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Research Article

Effects of Combined Application of Biochar and Inorganic Fertilizers on Yields and Nutritive Value of Chomo Grass (Brachiaria Humidicola) in Western Oromia, Ethiopia

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Abstract

The study was carried out to evaluate the growth performance, yields and chemical composition of chomo grass (Brachiaria humidicola) by application of different levels of coffee husk biochar and inorganic fertilizers (NPS and urea). The experimental design was a Randomized Complete Block Design with three replications. The treatments were: T1= Zero fertilizer, T2= 100% Biochar (5 t/ha), T3= 75% Biochar (3.75 t/ha) and 25% inorganic fertilizer (37.5 kg/ha), T4=50% Biochar (2.5 t/ha), 50% inorganic fertilizer (75 kg/ha), T5=25% Biochar (1.25 t/ha) and 75% inorganic fertilizer (112.5 kg/ha), T6=100% inorganic fertilizer (150 kg/ha). The result revealed that the combined application of biochar and inorganic fertilizer significantly affected ($P<0.05$) phonological variables, growth parameters except plant height, dry matter and seed yields, and chemical composition of the grass. Delayed days to 50% flowering (126.3 days) and maturity (163 days) were obtained due to the application of 100% biochar and 75% biochar with 25% inorganic fertilizer. The highest number of leaves per plant and leaf to stem ratio was recorded for T6 and T2 while the lowest was from T1 and T3, respectively. Combining of biochar and inorganic fertilizer improved dry matter and seed yields, and crude protein contents of chomo grass. The partial budget analysis also affirmed the combined application of 50% biochar with 50% recommended inorganic fertilizer (T4) gave a higher net benefit. Therefore, it is advised to use a combination of 50% biochar with 50% inorganic fertilizer (T4) to enhance the dry matter yield and nutritional value of chomo grass.

Keywords: Biochar; Chemical composition; Chomo grass; Dry matter yield; Fertilizer

Introduction

The forage productivity is low in quality and quantity due to the decline of soil fertility, rainfall variability, poor agronomic practice, and poor accessibility of quality seed. Productivity can mainly be improved through the use of improved forages, the application of fertilizers, and other good agronomic practices. Many grass species like Chomo grass have been introduced in Ethiopia. Chomo grass is a type of perennial improved grass that can be grown on farms and harvested by small-holder farmers. Chomo grass grows better in areas where a wide range of soil types from very acid-infertile (P^H 3.5) and annual rainfall is between 600 -2800 mm and altitude ranges between 1000 m and 2400 m [1]. The productivity of Chomo grass in the ranges of 7-34 t/ha/year depending on soil fertility and its nutritive value ranges between 5-17% CP when compared with natural pasture. Currently, farmers used Chomo grass for degraded land rehabilitation, sources of income in addition to forage use [2].

Fertilizers are frequently applied to enhance fodder production and quality; however, because plant tissue reflects the mineral contents of the soil in which the plants grow, quality is also negatively affected [3]. Inorganic fertilizer application is essential for plant growth and productivity of forage grass. However, the increased cost of inorganic fertilizer and application of recommended doses is difficult to be afforded by farmers. Hence, an easily accessible and low-cost organic source of plant nutrients for supplementing and enhancing chemical fertilizer should be substituted. In this context, integrated nutrient management would be an available strategy for the effective use of inorganic fertilizer with the addition of organic soil amendment. Biochar is a carbon-rich solid material that is produced during pyrolysis. Pyrolysis is a thermo chemical process that involves heating biomass without the presence of oxygen [4]. Adding biochar to soil has a variety of effects on the soil, including chemical, physical, and biological impacts [5].

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Biochar is a recently well-known organic component of an integrated nutrient supply system, which improves soil health, increases productivity, and releases some amount of macro and micronutrients [6]. The ability to retain nitrogen and prevent its leaching can increase nutrient use efficiency, thereby maintaining crop yield under small nitrogen applications [7]. However, the physical, chemical, and nutritional properties and thus the quality of biochar depends on the chemical composition of the feedstock used, the pyrolysis system, and production conditions, including temperature and residence time [8]. Soil study in the western area indicated that decline of total nitrogen which is below the critical level due to nitrogen leaching problems as the area received high rainfall and farmers have a limited cultural practice to integrate chemical fertilizer with organic amendments for enhanced forage production around study area condition is lacking. So far biochar has been applied to amend the soil for crop production and not any information is available for its application mainly around the study area. Hence, the objective of this study was to evaluate the effect of the application of different levels of biochar and inorganic fertilizer on the growth performance, productivity and chemical composition of chomo grass.

Materials and Methods

Description of the Study Site

The experiment was carried out at on station site of Haro sabu Agricultural Research Center in Kellem Wollega and Nedjo in West Wollega during the year 2019 – 2021 main cropping seasons. Haro sabu is located at 8°9'N latitude, 35°23'E longitude, with an elevation of 1515 m above sea level. It has a warm humid environment with an average annual minimum and maximum temperatures of 14 °C and 30°C, respectively. The area receives an average annual rainfall of 1000 mm. Nedjo is located at 9°30'N latitude, 35°30'E longitude and an altitude of 1821 m above sea level. The means of annual minimum and maximum temperatures were 12 °C and 26 °C, respectively. The area receives an average yearly rainfall of 1300 mm. Both the test locations have uni-modal rainfall distributions and represent the midland area.

Experimental Biochar Preparation

The coffee husk used as a feedstock was taken from a nearby coffee processing enterprise located in the study vicinity. After separating impurities, it was dried in the sun until about the moisture content of 15%, the coffee husks and then taken to the pyrolysing place. The prepared coffee husks were processed by the process of pyrolysis with a temperature of 350 °C (approximately) for 2 hours in a dug hole. After it was pyrolysed, it was watered to cool down; the biochar was taken and spread out in the sun (air-dried). Finally, the biochar was collected and put ready till it was used.

Planting Material, Experimental Design and Treatments

The planting material was Chomo grass (*Brachiaria humidicola*). A Randomized Complete Block Design was employed with three replications consisting of six fertilizer levels. The entire area of land 25 m x 15 m was selected and cleared by removing all unwanted materials before ploughing. Then, the selected land was ploughed to make a well field prior being harrowed with a hoe and rack to break down the clods. The trial field was divided into 3 blocks with 18 plots. Each plot size was 4 m x 3 m and consisted of six rows with 1m between rows. The seed rate of 6 kg/ha was used. The spacing between plots and blocks was 1 m and 1.5 m, respectively. Treatments were assigned to each plot within a block by SAS generated randomization code. The assigned plots were top-dressed using biochar at the rate of 5 t/ha for 15 days prior to planting chomo grass. The application was done in the assigned plots by incorporating coffee husk biochar into the top 15 cm of the soil with the aid of a hoe. The rate of application was made following the recommendation suggested by Dennis and Kou [9].

The assigned plots were fertilized with NPS at a rate of 100 kg/ha at planting, followed by 50 kg/ha of urea after establishment. Weeds were managed manually by slicing inters row spaces to decrease weed competition inside the replications and pest monitoring was carried out every day during the whole trial period.

Data Collected

Phonological and Agronomic Parameters

Days to 50 % flowering for chomo grass was determined by recording the number of days after planting when half of the plants were flowering. Also, days to maturity were determined by recording the number of days from planting to the time when the plant seed get matured by continuous visual observation [10]. Growth parameters like plant height and leaves number per plant were recorded at the forage harvesting stage from five sample plants selected randomly from each plot area and tagged using thread on the plant. Plant height was determined using a steel ruler and measuring the vertical from the ground to the last leaf (flag leaf) of the main shoot. The number of leaves per plant was determined by counting the total number of leaves from the main five randomly selected plants in each plot and the average of five plants was taken for each plot.

Biomass and Seed Yield

The biomass yield of forages per plot was evaluated at 50 % flowering based on continuous visual observation. Samples were collected from two inner rows of each plot and replication and harvested at stubble 5 cm height of cutting. The harvested green forage was weighed plot by plot using a sensitive field balance. The fresh sub sample was measured from the inner rows of each plot, weighed and chopped into small pieces (2-3 cm), labeled and kept in separate perforated bags. 300 gm fresh weight of subsamples was taken from each plot and dried in an oven at 65 °C for 72 hours to constant weight. The dry weight of the sub sample was reweighed to have an estimate of dry matter production as per the formula suggested by Tarawal [11]. Ripened seeds of Chomo grass, along with the inflorescence was mowed at the right stage of seed development and sweating immediately after harvest and left under a shed to assist the final maturation. Thereafter, the seeds were gently trashed to separate the seed from the sheaves, cleaned and weighed using a sensitive balance to determine seed yield.

Laboratory Analysis

From each plot, subsamples of grass were taken and dried for 72 hours at 60°C in a forced draft oven. The grass was then crushed in a Wiley mill and passed through a 1mm sieve screen for chemical analysis. The AOAC [12] procedure was used for the determination of DM, Ash and CP. The DM content was determined by oven drying at 105°C for 24 hours. The ash component was determined by igniting the dried sample in a muffle furnace at 600°°C overnight. The nitrogen is determined using the micro-Kjeldahl technique. The CP was calculated as 6.25 x

N. fibers (NDF, ADF and ADF) were determined by the Van Seost method [13].

Partial Budget Analysis

A partial budget analysis of dry matter yield for the selection of the economically feasible and profitable levels of biochar applied to the soil in combination with the inorganic fertilizer rate was done according to the CIMMYT procedure [14]. To estimate economic parameters, DM yield was valued at an average open market price of 2.52 Ethiopian birr kg^{-1}, with NPS and urea fertilizers were 16.25 and 15.60 ETB/kg, respectively. The costs of organic fertilizer preparation and application were estimated. The potential responses of the grass toward the added fertilizers ultimately determine the economic feasibility of fertilizer application [14].

Data Analysis

The data was analyzed by using GLM (ANOVA) with SAS software [15]. Significantly different means were separated and compared using least significant difference (LSD) test at 5% significance level. The model used for data analysis was:

$$Y_{ij} = \mu + B_i + T_i + e_{ij}$$

Where, Y_{ij} = Response variable; μ = Overall mean; T_i = Treatment effect; B_i = Block effect; e_{ij} = Random error.

Results and Discussion

Phonological Parameters of Chomo Grass

Analysis of variance showed a combination of biochar and inorganic fertilizers significantly ($P<0.05$) affected days to 50% flowering and days to maturity of chomo grass (Figure1). Delayed days to flowering (126.3) and maturity (163) were observed for biochar alone (T2) and 75% biochar with 25% inorganic fertilizer application (T3), while the control treatment (T1) had the earliest (119.7 and 157). This could be due to the application of biochar with inorganic fertilizer promoting vegetative growth, as it retains and contains a high amount of nutrients especially nitrogen for fast vegetative growth and longer photosynthetic apparatus by delayed flowering [16]. Similarly, Zelalem et al. [17], reported that increasing nitrogen and phosphorus fertilization levels significantly delayed the day required for 50% flowering. Delayed days to maturity results indicated that the days to physiological maturity were prolonged in response to the increased level of biochar and inorganic fertilizer.

Agronomic Parameters of Chomo Grass

Plant Height

The result showed that plant height was not significantly ($P>0.05$) affected by biochar and inorganic fertilizer applications (Table 2). The mean plant height of chomo grass in different levels of fertilizers application was 89.58 cm at Haro sabu and 81.14 cm at Nedjo sites. The overall mean plant height (85.36 cm) of chomo grass with the higher plant height (89.06 cm) was recorded at 75% biochar with 25% inorganic fertilizer application (T3) while the lower (81.76 cm) was recorded at 25% biochar with 75% inorganic fertilizer (T5) numerically. This difference was attributed to the addition of inorganic fertilizer and biochar that incites the plant cell division and increased the plant height. This result contrary to the findings of Tadesse et al. [18], reported that the application of biochar with inorganic fertilizer at different levels significantly affected the plant height of *Chloris gayana* and *Panicum coloratum*in South-western Ethiopia.

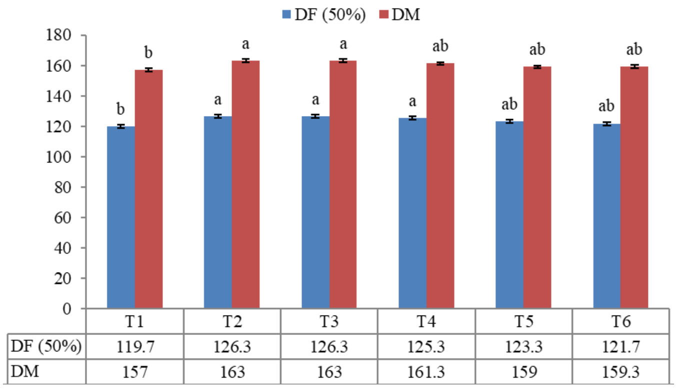

Figure 1: Days to 50% flowering and maturity of chomo grass at different level of biochar and inorganic fertilizer application.
T1= Zero fertilizer, T2= 100% Biochar (5 t/ha), T3= 75% Biochar (3.75 t/ha) and 25% inorganic fertilizer (37.5 kg/ha), T4=50% Biochar (2.5 t/ha), 50% inorganic fertilizer (75 kg/ha), T5=25% Biochar (1.25 t/ha) and 75% inorganic fertilizer (112.5 kg/ha), T6=100% inorganic fertilizer (150 kg/ha).

Number of leaves Per Plant

The leaf number per plant was significantly varied at Haro sabu between treatments due to the combined application of biochar and inorganic fertilizer though insignificant at the Nedjo site. At Haro sabu site, the highest leaf number per plant was recorded for T6 (4.4) followed by T3 (4.2), and the lowest was recorded for the control treatment (3.4). While at the Nedjo site, the higher leaves number per plant (4.67) was recorded for T5, T2 and T6, and the lower leaf number was recorded for T1 (3.93). The leaf number per plant of chomo grass across sites showed significant differences among treatments (Table 2). The highest number of leaves per plant (4.4) was recorded at 25% biochar with 75% inorganic fertilizer application (T5) which was at par with other treatments except for the control treatment (T1) while the lowest (3.67) was recorded in neither biochar nor inorganic fertilizer application (T1). Combined application of inorganic fertilizer with biochar has improved the leaf amount as compared to the control treatment. This result is in line with Saarnio et al. [19], who reported that biochar application integrated with fertilizer helps to increase plant leaf number. Xu et al. [6] also reported that considerable improvement of leaf photosynthesis and capacity were observed on biochar amended soils, which they attributed to increased leaf number and soil available nitrogen. Koul [20], reported that the level of fertilizer increased the leaf number increased due to the ability of fertilizer that promoted leaf yield via cell division and elongation. The leaf number per plant is an excellent indicator of herbage yield and nutritional value and a higher amount of leaves has a higher content of protein and digestible dry matter [21].

Table 1: Treatment arrangements for the six fertilizer levels.

Treatments	Level of fertilizer
T1	Zero fertilizer application (control)
T2	Biochar alone (100%) = 5 t/ha
T3	75% Biochar (3.75 t/ha) and 25% inorganic fertilizer (25 kg/ha NPS and 12.5 kg/ha urea)
T4	50% Biochar (2.5 t/ha) and 50% inorganic fertilizer (50 kg/ha NPS and 25 kg/ha urea)
T5	25% Biochar (1.25 t/ha) and 75% inorganic fertilizer (75 kg/ha NPS and 37.5 kg/ha urea)
T6	Inorganic fertilizer alone (100%)= 100 kg/ha NPS and 50 kg/ha urea)

Table 2: Mean plant height, leaf number per plant and leaf to stem ratio of chomo grass tested at Haro sabu and Nedjo site.

Treatments	PH (cm)			NLPP			LSR		
	Haro sabu	Nedjo	Mean	Haro sabu	Nedjo	Mean	Haro sabu	Nedjo	Mean
T1	88.53	84.86	86.70	3.40^{b}	3.93	3.67^{b}	0.43^{b}	0.49^{ab}	0.46^{ab}
T2	88.53	81.67	85.10	4.13^{ab}	4.67	4.30^{a}	0.50^{ab}	0.51^{a}	0.51^{a}
T3	94.60	83.53	89.06	4.20^{a}	4.20	4.20^{a}	0.42^{b}	0.38^{b}	0.41^{b}
T4	88.4	80.60	84.50	3.80^{ab}	4.33	4.07^{ab}	0.49^{ab}	0.47^{ab}	0.48^{a}
T5	86.33	77.2	81.76	4.13^{ab}	4.67	4.40^{a}	0.47^{ab}	0.40^{ab}	0.43^{ab}
T6	91.13	79	85.06	4.40^{a}	4.67	4.43^{a}	0.54^{a}	0.47^{ab}	0.51^{a}
Mean	89.58	81.14	85.36	4.01	4.34	4.17	0.47	0.45	0.46
CV (%)	8.84	7.48	8.05	10.52	10.41	9.74	11.49	15.14	13.55
LSD $_{(5\%)}$	ns	ns	ns	0.76	ns	0.48	0.10	0.12	0.075

$^{a-b}$ means with different letters in a column significantly differ (P<0.05).
PH=plant height; NLPP=number of leaves per plant; LSR=leaf to stem ratio; CV= coefficient of variance; LSD= least significance difference; cm= centimeter; ns= non-significant.

Leaf to Stem Ratio

Combined application of different levels of biochar with inorganic fertilizer showed significant differences (P<0.05) in the Leaf to Stem ratio of chomo grass at the forage harvesting stage (Table 2). The highest LSR (0.54 and 0.51) was recorded in sole inorganic fertilizer application (T6) and biochar alone (T2) at Haro sabu and Nedjo site, respectively. While the lowest (0.42 and 0.38) was recorded in 75% biochar with 25% inorganic fertilizer application (T3) at both sites. From the overall mean of LSR of chomo grass, the highest LSR (0.51) was recorded at sole inorganic fertilizer application (T6) and biochar alone (T2) while the lowest (0.41) was recorded in75% biochar with 25% inorganic fertilizer application (T3). Higher leaves to stem ratio is generally an indication of the better nutritional value of grass. This could be because of the slow release of nutrients from biochar that helps to enhance the increment of leaf than stem. The current result agreed with Xu et al. [6], who reported that significant improvement in leaf photosynthesis and capacity were seen on biochar-amended soils, which they attributed to increased leaf number.

Dry Matter and Seed Yields of Chomo Grass

The analysis of variance showed that dry matter yield of chomo grass was significantly (P<0.05) affected by biochar and inorganic fertilizer usage as well as at each testing site (Table 3). The highest DM yield (5.34 t/ha) was recorded from T3 and followed by T6 (5.26 t/ha), T4 (5.21 t/ha) at Haro sabu, while T5 (4.02 t/ha) gave highest dry matter yield followed by T4 (3.64 t/ha) at Nedjo site. The lowest yield (3.82 and 2.79 t/ha) was recorded in control treatment (T1) at Haro sabu and Nedjo site, respectively. Integrated application of biochar with inorganic fertilizer enhanced DM yield of chomo grass and this might be attributed to better soil fertility, nutrient availability and water retention as a consequence of biochar characteristics added to the soil in addition to inorganic fertilizer. This result is in line with earlier reports [19, 22], who reported that the highest above ground biomass was in the treatment with fertilizer addition and highest level of biochar application to the non-fertilized and non-biochar amended soil. Tufa et al. [23], noted that above ground biomass of maize increased due to combined application of biochar with NPS fertilizer at the western Ethiopia. According to their findings, increasing fertilizer levels increased fresh and forage dry matter yield. This was because nitrogen and other macro elements, which are crucial for plant growth and physiological processes, promoted vegetative growth, which in turn increased plant weight by creating more dry matter.

Table 3: Dry matter and seed yield of Chomo grass as affected by fertilizer levels across sites.

Treatments	DMY (t/ha)			Seed yield (kg/ha)		
	Haro sabu	Nedjo	Mean	Haro sabu	Nedjo	Mean
T1	3.82^{b}	2.79^{c}	3.30^{b}	74.39^{bc}	34.73	54.56^{bc}
T2	4.22^{b}	3.56^{ab}	3.89^{ab}	62.20^{c}	36.09	49.15^{c}
T3	5.34^{a}	3.11^{bc}	4.23^{ab}	89.87^{ab}	42.62	66.25^{ab}
T4	5.21^{a}	3.64^{ab}	4.43^{a}	76.67^{bc}	37.16	56.92^{bc}
T5	4.66^{ab}	4.02^{a}	4.34^{a}	82.48^{ab}	44.81	63.65^{ab}
T6	5.28^{a}	3.30^{b}	4.29^{a}	99.5^{a}	43.64	71.57^{a}
Mean	4.75	3.41	4.08	80.85	39.84	60.34
CV (%)	17.27	14.70	22.19	19.49	27.41	25.01
LSD $_{(5\%)}$	0.98	0.59	0.74	18.87	ns	12.40

$^{a-c}$ means with different letters in a column significantly differ (P<0.05).
DMY=dry matter yield; CV= coefficient of variance; LSD= least significance difference; t=tone; ha=hectare; kg=kilogram; ns= non-significant.

The overall mean DM yield was 4.08 t/ha which ranged from 3.30 t/ha to 4.43 t/ha. Integrated application of 50% biochar and 50% inorganic fertilizer rates (2.5 t/ha x 50 kg/ha NPS + 25 kg urea) (T4) resulted in the highest DM yield, which was at par with the DM yield harvested from other treatments except the control treatment (T1). However, the grass planted neither biochar nor inorganic fertilizer (T1) gave the lowest DM yield of 3.30 t/ha. This result indicated that combined biochar with inorganic fertilizer increased DM yield as compared to neither inorganic fertilizer nor biochar (T1) and biochar alone application (T2).The result is concur with Tadesse et al. [18], who found that the highest dry biomass yield of *Chloris gayana and Panicum coloratum* grasses recorded on biochar with inorganic fertilizer combined application at the Southwestern Ethiopia. Dutta et al. [24] noted that the use of organic together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher biomass yield and hence soil health for biomass yield production. Moreover, this study is in line with that of Workineh et al. [25] and Sarwar et al. [26], who reported that straw yield was significantly increased by organic along with inorganic fertilizers application.

Table 4: Chemical composition (%) of chomo grass.

Treatments	Parameters					
	DM	Ash	CP	NDF	ADF	ADL
T1	92.37^{c}	7.79^{cd}	7.21^{f}	63.86^{a}	41.15^{a}	7.88^{a}
T2	92.4b^{c}	8.42^{a}	7.55^{e}	61.84^{d}	39.84^{b}	6.86^{c}
T3	91.99^{d}	8.34^{a}	9.29^{c}	63.02^{b}	38.04^{e}	6.57^{d}
T4	92.83^{a}	8.13^{b}	10.75^{a}	63.16^{b}	39.2^{c}	6.91^{c}
T5	92.51^{b}	7.73^{d}	9.87^{b}	62.44^{c}	38.49^{d}	6.81^{c}
T6	92.75^{a}	7.94^{c}	8.4^{d}	63.83^{a}	36.52^{f}	7.54^{b}
Mean	92.47	8.05	9.51	63.02	38.87	7.09
CV(%)	0.06	1.12	1.28	0.22	0.26	1.41
LSD$_{(5\%)}$	0.11	0.16	0.22	0.26	0.18	0.18

$^{a-f}$ means with different letters in a column significantly differ (P<0.05).
DM=dry matter; CP= crude protein; NDF= neutral detergent fiber; ADF= acid detergent fiber; ADL= acid detergent lignin; CV= coefficient of variance; LSD= least significance difference.

Table 5: Partial budget analysis of different levels of fertilizers for DMY of Chomo grass.

Variables	Different levels of Biochar (t/ha) and Inorganic fertilizer (kg/ha)					
	T1 (control)	T2 (100% biochar)	T3 (75% biochar + 25% IF)	T4 (50% biochar + 50% IF)	T5 (25% biochar + 75% IF)	T6 (100% IF)
Average DM yield (t/ha)	3.30	3.89	4.23	4.43	4.34	4.29
Adjusted yield-10%(t/ha)	2.97	3.5	3.81	3.99	3.91	3.86
Gross benefit (ETB/ha)	7603.2	8960	9753.6	10214.4	10009.6	9881.6
TVC (ETB/ha)		1025	1370	1715	2060	2405
NB (ETB/ha)	7603.2	7935	8383.6	8499.4	7949.6	7476.6
MRR (%)	-	32.37	56.96	52.25	16.82	-5.26
Dominance	-	D			D	D

Unit cost of NPS fertilizer: *16.25 ETB/kg; unit cost of urea fertilizer= 15.60 ETB/kg;* ***unit price of DMY =*** *2.52 birr/kg; ETB= Ethiopian birr; TVC= total variable cost; NB= net benefit; MRR= marginal rate of return; D= dominated; IF= inorganic fertilizer.*

The effect of biochar and inorganic fertilizer application was significantly affected (P<0.05) seed yield of chomo grass at Haro sabu site though non-significant variation was observed among the treatments at Nedjo site. Chomo grass gave higher seed yield at Haro sabu as compared to Nedjo, which might be because of differences of soil and climatic factors of the sites. The establishment and growth of chomo grass was slow and seed yield was obtained by harvesting four to five weeks later the first head start shattering. The highest seed yield (99.50 and 44.81 kg/ha) was obtained from T6 and T5 followed by T3 and T6 while the lowest seed yield (62.20 and 34.73 kg/ha) in sole biochar (T2) and control treatment (T1) for Haro sabu and Nedjo site, respectively. The overall mean seed yield was significantly varied (P<0.05) among treatments. The highest seed yield (71.57 kg/ha) obtained from sole inorganic fertilizer application (T6), which was at par with T3 (66.25 t/ha) and T5 (63.65 t/ha), while the lowest seed yield (49.15 kg/ha) obtained in biochar alone (T2). This finding is consistent with Getnet et al. [27], who showed that seed production varied significantly depending on nitrogen fertilization rate, with the maximum seed yield obtained by applying a large amount of nitrogen fertilizer.

Chemical Composition of Chomo Grass

The analysis of variance showed combined application of biochar with inorganic fertilizer at different levels were significantly (P<0.05) affected the chemical composition of chomo grass (Table 4). DM content was varied among treatments, and the highest DM content recorded at 50% biochar with 50% inorganic fertilizer application (T4) followed by inorganic fertilizer applied alone (T6) though the lowest (91.99%) was obtained in 75% biochar with 25% inorganic fertilizer application (T3). The highest ash content (8.42 %) was obtained from application of biochar alone followed by combined application of 75% biochar and 25% inorganic fertilizer (T3), while the lowest (7.73%) was obtained in application of 25% biochar and 75% inorganic fertilizer (T5). This result might be attributed to the addition of biochar to the soil which resulted increment of minerals.

The crude protein content of chomo grass was significantly (P<0.05) different between the treatments when the field was incorporated with different levels of biochar and inorganic fertilizer as compared to control. The highest CP content (10.75%) was obtained from 50% biochar and 50% inorganic fertilizer application level (T4) followed by 25% biochar and 75% inorganic fertilizer application (T5), however, the lowest CP content (7.21%) was obtained at zero application of fertilizers (control treatment). Higher CP content of chomo grass was observed due to biochar and inorganic fertilizer combined application at different levels as compared to zero application of fertilizer and sole application either organic or inorganic fertilizer. This might be because the mix of organic and inorganic fertilizer allows continuous growth of the vegetation, which was fresh even during forage harvest as compared to alone and no fertilizer application. This result is in agreement with Tadesse et al. [18], who reported that higher crude protein content was recorded in the combination of biochar with inorganic fertilizer application whereas lowest in neither biochar nor inorganic fertilizer application for *Chloris gayana* and *Panicum coloratum*. Similarly, Abdi et al. [28] reported that level of fertilizer application affected crude protein content of grass and it increased with increasing level of fertilizers.

Analysis of variance showed that crude fibers (NDF, ADF and ADL) of chomo grass were affected by different levels of biochar and inorganic fertilizer application at forage harvesting stage (Table 4). The highest crude fibers (63.86, 41.15 and 7.88 %) were observed from control treatment for NDF, ADF and ADL, respectively. Though, the lowest crude fibers were recorded in sole biochar (61.84%), sole inorganic fertilizer (36.52%) and 75% biochar with 25% inorganic fertilizer application (6.57%) for NDF, ADF and ADL, respectively. Combining of organic (biochar) and inorganic fertilizer at different levels reduced the fiber contents of chomo grass as compared to grass planted without fertilizer. This might be due to increased growth rate of new leaves and shoot which are lower in plant structural components because of biochar with inorganic fertilizer combined application. In addition, biochar retain water and nutrients in the soil and slowly release as plant needed which made grass green and soft leaves. The current result is concur with Balabanli [29], who reported that the crude fibers concentrations of fertilized herbage was significantly lower in treatment with additions fertilizer than in treatment without added fertilizer. A high NDF that had above 72 % will cause reduce forage intake [30] and as NDF percentages increase, dry matter intake generally will decrease. This result is concurs with Abdi et al. [28], who reported that ADL show significant difference in different rate of urea fertilizer used.

Economic Analysis

The outcomes revealed that the combination of organic (biochar) and inorganic fertilizer applied together produced a higher dry matter yield than the control. The partial budget analysis reveals that the application of 50% biocharwith50% recommended inorganic fertilizer (T4) resulted in the highest net benefit of (8499.4 ETH ha^{-1}) with a marginal rate of return (52.25%). This was followed by 75% biochar with 25% inorganic fertilizer application (T3) with a net benefit of (8383.6 ETH ha^{-1}), while the minimum net benefit of 7476.6 ETH ha^{-1} was obtained from the application of sole recommended inorganic fertilizer (T6) (Table 5). In comparison to the control treatment, the combined application of 50% coffee husk biochar with 50% inorganic fertilizer (T4) and 75%biochar with 25% inorganic fertilizer (T3) provided 12.42% and 12.27% of net benefits, respectively. Based on this finding, farmers produce forage in the study area chose to apply

50% of biochar with 50% of recommended inorganic fertilizer because it produced the highest adjustable dry matter yield.

Conclusions

The current study revealed that using biochar with inorganic fertilizer application significantly influenced ($P<0.05$) the phonology, growth, yield parameters, and chemical composition of chomo grass. Higher rates of biochar combination with inorganic fertilizer delayed days to 50% flowering and maturity as compared to other treatment combinations. Integration of biochar with inorganic fertilizer did not significantly vary on plant height, however there was a significant difference in the leaf number per plant and leaf to stem ratio. The dry matter and seed yields of chomo grass was affected by biochar with inorganic fertilizer combined application and higher dry matter and seed yields were recorded in the integration of biochar with inorganic fertilizer as compared to control and biochar alone application. The crude protein content of chomo grass significantly varied among the treatments when the field was incorporated with different levels of biochar and inorganic fertilizer as compared to the control. Higher CP content of chomo grass was observed due to the combined application of biochar and inorganic fertilizer at different levels as compared to zero application of fertilizer and sole application of either organic or inorganic fertilizer. Contrarily, the combined application of organic (biochar) and inorganic fertilizer at different levels reduced the fiber contents of chomo grass as compared to grass planted without fertilizer. The partial budget analysis showed that the combined application of 50% biochar with 50% recommended inorganic fertilizer produced the maximum net benefit (8499.4 ETB ha^{-1}) and a marginal rate of return of (52.25%), whereas the sole applied inorganic fertilizer produced the lowest net benefit (7476.6 ETB ha^{-1}). Therefore, it is advised to use a combination of 50% level of biochar with 50% of recommended inorganic fertilizer (T4) to enhance the dry matter yield and nutritive value of chomo grass.

Author Statements

Author Contributions

Yerosan Wekgari: conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; visualization; writing original draft; writing-review and editing. **Fikre Dereba:** conceptualization; investigation; visualization; methodology; writing-review and editing. **Negasu Gamachu:** conceptualization; methodology; writing-review and editing.

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare that they have no conflict of interest.

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