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Research Paper

Effect of ginger based agroforestry system on soil properties in Mizoram North East India

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ABSTRACT: *Agroforestry systems are the land management practices viable both ecologically and economically than any other land management unit. Degradation in soil fertility has been caused through various monoculture practices. Intercropping and mixed cropping sustains soil fertility and productivity. A study was conducted in Kawnpui, Kolasib District, to evaluate the soil physiochemical parameters of ginger (ZingiberofficinaleRosc.) and rubber (Heveabrasiliensis) intercropping.The goal of the present study is to compare changes in each treatment, such as Rubber + Ginger (RG), Sole Ginger (SG), and Control (CTRL), at different stages of cropping, such as pre-cultivation (PC), flowering stage (FS), and post-harvest (PHV).The results showed that soil pH was acidic in all the soils. FS soil samples have higher soil moisture content, whereas PC and PHV soil samples have lower soil moisture content.Soil Organic Carbon (SOC) and Total Nitrogen (TN) values range from 2.79%-1.74% and 0.34%-0.18% respectively. Soil moisture content highly affect SOC and TN. SG and CTRL plots harbored higher amount of Available Phosphorus during Pre-cultivation and Flowering Stage. No significant changes were found in soil physical properties. It was also observed that soil physico-chemical properties were influenced by sloppy terrain.*
KEYWORDS: *Agroforestry, Intercropping, Soil fertility,Zingiberofficinale,Heveabrasiliensis*

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I. INTRODUCTION

Ginger (*Zingiberofficinale*Rosc) a member of Zingiberaceae family, is a perennial herbaceous monocotyledon, typically grown as an annual, and is known to human generations as a medicinal and spice crop. Ginger is one in all the foremost important cash crops in Mizoram, and is usually grown in Jhum land. Because Mizoram's agro-climatic conditions are favourable for ginger cultivation, cultivars do not use manures, fertilisers or pesticides. Its cultivation as a harvest within the state is known to have started in late 1970s. Thingpui, Thingria and Thinglaidum are the three major varieties of ginger grown in Mizoram of which Thinglaidum is the most popular. However, this variety of ginger does not seem to have any implication in the price fetched and hence, most of the farmers are unaware of the quality of the variety they grow.

The planting season of ginger in Mizoram starts during the month of April-May that coincides with onset of monsoon. The first two weeks of April is the best time for planting ginger. The stored rhizome of ginger for planting should be sorted with large, shiny; disease-free, spots, marks, bud or eye injury should be selected for planting. The seed rhizome can be planted whole or broken into parts, with each cutting bearing 2-4 sprouts. Ginger is one of the most suitable vegetables for intercropping in agroforestry systems in pre humid-sub humid and semi humid-semiarid regions from lowlands (%00mt) to medium elevation (500-1000mt)[1].

Extensive cultivation methods like heavy spading, earthing up, crop cultivation along with slope, slash and burn caused soil loss from the hill slope for cultivation of different crops. The hilly people cultivate ginger, turmeric, aroid and jhum rice along the slope land of the hill. They usually harvest the rhizome from soil by spade. Thus, soils become loose and soil erosion occurs in hilly areas that causes appreciable depletion in organic matter content resulting nutrient exhaustion in soil. This accelerates soil erosion and causes flash floods.

Agroforestry systems have enormous potential for improving the productivity and sustainability of agricultural lands or land resources, which have never been put into service due to so many factors, can be better used by adopting different agroforestry practices like inclusion of ginger cultivation in it for high remuneration and useful combination, if properly managed could increase the production potential sufficiently. Hence, such systems need to be made popular among farmers for sustainable livelihood.

II. MATERIALS AND METHOD

Study site: The study was conducted at Kawnpui, Mizoram where ginger (*Zingiberofficinale*Rosc.) and rubber (*Heveabrasiliensis)* are intercropped. Kawnpui is a village in Kolasib District of Mizoram. It is 10 km south of the district headquarters in Kolasib and 56 km north of the state capital in Aizawl.The study site is located between the latitudes of 24o05'13" N and the longitudes of 92o67'21" E.It is situated at an altitudinal range of 930 m (3050 ft) msl. The average temperature of the study area ranges from 11^{o}C to 34^{o}C. The annual rainfall varies from 2500 to 3000mm.

Soil sampling: Soil samples of three replicates at a depth of 0-15cm were collected at an interval of(i) Pre-cultivation (April/May); (ii) Flowering stage (Sept/Oct); and (iii) Post Harvest (Feb/Mar) within each treatment i.e., Rubber + Ginger (RG), Sole Ginger (SG) and Control (CTRL).Roots, stones, and other debris were removed, and the soil was hand sieved through a 2 mm mesh and divided into two parts.One component was air dried, while the other was stored in the deep freezer for later analysis.

Analysis of soil properties: Soil bulk density (BD) was determined by taking a known volume of soil and pressing a metal ring into it (intact core), then weighing it after drying [2]. The hydrometer method was used to determine the texture of the soil [3]. The textural classification of the United States Department of Agriculture (USDA) was used to determine the textural class of the soil.A pH analyzer was used to measure the pH of the soil in a soil-water suspension (1:2.5 soil-water ratios).The soil moisture content was determined using the gravimetric method (SMC).Soil organic carbon (SOC) and total nitrogen (TN) was determined by dry combustion in a CHNS/O Elemental Analyzer with auto sampler and TCD detector –Euro Vector, Model: EuroEA3000. For the analysis of soil exchangeable nutrients (Pavailand K) air dried soil samples were extracted in Mehlich-I solution (0.05 M HCl + 0.025 M H2SO4) and analyzed using the inductively coupled plasma spectrometer (iCAP6300 series, Thermo scientific).

Statistical analysis: The data obtained are presented as mean and standard error (SE). The soil physical properties were subjected to a one-way analysis of variance (ANOVA) and two-way analysis of variance (ANOVA) was used for soil chemical properties. Significant differences among soil variables were determined and the least significant difference (LSD) was calculated to determine significant differences between means at $p \leq 0.05$. The open source OPSTAT was used for all statistical analysis (free Online Agriculture Data Analysis Tool developed by O.P. Sheoran, Computer Programmer at CCS HAU, Hisar, India).

III. RESULTS AND DISCUSSION

The physical properties of the soils studied were found to be significantly different between the treatment ($p<0.05$), as shown in Table 1. Bulk density (BD) values ranged from 0.98g/cm^3-1.36g/cm^3 with maximum density in intercropped ginger (R+G) followed by SG>Control. Due to extensive root growth and dense root distribution, the control site may have the lowest bulk density when compared to other land uses.The loss of soil organic matter (SOM) caused by the conversion of natural forests to plantations is thought to have resulted in increased bulk density in plantation soils. In Indonesia, higher bulk densities were previously recorded under intense rubber plantation [4] [5].All of the treatments had sandy loam soil texture, with sand, silt, and clay values ranging from 59.8% to 60.5%, 21.2% to 29.6%, and 12.3% to 19.8%, respectively. In different Mizoram land use systems, the percentages of sand, silt, and clay were 62–72 percent, 17–21 percent, and 11–17 percent, respectively [6].

The pH of the soil differed significantly between treatments (T) and seasons (S) (p0.05), but not between their interactions (Table 2). Soil pH was acidic in all the treatments ranging from 4.9 to 6.05 in PC, 5.16 to 6.07 in FS and 5.26 to 6.19 in PHV. Higher soil pH in the surface layer of SG and Control as compared to R+G is well attributed to the release of cations as a result of the traditional slash and burn technique in the SG land use system. Burning enhances the release of nutrients in the soil and thus increasing the soil pH [7]. The higher values of pH in the cultivated lands may also result from the conversion of natural forest into cultivation, which leads to an increment in pH at the surface soil layers [8]. The present values of pH are in accordance with other findings from the study area, indicating strongly acidic natures of reaction in these soils [9] [10] [11].Similarly, the moisture content was also higher in Control soils. High organic matter content and dense vegetation in the Control site probably conserve the soil moisture. Forest conversion to plantations has been documented to result in low moisture availability due to losses in top soil and vegetation in Indonesia, Peru, and Southern Cameroon [12] [13].

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Table 1 Effect of different treatments (Rubber+Ginger=R+G, Sole Ginger=SG, and Barren land/control=BL) on soil physical properties.

Treatments	Soil Physical properties					Textural class
	BD (g/cm^3)	Porosity (%)	Clay (%)	Silt (%)	Sand (%)	
R+G	1.36±0.02	61.13±3.00	17.83±0.96	28.77±0.79	60.31±4.18	Sandy loam
SG	1.27±0.06	79.14±0.54	12.36±1.32	29.60±2.14	60.52±3.04	Sandy loam
CONTROL	0.98±0.06	56.17±2.99	19.82±1.59	21.26±3.24	59.82±1.45	Sandy loam
$LSD_{0.05}$						
T=	0.202	8.717	4.658	NS	NS	

Note:T= treatments, $LSD_{0.05}$: $p<0.05$, NS=Non-significant.

Different treatments (T), seasons (S), and their interactions (TxS) all had a significant impact on soil organic carbon ($p<0.05$). The highest value during the flowering stage (FS) was reported from SG followed by R+G and the least in Control with values of 2.79%, 2.69% and 2.43%, respectively. However, during PHV Soil Organic Carbon is highest in Control treatments (2.27%) (Table 2).The high SOC in the Control site can be attributed to a large quantity of litter decomposition and soil nitrogen availability. Higher organic matter and nutrient inputs through litter fall have been reported to have a favourable impact on soil organic matter [14] [15]. In tropical ecosystems, SOC availability is a good indicator of soil nutrient supply [16].

The value of TN was found highest during the FS Stage of the Control site (0.34%) followed by SG (0.28%)>R+G (0.27%). Total Nitrogen was significantly affected by different treatments (T) and stages (S) but does not show significant affect between their interactions (TxS). Available forms of nitrogen play an important role in N transformation.

P_{avail} concentrations in soil were significantly affected by different stages (S) and their interactions (TxS) ($p<0.05$). The highest value was recorded at the Control site during the flowering stage (FS) (16.77 mg g^{-1}) and the least in R+G (7.47mg g^{-1}) (Table 2). The higher Pavail content in the Control site could be attributable to the quick recycling of nutrients through litter breakdown and mineralization.Less use of FYM, no addition of chemical fertilizers, higher leaching loss from litter residues may also have resulted in low P content in the soils of rubber plantation [17] [18]. In addition, SOM influences P_{avail}through anion replacement of H2PO4 from adsorption sites and the formation of organophosphate complexes which are readily taken up by plants as reported in different studies [19] [20] [21]. Our values of P_{avail} falls within the range of low to medium among the various land use systems and soil depths as per the range of [22].

Exchangeable K showed no significant affect between the Season (S) and their interaction (TxS), while it varied significantly between treatments (T) ($p<0.05$). The greater exchangeable K values in both R+G and CTRL could be attributed to the establishment and presence of herbaceous vegetation and canopy cover that shielded the soil from direct rainfall and reduced nutrient loss through runoff and erosion (Table 2).

Table 2.Effect of different treatments ((Rubber+Ginger=R+G, Sole Ginger=SG, and Barren land/control=BL)and different stages/seasons (Pre Cultivation-PC, Flowering Stage-FS, Post-Harvest-PHV) on soil chemical properties.

Treatment with season		Soil Chemical Properties					
R+G		SMC (%)	pH	Soil Organic Carbon (%)	Total Nitrogen (%)	P_{avail}	K
	PC	27.27±1.84	4.9±0.18	1.88±0.06	0.19±0.008	7.56±0.33	0.22±0.02
	FS	17.37±0.49	5.23±0.04	2.69±0.09	0.27±0.005	7.47±3.51	0.23±0.02
	PHV	10.18±0.81	5.26±0.11	1.79±0.07	0.18±0.02	7.98±0.11	0.21±0.01
SG							
	PC	17.98±2.94	5.05±0.06	1.74±0.08	0.22±0.009	13.26±0.56	0.16±0.01
	FS	34.88±2.75	5.16±0.08	2.79±0.04	0.28±0.01	10.38±0.49	0.14±0.01

	PHV	12.19±0.40	5.36±0.07	1.83±0.05	0.19±0.01	8.88±0.08	0.09±0.01
CONTROL							
	PC	19.58±0.91	4.05±0.15	2.53±0.07	0.28±0.006	13.87±0.54	0.24±0.01
	FS	31.08±0.54	5.07±0.10	2.43±0.11	0.34±0.02	16.77±0.04	0.24±0.018
	PHV	17.37±0.49	4.19±0.05	2.27±0.04	0.27±0.02	14.98±0.02	0.26±0.02
$LSD_{0.05}$							
	T	2.707	0.186	0.132	0.027	NS	0.032
	S	2.707	0.186	0.132	0.024	2.556	NS
	T x S	4.688	NS	0.229	NS	4.427	NS

Note: T= Treatments; S= stages/season; T x S= Treatments x stages/season $LSD_{0.05}$: $p<0.05$, NS=Non-significant.

IV. CONCLUSION

The present study concluded that the clearing of native forests for cultivation led to negative feedbacks on soil. From our result, the effect of jhum land and/or monoculture clearly indicates the decline of soil fertility. To regain the soil fertility, at least lengthening of the fallow period should be considered or either the fertility of the soil should be enhanced with suitable and appropriate fertilizers to keep the productivity of the land. Thus, a diversified land use system i.e. agroforestry will increase the soil fertility status, increased crop yield and forest wealth; improve the biodiversity and environment degradation. However, careful consideration should be given in selecting the right combination of soil-enriching nitrogen-fixing tree species, as well as remunerative pulses/legumes with adequate surface-covering capability, to ensure long-term land productivity. Therefore, it can be concluded that for reclamation and restoration of soil health in degraded jhum lands, especially in Northeastern Hilly Regions of India, adoption of agroforestry system can be a viable option, provided selection of proper combination of crops and trees are done which should be soil enriching and complimentary to each other. Agroforestry system also helps in providing an alternate livelihood strategy to many people.

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