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Management Effect on Crop Yield in a *Gmelina arborea* Based Agroforestry System in Humid Tropic of North East India

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ABSTRACT

The effects of mulches on tree growth and yield of ginger, turmeric and maize in a Gmelina arborea based agroforestry system were studied during 2003-2005 in the humid tropic of India. The Mean Annual Increment (MAI) in height, collar diameter, crown diameter and biomass of the tree was higher in mulched treatments compared to control (without mulch). Amongst treatments, plots with subabul leaves mulch showed better growth of tree (MAI) compared to other treatments (rice straw and weeds mulch). Plots having higher mulch doses (10 t/ha) also had more benefits to the trees growth compared to other treatments (8 and 6 t/ha). The crop yield from mulch application (ginger, turmeric and maize intercropping) was low in the first year, which significantly (P d" 0.05) increased after two years. In all the crops, the crop yield was higher under mulch treatments compared to control (without mulch). The study depicts that mulching can be an effective tool to improve crop productivity under Gmelina arborea based agroforestry system in humid tropic of north east India

INTRODUCTION

Agroforestry, growing of multipurpose trees along with agricultural crops, has been an important practice for optimum productivity of land and crop. Various management practices that are adopted in agroforestry can favour crop yield through minimizing competition for growth resources among the tree-crop components. *Gmelina arborea* (Roxb) a multipurpose and fast growing tree is quite common in traditional agroforestry systems in Mizoram.

This species is popular because it provides fuel wood and wood for a variety of purposes and has a wider ecological amplitude which makes it a useful species for reforestation of difficult sites (Parrotta and Roshetko, 1997). A diverse variety of crops are found to be grown under this tree with different cultural operations. However, very little is known on the beneficial effects of different cultural practices on the crop yield. The present study aimed at evaluating some available organic mulch (rice straw, weeds, subabul leaves) for improving crops productivity under *Gmelina arborea* based agroforestry system involving three intercrops viz. *Zingiber officinales* Roscue, *Curcuma longa* L., *Zea mays* L. in the hilly terrains of the state.

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MATERIALS AND METHODS

Study area

A field experiment was conducted during 2003 to 2005 at Tanhril Campus of Mizoram University located at 15 km on the south-western part of Aizawl city, the capital of Mizoram. The area lies between 23Ú422 to 23Ú462 N latitude and 92Ú382 to 92Ú422 E longitude and has a humid tropical climate characterized by short and dry winter, and long summer. The temperature variation is small throughout the year. The mean minimum and maximum summer and winter temperature recorded during the study period were 20Ú, 30ÚC and 8Ú, 18ÚC respectively. The mean annual rainfall is 2500 ± 105 mm

(based on the data for the last five years). The average slope of the study site is about 25 %. The soil of the study site is sandy loam, red brown in colour and acidic (pH 5.03 - 5.40) in nature.

Treatments

The experiment consisted of 10 treatments laid in randomized block design involving three mulch types (rice straw, weeds, subabul (*leucaena*) leaves) and three mulch quantity (6, 8 and 10t/ha) and a control (without mulch) replicated thrice, thus involving a total of 30 sub-plots. *Gmelina arborea* was planted as tree component. The intercrops tried for evaluation were local variety of ginger, turmeric and maize. Mulches were applied immediately after sowing of the crop. Three weeding were carried out during a cropping period in order to prevent the growth of weeds and improve crop growth. Each sub plot had 56 trees (tree spacing 2.5 m x 2.5 m) with plot size 306.25 m^2.

For planting trees, pits of size 1 ft x 1 ft were dug and filled with sand, soil and farmyard manure in the ratio of 1:2:1 and three months old seedlings of *Gmelina arborea* (initial average height 22.8 cm and initial average collar diameter 0.6 cm) planted in the dig in the third week of May 2003 in the prepared pit at 2.5 m x 2.5 m spacing. The detailed cultural practices followed for each intercrop are mentioned in Table 1.

Ten (10) tree saplings from different treatment per mulch type were measured each year for the Mean Annual increment (MAI) of height, collar diameter and crown diameter. Two (2) tree seedlings were also harvested from each treatment for biomass production. The data were subjected to two way (ANOVA) analysis of variance to see the effect of management practices on tree growth and crop yield.

RESULTS AND DISCUSSION

Effect of mulch management on tree growth

The rate of growth of *Gmelina arborea* during the initial two years was somewhat slower, however, it was significantly (P d" 0.01) higher in the third year. The Mean Annual Increment (height, collar diameter, crown diameter and biomass) of tree growth was always higher in the mulched treatments compared to control (without mulch). This was true for all the intercroped plots (Table 2). Better growth under mulch treatments may be attributed to increased availability of nutrients owing to increased moisture retention and to improvement of soil conditions through mulching, which helped the soil water retention capacity and increased soil water supply (Singh *et al.*, 1998). Among the treatments, tree with subabul leaves mulch caused better growth of tree (MAI) compared to other treatments (rice straw and weeds mulch). This could have been due to quick decomposition of subabul leaves releasing/adding some nutrients to the soil with the mulch application causing better growth performance of the tree in the system. Plots having higher mulch doses (10 t/ha)

Table 1. Management practices used for different crops

Crop	**Ginger**	**Turmeric**	**Maize**
Sowing	April, 2003 April, 2004 April, 2005	April, 2003 April, 2004 April, 2005	April, 2003 April, 2004 April, 2005
Spacing (cm)			
Row to row	20	25	40
Plant to plant	30	35	60
Mulch types	Rice straw Weeds Subabul leaves	Rice straw Weeds Subabul leaves	Rice straw Weeds Weeds
Mulch Quantity (t/ha)	6, 8 ,10 6, 8 ,10 6, 8 ,10	6, 8 ,10 6, 8 ,10 6, 8 ,10	6, 8 ,10 6, 8 ,10 6, 8 ,10
Time of application	Just after sowing	Just after sowing	Just after sowing
Harvesting	October, 2003 October, 2004 October, 2005	October, 2003 October, 2004 October, 2005	September, 2003 September, 2004 September, 2005

Table 2. Mean growth annual increment of *Gmelina arborea* under different treatments

	Height (cm)			Collar diameter (cm)			Crown diameter (m)			Biomass (g/plant)		
	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
Ginger plot												
Mulch types												
Control	42.27	64.03	114.11	1.47	1.89	3.10	1.12	1.25	1.37	8.02	10.82	15.38
Rice straw	47.07	72.67	119.78	1.76	2.21	3.17	1.23	1.37	1.44	9.68	12.86	21.35
Weeds	44.27	68.67	116.22	1.65	2.01	3.13	1.21	1.34	1.42	9.42	12.80	21.02
Subabul leaves	49.34	81.57	125.38	1.90	2.32	3.22	1.29	1.53	1.61	10.08	13.11	21.69
CD at 5 %	7.95	3.69	3.64	0.49	0.45	0.09	0.19	0.10	0.09	2.04	2.06	6.32
Mulch quantity												
Control	42.26	64.03	114.12	1.46	1.87	3.08	1.12	1.24	1.37	8.02	10.83	15.38
6 t/ha	45.32	70.26	119.45	1.67	2.09	3.16	1.22	1.34	1.43	9.43	12.82	21.02
8 t/ha	48.62	74.59	120.26	1.77	2.23	3.19	1.25	1.38	1.46	9.74	12.89	21.37
10 t/ha	49.25	79.57	123.89	1.86	2.31	3.22	1.27	1.52	1.59	10.07	13.09	21.68
CD at 5 %	7.98	4.65	4.62	0.42	0.46	0.21	0.17	0.11	0.07	2.03	2.07	6.32
Turmeric plot												
Mulch types												
Control	42.26	64.04	114.13	1.47	1.88	3.09	1.11	1.25	1.36	8.03	10.81	15.37
Rice straw	47.15	74.09	119.97	1.77	2.23	3.19	1.24	1.37	1.46	9.69	12.88	21.34
Weeds	44.32	69.58	117.09	1.65	2.02	3.14	1.22	1.36	1.43	9.44	12.82	21.03
Subabul leaves	49.89	82.41	126.53	1.91	2.35	3.24	1.31	1.54	1.62	10.11	13.13	21.69
CD at 5 %	7.67	4.75	4.77	0.46	0.48	0.17	0.22	0.13	0.09	1.99	2.05	6.33
Mulch quantity												
Control	42.28	64.05	114.11	1.48	1.87	3.08	1.12	1.24	1.35	8.01	10.82	15.37
6 t/ha	45.35	69.62	120.15	1.67	2.10	3.17	1.23	1.34	1.44	9.44	12.83	21.02
8 t/ha	49.02	76.13	121.39	1.78	2.24	3.21	1.26	1.39	1.48	9.76	12.91	21.38
10 t/ha	50.96	80.25	125.21	1.88	2.35	3.24	1.29	1.53	1.61	10.09	13.10	21.69
CD at 5 %	8.73	4.72	4.75	0.42	0.49	0.18	0.15	0.12	0.11	1.97	2.04	6.34
Maize plot												
Mulch types												
Control	42.25	63.73	115.68	1.19	1.86	3.09	1.12	1.23	1.35	8.01	10.82	15.36
Rice straw	49.86	79.96	124.63	1.78	2.24	3.20	1.25	1.37	1.48	9.71	12.89	21.34
Weeds	45.87	71.52	119.54	1.67	2.03	3.14	1.23	1.38	1.44	9.46	12.83	21.04
Subabul leaves	51.63	84.32	128.52	1.93	2.37	3.25	1.32	1.56	1.64	10.13	13.15	21.71
CD at 5 %	9.42	6.05	6.01	0.75	0.53	0.17	0.18	0.18	0.10	2.01	2.09	6.37
Mulch quantity												
Control	41.09	62.59	115.63	1.18	1.87	3.10	1.11	1.23	1.34	8.03	10.82	15.35
6 t/ha	46.05	73.12	121.23	1.68	2.11	3.18	1.24	1.35	1.46	9.47	12.85	21.03
8 t/ha	50.12	77.63	123.52	1.79	2.24	3.23	1.27	1.41	1.51	9.77	12.93	21.39
10 t/ha	51.96	82.13	127.09	1.89	2.37	3.25	1.32	1.56	1.68	10.13	13.14	21.70
CD at 5 %	10.91	7.11	6.05	0.72	0.52	0.17	0.20	0.14	0.14	1.88	2.07	6.38

Table 3. Analysis of variance (ANOVA, 2-way, fixed effect model) on mean annual increment of *G. arborea* due to different treatments.

Treatments	Height (cm)			Collar diameter (cm)			Crown diameter (m)			Biomass (g/plant)		
	Ginger plot											
	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
Mulch types	20.25926**	29.09677**	24.77354**	0.833333	1.333333	0.277778	0.833333	0.606061	0.277778	5.581395**	4.890476**	3.595122**
Replication	0.25490	2.4355	0.38413	0.214286	1.300000	0.125000	0.125000	0.363636	1.041667	0.069767	7.328571*	0.98780
Mulch types x Rep	0.71678	2.8226*	0.36720	0.976190	0.633333	0.069444	0.958333	0.242424	0.652778	0.720930	0.433333	0.15854
Mulch doses	19.25143**	10.13406**	20.04040**	3.033333*	5.454545**	4.444445**	1.481481	2.185185	1.037037	6.700000**	7.25000**	3.863374**
Replication	0.43429	1.0146	0.78788	0.300000	0.818182	1.333333	0.333333	0.777778	0.666667	0.175000	10.68750*	0.70370
Mulch doses x Rep	0.38857	1.5012	0.55556	2.033333	1.181818	0.444444	0.481481	0.629630	1.259259	0.775000	0.93750	0.22634
	Turmeric plot											
Mulch types	28.31496**	18.15421**	30.94555**	1.638889	3.151515*	1.388889	3.466667*	1.733333	1.098039	7.114035**	6.621469**	3.973593**
Replication	0.29134	0.8692	0.37000	0.333333	1.727273	0.055556	0.400000	1.200000	1.470588	0.315789	8.406779	0.94805
Mulch types x Rep	0.73228	2.8879*	0.33889	0.888889	1.2424.24	0.555 56	0.666667	0.133333	1.392157	0.982456	0.519774	0.25541
Mulch doses	47.43262**	195.6626**	38.33151**	2.166667	4.972222**	2.098039	2.272727	1.787879	0.833333	7.905797**	7.186440**	48.11594**
Replication	0.13830	0.5904	0.60656	1.500000	2.083333	0.176471	0.636364	0.272727	1.500000	0.282609	4.389831*	1.17391
Mulch doses x Rep	1.18794	3.0964*	1.25501	1.166667	0.38889	0.098039	0.636364	0.878788	1.404762	0.688406	0.389830	0.24638
	Maize plot											
Mulch types	97.12308**	213.9454**	70.70163**	2.333333	5.333333**	2.098039	3.851852*	4.444445*	2.311111	10.24762**	7.040936**	49.24876**
Replication	0.93846	0.7459	0.04895	0.333333	0.307692	0.176471	1.777778	0.777778	0.866667	0.25714	5.736842*	1.00000
Mulch types x Rep	1.24615	1.2486	0.58974	0.666667	0.717949	0.98039	0.740741	0.777778	1.044444	0.90476	0.356725	0.44279
Mulch doses	90.62745**	160.0296**	55.87387**	1.944444	6.393939**	3.076923*	6.619048*	3.851852*	2.888889	8.966666**	8.104167**	49.42723**
Replication	0.57353	0.0081	0.8108	2.666667	1.909091	0.076923	2.714286	0.444444	1.750000	0.775000	3.578125*	2.38028
Mulch doses x Rep	0.96569	0.8038	1.44144	2.444444	1.303030	0.384615	1.190476	0.740741	0.972222	0.741667	0.432292	0.42723

* P< 0.05, **P < 0.01

Table 4. Effect of different treatments on crop yield of intercrop

Treatments	Ginger Yield (t/ha)			Turmeric Yield (t/ha)			Maize Yield (t/ha)		
	2003	2004	2005	2003	2004	2005	2003	2004	2005
Mulch types									
Control	5.20	5.18	5.15	5.19	5.17	5.12	3.21	3.19	3.15
Rice straw	6.88	7.95	8.53	7.06	7.95	8.47	5.65	5.92	6.27
Weeds	5.59	6.57	7.70	5.68	6.57	7.69	3.52	4.36	5.96
Subabul leaves	7.36	8.48	9.17	7.29	8.44	9.04	5.98	6.54	7.12
CD at 5 %	2.10	1.96	1.99	2.00	2.15	2.56	2.01	2.12	2.34
Mulch quantity									
Control	5.22	5.19	5.12	5.18	5.16	5.12	3.19	3.18	3.15
6 t/ha	6.40	7.31	8.11	6.15	7.14	7.79	4.42	5.09	5.75
8 t/ha	6.81	7.80	8.72	6.70	7.57	8.53	4.53	5.28	6.49
10 t/ha	7.32	8.35	9.26	7.18	8.25	9.08	5.85	6.32	7.15
CD at 5 %	6.46	3.81	2.79	3.29	3.62	2.64	3.12	3.25	2.02
	Number of fingers			Number of fingers			Number of cobs per plant		
Mulch types									
Control	6.14	6.00	5.94	5.93	5.79	5.73	4.43	4.41	4.40
Rice straw	6.45	6.56	6.64	6.29	6.38	6.49	5.67	5.85	5.96
Weeds	6.25	6.36	6.47	6.11	6.20	6.31	6.73	6.84	6.92
Subabul leaves	6.56	6.65	6.72	6.42	6.51	6.58	7.81	7.95	8.03
CD at 5 %	0.54	0.48	0.94	0.58	0.55	0.82	0.59	0.61	0.63
Mulch quantity									
Control	6.13	6.00	5.93	5.93	5.80	5.73	4.42	4.42	4.41
6 t/ha	6.29	6.41	6.49	6.13	6.22	6.33	5.53	5.62	5.7
8 t/ha	6.42	6.51	6.60	6.29	6.36	6.47	6.84	6.92	6.99
10 t/ha	6.53	6.64	6.70	6.41	6.51	6.58	7.79	7.93	8.01
CD at 5 %	0.65	0.57	0.88	0.65	0.60	0.84	0.60	0.59	0.64
	Finger size (cm)			Finger size (cm)			Cobs length(cm)		
Mulch types									
Control	7.50x6.31	7.47x6.59	6.80x5.71	5.42x5.27	5.41x5.25	4.59x4.13	15.70	15.68	15.67
Rice straw	8.21x8.12	8.21x8.13	8.23x8.14	6.23x6.12	6.27x6.14	6.65x6.28	16.21	16.27	16.
Weeds	8.18x8.09	8.19x8.10	8.21x8.10	6.17x6.11	6.18x6.12	6.22x6.16	15.97	16.09	16.18
Subabul leaves	8.23x8.15	8.25x8.16	8.27x8.18	6.28x6.19	6.30x6.23	6.71x6.30	16.45	16.56	16.72
Mulch quantity									
Control	7.50x6.31	7.47x6.59	6.80x5.71	5.42x5.27	5.41x5.25	4.59x4.13	15.70	15.67	15.66
6 t/ha	8.01x7.82	8.19x6.82	8.21x7.83	6.23x6.11	6.27x6.14	6.65x6.26	16.18	16.25	16.31
8 t/ha	8.18x7.89	8.20x7.89	8.22x7.91	6.26x6.13	6.28x6.17	6.35x6.20	16.23	16.28	16.34
10 t/ha	8.21x7.93	8.24x7.95	8.27x7.99	6.38x6.18	6.39x6.23	6.52x6.31	16.42	16.54	16.71

Table 5. Analysis of variance (ANOVA, 2-way, fixed effect model) on crop yield due to different treatments

Treatments	Ginger			Turmeric			Maize		
	2003	2004	2005	2003	2004	2005	2003	2004	2005
	Yield			Yield			Yield		
Mulch types	15.31818**	20.90805**	74.04444**	16.45000**	23.32051**	72.24445**	10.49462**	23.51613**	52.84848**
Replication	5.31818*	0.93103	2.86667	5.00000*	0.73077	2.40000	0.30645	0.22581	2.18182
Mulch types x Rep	1.50000	0.70115	1.44444	1.80000	1.08974	1.77778	0.41398	1.00000	0.48485
Mulch doses	12.94118**	33.83333**	90.13333**	3.919753*	25.00000**	32.91667**	7.918239**	34.24561**	72.86275**
Replication	2.82353	1.55556	0.86667	0.351852	0.84000	0.40625	0.924528	0.47368	1.82353
Mulch doses x Rep.	3.05882*	1.55556	1.66667	1.216049	1.16000	1.32292	0.672956	0.82456	1.03922
	Number of finger			Number of finger			Number of cob		
Mulch types	0.740741	1.120000	3.314815*	0.740741	3.166667*	4.137255**	28.90667**	24.54167**	17.73809**
Replication	0.166667	0.640000	2.055556	0.888889	1.722222	0.411765	0.76000	0.21875	0.09524
Mulch types x Rep.	0.907407	0.640000	0.648148	0.518519	1.722222	0.725490	0.54667	0.76042	0.57143
Mulch doses	0.819444	1.106667	2.666667	0.866667	2.729167	3.196970*	26.95238**	26.13333**	25.58333**
Replication	3.041667	0.360000	0.280000	0.050000	1.000000	0.136364	0.57143	0.13333	0.11111
Mulch doses x Rep.	0.486111	0.786667	0.546667	0.516667	1.666667	0.560606	0.23810	0.93333	0.77778

* P < 0.05, **P < 0.01

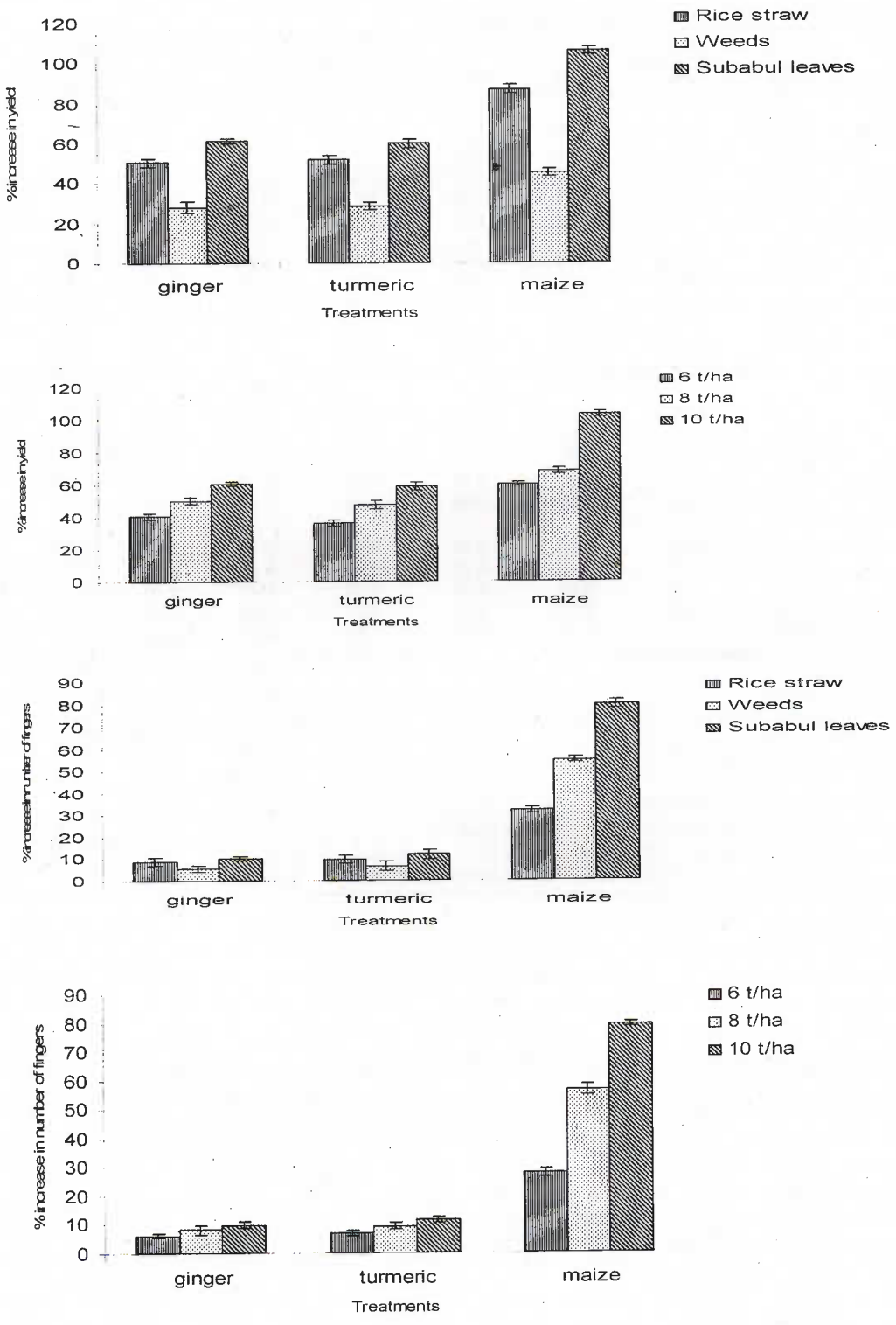

Fig. 1. Percent increase in yield of attributes intercrops by mulch management over control (The data is the pooled mean of three years)

also had more benefits to the trees growth compared to other treatments (8 and 6 t/ha). These results indicated that mulches have beneficial effects on growth performance of tree. Similar findings are also reported by Moitra *et al.* (1994); Singh *et al.,* (2002) and Sonia Aggarwal *et al.,* (2003). The MAI of tree growth in plots was in the order of maize > turmeric > ginger and MAI of tree growth in tree-crop combination was always comparatively better than that of control (pure tree). A relatively higher growth rate under species mixture could also be due to the possibility of their beneficial compatibility, interaction and greater biological efficiency of crops grown in association (Moitra *et al.,* 2000).

Effect of mulch management on crop growth and yield

Tree growing with mulch treatment significantly (P d" 0.05) produced higher crop yield of intercrops as compared to trees growing in control (pure tree) during 2004 and 2005. The crop yields of intercrop (ginger, turmeric and maize) under these treatment were statistically significant ((P d" 0.01) during the study period (Table 3). Tree having subabul leaves mulch gave significantly (P d" 0.05) higher yield over rice straw and weeds mulch. Similarly, tree growing with higher mulch doses (10 t/ha) also gave better yield than those of medium (8 t/ha) and low (6 t/ha) mulch dose. The findings are in conformity with Sahoo *et al.,* (2005). The crop yield was significantly (P<0.01) higher in mulched plots compared to control (Table 5). The higher in crop yield due to spread of mulch could be attributable to the beneficial influence of mulches on soil properties particularly the organic matter content favouring plant growth as also argued by Escober *et al.,* (2002). The mulched plots have produced better finger size and more finger number in respect of tuberous crops and better cob length and more number of cobs per plant in maize compared to the un-mulched plots (Table 3) resulting into higher crop yield. The percent increase of yield due to mulch application has ranged from 28 to 61.12 % for ginger, 28.68 to 59.88 % for turmeric and 44.96 to 105.66 % for maize during three years (Fig. 1). Singh *et al.,* (2002) found an increase in crop yield over 60% due to spread of mulch in the whole plot compared to un-mulch/ control plot.

The study suggests that the application of mulch material is an important tool to get successful crop yield in the humid tropic of Mizoram. Besides, management of mulches in agroforestry system can significantly increase MAI (height, collar diameter, crown diameter and biomass) of tree growth.

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