E3 Journal of Agricultural Research and Development Vol. 5(4). pp. 066-071, August, 2014
Available online http://www.e3journals.org
ISSN: 2276-9897 © E3 Journals 2014

Full Length Research Paper

Forage production potential and nutritive value of cowpea (Vigna unguiculata) genotypes in the northern lowlands of Ethiopia

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Accepted 10 June, 2014

The experiment was conducted in northern lowlands of Ethiopia for three consecutive years, 2010 to 2012 to identify adaptive, high yielding and quality genotypes. Five Genotypes were grown as experimental treatments in a randomized complete block design (RCBD) with three replications. Plot size was 3 x 2m with an inter-row spacing of 40 and 1m path. Days to 50% flowering, days to maturity, dry matter herbage yield and grain yield showed statistically significant variation among genotypes. Percentage dry matter, crude protein, neutral detergent fiber, acid detergent fiber, acid detergent lignin, dry organic matter, in vitro dry organic matter digestibility of the genotypes were in the range of 89.2 to 89.9 % , 14.7 to 15.6%, 56.3 to 60.7%, 47.0 to 57.2%, 11.6% to 14.1%, 84.9 to 86.5% and 55.1 to 60.2%, respectively. Except percentage dry matter, neutral detergent fiber and acid detergent lignin, the cowpea genotypes were significantly different in chemical composition and digestibility (p<0.05). In general, animal feed potential differences between the cowpea genotypes were significant, indicating the potential for selecting superior genotypes. As cowpea can fix nitrogen to improve soil fertility and cropping system productivity and serves as an excellent protein source for both animals and humans, it can play its role in food security of the society in the study area. Further researches as to the inclusion level in farm animals' diet, grain nutritional composition and conservation techniques of these genotypes should be conducted to fill the existing knowledge gap.
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Key words: Chemical composition, cowpea, DM, grain yield

INTRODUCTION

Feed shortage both in quantity and quality remains the leading constraint to good animal performance in Ethiopia (Yayneshet et al 2009). Natural pasture and crop residues are the main feed sources. However, most of the feedstuffs obtained from natural pasture and crop residues have crude protein (CP) levels below 8% and neutral detergent fiber (NDF) of above 55% (Seyoum and Zinash 1995). Feedstuffs of such composition are insufficient to provide year round supply of adequate quantity and quality of nutrients beyond maintenance (Hindrichsen et al 2001). Various options have been advocated as possible solutions to this perennial problem. This includes feeding of treated and, untreated crop residues or integration of forage legumes into the feeding strategies. Legumes are the most important forage plants that substantially improve the feed available for livestock as they can provide the essential protein for animals, improving soil fertility, food crop production and household nutrition through a more reliable supply of milk and meat (Akinlade et al 2005; Alemayehu 1997).

Western zone of Tigray, northern Ethiopia is known by its mixed crop-livestock farming system with sorghum (Sorghum bicolor L.) as the major crop cultivated for food security while Sesame (Sesamum indicum L.) is cultivated as cash crop. These two crops have been cultivated continuously on a single plot or one after the other without integration of any legume crop for several years (EARO 2002). As a result, the fertility and then the

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productivity of the land have been declining. Moreover, livestock are dependent on the residue of these crops and natural pasture which can't provide nutrients beyond maintenance. However, little efforts have been done in the area to introduce and evaluate forage legumes that enhance soil fertility and livestock production and productivity.

Cowpea (Vigna unguiculata (L.) Walp) is a leguminous crop grown throughout West Africa, often in association with pearl millet (Pennisetum glaucum L.) and sorghum (Sorghum bicolor L.). Cowpea is well adapted to the harsh growing conditions, including low soil fertility, high temperatures, and drought (Turk et al 1980). Cowpea can fix nitrogen to improve soil fertility and cropping system productivity. Additionally, farmers feed cowpea fodder to livestock to increase income, and collect the manure produced for use in their fields thereby reduces farmers' reliance on commercial fertilizers and sustains soil fertility (Odion et al 2007; Akinlade et al 2005). Previous studies with cow pea (Gwanzura et al 2012; Akinlade et al 2005; Ebro et al 2004; Alemayehu 1997) indicated this legume improves soil fertility and enhances the intake and utilization of poor quality roughage consequently improves livestock production and productivity. Another important feature of cowpea is also its ability to suppress weeds particularly Striga species (Dawit et al 2009) where it highly infests western zone of Tigray with great yield loss. Hence, Integration of cowpea with the existing farming system could have significant importance in improving feed quality and soil fertility and productivity. Therefore, this experiment was conducted with the objective of identifying adaptive, high yielding and quality cowpea genotypes for the northern lowlands of Ethiopia.

MATERIALS AND METHODS

Description of study area

The trial was conducted in western zone of Tigray, northern Ethiopia, bordering Eritrea (13^0 40'-14^0 27' north latitude and 36^0 27'-37^0 32' east longitude, 612 m above sea level) for the period 2010 to 2012. The dominant soil type is Vertisol characterized by deep soils (> 150 cm), clay content of 40 - 60%, electrical conductivity of 0.047 - 0.179 mmohs/cm, organic matter content of <2% and CEC ranging from 37 – 77 meq/100 g soil. The area has a semi arid climate with unimodal rainfall pattern. The mean annual rainfall and mean minimum and maximum temperatures are 448.8mm, 25^oc and 32^oc, respectively (EARO 2002)

Treatments and data collection

The Genotypes, 12668, white wonder, 9333, black eyed and small seed were obtained from Werer agricultural research center and grown as experimental treatments in a plot size of 3 x 2m with an inter-row spacing of 40 and 1m path. Two seeds were sown together 20cm apart at the onset of main rainy season around late June or early July with extra seedling thinned 14 days after germination, leaving one plant per station. A 100 kg/ha Diammonium phosphate (DAP) fertilizer was applied right before sowing. All plots were weeded two times before flowering.

At 50% flowering stage the middle rows of each plot were harvested for dry matter herbage determination and chemical analysis. Plants were harvested at ground level and fresh biomass weighed immediately using a 0.1 g scale. Then, a sub-sample of 15-20% of the total weight was separated and put into a paper bag for dry matter herbage determination. The samples were oven dried at 105 ^{0}C for 24 hours. To determine grain yield, the pods were harvested from the rest rows at optimum physiological maturity by hand picking.

Chemical analysis and in vitro dry matter digestibility

Dried samples of the third experimental period were ground to pass through 1 mm sieve for quality determination. Ground samples were bulked on the basis of replicates and a sub sample of each taken for analysis. To determine ash contents, samples were ignited in a muffle furnace at 550 °C (AOAC, 1990) and Crude Protein (CP) was determined using Kjeldahl method (AOAC, 1990). Van Soest et al (1991) procedure was used to determine Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and acid detergent lignin (ADL). The in vitro Dry Matter Digestibility (IVDMD) was determined according to the two stages method outlined by Tilley and Terry (1963). All chemical composition and IVDMD analyses were carried out at Holeta Agricultural Research Center, Nutrition laboratory.

Statistical analysis

The trial was laid out in a complete randomized block design with three replications and analysed by analysis of variance using general linear model procedure of SAS software (SAS institute, 2002). Differences among means with $P<0.05$ were accepted as representing statistically significant differences. Tukey multiple comparisons were deployed to separate treatment means.

RESULTS

Days to flowering and maturity

Days to flowering and days to maturity obtained from the crops sown during the consecutive three years are presented in Table 1. The difference in days to flowering among genotypes during first, second and third growing periods were found significant ($p<0.05$). Genotypes

Table 1: Days to 50% flowering and days to maturity of the cowpea genotypes

Genotypes	Days to flowering				Days to maturity			
	Year1	Year2	Year3	Mean	Year1	Year2	Year3	Mean
12668	49.7^{ab}	49.7^{ab}	50.7^{ab}	50.0^{a}	75.3	76.3	75.7^{a}	75.8^{a}
White wonder	50.1^{a}	50.3^{a}	51.1^{a}	50.4^{a}	73.7	74.7	72.3^{ab}	74.2^{ab}
9333	48.3^{ab}	48.7^{ab}	41.7^{d}	46.2^{bc}	75.3	76.3	64.1^{ab}	70.8^{b}
Small seed	50.3^{a}	50.3^{a}	46.3^{bc}	49.0^{ab}	75.3	76.3	64.7^{ab}	72.1^{ab}
Black eyed	46.3^{b}	46.3^{b}	45.7^{cd}	46.1^{c}	74.7	75.7	63.1^{b}	71.6^{ab}
Mean	48.9	49.2	47.1	48.4	74.9	75.9	67.9	72.9
CV	4.04	4.25	8.17	5.91	10.1	1.79	9.1	7.00
P-level	0.0258	0.0308	0.0005	0.0001	0.337	0.337	0.0414	0.0193

Means with the same letter in the same column are not significantly (p<0.05) different.

Table 2: Herbage dry matter and grain yields obtained from the cowpea genotype sown during the consecutive three years

Genotypes	Dry Matter yield (t/ha)				Grain yield (Quintal/ha)			
	Year1	Year2	Year3	Mean	Year1	Year2	Year3	Mean
12668	11.2^{a}	9.54^{a}	15.1^{a}	11.9^{a}	32.1^{b}	26.7^{b}	33.1^{b}	30.6
White wonder	9.61^{ab}	8.06^{b}	12.6^{b}	10.1^{b}	22.8^{c}	19.9^{c}	22.9^{c}	21.9
9333	6.15^{c}	5.71^{c}	8.52^{c}	6.79^{c}	23.7^{c}	19.1^{d}	20.8^{d}	21.2
Small seed	8.54^{b}	6.49^{c}	11.9^{b}	8.97^{b}	34.4^{a}	29.9^{a}	35.3^{a}	33.2
Black eyed	5.95^{c}	4.53^{d}	6.52^{d}	5.67^{c}	19.5^{d}	17.4^{e}	20.1^{d}	19.0
Mean	8.25	6.87	10.9	8.68	26.5	22.6	26.4	25.2
CV	11.1	13.4	10.4	12.8	9.85	10.1	8.23	9.31
P-level	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Means with the same letter in the same column are not significantly (p<0.05) different.

significantly varied (p<0.05) in days to maturity only in the third growing period. In most cases black eyed was earlier to reach days to flowering and days to maturity (Table 1).

Dry matter herbage and grain yields

Dry matter herbage yield was significantly different (P<0.05) for the first, second and third growing years. During the first growing year, highest dry matter herbage yield of 11.02 t ha^{-1}, 9.61 t ha^{-1} and 8.54 t ha^{-1} was obtained from genotypes 12668, Whit wonder and small seed, respectively. During the second growing year, 12668, Whit wonder and small seed genotypes produced highest dry matter herbage yield of 9.54 t ha^{-1}, 8.06 t ha^{-1} and 6.49 t ha^{-1}, respectively. Similarly, during the third growing year, 12668, White wonder and small seed genotypes produced highest yield of 15.1 t ha,$^{-1}$ 12.5 t ha^{-1} and 11.9 t ha^{-1}, respectively. In all the three consecutive growing years, genotype 12668 was found outstanding in dry matter herbage yield (Table 2).

Significant differences (P<0.05) were observed among the genotypes in grain yield across all the experimental years. Grain yield varied between 19.5 and 34.4 quintal ha^{-1} with a mean of 26.5 quintal ha^{-1} over genotypes in the first year. In the second experimental period, the yield varied between 17.4 quintal ha^{-1} and 29.9 quintal ha^{-1} with a mean of 22.6 quintal ha^{-1} and it was between 20.1 quintal ha^{-1} and 35.3 quintal ha^{-1} with a mean of 26.4 quintal ha^{-1} in the third growing period (Table 2).

Chemical composition

There were significant differences (P< 0.05) among cow pea genotypes in Ash, OM, CP, ADF and in vitro dry organic matter digestibility (IVDOMD) (Table 3), but not in DM%, NDF and ADL (P > 0.05). Ash content of cow pea genotypes varied from 13.5 to 15.1% with a mean of 14.2%. Genotypes, White wonder, 12668 and 9333 were superior in OM% with 86.5, 86.3 and 86.1, respectively. Crude protein content of cow pea genotypes varied from 17.7 to 18.6% with a mean of 18.1%. In vitro dry matter digestibility was higher for black eyed (60.2%) followed by white wonder and 9333 with corresponding values of 57.4% and 57.3, respectively. Average ADF content was 53% with a range of 47.1 – 57.2% and, average NDF content was 58.1% with a range of 56.3 – 60.7% among genotypes. ADL varied from 11.6% to 14.1% with a mean of 13.1%. The lowest ADF and NDF were in black eyed. The highest ADF and NDF were determined in 9333 and 12668 genotypes, respectively (Table 3).

Table 3: Mean dry matter (DM%), ash (ASH%), dry organic matter (OM%), crude protein(CP%), neutral detergent fiber (NDF%), acid detergent fiber (ADF%), acid detergent lignin and in vitro dry organic matter digestibility (IVDOMD%) of cowpea genotypes.

Genotypes	DM%	Ash%	OM%	CP%	NDF%	ADF%	IVDOMD%	ADL%
12668	89.2	13.7^{bc}	86.3^{ab}	18.6^{a}	60.7	53.2^{ab}	55.1^{b}	13.6
White wonder	89.9	13.5^{c}	86.5^{a}	17.7^{b}	58.0	52.3^{ab}	57.4^{ab}	12.1
9333	89.5	14.0^{bc}	86.1^{ab}	18.0^{b}	57.0	57.2^{a}	57.3^{ab}	14.1
Small seed	89.6	14.6^{ab}	85.4^{bc}	17.7^{b}	58.3	55.2^{a}	56.2^{ab}	13.9
Black eyed	89.4	15.1^{a}	84.9^{c}	18.6^{a}	56.3	47.1^{b}	60.2^{a}	11.6
Mean	89.6	14.2	85.8	18.1	58.1	53	57.3	13.1
CV	0.341	4.47	0.742	2.71	4.11	7.12	3.53	10.1
P-level	0.086	0.0106	0.0106	0.0011	0.5984	0.0156	0.0491	0.2033

Means with the same letter in the same column are not significantly ($p<0.05$) different

DISCUSSIONS

Days to flowering and maturity

The trial demonstrates variability in days to 50% flowering and days to maturity within the cow pea genotypes. Days to 50% flowering and maturity ranged from 45.7 days to 51.1 days and 63.1 days to 76.3 days, respectively. Though the area is known by its moisture stress, these genotypes could easily reach 50% flowering and maturity, indicating their tolerance to moisture stress. Early maturity is a relatively important agronomic characteristic and is measured by such criteria as days to flowering or days to maturity (Singh and Rachie1985).

Our results for days 50% flowering and maturity were higher than reported by Cobbinah et al (2011) who found average results of 39.5 and 51.6 days to reach 50% flowering and maturity for cow pea genotypes in Ghana, respectively. Contrary to this, our result for 50% flowering was lower than reported by Agza et al (2012) and Rao and Shahid (2011) who found average results of 63 and 63.7 days, respectively, possibly due to ecological and genetic differences.

Dry matter herbage and grain yields

In previous studies on cowpea, Ayana et al (2013) and Agza et al (2012) reported dry matter herbage yield of different cowpea genotypes ranging between 2.78 t ha^{-1} and 7.67 t ha^{-1} and 2.33 t h^{-1} and 7.13 t h^{-1}, respectively. Ibrahim et al. (2006) obtained dry matter yields of over 4 t ha^{-1}. The average herbage dry matter yields obtained in our study for the three experimental years were considerably higher than those reported by (Ayana et al 2013; Ibrahim et al 2006) but lower than Rao and Shahid (2011) who found an average dry matter herbage yield of 18.1 t ha^{-1} for different cowpea genotypes.

Cowpea grain yield ranged 3.71 quintal to 11.4 quintal ha^{-1} in Ethiopia Ayana et al (2013), 2 quintal to 4 quintal ha^{-1} in Uganda (Omongo et al 1997), and 2 quintal to 3 quintal ha^{-1} in Nigeria (Alghali 1992) which was by far below the yield recorded in this study. But the range of grain yield recorded for the different cowpea genotypes in this study agree with the report of Agza et al (2012) and Goenaga et al (2011) who found that grain yield of different cowpea genotypes varied between 17.2 t h^{-1} to 34.7 t ha^{-1} and 15.56 quintal ha^{-1} to 36.82 quintal ha,$^{-1}$ respectively. Although cowpea could give promising grain yield even higher than the staple crop sorghum (Sorghum bicolor L.) in the study area, the awareness of people towards its importance as human food is low.

In the study area, pest was the major post-harvest problem, affecting the seed at storage and this aggravated when the environmental temperature gets higher (> 30 ^{o}C). Harvesting the seed when well matured, storing the seed in cool and ventilated room and pesticide treatments were the measures taken during the study period. However, these measures were not good enough to store pure seeds and needs further investigation to assess efficient storing mechanisms.

Chemical composition

The minimum CP content in ruminant diet should be around 6.0 - 8.0% of dry matter for adequate activity of rumen microorganism (Van Soest 1994), suggesting that hay CP content in investigated cowpeas are more than twice needed rations. Based on its CP% content, Gwanzura et al (2012) suggested that cowpea has potential of being utilized as protein supplement for ruminants on low quality roughages. Akinlade et al (2005) realized that supplementation of dairy cows with cowpea hay stimulated the voluntary intake of maize stover which as a result could bring an increment in milk yield. Ebro et al (2004) revealed that legume supplementation is an appropriate option where protein sources such as oilseed cakes and those of animal origin are produced in limited quantities and are beyond the economic reach of most of the small holder farmers in Ethiopia. The mean CP content obtained in the present study was considerably lower than reported by Agza et al (2012) and Ayana et al (2013) who found that CP contents of cow pea samples were 20.33 and 23.9%, respectively.The maximum NDF content of diet that does not hinder production may be as high as 750 g/kg for mature beef cows and as low as 150 g/kg DM for growing or fattening ruminants (Barnes et al 1995). NDF and ADF contents determined in present study are higher than reported for genotypes of cowpea (Agza et al 2012; Ayana et al 2013).

This difference could be due to harvest time, different ecological conditions. According to Barnes et al (1995) the total digestible nutrient ranged from 500 g/kg for mature animals to 800 g/kg DM for dairy and rapidly growing young animal. The average digestibility recorded in the present study is lower than reported by Agza et al (2012) who found that average digestibility of cowpea genotypes was 71.5%.

Disease and Pest

Fungal, bacterial and viral diseases affect different parts of cowpea at different stages of growth. Insect pests are also other constraining factors in cowpea production that severely attack the crop at every stage of its growth and make the use of tolerant varieties and insecticide sprays mandatory (Dugje et al 2009). In this study, the disease observed on the crop was leaf spot (Xanthomonas axonopodis Pv.vignicola). This disease was observed during the second experimental period. The common pests observed during the experimental period were blister beteele (Lytta aenea) and aphid (Aphis craccivora). Blister beteele mostly damaged when the seedlings were at their flag leaf stage and aphid's invasion occurred during early maturing on flag shoots and immature green pods.

CONCLUSION AND RECOMMENDATIONS

The current study revealed that the tested cowpea genotypes can adapt well to the semi arid lowlands of northern Ethiopia. The trial demonstrates the variability of yield attributes among cow pea genotypes, indicating the potential for selecting superior genotypes for both forage and grain. Dry matter herbage yield was higher than previous local reports. All the cowpea genotypes tested had adequate CP content for growth and lactation of ruminants and fair amounts of NDF.

The genotypes are nutritious and can supplement deficient roughage feeds in ruminant animal production and recommended for production in the northern lowland of Ethiopia. However, further research should be conducted to identify the level of inclusion of the biomass yields of these cowpea genotypes in various ruminants' supplementation and to characterize grain nutritional composition. Awareness on its importance as valuable human food should be created. Researches that focus solution to pest infestation are also recommended to reduce post-harvest grain losses in cowpea production.

ACKNOWLEDGEMENTS

The authors are grateful to the Tigrat Agricultural Research Institute for financial support to implement the study. Animal science researchers of Humera Agricultural Research Centre, Shushay Markos, Mengstu Regasa, Bahlbi Weldegebrel and Tewldmedhn Mekonen are also acknowledged for their support during the field research work. The animal nutrition laboratory workers of Holetta Agricultural Research Center are also acknowledged for their support in the chemical analysis of the feed samples.

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