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Growth Performance of Ginger Under Bamboo (*Dendrocalamus strictus*) Based Agroforestry System in Chhattisgarh

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ABSTRACT

Ginger was cultivated in under Bamboo (*Dendrocalamus strictus*) plantation and in open *i.e.* without tree, at research farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) in 2018-19. The experiment was laid out in Factorial RBD with four replications in 24 plots of 6 x 3m size. The growth performance of ginger showed that maximum number of tillers was recorded in open (10.44) as compare to AFS (4.41) at 150 DAS. The maximum average crop height was recorded in AFS (62.47 cm) as compare to open (41.42 cm) at 180 DAS. The maximum collar diameter was recorded in AFS (7.61 mm) at 90 DAS and open (6.59 mm) at 120 DAS. The maximum number of leaves was recorded in open (127.28) at 180 DAS and AFS (50.11) at 150 DAS. The maximum leaves length was recorded in AFS (21.19 cm) at 90 DAS and open (15.75 cm) at 150 DAS. The maximum leaves width was recorded in AFS (2.15 cm) as compare to open (1.71 cm) at 60 DAS with statistically significant variation. The yield of fresh ginger was received 22.12 q ha^{-1} from open as compare to agroforestry systems (18.46 q ha^{-1}).

Key words: *Ginger, Bamboo, Growth, Agroforestry, Height and Tillers.*

Introduction

Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components (Lundgren and Raintree, 1982). Most of them are the long term land management practices having a life cycle of more than one year. It is a complex form of land management practices both in the form of ecologically and economically than other land management unit.

Agroforestry is a form of sustainable land use systems that integrates trees with crops or animal husbandry to initiate an agroecological succession (FAO, 2013). Due to its economic, social and environmental benefits (Abrha, 2016); agroforestry is widely promoted throughout the world and is an instrument for diversifying and enhancing production (Mbow *et al.*, 2014). Mixing trees with annual crops also helps farmers to overcome the crop failure due to climate change (Linger, 2014) and land degradation (Leakey, 2020).

In Ethiopia, smallholder farmers practice various agroforestry practices depending on the socioeconomic and biophysical conditions (Jamala *et al.*, 2013; Abrham *et al.*, 2016; Iiyama *et al.*, 2017). These include: coffee shade trees, scattered trees on farm-land, home-gardens, woodlots, boundary (wind-breaks) and silvo-pastures (Zebene and Agren, 2007).

Bamboo (*Dendrocalamus strictus)* is a perennial, woody grass has great potential in Chhattisgarh, not only for increasing green cover but also for fast re-muneration generating species for tribal belt (Naugraiya and Puri, 1997). Ginger is a subtropical plant grown for its root (rhizome or underground stem). The root has tan skin, ivory to pale green flesh, peppery, slightly sweet flavor. Ginger has many medicinal uses; the fresh or dried rhizome is used in oral or topical preparations for treatment a variety of ailments, while the essential oil is applied topically as an analgesic (Singh *et al.*, 2018) and it can be grown as cover crops under tree crop plantation to earn peasant. Thus present study has been focused to work out the growth performance of ginger in Bamboo plantation as under-storey cover crop land area and to estimate the benefits.

Materials and Methods

The study was conducted at research farm of IGAU, Raipur during 2018-19 in existing plantation of Bamboo (*Dendrocalamus strictus*) at 8 x4m spacing and adjacent open field toward south-east edges. Quality rhizome seeds of Ginger (var- Suprabha) was cultivated as per recommended field operation with application of fertilizers *i.e.* 10 t ha^{-1} FYM at time of field preparation along with split doses of 120 Kg Nitrogen, 60 Kg Phosphorus and 60 Kg Potassium per hectare in form of Urea, SSP and MoP as recommended. The experiment was laid out in Factorial RBD with four replications for statistically significant test.

Growth parameters of ginger crop *viz;* Number of tillers plant^{-1}, crop height (cm), collar diameter (mm), number of leaves (plant^{-1}), leaves length (cm), leaves width (cm) were observed at 30, 60, 90, 120, 150 and 180 days after sowing (DAS) while yield of ginger (q ha^{-1}) was recorded at seed formation stage.

Results

Soil

The soil components of experimental field was analysed by Harne (2013) showed the physical structure *viz.*, 20-30 % sand, 20-30% silt, >45% clay with wilting point of 20.20 cm, where its EC was measured 0.30 (ds/m) with pH of 7.5. The soil was found very rich in organic matter and other nutrients *i.e.*, 0.67% organic carbon, 166.2 kg N ha^{-1}, 9.7 kg P ha^{-1} and 544.8 kg K ha^{-1}.

Microclimatic status

PAR, Temperature and Relative humidity recorded at 15 days interval during crop period PAR was measure higher for open field crop (187.6-1003.6 µmol s^{-1} m^{-2}) than crop of AFS (89.5-606.86 µmol s^{-1} m^{-2}). The maximum PAR was recorded in open area as compare to AFS and in rainy season July to August its intensity and duration was less as compare to September to January. The average temperature was measured in more or less in similar pattern for crop of field of open and AFS during growing period of crop and it was in range of 23.6-32.6 ^{o}C and 22.2-32.6 ^{o}C respectively. The average relative humidity was recorded in little higher in AFS than open field during crop growing period due to shading of bamboo canopy and it was over all in range of 36.0-96.0 % and 37.7-96.5 % respectively. Similar results of micro-climatic characteristics were recorded by Dindekar (2012), Harne (2013) and Naugraiya (2003-2013) during cultivation of various Rabi and Kharif crops under bamboo.

Growth parameters

The growth parameters of ginger *viz*., number of tillers, crop height (cm), Collar diameter (mm), number of leaves, leaves length (cm) and leaves width of ginger crop was measure at 30, 60, 90, 120, 150, and 180 day after sowing (DAS) are presented in Table 1.

Number of tillers (plant^{-1})

Formation of tillers per plant was showed statistically significant (P<0.05). The maximum plant^{-1} average number of tillers of ginger crop was observed 4.41 plant^{-1} in AFS (CS-1) and 10.44 plant^{-1} open (CS-2) at 150 DAS and number of tillers of ginger crop decrease at 180 DAS in significant variation. While during early days of growing (30 DAS) average number of tillers of ginger crop was observed 1.69 and 1.97 plant^{-1} in AFS (CS-1) and open (CS-2) respectively with non-significant variation. Over all number of tiller of ginger crop was recorded less in AFS (CS-1) as compared to open (CS-2). The average number of tillers of ginger crop increased much faster in open (CS-2) than AFS (CS-1).

Crop height (cm)

Crop height of ginger crop was showed statistically significant (P<0.05). The maximum average crop height of ginger plant was observed 62.47 cm in AFS (CS-1) and 41.42 cm open (CS-2) at 180 DAS. While during early days of growth (30 DAS) average crop height of ginger plant was observed 34.34 and 30.03 cm in AFS (CS-1) and open (CS-2) respectively with non-significant variation. Over all crop height of ginger plant was recorded less in open (CS-2) as compare to AFS (CS-1). The average crop height of ginger plant increased much faster in AFS (CS-1) than open (CS-2).

Collar diameter (mm)

Collar diameter on plants of ginger crop showed statistically significant (P<0.05). The maximum average collar diameter was observed 7.61 mm in AFS (CS-1) at 90 DAS and 6.59 mm open (CS-2) at 120 DAS, afterward it was decreased in collar diameter. While during early days of growing (30 DAS) average collar diameter of ginger crop was observed 5.11 and 2.69mm in AFS (CS-1) and open (CS-2) respectively. Over all collar diameter of ginger crop was recorded less in open (CS-2) as compare to AFS (CS-1). The average collar diameter of ginger crop increased much faster in AFS (CS-1) than open (CS-2).

Number of leaves (plant^{-1})

Formation of number of leaves showed statistically significant (P<0.05). The maximum average number of leaves of ginger crop was observed 50.11 plant^{-1} in AFS (CS-1) and 85.97 plant^{-1} open (CS-2) at 150 DAS and number of leaves of ginger crop increase in open (CS-2) but decrease in AFS (CS-1) at 180 DAS. While during early days of growing (30 DAS) aver-

Table 1. Growth performance of ginger in bamboo based agroforestry system.

Treatments	Days after sowing the crop (DAS)					
	30	60	90	120	150	180
Numbers of tillers plant^{-1}						
AFS (CS-1)	1.69	2.05	3.22	4.3	4.41	3.78
Open (CS-2)	1.97	3.28	6.39	9.25	10.44	9.75
SEm±	0.11	0.14	0.27	0.31	0.35	0.29
CD (at 5%)	NS	0.44	0.82	0.95	1.09	0.89
Crop Height (cm) plant^{-1}						
AFS (CS-1)	34.34	57.85	58.64	62.13	62.35	62.47
Open (CS-2)	30.03	32.20	35.28	38.17	39.66	41.42
SEm±	0.96	0.83	0.85	1.12	1.00	0.88
CD (at 5%)	NS	2.55	2.61	3.44	3.07	2.71
Collar diameter (mm) plant^{-1}						
AFS (CS-1)	5.11	6.47	7.61	7.55	7.33	7.21
Open (CS-2)	2.69	4.28	5.14	6.59	6.08	6.09
SEm±	0.11	0.13	0.21	0.10	0.05	0.08
CD (at 5%)	0.33	0.41	0.65	0.31	0.15	0.24
Number of leaves plant^{-1}						
AFS (CS-1)	4.30	16.97	28.86	42.16	50.11	42.77
Open (CS-2)	11.50	25.00	45.36	58.69	85.97	127.28
SEm±	0.29	0.89	1.72	2.65	3.39	3.89
CD (at 5%)	0.91	2.73	5.29	8.16	10.44	11.99
Leaves length (cm) plant^{-1}						
AFS (CS-1)	13.03	22.08	21.19	18.80	16.95	17.17
Open (CS-2)	14.73	15.46	15.02	15.62	15.75	14.17
SEm±	0.36	0.21	0.23	0.26	0.19	0.11
CD (at 5%)	NS	0.63	0.72	0.79	0.58	0.34
Leaves width (cm) plant^{-1}						
AFS (CS-1)	1.84	2.15	1.92	1.60	1.48	1.40
Open (CS-2)	1.83	1.71	1.43	1.37	1.38	1.33
SEm±	0.03	0.02	0.02	0.02	0.01	0.01
CD (at 5%)	NS	0.06	0.06	0.06	0.04	0.03

age number of leaves of ginger crop was observed 4.30 plant^{-1} and 11.50 plant^{-1} in AFS (CS-1) and open (CS-2) respectively. Over all number of leaves of ginger crop was recorded less in AFS (CS-1) as compare to open (CS-2). The average number of leaves of ginger crop increased much faster in open (CS-2) than AFS (CS-1).

Leaves length (cm)

Growth of leaves length of ginger crop showed statistically significant (P<0.05). However during early days of growing (30 DAS) average leaves length of ginger crop was observed 13.03 and 14.73 cm in AFS (CS-1) and open (CS-2) respectively with non-significant variation. The maximum average leaves length of ginger crop was observed 22.08 cm in AFS (CS-1) and 15.46 cm open (CS-2) at 60 DAS. The average leaves length of ginger crop was recorded at 90 to 180 DAS in AFS (CS-1) while it was increased in CS-2. Over all leaves length of ginger crop was recorded less in open (CS-2) as compare to AFS (CS-1). The average leaves length of ginger crop increased much faster in AFS (CS-1) than open (CS-2).

Leaves width (cm)

Growth on leaves width of ginger crop showed statistically significant (P<0.05). The maximum average leaves width of ginger crop was observed 2.15cm in AFS (CS-1) and 1.71cm open (CS2) at 60 DAS and decrease in leaves width of ginger crop was observed at 90 to 180 DAS in both AFS (CS-1) and open (CS-2), While during early days of growing (30 DAS) average leaves width of ginger crop was observed 1.84 and 1.83 cm in AFS (CS-1) and open (CS-2) respectively with non-significant variation. Over all leaves width of ginger crop was recorded less in open (CS-2) as compare to AFS (CS-1). The average leaves width of ginger crop increased much faster in AFS (CS-1) than open (CS-2).

Yield of ginger (q ha^{-1})

The fresh yield of rhizome showed statistically significant variation (P<0.05), where the yield of fresh weight of rhizome was recorded 18.46 q ha^{-1} under AFS (CS-1) and 22.12 q ha^{-1} open field (CS-2) respectively.

Discussion

The count of number of tillers was highest in crop of open field (CS-2) as compare to crop of AFS (CS-1), this might be due to sun light intensity and duration in open field was higher as compare to AFS. The quality of tillers was found to be positively correlated to soil moisture and nutrient in a significant manner (Amin *et al.*, 2010). Kandiannan *et al.* (1999) recorded insignificant variation in population of tiller in ginger plant, grown alone and with maize, Hegde *et al.* (2000) found it with areca nut plantation and Singh *et al.* (2004) observed significant impact between moderately shaded (30 to 40 per cent) and heavily shaded more than 90 percent cultivated crops, whereas, intercropping of ginger with *populus* species also showed increased in tiller population (Jasural *et al.,* 1993).

Height of ginger plants was found highest in AFS as compare to open field crop. This might be due to shade loving nature of species and higher nutrient availability in soil of AFS compare to open field. Growth in plant height was also found to be positively correlated to soil moisture content in a significant manner. Nair and Jayachandran (1998) studied that the similar results for growth height of plant which was maximum beneath 50 per cent shade condition, Singh *et al.,* (2004) found the maximum height of plants of ginger crop under dense shade more than 90 percent of *Cajanus cajan* though Tabin *et al.,* (2015) observed maximum height under 70% orange tree. In several studies on intercropping of ginger showed better growth in height of plants under *populus* species Jasural *et al.*, 1993, with *Areca catechu* plantation Hegde *et al.,* 2000 and with coconut Roy *et al.,* (2008) as compare to monocropping.

The collar diameter of ginger plant at basal area was highest in AFS (CS-1) as compare to open field (CS-2). Similar results was reported by Roy *et al.* (2008) when ginger was intercropping with coconut plantation where the result was observed for increase in girth of ginger crops as compared to monocropping.

Leaves size and number in a plant regulate the overall performance and yield of a plant as the major source of food synthesization for its own requirement thus it an important component of any crop. Here in case of ginger the number of leaves was more in open field as compare to agroforestry system, and this might be due to availability of little higher amount of sunlight and temperature in open field, while leaves length and width of ginger plant were recorded more in agroforestry system (CS-1) as compare to open field (CS-2) as result of shade loving nature of plant as well availability comparatively better soil organic substances having excess NPK with moisture.

Vikram and Hegde (2014) and Choudhary *et al.* (2015) reported in their studies that when ginger crop was intercropped with coconut, cashew and *Alnus nepalensis* tree crop respectively as compared to sole crop of ginger. The intercropping of ginger with *populus* species increased length of leaves (Jasural *et al*., 1993), though Bhuiyan *et al.* (2012) found better growth in leaves under 25-30 % shade, further it is supported by Choudhary *et al.* (2015) in their studies that shade of *Alnus nepalensis* had statistically significant positive impact on growth in length as compared to sole crop of ginger but it had insignificant variation for growth in width.

Fresh weight yield of ginger was highest in open field (CS-2) it might be due to in open field are received higher amount of sun light. Ginger prefers warm and humid climate and it grow well in medium light intensity (Zhenxian *et al.,* 2000). Bhardwaj *et al.* (2011) studied maximum yield of ginger under *D. asper*.

Conclusion

As cover crop of ginger under wider spacing bamboo plantation, number of tillers (plant^{-1}), crop height, collar diameter, number of leaves and its length and width were comparatively found more in crop under bamboo based agroforestry system at 180 DAS with statistically significant variation. While the yield of fresh ginger rhizomes was recorded 22.12 q ha^{-1} in open field crops which was significantly 20 percent higher from Bamboo based cropping systems.

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