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Preface

We would like to present, with great pleasure, the inaugural volume-5, Issue-7, July 2019, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development,* and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Environmental & Agriculture as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Environmental & Agriculture community, addressing researchers and practitioners in below areas

Environmental Research:

Environmental science and regulation, Ecotoxicology, Environmental health issues, Atmosphere and climate, Terrestric ecosystems, Aquatic ecosystems, Energy and environment, Marine research, Biodiversity, Pharmaceuticals in the environment, Genetically modified organisms, Biotechnology, Risk assessment, Environment society, Agricultural engineering, Animal science, Agronomy, including plant science, theoretical production ecology, horticulture, plant, breeding, plant fertilization, soil science and all field related to Environmental Research.

Agriculture Research:

Agriculture, Biological engineering, including genetic engineering, microbiology, Environmental impacts of agriculture, forestry, Food science, Husbandry, Irrigation and water management, Land use, Waste management and all fields related to Agriculture.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.

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Fields of Interests

Agricultural Sciences	
Soil Science	Plant Science
Animal Science	Agricultural Economics
Agricultural Chemistry	Basic biology concepts
Sustainable Natural Resource Utilisation	Management of the Environment
Agricultural Management Practices	Agricultural Technology
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Crop Production	
Cereals or Basic Grains: Oats, Wheat, Barley, Rye, Triticale, Corn, Sorghum, Millet, Quinoa and Amaranth	Oilseeds: Canola, Rapeseed, Flax, Sunflowers, Corn and Hempseed
Pulse Crops: Peas (all types), field beans, faba beans, lentils, soybeans, peanuts and chickpeas.	Hay and Silage (Forage crop) Production
Vegetable crops or Olericulture: Crops utilized fresh or whole (wholefood crop, no or limited processing, i.e., fresh cut salad); (Lettuce, Cabbage, Carrots, Potatoes, Tomatoes, Herbs, etc.)	Tree Fruit crops: apples, oranges, stone fruit (i.e., peaches, plums, cherries)
Tree Nut crops: Hazlenuts. walnuts, almonds, cashews, pecans	Berry crops: strawberries, blueberries, raspberries
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Dairy Sheep	Water Buffalo
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Effect of Cutting Frequency on Forage Growth and Yield in Elephant Grass in the Southern Rainforest of Nigeria

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Abstract— *Pot experiment was conducted at Ndele, Rivers state, southern rainforest of Nigeria to determine the effect of cutting frequency on forage growth and yield in elephant grass, Pennisetum purpureum. The study was a single factor experiment of cutting intervals (5 days; 10 days; 15 days and 20 days) replicated 3 times, arranged in a randomized complete block design using replicates as blocks. Data collected were plant height, number of leaves, leaf area, forage fresh weight and dry weight. Results showed that cutting frequency significantly influenced plant height or growth rate, leaf area and number of leaves. Leaf area and number of leaves reduced with higher frequency or shorter interval of cutting. Grasses cut at 20 days interval recorded the greatest number of leaves and highest leaf area. Cutting frequency markedly affected forage fresh weight and dry matter production (dry weight) and there was noticeable forage yield reduction in grasses cut at 5 days interval (higher frequency) with progressive cuttings as against those cut at 20 days interval (low frequency). Grasses cut at 20 days interval recorded the highest growth and leaf production, the most forage fresh weight and dry matter yield. 20 days interval is hereby recommended for cutting Pennistum purpureum cutting or gracing in southern rainforest of Nigeria.*

Keywords*— *Cutting interval, forage production, Pennisetum purpureum, southern rainforest, Nigeria.

I. INTRODUCTION

Elephant grass (*Pennisetum purpureum* Schumach) is a popular, valuable and high yielding tropical grass that can survive in dry and wet growing conditions or in smallholder or large-scale production system (Rusdy, 2016). Though it derived its name from been the forage used to feed elephants in Africa (Cook *et al*., 2005), the high productivity of elephant grass has made it suitable for livestock grazing and also a major source of herbage in zero grazing, fed in stalls and the making of silage and hay (FAO, 2015).

In addition to factors such as grass species, soil quality and growing season, cutting frequency has been shown to influence forage characteristics like forage yield, chemical composition and nutritive value of herbage (Njarui and Wandera, 2004; Enoh et al., 2005). According to Ansa and Iyagba (1999), cutting frequency affects forage production, re-growth potential and species survival among other factors; the plants gets weak and thin out probably as a result of reduction in carbohydrate storage levels.

Cutting frequency studies have been carried out in most grass species including *Pennistum* spp in different agro-ecological zones but, literature is scarce about such studies in the southern rainforest of Nigeria

The objective of this study is therefore to determine the effects of cutting frequency on forage growth and yield of elephant grass in the southern rainforest zone of Nigeria.

II. MATERIALS AND METHODS

The study was carried out at the Teaching and research farm of the department of Agriculture, Ignatius Ajuru University of Education,(Ndele Campus) Port Harcourt, Rivers State, Southern Rain Forest zone of Nigeria, characterized with about 10 months rain over 100mm and a solar radiation of 120-160 kcal/cum per annum that favors crop performance (Ansa 2015 and 2016)

2.1 Materials

Materials used included polybags, sandy loam soil, shovel, wheelbarrow, hand gloves, meter rule, watering can and weighing scale.

The propagule used for planting was 20 cm long stems of elephant grass with 3 nodes.

2.2 Methods

2.2.1 Experimental design

The cutting frequencies or interval of 5days, 10days, 15days and 20days were the treatments; replicated 3 times and arranged in a randomized complete block design.

2.2.2 Agronomic Practice and layout

The poly bags with height 25 cm were perforated and filled with sandy loam soil to a soil depth of 23 cm and arranged such that same treatment replicate don't occur in same column or blocks and placed in open field. Two stem cuttings were inserted directly into the perforated poly bags and later thinned to one stand of elephant grass per pot after the propagule established. N.P.K. 20:10:10 fertilizer was applied at the rate of 20 grams to all treatments units or pots. The established stands were rain fed and weeds were controlled by direct hand removal.

2.2.3 Data collection and Analysis

All measurement of parameters was taken just before clipping of the prescribed cutting intervals. Parameters measurement were plant height, number of leaves, number of tillers, leaf area, herbage fresh weight and dry weight. Values of measurement collected were subjected to analysis of variance of the randomized complete block design and means were separated by Duncan Multiple Rang Test (DMRT) using SPSS 18th statistical software.

III. RESULTS

3.1 Plant Height

The height elongation of *Pennisetum* grass to cutting frequency is shown in Table 1.Grasses cut at 5 days interval or highest frequency had progressively plant height reduction with shortest height, while those clipped at 20 days interval or less frequent, produced the tallest grasses with highest growth rate. Those plant cut at 20 days almost reached the initial cutting height at every clipping. Cutting *Pennisetum* grasses at 10 day or 15 days interval did not express marked height variations in their response to height increment.

TABLE 1
EFFECT OF CUTTING FREQUENCY ON GROWTH RATE (HEIGHT INCREMENT) IN ELEPHANT GRASS *Pennisetum purpureum* (cm)

	Plant height cm		
Cutting frequency	**Cut 1**	**Cut 2**	**Cut 3**
5 days	57.14^{b}	26.22^{a}	15.19^{a}
10 days	60.52^{b}	52.11^{b}	50.56^{b}
15 day	49.72^{a}	47.72^{b}	48.67^{b}
20 day	85.67^{c}	83.17^{c}	84.00^{c}
SE	2.889	2.599	3.007
Fcal	*	*	*

Mean with different alphabetic in the same column are significantly different at p. 05 by LSD * =significant

TABLE 2
EFFECT OF CUTTING FREQUENCY ON NUMBER OF LEAVES IN ELEPHANT GRASS *Pennisetum purpureum. Schum.*

	No of Leaves		
Cutting frequency	**Cut 1**	**Cut 2**	**Cut 3**
5 days	17.17^{a}	7.83^{a}	7.33^{a}
10 days	24.28^{a}	22.33^{b}	28.67^{c}
15 day	24.00^{a}	24.67^{b}	23.00^{b}
20 day	40.33^{b}	38.50^{c}	42.67^{d}
SE	2.514	2.290	1.599
Fcal	*	*	*

Mean with different alphabetic in the same column are significantly different at p. 05 by LSD * = significant

TABLE 3
INFLUENCE OF AND FREQUENCY ON LEAF AREA IN ELEPHANT GRASS *Pennisetum purpureum. schum* (Cm^3)

	Leaf Area		
Cutting frequency	**Cut 1**	**Cut 2**	**Cut 3**
5 days	237.79[a]	47.33[a]	26.889[a]
10 days	131.59[b]	162.11[b]	147.50[b]
15 day	164.28[b]	203.60[b]	172.00[b]
20 day	292.00[c]	281.58[c]	263.56[c]
SE	17.321	15.685	11.604
Fcal	*	*	*

Mean with different alphabetic in the same column are significantly different at p. 05 by LSD * = significant

3.2 Number of leaves

The influence of cutting frequency on number of leaves produced by elephant grass is displayed in table 2. The cutting frequency had pronounced effect on number of leaves in the grass. The number of leaves produced was strongly affected by cutting interval. Number of leaves reduced with cutting frequency. That is, as the frequency becomes higher (i.e reduced cutting interval) the production of leaves reduced. The frequently cut *Pennisetum* grasses (at 5 days interval) showed progressively marked reduction in number of leaves produced from the first to the third cutting. The difference in the number of leaves reduction between the first clipping and the third cutting was 57.3%.Those cut at widest interval of (20days interval) were not affected, as the number of leaves produced at the 3rd cut was about the same number produced initially before cutting. The effect of cutting frequencies on leaf production was significant.

3.3 Leaf Area

The effect of cutting frequency on leaf size of *Pennisetum* is highlighted in table 3. Leaf area reduced with cutting at all cutting interval, but the reduction was shape and more obvious in the more frequently cut grasses (short cutting interval of 5 days). The reduction in leaf size was 8 times less between the 1st and 3rd cutting for those cut at 5 days interval while in those cut at 20 days interval it was about a unit less. The variation in leaf area was significantly due to the different cutting frequencies.

3.4 Forage fresh weight

Table 4 reveals the forage yield response of elephant grass *Pennisetum purpureum* to cutting frequency. Cutting frequency had a marked reducing effect on forage yield in the *Pennisetum* grasses in this study. There was significant reduction in weight of forage harvested at all frequencies of cutting. Also grasses cut at 5 days interval showed marked reduction between cut 1 and cut 3 compared to other frequencies. The reduction in forage yield was about 74% less in those cut at 5 days interval, compared to 50% reduction in the grasses cut at 20 days interval.

3.5 Dry matter production

The effect of cutting frequency on forage dry weight in *Pennisetum purpureum* is shown in table 4. Dry matter yield increased with cutting interval. As the number of days between harvesting increased, a corresponding increase in dry matter was observed. *Pennisetum* grasses harvested at 5 days interval had significantly the least dry matter while those harvested at 20 days interval had significant highest dry matter yield.

TABLE 4
EFFECT OF CUTTING FREQUENCY ON HERBAGE FRESH WEIGHT IN ELEPHANT GRASS *Pennisetum purpureum*. Schum.

	Fresh Weight		
Cutting frequency	**Cut 1**	**Cut 2**	**Cut 3**
5 days	31.00[a]	3.67[a]	7.83[a]
10 days	26.67[a]	29.50[b]	25.50[b]
15 day	24.33[a]	24.61[b]	22.83[b]
20 day	86.17[b]	79.11[c]	42.83[c]
SE	3.373	3.069	3.328
Fcal	*	*	*

Mean with different alphabetic in the same column are significantly different at p. 05 by LSD * = significant

TABLE 5
EFFECT OF CUTTING FREQUENCY ON HERBAGE DRY WEIGHT IN *Pennisetun purpureum*

	Dry Weight		
Cutting frequency	**Cut 1**	**Cut 2**	**Cut 3**
5 days	5.64[a]	3.05[a]	1.53[a]
10 days	7.29[b]	7.27[b]	5.89[c]
15 day	11.64[c]	6.92[b]	4.91[b]
20 day	14.36	9.68	7.88
SE	.398	.321	.181
Fcal	*	*	*

Mean with different alphabetic in the same column are significantly different at p. 05 by LSD * = significant

IV. DISCUSSIONS

4.1 Forage growth

In this study it was observed that cutting frequency had significant effect on plant height or growth rate in the Pennisetum grasses. The more frequently cut grasses were increasing getting shorter while the less frequently cut grasses maintained their growth rate. This finding is similar to the observation of Onyeonagu and Asiegbu (2005), who reported higher plant height increment in the grasses they investigated that were harvested at wider intervals or frequencies. The number of leaves and the sizes of leaves i.e leaf area were also significantly influenced by cutting interval. Leaf area and number of leaves increased as the frequency of harvesting reduced. This trend was also observed by Da Silveira *et al.*, (2010) who reported higher leaf production in higher cutting interval. However, the findings were contrary to those of Wen and Jiang (2005) who reported that increased cutting frequency i.e. shorter interval stimulated leaf production in rye grass. This reduction in growth rate and shoot development might be an indication that high cutting frequency may suppress the grass regeneration and reduce re-growth potential.

4.2 Forage Yield

It was observed in this study that cutting frequency had pronounced effects on forage fresh weight and dry matter yield of the *Pennisetum* grasses. There was yield reduction has cuttings progressed and with cutting frequency. Grasses cut too frequently (5 days interval) were increasingly recording lower weights while those cut less frequently (20 days interval) produced higher fresh weight of forage and higher dry matter. Lounglawan et al., (2013) had similar observation and stated that forage and dry matter in Napier grass (*Pennisetum purpureum x Pennisetum americanum*), in Thailand, increased as cutting interval increased. Onyeonagu and Asiegbu (2005), also reported significant increase in dry matter production with increasing cutting interval in *Pennisetum* grasses in Nsukka, Nigeria.

V. CONCLUSION

Cutting frequency significantly influenced plant height or growth rate, leaf area and number of leaves. Leaf area and number of leaves increased by cutting frequency reduced. *Pennisetum* grasses cut 20 days interval in this study, recorded the greatest number of leaves and highest leaf area. Forage yield was markedly influenced by cutting frequency, grasses cut at shorter interval or higher frequency were increasingly recording less forage weight and dry matter weight while those cut at wider interval or shorter frequency had higher forage fresh weight and higher dry matter. Grasses cut at 20 days interval produced the highest fresh weight and dry matter yield. Cutting Pennisetum grasses at 20 days interval for the cut system or as grazing interval is recommended in the southern rainforest of Nigeria.

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Effects of Paclobutrazol on fruit yield and physico-chemical characteristics of mango Cvs. Dashehari, Langra, Chausa and Fazri

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Abstract— *Paclobutrazol is triazoles derivatives [(2 RS, 3RS)-1-(4-Chloropheny)-4, 4-dimethyl-2- (1, 2, 4 triazole-1-yl)] Pentane - 3 - ethanol. It is taken up of xylem and translocated acropetally to sub apical meristem. Paclobutrazol is metabolized in plant in 10-15 days but persists in soil generally for more than one year Pactbutrazol was applied on a basic trunk drench (1.0 g/m, 0.5 g/m tree canopy diameter) in 21-22 year old mango tree Paclobutrazol treatment induced early ripening, reduced fruit sized when applied continuously for more than one year. However that quality was better in terms of higher TSS, total sugar, and β-carotene and Ascorbic aid.*

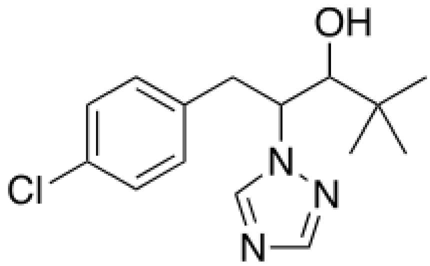
Keywords— Paclobutrazol (PBZ), Auxins (IAA), Gibbcrellins, Cytokinins and Plant growth regulator.

I. INTRODUCTION

Mango (*Mangifera Indica L.)* is the most important fruit crop of India. The production scenario of different fruits in India indicates that all the fruits occupied 6,480 thousand ha area with 92,846 thousand MT production and 14.3 MT/ha productivity during 2016-17. The total allocation to the fruits in the country has been increased from 6,235 to 6,480 thousand ha over the previous year, while the total production of fruits has also been increased from 89,512 to 92,846 thousand MT. The area and production of mango has been almost continuously increases over the years. The area under mango cultivation was 1077.6 thousand ha during 1991-92 which reaches up to 2516 thousand ha in 2013-14 and recorded 2262.8 thousand ha in 2016-17. However, the production has been fluctuating drastically. During 1991-92, the total production was 8,715.6 thousand MT which was increased up to 13,997 thousand MT in 2007-08. During 2008-09 the production was declined from 13997 thousand MT to 12,750 thousand MT. From 2009-10 there is continuous increase in the mango production (15,026.7 thousand MT) to 2016-17 (19,686.9 thousand MT). A total 109.99 % increase in area under mango cultivation has been recorded from 1991-92 to 2014-15 while, 125.88 % increase in production was recorded during the same period. However, productivity has been fluctuating drastically from 1991-92 to 2014-15. The productivity of 8.1 MT/ha was recorded during 1991-12 whereas, it was declined up to 5.5 MT/ha in 2008-09 and again increased up to 8.5 MT/ha in 2014-15 and reached up to maximum productivity of 8.7 MT/ha in 2016-17. There was overall increase of 7.41 % in productivity of mango from 1991-92 to 2014-15. In 2017, global mango production amounted to about 50.65 million metric tons. In India it is grown on an area of 2.516 million hectares with annual production of 18.431 million tonne having productivity of 7.3 metric tonne per hectare Anonymous (2017).

Although, alternate bearing is a major problems in mango production and its means "a condition at which high or optimum fruit production in on year or higher and certain year bear little or no fruit (off year), but growth regulators such as cultar reported to be effective on inducing flowering mango off year (Sinde et al.,2000). Paclobutrazol increased photosynthesis activity in apple (16%) (Kirn et al., 1990: Steffens, et al., 1990). Pecan (7.54%) (Wood 1984: Deyton, et al., 1991). Citrus (Deng et al, 1990). It also increased chlorophyll content in apple (Steffens, et al, 1983, 1984; Steffens and Wang, 1984, Wang et al, 1985, San Wavini et al, 1986; Kwon and Lee, 1986; Kim et al, 1990; Hao, et al, 1991, Pear (Bonomo and Neri, 1986), Peach (Coston, 1986; Choi et al, 1988), Strawberry (Archibold and Houtz, 1988), Grape (Shaltout et al., 1988), Banana (El-Qtmani et al, 1992) and Citrus (Deng et al., 1990). Paclobutrazol did not affect Sugar, pH, Colors or Glucose, Fructose ratio in Grape (Zoeckleni et al., 1991), Amino Cyclopropane, Carboxylic Acid, Ethylene, Respiration Sorbitol, Fructose, Glucose, Sucrose and Malic Acid in Apple (Wang and Steffen's, 1987). Paclobutrazol reduced sugar concentration in Apple (Green and Murray, 1983; Greene, 1986; Byun and Chang. 1986; Luo et al, 1989; El fving et al., 1990; El-Khoreiby et al 1989; Forlanin and Cappola, 1992), Persimmon (Lee and Kim, 1991), TSS in Cherry (Looney and Mc Killar, 1987), acidity in Apricot (Mehta et al., 1990), and grape (Shaltout et al, 1988; Zoecklein et al. 1991, Reynold et al, 1992).

Paclobutrazol



[Paclobutrazol: (2*RS*, 3RS)-1-(4-chlorophenyl)-4, 4-dimethyl-2-(1, 2, 4-triazol-1-yl) pentan-3-ol.]

FIGURE 1: TOXICITY

TABLE 1
EFFECTS PACLOBUTRAZOL TREATMENT POST HARVEST LIFE OF MANGO CVS. DASHERI, LANGRA, CHAUSA AND FAZRI (1998-99)

Treatment	TSS (%)	Acidity (%)	Total Sugar (%)	Reducing Sugar (%)	Non reducing Sugar (%)	βcarotene	Ascorbic acid (mg)
Dashehari Control 1.0g PBZ m tree canopy diam.	23.40 23.73	0.22 0.20	15.33 15.39	3.89 3.90	11.46 11.51	1.42 1.14	36.79 37.16
Langra Control 1.0g PBZ m tree canopy diam.	21.07 21.83	0.18 0.17	17.35 17.39	5.82 5.85	11.54 11.56	1.38 1.39	132.34 132.43
Chausa Control 1.0g PBZ m tree canopy diam.	21.66 21.71	0.26 0.25	17.47 17.51	5.34 5.36	12.14 13.23	1.12 1.13	38.86 39.35
Fazri Control 1.0g PBZ m tree canopy diam.	17.57 17.81	0.31 0.29	13.64 13.69	5.66 5.67	7.98 8.05	1.15 1.16	12.91 13.21
CD at 5% Cultivar Treatment Interction	0.20 0.14 0.28	0.84 0.59 NS	0.19 0.13 NS	0.12 0.86 NS	0.40 0.28 NS	0.76 0.54 NS	0.51 0.36 0.72

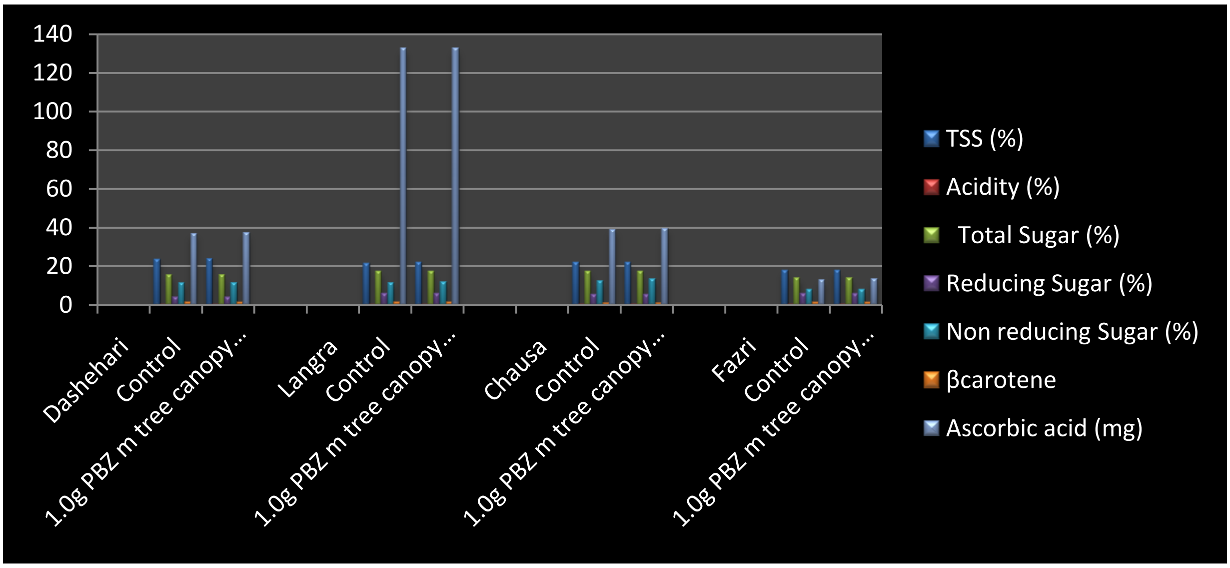


FIGURE 2: Effects Paclobutrazol treatment on Post Harvest life of Mango cvs. Dashehari, Langra, Chausa and Fazli. (1997-98).

TABLE 3
PACLOBUTRAZOL TREATMENT ON POST HARVEST LIFE OF MANGO CVS. DASHERI, LANGRA, CHAUSA AND FAZRI (1998-99)

Treatment	TSS (%)	Acidity (%)	Total Sugar (%)	Reducing Sugar (%)	Non reducing Sugar (%)	βcarotene	Ascorbic acid (mg)
Dashehari Control 0.5g PBZ m tree canopy diam.	23.31 23.65	0.23 0.20	15.35 15.42	3.88 3.88	11.44 11.48	1.13 1.14	37.75 37.12
Langra Control 0.5g PBZ/ m tree canopy diam.	21.11 21.78	0.18 0.17	17.37 17.41	5.81 5.83	11.54 11.54	1.37 1.38	132.32 132.37
Chausa Control 0.5g PBZ/ m tree canopy diam.	21.64 21.81	0.26 0.25	17.48 17.54	5.33 5.36	12.13 13.15	1.11 1.13	38.97 39.33
Fazri Control 0.5g PBZ/ m tree canopy diam.	17.54 17.75	0.31 0.29	13.64 13.73	5.67 5.65	8.46 8.04	1.14 1.16	22.89 13.17
CD at 5% Cultivar Treatment Interction	0.60 0.43 0.86	0.84 0.59 NS	0.11 0.79 NS	0.43 0.30 0.61	0.37 0.26 NS	0.56 0.40 NS	0.44 0.31 0.63

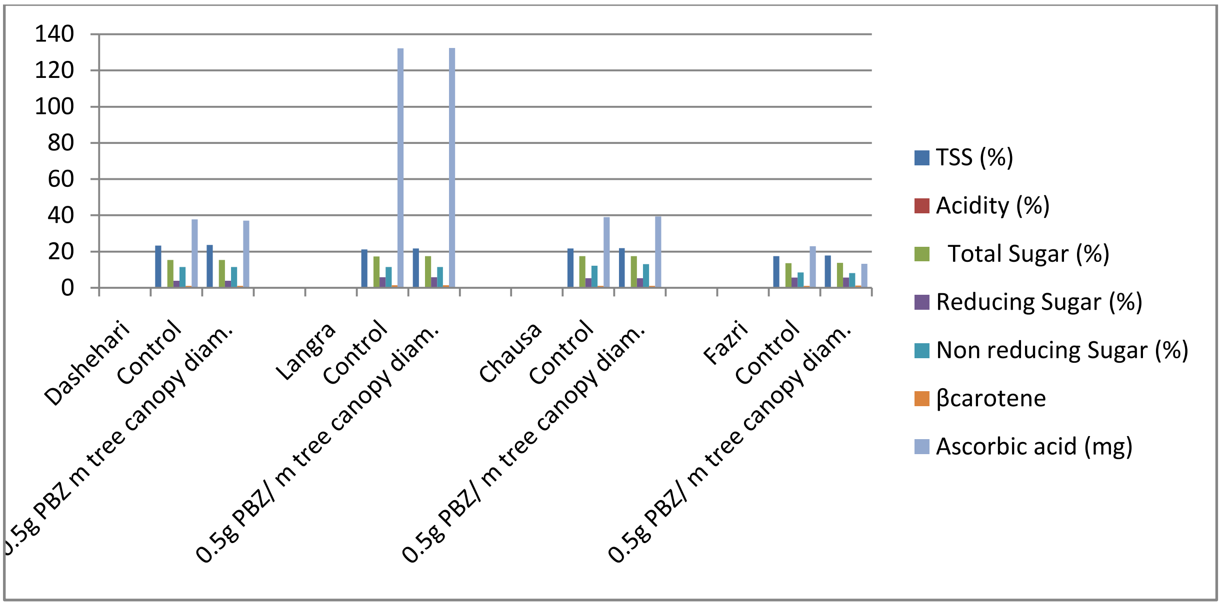


FIGURE 3: Effects Paclobutrazol treatment on Post Harvest life of Mango cvs. Dasheri, Langra, Chausa and Fazri (1998-99)

The acute oral LD50 of rats was 2000mg/kg (male), 1300mg/kg (female); for mice oral: 490mg/kg (male), 1,200mg/kg (female); for rabbit, the acute oral LD50: 840 mg/kg (male), 940 mg/kg (female). Rat and rabbit: acute percutaneous LD50> 1000mg/kg. For rat, acute inhalation has a LC50: 4.79mg/L (male) (4h), 3.13mg/L (female) (4h). It has certain irritant effect on the skin and eyes of the rat and rabbit. The no-action dosage for feeding rats of 2 years is 250 mg/kg; the no-action dosage for feeding dog of 1 year is 75 mg/kg; No mutagenicity effect. For rainbow trout, LC50:27.8mg/L (96h), carp LC5023.5mg/L (48h), and Daphnia LC50> 7900mg/L. Low toxicity to bees, LD50> 0.002mg/only.

II. MATERIAL AND METHODS

The uniform size fruits were harvested along with 5 cm stalk length with help of hand Scatters. Harvested fruits were washed and kept in Corrugated Fiber Board (CFB) boxes in single layer, under ambient temperature (30-33 C) for shelf life study.

2.1 Physio Chemical Analysis

The observation on various physio-chemical characters were recorded from 22 June and 22 July, harvested fruits were recorded at 10 days of storages in all replications according to the experiments. The physio-chemical parameters viz. TSS (Total Soluble Solids) was determined with the help of hand refractometer. Fruit Acidity was estimated by titrating pulp extract with O.1N NaOH using phenolphthalein indicator Total sugar, β-carotene was determined according to method suggested by Raganna (1992).

2.2 Statically Design

The observation recorded were subjected to statically analysis by using Completely Randomized Design for lab experiments valid conclusions were drawn only on significant differences between the treatment mean at 5 % level of Probability (Conchran and Cox, 1959) In order to compare treatment means, critical difference were calculated

III. RESULT AND DISCUSSION

The fruits were kept in corrugated Fiber Board (CFB) boxes in single layer under ambient temperature (30-33°C). The time taken for ripening of fruits in cultivars Dashehari, Langra. Chausa and Fazri were 1-2 days earlier in both the consecutive years. However, lowest doses of Paclobutrazol 0.5 g/m canopy diameter was ineffective on early ripening, similar was the dots, oblong to oblong oblique with base rounded to oblique round medium sized, skin smooth, medium thick, though and non adhering. The flesh is yellow, firm with almost no fibber, scanty juice and delightful aroma, very sweet test of excellent quality. Table 1A,1B shown that Paclobutrazol treated Dashehan Mango is slightly increase TSS (23.40%), acidity (0.22%), total sugar (15.33%), reducing sugar (3.89%) non-reducing sugar (11.46%), ß-carotene (1.42%) and ascorbic acid (36.79mg) However, this treatment is better in higher doses of Paclobutrazol (1.0 g/meter canopy diameter) compare to lower doses (0.5 g/meter canopy diameter).

The fruit of Langra Mango is greenish yellow with medium is big dark green dots ovals-oblong, 8-10.5 cm long by 6.5-7.5 cm broad by 6-7 cm thick, weighting 235-735 g. The skin is medium smooth thick. The flesh firm to soft, fibreless, lemon yellow, very sweet with strong pleasant aroma, juice moderately abundant, mono embryonic seed is medium sized, flattened stone covered with dense, soft and short fibber, quality is very good, early to mid season varieties.

Therefore, the fruits taken time for ripening in general 8-10 days higher doses of PBZ (1.0 g/meter canopy diameter) were effective on early ripening. Langra Mango, 2-3 days early ripe with slightly significant effect on TSS, acidity, totals sugar, reducing and non-reducing sugar percent. Data 1A, 1B is shown that higher doses of PBZ (1.0 g/meter canopy diameter) is slightly increased TSS (21.07%), acidity (0.18%), total sugar (17.35%), reducing sugar (5.82%), non-reducing sugar (21.83%), ß-Carotene (1.38%), total sugar (17.39%) reducing (5.85%), non-reducing (11.56%), ß-Carotene (1.39), ascorbic acid (132.43 mg) as well as lower doses (0.5 g/m canopy diameter).

Chausa is late maturing cultivars of Mango. The fruit is canary yellow raw sienna when fully ripe with numerous obscure medium sized dotes with minute specks inside them, oblong with prominent beak, obtuse to rounded medium sized. The skin is thin and same what adhering pulp raw sienna soft and fucy with canty fine long fibber near the skin. The fruit is very sweet with luscious, delightful aroma of excellent quality. Seed mono embryonic in a thick, medium sized oblong stone with fine, short fibbers all over the surface and a tuft of long fibbers on the ventral edge and a light bearer.

The fruits of Chausa are harvest on 24th July was kept at ambient temperature (30-33°C) for ripening and data on their weight, TSS, acidity, total sugars, β-Carotene and change of peal and pulp color during ripening. Data's further show that Chausa fruit take 6-8 days to ripen when harvested on 24^{th} July. Data on fruit quality in table 1A, 1B show that Paclobutrazol forces the fruit to ripen early (1-2 days) without any significant on percent fruit weight loss, stone ratio, width of fruit and stone. Data again shows that Paclobutrazol reduced fruit weight, fruit volume, and width of fruit and length of fruit. The various cultivars responded effectively to reduction of fruit size and stone.

Data further shows that higher doses of PBZ (1.0 g/meter canopy diameter) were more effective than lower doses of PBZ (0.5 g/meter canopy diameter) and slightly increased fruit quality in terms of TSS, Acidity percent, reducing and non-reducing sugar, ß –Carotene content and ascorbic acid. The fruit of Fazri is light chrome yellow with small, dark colored fairly sparse dots. Oblique oval with base slightly rounded and beak distinct to slightly prominent, large. average 14.3 cm long by 9.8 cm board, weighting 500 g. on average with a medium thick skin average with a medium thick skin that is smooth with some inclination to be warty and firm to soft fibreless flesh of a light cadmium yellow with a pleasant aroma and a sweet taste, having juice that may be scanty to moderately abundant seed mono embryonic in large oblong stone that is covered with sparse short and soft fibber, mid to late varieties.

Fazri took 11.5 days for ripening at ambient temperature. Data 1A, 1B show that Paclobutrazol. Higher doses of 1.0 g/m tree canopy diameter treatments had slightly increase acidity percent; total sugar percent and ascorbic acid than control (expect TSS, reducing and non-reducing sugar percent and β-carotene). The interaction between Paclobutrazol and cultivars were non-significant except TSS percent, fruit quality was differed in different cultivars without any interaction effect between PBZ and cultivars. Data 1A, 1B on fruit quality show that Paclobutrazol forces the fruit to ripen early 1-2 days.

Paclobutrazol treatment induced early ripening, reduced fruit size, when applied continuously for more than one year. However, fruit quality was better in terms of higher TSS, Ascorbic Acid, β-carotene and total sugar. The fruit produced by PBZ treatment were settler in terms of TSS, acidity and ascorbic acid reducing and non-reducing sugar and β- carotene. However, fruits were slightly smaller than those of untreated control. In general, post bloom application of Paclobutrazol in soil is better than the pre bloom Paclobutrazol in early maturing Cvs. Dashehari. However, such effects were not observed in medium and late maturing Cvs. Langra, Chausa and Fazr.

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Carbon stock of woody species along Altitude gradient in Alemsaga Forest, South Gondar, North Western Ethiopia

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Abstract—

Purpose: *Forest ecosystems play a significant role in the climate change mitigation and biodiversity conservation. Therefore carbon determination provide clear indications of the possibilities of promoting forest development and management for mitigating of climate change through soil and vegetation carbon sequestration. The study was carried out to quantify carbon stock potential in Alemsaga Forest, South Gondar zone.*

Research method: *Vegetation data Collection was made using a systematic sampling method; laying six transect lines with 500 m apart and 54 quadrants of 20 m X 20 m established 200 m distant to each other along the transect lines. In these plots, abundance, DBH and heights of all woody species were recorded, and soil sample was collected 1m X1m* from the four corners and center of each quadrant. *General allometric model was used for estimating above and belowground biomass. The organic carbon content of the soil samples was determined in the laboratory.*

Finding: *A total of 66 woody plant species belong to 42 families were identified*, Fabaceae was the most dominant families. *The total mean above and belowground carbon stock was 216.86 ton/ha and 114.71 ton/ha respectively and soil organic carbon (SOC) 103.15 ton/ha. Above and belowground carbon increased as altitude decreased, but SOC increases with increase of altitude.*

Originality/value: *Carbon stock estimation in the forest helps to manage the forests sustainably from the ecological, economic and environmental points of view and opportunities for economic benefit through carbon trading to farmers.*

Key word: Altitude, Carbon stock, Forest, Woody species.

I. INTRODUCTION

Forests provide a diversity of ecosystem services including converting carbon dioxide into oxygen and biomass, acting as a carbon sink, aiding in regulating climate, protection of hydrological services, biodiversity conservation and aesthetic values (Scherr *et al*., 2004). Climate change is a real recent problem that harmfully affects environmental norms and populations, causing a severe negative impact worldwide. It is supposed that the aim of decreasing carbon sources and increasing the carbon sink that can be attained through keeping and maintaining the carbon pools in existing forests is among the top priorities of climate change mitigation (Brown *et al*., 1996). Carbon sequestration is the removal of CO_2 from the atmosphere and storing it in the ocean, vegetation, soil and geological formation (IPCC, 2000). Forests are a current focus for action since they play a significant contribution to mitigating climate change by absorbing carbon emission from the atmosphere (IPCC, 2000).

The sequestration of carbon is one of the many ecosystem services supported by biodiversity (Maestre *et al.,* 2012). Therefore biodiversity is very important for carbon storage to enhance nutrient availability and socio economic benefits (Brown, 2002). Carbon is initially sequestered through photosynthesis before being transferred to one of a number of terrestrial pools including aboveground biomass, dead wood, litter, roots and soil (Gorte, 2009). Carbon stock can be influenced by different factors, including altitude, tree species, climate, soil nutrient availability, disturbance and management regime (Houghton, 2005). Carbon stock in trees increases with temperature, nutrient availability , soil moisture and tree density, and SOC increase with precipitation, and decrease with temperature (Jobbagy and Jackson, 2000).These pools are then subject to gains and losses depending on rates of growth, mortality and decomposition that are in turn affected by varying human and natural disturbances (Maestre *et al.*, 2012).

Alemsaga Forest is found in the western edge of the Farta district of Northern Ethiopia. The area is protected starting from 1978 with the objectives of providing seed source, maintaining the remnant natural forests and recovering the degraded area. Between 1990 and 1992, during the government transition, the area was converted into pasture and farm lands. After political stability in 1993 of the country the area was re-protected as forest area (Farta woreda agricultural office, 2017). Deforestation and grazing are ongoing challenges for conservation of study forest (Farta woreda agricultural office, 2017). Carbon determination may provide clear indications of the possibilities of promoting forest development and management for mitigating of climate change through soil and vegetation carbon sequestration. Therefore, the study was to quantify above and belowground biomass, and their carbon stock of forest, to quantify soil organic carbon stock, and to determine the variation of carbon stock along altitudinal gradient.

II. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted on Alemesaga forest, Farta woreda, south Gondar zone; Amhara region of north western Ethiopia (Figure 1).The forest covers 780 ha including plantation forest. The soils are reddish brown or brown of clay loam, slit clay and sandy loam texture, and freely draining with predominantly nithosols and leptosol. The forest has an elevation range between 2100 m and 2470 m above sea level.

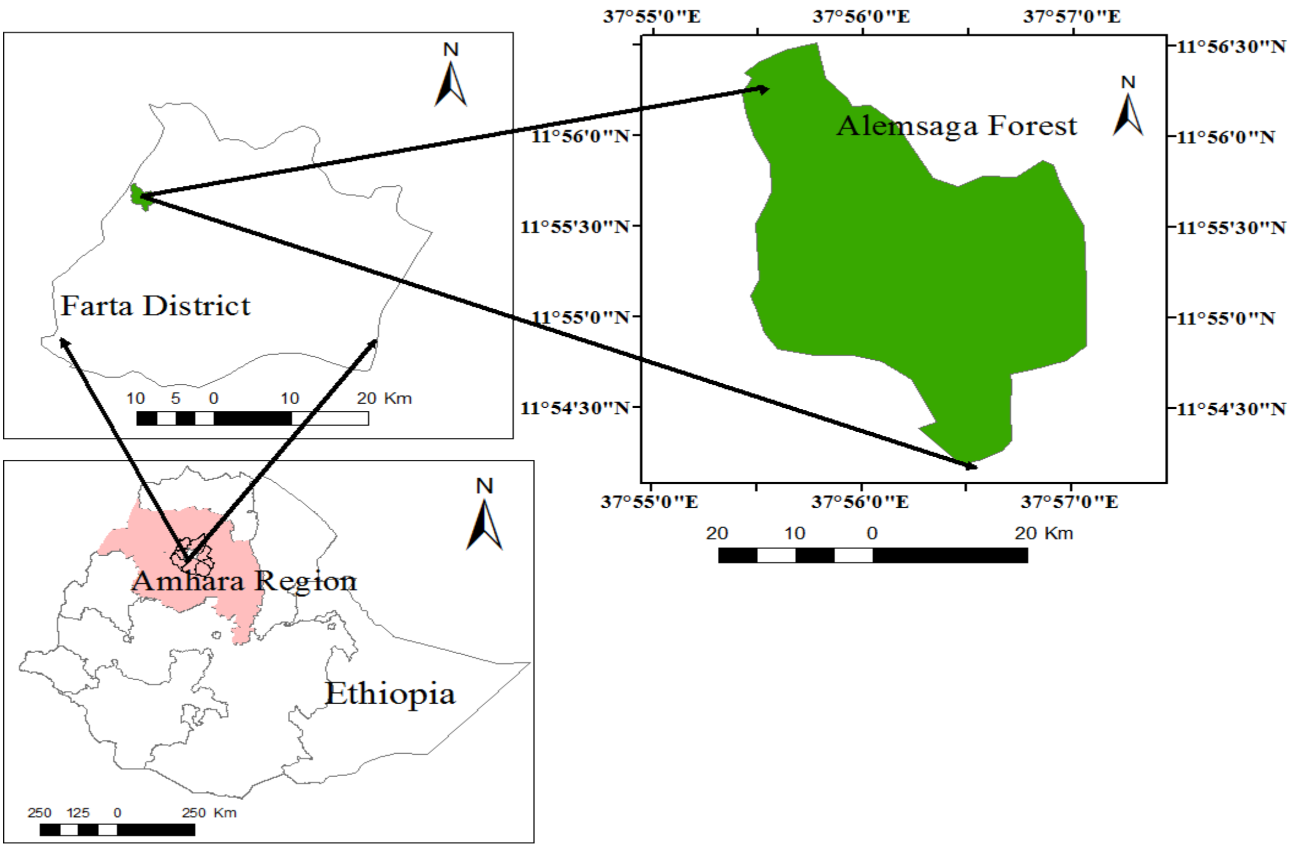

FIGURE 1: Map of Alemsaga forest, South Gondar, North Western Ethiopia

2.2 Climate

The mean monthly temperatures 14.62°C (Figure 2). The agro ecological zone of this forest is moist wenadega. The rainfall pattern is unimodal, which obtain high rainfall from June to August and long term average of 1484 mm (Debre Tabor metrological station, 2018).

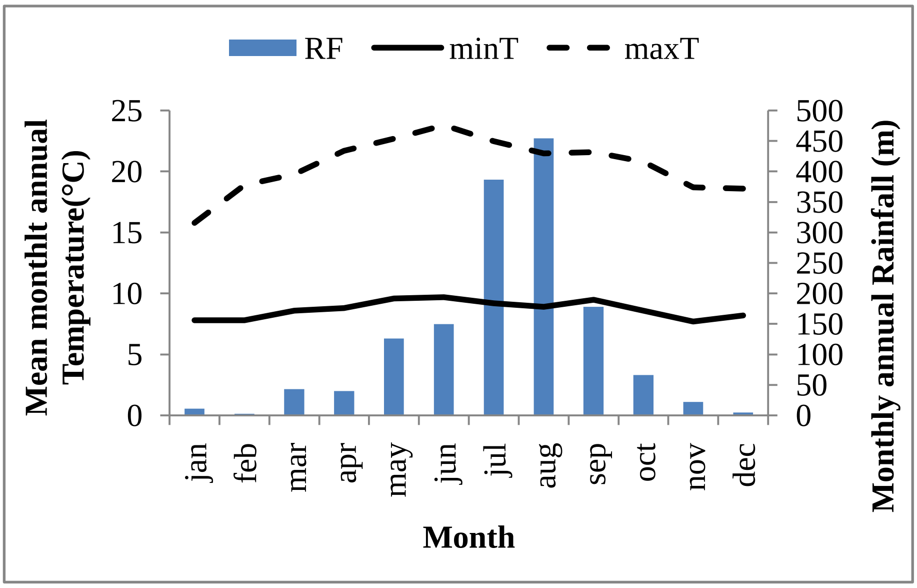

FIGURE 2: Average rainfall (mm) and temperature (°C) (1990-2017) in Alemsaga forest South Gondar, North Western Ethiopia (Debre Tabor metrological station, 2018).

III. SAMPLING TECHNIQUES AND SAMPLING SIZE

A Stratified systematic sampling technique was employed in this study. The stratified based on altitude gradient. The distance between transect line and plots was determined based on vegetation density, spatial heterogeneity of vegetation and size of the forest (Tefera *et al.*, 2005).To reduce edge effect transects were laid at a distance of 50 m far from both edges of forests. The first transect line was laid randomly at the edge of northern direction forest started from top to bottom of the mountain Totally six transect lines laid dawn with 500 m apart and, 54 quadrants (20m x 20m) were established 200m distance to each other along the transect lines. The GPS points also that helped to indicate each sample plots (Figure 3).

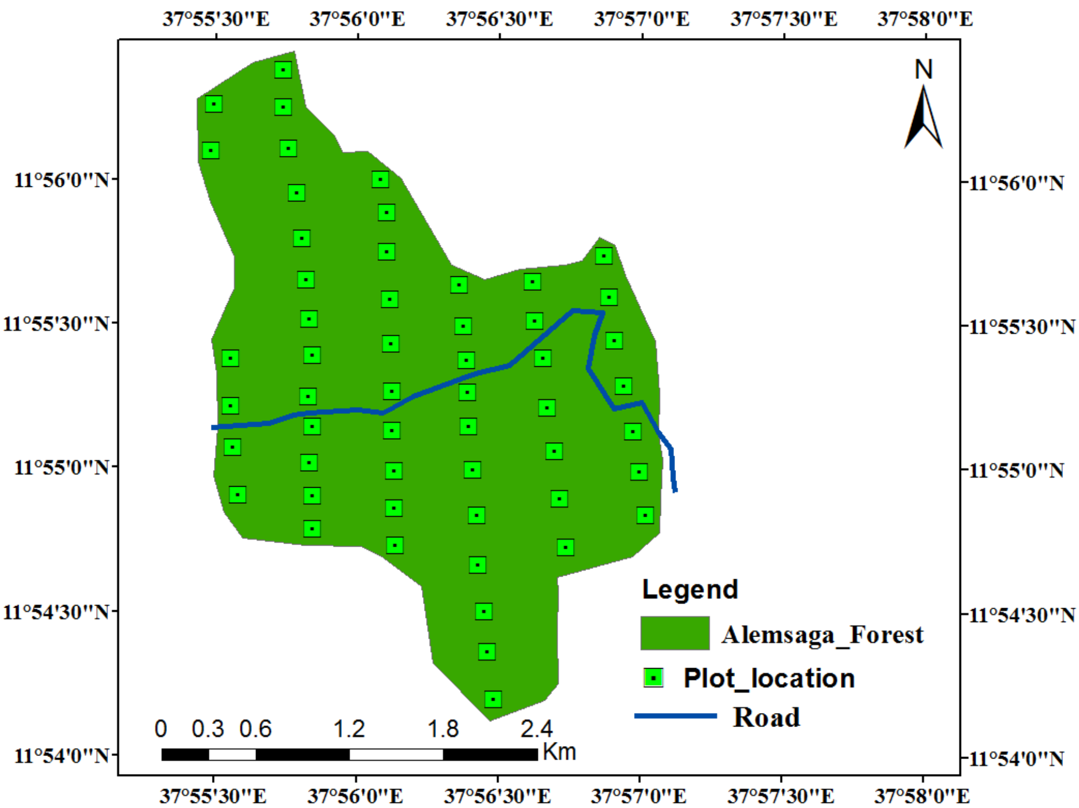

FIGURE 3: Plot location in Alemsaga forest, South Gondar, North western Ethiopia

3.1 Vegetation data collection

In each plot woody vegetation was counted, diameter was measured at breast height (DBH) and height from the ground. DBH was measured using diameter tape and tree height was measured using clinometer. Plant identification was done in the field by the knowledge of the local people and using Flora of Ethiopia and Eritrea.

3.2 Soil sampling

The carbon in the soil is concentrated in the top 30 cm layer of soil profiles, (IPCC, 2006). Therefore soil organic carbon pool was sampled up to the depth of 30 cm in this study. According to the principles of Pearson e*t al.*, (2005) soil samples for soil carbon determination was collected from the field within the area of $1m^2$ five subplots within each major plot. The samples were dug using auger at depth of up to 30 cm from the four corners and center of each quadrant, and sample for bulk density (BD) was collected using a core sampler. Mixing of soils was done properly by taking an equal amount of soil from each subplot to make a composite in order to make homogeneity.

3.3 Data analysis

3.3.1 Estimation of aboveground carbon stock (AGC)

To estimate the above and belowground biomass/carbon, a nondestructive approach which involves the use of allomoteric models were used. The popular allomotric equation of Chave *et al*. (2014) was used in this study to determine the biomass of tree species having ≥ 5 cm DBH as it fits to biophysical conditions of the study area. . The model:

$$AGB = 0.0673 \times (\rho D^2 H)^\wedge 0.976 \quad (1)$$

Where, AGB – aboveground biomass (kg),

H– Height of tree (m),

D– Diameter (cm) at breast height (1.3m), and

ρ– Wood density (t/m^3), the African trees average wood density values (0.58 ton/m^3) (Brown et al., 1997).

The tree biomass was converted into C by multiplying the above ground tree biomass by 0.5 (Brown, 2002).

$$\mathrm{AGC} = \mathrm{AGB\ X\ 0.5} \quad (2)$$

Where, AGC – Aboveground carbon

3.3.2 Estimation of belowground carbon stock (BGC)

Estimation of below ground biomass is much more difficult and time consuming due to uncertainty of root biomass measurement. Root biomass is often estimated from root-shoot ratios (R/S) by taking 25% of aboveground biomass (Cairns *et al*., 1997).

$$\mathrm{BGB} = \mathrm{AGB} \times 0.25 \quad (3)$$

$$\mathrm{BGC} = \mathrm{BGB\ x\ 0.5} \quad (4)$$

Where, BGC = carbon content of below ground biomass, BGB= below ground biomass

3.3.3 Estimation of soil organic carbon (SOC)

The carbon stock of soil was done by using Pearson *et al*., (2005) formula,

$$\mathrm{SOC} = \mathrm{BD} * \mathrm{D} * \%\,\mathrm{C} \quad (5)$$

Where, SOC= soil organic carbon stock per unit area (t/ha),

BD = soil bulk density ($g\ cm^3$),

D = the total depth at which the sample was taken (30 cm), and

%C = Carbon concentration (%).

About 100 gm of evenly mixed soil samples from the five subplots was taken to the laboratory, and then the carbon content of the soil samples was determined in the laboratory using (Walkley-Black Method, 1934). Determination of percentage of organic carbon was conducted in Bahir Dar regional soil laboratory center.

Then the bulk density of a soil sample was calculated as follows:

$$\text{Bulk density } (gm/cm^3) = \frac{\text{Oven dry weight of the soil}}{\text{Volume of the core}} \tag{6}$$

The volume of the soil in the core sampler was calculated as follows:

$$V = h * \Pi r^{\wedge}2 \tag{7}$$

Where, V is the volume of the soil in the core sampler in cm^3,

h is the height of core sampler in cm, and

r is the radius of core sampler in cm (Pearson *et al*., 2005).

3.3.4 Estimation of total carbon stock

The total carbon stock is calculated by summing the carbon stock densities of the individual carbon pools of the stratum using the Pearson *et al*., (2005) formula.

$$\mathrm{TC} = \mathrm{AGC} + \mathrm{BGC} + \mathrm{SOC} \tag{8}$$

Where, TC = Total Carbon stock for all pools (ton/ha) and AGC=aboveground carbon stock (t/ha), BGC= belowground carbon stock (ton/ha.

Where, Aboveground biomass (kg/tree). The total carbon stock was converted to tons of CO_2 equivalent by multiplying it by 44/12, or 3.67 as indicated by (Pearson *et al*., 2007).

3.4 Statistical Analysis

The significance of species diversity and carbon stock was analyzed by using Statistical Package for Social Science (SPSS) software version 20. The relationship between each parameter was tested by descriptive statistics such as mean, standard deviation, minimum and maximum value. The significant difference of above and below ground carbon stock, and soil organic carbon stock along altitude at 5% of the level of significance tested by one-way ANOVA, and Gabriel post-hoc test for multiple comparisons was used. The above and belowground carbon stock were transformed using ln transformation.

IV. RESULTS AND DISCUSSIONS

4.1 Floristic composition

A total of 66 woody plant species belong to 42 families were identified, Fabaceae was the most dominant families. The most frequent species were *Dodonaea angustifolia*, *Croton macrostachyu and Carissa edulis* with 70.37 %, 64.81 and 53.70 % of occurrence respectively.

4.2 Biomass and Carbon Stock in Different Carbon Pools

4.2.1 Above ground Biomass (AGB) and Carbon Stock (AGC)

The mean AGB and AGC stock was 183.7±141.03ton/ha and 91.85±70.51ton/ha respectively. The minimum and maximum AGB was 43.79 ton/ha and 772.12 tons/ha, and the minimum and maximum AGC was 21.90 and 386.06 ton/ha respectively. The minimum and maximum above ground carbon dioxide equivalent (Co_2equ) 80.36 and 1416.84 ton/ha respectively. The mean abovegroundCo_2equof the study forest was 337.09±259.78 ton/ha.

When compared with other dry Afromontane forest, it was less than the AGC stock of Mount Zequalla Monastery (237.75 ton/ha) (Abel *et al.*, 2014); Egdu Forest (278.08 ton/ha) (Adugna *et al*., 2013;); Mengesha saba state forest (133 ton/ha) (Mesfin, 2011); Tara Gadam forest (306.37 ton/ha) (Mohammed et *al.*, 2015) and Woody Plants of Arba Minch Ground Water Forest (414.70 t/ha) (Belay *et al*., 2014). This is due to the presences of dominant small size tree species, and might be selective removal of trees of mature tree for charcoal, fuel wood, timber production and house construction due to weak management practices. In contrast, the value of AGC stock in the study forest was higher than the AGC stock, estimated in the Mountain Dirki woodland (41.5 ton/ha) (Deresa, 2015), Humbo forest (30.77 ton/ha) (Alefu *et al.*, 2015). This variation might be the age of the trees, environmental gradient, tree species, and management option of the forest.

4.2.2 Below ground Biomass (BGB) and Carbon Stock (BGC)

The mean value of BGB and BGC stock was 45±35t/ha and 22.86±17.69ton/ha respectively. The minimum and maximum BGB was 10.94 ton/ha and 193.03 ton/ha respectively. The minimum and maximum BGC was 5.47 and 96.52 ton/ha respectively. The mean below ground CO_2 equivalent of the study forest was84.76± 64.69 ton/ha. The minimum and maximum belowground CO_2 equivalent was 20.09 and 354.21ton/ha respectively.

When compared with other dry Afromontane forest, it was less than the BGC stock of woody plants of the Mount Zequalla Monastery (47.6 ton/ha) (Abel *et al.*, 2014); Egdu Forest (55.62 ton/ha) (Adugna *et al*., 2013;); Mengesha saba state forest (26.99 ton/ha) (Mesfin, 2011); Tara Gadam forest (61.52 ton/ha) (Mohammed et *al.*, 2015) and Woody Plants of Arba Minch Ground Water Forest (83.48 t/ha) (Belay *et al*., 2014). This is due to the presences of dominant small size tree species, different management practices and methods used for estimated biomass.

4.3 Soil Organic Carbon (SOC)

The bulk density of the soil profile found in the study site was ranged from 0.8 g/cm^3 of minimum to 1.69 g/ cm^3 maximum value with the average value of 1.24 g/cm^3. The minimum and maximum soil organic mater in the study site was 3% and 8% respectively. The highest and the lowest soil carbon stock of the study forest range from 198.07 and 35.4 ton/ha, respectively. The mean SOC stock of the study forest was 102.15± 33.62 ton/ha. The soil carbon of the study site sequestered CO_2equ with the minimum and maximum value of 129.97 and 726.92 ton/ha, respectively.

When compared with other studies, it was less than the SOC stock of Danaba Community Forest (186.40 ton/ha) (Muluken *et al*., 2015); and Tara Gadam forest (274.32 ton/ha) (Mohammed et *al.*, 2015); Egdu Forest (277.56 ton/ha) (Adugna *et al*., 2013) and Menagasha Saba State Forest (121.8 ton/ha) (Mesfin, 2011).

The higher SOC was found as compared to other study forest such as Park Forest (69.238) ton/ha in Addis Ababa (Meseret, 2013); Mount Zequalla Monastery (57.6 ton/ha) (Abel *et al.*, 2014) and Woody Plants of Arba Minch Ground Water Forest (83.80 ton/ha) (Belay *et al*., 2014). This indicates that the study forest had high organic matter content and high decomposition of litter in the soil, which results maximum storage of carbon. The possibility for high carbon stock in soil can be due to the presence temperature, litter fall accumulation, presence of tree species, topography, and soil nutrient availability and rate of decomposition (Xiaoli *et al.*, 2010).

4.4 Total carbon stock of Alemsaga forest

The total mean carbon stock of Alemsaga forest was achieved by summing up the carbon stock found in each carbon pool. In the present study, the largest carbon stock was contributed by the soil carbon pool which accounted 47.2% of the three carbon pools and the second was AGC pool which accounted for 42.24%. The least was recorded in BGC stock, which accounted for 10.56% (Table 1).Therefore; the total carbon stock of Alemsaga forest was 216.86 tons/ha and contributed in CO_2 equivalent with the value of 796.74 ton/ha (Table 1).

TABLE 1
SUMMARY OF MEAN ± STANDARD DEVIATION CARBON STOCK IN DIFFERENT CARBON POOLS IN ALEMSAGA FOREST, SOUTH GONDAR, NORTH WESTERN ETHIOPIA.

Carbon pool	(ton/ha)	%	CO_{2equv}
Aboveground carbon stock	91.85±70.51	42.24	337.09±259.78
Belowground carbon stock	22.86±17.69	10.56	84.76± 64.69
Soil organic carbon	102.15±33.62	47.2	374.89±123.39
Total	216.86	100	796.74

When compared with other studies, it was less than the total carbon stock of Danaba Community Forest (505.83 ton/ha) (Muluken *et al*., 2015); and Tara Gadam forest (642.21 ton/ha) (Mohammed et *al.*, 2015); Egdu Forest (611.26 ton/ha) (Adugna *et al*., 2013) and Menagasha Saba State Forest (281.27 ton/ha) (Mesfin, 2011).The differences might be the size of tree, species composition, management practice and liter fall accumulation in the soil.

4.5 Carbon stock variation along altitudinal gradient

The mean AGC was 123.59±84.81ton/ha, 88.9± 66.59 ton/ha and 51.57 ±20.23 ton/ha for the lower class, middle class and higher altitude class respectively. The mean BGC stock was 30.89±21.2 ton/ha, 22.23±16.64 ton/ha and 12.86±5.06 ton/ha for the lower, middle and higher altitudinal class respectively. The result showed that the lower altitude was higher than middle and higher altitude with the carbon content of the woody plant species. There was a significant difference both AGC and BGC stocks along an altitude gradient ($p < 0.01$) (Table 2).

Forests have a large potential for temporary and long term carbon storage and the forest biomass and carbon stock is influenced by altitudinal variations (Alves *et al*., 2010).This may be due to the absence of matured large trees at higher altitude and lower altitudinal gradient was surrounded by a river and there were some big trees and possibly also due to the favorable conditions for tree growth in the lower part. The upper part of the forest was dominated by lower plants such as grasses, herbs shrub and bushes, there were a low number of mature trees, which have lower biomass. The same result in the Semen Mountain National Park (Tibebu and Teshome, 2015), Mountain Dirki woodland (Deresa, 2015), and Egdu Forest (277.56 ton/ha) (Adugna *et al*., (2013), while it showed dissimilarity with the study by Mohammed *et al*., (2015) in Tar Gedam Forest, (Muluken *et al*., 2015) Danaba Community Forest .

The mean SOC in higher altitude, middle and lower class were 112.3±28.53ton/ha, 99.8.1±37.79 ton/ha and 97.26±28.53ton/ha respectively (Table 2). The result showed that the maximum carbon stock was found at higher altitude class, but the variation of the mean carbon stock was not different along altitude gradient ($p>0.05$) (Table 2). As a whole the higher part of altitude contains higher amounts of carbon stocks in soil might be the contained indigenous shrubs and grass which have enough litter fall, but in lower and middle altitude was unsuitable for the growth of herbs and grasses due to a huge closed canopies of *Juniperus procera* L, *Eucalyptus camaldulensis*, and *Eucalyptus globules* up to the near ground. SOC were commonly higher in the indigenous shrubs and trees than the plantation forest (Guo and Gifford, 2002).

The result of this study was similar to the study of (Alem, 2015) in selected public parks. The result of SOC showed, there was a slight variation of carbon stock along altitudinal class of the study area. SOC increased with precipitation, and decreased with temperature (Jobbagy and Jackson, 2000). In the study forest, in general increasing trend the mean of SOC with increasing altitude was observed due to open canopy in higher altitudinal class might favor the growth of annual herbs and grasses, which agreed with the result found by Belay *et al*., (2014) in Woody Plants of Arba Minch Ground Water Forest.

TABLE 2
THE MEAN ± SD CARBON STOCKS (TON/HA) ALONG ALTITUDE GRADIENT IN ALEMSAGA FOREST, SOUTH GONDAR, NORTH WESTERN ETHIOPIA.

Altitude	Carbon stock (ton/ha)		
	AGC	BGC	SOC
Lower	$123.57{\pm}84.85^{a}$	$30.89{\pm}21.21^{a}$	$97.26{\pm}37.79^{a}$
Middle	$86.9{\pm}67.19^{ab}$	$22.23{\pm}16.79^{ab}$	$99.81{\pm}28.53^{a}$
Higher	$56.54{\pm}22.32^{b}$	$14.13{\pm}22.32^{b}$	$112.3{\pm}28.53^{a}$
P	0.01	0.01	0.419

The different letter the mean value has significant differences at ($p<0.05$)

V. CONCLUSIONS AND RECOMMENDATIONS

The mean above and below ground carbon stock was 91.43±70.78ton/ha and 22.86±17.69 ton/ha respectively. In general the result showed that, the lower altitude have higher carbon stock of woody species due to the presences of larger DBH trees species and favorable environmental condition such as moisture and nutrient availability. The mean SOC of the study site was 102.15± 33.62 t/ha, but the higher part of altitude contains higher amounts of carbon stocks in soil might be the contained indigenous shrubs and grass which have enough litter fall.

Forest soil was also found to be a good reservoir of carbon stock in the study forest as relative carbon stock was found. The total carbon stock in all carbon pools were 216.68 with the corresponding value of 796.74 ton/ha CO_2eq.Therefore, proper protection and management of woody species are very important for conservation of biodiversity as well as carbon storage.

Generally, the present study can contribute towards the understanding of above and below ground carbon stock, and soil organic carbon. Therefore, further studies should be conducted on soil seed bank, regeneration status and population structure is important for future restoration/rehabilitation and better conservation of forest resources in the area.

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