

Performance of ginger crop in response to integrated nutrient management under bamboo-based agroforestry system in mid-hill sub-humid conditions of Himachal Pradesh

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ABSTRACT

The study was conducted at the experimental farm of the Department of Silviculture and Agroforestry, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, HP during the rainy season of 2012. Experiment was laid out in split plot design comprising B₁ (*Dendrocalamus asper*) and B₂ (*D hamiltonii*) and B₃ (open field conditions) under which ginger crop was grown with five levels of nutrients supplied through organic and inorganic integrated fertilizer doses (T₁: recommended dose of fertilizer (RDF), T₂: farmyard manure (FYM) on N equivalent ratio + plant growth promoting rhizobacteria (PGPR), T₃: vermicompost (VC) on N equivalent ratio + PGPR, T₄: 75% RDF + PGPR, T₅: 50% FYM + 50% VC + PGPR). Though non-significant but higher rhizome sprouting, plant height and tillers per plant, rhizome length and yield were displayed by ginger crop under *D asper* than *D hamiltonii*. Treatment comprising FYM on N equivalent ratio + PGPR showed best results in respect of growth and yield parameters of ginger crop viz rhizome sprouting, tillers per plant, rhizome length and yield.

Keywords: Ginger; bamboo; rhizome; fertilizer doses; agroforestry

INTRODUCTION

Himachal Pradesh is a largely mountainous state lying in northwestern Himalayas and comprises hilly terrain, perennial rivers and significant forest cover. The state is bestowed with abundant water resources, mineral resources, horticulture and agriculture and has got potential for eco-tourism. It is however facing significant

challenges arising from its elevation, topography and ecological vulnerability. More than 90 per cent of the total population (Census 2011) lives in rural areas and their livelihood depends upon agriculture; 29 per cent people of the total population lives below poverty line. To improve the economic status of people and to earn more income from the same piece of land one has to shift from monocropping

to an ecologically sound agroforestry system.

Bamboo occurs in forests as well as is raised in homesteads in many countries including India. In homestead it is either found mixed with a large number of other species of trees or purely in patches. Many of the most useful bamboo species can occupy much the same ecological niche as tree and are well suited for agroforestry. Bamboo has got many advantages over trees such as it takes relatively shorter time for planting to harvest. Its sustainability provides building materials and edible products for many years or even decades and versatility of use outmatches most tree species.

The increasing use of chemical fertilizers to increase the production of food and fibre is causing concern due to declining land productivity, appearance of deficiency in secondary and micronutrients and deterioration in physical conditions of the soil. Excess use of nitrogenous fertilizers is leading to groundwater and environmental pollution apart from destroying the ozone layer through N_2O production. All these problems can be addressed or minimized through integrated nutrient management (INM) approach which utilizes different sources of plant nutrients to combat nutrient depletion and maintains soil health and crop productivity. Application of bulky organic manures to soil not only improves the physical properties of the soil but also

increases the availability of nutrients as well as organic carbon content and cation exchange capacity (CEC). Moreover it supplies plant nutrients including micronutrients and ultimately increases the yield of crop (Reddy and Reddy 1999). Plant growth promoting rhizobacteria (PGPR) are a heterogeneous group of bacteria which thrive in the rhizosphere and improve the extent or quality of plant growth directly or indirectly. The direct growth promotion of plants by PGPR entails either providing the plant growth promoting substances that are synthesized by the bacterium or facilitating the uptake of certain plant nutrients from the environment. The indirect plant growth promotion is due to preventing deleterious effects of the phytopathogenic microorganisms.

Ginger (*Zingiber officinale* Rosc) belonging to Zingiberaceae is a perennial herbaceous monocotyledon usually grown as an annual and known to human generations as a medicinal and spice crop. Being a shade-loving plant it is grown in association with a variety of trees and can be incorporated as important component in various agroforestry models.

Despite the overwhelming potential of bamboo species in the hills of Himachal Pradesh, positive role integrated nutrient strategy plays and the ability of the ginger crop to perform under the overhead canopy cover no scientific study has been carried out in this direction. Therefore the present

investigation was carried out to test the performance of ginger crop under two important multipurpose bamboo species viz *Dendrocalamus hamiltonii* and *D asper* and to optimize integrated fertilizer doses.

MATERIAL and METHODS

Experimental site was located in the mid-hill region of the state at Nauni having an elevation of 1200 m amsl. It lies between 30° 51' N latitude and 76° 11' E longitude. The area receives annual rainfall ranging from 1100 to 1400 mm. The experiment was laid out in split plot design having treatments B₁ (*D asper*) and B₂ (*D hamiltonii*) and B₃ (open field conditions) under which ginger crop was grown with five levels of nutrients supplied through organic and inorganic integrated fertilizer doses (T₁: recommended dose of fertilizer (RDF), T₂: farmyard manure (FYM) on N

equivalent ratio + plant growth promoting rhizobacteria (PGPR), T₃: vermicompost (VC) on N equivalent ratio + PGPR, T₄: 75% RDF + PGPR, T₅: 50% FYM + 50% VC + PGPR). Both bamboo species were 6 years old. Each treatment was replicated thrice. Rhizome seed sowing was done in the month of April.

Before sowing rhizomes were pre-treated with mancozeb M-45 (2.5 g/l) and carbendazim (1 g/l). After sowing plant growth promoting bacteria (PGPR) were applied uniformly followed by mulching with the tree leaves of *Ficus palmata*, *Celtis australis* and *Toona ciliata* in the month of May. Different treatment doses of organic and inorganic manures were applied to the plots randomly.

The rhizome sprouting was calculated as below:

$$\text{Rhizome sprouting (\%)} = \frac{\text{Number of rhizomes sprouted}}{\text{Total number of rhizomes sown}} \times 100$$

For measuring growth and yield traits of ginger viz plant height, tillers per plant, number of rhizomes per plant, rhizome length and rhizome fresh weight, five plants were randomly selected. Plant height and rhizome length were measured with the help of measuring tape and scale respectively and expressed in cm. Tillers per plant and number of rhizomes were calculated manually whereas rhizome fresh weight and yield were calculated

with the help of weighing balance. Yield was recorded for all the plants per plot and it was finally converted to yield per hectare.

The collected data on growth and developmental traits were statistically analyzed using split plot design to examine the variation of the results due to bamboo species and five integrated fertilizer treatments.

RESULTS and DISCUSSION

Growth parameters: Traits like rhizome sprouting, plant height and tillers per plant (Table 1) were significantly affected by the bamboo species and were maximum (30.13%, 60.86 cm and 8.86 respectively) in *D asper* followed by *D hamiltonii* and minimum were under open field conditions. This may be due to the shade effect of bamboo species which resulted in higher moisture conservation under the canopies than under control. In ginger crop moderate level of shade exerts a positive influence on these traits (Jayachandran et al 1991, Jaswal et al 1993). Amin et al (2010) also reported positive influence of shade on rhizome sprouting and tillers per plant of ginger crop. Under the integrated fertilizer nutrients treatment rhizome sprouting and tillers per plant were maximum (32.62% and 8.43 respectively) in treatment involving FYM. This can be owed to the reason that organic fertilizers release macro and micronutrients and improve physical, chemical and biological properties of soil. Sehgal and Thakur (2008) also observed that the growth of medicinal and aromatic plants was enhanced by the application of organic manures intercropped between hedgerows of *Morus alba*.

Yield traits: Data presented in Table 1 exhibit that bamboo species registered significant impact on rhizome length and yield. However no significant impact was reported on number of rhizomes and

rhizome fresh weight. Rhizome length and yield were found maximum in *D asper* (8.11 cm and 38.04 q/ha respectively) 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 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 ($50 \pm 5\%$) fostered higher yield of ginger crop. They reported maximum rhizome yield (124.2 q/ha) under partial shade of mango trees. In general lower yield (38.04 q/ha) was obtained in the present investigation which may be attributed to prevailing drought conditions and critically low moisture content during the month of May 2012 which might have resulted in excessively low rhizome emergence.

The yield parameters like rhizome length (7.65 cm), rhizome fresh weight (179.11 g) and yield (40.28 q/ha) were reported to be maximum in T₂ (FYM on N equivalent ratio + PGPR) which were significantly higher than all other treatments except T₅ (50% FYM + 50% VC + PGPR). The increase in yield by

Ginger under bamboo-based agroforestry system

Table 1. Effect of bamboo species and integrated nutrient management on growth and yield characters of ginger crop

Treatment	Rhizome emergence (%)	Plant height (cm)	Tillers/ plant	# rhizomes	Rhizome length (cm)	Rhizome fresh weight (g)	Yield (q/ha)
Species (main plot)							
B ₁	30.13	60.86	8.86	1.7	8.11	164.73	38.04
B ₂	29.24	57.90	7.89	1.89	7.9	166.74	36.36
B ₃	25.8	41.36	6.31	1.72	5.41	142.69	32.89
LSD	2.86	6.48	0.88	NS	0.47	NS	3.80
Integrated fertilizer treatment (sub-plot)							
T ₁	28.9	51.49	7.49	1.59	6.82	120.78	36.50
T ₂	32.62	57.04	8.43	1.84	7.65	179.11	40.28
T ₃	26.68	45.84	7.53	1.42	7.09	156.22	34.14
T ₄	24.46	57.84	6.77	2.04	6.78	162.92	31.18
T ₅	29.28	54.67	8.23	1.93	7.36	171.22	36.71
LSD	2.67	6.95	1.16	0.27	0.53	14.77	2.35

B₁ = *Dendrocalamus asper*, B₂ = *D hamiltonii*, B₃ = Open field conditions, T₁ = Recommended dose of fertilizer (RDF), T₂ = Farmyard manure (FYM) on N equivalent ratio + plant growth promoting bacteria rhizobacteria (PGPR), T₃ = Vermicompost (VC) on N equivalent ratio + PGPR, T₄ = 75% RDF + PGPR, T₅ = 50% FYM + 50% VC + PGPR, LSD = Least significant difference

the use of organic manure may be due to relatively high level of nutrients. FYM helps to hold soil moisture which has positive impact on yield components of ginger.

Ayuba et al (2005) also reported that application of organic manure increased rhizome yield of ginger ranging from 114.3 to 250.6 per cent over control. Plant growth promoting bacteria along with organic fertilizer can improve the extent and quality of plant growth either by providing the plant growth substances that are synthesized by the bacterium or facilitating the uptake of certain plant nutrients from the environment.

CONCLUSION

Ginger crop performed better under bamboo-based agroforestry system in comparison to mono-cropping system. Among different 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*. The integrated nutrient management registered positive impact on growth and yield traits of ginger under both agroforestry as well as mono-cropping systems. Application of FYM along with PGPR was found more effective in improving growth and yield traits of ginger viz rhizome emergence (32.62%), tillers per

plant (8.43), rhizome length (7.65 cm), rhizome fresh weight (179.11 g) and yield (40.28 q/ha). From the present investigation it can be concluded that ginger can thrive better under bamboo-based agroforestry system with integrated nutrient management than sole cropping system.

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