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Yield of *Zingiber officinale* under *Dendrocalamus strictus* based Agroforestry System in plains of Chhattisgarh

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A B S T R A C T

Zingiber officinale was cultivated at three plant spacing *viz;* S-1 (30 x 20cm), S-2 (30 x 25cm) and S-3 (30 x 30cm) under *Dendrocalamus strictus* AFS (8 x 6m) and in open, at research farm of IGAU, Raipur (C.G.) in 2018-19. The population of bamboo have 33.38±16.23 culm per clump to 45.00±19.06 after 8 month with 5.66±0.99 diameter of clumps. The average height of bamboo was record 8.35±0.54 m with 3.56±0.77 cm diameter at 3rd internodes. The soil physical structure *viz.*, 20-30 % sand, 20-30% silt, >45% clay with wilting point of 20.20cm, where its EC is 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}. The 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 average temperature is more or less in similar pattern for 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 is little higher in AFS than open field due to shading of bamboo canopy and it was over all in range of 36.0-96.0 % and 37.7-96.5 % respectively. The yield of fresh weight of rhizome was received 22.12 q ha^{-1} from open (CS-2) as compare to AFS (CS-1) (18.46 q ha^{-1}). The spacing S-2 gave highest yield of 24.70 q ha^{-1} followed by S1 (22.37 q ha^{-1}) and S3 (13.80 q ha^{-1}) respectively with significant variation. In case of interaction of cropping system x spacing, the highest yield was received 26.97 q ha^{-1} in CS-2 x S-2 followed by 24.58 and 22.44 q ha^{-1} in CS-2 x S-1 and CS-1 x S-2 respectively.

Keywords

Agroforestry; Bamboo; Ginger; Yield and Plains

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Introduction

Agroforestry is the collective name of the sustainable land management systems involving trees crops combination of agricultural crops in same piece of land. Agroforestry is the complex system that provided in timbers, food, fodder and fuels in farmers. The area under agroforestry in India, according to one estimate, is at 25.32 m ha or 8.2 percent of the total geographical area of the country (Dhyani *et al.*, 2013).

Research has focused on how agroforestry can help alleviate poverty through diversification of income, increased crop yields, and substitution of agricultural inputs (Cacho *et al.*, 2003; Ellis, 1992; Lundgren and Raintree, 1983; Nair, 1998; Pandey, 2007; Pratiwi and Suzuki, 2019; Quinion *et al.*, 2010; Steppler and Nair, 1987). More recent research has highlighted how agroforestry systems can provide a range of ecosystem services, such as soil enrichment, improvements in air and water quality, and biodiversity benefits (Barrios *et al.,* 2012; Jose, 2009; Sileshi *et al.,* 2007). A growing body of work has begun to demonstrate how agroforestry can advance climate change mitigation through carbon storage (Chapman *et al.,* 2020; Duguma *et al.,* 2019; Griscom *et al.,* 2017; Syampungani *et al.,* 2010).

The benefits of agroforestry systems are to some degree achieved on 43% of agricultural land with at least 10% tree cover in 2010, sequestering approximately 36.29 Pg Carbon (Zomer *et al.,* 2016). As a proven sustainable land use practice, global efforts are underway to achieve higher levels of agroforestry to advance global climate change mitigation (IPCC, 2019), sustainable development (World Bank, 2020), and conservation goals (Bhagwat *et al.,* 2008; Schroth and Harvey, 2007; Waldron *et al.,* 2012).

Bamboo is perennial, woody grass great potential fast growing species. In Chhattisgarh, Bamboo occurs in almost all the districts and *Dendrocalamus strictus* is spread over large areas. The annual estimated production of Bamboo in the Madhya Pradesh and Chhattisgarh is approximately 0.316 million tons (Naugraiya and Puri, 1997). *Zingiber officinale* is a herbaceous perennial plants growing as an annual crop. It is native to south eastern Asia and growing in tropics and subtropics regions of the world. The present study was focused to work out the yield performance of ginger under bamboo plantation for generating the benefits.

Materials and Methods

The study was conducted at research farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur during 2018-19 where the plantation of Bamboo species - *Dendrocalamus strictus* was made in year for the production of bamboo culms. The rhizome seeds of *Zingiber officinale* was sown in under Bamboo and open field at three spacing *viz;* 30 x20cm (S-1), 30 x 25cm (S-2) and 30 x 30cm (S-3) as per recommended standard methods of cultivation.

The application of fertilizers were made accordingly *i.e.* 10 t ha^{-1} FYM at time of field preparation, while chemical fertilizers *i.e.* 120N, 60P & 60K kg ha^{-1} were given in form of Urea, SSP and Murate of Potash as recommended for basal and split doses.

The yield parameters of ginger *viz;* mother rhizome length and width (cm); number of prime fingers and sub-finger; rhizome length and width (cm); finger length and width (cm), finger (cm); sub-finger length and width (cm); rhizome root length (cm) were measured after 180 DAS of crop at maturity, while the yield of fresh rhizome (q ha^{-1}) was observed after harvesting of crop at seed maturity stage and it was also estimated after oven dry at 80^{o}C.

The experiment was laid out in Factorial RBD with four replications and the data were analyzed statistically for significant test (Pansey and Sukhatme, 1961).

Growth status of Bamboo plantation during cropping period was also recorded for number of culms per clump, culm height, clump diameter and increment in their status after the crop.

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 20.20cm, 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} are presented in table-1.

Microclimatic features *viz;* PAR (µmol s^{-1} m^{-2}), Temperature (^{o}C) and relative humidity (%) available to the crops were also measured during cropping season.

Results and Discussion

Micro-climate

The microclimatic characteristics *viz;* PAR, temperature and relative humidity was measured in both open field and agroforestry system at every 15 days intervals during crop period *i.e.* July 2018 to January 2019 and data are presented in Table-2.

Photosynthetically Active Radiation (µmol s^{-1} m^{-2})

The PAR was recorded in *Zingiber officinale* crop of AFS received average PAR in ranges of 89.56 to 606.86, 105.56 to 202.65 and 132.02 to 338.03 µmol s^{-1} m^{-2} during July to August, September to November and December to January respectively, while in case of open average PAR received in ranges of 187.69 to 657.92, 275.61 to 919.99 and 519.92 to 1003.63 µmol s^{-1} m^{-2} during July to August, September to November and December to January respectively. The maximum PAR was recorded in open area as compare to AFS. In rainy season July to August PAR was recorded less as compare to September to November and December to January.

Temperature (^{o}C)

The average temperature was recorded in ranges of 27.30 to 32.26 ^{o}C, 29.78 to 33.31 ^{o}C and 22.19 to 27.99 ^{o}C during July to August, September to November and December to January respectively in AFS, where in case of open, it was recorded in ranges of 27.80 to 31.62 ^{o}C, 29.93 to 32.85 ^{o}C and 23.65 to 28.00 ^{o}C during July to August, September to November and December to January respectively. The average temperature was recorded in more or less similar pattern in field of open and AFS during growing period of crop.

Relative Humidity (%)

The average relative humidity was recorded in ranges of 76.58 to 96.58%, 37.75 to 83.58% and 38.33 to 55.75% during July to August, September to November and December to January respectively for the crop of AFS, while in case of open crop it was recorded in ranges of 77.75 to 96.00%, 38.17 to 81.33% and 36.00 to 57.75% during July to August, September to November and December to January respectively. The average relative humidity was recorded in little higher in AFS than open during crop growing period due to shading of bamboo canopy.

Bamboo growth status

Growth status of bamboo plantation at 8 x 6 m over 18 yrs of plantation with yearly removal of mature culms. Population of culm per clump was recorded 33.4 in July 2018 and it increased to 45.0 with share of matured (21.3%), young (43.2%), dead (9.7%) and new culm (25.8%) after 8 month in the growth period of crop. Diameter of clumps was also increased from 4.68m to 5.66m after 8 month of growth. Height of culm was enhanced by 14.8% from 7.27m, diameter of 3rd internodes of culms increased from 3.34 to 3.56cm after 8 month. Diameter of clumps was recorded 4.68m and it increased to 5.66m after 8 month of growth.

Yield Parameters of Ginger

The yield parameters of ginger *viz;* mother rhizome length (cm), mother rhizome width (cm), number of prime fingers, number of sub-finger, rhizome length (cm), rhizome width (cm), finger length (cm), finger width (cm), sub-finger length (cm), sub-finger width (cm), rhizome root length (cm) and rhizome yield - fresh and oven dry (q ha^{-1}) was observed after harvesting of crop (Table-3).

Mother rhizome length (cm)

The impact of cropping system on average mother rhizome length of ginger was recorded 3.98cm in CS-1 (AFS) and 4.37cm in open (CS-2) with statistically non-significant variation, in case of spacing it was found in 4.26cm in S-2 and S-3 both with minimum of 4.00cm in S-1 in insignificant variation, though the interaction of cropping system x spacing observed maximum 4.53cm in CS-2 x S-3 followed by 4.33cm and 4.27cm in CS-2 x S-1 and CS-1 x S-2 respectively with minimum of 3.67cm in CS-1 x S-1 (Table-3).

Mother rhizome width (cm)

The impact of cropping system on average mother rhizome width of ginger was recorded 2.95cm in CS-1 (AFS) and 2.80cm in open (CS-2) with statistically non-significant variation, in case of spacing it was found in order of S-2>S-1>S-3 in range of 2.99 to 2.73cm with insignificant variation, though the interaction of cropping system x spacing observed maximum 3.06cm in CS-1 x S-2 followed by 2.94cm and 2.92cm in CS-2 x S-1 and CS-2 x S-2 respectively with minimum of 2.55cm in CS-2 x S-3 (Table-3).

Number of prime fingers

The impact of cropping system on average number of prime fingers of ginger was counted 2.50 in CS-1 (AFS) and 2.12 in open (CS-2) with statistically non-significant variation, in case of spacing it was found in order of S-3>S-2>S-1 in range of 2.38 to 2.24 with insignificant variation, though the interaction of cropping system x spacing counted maximum 2.75 in CS-1 x S-3 followed by 2.42 and 2.34 in CS-1 x S-2 and CS-1 x S-1 respectively with minimum of 2.00 in CS-2 x S-3 (Table-3).

Number of sub-fingers

The impact of cropping system on average number of sub-fingers of ginger was counted 5.36 in CS-1 (AFS) and 6.47 in open (CS-2) with statistically non-significant variation, in case of spacing it was found in order of S-2>S-1>S-3 in range of 6.66 to 4.93 with insignificant variation, though the interaction of cropping system x spacing counted maximum 7.90 in CS-2 x S-2 followed by 6.40 and 5.92 in CS-2 x S-1 and CS-1 x S-1 respectively with minimum of 4.75 in CS-1 x S-3 (Table-3).

Rhizome length (cm)

The impact of cropping system on average rhizome length of ginger was recorded 8.46cm in CS-1 (AFS) and 7.28cm in open (CS-2) with statistically significant variation, in case of spacing it was found in order of S-2>S-1>S-3 in range of 8.08 to 7.56cm with insignificant variation, though the interaction of cropping system x spacing observed maximum 8.68cm in CS-1 x S-1 followed by 8.43cm and 8.26cm in CS-1 x S-3 and CS-1 x S-2 respectively with minimum of 6.69cm in CS-2 x S-3 (Table-3).

Rhizome width (cm)

The impact of cropping system on average rhizome width of ginger was recorded 4.38cm in CS-1 (AFS) and 4.58cm in open (CS-2) with statistically non-significant variation, in case of spacing it was found in order of S-2>S-1>S-3 in range of 4.76 to 3.95cm with insignificant variation, though the interaction of cropping system x spacing observed maximum 4.98cm in CS-2 x S-1 followed by 4.80cm and 4.72cm in CS-2 x S-2 and CS-1 x S-2 respectively with minimum of 3.93cm in CS-1 x S-3 (Table-3).

Fingers length (cm)

The impact of cropping system on average fingers length of ginger was recorded 4.35cm in CS-1 (AFS) and 6.09cm in open (CS-2) with statistically significant variation, in case of spacing it was found in order of S-2>S-1>S-3 in range of 5.65 to 4.61cm with insignificant variation, though the interaction of cropping system x spacing observed maximum 6.60cm in CS-2 x S-2 followed by 5.84cm and 5.82cm in CS-2 x S-1 and CS-2 x S-3 respectively with minimum of 3.40cm in CS-1 x S-3 (Table-3).

Fingers width (cm)

The impact of cropping system on average fingers width of ginger was recorded 2.97cm in CS-1 (AFS) and 3.87cm in open (CS-2) with statistically significant variation, in case of spacing it was found in order of S-1>S-2>S-3 in range of 3.61 to 3.07cm with insignificant variation, though the interaction of cropping system x spacing observed maximum 4.14cm in CS-2 x S-2 followed by 3.91cm and 3.55cm in CS-2 x S-1 and CS-2 x S-3 respectively with minimum of 2.59cm in CS-1 x S-3 (Table-3).

Sub-fingers length (cm)

The impact of cropping system on average sub-fingers length of ginger was recorded 1.78cm in CS-1 (AFS) and 2.21cm in open (CS-2) with statistically significant variation, in case of spacing it was found in order of S-2>S-1>S-3 in range of 2.24 to 1.81cm with insignificant variation, though the interaction of cropping system x spacing observed maximum 2.57cm in CS-2 x S-2 followed by 2.10cm and 1.95cm in CS-2 x S-1 and CS-2 x S-3 respectively with minimum of 1.67cm in CS-1 x S-3 (Table-3).

Sub-fingers width (cm)

The impact of cropping system on average sub-fingers width of ginger was recorded 1.41cm in CS-1 (AFS) and 1.57cm in open (CS-2) with statistically non-significant variation, in case of spacing it was found in order of S-2>S-1>S-3 in range of 1.61 to 1.41cm with insignificant variation, though the interaction of cropping system x spacing observed maximum 1.72cm in CS-2 x S-2 followed by 1.55cm and 1.49cm in CS-2 x S-1 and CS-1 x S-2 respectively with minimum of 1.36cm in CS-1 x S-1 (Table-3).

Rhizome root length (cm)

The impact of cropping system on average rhizome root length of ginger was recorded 10.67cm in CS-1 (AFS) and 12.59cm in open (CS-2) with statistically significant variation, in case of spacing it was found in order of S-1>S-2>S-3 in range of 12.12 to 10.71cm with insignificant variation, though the interaction of cropping system x spacing observed maximum 13.29cm in CS-2 x S-2 followed by 13.03cm and 11.46cm in CS-2 x S-1 and CS-2 x S-3 respectively with minimum of 9.96cm in CS-1 x S-3 (Table-3).

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

The rhizomes were dig out carefully and washed thoroughly with water to remove soil particles afterward dry in the shade to make it moisture free and then weighed according to replications of each treatments. Sub samples of each treatment were dried in hot air oven at 80^{o}C till remove of all water contents of rhizome and again weighed, thus on the basis of this observations per unit dry weight yield was estimated and presented in table -3

Fresh rhizome

The fresh weight yield of rhizome was 18.46 q ha^{-1} in AFS (CS-1) and 22.12 q ha^{-1} in open field (CS-2) with statistically significant variation, in case of spacing it was found in order of S-2>S-1>S-3 in range of 24.70 q ha^{-1} to 13.80 q ha^{-1} with significant results, though the interaction of cropping system x spacing showed maximum yield of rhizome 26.97 q ha^{-1} in CS-2 x S-2 followed by 24.58 q ha^{-1} and 22.44 q ha^{-1} in CS-2 x S-1 and CS-1 x S-2 respectively with minimum rhizome yield is 12.79 q ha^{-1} in CS-1 x S-3 interaction.

Oven dry rhizome

The oven dry weight yield of rhizome was 4.66 q ha^{-1} in AFS (CS-1) and 5.50 q ha^{-1} in open (CS-2) with statistically significant variation, in case of spacing it was found in order of S-2>S-1>S-3 in range of 6.27 q ha^{-1} to 3.46 q ha^{-1} with significant results, though the interaction of cropping system x spacing showed maximum dry weight 6.78 q ha^{-1} in CS-2 x S-2 followed by 6.03 q ha^{-1} and 5.76 q ha^{-1} in CS-2 x S-1 and CS-1 x S-2 respectively with minimum dry weight of 3.23 q ha^{-1} in CS-1 x S-3 interaction.

Table.1 Soil components in study area

Soil parameters	Value
Physical structure	
Sand (%)	20-30
Silt (%)	20-30
Clay (%)	>45
Wilting point (cm)	20.20
E. C. (ds/m)	0.30
pH	7.4-7.6
Organic carbon (%)	0.67
Nitrogen (Kg ha^{-1})	166.2
Phosphorus (Kg ha^{-1})	9.7
Potassium (Kg ha^{-1})	544.8
Reference : Harne (2013)	

Table.2 Micro climatic observations during cropping periods (July 2018 to Jan. 2019)

Date of Observation	PAR (µmol S^{-1} m^{-2})		Temperature (^{o}C)		Relative Humidity (%)	
	AFS	OPEN	AFS	OPEN	AFS	OPEN
1st July 2018	606.86 ±41.92	657.92 ±56.92	32.26 ±0.24	31.62 ±0.15	76.58 ±1.34	77.75 ±1.17
15th July 2018	188.32 ±41.95	187.69 ±1.69	27.30 ±0.26	27.80 ±0.00	96.58 ±0.32	96.00 ±0.00
15th Aug 2018	89.56 ±33.36	326.89 ±117.57	29.55 ±0.02	30.14 ±0.77	89.33 ±1.19	86.83 ±0.69
1st Sept 2018	137.78 ±18.36	327.92 ±111.07	29.78 ±0.02	29.93 ±0.10	83.58 ±0.50	81.33 ±1.12
15th Sept 2018	201.37 ±66.86	919.99 ±93.37	32.28 ±0.03	31.95 ±0.17	62.08 ±0.50	63.50 ±0.19
1st Oct 2018	105.56 ±16.42	671.74 ±97.40	33.31 ±0.28	32.85 ±0.28	54.92 ±0.17	57.42 ±1.03
15th Oct 2018	129.83 ±65.61	275.61 ±67.98	31.54 ±0.03	32.21 ±0.34	49.73 ±0.30	48.33 ±0.47
1st Nov 2018	147.65 ±75.67	836.09 ±162.04	32.63 ±0.24	32.69 ±0.37	49.83 ±0.64	51.58 ±1.62
15th Nov 2018	202.65 ±64.84	861.04 ±155.87	31.67 ±0.11	31.38 ±0.20	37.75 ±0.42	38.17 ±0.19
1st Dec 2018	132.02 ±59.59	519.92 ±12.87	27.99 ±0.25	28.00 ±0.26	47.75 ±0.57	48.67 ±0.47
15th Dec 2018	240.09 ±138.16	912.66 ±133.96	24.63 ±0.16	24.78 ±0.64	55.75 ±0.83	57.75 ±2.39
1st Jan 2019	338.03 ±150.21	1003.63 ±62.28	22.19 ±0.14	23.65 ±0.59	39.25 ±0.32	36.00 ±1.05
15th Jan 2019	212.90 ±103.40	839.33 ±72.69	26.46 ±0.19	26.32 ±0.43	38.33 ±0.27	38.67 ±0.77

Table.3 Yield of Ginger under Bamboo based Agroforestry System

Treatments	Mother rhizome		No. of Fingers		Rhizome		Fingers		Sub-fingers		Rhizome	Yield (q ha^{-1})	
	length (cm)	width (cm)	prime finger	sub-finger	length (cm)	width (cm)	length (cm)	width (cm)	length (cm)	width (cm)	root length (cm)	Fresh	Oven dry
Cropping System													
AFS (CS-1)	3.98	2.95	2.50	5.36	8.46	4.38	4.35	2.97	1.78	1.41	10.67	18.46	4.66
Open (CS-2)	4.37	2.80	2.12	6.47	7.28	4.58	6.09	3.87	2.21	1.57	12.59	22.12	5.50
SEm±	0.09	0.08	0.09	0.30	0.15	0.10	0.15	0.11	0.05	0.03	0.20	2.36	0.57
CD (at 5%)	NS	NS	NS	NS	0.46	NS	0.47	0.33	0.15	NS	0.60	7.27	1.77
Spacing													
S1 (30x20 cm)	4.00	2.91	2.24	6.16	7.97	4.74	5.48	3.61	1.93	1.45	12.12	22.37	5.52
S2 (30x25 cm)	4.26	2.99	2.31	6.66	8.08	4.76	5.56	3.57	2.24	1.61	12.06	24.70	6.27
S3 (30x30 cm)	4.26	2.73	2.38	4.93	7.56	3.95	4.61	3.07	1.81	1.41	10.71	13.80	3.46
SEm±	0.11	0.09	0.10	0.35	0.18	0.11	0.18	0.13	0.06	0.03	0.23	1.93	0.47
CD (at 5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	5.94	1.44
Interaction of cropping system x spacing													
CS1 x S1	3.67	2.88	2.34	5.92	8.68	4.50	5.12	3.32	1.77	1.36	11.21	20.17	5.01
CS1 x S2	4.27	3.06	2.42	5.42	8.26	4.72	4.53	3.00	1.90	1.49	10.83	22.44	5.76
CS1 x S3	4.00	2.90	2.75	4.75	8.43	3.93	3.40	2.59	1.67	1.38	9.96	12.79	3.23
CS2 x S1	4.33	2.94	2.15	6.40	7.27	4.98	5.84	3.91	2.10	1.55	13.03	24.58	6.03
CS2 x S2	4.25	2.92	2.20	7.90	7.90	4.80	6.60	4.14	2.57	1.72	13.29	26.97	6.78
CS2 x S3	4.53	2.55	2.00	5.10	6.69	3.96	5.82	3.55	1.95	1.43	11.46	14.82	3.69
SEm±	0.16	0.14	0.15	0.53	0.26	0.17	0.27	0.19	0.08	0.05	0.34	1.36	0.33
CD (at 5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

The microclimatic features *viz;* PAR (µmol s^{-1} m^{-2}), temperature (^{o}C) and relative humidity (%) available around the ginger crop, either grown under bamboo or in open field have interrelated association which ultimately reflected in performance of growing crops. Here the PAR was recorded maximum in open field as compare to agroforestry system. The temperature around crops of AFS and open field showed more or less similar pattern of fluctuation and availability during growing period of crop i.e.; July to January. In case of relative humidity which was always associated with availability of sun light and existing air temperature found little higher in agroforestry system as compare to open field. Similar results of micro-climatic features were recorded by Dindekar (2012), Harne (2013) and Naugraiya (2003-2013) during cultivation of various *Rabi* and *Kharif* crops under bamboo.

The formation and elongation new rhizome along with sub-fingers showed more or less similar trend in both cropping system with very narrow differences as resulted in width of rhizomes and its numbers, while length of rhizomes and its fingers and sub-fingers showed significant variation which lead to variation in yield of ginger, however the impact of crop spacing revealed the insignificant output in growth behaviour of rhizomes for numbers, length, width for prime and sub-fingers. In case of crop spacing S-2 (30 x 25 cm) gave better results than narrow (S-1) and wider (S-3) spacings for all the parameters. Similar results, were observed for ginger crop when intercropped with maize, (Lyocks *et al.,* 2013), with poplar trees (Jasural *et al.*, 1993). Das *et al.,* (2008) and Hazarika *et al.,* (2009) also observed more or less. The under shading impact of *Persea bombycina* and Tamarind trees for ginger crops.

The crop spacing showed significant yield at closer spacing which may be ascribed to higher density of plant per unit area with efficient utilization of nutrients, ultimately produced 20.17 to 22.4 q ha^{-1} rhizomes. Such results were narrated by Gosh and Hore (2011), Yadav *et al.,* (2013) for ginger and Mohamed *et al.,* (2014) for turmeric.

Fresh weight yield of rhizome was highest in open (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). Similar pattern of oven dry yield of ginger was recorded higher in open field.

As cover crop of *Zingiber officinale* under wider spacing Bamboo plantation showed the yield of fresh weight of rhizome was 20 percent more in open (CS-2) in 22.12 q ha^{-1} with significant variation along with various yield parameters. Yield of rhizome was found higher at spacing S-2 (30x25cm) in 24.70 q ha^{-1} with significant variation where it was very less at spacing S-3 (30x30cm) *i.e.*13.8 q ha^{-1}. Interaction of cropping system x spacing was found statistically insignificant results.

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References

Barrios, E., Sileshi, G., Shepherd, K. and Sinclair, F. (2012). Agroforestry and soil health: Linking trees, soil biota, and ecosystem services. In: The Oxford Handbook of Soil Ecology and Ecosystem Services, pp. 315–330. https://doi.org/10.1093/acprof:oso/9780199575923.003.0028.

Bhagwat, S. A., Willis, K. J., Birks, H. J. B. and Whittaker, R. J. (2008). Agroforestry: a refuge for tropical biodiversity? *Trends Ecol. Evol*. 23, 261–267. https://doi.org/10.1016/j.tree.2008.01.005.

Cacho, O. J., Marshall, G. R. and Milne, M. (2003). Smallholder agroforestry projects: Potential for carbon sequestration and poverty alleviation. In: FAO - Agriculture and Economic Development Analysis Division. https://doi.org/10.22004/ag.econ.289093.

Chapman, M., Walker, W. S., Cook-Patton, S. C., Ellis, P. W., Farina, M., Griscom, B. W. and Baccini, A. (2020). Large climate mitigation potential from adding trees to agricultural lands. *Global Change Biol*. https://doi.org/10.1111/gcb.15121 n/a.

Dhyani, S. K., Handa, A. K. and Uma. (2013). Area under agroforestry in India: An assessment for present status and future perspective. *Indian J. Agroforestry* 15(1):1-11.

Dindekar, K. (2012). Performance of Wheat crop under *Dendrocalamus strictus* based AFS in Chhattisgarh. M.Sc. Thesis Dept. of Forestry IGAU, Raipur.

Duguma, L. A., Minang, P. A., Kimaro, A. A., Otsyina, R. and Mpanda, M. (2019). Shinyanga: Blending old and new agroforestry to integrate development, climate change mitigation and adaptation in Tanzania. In: Van Noordwijk, M. (Ed.), Sustainable Development through Trees on Farms: Agroforestry in its Fifth Decade. World Agroforestry (ICRAF), Bogor, Indonesia, pp. 139–151.

Ghosh, D. K. and Hore, J. K. (2011). Economics of a coconut based inter-cropping system as influenced by spacing and seed rhizome size of ginger. *Indian Journal of Horticulture* 68 (4): 449-452

Griscom, B. W., Adams, J., Ellis, P. W., Houghton, R. A., Lomax, G., Miteva, D. A., Schlesinger, W. H., Shoch, D., Siikamaki, J. V., Smith, P., Woodbury, P., Zganjar, C., Blackman, A., Campari, J., Conant, R. T., Delgado, C., Elias, P., Gopalakrishna, T., Hamsik, M. R., Herrero, M., Kiesecker, J., Landis, E., Laestadius, L., Leavitt, S. M., Minnemeyer, S., Polasky, S., Potapov, P., Putz, F. E., Sanderman, J., Silvius, M., Wollenberg, E. and Fargione, J. (2017). Natural climate solutions. PNAS 114, 11645–11650. https://doi.org/10.1073/pnas.1710465114.

Harne, Shailesh Sudhanva. (2013). Performance of Paddy crop under *Dendrocalamus strictus* based AFS in Chhattisgarh. Ph.D. Thesis Dept. of Forestry IGAU, Raipur.

Hazarika, U., Dutta, R. K. and Chakravorty, R. (2009). Morphology and yield attributing features of ginger and turmeric under natural shade of som (*Persea bombycina* Kost) plants. *Advances in Plant Sciences* 22(1): 115-117.

IPCC. (2019). Climate Change and Land. UNEP. https://www.ipcc.ch/site/assets/up loads/2019/08/4.-SPM_Approved_Microsite_FINAL.pdf.

Jasural, S. C., Mishra, V. K. and Verma. K. S. (1993). Intercropping ginger and turmeric with poplar (*Populus deltoides* 'G-3' Marsh.). *Agroforestry Systems* 22(2): 111-117.

Lundgren, B. and Raintree, J. B. (1983). Sustained agroforestry. In: International Council for Research in Agroforestry (ICRAF), 3, pp. 1–26.

Lyocks, S. W. J., Tanimu, J. and Dauji, L. Z. (2013). Growth and yield parameters of ginger as influenced by varying populations of maize intercrop. *Journal of Agricultural and Crop Research* Vol. 1(2), pp. 24-29

Mohamed, M. A., Mahfouz, S. A. and Yosef, A. (2014). Effect of spacing and varieties on growth yield and chemical constituents of turmeric plants. *International Journal of Medicinal & Aromatic Plants* 4(1): 34-40.

Nair, P. K. R. (1998). Directions in tropical agroforestry research: Past, present, and future. In: Nair, P. K. R., Latt, C. R. (Eds.), Directions in Tropical Agroforestry Research, *Forestry Sciences. Springer* Netherlands, Dordrecht, pp. 223–245. https://doi.org/ 10.1007/978-94-015-9008-2_10.

Naugraiya, M. N. (2003 to 2013). Annual Research Report of All India Coordinated Research Project on Agroforestry of ICAR New Delhi. Raipur centre Dept of Forestry IGAU, Raipur. Pp 100

Naugraiya, M. N. and Puri, S. (1997). *Bahupyogian Sampada Bans: Utpadan Avam Upyog*. Pub. Directorate of Research Services, IGAU, Raipur. pp. 120

Pandey, D. N. (2007). Multifunctional agroforestry systems in India. *Curr. Sci.* 92, 455–463.

Pansey V. G. and Sukhatme, P. V. (1961). Statistical Methods for Agricultural Workers. *Indian Council of Agricultural Research*. 328pp

Pratiwi, A. and Suzuki, A. (2019). Reducing agricultural income vulnerabilities through agroforestry training: evidence from a randomised field experiment in Indonesia. *Bull. Indones. Econ. Stud.* 55, 83–116. https://doi.org/10.1080/ 00074918.2018.1530726.

Quinion, A., Chirwa, P. W., Akinnifesi, F. K. and Ajayi, O. C. (2010). Do agroforestry technologies improve the livelihoods of the resource poor farmers? Evidence from Kasungu and Machinga districts of Malawi. *Agrofor. Syst*. 80, 457–465. https://doi. org/10.1007/s10457-010-9318-7.

Schroth, G. and Harvey, C. A. (2007). Biodiversity conservation in cocoa production landscapes: an overview. *Biodivers. Conserv.* 16, 2237–2244. https://doi.org/ 10.1007/s10531-007-9195-1.

Sileshi, G., Akinnifesi, F. K., Ajayi, O. C., Chakeredza, S., Kaonga, M. and Matakala, P. W. (2007). Contributions of agroforestry to ecosystem services in the miombo eco-region of eastern and southern Africa. *Afr. J. Environ. Sci. Technol.* 1, 68–80. https://doi. org/10.4314/ajest.v1i4.

Syampungani, S., Chirwa, P. W., Akinnifesi, F. K. and Ajayi, O. C. (2010). The potential of using agroforestry as a win-win solution to climate change mitigation and adaptation and meeting food security challenges in Southern Africa. Agric. J. 5, 80–88.

World Bank. (2020). Climate-Smart Agriculture Implementation Brief : A Summary of Insights and Upscaling Opportunities through the Africa Climate Business Plan. World Bank, Washington, DC.

Yadav, A. R., Nawale, R. N., Korake, G. N. and Khandekar, R. G. (2013). Effect of dates of planting and spacing on growth and yield characteristics of ginger (*Zingiber officinale*) var. IISR Mahima. *Journal of Spice & Aromatic Crops* 22(2): 209-214.

Zhenxian, Z., Xizhen, A. and Qui, Z. (2000). Studies on the diurnal changes of photosynthetic efficiency of ginger. *Acta Hort Sinica* 27: 107-1

Zomer, R. J., Neufeldt, H., Xu, J., Ahrends, A., Bossio, D., Trabucco, A., van Noordwijk, M. and Wang, M. (2016). Global tree cover and biomass carbon on agricultural land: the contribution of agroforestry to global and national carbon budgets. *Sci. Rep.* 6, 29987. https://doi.org/10.1038/srep29987.

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