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(Citation)
神戸大学農学部研究報告,20(1):1-6

(Issue Date)
1992-01

(Resource Type)
departmental bulletin paper

(Version)
Version of Record

(JaLCDOI)
https://doi.org/10.24546/00198221

(URL)
https://hdl.handle.net/20.500.14094/00198221

神大農研報(Sci. Rept. Fac. Agr. Kobe Univ.) 20: 1 − 6, 1992

THE CLIMBING STRATEGY OF KUDZU-VINE (*Pueraria lobata* OHWI)

I. Comparisons of Branching Behavior, and Dry Matter and Leaf Area Production between Staked and Non-staked Kudzu Plants

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(Received for publication on August 9, 1991)

Abstract

Comparisons of branching behavior of the main stem, dry matter and leaf area production and other growth characteristics were made between staked and non-staked kudzu plants in pot culture. The highest percentage of primary branch production in main stem nodes was 38% at the 17th and 18th nodes in the staked plot, whereas in the non-staked plot it was 94% at the 7th node. No significant difference in the dry weight of aboveground plant parts existed between staked(13.8g) and non-staked (13.1g) plots. However, dry matter in all aboveground plant organs was mainly accumulated in the main stem in the staked plot and in the primary branches in the non-staked plot. No significant differences in root dry weight and basal diameter of roots were found between plots. Stem length per plant was greater in the non-staked plot (498cm) than in the staked (388cm) but there was no significant difference in leaf area per plant between plots.

From the results mentioned above, it is assumed that kudzu plants growing at forest edges twine upwards around the leaves and branches of trees by mainly developing the main stem and that a greater share of leaf canopy can be allocated to increased height so as to be favorable for light capture. Also, it is assumed that dry matter and leaf area production of climbing kudzu plants are not inferior to that of creeping ones on the ground. Kudzu -vines can grow in forest margins as one of constituent species of a mantle community because of its effective adaptation strategy.

Introduction

TSUGAWA *et al.* investigated branching behavior[5], and dry matter and leaf area production[4] in kudzu plants grown in pots without staking. On the other hand, SASEK and STRAIN[3] studied the growth response of kudzu-vine to CO^2 in pot culture with staking. Neither research group took into consideration whether staking or non-staking would affect the growth of kudzu plants. The respective cultivation methods were only adopted in the experiments owing to the presence or absence of spatial restriction in the experimental facility. If there are differences in the growth of kudzu-vine between staked and non-staked plots, comparisons of the growth response of kudzu-vine to various environmental conditions are not as meaningful between the two cultivaion methods.

Kudzu plants climb on trees in the fringes of forests and grow creeping on the ground in open places. Differences in the growth of kudzu-vine between two different growth habits, climbing and creeping, would have important ecological implications.

Thus, in this study , staked and non-staked plots were studied and comparisons of branching behavior, dry matter and leaf area producion and other growth characteristics were made between plots.

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Materials and Methods

Kudzu seeds were collected from a natural kudzu stand[7] in December 1988. The seeds were scarified with a razor blade on 8 June 1989 and were immediately germinated at 25℃ in darkness. Four germinated seeds were sown in a 1/5,000 are Wagner pot containing 4 kg of air-dried paddy soil. Fertilizer was incorporated into the soil at the rate of 0.16g N, 0.66g P_2O_5 and 0.38g K_2O. Planted pots were placed in a glasshouse of the Faculty of Agriculture, Kobe University.

On 3 July(the 3rd leaf emergence stage), seedlings were thinned to one per pot, and staked and non-staked treatments were immediately applied. In the staked plot, a commercial garden pole 0.6cm in diameter and 165cm in height from the upper surface of the pot was set upright at the center of the pot and all stems of the potted kudzu plant were induced to climb on the pole. In this plot, stems exceeding the height of the pole were induced to a 2 mm-diameter wire installed parallel to glasshouse bed surface at 20cm over the top of the pole. Accodingly, kudzu stems were curved at a height of approximately 180cm from the upper surface of the pots. In the non-staked plot, all stems were allowed to be prostrate on the glasshouse bed. Fifty and 46 pots were devoted to the staked and non-staked plots, respectively. Plants were provided with 200ml of 1/500 solution of Hyponex 5-10-5 fertilizer on 8 August.

Plants were harvested on 30 August. Branching status of each node of the main stems was determined and stem length, leaf area and dry weight of each organ were determined separately for the main stem, the primary and the secondary branches. Also, the basal diameter and dry weight of roots were measured.

Results

1. Production of the primary branches in main stem nodes

No production of primary branches was observed from the cotyledonary node(C node) to the 2nd node in the main stem of the staked plot(Table 1). The percentage of primary branch production in main stem nodes was less than 10% up to the 12th node from the C node. It increased from the 13th node upward, attained a maximum of 38% in the 17th node and tended to decrease gradually in higher positioned nodes. The node positions with relatively high percentages of branch production in the main stem were situated in the stem portion where the main stem elongated beyond the top end of the pole and twined around the wire installed perpendicular to the pole.

In the non-staked plot, very little branch production was observed in the three nodes below the 2nd node(Table 1). The percentage of primary branch production in this plot increased from the 4th node upward, attained a maximum of 93.5% at the 7th node and decreased gradually in higher positioned nodes. There were no branches in the nodes above the 14th node.

Each main stem node had three axillary buds but only the middle bud produced a branch. The right and left buds remained dormant at all nodes. There was an average of 4 primary branches per plant in the staked plot and 7 primary branches per plant in the non-staked plot at the harvest(Fig.1).

2. Dry weight

In the staked plot, main stem dry weight per plant was 3.9g, which was 86% of the total stem weight per plant(Table 2). The proportion of main stem dry weight to total stem dry weight in the non-staked plot was 33%, only a third of that in the staked plot. While opposite results were obtained for branch dry weight, stem dry weight per plant was about 20% greater in the staked plot than in the non-staked plot because increased branch dry weight did not compensate for less main stem dry weight in the non-staked plot.

Leaflet dry weight in the main stem and the proportion of leaflet dry weight in the main stem to total leaflet dry weight were 6.6g and 87%, respectively, in the staked plot, compared to 3.0g and 40% in the non-staked plot(Table 2). However, no significant difference existed in leaflet dry weight between plots because increased branch dry weight compensated for the shortage of the main stem dry weight in

Table 1. Percentage of primary branch production of each node on the main stem in staked and non-staked kudzu plants

Node position on main stem	Staked plot		Non-staked plot	
	%	No. of plants examined	%	No. of plants examined
C	0	50	2.2 (C, P, 1)	46 (C, P, 1)
P	0	50		
1	0	50		
2	0	50	4.3	46
3	2.0	50	6.5	46
4	4.0	50	15.2	46
5	8.0	50	41.3	46
6	8.0	50	73.9	46
7	6.0	50	93.5	46
8	8.0	50	71.7	46
9	4.0	50	60.9	46
10	4.0	50	30.4	46
11	4.0	50	4.3	46
12	6.0	50	15.2	46
13	12.0	50	2.3	43
14	28.0	50	0	40
15	36.0	50	0	39
16	32.0	50	0	32
17	38.0	50	0	28
18	38.0	50	0	22
19	36.7	49	0	15
20	16.3	49	0	7
21	8.5	47	0	5
22	13.0	46	0	3
23	4.3	46	0	1
24	4.5	44	0	1
25	2.4	42		
26	0	36		

C : cotyledonary node, P : primary leaf node

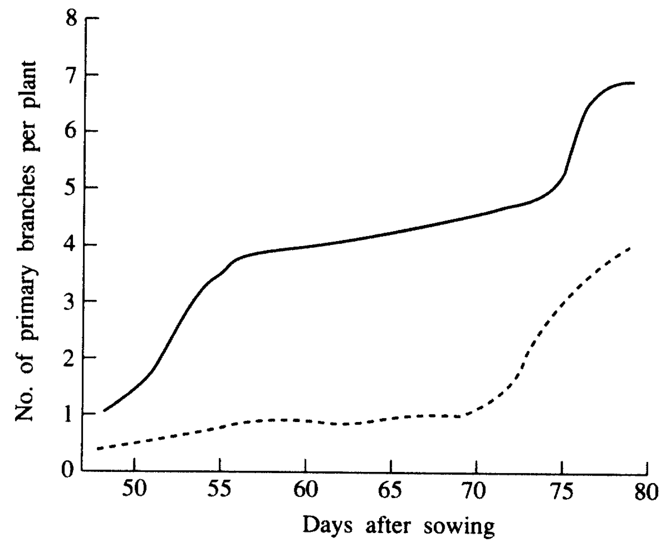

Fig. 1 . No. of primary branches per plant in the staked (broken line) and the non - staked (solid line) kudzu plants. Values are averages of 20 determinations.

the non-staked plot.

Petiole dry weight was greater in the main stem than in branches in the staked plot but the reverse was true for the non-staked plot(Table 2). Main-stem petiole dry weight in the non-staked plot was about half that in the staked plot, but branch petiole dry weight was 4.6 times larger. Hence petiole dry weight per plant was 20% higher in the non-staked plot than in the staked plot.

Since stem dry weight per plant was greater in the staked plot while the reverse occurred with petiole dry weight, as mentioned above, no significant difference existed in aboveground dry weight per plant between the staked(13.8g) and non-staked(13.1g) plots. Also, there was no significant difference in root dry weight between plots, with about 4g each(Table 2).

Table 2. Dry weights of each plant part in staked and non - staked kudzu plants

Plant part	Staked plot		Non-staked plot		F test
	Mean	95% confidence limit	Mean	95% confidence limit	
Stem dry weight (g)					
Main stem	3.93	0.17	1.18	0.17	*
Primary branch	0.59	0.23	2.28	0.23	*
Secondary branch	0.04	0.01	0.14	0.82	*
Total	4.56	0.23	3.60	0.23	*
Leaflet dry weight (g)					
Main stem	6.61	0.27	2.97	0.27	*
Primary branch	1.03	0.33	4.30	0.33	*
Secondary branch	0	0	0.17	0.06	*
Total	7.64	0.31	7.44	0.31	N.S.
Petiole dry weight (g)					
Main stem	1.30	0.06	0.69	0.06	*
Primary branch	0.29	0.09	1.25	0.09	*
Secondary branch	0	0	0.08	0.06	*
Total	1.59	0.09	2.02	0.09	*
Root dry weight (g)	4.23	0.21	4.08	0.21	N.S.

* : significant at 1% level, N.S. : non - significant.

3. Stem length, leaf area and basal diameter of the main root

The length of the main stem, with 83% of stem length per plant, was 3.2m in the staked plot(Table 3). On the other hand, while main-stem length in the non-staked plot was less than half that of the staked plot, stem length per plant was 20% greater in the non-staked plot because primary branch length compensated for the shortage of the main-stem length. No tertiary branches were found in either plot.

Main-stem leaf area comprised 86% of the leaf area per plant(2,750cm^2), compared to 35% in the non-staked plot(Table 3). While main-stem leaf area of the non-staked plot was less than half that of the staked plot, there was no difference in leaf area per plant between plots because branch leaf area of the non-staked plot, which was 5 times greater than that of the staked plot, compensated for the shortage of the main-stem leaf area. Since the number of leaves per plant was greater in the non-staked plot(148.6) than in the staked plot(108.0)(significant at 1% level), leaf area per leaf in the staked plot(29.3cm^2) was greater than that in the non-staked (22.2cm^2).

There was no difference in basal diameter of the main roots between plots, with about 7.5mm each(Table 3).

Table 3. Stem length per plant, leaf area per plant and basal diameter of roots in staked and non-staked plants.

Plant part	Staked plot		Non-staked plot		F test
	Mean	95% confidence limit	Mean	95% confidence limit	
Stem length (cm)					
Main stem	322.60	11.26	137.98	1.25	*
Primary branch	64.98	23.24	338.08	3.73	*
Secondary branch	0.26	0.98	22.05	8.17	*
Total	387.84	23.24	498.11	4.46	*
Leaf area (cm^2)					
Main stem	2,751.81	121.39	1,204.27	121.40	*
Primary branch	456.45	167.67	2,187.61	167.67	*
Secondary branch	0.87	0.98	78.36	33.73	*
Total	3,209.13	207.35	3,470.24	207.36	N.S.
Basal diam. of root (mm)	7.36	0.29	7.48	0.29	N.S.

* : significant at 1% level, N.S. : non-significant.

Discussion

In kudzu plants twining up a vertical support garden pole, it was generally observed that only the main stem elongated upward by producing successive nodes and internodes. The terminal bud at the tip of the main stem continued to grow but the axillary buds set abreast at each node remained dormant. The so-called "apical dominance" phenomenon of kudzu plants could be interpreted as follows from the standpoint of the production and translocation of plant hormones discussed in past studies[2,7,8]. At the terminal bud of the climbing main stem(upright stem), the production of auxin, a plant hormone which tends to move basipetally, was increased due to the negative geotropism of the stem, compared to the terminal bud of prostrate stems. Since cytokinin, which acts to break bud dormancy, and plant nutrients preferentially flowed into the plant portion where high auxin prodution occurred, the growth of the terminal bud remains vigorous. At the same time, auxim moved basipetally and the growth of the axillary buds was depressed.

On the other hand, the apical dominance of the main stem decreased in the non-staked plot because of the horizontal creeping of the stem. The dormancy of the middle of the three axillary buds was broken due to the accumulation of cytokinin in the bud. Branch production in only the middle bud was probably caused by the apical dominance acting differentially between the middle bud and the other two.

In the staked plot, primary branches were produced at the middle bud in the nodes located on the stem portions in which the main stems were curved between the top end of the pole and the wire. A similar phenomenon has been observed in Japanese morning glory(*Pharbitis nil* CHOISY)[1] . This was interpreted as indicating that apical dominance shifted from the terminal bud in the main stem to an axillary bud by bending of the stem.

TSUGAWA *et al.*[5] have obtained higher percentages of primary branch production in potted kudzu plants grown without staking than those of this study. This is attributable to the fact that sowing time was delayed by one month and the growth period was 40 days shorter in this study, compared to the previous study.

A shading experiment[6] revealed that kudzu plants were responsive to shading. Thus, the growth habit of kudzu plants, which grow by climbing on the support structures of other plants, prevents mutual shading of leaves by restricting branch production and allocating a greater share of the leaf canopy to increased height, resulting in favorable competitive characteristics for light capture. Moreover, the absence of any reduction in total dry matter and leaf area production in the climbing plants, compared to the creeping plants, is an excellent adaptation strategy of kudzu-vine. Forest margin parts have ecological conditions under which kudzu plants can exhibit both of the contrasting growth behaviors, climbing on trees and creeping on the ground. The presence of kudzu-vines in forest margins as a dominant constituent species of a mantle community seems due to effective use of the two growth behaviors.

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クズ（*Pueraria lobata* Ohwi）の登攀戦略

I. クズの有支柱栽培と無支柱栽培との間での分枝発生、乾物ならびに葉面積生産の比較

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要　約

クズを有支柱と無支柱で50日間ポット栽培し、分枝発生、乾物ならびに葉面積生産等について比較した。有支柱区では主茎第17、18両節の1次分枝発生率が最高で38%であった。一方、無支柱区では1次分枝の発生率は主茎第7節が最高で94%であった。地上部各器官の乾物蓄積は、有支柱区では主茎の方が分枝より大きく、無支柱区では逆であった。個体当たり全地上部重は両区の間で差は認められなかった（有支柱区13.8g、無支柱区13.1g）。根重、根基部直径とも両区間で有意差は認められなかった。個体当たり延べ茎長は有支柱区（388cm）より無支柱区（495cm）の方が大きく、個体当たり葉面積は両区間に差はなかった。

以上のことから、林縁部においてクズが樹木に登攀するときには主茎主体の生育を行ない、葉冠をより高いところに展開して光獲得を有利にする。しかも、ほ伏する個体に比べて乾物ならびに葉面積生産を低下させることはないと推察される。クズがマント群落の優勢な構成種でありうるのは、このような有利な適応戦略によるところが大きい。