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EFFECTS OF PLANT SPACING AND FERTILIZER LEVELS ON PLANT MORPHOLOGY OF HYBRID BRACHIARIA CV. MULATO II GRASS IN CHAGNI RANCH, AWI ZONE, ETHIOPIA

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ABSTRACT

A study was conducted to evaluate the effects of plant spacing and N fertilizer application on plant morphology of Brachiaria hybrid cv. Mulato II grass. A factorial experiment with 3 urea fertilizer levels (0, 50 and 100 kg/ha) and 4 spacing between plants and rows (20 x 20, 30 x 40, 40 x 60 and 50 x 80 cm) with 3 replications was used. Data collected on agronomic characteristics were plant height (PH), number of tillers per plant (NT/P), number of leaf per tiller (NL/T), number of leaves per plant (NL/P), leaf length (LL), leaf width (LW) and leaf area (LA). Results indicated that the agronomic parameters were significantly (P<0.05) affected by main effect and interaction effects of spacing and fertilizer levels. The highest NT/P, LN/T and LN/P were recorded for wider plant spacing (50 x 80 cm) with higher urea fertilizer level (100 kg/ha) (S4F3) and narrower plant spacing (20 x 20 cm) with medium higher fertilizer level (1000 kg/ha) (S1F3) gives longer plant and longer leaf. Therefore, it is concluded that it would be beneficial to produce Mulato II grass using a 50 x 80 cm spacing and 100 kg/ha urea fertilizer for maximum yield with best quality forage. Similar studies need to be conducted over much longer periods to determine to what extent these findings relate to performance over the life of a permanent pasture.

KEYWORDS: *Urea; Spacing; Plant Morphology; Mulato II*

INTRODUCTION

Livestock are an important component of nearly all farming systems in Ethiopia, providing milk, meat, draught power, transport, manure, hides and skins and serve as a source of cash income (Funk et al. 2012). The subsector contributes about 16.5% of the national Gross Domestic Product (GDP) and 35.6% of the Agricultural GDP. It also contributes 15% of export earnings and 30% of agricultural employment. The livestock subsector currently supports and sustains livelihoods for 80% of the total rural population (Samson and Frehiwot 2014). Despite the importance of livestock in the country, productivity is low (Sintayehu et al. 2010). One of the major constraints leading to such low productivity is shortage of feed in terms of both quantity and quality, especially during the dry season (Ahmed et al. 2010), combined with high feed prices (Sintayehu et al. 2010).

In order to solve the shortage of feed and increase livestock production, it is necessary to introduce and cultivate high-quality forages with high yielding ability and adaptation to the biotic and abiotic environmental stresses (Kahindi et al. 2007). Improved grasses, many of African origin, have greater palatability and productivity than other indigenous species and are therefore desirable additions to pastures and common grazing areas (Alemayehu 2002). Among the improved forage crops introduced into Ethiopia, Mulato II grass, which is the result of crosses of *Brachiaria ruziziensis, B. brizantha* and *B. decumbens*, is claimed to have the capacity to provide a significant amount of quality forage (CIAT 2006).

The optimization of production and nutritive value of grass can be achieved by planting on fertile soils (ILRI 2010) and utilizing forage management tools such as plant spacing (Sumran et al. 2009). Nitrogen fertilizer application is a common practice since this nutrient is found to be one of the most limiting factors influencing yield and chemical composition of grass pasture including crude protein (CP) concentration and digestibility, increases in which improve livestock production (Marques et al. 2017). Nevertheless, information regarding the effects of fertilizer levels and plant spacing on plant morphology of Mulato II grass is scarce in our country and specifically in the study area. I conducted the present study in order to generate information on plant morphology of Mulato II grass at different plant spacings with different rates of nitrogen fertilizer.

MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted in Chagni Ranch, Guangua Woreda, Awi Zone, Amhara National Regional State, Ethiopia. Chagni (10°57′N, 36°30′E; 1,583 masl), located at 528 km from Addis Ababa and 186 km west of Regional town, Bahir Dar, is the administrative center of Guangua District (Asnake 2009). The area has average annual rainfall of 1,689 mm and mean minimum and maximum annual temperatures of 23 ºC and 30 ºC, respectively (Chagni ranch office).

Experimental Layout, Design and Treatments

The study was conducted using a 3 x 4 factorial arrangement in a randomized complete block design (RCBD) with 3 replications. The factors were 3 levels of urea fertilizer (0, 50 and 100 kg/ha) and 4 spacings (20 x 20, 30 x 40, 40 x 60 and 50 x 80 cm) between plants and rows, respectively, giving 12 treatment combinations (Table 1) and 36 experimental plots.

Table 1 shows S1 = 20 x 20 cm spacing; S2 = 30 x 40 cm spacing; S3 = 40 x 60 cm spacing; S4 = 50 x 80 cm spacing between plants and rows, respectively; T = treatments 1-12; F1= 0 kg urea/ha; F2 = 50 kg urea/ha; F3 = 100 kg urea/ha.

Each plot was 3 m long by 3.2 m wide with a gross plot size of 9.6 m^2 and the total experimental area was 12.6 m by 41.5 m (522.9 m^2). The spacings between plots and replications were 0.5 and 1.5 m, respectively**.** Treatments were randomly assigned to plots within each replication.

Table 1: Treatment Combinations

Fertilizer Level	Spacing			
	S1	S2	S3	S4
F1	F1 X S1 [T1]	F1 X S2 [T2]	F1 X S3 [T3]	F1 X S4 [T4]
F2	F1 X S1 [T5]	F2 X S2 [T6]	F2 X S3 [T7]	F2 X S4 [T8]
F3	F3 X S1 [T9]	F3 X S2 [T10]	F3 X S3 [T11]	F3 X S4 [T12]

Land Preparation, Experimental Management, Soil Sampling and Analysis

Land was oxen-ploughed and harrowing and bed preparation were carried out before planting manually. Root splits of Mulato II grass were collected from Finota Selam grass nursery site at an age of 7 months regrowth and planted at the experimental site on 6 September 2017. Urea was purchased from the local market and applied by split application with half applied at planting and the remainder at 30 days after planting with different levels based on treatment. Weeding was done manually during the experimental period. The experiment was irrigated once a week when rain was limited, with precautions taken to avoid contamination of treatments by cross flooding. Soil samples were taken by auger from the center and corners of the experimental site prior to planting and from the individual plots immediately after harvesting to a depth of 15 cm. The collected samples were thoroughly mixed, dried, ground and preserved in plastic bags for chemical analysis to evaluate total nitrogen, available phosphorus, pH, organic matter and organic carbon. Total N was determined using the Kjeldahl procedure (Bermner and Mulvaney 1982) and available P using the Olsen method (Olsen et al. 1954). The total organic carbon of soil was determined based on the Walkely-Black chromic acid wet oxidation method. Organic matter (OM) was calculated indirectly from organic carbon (OC) concentration by multiplying OC by 1.724 and the pH was determined using the method described by Van Reeuwijk (1993).

Plant Morphology Data Measurement

Data on the plant morphology of the Mulato II grass were recorded at 90, 105, 120, 135 and 150 days after planting (with 15 days interval). Plant height was measured from ground level to the tip of the main stem using a tape measure. Tiller number per plant was determined by counting the number of tillers on the 10 randomly selected plants per plot. Leaf number was also determined by counting the number of leaves on the 10 randomly selected plants per plot Leaf length per plant was measured from the base of the collar region of the leaf to the tip of the leaf.

Statistical Analysis

Data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS 2007). Differences among treatment means were determined using Duncan's Multiple Range Test (DMRT) at $P<0.05$. The statistical model used was:

$$Y_{ijk} = \mu + B_i + F_j + S_k + (FS)_{jk} + e_{ijk},$$

where

Y_{ijk} = the response variable;

μ = overall mean;

B_i = i^{th} block effect;

F_j = j^{th} main factor effect (fertilizer level);

S_k = k^{th} main factor effect (spacing);

$(FS)_{jk}$ = jk^{th} interaction effect (fertilizer level x spacing); and

e_{ijk} = random error.

RESULT AND DISCUSSIONS

Plant morphology of *Brachiaria* Hybrid (Mulato II) grass

Tiller Number per Plant

The effect of N fertilizer level and spacing between plant and raw, and interaction was highly significant ($p<0.01$) on number of tiller. The highest tiller number was recorded at 100kg/ha urea level where as lowest was at non fertilized one at different sampling days (Table 2). This indicates, the tiller number was increased as urea level increased may be due to enhancing development of new shoots of grass by increasing soil fertility. This result is conformity with Tessema *et al.*, (2003) reported that; Tillers per plant was significantly affected by fertilizer application which increased as fertilizer level increased. Similarly Abdi (2014) on *cenchrus ciliaris* and *panicum maximum* showed tiller number increased with increasing rate of fertilizer indicating fertilizer application enhanced development of new shoots and encourages the development of new tillers. The numbers of tillers in all N treatments were higher than control (no N fertilizer) (Joorabi *et al*., 2014). In contrast to this, N significantly affected tiller numbers of the grasses, with 40 kg/ha N producing nearly 50% more tillers than plants receiving no N and N at 80 kg/ha reduced tiller numbers. This reduction may have been due to an abundance of green leaves from high N reducing tillering (Charouvanh *et al*., 2011).

Number of tillers per plant was significantly ($p<0.05$) affected by spacing, with highest value of at 50x80 spacing between plant and row (Table 2). In this study the tiller number was high at wider spacing, this may due to reduce competition of light, moisture, nutrient and space between plant which enhance nutrient consumption and new tiller initiation. The result is similar with other study (Genet, *et al*., 2017) reported that plant spacing had significant effects on tiller numbers. Corresponding number of tillers for different plant spacings were low at closest and high at wide spacing. In similar way, the number of tillers per plant of Bana grass increased as plant spacing increased due to that; at wider spacing, light can easily penetrate to the base of the plant, competition for nutrients is less and this may have stimulated tiller development (Birhanu, 2005). The highest and lowest tiller number in lemongrass was found at wider and closer inter row spacing respectively. In general, as the plant to plant and row to row spacing gets narrower, the number of tillers per hill decreased linearly. The reduction in tiller number per hill with deceasing intra and inter-row spacing may be due to superior plant competition for incident light, soil nutrient, soil moisture and mutual shading of each other at high plant density than at low plant density (Lulie and Chala, 2016). Nadaf (2009) on *Chloris gayana* and *Coelachyrum piercei* reported among the row-spacings, the mean number of tillers in wider was significantly higher than in closest spacing. Tillers per plant generally explained most of the differences in dry matter yield among sites and plant spacings. Orchard grass tiller more with greater plant spacing (Sanderson and Elwinger, 2002).

The interaction was also ($p<0.01$) significant on number of tillers. The highest tiller number was recorded at wider spacing (50x80cm) with 100kg/ha urea, this may be due to the reduction of competition of adequate ventilation and nutrients between plant which increased by increasing urea level. Similar to this, Olanite (2010) found that plants received N at the various levels generally performed better than the control (zero N fertilizer) for all the growth parameters under the different plant spacing arrangements. Tiller number were greater at less dense row spacing that received high fertilizer level (120 and 180 kg N/ha).

Table 2: Tiller Number Per Plant

			Days			
Fertilizer kg/ha	90	105	120	135	150	165
0	5.77^{b}	8.81^{b}	18.91^{b}	21.3^{b}	29.91^{b}	58.27^{b}
50	7.88^{a}	11.8^{ab}	21.33^{ab}	24.25^{b}	35.14^{ab}	81.3^{a}
100	8.11^{a}	12.52^{a}	23.55^{a}	30^{a}	38.91^{a}	88.21^{a}
P-value	<0.001	<0.01	<0.01	<0.001	<0.001	<0.001
Spacing						
Table 2 Contd.,						
20x20	5.81^{b}	8.38^{c}	19.29^{b}	19.48^{c}	25.77^{b}	59.58^{c}
30x40	6.33^{bc}	8.59^{bc}	19.59^{b}	20.37^{c}	29.55^{b}	73.55^{b}
40x60	7.29^{b}	10.96^{b}	21.26^{b}	25.59^{b}	39.18^{a}	81.59^{ab}
50x80	9.59^{a}	14.92^{a}	24.92^{a}	35.29^{a}	44.11^{a}	88.99^{a}
P-value	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001
Fertilizer * Spacing						
0 * 20x20	4.44^{e}	8.16^{bc}	18.88^{c}	20^{cd}	23.44^{f}	40.77^{e}
0*30x40	6^{cde}	8.55^{bc}	18.11^{c}	20.55^{cd}	29.33^{cdef}	63.21^{d}
0*40x60	5.44^{de}	9.11^{bc}	18.11^{c}	20.11^{cd}	37.44^{bcde}	63.21^{d}
0*50x80	7.22^{bcd}	9.44^{bc}	20.55^{c}	24.55^{c}	29.44^{cdef}	65.88^{d}
50*20x20	6.33^{cde}	10.22^{bc}	19.55^{c}	16.78^{d}	27.55^{def}	69.66^{cd}
50*30x40	7.66^{bcd}	10.66^{bc}	18.11^{c}	21.55^{cd}	29.55^{cdef}	73.33^{cd}
50*40x60	9.11^{b}	12.11^{b}	27.11^{b}	34.44^{b}	38.89^{bcd}	83.88^{bc}
50*50x80	8.44^{bc}	10.22^{bc}	20.55^{c}	24.22^{cd}	44.55^{b}	98.33^{ab}
100*20x20	6.66^{bcde}	6.78^{c}	19.44^{c}	21.66^{cd}	26.33^{ef}	68.33^{cd}
100*30x40	5.33^{de}	6.55^{c}	22.55^{bc}	19^{cd}	29.77^{cdef}	84.11^{bc}
100*40x60	7.33^{bcd}	11.66^{b}	18.55^{c}	22.22^{cd}	41.22^{b}	97.66^{ab}
100*50x80	13.11^{a}	25.11^{a}	33.66^{a}	57.11^{a}	58.33^{a}	102.76^{a}
p-value	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001
CV	19.79	23.1	15	15.49	18.53	11.57
SE	1.43	2.47	3.19	3.9	6.42	8.79

20x20cm, 30x40cm, 40x60cm, 50x80cm are spacing between plant*between raw, 0= 0kg/ha urea, 50= 50kg/ha urea, 100= 100kg/ha urea, CV = coefficient of variation, SE = standard error, means with different letters at same category are indicated significant different, whereas means with the same letters showed non-significant

Plant Height

The effect of spacing, urea level and their interaction was significant ($p<0.05$) on plant height (Table 3). The narrowest spacing gave highest plant height and which reduced as the spacing increased; this may be due to that; Interplant competition in grass causes rapid and exhaustive height increments. This result is in line with Birhanu (2005) plant height of Bana grass was the highest at low inter-and intra-row spacing as compared to wider spacing. Contrary to this, plant height increased with the lower spacing densities on the field showing observable differences on maize (Ukonze *et al*., 2016). Similarly, Nadaf, *et al*. (2009) reported that *Cenchrus ciliaris* had significantly higher mean plant height of 114.5 cm at 100--cm row spacing than at 50--cm row spacing (110.5 cm). No significant differences between plant spacing on plant height was detected among the spacing levels, but the narrower plant spacing 10cm gave the tallest plants compared to 15cm and 20cm (Martin ceasar lolia lamina, 2007). In addition, Plant height of Sorghum was not affected by row spacing in studies for which plant height data were available (John *et al*., 2012).

Plant height was also significantly affected ($p<0.05$) by urea level. It was highest at 100kg/ha fertilized and lowest at non-fertilized (Table 3). This result indicates that, as the fertilizer level increased the plant height increased because of increasing required nutrient (N) for grass development. This result is similar with Mechi (2015) on Zea maize reported the increases in plant height with respect to increased N application rate could be due to the maximum vegetative growth of the plants under higher N availability. The rates of N application significantly affected plant height of Zea maize. It increased with increasing N rates. So, the maximum plant height was obtained with the highest N rate, while the least value was recorded in plots without N application (Sharifi and Namvar, 2016). Application of nitrogen fertilizer showed significantly higher plant height of cowpea than that obtained in control group having no fertilizer (Hasan, *et al*., 2010). In contrary to this, plant height is not significantly affected by fertilizers. The non significant response of the crop obtained in this study may be due to the previous experiments in the site and the different agronomic practices done on it (Ahmed *et al*., 2013) and no difference was observed for height among the different nitrogen rates on *cenchrus ciliaris* and *panicum maximum* (Abdi, 2014).

The fertilizer level and spacing interaction also significantly affect ($p<0.05$) plant height. The highest value was observed at interaction 20x20cm spacing and 100kg/ha urea (Table 3). In contrary, plant height on Zea maize increased significantly with the increase in the rate of nitrogen application and inter row spacing. The increases in plant height with respect to increased N application rate could be due to the maximum vegetative growth of the plants under higher N availability. At wider spacing there is low competition for growth resources and plant height increased with lower plant densities (Mechi, 2015). Similarly, Olanite, *et al*. (2010) on Sorghum reported as, plant height was greater at less dense row spacing that received 120 and 180 kg N/ha).

Table 3: Plant Height

			Days			
Fertilizer (kg/ha)	90	105	120	135	150	165
0	4.83^{c}	5.2^{c}	14.5^{c}	18.88^{b}	21.36^{c}	33.13^{b}
50	5.55^{b}	6.47^{b}	17.55^{b}	20.3^{ab}	23.47^{b}	34.33^{b}
100	6.93^{a}	8.37^{a}	22.05^{a}	21.61^{a}	28.77^{a}	41.24^{a}
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
Spacing (cm)						
20x20	8.94^{a}	9.47^{a}	22.59^{a}	24.25^{a}	28.03^{a}	41.92^{a}
30x40	5.09^{b}	5.87^{b}	17.59^{b}	21.48^{b}	23^{c}	36.22^{b}
40x60	4.94^{b}	5.53^{b}	17.00^{b}	17.51^{c}	25.14^{b}	34.25^{b}
50x80	4.11^{c}	5.84^{b}	14.96^{c}	17.81^{c}	21.96^{c}	36.77^{b}
P-value	<0.001	<0.001	<0.001	<0.05	<0.001	<0.001
Fertilizer * Spacing						
0 * 20x20	46.16^{c}	6.32^{cde}	16.77^{cde}	19.11^{cdef}	21.55^{def}	36.32^{b}
0*30x40	4.22^{def}	4.85^{fg}	15^{ef}	21.11^{bcd}	21.11^{def}	36.33^{b}
0*40x60	5.05^{cdef}	4.33^{g}	13.44^{fg}	15.89^{f}	22.22^{cdef}	32.99^{bc}
0*50x80	3.88^{f}	5.29^{efg}	12.78^{g}	19.44^{bcdef}	20.55^{ef}	36.55^{b}
50*20x20	8.33^{b}	8.42^{b}	16.78^{cde}	23.55^{b}	22^{cdef}	28.66^{c}
50*30x40	5.16^{cde}	5.72^{cdef}	18^{bcd}	20.33^{bcde}	23^{cdef}	36.33^{b}
50*40x60	4.33^{def}	5.53^{defg}	19.22^{b}	20.22^{bcde}	29.11^{b}	37.33^{b}
50*50x80	4.39^{def}	6.22^{cde}	16.22^{cde}	17.11^{def}	19.77^{f}	34.99^{bc}
100*20x20	12.33^{a}	13.68^{a}	34.22^{a}	30.11^{a}	40.55^{a}	60.77^{a}
100*30x40	5.89^{c}	7.03^{c}	19.7^{b}	22.99^{bc}	24.89^{cd}	32.99^{bc}
100*40x60	5.44^{c}	6.74^{cd}	18.33^{bc}	16.44^{ef}	24.11^{cde}	32.44^{bc}
100*50x80	4.05^{ef}	6.03^{cdef}	15.88^{de}	16.89^{def}	25.55^{c}	38.77^{b}
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CV	11.5	10.64	6.68	10.96	8.26	9.8
SE	0.66	0.71	1.2	2.22	2.02	3.66

20x20cm, 30x40cm, 40x60cm, 50x80cm are spacing between plant*between raw, 0= 0kg/ha urea, 50= 50kg/ha urea, 100= 100kg/ha urea, CV = coefficient of variation, SE = standard error, means with different letters at same category are indicated significant different, whereas means with the same letters showed non-significant

Leaf Number per Tiller

Number of leaf per tiller was significantly (p<0.05) affected by spacing, fertilizer level and their interaction (Table 4). The highest leaf number per tillier was recorded at highest (100kg/ha) fertilizer levll as compared to other levels of urea. This indicates the number of leaf per tiller was increased as fertilizer level increased; may be due to as fertilizer level increase the soil fertility also increased. The highest leaf number per tiller was recorded at wider spacing (50x80cm) with 100kg/ha urea, this may be due to the reduction of competition of adequate ventilation and nutrients between plant which increased by increasing urea level; this enhance formation of new leaves.

The spacing between plant and raw was also significantly (p<0.05) affect the leaf number per tiller which increased as spacing become wide, this may be because of as spacing is wide the plants absorbed soil nutrients freely and they become vigorous. The maximum mean was recorded at wider as compared to narrow spacing (Table 4). In wider space the plants have less competition of light, moisture, space, nutrient and the individual tiller become branching of leafy. However, effect of planting patterns was not significant affect leaf number per tiller (Birhanu, 2005).

Table 4: Leaf Number per Tiller

			Days			
Fertilizer (kg/ha)	90	105	120	135	150	165
0	3.06^{b}	4.72	5.43^{b}	5.45^{b}	5.75^{b}	7.24
50	3.13^{b}	4.76	5.64^{b}	6.00^{ab}	6.36^{b}	7.3
100	4.34^{a}	5.09	6.27^{a}	6.28^{a}	7.33^{a}	7.52
P-value	<0.001	>0.05	<0.01	<0.05	<0.05	>0.05
Spacing (cm)						
20x20	3.07	4.27^{b}	5.36^{b}	5.33	6.03^{b}	6.44^{c}
30x40	3.54	4.83^{a}	5.59^{b}	5.7	6.18^{b}	7.21^{bc}
40x60	3.61	5^{a}	5.77^{b}	6.18	6.59^{ab}	7.51^{ab}
50x80	3.83	5.33^{a}	6.4^{a}	6.41	7.11^{a}	8.25^{a}
P-value	>0.05	<0.05	<0.01	>0.05	<0.001	<0.01
Fertilizer * Spacing						
0 * 20x20	2.38^{e}	4^{cd}	5.33^{cde}	5.33^{bc}	5.77^{c}	6.55
0*30x40	3.59^{bcd}	4.66^{bcd}	5.11^{de}	4.67^{c}	5.66^{c}	7.44
0*40x60	3.29^{bcde}	4.89^{bc}	5.11^{de}	5.33^{bc}	5.44^{c}	6.77
0*50x80	3^{cde}	5.33^{b}	6.22^{abcd}	6.44^{ab}	6.11^{bc}	8.22
50*20x20	2.58^{de}	5.11^{b}	5.66^{bcde}	5.22^{bc}	5.88^{c}	6.1
50*30x40	2.75^{de}	5^{b}	5^{e}	6.55^{ab}	6^{c}	7.44
50*40x60	3.92^{bc}	4.89^{bc}	5.89^{abcde}	6.78^{ab}	6.78^{bc}	8.44
50*50x80	3.27^{bcde}	4^{cd}	6^{abcde}	5.44^{bc}	6.78^{bc}	7.22
100*20x20	4.25^{ab}	3.72^{d}	5.11^{de}	5.44^{bc}	6.44^{bc}	6.66
100*30x40	4.27^{ab}	4.77^{bc}	6.67^{ab}	5.89^{abc}	6.89^{ab}	6.77
100*40x60	3.62^{bcd}	5.22^{b}	6.33^{abc}	6.44^{ab}	7.55^{ab}	7.33
100*50x80	5.22^{a}	6.66^{a}	7^{a}	7.33^{a}	8.44^{a}	9.33
p-value	<0.001	<0.001	<0.05	<0.05	<0.01	>0.05
CV	17.28	10.79	10.5	13.55	11.81	12.76
SE	0.6	0.52	5.78	0.8	0.76	0.93

20x20cm, 30x40cm, 40x60cm, 50x80cm are spacing between plant*between raw, 0= 0kg/ha urea, 50= 50kg/ha urea, 100= 100kg/ha urea, CV = coefficient of variation, SE = standard error, means with different letters at same category are indicated significant different, whereas means with the same letters showed non-significant

Leaf Number per Plant

Inter raw and intra raw spacing, fertilizer levels, and their interaction was significantly ($p<0.05$) affect leaf number per plant (Table 5). The number of leaf per plant was increased as fertilizer level increased. This may be due to higher number of tiller per plant was recorded at this level as a result of increasing soil fertility and soil nutrient. Contrary to this, number of leaves per plant of Rhodes grass was not significantly affected by fertilizers. The non significant response obtained in this study may be due to the previous experiments in the site and the different agronomic practices done on it (Ahmed *et al*., 2013). The highest leaf number per plant was recorded at wider spacing (50x80cm) with 100kg/ha urea, this may be due to the reduction of competition of adequate ventilation and nutrients between plant which increased by increasing urea level; this enhance formation of new leaves.

Spacing between plant and raw was also significantly ($p<0.05$) affect leaf number per plant. The number of leaf per plant was slightly increased as spacing become wider; this may be due to higher tillering and less competition between plants. The value collected at narrow spacing (20x20cm) was lowest as compared to wider spacing (50x80cm) spacing (Table 5). The present result agree with the result observed by Lulie and Chala (2016), who reported that the higher leaves number per hill was observed at wider intra and inter row spacing. The increased leaf number per hill at wider row spacing probably due to higher tiller number of lemongrass at larger intra and inter row spacing. Contrary to this, leaf number per plant, which in part, determines the photosynthetic capacity of the plants, was not significantly affected by plant spacing (Birhanu, 2005; Genet *et al*., 2017). Similarly, no significant differences in number of leaves per plant between plant spacing were reported. This could be attributed to difference in environmental conditions (Martin ceasar lolia lamina, 2007).

Table 5: Leaf Number per Plant

			Days			
Fertilizer (kg/ha)	90	105	120	135	150	165
0	18.17[c]	42[b]	103.69[b]	113.9[c]	184.71[b]	338.82[b]
50	25.25[b]	51.81[b]	121.43[b]	139.5[b]	205.68[b]	562.06[a]
100	36.47[a]	71.44[a]	151.29[a]	165.7[a]	284.08[a]	649.05[a]
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Spacing (cm)						
20x20	18.42[b]	36.51[c]	103.41[b]	88.45[c]	152.95[c]	368.62[c]
30x40	21.8[b]	41.83[bc]	110.76[b]	110.47[c]	186.16[c]	502.12[b]
40x60	26.74[b]	55.57[b]	123.8[b]	149.02[b]	257.25[b]	564.5[ab]
50x80	39.57[a]	86.45[a]	163.9[a]	210.85[a]	302.95[a]	631.29[a]
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Fertilizer * Spacing						
0 * 20x20	10.58[d]	31.61[bc]	99.88[d]	97.78[de]	127.12[f]	230.04[f]
0*30x40	21.21[bcd]	40.04[bc]	92.56[d]	96.22[de]	174.07[ef]	389.67[def]
0*40x60	19.24[cd]	46.38[bc]	93.76[d]	106.88[de]	252.42[bcd]	343.06[ef]
0*50x80	21.67[bcd]	49.99[bc]	128.55[bcd]	154.71[c]	185.25[def]	392.52[def]
50*20x20	16.45[cd]	52.79[bc]	111.13[cd]	78.38[e]	161.58[ef]	426.82[def]
50*30x40	21.22[bcd]	54.05[bc]	91.48[d]	134.43[cd]	179.64[def]	546.47[bcd]
50*40x60	35.57[b]	59.39[b]	159.98[b]	211.62[b]	211.72[cde]	630.56[bc]
50*50x80	27.75[bc]	41.04[bc]	123.12[bcd]	133.57[cd]	269.78[bc]	644.39[bc]
100*20x20	28.24[bc]	25.13[c]	99.23[d]	89.2[de]	170.15[ef]	449.01[cde]
100*30x40	22.96[bcd]	31.4[bc]	148.23[bc]	100.76[de]	204.77[cde]	570.32[bcd]

Table 5 (Contd.,)

100*40x60	25.41^{bcd}	60.96^{b}	117.65^{bcd}	128.57^{cd}	307.6^{b}	719.88^{ab}
100*50x80	69.28^{a}	168.29^{a}	240.03^{a}	344.27^{a}	453.81^{a}	856.97^{a}
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CV	30.83	28.42	19.52	17.67	17.72	20.4
SE	8.21	15.66	24.49	24.69	39.84	10.39

20x20cm, 30x40cm, 40x60cm, 50x80cm are spacing between plant*between raw, 0= 0kg/ha urea, 50= 50kg/ha urea, 100= 100kg/ha urea, CV = coefficient of variation, SE = standard error, means with different letters at same category are indicated significant different, whereas means with the same letters showed non-significant

Leaf Length

Leaf length was significantly ($p<0.05$) affected by spacing at 90, 105, 120 and 165 sampling day; but not significant at other days. In this study the longest leaf length was recorded at narrow inter and intra-raw spacing (20x20cm) with value of and smallest at wider spacing (50x80cm) (Table 6). This may be due to that; in narrow spacing the plant competition was high which increase individual weak leaf length but not number. This study supported by Genet *et al.* (2017) reported as individual leaves were longer at narrow than wider spacing plant spacing. Birhanu (2005) report opposite effect on Bana grass, where the leaves obtained from the relatively narrow spacing were shorter in length from the leaves obtained on plants for relatively medium and wider planting patterns.

The fertilizer level also highly ($p<0.01$) affect individual leaf length at different sampling, which was increased as fertilizer level increased from 0kg/ha to 100kg/ha (Table 6), this may be urea has ability to increase the absorption of required nutrient from soil which enhance growth development of leaves.

Leaf length was also significantly ($p<0.05$) affected by interaction between spacing and fertilizer level. The longest leaf was recorded at 20x20cm between plant and raw spacing which fertilized with 100kg/ha urea (Table 6).

Table 6: Leaf Length

			Days			
Fertilizer (kg/ha)	90	105	120	135	150	165
0	11.16^{b}	3.83^{b}	15.97^{b}	16.42^{b}	19.3^{b}	23.24^{b}
50	13.07^{a}	14.06^{b}	17.5^{a}	17.75^{ab}	20.04^{b}	25.1^{ab}
100	13.72^{a}	16.19^{a}	18^{a}	19.14^{a}	22.72^{a}	26.1^{a}
P-value	<0.001	<0.05	<0.01	<0.05	<0.001	<0.05
Spacing (cm)						
20x20	14.06^{a}	15.48^{a}	18.92^{a}	19.03	21.37	27.84^{a}
30x40	12.83^{ab}	15.45^{a}	17.19^{b}	17.98	21.51	23.99^{b}
40x60	11.96^{b}	15.29^{a}	16.62^{bc}	16.63	20.46	23.88^{b}
50x80	11.76^{b}	12.59^{b}	15.88^{c}	17.43	19.4	23.55^{b}
P-value	<0.01	<0.05	<0.001	>0.05	>0.05	<0.01
Fertilizer * Spacing						
0 * 20x20	11.96^{cde}	14.22^{ab}	16.44^{cde}	15.77^{cd}	19.22^{bc}	22.9^{b}
0*30x40	10.66^{de}	14.44^{ab}	16.57^{cde}	18.06^{abc}	18.89^{bc}	24.5^{b}
0*40x60	11.18^{de}	14.55^{ab}	15.64^{de}	15.44^{cd}	18.66^{bc}	22.9^{b}
0*50x80	10.84^{de}	12.11^{b}	15.22^{e}	16.42^{cd}	20.44^{b}	22.4^{b}
50*20x20	15.22^{a}	14.78^{ab}	19.55^{ab}	20.66^{ab}	20.66^{b}	26.9^{b}
50*30x40	14.76^{ab}	14.7^{ab}	17.33^{cde}	18.11^{abc}	21.66^{ab}	23.2^{b}
50*40x60	10.61^{e}	13.44^{ab}	15.89^{de}	18.33^{abc}	21.16^{ab}	24.3^{b}
50*50x80	11.7^{cde}	13.33^{ab}	17.22^{cde}	13.88^{d}	16.67^{c}	25.8^{b}
100*20x20	15^{ab}	17.44^{a}	20.78^{a}	20.66^{ab}	24.22^{a}	33.5^{a}

Table 6 (Contd.,)						
100*30x40	13.09[abcd]	17.22[a]	17.66[bcd]	17.77[bcd]	24[a]	24.2[b]
100*40x60	14.05[abc]	17.77[a]	18.33[bc]	16.11[cd]	21.55[ab]	24.3[b]
100*50x80	12.74[bcde]	12.33[ab]	15.22[e]	22[a]	21.11[ab]	22.3[b]
p-value	<0.001	>0.05	<0.01	<0.01	<0.001	<0.01
CV	10.02	16.41	6.87	11.69	8.34	9.9
SE	1.26	2.41	1.17	2.07	1.72	2.45

20x20cm, 30x40cm, 40x60cm, 50x80cm are spacing between plant*between raw, 0= 0kg/ha urea, 50= 50kg/ha urea, 100= 100kg/ha urea, CV = coefficient of variation, SE = standard error, means with different letters at same category are indicated significant different, whereas means with the same letters showed non-significant

Leaf Area

The data regarding leaf area showed that the main effect and interaction of fertilizer level and plant and raw spacing effect was no significant (p>0.05) on leaf area (Table 7). The leaf area was ranged from 24.87 cm^2 to 30.27 cm^2. This result is similar with Mechi (2015), where data regarding leaf area showed that the main effect and the interaction effect of N level and inter row spacing had no significant effect on maize leaf area. Similarly, no significant difference between plant spacing on leaf area was detected among the different spacing levels (Martin ceasar lolia lamina, 2007). Contrary to this, plant leaf area was affected significantly as observed between the highest and lowest populations. The leaf area reduced with closer plant density (Ukonze *et al*., 2016).

Table 7: Leaf Area

			Days			
Fertilizer (kg/ha)	90	105	120	135	150	165
0	13.57[b]	20.38	27.02	24.45	28.54	38.78
50	18.29[a]	21.55	26.26	26.78	32.32	40.99
100	17.63[a]	24.71	28.02	27.24	34.82	41.93
P-value	<0.05	>0.05	>0.05	>0.05	>0.05	>0.05
Spacing (cm)						
20x20	18.12	25.02	30.71	27.12	31.9	44.1
30x40	18.39	23.64	27.83	26.08	33.31	40.1
40x60	16.04	22.4	23.95	26.24	32.79	38.83
50x80	13.44	17.79	25.9	25.18	29.58	39.23
P-value	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
Fertilizer * Spacing						
0 * 20x20	13.02	23.71	31.41	22.89[bc]	27.95	38.16
0*30x40	14.16	21.05	25.69	26.17[abc]	29.26	39.95
0*40x60	14.17	20.13	24.08	23.73[abc]	27.3	39.8
0*50x80	12.95	16.62	26.9	25[abc]	29.68	37.22
50*20x20	22.51	23.82	29.92	32.21[a]	31.77	42.84
50*30x40	22.42	23.66	29.77	25.89[abc]	35.33	40.66
50*40x60	14.22	21.46	20.85	31.06[ab]	37.3	37.34
50*50x80	14.03	17.27	24.51	17.97[c]	24.86	43.16
100*20x20	18.83	27.53	30.82	26.26[abc]	35.98	51.29
100*30x40	18.58	26.23	28.03	26.2[abc]	35.34	39.7
100*40x60	19.72	25.61	26.93	23.91[abc]	33.76	39.35
100*50x80	13.35	19.49	26.31	32.58[a]	34.19	37.35
p-value	>0.05	>0.05	>0.05	<0.05	>0.05	>0.05
CV	25.2	24.73	22.93	17.53	19.62	17.49
SE	4.15	5.49	6.21	4.58	6.26	7.09

20x20cm, 30x40cm, 40x60cm, 50x80cm are spacing between plant*between raw, 0= 0kg/ha urea, 50= 50kg/ha urea, 100= 100kg/ha urea, CV = coefficient of variation, SE = standard error, means with different letters at same category are indicated significant different, whereas means with the same letters showed non-significant

REFERENCES

1. *Abdi HS. 2014. Effect of nitrogen fertilizer application on agronomic traits, biomass yield and nutritive value of cenchrus ciliaris and panicum maximum grown under irrigation at gode,somali region. M.sc. Thesis. November, 2014. Haramaya university.*
2. *Ahmed, H., Abule, E., Mohammed, K., Treydte A.C. 2010. Livestock feed resources utilization and management as influenced by altitude in the Central Highlands of Ethiopia. Livestock research for rural development. http://www.lrrd.org/lrrd/22/12/cont2212.htm.*
3. *Ahmed M. Yossif IM, Yassin M. Ibrahim YM. 2013. Effect of Organic and Inorganic Fertilizers on Proximate Analysis of Rhodes Grass (Chloris gayana L. Knuth.). Universal Journal of Plant Science. 1(4): 137-140.*
4. *Alemayehu M. 2002. Forage production in Ethiopia: a Case study with implications for livestock production. Ethiopian society of animal production. Addis Ababa, Ethiopia.*
5. *Alemayehu M, 2004. Pasture and forage resource profiles of Ethiopia. EDM printing Press, Addis Ababa, Ethiopia.*
6. *Asnake K. A. 2009. Federalism and ethnic conflict in Ethiopia: a comparative study of the Somali and Benishangul-Gumuz regions Department of Political Science, Faculty of Social and Behavioural Sciences, Leiden University, Doctoral thesis, p. 219*
7. *Berihun M. 2005. Effect of planting patterns and harvesting days on yield and quality of bana grass [pennisetum purpureum (l.) X pennisetum americanum (l.)]. Msc. Thesis, Alemaya, Ethiopia.*
8. *Bermner, and Mulvaney, 1982. Total nitrogen. In: p.l., Miller, and. Keeny (eds.), 1965. Methods of soil analysis II. Chemical and Microbiological properties. American Society of Agronomy, Wisconsin Agronomy.No.9 (2nd ed.). Pp.595-624.*
9. *Charouvanh Bouathong, Michael Hare, Manas Losirikul and Kitti Wongpichet (2011). Effect of nitrogen rates on plant growth, seed yield and seed quality of three lines of brachiaria hybrid grass. KHON KAEN AGR. J. 39 : 295-306.*
10. *CIAT (Centro internacional de Agricultura Tropical), 2006. Annual Report. 2005. Project IP-5. Tropical Grasses and Legumes: optimizing genetic diversity for multipurpose use 266p.*
11. *Funk, Rowland, Eilerts, Kebebe E, Biru, White and Galu G. 2012. Climate trend analysis of Ethiopia. Climate change adaptation series. U.S. Geological survey famine early warning systems Network-Informing (FEWSNET) Fact sheet 3053. 6p.*
12. *Genet T., Bimrew A. and Yeshambel M. (2017). Effects of harvesting age and spacing on plant characteristics, chemical composition and yield of desho grass (Pennisetum pedicellatum Trin.) in the highlands of Ethiopia. Tropical Grasslands-Forrajes Tropicales. Vol. 5(2):77–84 77 DOI: 10.17138/TGFT(5)77-84*

13. *Getnet, A. 1999. Feed Resource Assessment and Evaluation of Forage Yield, Quantity and Intake of Oats and Vetches Grown in Pure Stands and in Mixtures in the highlands of Ethiopia. An MSc. Thesis, Swedish University of Agricultural Sciences. 83p.*

14. *Hasan M. R., Akbar m. A., Khandaker z. H. and Rahman m. M. 2010. Effect of nitrogen fertilizer on yield contributing character, biomass yield and nutritive value of cowpea forage. Bang. J. Anim. Sci. 2010, 39(1&2) : 83 – 88 issn 0003-3588*

15. *ILRI, 2010. Information leaflet on livestock feeds and feeding technologies for small-scale farmers. Report of World Food Prize Borlaug-Ruan Intern, Trisha Collins.*

16. *John L. Snider, Randy L. Raper, Eric B. Schwab, 2012. The effect of row spacing and seeding rate on biomass production and plant stand characteristics of non-irrigated photoperiod-sensitive sorghum (Sorghum bicolor (L.) Moench). bUSDA, Natural Resources Conservation Service, 3381 Skyway Drive, Auburn, AL, 36830-6443, USA. Industrial Crops and Products 37 (2012) 527– 53.*

17. *Joorabi S., Akbari n., Chaichi m. R., Azizi kh., 2014. Effect of sowing date and nitrogen Fertilizer on sorghum (sorghum bicolor l. Var. Speed feed) forage production in a Summer intercropping system. Vol. Xlviii, no. 3 (163)*

18. *Kahindi RK, Abdulrazak SA, Muinga RW. 2007. Effect of supplementing Napier grass (Pennisetum purpureum) with Madras thorn (Pithecellobium dulce) on intake, digestibility and live weight gains of growing goats. Small Rumin Res. 69:83–87.*

19. *Lulie B, Chala M. 2016. Influence of Plant Population Density on Growth and Yield of Lemon Grass (Cymbopogon citratus L.) ;4(3):76-84.*

20. *Marques Danilo leal; aldi fernandes de souza frança; Leonardo guimaraes oliveira; emmanuel arnhold; reginaldo nassar ferreira; Daniel staciarini correa; debora carvalho bastos; ludmilla costa brunes, 2017. Production and chemical composition of hybrid brachiaria cv. Mulato ii under a system of cuts and nitrogen fertilization.* ***Biosci. J.,*** *Uberlândia, v. 33, n. 3, p. 685-696, May/June. 2017.*

21. *Martin ceasar lolia lamina, 2007. Effect of spacing between plants on Growth and forage yield of two maize (zea mays l.) Cultivars. Sudan university of science & technology, August, 2007.*

22. *Mechi KK. 2015. Effect of nitrogen rates and inter row spacing on Growth, yield and yield components of maize (zea mays l.) At nejo, western, Ethiopia, Msc thesis. Haramaya university, haramaya.*

23. *Nadaf SK, Farsi SMA-, Hinai SAA-, Harthi AASA-, Bakri ANA. 2009. Effect of Spacing on Seed Yield of Indigenous Rangeland and Forage Grass Species Grown under Drip Irrigation;8.*

24. *Olanite J. A., Anele U. Y., Arigbede O. M., Jolaosho A. O. and Onifade O. S. 2010. Effect of plant spacing and nitrogen fertilizer levels on the growth, dry-matter yield and nutritive quality of Columbus grass (Sorghum almum stapf) in southwest Nigeria. Grass and Forage Science, 65, 369–375.*

25. *Sanderson M. A. and Elwinger G. F. 2002. Plant Density and Environment Effects on Orchardgrass–White Clover Mixtures. Crop Sci. 42:2055–2063 (2002).*

26. *SAS, 2002. Statistical Analysis System software, Version 9.0, SAS Institute, Inc., Cary, NC, USA.*

27. *sharifi RS and Namvar A. 2016. Effects of time and rate of nitrogen application on phenology and some agronomical traits of maize (zea mays l.). Vol. 62. No. 1. P. 35–45.*

28. *Sintayehu, G., Samuel, A., Derek, B., and Ayele, S. 2010. Diagnostic study of live cattle and beef production and marketing. Constraints and opportunities for enhancing the system. The report commissioned by the Bill & Melinda Gates Foundation at the request of the Government of Ethiopia.*

29. *Sumran, W., L. Pornchai, A., Chutipong, 2009. Effects of Plant Spacing on Yields and Nutritive Values of Napier Grass (Pennisetum purpureum Schumach.) Under Intensive Management of Nitrogen Fertilizer and Irrigation. Pakistan Journal of Nutrition.*

30. *Tessema Zewdu, RMT Baars and Alemu Yami, 2003. Effect of plant height at cutting and fertilizer on growth of Napier grass (Pennisetum purpureum). Trop. Sci., 42, 57–61*

31. *Ukonze, Juliana Adimonye, Akor, Victor Ojorka and Ndubuaku, Uchenna Marbeln, 2016. Comparative analysis of three different spacing on the performance and yield of late maize cultivation in Etche local government area of Rivers State, Nigeria. African Journal of Agricultural Research. Vol. 11(13), pp. 1187-1193, 31 March, 2016.*

32. *Van Reeujik, L.P. 1992. Procedure for soil analysis 2nd edition, Int. Soil Reference and Information Center (ISRIC), the Netherlands, p 371.*