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Weed control potential of five legume cover crops in maize/cassava intercrop in a Southern Guinea savanna ecosystem of Nigeria

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Abstract

The use of leguminous cover plants to suppress weeds in plantation crops dates back to many decades, but the integration of the legumes into arable cropping systems has not been developed to a level acceptable to farmers. Five legume cover crops (*Pueraria phaseoloide*s (Roxb) Benths, *Stylosanthes guianensis* (Aubl.) Sw., *Mucuna pruriens* (L.) Dc *var. utilis* Wall ex Wight, *Mucuna preta* and *Mucuna jaspeada*] with a no legume cover as control were used as a sub-treatment in an integrated weed management in maize/cassava intercrop. The study was carried out at the Teaching and Research Farm of the University of Ilorin in 2002 and 2004. Significantly lower weed densities were obtained under *S. guianensis* and *M. pruriens* var. *utilis* (7.83 and 8.08 weeds/m², respectively) compared with densities in *P. phaseoloides* (9.87 weeds/m²), *M. jaspeada* (9.37 weeds/m²) and *M. preta* (11.71 weeds/m²) plots at 12WAP. *Mucuna preta* produced the highest ground cover at 10WAP while *M. pruiens (var utilis)* had the highest ground cover at 16WAP in 2002. In 2004, *M. jaspeada* produced the highest ground cover at both 10 and 16WAP (59.6 and 91.0% respectively). Total weed density was significantly reduced under *S. guianensis* and *M. pruriens* var. *utilis* at 48WAP in 2004. There was no significant difference in the yield of maize in the various legume cover crops plots in both years while average yield of fresh cassava tuber was significant in *M. preta* plots.

Keywords: cassava, cover crops, intercrop, maize, weed, yield.

Introduction

Leguminous cover crops have been extensively used in the tropics for soil conservation in plantation crops and for maintaining soil fertility. Fast growing legumes are potentially good for replacing many unwanted weeds that normally dominate farmlands especially after crop harvest (Akobundu, 1987). Generally these cover crops are easier to control than weeds either by slashing or with herbicides. Akobundu [1982] observed the beneficial effects of legume cover crops in plantation crops in the tropics but noted that these beneficial effects have not been successfully extended to food (arable) crop production in a form acceptable to farmers. He therefore suggested the integration of herbaceous legumes as cover crops or live mulch in the existing cropping systems. Other studies Akobundu [1980, 1984]; Akobundu *et al* [1999]; Ebong and Ononokpono [1970]; Tarawali [1994]; Vesteeg *et al*.[1998], Vissoh *et al* [1998]; Udensi *et al*., [1999] have shown that herbaceous cover crops can smother weeds, reduce the weeding frequency and increase crop yield in the savanna of West Africa. Desirable cover crops are those that do not only cover the soil surface quickly but also suppress weeds. Weeds and labour demand required for weed control are among the most important production constraint (Weber *et al*. [1997). In Nigeria farmers spend more time in controlling weeds than on any other aspect of crop production. Earlier report by Chikoye *et al*. (2000) has shown that the simultaneous cropping of cover crops with food crops has a good potential for reducing cost of weed control and production. Therefore, this study was designed to evaluate the potential of five legume cover crops as weed control agents in maize/cassava intercrop in a southern Guinea savanna ecology.

Table 1. Cover crops stand establishment in 2002 and 2004 at Ilorin, Nigeria

Legume cover crops	Stand establishment (%)	
	2002	2004
P. phaseoloides	79.7a	70.2a
S. guianenssis	55.6a	57.2a
M. pruriens	82.2a	51.7a
M. preta	91.9a	58.9a
M. jaspeada	74.0a	73.3a
S.E.D.	18.16	15.84

Means in the same column bearing the same letter(s) are not significantly different from each other at p = 0.05.

Materials and methods

This study was carried out at the Teaching and Research Farm of the University of Ilorin ($8^0$29′N; $4^0$35′E) Ilorin, Kwara State, Nigeria, in the southern Guinea savanna ecosystems, in 2002 and 2004 growing seasons. The Farm location has two rainfall

Table 2. Ground cover (%) and biomass (g) of legume cover crops at different periods in 2002 and 2004 at Ilorin, Nigeria

Legume cover crops	Ground cover (%)				Biomass (g)
	2002		2004		2004
	10WAP	16WAP	10WAP	16WAP	10WAP
P. phaseoloides	10.27b	13.30b	39.8a	71.8a	24.8a
S. guianensis	1.68c	3.51b	29.3a	53.0a	17.0a
M. pruriens	34.86a	30.49a	25.7a	54.8a	13.0a
M. preta	35.72a	26.6a	46.2a	66.8a	38.3a
M. jaspeada	21.75b	16.27a	59.6a	91.00a	35.8a
S.E.D	4.751	5.841	16.61	20.536	15.93

Means in the same column bearing the same letter(s) are not significantly different from each other at p = 0.05.

Table 3. Effect of legume cover crops on grass weed density at different periods in 2002 and 2004 at Ilorin, Nigeria

Legume cover crops	Weed density (no/m^2)					
	2002		2004			
	6WAP	12WAP	6WAP	12WAP	44WAP	48WAP
P. phaseoloides	13.7a	27.0a	66.9a	27.08b	4.54a	7.17a
S. guianensis	17.8a	28.4a	51.7a	17.67bc	4.29a	7.33a
M. pruriens	16.2a	23.3a	71.4a	42.50a	5.38a	7.83a
M. preta	13.5a	20.5a	68.5a	26.42bc	4.96a	9.50a
M. jaspeada	18.6a	24.7a	76.5a	40.33a	5.50a	9.00a
NL	23.9a	25.0a	57.5a	13.88c	4.08a	8.92a
S.E.D	4.60	3.72	14.02	3.69	0.96	0.07

Means in the same column bearing the same letter(s) are not significantly different from each other at p = 0.05.

Table 4. Effect legume cover crops on broadleaved weed density at different periods in 2002 and 2004 at Iorin, Nigeria

Legume cover crops	Broadleaved weed density (no/m^2)				
	2002	2004			
	6WAP	6WAP	12WAP	44WAP	48WAP
P. phaseoloides	3.50a	1.70a	2.37a	0.500a	0.96a
S. guianensis	1.37a	16.40a	3.87a	0.292a	0.54a
M. pruriens	1.54a	6.70a	4.92a	1.083a	1.33a
M. preta	3.50a	2.20a	1.63a	0.458a	0.29a
M. jaspeada	4.33a	4.4a	5.08a	0.750a	0.79a
NL	3.58a	8.2a	3.71a	0.708a	0.96a
S.E.D.	1.54	8.44	1.42	0.26	0.40

Means in the same column bearing the same letter(s) are not significantly different from each other at P = 0.05.

peaks at May and mid-August and September to mid-November. The average annual rainfall for Ilorin is 1000-1240mm. The experiment was a randomized complete block comprising a main plot ($36m^2 \times 7.8m^2$) of eight weed managements and a subplot ($6m^2 \times 7.8m^2$) of five legume cover crops (*Pueraria phaseoloide*s (Roxb) Benths, *Stylosanthes guianensis* (Aubl.) Sw., *Mucuna pruriens* (L.) Dc *var. utilis* Wall ex Wight, *Mucuna preta* and *Mucuna jaspeada*], with a no legume cover crop plot as control, replicated in three blocks. The experimental plots were ridged on 12 July, in 2002 and 22 June, in 2004. Each subplot was made up of 6 ridges of 1.3m apart, and 6m long. Maize var. DMRY, was planted on 19 July, 2002 and between 24 and 25 June, in 2004 at an intra-row spacing of 0.25m immediately after soil tillage, two seeds were dropped per hill which was later thinned to one plant per stand to make a plant population of 40,000 plants/hectare. Viable cassava stems

Table 5. Effect of legume cover crops on grass weed biomass at different periods in 2002 and 2004 at Ilorin, Nigeria

Legume cover crops	Weed biomass (g/m^2)						
	2002		2004				
	6WAP	12WAP	6WAP	12WAP	20WAP	44WAP	48WAP
P. phaseoloides	4.01a	26.4a	14.60ab	38.8ab	47.8a	27.1a	37.7a
S. guianensis	5.58a	26.1a	12.15b	34.3ab	39.9a	30.5a	47.4a
M. pruriens	5.48a	34.4a	23.10a	43.6ab	55.2a	23.7a	44.3a
M. preta	5.09a	24.9a	14.46ab	50.0a	50.8a	27.7a	60.1a
M. jaspeada	5.12a	22.9a	19.67ab	42.8ab	46.1a	32.0a	52.7a
NL	5.44a	28.1a	14.50ab	30.1b	51.4a	34.3a	61.2a
S.E.D.	0.81	6.07	2.93	5.27	16.44	6.70	9.57

Means in the same column bearing the same letter(s) are not significantly different from each other at p = 0.05.

Table 6. Effect of legume cover crops on broadleaved weed biomass (g/m^2) at different periods in 2004 at Ilorin, Nigeria

Legume cover crops	Broadleaved weed biomass (g/m^2)				
	6WAP	12WAP	20WAP	44WAP	48WAP
P. phaseoloides	0.90a	7.3b	15.4a	2.02a	13.9a
S. guianensis	3.92a	4.0b	15.4a	0.50a	11.8a
M. pruriens	4.27a	14.8a	12.1a	7.63a	10.6a
M. preta	1.62a	3.5b	15.3a	1.12a	10.1a
M. jaspeada	3.60a	20.7a	22.2a	3.33a	37.3a
NL	2.21a	4.3b	8.5a	3.29a	13.2a
S.E.D.	1.49	4.94	6.51	2.18	13.58

Means in the same column bearing the same letter(s) are not significantly different from each other at P = 0.05.

of a local variety ("Okoyawo".) grown by local farmers as an important staple crop were cut into 25cm setts each and planted on 16 and 17 August, in 2002 and 26 – 29 June, in 2004 at an intra-row spacing of 0.8m to make a plant population of 12,500 plants /hectare. Two of the legume cover crops (*P. phaseoloides* and *S. guianensis)* were planted, at the same time with maize in 2002 and 2004 cropping seasons at an intra-row spacing of 0.25m by drilling and later thinned to one per stand at 4WAP to make a plant population of 40,000 plants/hectare. The remaining cover crops (*M. pruriens var. utilis, M. preta* and *M. jaspeada)* were planted between 16 and 18 July, in 2002 and 23 July in 2004 at an intra-row spacing of 0.4m at one seed per stand to make a plant population of 25,000 plants/hectare. All the cover crop seeds were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Cover crop stand establishment for *M. pruriens* var. *utilis, M. preta* and *M. jaspeada* was determined at 2 weeks after planting (WAP) while that of *P. phaseoloides* and *S. guianensis* was determined at 4WAP. Ground cover of the legume cover crops was evaluated at 10 and 16WAP in both seasons of the experiment using the beaded string method (Sarrantino 1991). Weed density and weed biomass were determined at 6 and 12WAP in 2002 and at 6, 12 20, 44 and 48WAP. Maize cobs were harvested at 17WAP in 2002 and 21WAP in 2004 due to labour constraint while cassava tuber yield was determined at 11months after planting (MAP) in both years. All data collected were subjected to analyses of variance using Criss-Cross models by GENSTAT package. Significant means were separated by the Duncan's Multiple Range Test at 5% probability level.

Results

In both 2002 and 2004 cropping seasons, all the legume cover crops had comparable stand establishment which were higher in 2002 than 2004 (Table 1). *Mucuna preta* and *M. pruriens* produced the highest ground cover, which was significantly higher than the cover produced by other legumes, at both 10 and 16WAP in 2002 (Table 2). However, *M. preta* produced the highest ground cover at 10WAP, while *M. pruriens (var utilis)* had the highest ground cover at 16WAP. In 2004, *M. jaspeada* produced the highest ground cover at both 10 and 16WAP (59.6 and 91.0% respectively). These values were however, not significantly different from those of the other legumes. Cover crop biomass was not significantly high at 10WAP (Table 2). Grass weed density was not positively affected by the legume cover crops in 2002 however, *S. guianensis* and *P. phaseoloides* plots in 2004 at 12WAP produced significantly low grass weed density (Table 3) while broadleaved weed density was generally low in all the plots (Table 4). Grass weed biomass at 6 and 12WAP in 2002 was not significantly affected by the legume cover crops while in 2004, *M. preta* plots produced significant-

Table 7. Effect of legume cover crops on total weed density and biomass at different periods in 2002 and 2004.at Ilorin, Nigeria

Legume cover crops	Total weed density (no/m²)			Total weed biomass g/m^2	
	2002	2004		2004	
	12WAP	12WAP	48WAP	12WAP	48WAP
P. phaseoloides	26.50a	29.42b	9.87a	46.10b	61.70a
S. guianensis	34.20a	21.54b	7.83b	37.90bc	70.50a
M. pruriens	27.20a	47.42a	8.08b	58.80a	66.80a
M. preta	25.70a	28.04b	11.71a	53.40ab	68.40a
M. jaspeada	23.60a	45.42a	9.37a	63.50a	60.20a
NL	24.80a	17.58b	7.75b	34.40c	72.20a
S.E.D	4.39	4.06	0.99	7.66	12.85

Means in the same column bearing the same letter(s) are not significantly different from each other at P = 0.05.

ly higher grass weed biomass than no legume plot (Table 5). Also broadleaved weed biomass was significantly lower in all the legume cover crop plots except in *M. pruriens* and *M. jaspeada* plots (Table 6). Weed flora of the experi- mental plots in 2002 was dominated essentially by grass weeds at 12WAP. In 2004, total weed density produced in *M. pruriens var. utilis* and *M. jaspeada* plots were significantly higher than those produced in the other legume cover treat- ments at 12WAP (Table 7). However, *S. guianensis* and *M. pruriens* (var. *utilis*) plots at cassava harvest produced significantly lower total weed density than plots of other legume cover crops. Total weed biomass at 12WAP in 2004 was significantly higher in *M. pruriens* and *M. jaspeada* plots than other treatments while at cassava harvest, total weed biomass in all the legume cover plots was higher than no legume plot however, this effect was not statistically signi- ficant. Grain yield under the various legume cover crops was similar in both seasons (Table 8). Average grain yield for both seasons was obtained in *M. pruriens* var. *utilis* plots however, this was not statistically different from what was obtained in other cover crops and NL plots. Cassava tuber yield was significantly higher in *M. preta* plot (8, 256 kg/ha) than other legume cover crops plots except in *P. phaseoloides* in 2002, while treatment means were not significantly different at 2004 (Table 9). The average cassava tuber yield was significantly higher in *M. preta* plot than what was obtained in *M. pruriens* var. *utilis* and *S. guianensis* plots.

Table 8. Effect of legume cover crops on maize grain yield in 2002 and 2004 at Ilorin, Nigeria

Legume Cover crops	Maize grain yield (kg/ha)		
	2002	2004	Average
P. phaseoloides	765a	758a	761a
S. guianensis	810a	656a	733a
M. pruriens	822a	894a	858a
M. preta	659a	861a	760a
M. jaspeada	735a	796a	766a
NL	813a	687a	750a
S.E.D	111.9	97.8	87.4

Means in the same column bearing the same letter(s) are not significantly different from each other at P = 0.05.

Discussion

Stand establishment was best with *Mucuna preta* in 2002 and with *M. jaspeada* in 2004 while *M. Pruriens var. utilis* had the least. Generally, all the *Mucuna* species had rapid growth and this has been attributed to quick seedling emergence because of their large seed sizes (Karivaratharaju *et al*., 1982, Kolawole and Kang, 1997, and Vanangamudi *et al*., 1998). Percentage ground cover was the best at 16WAP with *M. jaspeada (91%)* followed by *P. phaseoloides* (71%) in 2004 while *S. guianensis* had the least (53%). This higher percentage cover of *M. jaspeada* agrees with the earlier report of Chikoye and Ekeleme (2001) who reported *M. jaspeada* to be superior to *M. pruriens* in leaf area index and dry matter production. Similarly, low percentage ground cover in *S. guianensis* in this study confirmed the earlier report of Marilla et al., (1992) and Abayomi et al., (2001) who variously observed slow growth and poor percentage ground cover in *S. guianensis* in the first year of establishment. At the initial stage of the growth of the legume cover crops, high weed density and biomass were observed in all the treatments because the cover crops had not developed enough canopy to suppress weeds. Earlier reports by Chikoye *et al*., (2001), Chikoye and Ekeleme (2001) and Ekeleme *et al*., (2003] observed poor weed control where cover crops grew poorly or where there is failure of complete ground cover. Weed density under *S. guianensis* and *P. Phaseoloides* cover was low at 12WAP, both were 12 weeks old just like the associated maize and cassava crops and not as aggressive in climbing the associated crops as the *Mucuna* species. The effect of cover crops on weeds has been attributed to how early the canopy of the cover crop covered the soil and to the duration of shading (Hairiah *et al*., 1993; Akobundu *et al*., 2000; Ekeleme et al., 2003]. Weed biomass under each cover crop was higher than that of NL plot at 12WAP of maize and cassava. The effect of the legume cover crops produced low maize grain yield in both seasons although there was no statistical difference betw- een the yields in the various cover crops and NL cover. Low grain yield under simultaneous cropping of legume cover crops with food crops has earlier been attributed to competition and the aggressive nature of cover crops by Tian *et al.*, (1999), Chikoye *et al*., (2002, 2004) and Fadayomi *et al*., (2005). Earlier report of Tian *et al*., (1999) suggested the use of legume

Table 9. Effect of legume cover crops on cassava fresh tuber yield kg/ha 2002 and 2004 at Ilorin, Nigeria

Legume cover crops	Cassava fresh tuber yield (kg/ha)		
	2002	2004	Average
	11WAP	11WAP	
P. phaseoloides	6397ab	6442a	6275ab
S, guianenesis	1854c	6800a	5044bc
M. pruriens	2667c	8835a	3811c
M. preta	8256a	7049a	7412a
M. jaspeada	4520bc	6098a	5110bc
NL	2933c	6807a	5803ab
S.E.D	769.7	942.4	514.9

Means in the same column bearing the same letter(s) are not significantly different from each other at P = 0.05.

cover crops with an initial slow growth habit such as *P. phaseoloides* which has less aggressive growth habit and competition. However, in this present study, grain yield in *P. phaseoloides* plots was much lower than that of *M. pruriens* var. *utilis* which suggests some degree of competition by *P. phaseoloides.* Low cassava tuber yield obtained under *S. guianensis, M. pruriens var. utilis* and *M. jaspeada* might be as a result of high competition for both above and below ground resources as all the cover crops climbed or spread aggressively to smother the cassava crop for about 20 weeks before their senescence. Chikoye *et al* (2001) also observed the same trend of result when cassava was intercropped with *M. cochinch-inensis* or *P. phaseoloides*. In this present study, *M. preta* plots produced the highest average tuber yield for both cropping seasons which is significantly different from the yields of other cover crops.

Conclusion

The cover crops showed varying potentials for weed supper-ssion. Significantly lower weed densities were obtained under *S. guianensis* and *M. pruriens* var. *utilis* at cassava harvest compared with *P. phaseoloides*, *M. jaspeada* and *M. preta*. These cover crops were easily established especially if planted early to receive enough rain. Average Cassava tuber yield was significantly high in *M. preta* plots.

References

Abayomi YA, Fadayomi O, Babalola JO, Tian G (2001) Evaluation of selected legume cover crops for biomass production, dry season survival and soil fertility improvement in a moist savanna location in Nigeria. African Crop Science Journal, (4):615-627.

Akobundu IO (1980) Weed Science research at the International Institute of Tropical Agriculture and research needs in Africa. Weed Science, 28, 439-44.

Akobundu IO (1982) The role of conservation tillage in weed management in the advancing countries. FAO Plant Production and Protection Paper 44 pp. 23 – 39.

Akobundu IO (1984) Advances in live mulch crop production in the tropics. Proc. Western. Soc. Weed Sci. 37 51 – 57.

Akobundu IO (1987) Weed Science in the Tropics. (John WIley and Sons, Chicester, UK).

Akobundu IO, Ekeleme F, Chikoye D (1999) The influence of the fallow management system and frequency of cropping on weed growth and crop yield. Weed Res. 39: 241 – 256.

Akobundu IO, Udensi EU, Chikoye D (2000) Velvetbean (*Mucuna* spp.) suppresses speargrass (*Imperata cylindrica* (L) Raeuschel) and increases maize yield. Int. J. Pest Management. 46: 103 – 108.

Chikoye D, Ekeleme F (2001) Growth characteristics of ten Mucuna accessions and their effect on dry matter of speargrass. Biological Agriculture and Horticulture 18: 191 – 201.

Chikoye D, Ekeleme F, Udensi EU (2001) Cogongrasss suppression by Intercropping cover crops in corn/cassava systems. Weed Science 49: 658 – 667.

Chikoye D, Manyong VM, Ekeleme F (2000) Characteristics of speargrass (*Imperata cylindrica*) dominated fields in West Africa: crops, soil properties, farmer's perceptions and management strategies. Crop Protection 19: 481 – 487.

Chikoye D, Manyong VM, Carsky RJ, Ekeleme F, Gbehounou G, Ahanchede A (2002) Response of speargrass (*Imperata cylondrica*) to cover crops integrated with hand weeding and Chemical control in maize and cassava. Crop Protection 21: 145 – 156.

Chikoye D, Ekeleme F, Gbehounou G (2004) Suppression of Spear grass (*Imperata cylindrica*) in maize using sweet potato and two leguminous cover crops. Nigerian Journal of Weed Science vol. 17: Nov., 2004 pp 35-42.

Ebong UU, Ononokpono AA (1970) Effect of cover crops on soil fertility. Federal Department of Agriculture Memorandum No. 94. 6p.

Ekeleme F, Akobundu IO, Fadayomi RO, Chikoye D, Abayomi YA (2003) Characterization of Legume cover crops for weed suppression in the moist savanna of Nigeria. Weed Technology. 2003. 17:1 – 13.

Fadayomi O, Abayomi YA, Ajayi AS, Tian G (2005) Intercropping and residual effects of six legume cover crops on weed suppression and crop yield in the southern Guinea savanna of Nigeria. Journal of Tropical Biosciences volume: 5 (1) : 51-56.

Hairiah K, Noordwijk M, Setijono S (1993) Tolerance to acid soil conditions of the Velvetbean mucuna pruriens var. utilis and M. deeringiana. Above ground growth and control of Imperata cylindrica. Plant and soil 152, 175 – 185.

Karivatharaju TV, Karishman V, Vadivelu KK, Ramaswamy KR (1982) Effect of seed size and seed coat colour on seed quality and productivity of red gram (*Cajanus cajan* L) .Madras Agric. J. 69: V 1. pp 13-54.

Kolawole GO, Kang BT (1997) Effect of seed size and phosphorus fertilization on growth of selected legumes. Common soil Sci. Plant Anal. 28 : 1223-1235.

Marilla LB, Jao RS, Dinas P, Jose VSR, Manod RR, Walter SC, David B, Douglas JL (1992) Legume green manures: Dry season survival and the effect on the succeeding maize crops. Soil management *CRSP* Bulletin. 92-04.

Sarrantino M (1991) Methodologies for screening soil improving legumes. Kutstown, P.A. Rhodale Institute Research Center 312p.

Tarawali SA (1994) Evaluating selected forage legumes for livestock and crop production in the sub-humid zone of Nigeria. J. Agric. Sci. (Cambridge) 123: 55 – 60.

Tian G, Kolawole GO, Salako FK, Kang BT (1999) An improved cover fallow system for sustainable management of

low activity clay soils of the tropics. Soil Science, 164: 671 – 682.

Udensi EU, Akobundu IO, Ayeni AO, Chikoye D (1999) Management of cogongrass (*Imperata cylindrica)* using velvet bean (*Mucuna prunens var. utilis*) and herbicides. Weed Technology 13, 201-208.

Vanangamudi K, Karivatharaju T, Balakrishman T (1998) Physical, Physiological and bio-chemical evaluation of graded seeds of pigeon pea cultivars. Madras Agric. J. 75: 5-6.

Versteeg MN, Amadji F, Eteka A, Gogan A, Koudokpon V (1998) Farmers' adoptability of mucuna fallowing and agroforestry technologies in the coastal savanna of Benin. Agroforestry Systems. 56: 269 – 287.

Vissoh PV, Manyong VM, Cansky RJ, Osei Bonsu P, Galiba M (1998) Green manure cover crop systems in West Africa: experiences with Mucuna. In cover crops in West Africa, contributing to sustainable Agriculture, (Buckles D, Eteka A, Osiname O, Galiba M, Gallano G eds.), pp. 1 – 32. International Development Research Center; Ottawa, Canada.

Weber G, Robert ABC, Carsky R J (1997) Handbook for use of LEXSYS (Legume Expert System): decision support for integrating herbaceous Legumes into farming systems. Ibadan, Nigeria. International Institute of Tropical Agriculture.