Animal Feed Science and Technology 163 (2011) 214–221

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Seed and forage yield, and forage quality determinants of nine legume shrubs in a non-tropical dryland environment

A. Larbi[a,*], A. Khatib-Salkin[a], B. Jammal[b], S. Hassan[a]

[a] International Center for Agricultural Research in the Dry Area (ICARDA), P. O. Box 5466, Aleppo, Syria
[b] Faculty of Agricultural Sciences, Lebanese University, Beirut, Lebanon

ARTICLE INFO

Article history:
Received 10 July 2010
Received in revised form 2 November 2010
Accepted 8 November 2010

Keywords:
Shrub
Legume
Forage
Seed
Chemical composition
In vitro digestibility
Gas production

ABSTRACT

The objective was to identify legume shrub species for development of agroforestry technologies based on seed and forage (leaves and twigs < 10 mm diameter) yield, and determinants of forage quality. Ten individual plants of *Bituminaria bituminosa* 'Ecotypes 1', *B. bituminosa* 'Ecotypes 2', *Medicago citrina*, and *M. arborea* from Spain; *Colutea istria* and *Onobrychis aurantiaca* from Syria; *C. istria* from Jordan; *Chamaecytisus mollis* from Morocco; and *Coronilla glauca* from France were randomly selected from plots established in a non-tropical dryland environment in northwest Syria in 2000. Five individual plants of each species were cut back to 0.5 m above ground in March 2004. Coppice regrowths were pruned in December 2004 and April 2005 to determine forage yield and proportion of forage in the total above ground biomass (PEFB). Forage samples were analyzed for concentrations of crude protein (CP), lignin(sa), acid detergent fibre (ADFom), neutral detergent fibre (aNDFom), *in vitro* organic matter (OM) digestibility (IVOMD), and *in vitro* 24 h gas production (IVGP24h). Matured seeds were hand harvested from the remaining five plants of each species to estimate seed yield. Forage (21–250 kg DM/ha) and seed (0–200 kg DM/ha) yields; PEFB (0.22–0.96); and concentrations of CP (85–115 g/kg DM), lignin(sa) (14–42 g/kg DM), ADFom (94–170 g/kg DM), aNDFom (122–217 g/kg DM), IVOMD (456–617 g/kg OM), and IVGP24h (27–42 ml 200 mg/DM) varied ($P<0.05$) among shrub species. The IVOMD and IVGP24h were positively correlated ($r = 0.75$, $P<0.032$), whereas IVOMD and IVGP24h were negatively correlated with ADFom, lignin(sa) and aNDFom. In terms of forage and seed yields and determinants of forage quality, *C. istria* from Jordan, *M. arborea*, *B. bituminosa* 'Ecotype-2', *C. istria* and *O. aurantiaca* have higher potential than *C. mollis*, *C. glauca* and *B. Bituminosa* 'Ecotype-1' for the development of agroforestry technologies in non-tropical dry areas.

1. Introduction

Rangelands are major source of feed, fuel and medicinal herbs for millions of resource poor pastoral and agro-pastoral communities in non-tropical dry areas of central and west Asia, and north Africa (CWANA) with average annual rainfall of 150–300 mm (Le Houérou, 1994; Gintzburger et al., 2003). However, over-grazing and frequent drought have degraded most

Abbreviations: aNDFom, neutral detergent fibre inclusive of ash residual; ADFom, acid detergent fibre exclusive of residual ash; CP, crude protein; CWANA, Central and West Asia and North Africa; DM, dry matter; ICARDA, International Center for Agricultural Research in the Dry Areas; IVGP24h, *in vitro* gas production after 24 hours of incubation in rumen liquor; IVOMD, *in vitro* OM digestibility; PEFB, proportion of forage in the total above ground biomass.

* Corresponding author. Tel.: +963 212213433; fax: +963 212213490.
E-mail addresses: a.larbi@cgiar.org, a_larbi@hotmail.com (A. Larbi).

0377-8401/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.anifeedsci.2010.11.006

rangelands, resulting in severe soil degradation, biodiversity loss, chronic feed deficits, and expanding desert margins (Le Houérou, 1994; Gintzburger et al., 2003; Tiedeman et al., 2005). Establishment of shrub plantations has been recommended as one of the strategies to mitigate rangeland degradation and desertification (Le Houérou, 1994; Robles et al., 2002; Gintzburger et al., 2003; Osman et al., 2006), however previous studies on forage shrubs focused on a few non-legume species, especially *Atriplex* (Le Houérou, 1994; Gintzburger et al., 2003; Osman et al., 2006; Larbi et al., 2009). Consequently, the potential of native and exotic legume shrub species for rangeland rehabilitation has not been fully exploited in CWANA due to lack of quantitative data on environmental adaptation, productivity, and determinants of forage quality.

The International Center for Agricultural Research in the Dry Areas (ICARDA) initiated collection and preliminary evaluation of legume and non-legume forage shrubs from CWANA. Data on 26 non-legume shrub species in the preliminary studies have been reported (Larbi et al., 2009). The objective of this study was to examine forage and seed yields, and determinants of forage quality of nine native and introduced legume shrub species and ecotypes, and to identify promising shrubs based on yield and quality attributes.

2. Materials and methods

2.1. Study site and shrub establishment

The study was conducted at ICARDA's research station at Tel-Hadya (35°55′N, 36°55′E, altitude 362 m) in north-west Syria. The climate is Mediterranean, with annual rainfall occurring between October and May of about 342 mm. The soil is well structured reddish brown clay classified as Vertic Luvisols (Cooper et al., 1987).

2.2. Experimental design

A randomized complete block design with five randomly selected individual plants of each legume shrub species as replicates was used. Treatments were nine legume shrub species, namely: *Bituminaria bituminosa* 'Ecotype 1', *B. bituminosa* 'Ecotype 2', *Medicago citrina*, and *M. arborea* from Spain; *Colutea istria* and *Onobrychis aurantiaca* from Syria; *C. istria* from Jordan; *Chamaecytisus mollis* from Morocco; and *Coronilla glauca* from France. The shrub species were established at a density of 1000 seedlings per hectare in March 2000. A unit plot consisted of two rows of each shrub, 25 m long, with 2 m space between rows and 1 m space within rows.

2.3. Fodder and seed yield estimation

Ten individual plants of each shrub species were randomly selected from the existing plots in February 2004 and tagged. Five individual plants of each species were used to determine forage yield, and the rest of the plants were used to estimate seed yield.

For forage yield determination, individual plants of each shrub species were cut back to 0.50 m above ground in March 2004. Coppice regrowths were harvested at end of December 2004 and April 2005, weighed fresh, and separated into forage (*i.e.*, leaves + twigs < 10 mm diameter) and wood fractions. Forage yield of each plant was divided by total above ground biomass and multiplied by 100 to estimate the proportion of forage in the total above ground biomass (PEFB). Sub-samples of the forage were oven dried at 60 °C for 48 h to determine dry matter (DM) content.

Seed yield was estimated by monitoring individual plants of each species for flowering and seed maturity. Matured seeds from each individual plant were hand harvested periodically, air-dried, cleaned, and weighed. Seed yield from each individual plant was bulked at end of the study period to estimate total seed yield per plant.

2.4. Chemical analyses

Forage samples from the April 2005 harvest were ground through a 1 mm screen for laboratory analyses. Total N was determined using the Kjeldahl method (AOAC, 1990; # 973.18). Acid (ADFom) and neutral detergent fibre (aNDFom) concentrations were determined by the sodium sulphite and α-amylase procedure (Van Soest et al., 1991), and expressed exclusive of residual ash. Lignin(sa) was determined by solubilization of cellulose with sulphuric acid.

In vitro OM digestibility (IVOMD) was determined by a modified two-stage procedure (Moore and Mott, 1974). Rumen fluid was obtained from four 3 year old, rumen fistulated Syrian × Turkish Awassi rams fed oat and vetch hay and concentrates in a ratio of 2:1. Rams had free access to water and mineral and vitamin licks. Concentrations of CP, ADFom, aNDFom and IVOMD in the hay were 118, 264, 523 g/kg DM and 674 g/kg OM respectively. The concentrate contained 178 g/kg DM CP and 12.1 MJ/kg DM metabolizable energy. One kilogram of the mineral and vitamin pre-mix contained: vitamin A, 12 500 000 IU; vitamin D3, 3000 IU; vitamin E, 5 000 000 IU; vitamin B1, 2000 mg; vitamin B2 4000 mg; vitamin B6, 2000 mg, vitamin B12, 13 mg; vitamin B5, 7000 mg; folic acid, 20 000 mg; sodium chloride 14 g, magnesium oxide, 7.5 g; ferrous sulphate 25 g; copper sulphate 3 g; potassium iodide, 1 g; and manganese oxide, 10 g.

Procedures described by Nsahlai et al. (1994) were used to estimate *in vitro* gas production after incubation of samples for 24 h with rumen liquor (IVGP24h).