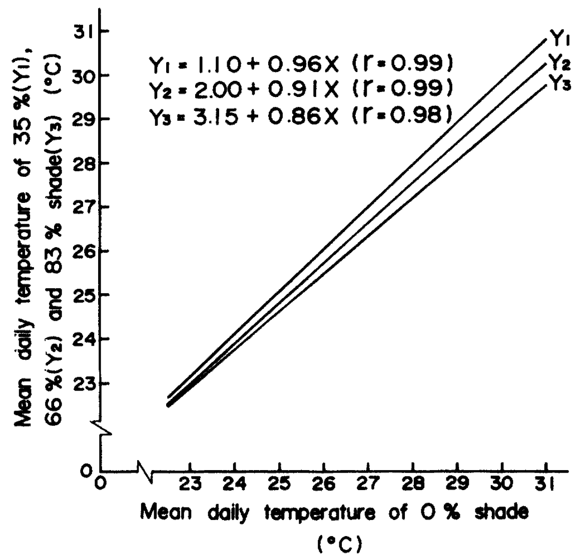

Fig. 2. Relationships in mean daily temperature between 0% shade and 35, 66, and 83% shade.

3. Emergence percentage and date of the primary branches

Axillary buds of kudzu vine stand three abreast on a node. In general, branches arise from the median buds in the first year of growth, and the right and/or left buds occasionally produce the branches after the median buds had sprouted (unpublished). In this study, the branching from the right and left buds was found only on 3 main-stem nodes in 0% shade.

Emergence percentage of the primary branches is shown in Table 1. The primary branch from the cotyledonary node (C) was observed in only one plant (6.7% in emergence percentage) at 0% shade and in two (13.3%) at 35% shade. No plants produced the branches from C nodes under 66 and 83% shade. There was no emergence of the branches from unifoliolate nodes (P) in all treatments and up to the third node in 83% shade. Emergence percentage of the primary branches increased from basal toward

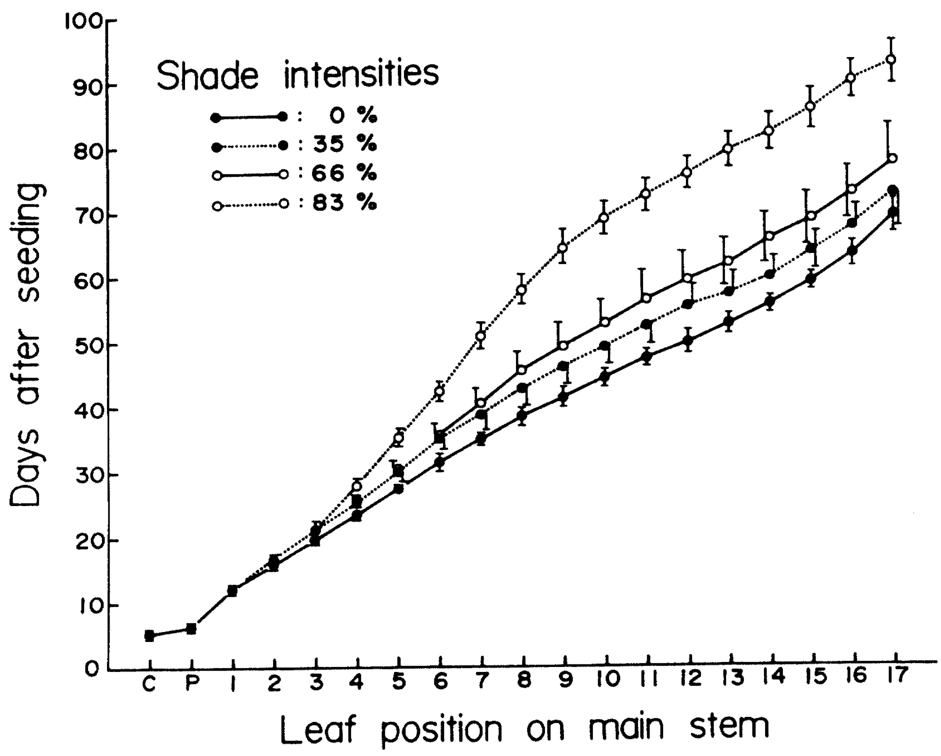

Fig. 3. Leaf emergence dates of the main stem in four shade treatments. C and P indicate the cotyledon and the unifoliolate leaf, respectively. Values show mean ± 95% confidence limit.

intermediate nodes. The emergence percentage on comparable nodes among treatments tended to decline with increasing shade. The number of emerged primary branches per plant was 11.6, 11.2, 8.6 and 4.3 in 0, 35, 66 and 83% shade, respectively.

Emergence dates of the primary branches are presented in Table 2. The primary branch was observed at first on a C node at 0 % shade. The branches arose from the lst to 7th nodes of the main stems between 43 and 53 days after seeding in 0% shade. The branch emergence for lower and intermediate nodes of the main stems generally tended to be delayed in heavier intensities of shade.

4. Stem length and leaf area of the main stem and the branches per plant

Table 3 shows stem length and leaf area of the main stem, the primary and the secondary

Table. 1. Emergence percentage of the primary branch at each node on the main stem (%)

Node orders	Shade intensities			
	0%	35%	66%	83%
C	6.7	13.3	0.0	0.0
P	0.0	0.0	0.0	0.0
1	53.3	40.0	26.7	0.0
2	80.0	60.0	40.0	0.0
3	100.0	80.0	66.7	0.0
4	100.0	93.3	86.7	6.7
5	100.0	100.0	86.7	26.7
6	100.0	100.0	100.0	53.3
7	93.3	100.0	100.0	53.3
8	73.3	86.7	86.7	100.0
9	86.7	80.0	53.3	93.3
10	93.3	100.0	40.0	40.0
11	93.3	93.3	46.7	20.0
12	73.3	60.0	53.3	26.7
13	53.3	40.0	20.0	6.7
14	33.3	40.0	26.7	6.7
15	13.3	20.0	13.3	
16	6.7	6.7	6.7	
17		6.7	0.0	
18			6.7	

C=Cotyledonary node, P=Unifoliolate node.

branches per plant. There were significant differences in the main stem length between 35 or 66% shade and 83% shade and the main stem length was about 20 cm shorter in the latter than in the former two. The length of primary branches per plant under 83% shade was only one fifth of that in 0 % shade. No significant difference in the length of secondary branches was found among 3 shade levels of 66% and below. Total stem length (including the main stem and branches) per plant averaged about 780 cm in 0% shade, being about 3 times as long as that in 83% shade.

Stem length partitioning of the primary branches to the total stem length was a maximum of 75% in 0% shade and declined progressively to a minimum of 47% in 38% shade. Inversely, stem length partitioning of the main stem increased in heavier intensities of shade, ranging from 19% in 0% shade to 51% in 83% shade. That of the secondary branches was small, ranging from 7.1% to 1.3% in all treatments One tertiary branch 1.5 cm long arose from the 6th node on the main stem of a plant under 66% shade.

Leaf areas of the main stem per plant did not differ among all four treatments. The primary branches had more leaf area at shade levels below 66%. Leaf area of the primary branches in 83% shade was only one eighth of that in 0% shade. Total leaf area per plant declined in shade levels above 35%. At 83% shade, the total leaf area was 37% of that in 0 % shade. Leaf area partitioning of the primary branches to the total leaf area per plant occupied more than 50% in shade levels of 66% and below, whereas 23% in 83% shade. Only one plant produced a tertiary branch with 0.3 cm^2 of leaf area in 66% shade, this value being omitted in Table 3.

5. Distribution of dry matter in the main stem and branches

Distribution of dry weights (including leaflet, petiole and stem tissues) of the main stem, primary and secondary branch per plant is given in Fig. 4. The dry weights of both the main stems and primary branches were smaller in deeper shade treatments. The dry weight of the main stems was cut nearly in half from 4.9 g

Table 2. Emergence date of the primary branch at each node on the main stem (days after seeding).

Node orders	Shade intensities			
	0 %	35%	66%	83%
C	30.0	54.5± 16.1		
P				
1	43.6 ± 8.0	56.5± 6.6	63.3 ± 9.0	
2	45.4 ± 5.9	56.1± 6.2	65.0 ± 7.9	
3	46.1 ± 3.9	55.8± 5.7	69.0 ± 9.2	
4	44.5 ± 2.9	56.3± 5.1	68.2 ± 7.2	91.0
5	45.3 ± 2.5	55.6± 5.2	62.5 ± 5.8	79.5 ± 9.9
6	45.6 ± 1.5	53.9± 4.1	61.4 ± 5.7	87.6 ± 7.1
7	52.1 ± 5.1	56.9± 4.7	62.3 ± 5.5	82.6 ± 8.8
8	63.1 ± 8.1	64.2± 6.7	69.3 ± 7.7	84.9 ± 4.2
9	69.7 ± 4.4	70.3± 7.7	81.4 ± 6.3	90.6 ± 3.9
10	70.0 ± 4.4	72.5± 5.3	88.7 ± 10.0	91.3 ± 4.0
11	72.9 ± 4.3	78.9± 7.6	87.6 ± 8.3	94.7 ± 9.6
12	74.3 ± 4.6	82.0± 8.9	85.9 ± 6.3	94.5 ± 11.5
13	78.1 ± 6.7	83.7± 6.2	79.7 ± 16.9	95.0
14	77.6 ± 12.9	89.0± 7.8	86.3 ± 11.8	96.0
15	89.5 ± 18.6	87.7± 13.5	87.0 ± 17.0	
16	81.0	97.0	93.0	
17		100.0		
18			95.0	

C=Cotyledonary node, P=Unifoliolate node.
Values show mean±95% confidence limit.

in 0% shade to 2.4 g in 83% shade, while that of the primary branches was reduced to about one tenth from 12.6 g to 1.3 g. No significant difference in dry weights of the secondary branches was found among shade levels of 66% and below. Total dry weight of top per plant in 0% shade was a maximum of 18.3 g and was 5 times as large as that in 83% shade. Dry weight partitioning of the main stems to total plant tops increased as the degree of shade increased, but that of the primary branches was reversed. For 83% shade, the main stems exceeded the primary branches in dry weight partitioning.

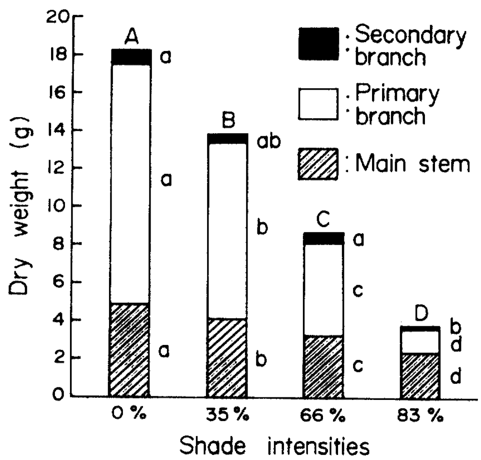

Fig. 4. Distribution of dry weights of the main stem, primary and secondary branch per plant. Bars having the same small letter within each plant part are not significantly different at the 5% level according to Duncan's multiple range test. Total dry weights (capital letters) were also compared using the same method.

6. Distribution of dry matter in each organ of plant tops

As seen in Fig. 5, stem-, petiole-, and leaflet-dry weights in 83% shade were approximately one eighth, one fifth and one third of those in 0% shade, respectively. Thus, the decrease in stem dry weight was especially pronounced.

Table 3. Stem length and leaf area of the main stem and the branches per plant.

Plant parts	Shade intensities			
	0 %	35%	66%	83%
	Stem length(cm)			
Main stem	145.4	162.2	162.1	138.1
	ab	a	a	b
Primary branch	586.1	463.8	361.2	127.3
	a	b	b	c
Secondary branch	46.0	22.0	39.9	3.4
	a	ab	a	b
Total	777.5	648.0	563.2	268.8
	a	b	b	c
	Leaf area(cm^2)			
Main stem	906.5	900.4	947.4	900.5
	a	a	a	a
Primary branch	2,203.0	1,848.7	1,251.2	274.1
	a	a	b	c
Secondary branch	85.9	62.2	99.3	12.8
	a	ab	a	b
Total	3,195.4	2,811.3	2,297.9	1,187.4
	a	a	b	c

Means within a rank followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

Dry weight partitioning of leaflets to total plant tops increased gradually from 47% at 0% shade to 62% at 83% shade, while that of the stems decreased from 42% to 26%. Dry weight partitioning of the petioles changed slightly with the range of 10% to 12%.

7. Diameter and dry weight of root

Table 4 shows diameter at the base of the main root and dry weight of the main and lateral roots per plant. Root diameter averaged 1.1 cm in 0% shade became smaller as shade increased, and in 83% shade it was only about a half of the value in 0% shade.

Dry weight of both the main and lateral roots was highest in 0 % shade and decreased progressively as the shade became more intense. Total root weight per plant in 0% shade was 5.9 g compared with 0.9 g in 83% shade. Plants produced larger dry matter in the lateral roots than in the main roots for each treatment, and the percentage of dry weight of the lateral roots ranged from 82% to 89%. For the main root, compared to the dry weight in 0% shade as 100 %, that in 35, 66 and 83% shade was 48, 31 and 14% respectively and for the lateral root, that in 35, 66 and 83% shade was 85, 52 and 15%, respectively. Top-root ratio had a value of 3.1 in 0 % shade and 3.0 in both 35% and 66 % shade, whereas it had the largest value of 4.2 in 83% shade.

Discussion

OIZUMI[10], working with soybeans (*Glycine max* Merr.), reported that the leaf emergence interval became longer in the early stages of growth under deep shade of 75%, however the leaf emergence were hastened after the turning time of leaf emergence rate and differences in the leaf emergence intervals disappeared within the range of 0% to 75% shade. In this study, we obtained basically similar results as that reported by OIZUMI[10] on the difference in the leaf emergence inteavals before and after the turning time. We reported that leaf emergence dates of the main stem were presented in a straight line for unshade-grown seedlings of kudzu vine[14]. The previous result was slightly different from the result obtained in this study. This is thought to be associated with difference in weather between growing seasons in both years.

Shaded plants of soybeans[15] and blueberries[5] have been reported having less branches than plants with no shade. Kudzu vine was also found to be placed at a disadvantage for emergence and growth of their axillary shoots by shade. Smaller top dry weight and leaf areas per plant in heavier shades are obviously attributed to more decline in emergence percentage and more growth suppression of the primary branches.

Reduction in dry matter yields of both top and root due to shade have been observed for several gramineous[4,6,11] and leguminous[7,11,13] plants. LANGILLE and MCKEE[7] reported that in crown-vetch (*Coronilla Varia* L.) dry weight of plant tops under 69% shade decreased to 40% of that under 0% shade, whereas root dry weight only decreased to 22%. PRICHETT and NELSON[11] and GIST and MOTT[3] noted that for both alfalfa (*Medicago sativa* L.) and bromegrass (*Bromus* sp.) under shaded conditions root growth was affected to a greater extent than top growth. MITCHELL[8] also found similar results for ryegrass (*Lolium* sp.). Top-root ratio at 83% shade is largest in this study, indicating that the root growth of kudzu vine was suppressed more strongly compared with top growth under deep

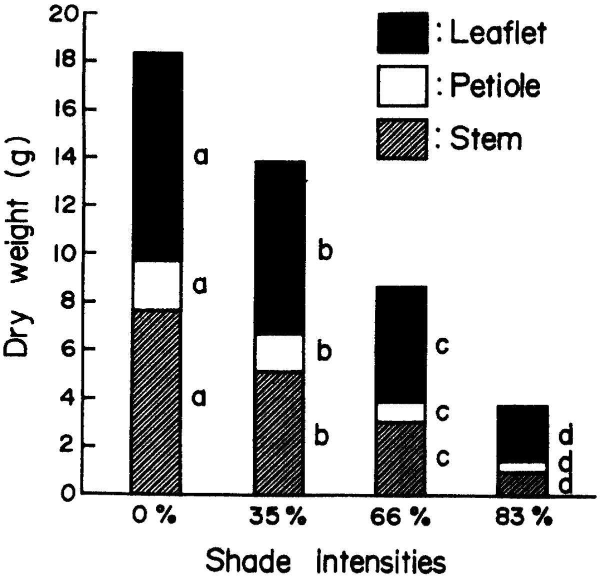

Fig. 5. Distribution of dry weights of each organ in plant top per plant.
Bars having the same letter within each organ are not significantly different at the 5 % level according to Duncan's multiple range test.

Table 4. Diameter at the base of main root, and dry weight of the main and lateral roots per plant.

Characters of root	Shade intensities			
	0 %	35%	66%	83%
Diameter (cm)	1.14 a	0.83 b	0.60 c	0.41 d
Main-root weight (g)	1.07 a	0.51 b	0.33 b	0.15 c
Lateral-root weight (g)	4.86 a	4.13 a	2.51 b	0.74 c
Total weight (g)	5.93 a	4.64 b	2.84 c	0.89 d

Means within a rank followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

shade. As BLACKMAN and TEMPLEMAN[1] interpreted for Astria bent (*Agrostis tinuis* Sibth) and red fescue (*Festuca rubra* L.), the restriction in root growth of kudzu vine by shade can be also attributed to lack of mobilization of carbohydrates into the root.

MIYAURA and HOSOKAWA[9] reported that in sugar beets (*Beta vulgaris* L.) root diameter at the base of main root decreased by shade treatment. Similar result was showed from the data of kudzu vine. In addition, the findings of this study showed that the reduction in dry weight of the main roots was more striking than that of the laterals. Accordingly, it was speculated that the main root growth was affected to a greater extent by shade than the lateral root growth.

As mentioned above, the top and root growth of kudzu vine seedlings was adversely affected by shade. Howerer, the seedlings are found to be able to grow even under considerably deep shade of 83%. Additional research is needed to examine growth response of kudzu vine to other stresses such as drought and overwetness of soils in evaluating the usefulness of kudzu vine as cover crop.

References

1) BLACKMAN, G. E. and W. E. TEMPLEMAN : *Ann. Bot. (Lond) N. S.*, **4**, 533-587, 1940.
2) ERIKSEN, F. I. and A. S. WHITNEY : *Agron. J.*, **73**, 427-433, 1981.
3) GIST, G. R. and G. O. MOTT : *Agron. J.*, **49**, 33-36, 1957.
4) HART, R. H. : *Agron. J.*, **68**, 683-685, 1976.
5) HOEFS, M. E. G. and J. M. SHAY : *Can. J. Bot.*, **59**, 166-174, 1981.
6) KNAKE, E. L. : *Weed Sci.*, **20**, 588-592, 1972.
7) LANGILLE, A. R. and G. W. MCKEE : *Agron. J.*, **62**, 552-554, 1970.
8) MITCHELL, K. J. : *Physiol. Plant*, **7**, 51-65, 1954.
9) MIYAURA, K. and S. HOSOKAWA : *Japan. Jour. Crop Sci.*, **42**, 72-78, 1973.
10) OIZUMI, H. : *Bull. Tohoku Agr. Exp. Stn.*, **25**, 1-95, 1962.
11) PRITCHETT, W. L. and L. B. NELSON : *Agron. J.*, **43**, 172-177, 1951.
12) STRIZKE, J.F., L.I. CROY and W.E. MCMURPHY: *Agron. J.*, **68**, 387-389, 1976.
13) TRANG, K. M. and J. GIDDENS : *Agron. J.*, **72**, 305-308, 1980.
14) TSUGAWA, H., M. TANGE and K. MASUI : *Sci. Rept. Fac. Agr. Kobe Univ.*, **13**, 203-208, 1979.
15) WAHUA, T. A. T. and D. A. MILLER : *Agron. J.*, **70**, 387-392, 1978.

遮光処理がクズ実生の出葉，分枝発生ならびに乾物生産におよぼす影響

津 川 兵 衛・丹 下 宗 俊・水 田 泰 徳

要　約

本研究では，1980年5月から8月までの期間に，ガラス室内において，0，35，66および83%の4遮光レベル下でクズ実生をポット栽培し，減光に対する生育反応を調べた。

83%遮光では主茎第9葉にかなり明瞭な出葉転換点を認めたが，他の3遮光処理ではその存在は不明確であった。処理間の出葉間隔に差が生じ始める第3葉から第9葉までの平均出葉間隔は，0遮光では3.8日，35%遮光では4.4日，66%遮光では4.9日，83%遮光では7.1日であった。しかし，それ以降第17葉までの平均出葉間隔にはほとんど差がみられなかった。

各処理とも1次分枝の発生率は下位節から中位節に向って上昇し，上位節になると低下した。一般に，同じ節位の分枝の発生率は弱光ほど低く，発生時期は遅れる傾向がみられた。

個体当りの地上部乾物重は0%遮光が18.3gと最大であり，遮光が強くなるほど低くなった。85%遮光の地上部乾物重は0%遮光の1/5であった。地上部乾物重のうち，主茎諸器管の割合は66%以下の遮光では1次分枝諸器管の割合より小さいが，83%遮光では逆転した。なお，器官別にみると，小葉重の割合は0%遮光の47%から83%遮光の62%へと増大するのに対して，茎重の割合は減少した。葉柄重の割合はほとんど変化しなかった。主根，側根とも弱光ほど乾物重は小であるが，主根重の減少程度がより顕著であった。

T－R比は0%遮光では3.1，35%と66%遮光では3.0であるのに対して，83%遮光では4.2と大きく，強い遮光下では地上部の生長は根の生長よりも強く抑制されることがわかった。その他，個体当りの茎長および葉面積も遮光により影響を受けた。