NATURE OF CLUMP GROWTH IN BAMBOOS WITH PACHYMORPH RHIZOMES

S. M. Hasan

Rhizome assemblies and clump form and growth of nine arboretum grown bamboo species have been studied. Rhizome stalk has been found to play an important role in determining the form, shape and growth of clumps. This is due to not only the characteristic length of the stalk in some species but also its role in orienting the rhizome in relation to the centre of the clump and the mother culm in general and the line of gravity in particular. In areas where bamboos are worked heavily it is the rhizome stalk that is first affected and may result in congested clumps in species otherwise monopodial or loosely tufted.

Rhizomes are commonly attacked by pathogenic soil microorganisms. Parts like rhizome stalks, whole rhizomes or only terminal bud of the rhizome may be partly or wholly consumed or otherwise become inoperative and although these parts contribute to the development of rhizome assembly they do not contribute towards the growth of clump. This reduces the rate of growth of clumps considerably. Irrespective of species, only 8 percent of the buds develop into normal culms, 77 percent remaining dormant and 15 percent are damaged by pathogenic soil microoganisms. It has been concluded that application of antipathogens individually or in combination with fertilizer will ameliorate the conditions of growth and considerably increase the outturn.

বৃক্ষবাগানে জন্মানো নয় প্রকারের বাঁশের কন্দমূল, ঝাড়-প্রকৃতি এবং বৃদ্ধির উপর সমীক্ষা চালানো হইয়াছে। বাঁশ ঝাড়ের আকৃতি প্রকৃতি ও বৃদ্ধির উপর কন্দ মূলের প্রভাব গুরুত্বপূর্ণ বলিয়া পরিলক্ষিত হইয়াছে। ইহা শুধু কয়েকটি প্রজাতির কাণ্ডের দৈর্ঘ্যের চারিত্রিক বৈশিষ্ট্যের জন্যই নহে বরং সাধারণ ভাবে ঝাড় ও আদি কাণ্ডের কেন্দ্র এবং বিশেষ ভাবে অভিকর্ষ রেখার অবস্থানের সহিত সম্পর্কযুক্ত। যে সমস্ত এলাকায় নিবিড়ভাবে বাঁশ সংগ্রহ অভিযান পরিচালিত হয় সে সমস্ত স্থানে কন্দ মূলই প্রথমতঃ ক্ষতিগ্রস্থ হয় এবং ফলশ্রুতিতে হালকা ঝোপের সারিতে ঘন সন্নিবিষ্ট ঝাড়ের সৃষ্টি হয়।

কন্দমূলগুলি প্রায়শঃই সংহারকারী মৃত্তিকা জীবানুদ্বারা আক্রান্ত হয়। কন্দ মূলের কাণ্ড, সম্পূর্ণ-কন্দমূল অথবা শুধুমাত্র প্রান্তীয় মুকুল সম্পূর্ণ বা অংশতঃ বিনষ্ট অথবা অন্যভাবে অকেজো হইয়া পড়িতে পারে। যদিও এই অংশগুলি কন্দমূল গুচ্ছ গঠনে সাহায্য করে, তবুও ঝাড় সৃষ্টিতে ইহারা সহায়ক নহে। ফলে ঝাড় বর্দ্ধনের গতি যথেষ্ট হ্রাসপ্রাপ্ত হয়। প্রজাতি নির্বিশেষে শুধুমাত্র শতকরা ৮ ভাগ মুকুল আদিকাণ্ডে রূপান্তরিত হয়, শতকরা ৭৭ ভাগ সুপ্ত থাকে এবং বাকী ১৫ ভাগ সংহারকারী মৃত্তিকা জীবানুদ্বারা বিনষ্ট হয়। উপসংহারে বলা যায় যে সংহারকারী জীবানু প্রতিষেধক পৃথকভাবে অথবা রাসায়নিক সার সহযোগে ব্যবহার করিলে বর্দ্ধনের গতি ত্বরান্বিত হইবে এবং উৎপাদন বিশেষ ভাবে বৃদ্ধি পাইবে।

INTRODUCTION

In bamboos what we see aboveground is equivalent to the crown of other plants the main body, remaining underground. The characters for underground part greatly contribute to the form, shape and growth of the aboveground part. Since this part is entirely out of sight and is not easily accessible, it has been ignored by all. Consequently the rhizome system is one of the least understood part of bamboo. Some studies have, however, been undertaken in the near past and we are starting to understand this vital part of bamboo.

The most exhaustive study has been made by McClure (1966) where he has concentrated on morphological differences, description of varients and identification of the two major rhizome types - the pachymorph and leptomorph rhizomes found in bamboos. The major differences between the two are that in pachymorph rhizome the maximum thickness is somewhat greater than that of the culm, internodes are broader than long, solid, lateral buds solitary, circular with intramarginal apex which produce rhizomes only and culms emerge from the terminal bud only. In leptomorph rhizomes the rhizome proper is long, slender with a diameter usually less than that of culm, internodes longer than broad, rarely solid. lateral buds in dormant state boat-shaped with a distinctly oriented marginal apex and culms emerge directly from lateral buds, terminal buds seldom produce culms. All tropical and subtropical species have pachymorph rhizomes and all temperate species have leptomorph rhizomes Shigmatsu (1960) has described the physiological differences between the types and found that the former is typically the summer-sprouting type where moisture plays an important part and the latter are characteristically spring-sprouting where temperature plays an important role. All species included in this study have pachymorph rhizomes Studies on the growth, habit, etc., of pachymorph rhizomes have been few. Gupta (1964) and Krishnaswamy (1956) working with *Dendrocalamus strictus* and Tomar (1963) with *Bambusa arundinaceae* have made some references to their rhizomes. Hasan (1966) had made similar studies earlier in forest areas only where bamboos were very heavily worked and came to certain erroneous conclusions. This paper is the result of further study of the same subject in the forest and on arboretum grown stock and it has been possible to correct the earlier commissions and omissions regarding relationship between rhizome assemblies and clump form.

MATERIAL AND METHODS

Studies were made on bamboos growing in Forest Research Institute Arboretum, Chittagong. The arboretum was planted by using offsets, branch cuttings and seeds during the period 1970-76. For the purpose of this study only clumps produced by offsets were used. Clumps of six species were dug from the arboretum and clumps of *Bambusa tulda, Melocanna bambusoides* and *Neohauzeaua dullooa* were brought from the forests 40 miles away. Dug up clumps were washed and all soil cleared. All sheaths on rhizome and stalks were removed and measurements, photographs and drawings of the underground part were prepared from these. Observations on growth of clumps, i. e., emergence of culms during growing season were recorded monthly, girth of clump at ground level and diameter of culms at breast height were recorded annually.

OBSERVATIONS

Rhizome assemblies :

Rhizome assembly is a combination of many rhizomes knit together with their stalks. The size of individual rhizomes varies greatly depending on the species. Large species like *Bambusa burmanica, B nutans, B. polymorpha, B. vulgaris* have large and the smaller species like *Melocanna bambusoides, Neohauzeaua dullooa* have small rhizomes. However, there are differences in size of the rhizome within species which is determined more by factors of growth and working. The manner of linking up with each other within the assembly is remarkably similar in all species. Figure 1 gives photographs of rhizome assemblies showing the different forms they may take Each mother rhizome is connected to the daughter by a stalk. The stalk is segmented, obconical when short otherwise terate, clothed with persistent, relatively small scale-like sheaths, the nodes are always without bud, lack roots and root primordia and is possessed with geotropic to diageotropic properties. The tip of the stalk carries the rhizome bud. The outer prophylls are cone-shaped and are probably sheaths of budless nodes so closely set that they can not be seen. The real prophylls of the bud are appressed to it. Measurements of stalks recorded are given in Table 1. The average number of nodes on the stalk varies with the species. In most species length of stalk varies from 1-3 inches. There appears to be no relation between the number of nodes and length of the stalk. *Melocanna bambusoides*, however, differs from other species in having greatly elongated rhizome stalks. The mean length of rhizome stalks in this species being 40 inches. The longest rhizome stalk found was 76 inches. This is not always the case in this species as parts of clumps have been dug where rhizome stalks, rhizomes and culms are relatively small. This is a common feature in areas where bamboo working is very intensive. Such a clump has been shown in Figure 1 (C). This species is also remarkable because any time a rhizome is dug all stages of rhizome development can be found. It is from rhizome assemblies of this species that the drawings in Figure 2 were made.

Table 1. End product of buds on rhizome assemblies

Species	No. of clumps studied	Mean number of buds in stages					Rhizome stalks	
		dormant	rotted stalks	rotted rhizome	dead terminal buds	culms	mean nodes	mean length (inches)
Bambusa burmanica	2	32	1,5	—	3,5	4,5	13	3 1
Bambusa nutans	1	9	1	1	1	1	15	1,8
Bambusa polymorpha	1	33	—	—	2	4	8	1,5
Bambusa tulda	1	160	18	8	28	15	15	2,5
Bambusa vulgaris	4	30	3	—	0.5	5	14	3,3
Dendrocalamus strictus	1	57	—	—	4	5	14	3,2
Melocanna bambusoides	1	228	6	5	14	15	25	40,2
Neohauzeaua dullooa	1	20	10	1	3	6	10	1,2
Thyrsostachys oliveri	1	43	4	2	3	7	14	2,2
Irrespective of species (percent)		77.6	5,2	2,0	7,2	8,0		

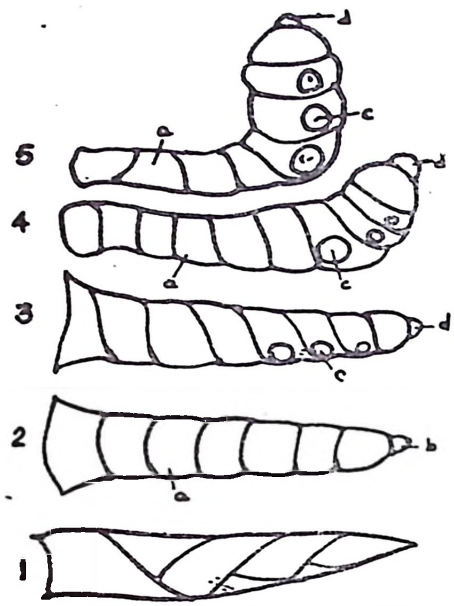

Figure 2. Drawing from rhizome assembly of *Melocanna bambusoides* depicting development of rhizomes, a—rhizome stalk, b—rhizome bud, c—lateral bud of rhizome, d—terminal bud of rhizome which is also the culm bud.

Abnormalities in rhizome assemblies are common in all species. All buds do not develop into normal culms. Table 1 gives enumeration of the end products of rhizome buds. The stages identified are dormant buds, rotted stalks, rotted rhizomes, rhizomes with dead terminal bud and culms. Figure 3 gives photographs of the damaged parts. The enumeration figures show that species vary greatly in the number of rhizome buds that remain dormant, number of developing buds that are damaged and the number that end up in normal culms. Irrespective of species only 8 percent buds end up in normal culms. 15 percent are damaged and 77 percent remain dormant.

Rhizomes :

Individual rhizomes are segmented and consist of two parts—the rhizome stalk and rhizome proper A description of rhizome stalk has been given earlier. Rhizome proper like the stalk is also subterranean, it is short thick, fusiform, more or less curved at base with the maximum thickness in the middle and somewhat thicker than the culm, internodes broader than long, asymetric, solid, in the dormant state asymetrically dome-shaped, with circular margin and an intramarginal apex. Rhizome sheaths appearing at each node completely cover it, profuse stiff roots develop on the body of the rhizome after one year. *Bambusa tulda* rhizome differ from all others in being dorsiventrally flattened, being oval in cross section and lying horizontally on the ground, lower part straight with the stalk, upper part curved upwards, all roots and buds are found on the lower side. All rhizomes have two rows of 4-10 lateral buds on alternating nodes and on terminal bud The lowest bud is the largest and reduce in size in the ascending order. In longitudinal section (Figure 4) the rhizome consists of a thick walled bony shell. The inside of the shell is filled with long fibres and food material. The lateral buds are set in hollows in the shell with a small hole on the lower side of the hollow through which the vascular system passes to the bud. In cross section (Figure 4) rhizome of all species excepting *Bambusa tulda* are circular. shells filled with fibre and food. The buds are set on the outer side of the circular shell in relation to the rhizome stalk. Lateral buds on the rhizome circular, flat, yellow

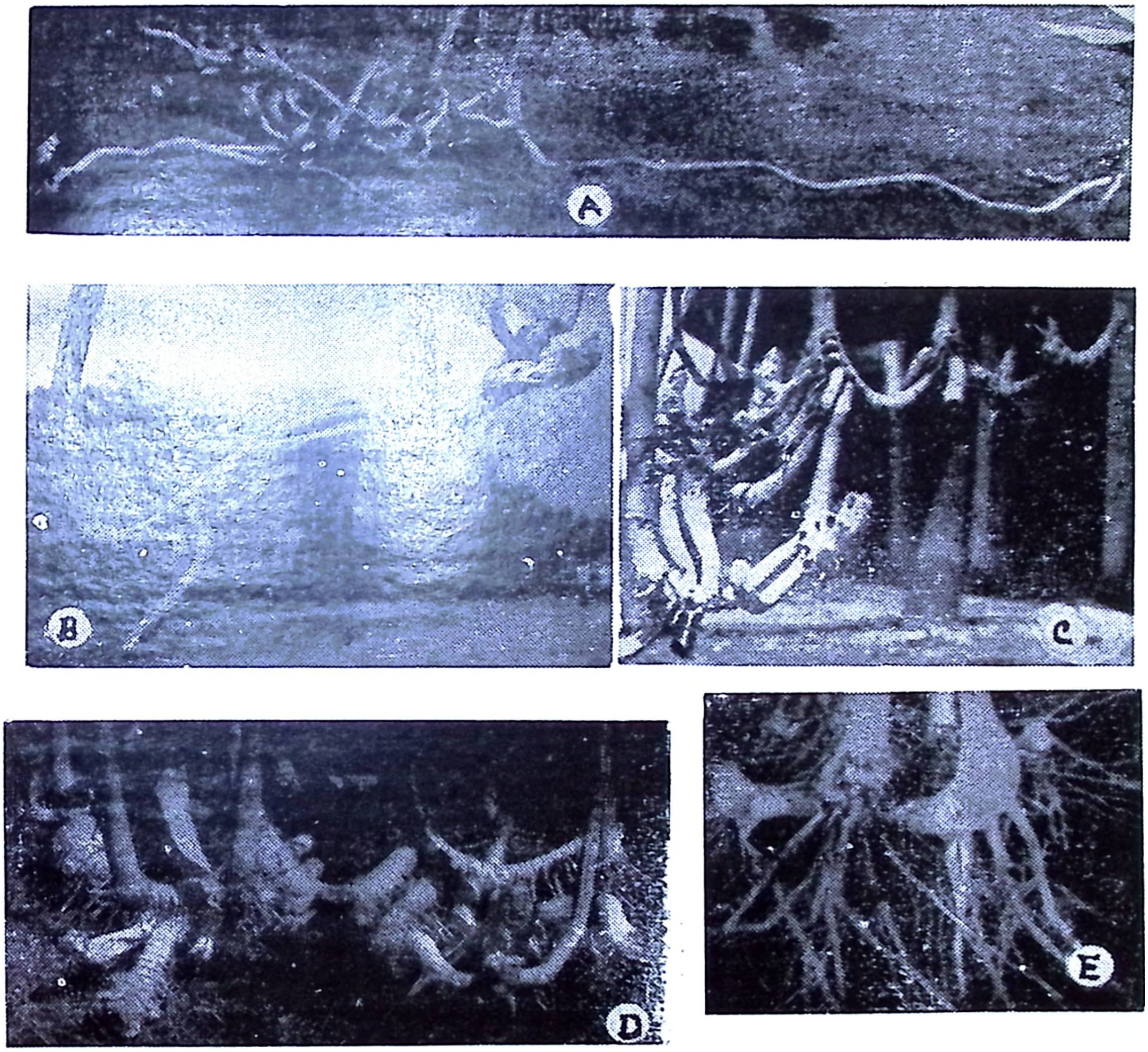

Figure 1, Part rhizome assembly of A — *Melocanna bambusoides.* The entire part from end to end was 12 ft. long. Close up of B – normal and C — congested parts of A, D — *Bambusa tulda* and E — *Neohouzeaua dullooa,* Rotted rhizome stalks and rhizomes can be seen in every photo. Rhizomes with dead terminal buds can be seen as complete rhizpmes without culms.

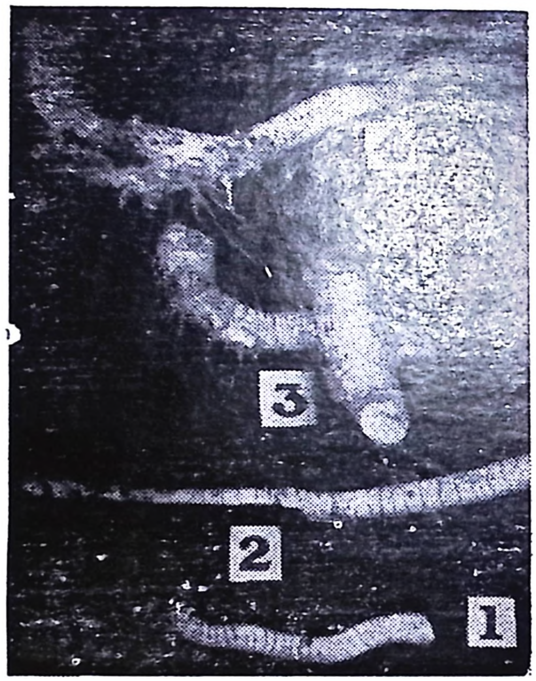

Fig. 3. Naturally damaged rhizomes of *Melocanna bambusoides* due to attack by pathogenic organism. 1—Normal rhizome, 2—Rhizome stalk partly damaged. 3—Rhizome of *Dendrocalamus strictus* with the terminal portion dead, 4—Rhizome of *Melocanna bambusoides* partly damaged, The lowest bud has been killed and the part of the rhizome has been damaged leaving a hollow,

with an intramerginal apex. Some buds are, however, swollen and these are the buds that have been activated and are starting to grow. Lateral buds produce only rhizomes Terminal bud of the rhizome is dome-shaped, yellow with an intramarginal apex. The outer prophylls are cone-shaped which are probably sheaths of budless nodes that are closely set and can not be seen. The real prophylls of the buds are appressed to it. The terminal part of the rhizome is the zone where a transformation of the rhizome to culm takes place and is different from the rest of the rhizome in being phototropic. The terminal bud develops into a culm.

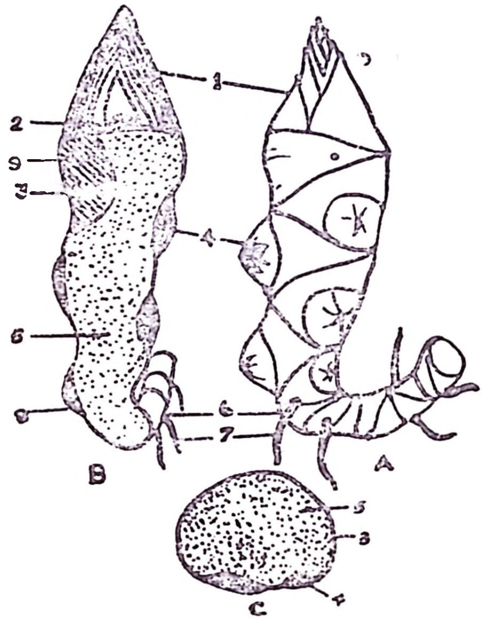

Figure 4. Drawings of a rhizome of *Melocanna bambusoides*. A—whole rhizome, lower sheaths removed but upper sheath left intact. B—longitudinal and C—cross section of A, 1—sheaths, 2—terminal or culm bud, 3—hard bony shell of rhizome, 4–lateral or rhizome bud, 5—inside of the shell filled with fibrous material and food, 6–rhizome stalk, 7—roots, 8—hole in the shell of rhizome through which vascular tissue connects the bud, 9—a patch of darker and wetter tissue probably caused by a pathogen, a lateral bud expected in the hollow of the shell has been consumed by tne pathogen. Different sizes of buds on cross section are due to their position along the height of rhizome.

In longitudinal section given in Figure 4 the top left side of the rhizome has been shown shaded and the bud at that position is absent, This patch was darker in colour and appeared wetter in consistency than the rest of the surface. This patch is probably due to a pathogenic condition caused by soil microorganisms and probably the starting point of the damage which results in rotted rhizomes, rhizome stalks and rhizomes with dead terminal bud described earlier and shown in Fingure 3.

Clump and Its Growth :

Bamboo clump is the above-ground part of the rhizome assembly. The clumps of different species take various forms. The mean distance between culms within the clump is given in Table 2. The species included in this study have forms from congested clumps to monopodial. *Bambusa polymorpha* has clumps where the distance between culms is very small. This is because a culm may emerge 5-6 inches away from the mother culm but it is inclined towards the main clump and the culm grows into it so that the clump forms a tangle of culms. This species is very difficult to work. On the other extreme is *Melocanna bambusoides* where individual culms appear to grow singly and does not give the impression of a clump. In the Forest Research

Table 2. Monthwise addition of culms to clumps during four growing seasons (1973-77)

Species	No. of clumps studied	Total culms emerged during (month)										Mean periodic addition	culm distance in clumps (inches)
		3	4	5	6	7	8	9	10	11	12		
Bambusa burmanica	19	—	—	—	24	7	11	7	21	5	—	3.7	10—15
Bambusa nutans	60	2	4	50	90	50	50	31	45	14	7	5.5	5—15
Bambusa polymorpha	65	—	1	2	32	53	64	49	46	13	3	3.9	0—2
Bambusa tulda	56	—	1	4	72	34	50	64	40	21	11	5.1	4—10
Bambusa vulgaris	86	—	—	3	95	45	31	39	31	15	4	3.1	4—20
Dendrocalamus strictus	27	—	—	—	6	4	13	5	8	2	—	1.3	1—4
Melocanna bambusoides	45	2	—	4	13	28	74	66	116	45	7	7.0	6—12
Neohauzeaua dullooa	24	—	—	1	6	3	43	52	27	—	1	5.9	3—5
Thyrsostachys oliveri	29	1	—	1	35	34	11	7	2	5	5	3.5	3—10

Institute Arboretum where these observations have been taken clumps were planted 20 × 20 ft and each clump can still be identified. In forests the clumps merge into each other and no distinction between clumps is possible. All other species are intermediate between the two but a clump can be distinctly identified. It has yet to be seen if *Bambusa burmanica* and *B. vulgaris* in which the distance between culms is greatest (even more than that of *Melocanna*) will give the same effect as the clumps become larger.

Growth of clumps may be considered in a number of ways i. e. (1) addition of new culms to the clump, (2) increase in girth of clump and (3) increase in the diameter of culms of successive years. Measurements recorded for all these items are given year-wise in Table 3. For all practical purposes the first is the most important as it is the real increment in bamboos. The second is an important factor in determining the annual increment and the last is of relatively little significance as once culms of the diameter typical for the species have started to be produced the diameter keeps fluctuating within narrow limits.

Addition of new culms to the clump is mainly during the rainy season, i. e., May to September. Depending on the rainfall this may, however, be extended at both ends (Table 2). Extension of the growth period towards the earlier side is less frequent and can be seen only in *Bambusa nutans*, *Melocanna bambusoides* and *Thyrsostachys oliveri*. Extension of growth period towards the late end is more common and can be seen in all species. The figures in Table 2 also show that

Table 3. Growth of clumps in No. of culms, girth and diameter of culms

Species	Clumps			No. of culms added per clump	Mean culm diameter (inches)
	Physical age (years)	Nos. studied	Girth (inches)		
Bambusa burmanica	1	3	27	1,6	0,4
	2	5	48	2,0	1,1
	3	6	69	4,3	2,0
	4	5	163	6,8	2,6
Bambusa nutans	1	12	23	2,5	0,5
	2	16	35	3,6	0,8
	3	16	71	6,9	1,3
	4	16	117	9,0	1,7
	5	[4	134	10,5	2,4
Bambusa polymorpha	1	15	19	2,4	0,8
	2	16	31	3,8	1,1
	3	18	52	5,1	1,5
	4	16	70	4,4	2.0
Bambusa tulda	1	14	19	2,9	0,6
	2	14	57	3,5	0,7
	3	14	91	8,0	1,1
	4	14	109	6,0	1,6
	5	2	116	12,0	1,3
Bambusa vulgaris	1	15	19	2,9	0,6
	2	20	32	2,8	0,8
	3	26	52	3,7	1,2
	4	25	113	3,2	1,9
	5	12	184	5,5	2,8

Species	Clumps			No. of culms added per clump	Mean culm diameter (inches)
	Physical age (years)	Nos. studied	Girth (inches)		
Dendrocalamus strictus	1	3	11	1,0	0,3
	2	9	17	1,5	0.6
	3	7	23	1.5	0,7
	4	8	25	1,3	0,5
	5	2	27	1,5	0,9
Melocanna bambusoides	1	6	24	2,3	0.4
	2	13	54	6,3	0,4
	3	13	88	7.5	0.5
	4	13	138	12,1	0,6
	5	1	276	10,0	0,8
Neohauzeaua dullooa	1	11	22	3,8	0,1
	2	7	31	7.8	0,4
	3	3	36	7.0	0,6
	4	3	46	5,0	0,6
Thyrsostachys oliveri	1	9	21	2,3	0 6
	2	7	34	2,7	0,9
	3	6	58	4,6	1,2
	4	7	92	4,7	1,9
	5	6	93	4,8	1,6

Bambusa polymorpha, Dendrocalamus strictus, Melocanna bambusoides and *Neohauzeaua dullooa* may be regarded as late sprouting and all the other species as early sprouting. The figures also show that *Bambusa polymorpha* and *Neohauzeaua dullooa* produce a distinctly mono-modal, *Dendrocalamus strictus* and *Thyrsostachys oliveri* a faintly bi-modal and all the other species a distinctly bi-modal frequency distribution curve. Table 2 gives the total number of culms produced in all clumps studied during the four year period. Annual means have not been taken as the figures become so small that they do not show the differences so distinctly. This is because the physical age of the clumps is only four years, However, mean periodic addition of culms per clump shows marked differences between species, *Melocanna bambusoides* adds the highest and *Dendrocalamus strictus* the lowest number of culms per clump per year during the period of four years.

As new culms are added to the clump every year the size of the clump increases and is indicated by the girth of the clump at ground level given in Table 3. With the increase in girth the rate of annual addition of culms to the clump increases. In *Bambusa burmanica*, *B. nutans*, *B. tulda* and *Thyrsostachys oliveri* the increase is continuous throughout the period, while in other species the rate of increment steadily rises in the early life but shows annual fluctuations in the later part. This has a significant bearing on the earlier observations on rhizome assembly and will be discussed later. The girth of clumps shows a continuous rise.

The diameter of culms that emerged in the early years after planting was relatively small but it appears that in all species a stage has reached when normal sized culms, under the present conditions of growth, are being produced and no more increase is expected in the future. The size of the rhizome and culm depends on the size of the bud. The lowermost buds being the largest produce larger rhizome and culm reducing in size when they appear from buds higher up. This is the main reason why the culms of the same year vary in size.

DISCUSSION

Clump Form in Relation to Rhizome :

Melocanna bambusoides, with its long rhizome stalks does not appear to complete the growth initiated in the underground part during the same season Buds that are initiated late in the season appear to cease further growth temporarily with the end of rainy season. Thus all stages of rhizome development are found on rhizome assemblies dug up at any time during dry season. Rhizomes in their different stages of development can be identified easily and these have been picked up and drawings have been shown in Figure 2. From the drawings the process of rhizome development can be depicted easily. The rhizome stalk carries the rhizome bud farther away from the mother rhizome and due to the geotropic and diageotropic properties orients its path on hill slopes keeping fixed depth in the soil. Development of rhizome bud starts and elongation of the stalk continues. As soon as rhizome starts swelling [Figure 4 (4)] extension of the stalk is checked due to physical obstruction caused by loss of the tip and enlarged surface of rhizome. Further swelling of rhizome takes place only on the adaxial side thus making it oblique in relation to lateral buds. However elongation of the stalk continues, pushing the base of rhizome outwards and orienting the rhizome into an upright position or at an angle characteristic for the species. This is probably also helped by the phototropic properties of terminal bud of the rhizome which is also the culm bud.

Judging from the shape of clumps this orientation of rhizome is outwards in most species excepting in *Bambusa polymorpha* where this orientation being inwards all culms, no matter how far from the mother culm they may emerge, grow into the clump and make it naturally congested However, there are growth forms in *Bambusa polymorpha* where culms grow outwards and the clump is loosely tufted. This variety does not differ only in this habit but some others also like culm colour, sprouting habit of culm buds, size of leaves, etc. From the photograph in Figure 1 it is clear that rhizomes of *Bambusa tulda* lie flat and only a small part near culm base is upturned. In this species the stalk does not appear to posses the property of continued elongation after rhizome bud starts developing and thus the orientation of rhizome remains flat and only the terminal part of the rhizome is upturned due to the phototropic properties of culm buds.

The details of development of rhizome in all species with pachymorph rhizome are probably the same as described for *Melocanna bambusoides.* In all the other species different stages are not discernable because the whole process is completed in quick succession and during the same growing season. Development of stalk, rhizome and culm is probably simultaneous no buds being distinguishable. A more appropriate term will probably be primordia. Excavations during the rainy season may throw some light on the subject. There are, however, some deviations as described for *Bambusa tulda.* Rhizome stalk has, therefore, a very important role in determining the form of the clump. This is not only due to the characteristic length of the stalk but also due to its role in orienting the rhizome in relation to centre of the clump and mother culm in general and line of gravity in particular. In areas where bamboos are worked very heavily it is the rhizome stalk that is first affected. Although *Melocanna bambusoidea* is monopodial, when this species is frequently cut congested clumps do result. One such clump is shown in Figure 1 (C). Here the rhizome stalks are short and thin. Hasan (1966) had described *Bambusa tulda* as clump of clumps. It has now become apparent that this was due to erroneous observation in heavily worked areas. The first part affected due to heavy working is the rhizome stalk and consequently the clump form is modified.

Relation Between Rhizome and Clump Growth :

It is clear from Figure 3 and Table 1 that growth of rhizome assemblies is never normal. The cause is probably pathogenic coming from soil microorganisms. In Figure 4 the primary infection and its effect in consuming a rhizome bud has been shown. Before the shell of the rhizome is formed infection may take place anywhere in the soft developing tissue but once the shell has been formed the infection is likely to come only through the buds which are the softest portion and spread through the rest of the tissue consuming it partly or completely. Such partly consumed organs have been shown in Figure 3. This may happen to developing stalk, developing rhizome or the terminal bud of rhizome. In all such cases the part becomes inoperative and does not grow any further and though may contribute to the growth of rhizome assemblies, does not contribute to the growth of clump. These parts remain underground and depending on the degree of damage may contribute, what it is worth, when some accident happens to the above-ground part. It is a matter of common observation, and has been reported in almost all species by many workers that cones of sheaths appear above ground but do not grow any further but an explanation was not forthcoming. Detail observations show that the terminal part below the sheaths is dead and in some cases the rhizome is completely hollow leaving only the shell. It is now clear that this is a case where the terminal bud of the rhizome is destroyed by pathogens and it ceases to grow and many such stubs can be seen in photographs in Figures 1 and 3.

The percentage of developing buds or parts that may be damaged in this way varies greatly with the species and from the data in Table 1 it is difficult to say which species is more seriously affected. Normally it is expected that as the girth of clump increases the rate of annual addition of culms to the clump will also increase and Tomar (1963) has demonstrated this by finding a linear relationship between the production of new culms and the size of clump in *Dendrocalamus strictus*. This can also be seen from the data in Table 3 in the case of *Bambusa burmanica, B. nutans* and *Thyrsostachys oliveri*, but in all other species after some years of increase this starts fluctuating from year to year. It is, therefore, becoming apparent that the pathogens have become active in these species and sooner or later the same thing will happen in species which are not showing any signs of interference by external factors. This problem can probably be controlled.

CONCLUSIONS

The role of rhizome stalk in determining the form and shape of clump is important but more of acadamic than practical value. The fact that irrespective of species only 8 percent of rhizome buds end up in normal culms and 15 percent are a victim of pathogenic soil microorganisms is of great practical value. Any attempt to ameliorate the conditions of growth must take this point into consideration. Only fertilizer application may not give commensurate results unless antipathogens are made a part of this treatment. Probably antipathogens alone will improve the outturn considerably. The best antipathogen to use is probably copper sulphate and the dosage will have to be worked out for each soil type.

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