綠肥作物供作芻料利用之評估
I. 綠肥作物之產量及化學成分分析(1)

許福星(2)(7) 張世融(2) 陳玉燕(3) 張溪泉(4) 陳文(5) 顏素芬(6)

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摘要

綠肥作物是目前國內農地休耕，且為政府獎勵種植的作物。本試驗研究目的乃在探討各種綠肥作物在各地的產量及化學成分，以供作為芻料利用的參考。在台南及台東以綠肥大豆（*Glycine max*）台南7號之乾物產量最高，屏東則以田菁（*Sesbania roxburghii*）產量最高，在彰化以油菜（*Brassica napus*）比埃及三葉草（*Trifolium alexandrinum*）高。田菁的粗蛋白質含量在各地均比綠肥大豆台南4號及7號為高，同時田菁酸洗纖維（ADF）及中洗纖維（NDF）均比綠肥大豆台南4號及7號為低，田菁的水溶性碳水化合物及澱粉含量也較低。油菜的粗蛋白質及水溶性碳水化合物比埃及三葉草高，其ADF及NDF則較低。綠肥大豆台南4 號及7號在各地之乾物產量均以春作較秋作為高，兩品種的產量均以台南最高，其次為台東，而以屏東最低。綠肥大豆的植體化學成分，兩品種在春、秋作之間及各地區之間均沒有顯著性差異，顯示綠肥大豆的化學成分於收割時，其化學成分不受生長季節及地區之影響而有很大的變化。綠肥作物在台灣地區適合種植生產，可生產品質優良的芻料，值得進一步探討其生產利用，以補充國內豆科芻料來源之不足。

關鍵詞：綠肥作物、芻料產量、化學成分分析。

（1）行政院農業委員會畜產試驗所研究報告第1467號。
（2）行政院農業委員會畜產試驗所飼料作物組。
（3）行政院農業委員會畜產試驗所高雄種畜繁殖場。
（4）行政院農業委員會畜產試驗所台東種畜繁殖場。
（5）行政院農業委員會畜產試驗所彰化種畜繁殖場。
（6）行政院農業委員會畜產試驗所花蓮種畜繁殖場。
（7）通訊作者，E-mail：fhhsu@mail.tlri.gov.tw。

緒言

綠肥作物乃是於生育旺盛期將其耕犁翻入土中，使其分解能直接或間接供作作物養分，及改良土壤理化性者均謂之。綠肥作物包括豆科、禾本科、十字花科、蓼科及菊科等，其中以豆科綠肥作物最受推廣栽培，因其根部有共生的根瘤菌可固定空氣中的氮素，增加土壤中氮素之來源，有助於減少化學肥料的施用。

自從我國加入世界貿易組織（World Trade Organization, WTO）之後，許多農產品均可自國外以低關稅低價進口，政府為了避免糧食生產過剩，及防止穀賤傷農，乃以休耕補助方式，鼓勵農地休耕種植綠肥作物，目前所種的綠肥作物包括田菁（*Sesbania roxburghii*）、綠肥大豆（*Glycine max*）、太陽麻（*Crotalaria juncea*）、埃及三葉草（*Trifolium alexandrinum*）及油菜（*Brassica napus*）等為主，至今休耕面積約為十七萬多公頃 (行政院農業委員會，2006)，該等種植的綠肥作物也具有極佳的營養成分。本試驗研究的目的，乃在探討國內種植的綠肥作物，供作芻料利用的可行性，以期補充國內豆科芻料來源之不足，進而能降低乳酪產業生產成本，提高其競爭力。

材料與方法

Ⅰ. 供試材料：

田菁、綠肥大豆台南4號及7號、油菜及埃及三葉草等。

Ⅱ. 參試的綠肥作物在各地之栽培期列如表1，油菜、綠肥大豆台南4 號及7號及埃及三葉草等均於盛花期（50%開花）收割。2005年綠肥大豆於春作及秋作的生育日數分別為75至85日及69至80日，田菁為74至86日，埃及三葉草為66日，油菜為63日。2006年綠肥大豆於春作及秋作的生育日數分別為81至84日及70至76日，田菁為70至77日，埃及三葉草為64日，油菜為68日。綠肥作物播種前施用禽畜堆肥作基肥，未再追施任何肥料。各地區試驗小區面積為4 × 4 m^2 ，採完全逢機區集設計，3重複。

表 1. 各地區種植之綠肥作物及栽培期

Table 1. Green manure crops and planting time grown at different locations

Location	Green manure crop	Planting time
Tainan	Sesbania	Spring crop, 2005 and 2006
	Soybean cv. Tainan No. 4 and 7	Spring and fall crops, 2005 and 2006
Pingtung	Sesbania	Spring crop, 2005 and 2006
	Soybean cv. Tainan No. 4 and 7	Spring and fall crops, 2005 and 2006
Taitung	Sesbania	Spring crop, 2005 and 2006
	Soybean cv. Tainan No. 4 and 7	Spring and fall crops, 2005 and 2006
Hwalien	Sesbania	Spring crop, 2005 and 2006
Changhua	Rape	Fall crop, 2005 and 2006
	Berseem clover	Fall crop, 2005 and 2006

Ⅲ. 收割時調查株高及鮮重產量，並取樣測定乾物率及化學成分，包括粗蛋白質、酸洗纖維、中洗纖維、水溶性碳水化合物及澱粉等，化學分析方法如下：

以Kjeldahl方法測定植體全氮（Bremner and Mulvaney, 1982），再將N×6.25即得粗蛋白質（Crude protein, CP）。酸洗纖維（Acid detergent fiber, ADF）及中洗纖維（Neutral detergent fiber, NDF）參照Goering and Van Soest（1970）所提方法測定；水溶性碳水化合物（Water soluble carbohydrate, WSC）及澱粉（Starch）參照Paleg（1959）所提修正Somogyi（1952）比色法分析。

結果與討論

試驗前後試區土壤取樣分析結果列於表2，由表2可知，綠肥大豆及田菁種植之後，土壤中的pH值、電導度、有機質、氮、磷及鉀等含量均會增加，顯示種植綠肥作物確有改善土壤肥力的效果。

表 2. 綠肥作物試驗前後土壤分析

Table 2. The soil analysis of the experimental plots before and after trial of green manure crops

Crop	Sampling time	pH	EC#	OM	N	P	K
				%	%	ppm	ppm
Soybean	Before trial	6.11	0.09	1.65	0.042	213	136
	After trial	7.28	0.14	2.48	0.044	358	197
Sesbania	Before trial	5.92	0.12	2.23	0.066	109	96
	After trial	6.54	0.16	2.74	0.082	148	122

#EC: Electric conductivity； OM: Organic matter.

表3所列者為田菁、綠肥大豆台南4號及7號等於春作在台南、屏東及台東等地區，及埃及三葉草與油菜於秋作在彰化地區之農藝性狀及乾物產量。在台南及台東地區，以綠肥大豆台南7號之乾物產量最高，彰化地區則以油菜的產量較高。在各地區的綠肥作物中，綠肥大豆之乾物率均比田菁為高，而以油菜的乾物率最低，只有5.9%，但在彰化地區油菜的產量比埃及三葉草高。由表4可知，田菁乾物產量在屏東及台東地區最高，其次為花蓮及台南。

表 3. 綠肥作物在各地區之農藝性狀及產量（春作）

Table 3. Agronomic traits and dry matter yields of green manure crops at different locations (spring crop)

Location	Crop	Plant height	Dry matter percent	Dry matter yield
		cm	%	mt/ha
Tainan	SES#	174.8^{ab*}	19.5^{b}	2.67^{c}
	TN4	168.2^{b}	26.4^{a}	9.32^{b}
	TN7	182.0^{a}	26.8^{a}	11.40^{a}
Pingtung	SES	177.2^{a}	17.8^{b}	5.25^{a}
	TN4	140.2^{b}	26.3^{a}	4.04^{b}
	TN7	188.0^{a}	25.0^{a}	4.41^{b}
Taitung	SES	176.8^{b}	17.8^{c}	5.44^{b}
	TN4	163.8^{b}	28.1^{b}	6.55^{b}
	TN7	235.3^{a}	30.2^{a}	8.00^{a}
Changhua	Rape&	46.5^{a}	5.9^{b}	5.58^{a}
	BC&	49.2^{a}	24.5^{a}	2.39^{b}

#SES: Sesbania; TN4; Soybean cv. Tainan No.4; TN7; Soybean cv. Tainan No.7;
BC : Berseem clover.

&Fall crop.

*Means with the same letter within the same location in the same column are not significantly different at 5% level according to Duncan's test.

表 4. 田菁在不同地區之農藝性狀及產量（春作）

Table 4. Agronomic traits and dry matter yields of sesbania at different locations (spring crop)

Location	Plant height	Dry matter percent	Dry matter yield
	cm	%	mt/ha
Tainan	174.8[a*]	19.5[b]	2.67[c]
Pingtung	177.2[a]	17.8[b]	5.25[a]
Taitung	176.8[a]	17.8[b]	5.44[a]
Hwalien	179.2[a]	23.0[a]	4. 85[b]

[*] Means with the same letter in the same column are not significantly different at 5% level according to Duncan's test.

田菁的粗蛋白質含量在各地區均比綠肥大豆台南4號及7號為高（表5），同時田菁ADF及NDF均比綠肥大豆台南4 號及7號為低，而田菁的水溶性碳水化合物及澱粉含量也較低。在彰化地區油菜的CP及WSC比埃及三葉草高，但其ADF及NDF則較低（表5），田菁在各地的植體化學成分列如表6。由表6可知，田菁的CP在18.2~22.2%，ADF在27.1~31.9%，NDF在42.0~51.9%，WSC為2.23~3.45%，澱粉為1.52~2.14%。由上可知，田菁含有品質優良的成分，可供作芻料餵飼動物。

表 5. 綠肥作物在各地區植體化學成分(春作)

Table 5. The chemical contents of green manure crops at different locations (spring crop)

Location	Crop	CP[§]	ADF	NDF	WSC	Starch
		%				
Tainan	SES[#]	18.2[a*]	31.9[b]	51.9[b]	3.45[b]	2.14[b]
	TN4	11.2[c]	36.9[a]	55.8[a]	3.77[ab]	3.32[a]
	TN7	14.0[b]	37.3[a]	53.6[ab]	4.05[a]	2.08[b]
Pingtung	SES	19.4[a]	27.1[b]	42.0[b]	2.23[c]	1.52[c]
	TN4	11.6[b]	34.2[a]	52.2[a]	3.02[b]	3.54[a]
	TN7	12.1[b]	35.3[a]	54.2[a]	3.60[a]	2.52[b]
Taitung	SES	22.2[a]	31.1[b]	44.2[b]	3.05[ab]	2.01[b]
	TN4	11.8[b]	35.8[a]	53.5[a]	2.90[b]	3.05[a]
	TN7	12.4[b]	34.4[a]	53.1[a]	3.55[a]	2.37[b]
Changhua	Rape[&]	22.2[a]	23.6[b]	40.4[b]	4.20[a]	1.81[a]
	BC[&]	14.8[b]	38.1[a]	54.7[a]	2.57[b]	1.33[a]

[#] As shown in Table 3.

[&] As shown in Table 3.

[§] CP:Crude protein; ADF:Acid detergent fiber; NDF:Neutral detergent fiber; WSC:Water soluble carbohydrate.

[*] Means with the same letter within the same location in the same column are not significantly different at 5% level according to Duncan's test.

表 6. 田菁在不同地區植體化學成分之比較（春作）

Table 6. Comparison of chemical contents of sesbanina at different locations (spring crop)

Location	CP#	ADF	NDF	WSC	Starch
	%				
Tainan	18.2[b]*	31.9[a]	51.9[a]	3.45[a]	2.14[a]
Pingtung	19.4[b]	27.1[b]	42.0[b]	2.23[b]	1.52[b]
Taitung	22.2[a]	31.1[a]	44.2[b]	3.05[a]	2.01[a]
Hwalien	20.0[b]	30.9[a]	43.4[b]	3.14[a]	1.93[a]

As shown in Table 5.

* Means with the same letter in the same column are not significantly different at 5% level according to Duncan's test.

表7所示者為綠肥大豆台南4號及7號在台南、屏東及台東於春、秋作之農藝性狀及乾物產量。由表7可知，綠肥大豆台南4號及7號的株高及乾物產量在各地均以春作較秋作為高，而春、秋作的乾物產量，兩品種均以台南地區者最高，其次為台東地區，而以屏東地區最低。其乾物率在生長季別及各地區有很大的差異。至於植體化學成分如CP、ADF、NDF、WSC及澱粉等兩品種在春秋作之間及各地區之間均沒有顯著性差異，顯示綠肥大豆的化學成分於收割時，其化學成分不受生長季節及地區之影響而有很大的變化（表8）。

表 7. 綠肥大豆在不同地區及生長季節之農藝性狀及乾物產量

Table 7. Agronomic traits and dry matter yields of soybean at different locations in different growth seasons

Cultivar	Location	Plant height		Dry matter percent		Dry matter yield	
		Spring	Fall	Spring	Fall	Spring	Fall
		cm		%		mt/ha	
TN4#	Tainan	168.2[a*A]	112.2[aB]	26.4[bB]	28.1[aA]	9.32[aA]	6.26[aB]
	Pingtung	140.2[bA**]	102.2[aB]	26.3[bA]	26.8[aA]	4.04[cA]	3.51[bB]
	Taitung	163.8[aA]	74.0[bB]	30.2[aA]	28.2[aA]	6.56[bA]	4.13[bB]
TN7	Tainan	182.0[bA]	135.3[aB]	26.9[aA]	29.4[abA]	11.4[aA]	5.69[aB]
	Pingtung	188.0[bA]	147.3[aB]	25.0[aA]	25.3[bA]	4.41[cA]	3.57[cB]
	Taitung	235.3[aA]	142.5[aB]	28.1[aB]	30.7[aA]	8.00[bA]	4.43[bB]

#As shown in Table 3.

*Means with the same small letter within the same cultivar in the same column are not significantly different at 5% level according to Duncan's test.

**Means with the same capital letter within the same item in the same row are not significantly different at 5% level according to Duncan's test.

表8. 綠肥大豆在不同地區及生長季節植體化學成分

Table 8. The chemical contents of soybean at different locations in different growth seasons

Cultivar	Location	CP§		ADF		NDF		WSC		Starch	
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
		%									
TN4#	Tainan	11.2^{aA*}	12.3^{aA}	36.9^{aA}	33.9^{aB}	55.8^{aA}	49.7^{bB}	3.77^{aA}	3.50^{aA}	3.32^{aA}	2.41^{aA}
	Pingtung	11.6^{aA**}	11.7^{aA}	34.2^{aA}	33.8^{aB}	52.2^{aA}	53.4^{aA}	3.02^{abA}	3.33^{aA}	3.54^{aA}	2.80^{aA}
	Taitung	11.8^{aA}	12.0^{aA}	35.8^{aA}	35.1^{aA}	53.5^{aA}	54.3^{aA}	2.90^{bB}	3.89^{aA}	3.05^{aA}	2.90^{aA}
	Tainan	14.0^{aA}	11.7^{aB}	37.3^{aA}	34.0^{bA}	53.6^{aA}	50.3^{bB}	4.05^{aA}	2.89^{bA}	2.08^{aA}	2.23^{aA}
TN7	Pingtung	12.1^{aA}	12.6^{aA}	35.3^{aA}	35.2^{aA}	54.2^{aA}	53.4^{aA}	3.60^{aA}	3.34^{aA}	2.52^{aA}	2.35^{aA}
	Taitung	12.4^{aA}	11.1^{aA}	34.4^{aA}	35.1^{aA}	53.1^{aA}	55.0^{aA}	3.55^{aA}	3.35^{aA}	2.37^{aA}	2.46^{aA}

As shown in Table 3.

§ As shown in Table 4.

* Means with the same small letter within the same cultivar in the same column are not significantly different at 5% level according to Duncan's test.

** Means with the same capital letter within the same item in the same row are not significantly different at 5% level according to Duncan's test.

根據台灣省政府農林廳編印的「綠肥作物栽培利用」（1995），田菁的鮮草產量每公頃為25~35公噸、油菜為20~35公噸、埃及三葉草為20~30公噸；吳及連（2004）報告綠肥大豆台南4號之鮮草產量為20~37公噸/公頃，台南7號為25~35公噸/公頃。若換算為乾物產量，則田菁乾物產量為4.6~6.5公噸/公頃，埃及三葉草為4.9~7.4公噸/公頃，綠肥大豆台南4號為5.4~9.9公噸/公頃、台南7號為6.8~9.6噸/公頃。由表3可知台南地區的田菁產量似乎低了一些，可能生長期間遭受較嚴重的蟲害所致，而在屏東及台東地區的乾物產量則表現正常；至於綠肥大豆台南4號及7號的乾物產量，在屏東地區則較低，在台南及台東地區則表現正常。

田菁由於其初期生長迅速、耐鹹、耐鹽及耐淹水，且具嗜口性及高的營養價值，最近乃引起許多學者的重視及研究（Heering *et al.,* 1996）。雖然田菁比一些灌木植物具有較高的試管乾物消化率（IVDMD）及營養成分，但其增重效果並不比其他灌木植物高，也許田菁可能含有某些影響營養品質的成分（Ahn *et al.,* 1989; Akkasaen *et al.,* 1989; Alam *et al.,* 2007），田菁的蛋白質含量更與大豆相近（Prakash *et al.,* 2001）。Heering *et al.*（1996）對田菁中的酚酸化合物進行定性及定量分析，期能改進田菁之營養價值。Aganga and Tshwenyane（2003）指出田菁中含有sesbaine會導致haemorrhagic diarrhoea。Niang *et al.*（1998）指出以田菁與狼尾草混植，可改善芻料之品質。由以上可知，綠肥作物在台灣地區適合種植，可生產品質優良的芻料，為了解決國內豆科芻料之不足，有必要從現有的豆科綠肥作物中去尋找可能的替代來源，因此，對綠肥作物供作芻料利用的栽培利用方式，值得進一步探討。

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Evaluation of green manure crops used for forages I. Forage yield and approximate analysis of green manure crops(1)

Fu-Hsing Hsu(2)(7) Shyh-Rong Chang(2) Yuh-Yann Chen(3)
Si-Chuan Chang(4) Wen Chen(5) and Su-Fan Yen(6)

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Abstract

Green manure crops are promoted with subsidy by government to grow on the fallow land in Taiwan. The objective of this study was to determine the forage yields and the approximate analysis of green manure crops at different locations. Soybean (*Glycine max*) cv. Tainan No. 7 had the highest dry matter yield in both Tainan and Taitung and sesbania (*Sesbania roxburghii*) had the highest in Pingtung, respectively. In Changhua, rape (*Brassica napus*) had higher dry matter yield than berseem clover (*Trifolium alexandrinum*). The content of crude protein in sesbania was higher than those of soybean cv. Tainan No. 4 and No.7. In addition, the contents of acid detergent fiber (ADF), neutral detergent fiber (NDF), water soluble carbohydrate and starch were lower than those of soybean cv. Tainan No. 4 and No. 7. The contents of crude protein and water soluble carbohydrate of rape were higher than those of berseem clover, while the contents of ADF and NDF of the former were lower. The dry matter yields of soybean cv. No. 4 and 7 were higher in spring crop than those of fall crop. Both cultivars had the highest dry matter yields in Tainan, followed by Taitung, the lowest in Pingtung. No significant difference was observed for the approximate analysis of soybean between spring and fall crops and among different locations. It showed that the approximate analysis of soybean was not affected by growth seasons or locations. The results showed that green manure crops could be grown to produce forage with good quality. It was suggested that further study is required to determine the methods of production and utilization of the green manure crops used as forages to feed animals. It might be helpful to supply the short of forage legumes to a certain extent in Taiwan.

Key words : Green manure crops, Forage yield, Approximate analysis.

（1）Contribution no. 1467 from Livestock Research Institute, Council of Agriculture, Executive Yuan.
（2）Division of Forage Crops, COA-LRI, Hsinhua, Tainan, Taiwan, R.O.C.
（3）Kaohsiung Animal Propagation Station, COA-LRI, Pingtung, Taiwan, R.O.C.
（4）Taitung Animal Propagation Station, COA-LRI, Taitung, Taiwan, R.O.C.
（5）Changhua Animal Propagation Station, COA-LRI, Changhua, Taiwan, R.O.C.
（6）Hwalien Animal Propagation Station, COA-LRI, Hwalien, Taiwan, R.O.C.
（7）Corresponding author, E-mail : fhhsu@mail.tlri.gov.tw