PJN
ISSN 1680-5194
ansinet.com/pjn

PAKISTAN JOURNAL OF NUTRITION

Science Alert
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OPEN ACCESS Pakistan Journal of Nutrition

ISSN 1680-5194
DOI: 10.3923/pjn.2024.39.45

Research Article
Evaluation of Proximate and Fibre Composition, Metabolizable Energy and Organic Matter Digestibility of Maize (*Zea mays*) and Wheat (*Triticum aestivum*) Hydroponic Fodder as Affected by Source of Water and Days to Harvest

Adekeye, Adetayo Bamikole

International Livestock Research Institute, Ibadan, Nigeria

Abstract
Objective: This study was conducted to evaluate the fodder yield and nutritive values of maize and wheat under hydroponic conditions as affected by sources of water and days to harvest. **Materials and Methods:** A randomized complete block design with a 2×3 factorial arrangement was used to study the three sources of water [nutrient solution (NS), borehole water (BW) and fish hatchery wastewater (FHW)] and three days to harvest [8, 10 and 12] after sowing with five replicates. At harvest, fodder samples were oven-dried at 70°C for 48 hours, milled and subjected to chemical analyses. The Crude protein (CP) content recorded from both fodders varied ($p<0.05$) from 9.31-11.43%. Neutral detergent fibre and acid detergent fibre from both fodders also ranged from 55-62 and 33-39%, respectively. **Results:** Organic matter digestibility (OMD) declined with delayed harvesting for both fodders. The OMD ranged from 65-81% for maize and from 53-71% for wheat fodder. The highest metabolizable energy was recorded at 10 and 8 days after sowing (DAS) using FHW and BW for maize and wheat, respectively. **Conclusion:** It can be concluded from this study that hydroponic fodder production from maize and wheat is possible between 8-12 DAS but for fodder optimum yield and nutritive value, the fodder is best harvested at 8-10 DAS, using NS for maize, as well as BW and FHW for wheat.

Key words: Days to harvest, hydroponic fodders, maize, proximate compositions, sources of water, wheat

Citation: Adekeye A.B., 2024. Evaluation of proximate and fibre composition, metabolizable energy and organic matter digestibility of maize (*Zea mays*) and wheat (*Triticum aestivum*) hydroponic fodder as affected by source of water and days to harvest. Pak. J. Nutr., 23: 39-45.

Corresponding Author: Adekeye, Adetayo Bamikole, International Livestock Research Institute, Ibadan, Nigeria Tel: +2348030814388

Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

As the livestock population increases, a large gap exists between requirements and availability of feed resources for maintenance and productivity and recently there has been an increased interest in ruminant farming, especially in southwest Nigeria leading to an unprecedented increase in livestock products and by-products[1]. However, this has tremendously improved the livelihood and standard of living of many households, especially rural women. Though ruminant productivity is largely determined by nutrition, since 70-75% (of which forages constituted about 70%) of the total production costs go into feeding which determines the success or failure of an animal production enterprise. Ruminants' diets are largely composed of forage for a large part of the year, which is the cheapest major feed resource.

Consequently, the major limitations to livestock production in Nigeria and many other tropical countries are the limited quantities and low quality of green forage in addition to the high cost of imported feed, decreasing land size for fodder cultivation, fluctuations in the quality and quantity of the animal feed year-round[2]. As the plant ages, the cell wall contents increase, which results in an increase in the lignin content and reduces crude protein, digestibility and utilization, these have posed a great threat to the feed intake and production of livestock mostly under a natural grazing system[2]. Furthermore, as the gap between the demand and supply of green fodder for ruminant livestock increases, there is a need for an alternative and contemporary fodder production method that would enhance fodder and animal productivity[3].

One such fodder production that guarantees an uninterrupted provision of quality green fodder as an alternative to conventional fodder production is hydroponic. The system guarantees quality green fodder production within a period of 8-10 days with limited land use and low labour requirement[3]. Various fodder crops are being grown under hydroponics in Nigeria using varying water irrigation methods on different days to harvest the fodder. This trial thus aimed to evaluate the proximate and fibre composition, metabolizable energy and organic matter digestibility of hydroponically grown maize (*Zea mays*) as affected by the source of water and days to harvest.

MATERIALS AND METHODS

Experimental site: This experiment was conducted in the Hydroponic Fodder Unit of Azemor Agribiz Ltd., Ibadan, Nigeria.

Hydroponic housing system: This study used a hydroponic fodder housing system composed of planks covered with a poultry net and mosquito net. The roof was made of white translucent polyethylene materials. The house consisted of metal shelves coated with aluminum. The experiment was conducted under an average room temperature of $25.27 \pm 0.78\,^{\circ}C$ (absolute natural climatic conditions).

Plant materials: For this trial, seeds of maize (*Z. mays*) and wheat (*Triticum aestivum*), free from any chemical treatment, were sourced from a reputable agro-allied store. Before the commencement of germination, the seeds were tested for viability.

Irrigation water: Three sources of irrigation water were used in this study, which were the nutrient solution (NS), Borehole Water (BW) and fish hatchery wastewater (FHW). The NS was constituted using BIC® concept hydroponic liquid solution A and B at 1- and 2.5-mL/L, respectively while borehole water was collected from the main source of water used on the farm (the borehole water is safe for drinking). The fish hatchery wastewater was sourced from the main hatchery.

Pre-sowing seeds treatment: Experimental seeds were cleaned from debris and other dirty materials and sterilized by soaking in a 20% sodium hypochlorite solution for 30 min to control the formation of mould. The trays were also cleaned and disinfected. Thereafter, the seeds were thoroughly washed to remove residues of the sterilized solution and soaked overnight in borehole water (for 10 hrs) before sowing.

Seed sowing and irrigation: The seeds were sown in trays which were lined with an aluminum sheet at 2.15 kg/tray and labeled accordingly and stacked on the shelves. The same irrigation water treatments were randomly stacked on the same shelf and irrigated manually twice daily as sufficient to keep the seeds/seedlings moist.

Experimental design and procedure: This experiment involved maize (*Z. mays*) and wheat (*Triticum aestivum*) irrigated with nutrient solution and borehole water and harvested at 8, 10 and 12 days after sowing (DAS). A randomized complete block design with a 2×3 factorial arrangement with five replicates was used.

Data collection: At harvest, the entire mat of the fodder from each species (comprising the root and the green leaves) was lifted and removed from the tray, while a representative fresh fodder sub-samples (300 g) from each tray was taken, oven-dried, milled for onward chemical analysis.

Laboratory analysis: The oven-dried samples from each replicate were milled in the laboratory stainless steel mill using 1mm sieves. The milled samples were analyzed as follows:

Proximate composition: Proximate analyses of the samples were carried out according to A.O.A.C.[4] procedure to determine the crude protein (CP), ether extract (EE) and ash contents.

Fiber fraction analysis: Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) contents were determined as described by Van Soest *et al.*[5]. Cellulose was taken as the difference between ADF and ADL while hemicellulose was taken as the difference between NDF and ADF, while non-fibre carbohydrate (NFC) was calculated as:

$$NFC = 100\text{-}NDFn\text{-}CP\text{-}Ash\text{-}EE$$

Organic matter digestibility (OMD): Organic matter digestibility (OMD) was estimated as:

$$OMD = 14.88+0.889GV+0.45\ CP+0.651\ ash$$ [6]

Metabolizable energy (ME): Metabolizable energy (ME) was calculated as:

$$ME = 2.20+0.136GV+0.057\ CP+0.029CP$$ [2,6]

Statistical analysis: Data were analyzed using Two-way Analysis of Variance (ANOVA) followed by Duncan's Multiple Range Test using statistical package SAS[7]. Significant means were separated and compared at a 5% level of significance.

RESULTS

Table 1 shows the pH and mineral composition of the three irrigation water sources before and after the trial. Results showed that the pH of the water samples ranged from 6.20-6.70 while the nitrogen and P contents varied from 0.01 -0.02%. K, Ca, Mn and Fe composition of nutrient solution (NS) were higher than those of the other sources of water.

Main effect: Crude protein (CP), ether extract (EE), ash, neutral detergent fibre (NDF), hemicellulose and non-fibre carbohydrate (NFC) contents were significantly different ($p<0.05$) among irrigation water sources (Table 2). Crude protein content was the highest ($p<0.05$) in the fodder irrigated with NS (10.91%) while the lowest in the fodder irrigated with FHW (9.59%). The ether extract, Ash and NFC contents of fodder irrigated with NS and FHW were higher ($p<0.05$) than those of fodder irrigated with borehole water. On the other hand, fodder irrigated with borehole water produced the highest content of hemicellulose value. A higher level of neutral detergent fibre fractions was obtained when maize was irrigated with NS and borehole water compared to FHW. All parameters except ADL content were significantly affected by days to harvest.

The dry matter (DM) percentage of maize increased from 8-10 DAS. Crude protein (10.67%) and ash (12.03%) contents reached their peaks at 10 DAS, before declining. There was a decline ($p<0.05$) in the proportions of EE and ADF at 10 DAS but later increased by 12 DAS. NDF and hemicellulose values increased as the age of fodder increased, while the NFC values decreased. Organic matter digestibility (OMD) was the highest in the fodder harvested at 10 DAS and least at 12 DAS. The ME values were not different from each other across the treatments.

Wheat: All parameters examined except NDF were significantly ($p<0.05$) affected by the sources of water (Table 3). The highest ($p<0.05$) values for DM, EE, ADF, ADL and cellulose were recorded in fodder irrigated with borehole water. Values for these parameters were similar for fodder irrigated with FHW and NS. The highest crude protein (10.87%) and Ash (10.82%) contents were observed in the fodder irrigated with FHW. The main effect of days to harvest showed

Table 1: pH and mineral composition of different irrigation water

Parameters	Borehole water	Nutrient solution	Fish hatchery wastewater
pH	6.40	6.20	6.70
N (%)	0.01	0.02	0.01
P (mg/kg)	0.01	0.01	0.02
K (mg/kg)	23.50	558.43	60.13
Ca (mg/kg)	6.40	230.46	8.50
Mg (mg/kg)	14.07	18.50	19.10
Mn (mg/kg)	0.07	3.00	0.17
Fe (mg/kg)	6.56	12.90	7.50
Cu (mg/kg)	0.56	0.34	1.32
Zn (mg/kg)	3.91	2.00	0.25

Table 2: Main effects of sources of water and days to harvest on proximate and fibre composition of maize fodder

	Irrigation Water				Days to harvest			
Parameters (%)	NS	BW	FHW	SEM	8	10	12	SEM
Proximate								
Dry matter	96.50	96.28	96.50	1.88	95.50^{b}	96.94^{a}	96.83^{a}	1.84
Crude protein	10.91^{a}	10.14^{b}	9.59^{c}	0.34	9.75^{c}	10.67^{a}	10.22^{b}	0.24
Ether extract	6.00^{a}	5.07^{b}	6.30^{a}	0.29	6.07^{a}	5.17^{b}	6.14^{a}	0.43
Ash	11.83^{a}	10.90^{b}	11.78^{a}	0.74	11.27^{b}	12.03^{a}	11.19^{b}	0.63
Fibre fractions								
NDF	60.13^{a}	60.60^{a}	57.67^{b}	4.01	58.47^{b}	60.00^{a}	59.93^{a}	3.06
ADF	37.75	37.67	37.33	1.85	38.33^{a}	36.67^{b}	37.75^{a}	1.17
ADL	9.00	8.00	8.67	2.11	8.67	8.67	8.33	2.01
Hemicellulose	21.00^{ab}	23.07^{a}	20.73^{b}	4.01	20.07^{b}	23.33^{a}	22.40^{a}	3.70
Cellulose	29.25	29.73	28.33	4.35	29.93^{a}	28.09^{b}	29.39^{ab}	4.05
NFC	11.38^{c}	12.96^{b}	15.18^{a}	3.09	15.12^{a}	12.12^{b}	12.27^{b}	3.29
OMD (%)	74.83^{a}	72.62^{b}	72.02^{b}	11.15	72.06^{ab}	76.58^{a}	70.83^{b}	19.22
ME (MJ/kg DM)	10.82	10.87	10.67	1.03	10.74	11.12	10.51	1.13

NS: Nutrient solution, BW: Borehole water, FHW: Fish hatchery wastewater, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, ADL: Acid detergent lignin, NFC: Non-fibre carbohydrate, OMD: Organic matter digestibility and ME: metabolizable energy, ^{a,b,c}Means on the same row with different superscripts are significantly different (p<0.05), SEM: Standard error of mean

Table 3: Main effects of sources of water and days to harvest on proximate and fibre composition of wheat fodder

	Irrigation water				Days to harvest			
Parameters (%)	NS	BW	FHW	SEM	8	10	12	SEM
Proximate								
Dry matter	96.24^{b}	97.50^{a}	96.19^{b}	0.39	96.95^{b}	97.81^{a}	95.17^{c}	0.40
Crude protein	9.76^{c}	10.07^{b}	10.87^{a}	0.06	10.53^{a}	9.98^{c}	10.18^{b}	0.05
Ether extract	6.15^{b}	6.77^{a}	6.10^{b}	0.15	6.33	6.46	6.22	0.15
Ash	10.95^{b}	10.82^{b}	12.03^{a}	0.74	11.10	11.03	11.67	0.53
Fibre fractions								
NDF	59.44	59.19	60.02	2.59	61.19^{a}	59.69^{b}	57.78^{c}	2.60
ADF	35.42^{b}	37.67^{a}	35.54^{b}	0.97	35.67^{b}	35.51^{b}	37.49^{a}	0.99
ADL	7.96^{b}	9.00^{a}	7.92^{b}	0.73	8.00	8.62	8.25	0.07
Hemicellulose	24.00^{a}	21.70^{b}	24.36^{a}	2.89	26.67^{a}	24.02^{b}	20.37^{c}	2.89
Cellulose	24.21^{b}	28.66^{a}	27.71^{b}	1.17	27.55^{b}	27.04^{b}	29.00^{a}	1.07
NFC	13.49^{a}	12.92^{a}	10.91^{b}	4.74	10.63^{b}	12.63^{a}	14.07^{a}	4.84
OMD (%)	63.18^{b}	69.44^{a}	65.06^{b}	19.89	70.75^{a}	67.27^{b}	59.65^{c}	21.89
ME (MJ/kg DM)	9.59^{b}	10.73^{a}	9.67^{b}	0.70	10.71^{a}	10.32^{a}	8.95^{b}	0.70

NS: Nutrient solution, BW: Borehole water, FHW: Fish hatchery wastewater, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, ADL: Acid detergent lignin, NFC: Non-fibre carbohydrate, OMD: Organic matter digestibility and ME: Metabolizable energy, $^{a-c}$Means on the same row with different superscripts are significantly different (p<0.05) and SEM: Standard error of mean

an increase in dry matter (DM) percentage from 8-10 DAS before declining. NDF and hemicellulose values declined as harvest was extended from 8-12 DAS. On the other hand, cellulose and NFC values increased.

Interaction effects

Maize: All parameters except DM contents and acid detergent lignin (ADL) were significantly (p<0.05) affected by the sources of water and days to harvest (Table 4). The highest CP contents were recorded in fodder irrigated with NS on 10 DAS (11.43%) and 12 DAS (11.14%) (Table 4). The CP contents across the days to harvest were similar in fodder irrigated with FHW. The ash content in the maize fodder irrigated with NS and FHW was the highest at 12 DAS. The highest NDF value (62.00%) was observed in fodder irrigated with borehole water harvested at 10 DAS. The highest acid detergent fibre (ADF) content was observed at 12 DAS irrigated with NS and 8 DAS irrigated with borehole water and FHW. Sources of water and days to harvest did not influence the content of Acid detergent fibre (ADL). The highest (25%) hemicellulose content was recorded in fodder irrigated with borehole water harvested at 10 DAS, the content of cellulose was significantly equal and highest (p<0.05) in fodder harvested at 12 DAS irrigated with NS and borehole water (across treatments) and 8 DAS irrigated with FHW. The lowest value (10.11%) for NFC was recorded for maize fodder irrigated with NS harvested at

Table 4: Interaction effects of sources of water and days to harvest on proximate and fibre composition of maize hydroponic fodder

	Nutrient solution			Borehole water			Fish hatchery wastewater			
Parameters (%)	8	10	12	8	10	12	8	10	12	SEM
Proximate										
Dry matter	95.50	96.50	97.50	95.50	97.32	96.00	95.50	97.00	97.00	1.88
Crude protein	10.17^{bc}	11.43^{a}	11.14^{a}	9.73^{c}	10.47^{ab}	9.95^{c}	9.35^{c}	9.84^{c}	9.65^{c}	0.34
Ether extract	6.00^{ab}	5.50^{b}	6.50^{a}	5.50^{b}	4.50^{c}	5.20^{bc}	6.70^{a}	5.50^{b}	6.37^{a}	0.49
Ash	11.50^{abc}	11.60^{abc}	12.38^{a}	10.50^{cd}	12.00^{ab}	10.20^{d}	11.83^{ab}	12.50^{a}	11.00^{bcd}	0.74
Fibre fraction										
NDF	60.40^{ab}	60.00^{ab}	60.00^{ab}	60.00^{ab}	62.00^{a}	59.80^{ab}	55.00^{c}	58.00^{b}	60.00^{ab}	3.06
ADF	37.00^{b}	37.00^{b}	39.25^{a}	39.00^{a}	37.00^{b}	37.00^{b}	39.00^{a}	36.00^{b}	37.00^{b}	1.85
ADL	9.00	9.00	9.00	9.00	8.00	7.00	8.00	9.00	9.00	2.11
Hemicellulose	23.00^{abc}	23.00^{abc}	20.00^{c}	21.00^{bc}	25.00^{a}	23.20^{ab}	16.20^{d}	22.00^{abc}	24.00^{ab}	4.71
Cellulose	28.80^{ab}	28.26^{ab}	31.00^{a}	30.00^{a}	29.00^{a}	31.18^{a}	31.00^{a}	27.00^{b}	27.00^{b}	4.25
NFC	12.58^{bcde}	11.44^{cde}	10.11^{e}	14.27^{b}	10.76^{ab}	13.85^{bc}	18.53^{a}	14.16^{b}	12.85^{bcd}	3.19
OMD (%)	74.95^{ab}	71.64^{bc}	71.27^{bc}	75.88^{ab}	77.31^{ab}	71.31^{bc}	65.36^{c}	80.79^{a}	69.91^{bc}	11.15
ME (MJ/kg DM)	11.20^{ab}	10.54^{ab}	10.73^{ab}	11.26^{ab}	11.02^{ab}	10.36^{ab}	9.76^{b}	11.81^{a}	10.45^{ab}	1.03

NDF: Neutral detergent fibre, ADF: Acid detergent fibre, ADL: Acid detergent lignin, NFC: Non-fibre carbohydrate, OMD: Organic matter digestibility and ME: metabolizable energy, a-e Means on the same row with different superscripts are significantly different (p<0.05) and SEM: Standard error of mean

Table 5: Interaction effects of sources of water and days to harvest on proximate and fibre composition of wheat fodder

	Nutrient solution			Borehole water			Fish hatchery wastewater			
Parameters (%)	8	10	12	8	10	12	8	10	12	SEM
Proximate										
Dry matter	96.86^{cd}	96.86^{cd}	95.00^{e}	97.50^{bc}	98.50^{a}	96.50^{d}	96.50^{d}	98.07^{ab}	94.00^{f}	0.39
Crude protein	9.66^{e}	10.30^{cd}	9.31^{f}	10.15^{d}	9.56^{ef}	10.53^{bc}	11.80^{a}	10.09^{d}	10.72^{b}	0.06
Ether extract	5.00^{e}	7.59^{a}	5.86^{d}	7.50^{a}	6.00^{cd}	6.82^{b}	6.50^{bc}	5.80^{d}	6.00^{cd}	0.15
Ash	11.86^{ab}	9.50^{d}	11.50^{ab}	9.95^{cd}	11.00^{bc}	11.50^{ab}	11.50^{ab}	12.60^{a}	12.00^{ab}	0.74
Fibre fraction										
NDF	61.00^{ab}	61.00^{ab}	56.33^{d}	61.56^{a}	59.00^{bc}	57.00^{cd}	61.00^{ab}	59.07^{bc}	60.00^{ab}	2.59
ADF	35.00^{c}	33.89^{c}	37.38^{b}	37.00^{b}	39.00^{a}	37.00^{b}	35.00^{c}	33.64^{c}	38.00^{ab}	0.97
ADL	9.00^{a}	9.00^{a}	7.86^{ab}	9.00^{a}	9.00^{a}	9.00^{a}	8.00^{ab}	7.87^{ab}	7.89^{ab}	0.73
Hemicellulose	26.00^{a}	27.00^{a}	19.00^{c}	25.00^{a}	20.00^{bc}	20.10^{bc}	26.00^{a}	25.07^{a}	22.00^{b}	2.89
Cellulose	27.64^{bc}	25.00^{e}	29.00^{ab}	28.00^{bc}	29.99^{a}	28.00^{bc}	27.00^{cd}	26.13^{de}	30.00^{a}	1.07
NFC	12.34^{bcd}	11.20^{cd}	16.94^{a}	10.35^{d}	14.44^{ab}	13.97^{bc}	9.20^{d}	12.25^{bcd}	11.28^{cd}	4.94
OMD (%)	69.71^{a}	67.48^{a}	53.34^{c}	71.29^{a}	69.00^{a}	68.00^{a}	71.24^{a}	65.31^{a}	58.63^{b}	21.89
ME (MJ/kg DM)	10.00^{cd}	11.04^{ab}	7.72^{e}	11.35^{a}	10.35^{abc}	10.48^{abc}	10.77^{abc}	9.59^{cd}	8.64^{de}	0.70

NDF: Neutral detergent fibre, ADF: Acid detergent fibre, ADL: Acid detergent lignin, NFC: Non-fibre carbohydrate, OMD: Organic matter digestibility and ME: Metabolizable energy, a-f Means on the same row with different superscripts are significantly different (p<0.05) and SEM: Standard error of mean

12 DAS while the highest value (18.53%) was recorded for maize fodder irrigated with FHW harvested at 8 DAS. The highest values of ODM (80.79%) and ME (11.81Mj/kg DM) were recorded for maize fodder irrigated with FHW harvested at 10 DAS.

Wheat: All parameters were significantly (p<0.05) affected by the interaction of sources of water and days to harvest (Table 5). The dry matter contents recorded in fodder irrigated with borehole water and FHW and harvested at 10 DAS were higher than those harvested on other days. Crude protein content was the highest in fodder harvested on 8 DAS (11.80%) and irrigated with FHW, while the lowest CP (9.31%) was recorded in fodder harvested at 12 DAS and irrigated with NS. There was no consistent trend in values of CP across the treatments. Value for ADF was the highest (p<0.05) in fodder harvested at 10 DAS and irrigated with borehole water. There was no significant variation in the proportions of ADL across the treatments. The values for NCF in the fodder were more than 10% except for the fodder harvested at 8 DAS and irrigated with FHW.

DISCUSSION

The CP contents of both crops varied in response to the sources of water. The contents were the highest in maize and wheat fodder using NS and FHW. The decline in CP contents of both fodders after 10 DAS indicated an optimum time to harvest the forages. Generally, CP content of both crop species and under different water sources was above 9.0%, which exceeded the minimum level (7%) recommended in the feed of ruminants[8]. If the CP content of the feed is lower than 7%, animal production will decline due to low voluntary intake, low rate of digestibility and negative nitrogen balance. This finding agrees with the report of NRC on feed supplement for cattle and ewe at different stages of gestation[9,10]. The use of nutrient solution enhanced the CP content of the maize fodder. This can be attributed to the higher uptake of nitrogenous compounds than that of borehole water and FHW and this result agrees with Dung *et al.*[11] who grown the barley and used the nutrient solution or borehole water.

There was an increase in the CP content (17.8%) of maize fodder compared to the unsprouted grains. This increase could be attributed to a loss in dry weight, particularly carbohydrates, through respiration during germination[12]. This increase was also reported by Morgan *et al.*[13] who observed that on day 8, the CP content of barley hydroponic fodder reached a maximum of 48%. On the other hand, Chavan *et al.*[12] reported a decrease in CP content of wheat fodder compared to the initial grain. This may be attributed to leakage of the solutes (proteins, amino acids, sugars, organic acids and inorganic ions) during soaking. It is then noteworthy that, crops react differently to similar pre-sowing seed treatments under hydroponic conditions in terms of nutrient uptakes and reductions.

The highest ash contents were observed in both fodders irrigated with NS and FHW. This result agrees with Dung *et al.*[14] who reported that the ash contents of the sprouts increased with the use of nutrient solution rather than borehole water due to the absorption of minerals by the roots. Fish hatchery wastewater appeared richer in nutrients than borehole water. Both ash and ether extract contents of the produced fodder were higher than the content present in the unsprouted grain. This may be due to the metabolic processes; thus the increase in ether extract content of the hydroponics fodder may be due to the increase in the structural lipids and production of chlorophyll associated with the plant growth. Supporting converts starch into soluble sugars to support the metabolism and energy requirement of the growing plants for respiration and cell wall synthesis. Furthermore, as the amount of starch decreases, the amount of dry matter and organic matter decreases, resulting in an increase in ash content.

Results of the present study showed that the as DAS increased from 8-12, values of neutral detergent fibre (NDF) increased in maize while they declined in wheat. It was observed that as DAS increased, maize and wheat fodder responded differently to changes in NDF. For maize, It increased with DAS while for wheat, it declined with DAS. The value for Acid detergent fibre (ADF) was the highest at 12 DAS for both fodders. There were variations and inconsistent trends in the fibre contents of the fodders in response to sources of water and days to harvest; these variations were confusing since they only showed the alterations in the fibre proportions during sprouting. Nonetheless, the fibre contents in the fodders were higher than the proportions recorded in the sown seeds. This increase may be attributed to the increase in the number and size of cell walls synthesizing structural carbohydrates. This result is in line with a previous study conducted by Chung *et al.*[15] who reported an increase in fibre content from 3.75% in unsprouted barley seed to 6% in 5-day sprouts. Several studies on the effect of germination on legumes found that germination process can increase protein content, dietary fiber and mineral bioavailability while reducing tannin and phytic acid contents[16,17].

The NDF range in maize and wheat fodders was 55-62% as a result of the interaction between water sources and days to harvest, while ADF range in both fodders was 33-39% under different irrigation water sources and days to harvest. The range of NDF and ADF in this research were higher than the recommended minimum values (33 and 17%, respectively), for forage crops[9] and NDF (25-30%) and ADF (21-30%) for dairy cows[18]. This is an indication that the inclusion of hydroponic fodder as a supplement in the ruminant feed improved the performance. McDonald *et al.*[19] expounded that NDF was the best single chemical trait related to feeding intake or bulk which can be used in ration formulation to predict forage intake and quality by ruminants since ADF includes the cellulose and lignin from cell walls and a variable amount of xylans and other components that are resistant to fermentative degradation, therefore, reducing the DM intake and digestibility which directly affect the performance of the animals. Forages low in NDF are of higher quality and have higher intake rates than high-NDF forages. Increasing NDF and ADF of the fodders with advancing days to harvest might be due to stem proportion and cell wall lignification as the plants grow.

A steady increase in gas production was recorded as incubation progressed from 0-36 hrs. There might be a correlation between low CP levels and high fibre levels with higher non-degradable fibre and less non-structural carbohydrates, resulting in low digestibility. Organic matter digestibility (OMD) and fermentation of the insoluble fraction of both fodders declined with an increase in days to harvest for all irrigation water sources. This could be partly attributed to CP content which declined with delayed harvest and fibre contents which increased with an increase in days to harvest. This is an indication that as grass matures (irrespective of the growing medium), the digestibility declines, which might be due to the deposition of lignin in the cell wall with increasing maturity and the increasing proportion of stem that becomes less digestible when compared with the leaf portion at advanced maturity[20].

Results of the current study showed that the metabolizable energy (ME) of maize fodder was not affected by the two factors while wheat ME declined with a delay in harvest. In the present study the fodder had higher OMD and ME than those reported by Adekeye *et al*.[2] who used P. maximum and A. tectorum under field conditions cut every 4-8 weeks at a height of 20-30cm. As days to harvest increased, OMD and ME content reduced, suggesting that both fodders were utilized before 12 days, during a period of higher CP content.

CONCLUSION

As compared to the sown seeds, the fodder produced had different nutrient compositions. For instance, crude protein of maize seeds increased whereas, the CP content of wheat decreased during the post-sprouting period.

ACKNOWLEDGMENT

The author would like to thank the World Bank African Centre of Excellence in Agricultural Development and Sustainable Environment (CEADESE), Federal University of Agriculture, Abeokuta (FUNAAB), Nigeria for funding this research project and supervisory committee led by Prof. Femi Onifade for their efforts during the conduct of this study.

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