

## Identification of cover crops for the semi-arid savanna zone of West Africa

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### Abstract

Leguminous cover crops may be an appropriate component of sustainable food-production systems in the semi-arid savannas of West and Central Africa. A set of erect and spreading legumes was observed for adaptation to a semi-arid climate (700–900 mm annual rainfall), without fertilizer application, on three soil types in northern Cameroon. *Mucuna pruriens* generally reached 100% ground cover 60–90 d after planting, whereas *Canavalia ensiformis* rarely reached 100% ground cover. Two *C. ensiformis* accessions, one erect and one spreading, differed in their ability to cover the soil surface. Maximum foliage dry matter (DM) exceeded that of the locally adapted spreading cowpea in most cases. Foliage DM of *M. pruriens*, *C. ensiformis*, *Crotalaria ochroleuca*, and *Cajanus cajan* generally exceeded 4 t ha<sup>-1</sup> at all but the most degraded site. At the degraded site, the erect *C. ensiformis* accession produced 5–7 t DM ha<sup>-1</sup>. *Canavalia ensiformis* grew longer into the dry season and maintained higher moisture content, suggesting some drought resistance. Because of strong winds during the dry season and trampling during seed collection, foliage DM less than about 4 t ha<sup>-1</sup> did not persist through the dry season. Uncontrolled cattle grazing was another threat to persistence of mulch through the dry season.

### Résumé

Les cultures de couverture de légumineuses peuvent être un élément convenant aux systèmes de production alimentaire durable dans les savanes semi-arides de l'Afrique occidentale et de l'Afrique centrale. Un ensemble de légumineuses érigées et rampantes ont fait l'objet d'une étude afin d'être adaptées à un climat semi-aride (700–900 mm de précipitations annuelles) sur trois types de sol du nord du Cameroun sans application d'engrais. En général, la couverture de *Mucuna pruriens* atteint une maturité de 100 % dans les 60–90 jours après semis, alors que la couverture de *Canavalia ensiformis* atteint rarement 100 %. Deux obtentions de *C. ensiformis*, l'une dressée et l'autre étalée, n'ont pas la même capacité de couvrir le sol. Dans la plupart des cas, la culture sèche de feuillage maximale a dépassé celle des doliques étalées et adaptées à la région. La biomasse de *M. pruriens*, de *C. ensiformis*, de *Crotalaria ochroleuca* et de *Cajanus cajan* a généralement dépassé 4 t ha<sup>-1</sup> sur tous les terrains, sauf sur les plus dégradés. Sur un terrain dégradé, l'obtention de *C. ensiformis* dressés a produit de 5 à 7 t ha<sup>-1</sup> de matière sèche. Les *C. ensiformis* ont poussé davantage pendant la saison sèche et ont maintenu une teneur en eau plus élevée, démontrant ainsi une certaine résistance à la sécheresse. La culture sèche de feuillage d'une densité inférieure à 4 t ha<sup>-1</sup> n'a pas résisté aux vents forts de la saison sèche et aux dommages dus aux piétinements pendant la collection des semences. Le pâturage permanent des bovins a aussi été une menace à la persistance du paillis tout au long de la saison sèche.

### Introduction

In the semi-arid zone, bare soil is susceptible to wind and water erosion, especially at the beginning of the rainy season. Live or dead vegetative cover can protect the soil surface from raindrop impact, runoff, and erosion. The mulch may also favour the activity of

mesofauna, such as tunneling of termites, thereby increasing rainfall infiltration (Chase and Boudouresque 1989). Lal (1993) recommended mulch farming as a sustainable-management option for soil and water conservation in the semihumid zone, which he defined by the criterion of 800–1 000 mm annual rainfall. Sources of mulch could include crop residues or leguminous cover crops. Leguminous cover crops would not only protect the soil surface from erosion (Young 1989) and maintain the lower soil temperature (Budelman 1989) needed for soil biological activity, but also provide nutrients, particularly N. The mulch should ideally be in place when the first rains come at the beginning of the rainy season, if it is to protect the soil from erosion. From existing literature, it can be hypothesized that about 4 t ha<sup>-1</sup> of dry matter (DM) is needed to protect the soil from erosion and to conserve soil water. This was observed in several studies in the forest savanna transition zone (De Vleeschauwer et al. 1980) and also in the northern Guinea savanna (Adeoye 1984).

Some leguminous cover crops have been adopted in West Africa but not in the semi-arid savanna zone. Herbaceous legumes with some adoption potential are *Mucuna pruriens* (CTA 1995), *Canavalia ensiformis* (NAS 1979; Udedible 1990), and *Crotalaria ochroleuca* (Wortmann et al. 1994).

In 1991, we initiated screening of multipurpose cover crops to identify species or accessions that not only cover the soil quickly during the rainy season but also accumulate substantial biomass and persist as live or dead cover during the dry season. We used a range of sites with different soil types.

### Materials and methods

All trials were conducted in 1992 and 1993 in northern Cameroon, within 150 km of Maroua (lat. 10°30' N, long. 14°10' E), at Mouda (gravelly ferruginous Alfisol), Ndonkole (Vertisol), and Guetale (alluvial loam Inceptisol in the Mandara mountains). Annual rainfall in these environments was 700–900 mm. Soil properties varied from site to site (Table 1), with a high clay content at Ndonkole and a high level of available P at Guetale. Species screened included *M. pruriens*, *C. ensiformis* (one erect and one spreading type), *Cajanus cajan* (one early and one late type), and *C. ochroleuca*. A local spreading cowpea cultivar was used as a control in 1992.

**Table 1.** Properties of soil (0- to 30-cm depth) at sites of cover-crop screening in northern Cameroon at the beginning of the experiment.

Property	Mouda (Alfisol)	Ndonkole (Vertisol)	Guetale (Inceptisol)
Organic C (%)	0.48	0.49	0.26
Available P, Bray-1 (ppm)	3.1	6.2	32.1
Sand (%)	57	34	49
Silt (%)	29	31	39
Clay (%)	14	35	12

In 1992, planting was done on 19 June at Guetale, 30 June at Ndonkole, and 1 July at Mouda. The experimental design was a randomized complete block, with two replications per site. Plot size was 6 m x 8 m, except at Ndonkole, where it was 5.5 m x 8 m. Interrow distance was 1 m for all species. Ground cover was estimated using a line-point transect method (Daughtry et al. 1995). A cord marked at 5-cm intervals was stretched diagonally across the plot and the proportion of points in line with vegetation was recorded. Biomass was sampled twice from 3.2 m<sup>2</sup>, and a final sample was taken later from 12 m<sup>2</sup>. Dates for ground-cover and DM determination depended on availability of transport to the sites. A subsample of the fresh biomass was oven-dried at 65°C for 48 h

for DM determination.

In 1993, species or accessions were planted in a randomized complete-block design, with three replications, at Mouda (20 June), Ndonkole (21 June), and Guetale (22 June), near the plots used in 1992. Ground cover was determined at approximately 30, 60, and 90 d after planting (DAP), and DM was determined at 60, 120, and 180 DAP.

The data for ground cover of *M. pruriens* and both *C. ensiformis* types were combined for the three sites in each year. Data for aboveground DM were subjected to analysis of variance, calculated separately for each year, each site, and each observation date. The maximum DM accumulation is presented; however, a combined analysis was not done over years because species and sampling times changed over the years.

## Results and discussion

Cowpea often gave best early growth and ground cover; however, by the second month of growth, *Mucuna* covered the soil better than cowpea and thereby reduced soil temperature effectively during the growing season (data not shown). *Mucuna pruriens* attained 100% ground cover by 60–70 DAP in 1992 (Figure 1) and by 90 DAP in 1993 (Figure 2). In 1992 and 1993, the erect type of *C. ensiformis* gave consistently less ground cover than the spreading type. The spreading *C. ensiformis* gave consistently less ground cover than *M. pruriens* in 1992, but its ground coverage at the early-growth stage was slightly higher in 1993.

Maximum foliage DM yield is presented in Table 2. DM yields at Guetale were on average about 50% higher than those at Mouda and 30% higher than those at Ndonkole. This was probably due to the high level of available P at Guetale (see Table 1).

### **Figure 1. Percentage ground cover, 1992.**

### **Figure 2. Percentage ground cover, 1993.**

**Table 2.** Maximum foliage DM of legumes during 1992 and 1993 rainy seasons.

	DM (t ha <sup>-1</sup> )					
	Mouda		Ndonkole		Guetale	
	1992	1993	1992	1993	1992	1993
Cowpea	1.8	—	3.1	—	2.5	—
<i>Mucuna pruriens</i>	3.4	3.6	5.2	4.2	5.0	6.0
<i>Canavalia ensiformis</i> (erect)	3.9	2.7	5.0	1.9	6.2	9.3
<i>C. ensiformis</i> (spreading)	7.8	5.2	5.3	2.0	6.1	9.2
<i>Cajanus cajan</i> (early)	4.7	3.0	4.7	4.3	3.5	4.5
<i>C. cajan</i> (late)	7.0	—	5.7	—	5.1	—
<i>Crotalaria ochroleuca</i>	2.9	3.5	4.3	6.1	6.1	6.5
SE	0.97	0.67	1.07	0.73	0.64	0.92

Note: DM, dry matter; SE, standard error.

Foliage DM of cowpea was lowest at each site in 1992, averaging less than 2.5 t ha<sup>-1</sup>. The cover-crop foliage yields were usually well more than 3.0 t ha<sup>-1</sup>. Maximum *M. pruriens* DM averaged 4.5 t ha<sup>-1</sup> in 1992 and 4.6 t ha<sup>-1</sup> in 1993. Erect *C. ensiformis* DM averaged 5.0 t ha<sup>-1</sup> in 1992 and 4.7 t ha<sup>-1</sup> in 1993, which includes low yields at Mouda and Ndonkole. Spreading *C. ensiformis* averaged 6.4 t ha<sup>-1</sup> in 1992 and 5.4 t ha<sup>-1</sup> in 1993, which include a low yield at Ndonkole.

Cowpea leaves and stems generally blew away during the dry season because vegetative

DM was rarely above 2.5 t ha<sup>-1</sup>. Much of the biomass at Mouda (where all but spreading *C. ensiformis* produced less than 3.5 t ha<sup>-1</sup>) was blown away by the dry-season winds. Many of the species persisted as mulch during the dry season (1993/94) at Guetale, where all species produced at least 4.5 t ha<sup>-1</sup> of DM. It appears therefore that 3.5–4.5 t DM ha<sup>-1</sup> is the minimum quantity of DM required to resist being blown away by the wind during the 8-month dry season of the semi-arid zone.

*Mucuna* DM accumulation has been reported in several agroecological zones of the tropics. DM is accumulated at rates of 7–12 t ha<sup>-1</sup> in the humid zones of Honduras (Triomphe 1996) and Brazil (Smyth et al. 1991), 4.9–8.5 t ha<sup>-1</sup> in the subhumid zone with bimodal rainfall pattern in Brazil (Lathwell 1990) and Nigeria (Sanginga et al. 1996), and 6–8 t ha<sup>-1</sup> in the subhumid zone with monomodal rainfall pattern in Cameroon (Klein 1994). The accumulation of *Mucuna* DM in our trials was 3.4–6.0 t ha<sup>-1</sup>, and the average was 4.6 t ha<sup>-1</sup>, very near the threshold below which mulch cannot persist through the dry season, as discussed above.

The problem of persistence was exacerbated by grazing cattle. At Ndonkole, cattle came through the area in November and ate the dry and green vegetation in most of the plots. All species except *C. ensiformis* (both accessions) were eaten. Eventually, later on in the dry season, the *C. ensiformis* was also eaten. *Cajanus cajan* displayed a moderate regrowth after grazing by cattle.

Surface-soil crusting influenced establishment of some legumes. Small-seeded legumes were very much affected at Mouda in a preliminary trial in 1991. In 1993, establishment was generally lower at Mouda, with a gravelly Alfisol prone to crusting, and higher at Ndonkole, with a well-structured Vertisol. Small-seeded *C. ochroleuca* was most affected (data not shown).

In the semi-arid zone, drought resistance may be an important characteristic for a cover crop. *Canavalia ensiformis* generally continued to accumulate biomass after the end of the rains. The moisture content of *C. ensiformis* was usually much higher than that of *M. pruriens* during the early dry season (Table 3), suggesting that it still had active roots. Only *C. cajan* (late and early) and *C. ensiformis* (both varieties) still had green leaves by December. *Mucuna* reached senescence soon after the end of the rains. Late pigeon pea stayed green longest and in some cases survived the dry season. The biomass-yield potential of the early variety is lower than that of the late variety, but grain is more likely to be harvested from the early variety. Grain was harvested from the early variety but not from the late one at the Mouda site in 1992.

**Table 3.** Moisture content of aboveground foliage of *Mucuna* and *Canavalia* during early dry season.

	Moisture content (%)			
	Mouda		Guetale	
	1991, 122 DAP	1993, 178 DAP	1993, 120 DAP	1993, 180 DAP
<i>Mucuna pruriens</i>	35.5	4.0	46.4	22.4
<i>Canavalia ensiformis</i>	73.5	60.3	72.0	38.5
SE	3.48	0.01	0.10	0.02
Note: DAP, days after planting; SE, standard error.				

Legume-planted fallows may not be adopted if the fallow species has no direct economic use (Greenland 1985). Because farmers are unlikely to grow a crop that produces no food for human consumption or any other obvious benefit, recommendations must be carefully formulated. It should be noted that the grain of *M. pruriens* and *C. ensiformis*

can be used as food, but it needs to be processed and should constitute a small fraction of the human diet (Kay 1979). Future research on detoxification of these grains for human consumption should be encouraged. Other grain legumes that produce substantial biomass, such as *Lablab purpureus* should be tested.

For regeneration of degraded soils, a sole crop of *Mucuna* or *C. ensiformis* or a combination of the two species might be envisioned. These large-seeded species can break through a crusted, unplowed soil. They require very little or no weeding, and they provide the most rapid and complete cover. The major problem is that they must be protected from grazing and fire if their residues are to persist as mulch throughout the dry season. Intercropping with a drought-resistant cereal, such as millet, may increase the DM and the likelihood of persistence. Protection of mulch by fencing may be justified if the mulch proves to sustain crop production. An economic analysis will be required once the agronomic benefit of mulch is estimated.

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