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Growth behaviour of bamboo species in bamboo-based agroforestry system in mid-hill sub-humid conditions of Himachal Pradesh, India

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ABSTRACT

An experiment was carried out at the experimental farm of the Department of Silviculture and Agroforestry, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP during the year of 2012 with two bamboo species viz *Dendrocalamus asper* and *D hamiltonii* in open field conditions in which ginger was grown as field crop. *D asper* displayed superiority over *D hamiltonii* in respect of traits viz average height, average diameter growth, number of culms per clump, clump weight (tonnes/ha), leaves biomass (tonnes/ha), emergence of new shoots, biomass production (tons/ha), raw tender shoot biomass (tonnes/ha) and edible portion of shoot biomass (tonnes/ ha). Significant increase in yield of ginger was observed under *D asper* (38.04 q/ha) in comparison to *D hamiltonii* and open field conditions.

Keywords: Bamboo species; agroforestry; ginger; growth behaviour

INTRODUCTION

Cultivating trees and agricultural crops in intimate combination is an ancient practice that farmers have used throughout the world. Agroforestry refers to land use systems in which trees are grown in association with agricultural crops, pastures or livestock. This association may be in time such as a rotation between trees and other components or in space with the components grown together on the same piece of land. Application of agroforestry principles can be separated into ecological, economic and social components. The primary objective is perhaps to obtain ecological benefits and resultant environmental protection. Because of its various positive contributions emphasis has been laid on promoting agroforestry as a viable land use in different parts of the world particularly in developing countries.

Bamboo together with several groups of herbaceous bambusoid grass is classified by taxonomists as the sub-family Bambusoideae within the grass family Gramineae (Poaceae). These are known to be the fastest growing woody plants with a growth rate ranging from 30 to 100 cm per day in their active growing seasons. It can grow up to a maximum height of more than 36 m with a diameter ranging from 1-30 cm. The culms attain their height growth potential in a matter of two to three months. It also has the fastest growing canopy for the regreening of degraded areas. As ornamental plant and source of raw material for paper making, textile, basketry, matting, rope, house construction, furniture, bridges and fishing equipments, bamboo provides a greater diversity of uses in Asia than any other group of closely related plants (McClure 1956).

Bamboo is an important non-timber forest produce (NTFP) with high commercial value. As an important resource bamboo has been exploited and utilized by various institutions. However increasing demand of world's bamboo resources is related to a series of threats to bamboo diversity and has led to the extinction of a number of its genetic resources. Over-exploitation and habitat destruction of bamboo genetic resources increase these threats. For example in the Indian Himalayan region twelve species of bamboo have been marked as rare and endangered due to biotic pressure coupled with biological phenomenon such as periodic flowering, poor seed setting and indiscriminate exploitation.

Under the above scenario the only viable option to meet out the target is to narrow the gap between demand and supply and to become self-reliant by producing bamboo outside the existing forest area. Keeping this in view great emphasis is being given on introduction of bamboo outside the conventional forest area by development of bamboo-based agroforestry model the world over. Agricultural land near bamboos can be effectively utilized for growing shade loving crops like ginger, turmeric, large cardamom, orchard grass and Dinanath grass up to a distance of 11-15 m from the bamboo rows (Singh et al 1992).

Keeping in view the potential of bamboo species in the hills of Himachal Pradesh and the ability of shade loving crop to perform under the overhead canopy cover, present investigations were carried out to test the performance of ginger crop under two important multipurpose bamboo species viz *Dendrocalamus asper* and *D hamiltonii*.

MATERIAL and METHODS

Experimental site was located in the mid-hill zone of Himachal Pradesh at Nauni having an elevation of 1200 m amsl in the mid-Himalayan zone. It lies between 30°51' N latitude and 76°11' E longitude. The area experiences a wide range of temperature with a minimum of 1°C in winter to a maximum of 37°C with May and June as the hottest months whereas December and January the coldest ones. The area receives annual rainfall ranging from 1100 to 1400 mm. The experiment comprised two bamboo species viz *D asper* and *D hamiltonii* (6 years old) and open field conditions under which ginger crop was grown. There were three replications for each treatment. Experimental field was prepared by ploughing the field and was made smooth by harrowing followed by planking. Rhizome seed sowing was done in the month of April. Weeding was done as and when required.

In the bamboo species the culm height was measured with the help of Ravi multimeter. The diameter was measured with the help of digital caliper. Culms of the individual clump were counted manually of each bamboo species. New shoots emerging from the individual culm were counted manually of each bamboo species. The counting was done every month starting from 30 September 2012 to 31 December 2012. Crown spread of the clumps was measured in eastwest and southnorth directions with the help of measuring tape. Culm dry weight was calculated by adding shoot dry weight with leaf dry weight. To estimate shoot dry weight 3 shoots were randomly selected, cut into small pieces and kept in oven at 80 ± 5°C (Chidumayo 1990) to get constant dry weight. Leaves from culms were removed for fresh weight determination. Fresh weight of leaves was recorded with the help of electronic balance and leaves were kept in oven at 80 ± 5°C (Chidumayo 1990) to get a constant weight. Clump weight was calculated by multiplying culm dry weight with number of tillers as presented in equation 1:

Clump weight= Culm dry weight (kg) × number of culms/clump .... (Equation 1)

Dry biomass was calculated on per hectare basis and expressed in tonnes/ha. It was estimated by multiplying dry clump weight with number of bamboo clumps in a hectare for each bamboo sp.

Dry biomass (tonnes/ha)= Clump weight × number of bamboo clumps/ha .... (Equation 2)

Leafy biomass was calculated on per hectare basis and expressed in tonnes/ha. Leaves from culms were removed for fresh weight determination. Fresh weight of leaves was recorded with the help of electronic balance and leaves were kept in oven at 80 ± 5°C (Chidumayo 1990) to get a constant weight.

Leafy biomass (tonnes/ha)= Leaf biomass/culm × number of tillers/clump × number of bamboo clumps/ha .... (Equation 3)

The tender shoots (3) of both the bamboo species were measured when they were 25 ± 2 cm in height. The yield of raw shoots was calculated as below:

Raw shoot biomass (tonnes/ha)= Average of the freshly harvested shoots × number of newly emerged shoots in a year/clump × number of bamboo clumps/ha .... (Equation 4)

Fresh tender shoots were dissected into edible and non-edible portions. The edible portion obtained was weighed and the yield on per hectare basis was calculated as below:

Edible shoot biomass (tonnes/ha)= Fresh weight of the dissected tender shoots × number of newly emerged shoots in a year/clump × number of bamboo clumps/ha .... (Equation 5)

For measuring yield trait of ginger five plants were randomly selected. Yield was calculated with the help of weighing balance. Yield was recorded for all the plants per plot and it was finally converted to yield on per hectare basis.

The growth and developmental traits of bamboo species were analysed using standard deviation and coefficient of variation methodology. The collected data on yield of ginger crop were statistically analyzed to examine the variation of the results due to bamboo species using RBD design.

RESULTS and DISCUSSION

Growth and production behaviour of bamboo species: Table 1 reveals that there was a significant difference between *D asper* and *D hamiltonii* for different growth parameters viz height, diameter, crown spread, dry weight, emergence of new shoots, biomass production, tender raw shoot biomass and edible portion of tender shoot biomass. *D asper* displayed clear-cut superiority over *D hamiltonii* in respect of most of the growth traits viz average height (6.35 m), average diameter (3.30 cm), emergence of new shoots (10.5), raw shoot biomass (11.43 q/ha) and edible shoot biomass (6.02 q/ha). However average crown spread (4.36 m^2) and culm dry weight (2.95 kg/culm) were registered to be higher in *D hamiltonii* than *D asper.* Variation in tillers per clump, clump weight, bamboo dry biomass and leafy biomass was found to be non-significant. Emergence of new shoots was also recorded significantly higher (10.50/clump) under *D asper* than *D hamiltonii* (Table 1). Growth and developmental behaviour of individual species depends upon its genetic make up, environment and genotype and environment interaction. *D asper* falls under one of the giant bamboo species of the world the other two being *Phyllostachys pubescens* and *D giganteus*. Therefore its superiority over *D hamiltonii* is somewhat natural. Bhardwaj et al (2011) also observed superiority of *D asper* over *D hamiltonii.*

Ginger yield: Data presented in Table 2 demonstrate that bamboo species registered significant impact on yield which was found maximum under *D asper* (38.04 q/ha) and minimum in open field conditions. Bhardwaj et al (2011) also reported higher yield of ginger under *D asper* than *D hamiltonii* in 4 year old bamboo stand and concluded that ginger displayed better performance under *D asper* under mid-hill sub-humid conditions. Higher rhizome yield under bamboo canopy than sole crop can be explained based on shade loving nature of the crop. Kumar et al (2001) reported higher rhizome yield in ailanthus + ginger combination than sole crops. Amin et al (2010) also found that partial shade (50 ± 5%) fostered higher yield of ginger crop.

Table 1. Species-wise variability for growth parameters of bamboo species under bamboo-based agroforestry system

Parameter	*D asper*			*D hamiltonii*			F-ratio
	Mean	SD	CV (%)	Mean	SD	CV (%)	
Height (m)	6.35	0.65	10.28	5.72	1.15	20.11	3.10
Diameter (cm)	3.30	0.39	11.84	2.78	0.20	7.29	3.80
Culms/clump	44.95	5.48	12.19	25.85	6.64	25.67	1.47
Crown spread (m^2)	3.80	0.65	17.12	4.36	1.07	24.52	2.70
Culm dry weight (kg)	2.50	0.22	8.78	2.95	0.52	17.66	5.65
Clump weight (kg)	113.47	22.23	19.59	82.37	33.39	40.53	2.26
Bamboo dry biomass (tonnes/ha)	25.19	4.93	19.59	18.27	7.41	40.58	2.26
Leafy biomass (tonnes/ha)	3.69	0.45	12.18	2.15	0.58	27.04	1.67
New shoots/clump	10.5	1.20	10.0	7.21	0.91	8.0	3.01
Tender raw shoot biomass (q/ha)	11.43	1.10	9.50	4.95	4.32	8.32	3.20
Edible portion of tender shoot biomass (q/ha)	6.02	0.59	4.80	3.91	0.32	8.57	3.40

SD= Standard deviation, CV= Coefficient of variation

Table 2. Effect of bamboo species and open field conditions on yield of ginger under bamboo-based agroforestry system

Treatment combination	Yield (q/ha)
D asper (B_1)	38.04
D hamiltonii (B_2)	36.36
Open field conditions (B_3)	32.89
Least significant difference	3.80

CONCLUSION

D asper displayed better growth and development behavior over *D hamiltonii* under mid-hill conditions of Himachal Pradesh. Ginger crop performed better under bamboo-based agroforestry system in comparison to mono-cropping system. Among two bamboo species performance of ginger was found to be better under *D asper* with maximum rhizome yield (38.04 q/ha) than under *D hamiltonii*.

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