On-Farm System Study on the Performance of *Pueraria phaseoloides* (Benth.) and *Centrosema pubescens* (Benth.) as Enriched Fallow Vegetation for *Imperata cylindrica* (Beauv.) Dominated Natural Follows

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ABSTRACT

On-farm systems and dynamic experimentation with farmers' participation tested the performance of creeping legumes as enriched fallow vegetations for cogon dominated follows in Daro, Jaro, Leyte. Two legumes, C. pubescens and P. phaseoloides, were tried. The experiment used paired treatments considering legume enriched fallow system as treatment and the natural fallow system of cogon as control plots. Twenty-one farmers participated in studying them within 27 paired plots treatments.

There were four major systems objectives in the legume enriched fallow experiment; control of Imperata cylindrica (cogon); improvement of soil fertility, im-

provement in pasture quality, and reduction in recultivation costs after fallow.

Started in 1985 the experiment found that cogon is virtually controlled by cover cropping, specifically by the use of P. phaseoloides. Moreover, sufficient organic matter levels is attained within a year while providing a legume vegetation that is better as a pasture and required less time and labor in recultivation.

RATIONALE

The traditional practice of tilling the land under coconuts by farmers in and around Jaro, Leyte is shifting cultivation. As described by Aves et al., this is done by cultivating and planting a piece of land, then leaving or resting it for a number of years (fallow) before it is recultivated and planted again. Farmers have to fallow their farms after 4-6 years (Fig. 1) of continuous cropping.

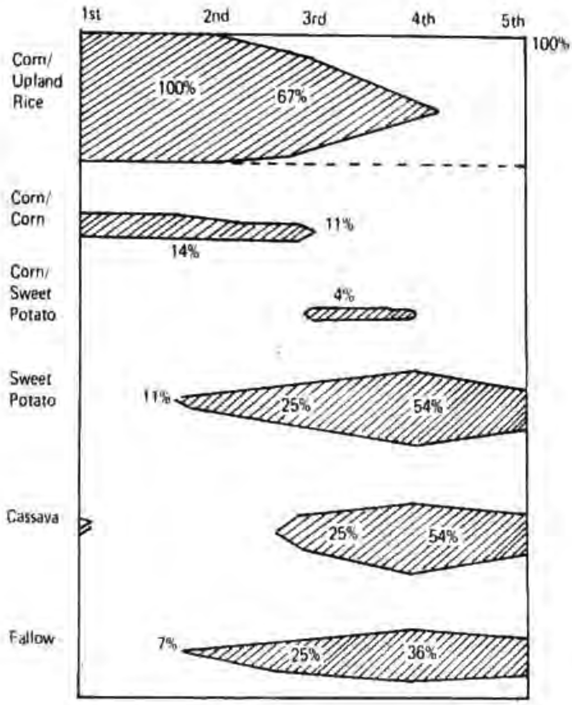

Fig. 1. Distribution of farms by crop rotation.

It is observed that fallowing enhances vegetative succession that eventually restore the soil fertility. This practice has worked for farmers over the decade, however, its usefulness is limited because of some inherent problems like cogon and less access to land.

The growth of *Imperata cylindrica* (cogon) becomes a problem during the last cropping. It eventually dominates the farm by the time it is fallowed or rested. Under this type of vegetation, farmers should have to wait for 3-4 years until shrubs and other woody bush grow and restore soil fertility after 2-6 more years. Hence, best fallow periods extends from five to 10 years which is too long for the majority of farmers managing less than 3 ha (Fig. 2). Many farmers are constrained to recultivate even only

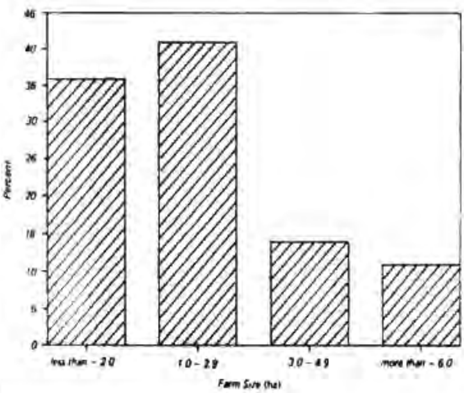

Fig. 2. Percent distribution of farms by farm size, Daro, Jaro, Leyte.

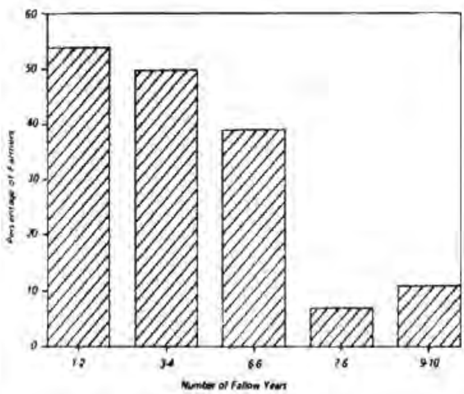

Fig. 3. Percent distribution of farmers by fallow years, Daro, Jaro, Leyte.

after 3 years as which results in poor growth and yield of crops (Fig. 4).

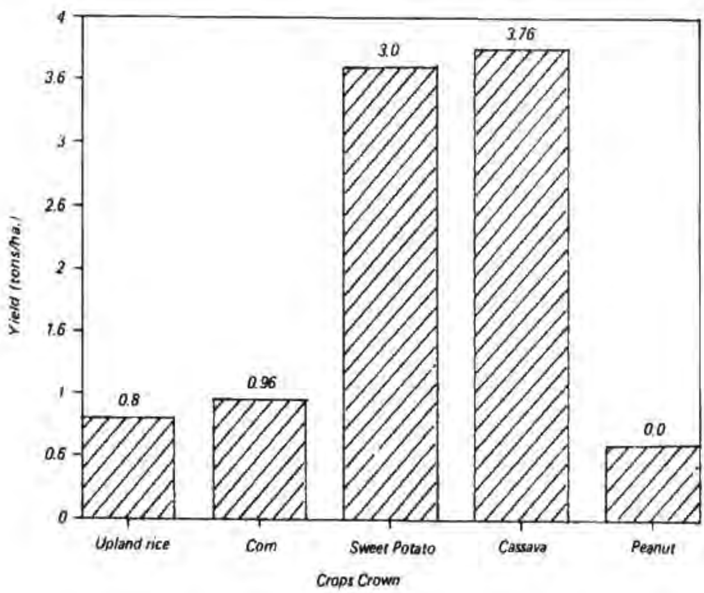

Fig. 4. Average crop yields in tons/hectare, Leyte Province 1985.

The proliferation of cogon is compounded by the problems affecting the total natural fallow systems. Cogon is a valuable pasture for goats and carabaos only during the first 2 months of growth and availability of quality pasture area when ferns and woody bush overgrow. In addition, recultivation of the fallowed land is too laborious because of the numerous viable cogon rhizomes and other rootstocks.

OBJECTIVES

This research was conducted to measure the performance of two creeping legumes, kudzu and centrosema, as legume-enriched fallow vegetation on;

a. cogon eradication;
b. soil nutrient improvement;
c. pasture quality improvement, and;
d. recultivation cost reduction.

METHODOLOGY

A systems and dynamic experiment characterized by farmer participation in the problem identification, designing and conduct of research were used. Farmers established their experiments based on options set to allow for experiment measurements. An experiment set-up composed of a parcel planted to the legume and adjacent to it the natural fallow or control plot were marked. Each set-up were considered a paired treatment, and a replication.

Control plot sizes ranged from 25 to 150 sq. m. and treatment plots sizes ranged from 100 to 500 sq. m. Treatment options were centrosema and kudzu. Experiments were set-up on flat sloping areas in undulating or rolling topography, with ultisol of the Guimbaloan clay soil series and vegetation cover of usually one meter high cogon and other grasses.

In the initial round of the experiment, 13 farmers established their centrosema plots between September and October 1985 by plowing a hand drilling. In the early months, centrosema was slow. Growth was further reduced by accidental/unscheduled grazing. Farmers and researchers at that time, as part of the continuous analysis required by dynamic designs, resorted on changes in both method of establishment and legume species. Thus beginning February 1986, farmers turned to kudzu and either overseeded their centrosema or established new plots. A total of 21 farmers had a total of 27 paired treatments established in staggered schedules.

DATA COLLECTIONS AND ANALYSIS

Performance of the Legumes in Eradication of Cogon

Legume effect on the cogon was initially measured using monthly estimated legume and cogon cover from 5 one meter quadrats per plot. Observation quadrat plots were randomly determined each time vegetation percent cover was collected. When it was finally determined that cogon was effectively covered and controlled by the legumes, farmers refused to accept and reasoned that the rhizomes were still numerous and viable. This lead us, with help from the Visayas State College of Agriculture (VISCA) in late 1988 to shift data collection and develop a back-up study on the viability of rhizomes as affected by cover cropping.

Plots that have attained a kudzu cover of 80-100% for 6, 23, 18 and 24 months were used as samples. A mass rhizome per unit volume of soil were collected from grab samples of 169 cm^3 (20 cm deep) from the experiment units at 3 months interval and was converted to tons per hectare basis. The grab samples were soaked in running water to loosen and remove the soil particles, leaving the cogon rhizome per unit volume of soil.

Determination of rhizome viability was done actually at the farmers field. Three randomly selected quadrats (.25cm^2) from each treatment plots were cleared of kudzu vines and other vegetations then, tilled using a pick muttock. The number of germinated cogon were recorded a month after clearing by counting the number of coleoptile foliage leaf or tillers that emerged.

Statistical analysis used was t-test for paired samples at 6, 12, 18 and 24 months after 80-100% canopy cover was attained.

Performance of Creeping Legumes in Improving Soil Fertility

To measure the effects of the legumes on soil fertility, soil analysis was done from soil samples collected initially, and every 6 months thereafter from both the treatment and control plots. Pooled samples were collected in each plot and sent to the laboratory for analysis. In each collection sites, the live, vegetation and undecayed matter were removed then a sample was collected by digging one centimeter vertical slice down to 6 inches plow deep.

Later on however, this procedure was changed by decaying the vegetation within one square meter and collecting the soil samples a month later. Pooled samples were consequently sent to the laboratory for analysis. In both methods, organic matter, phosphorus and potassium soil analysis in the legume treatment were compared to that of the control, using t-test.

Supplementary information was also sought but little relevant information could be gathered due to implementation problems. Test corn planted in a few plots for leaf analysis and growth performance every 6 months was simply impractical considering the fallow conditions with pests.

Moreover, in early 1989, and IRRI-VISCA-DA collaborative back-up research was initiated to measure Agronomic Benefits of the Enriched Fallows. This supplementary study however has not yet progressed much and there is no relevant information available yet.

Performance of Creeping Legumes in Improving Pasture Quality

Pasture quality measurements desired were to compare the natural fallow vegetation to that of the legume enriched plots in terms of potential for pasture use. One measure was based on percent pasture species cover included in the reading of data to measure effects on cogon. Pasture species were summed up in both treated and control plots and ploted in a graph to show the rates of increases or decline. The legumes were included as pasture vegetation while cogon was considered as a pasture until it reached 30 days old.

Biomass and proximate analysis measure were initially undertaken but were differed because the former was irrelevant considering the experimental plot size and the latter was costly and unnecessary. The desire to determine the effects of grazing on the growth of legumes could not be done due to farmers refusal to try grazing carabaos on their kudzu experiment. However, observation were collected from accidental grazing that occurred.

A supplementary study is being initiated to measure growth and reproduction performance of goats fed in kudzu enriched native pastures.

Performance of Creeping Legumes in Reducing Recultivation Costs

Cultivation of *Sacharum spontaneum, Imperata cylindrica*, bush/woody plants, *Pueraria phaseoloides*, dominated fallows were compared based on process and labor cost. Data collection was done through individual farmer interview and actual documentation of the process and costs in cultivating these fallows as practiced by farmers.

RESULTS AND DISCUSSIONS

Performance of the Legumes in the Eradication of Cogon

Farmers' judged centrosema as being too slow. Results from quadrats of visual percentage cover estimates taken at thirty days intervals, showed the growth rate of centrosema as slow (Fig. 5). Over a period of 420 days after establishment, centrosema had little effects on the growth itself and its seasonal leaf shedding, removing the cover its canopy provide thus giving chance for the cogon grass to regrow. It took a number of months for centrosema to regain its growth, but before it covered the cogon, it sheded off again, never able to overshade the grass.

According to a few farmers, and suggested by Venkaramani (1956) as cited by Mercado (1986), *Pueraria phaseoloides* is an alternative to centrosema as a legume that could compete with the

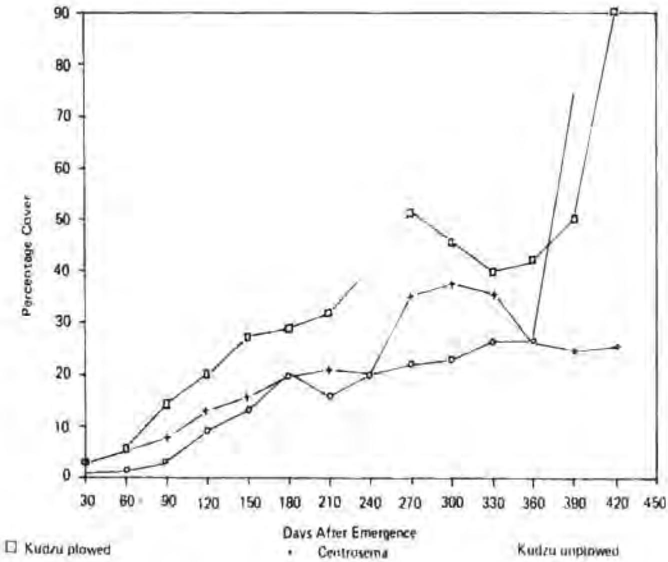

Fig. 5. Comparative percent growth rates of plowed kudzu, unplowed kudzu, and centrosema, Daro, Jaro, Leyte.

shade tolerant cogon grass. With dynamic research and the consequent shifting to faster growing and more competitive kudzu (Fig. 6), cogon reduction was hastened. Within a period of 270 days after establishment, kudzu established with plowing/tillage, have already covered cogon (Fig. 7) though kudzu established without plowing takes longer time to cover the cogon (Fig. 8).

This results however did not totally convince farmers who argued that live cogon rhizomes found beneath the soil would germinate from untimely recultivation. This concerns supported description of Mercado (1986) that the rapid take over of an area by cogon is attributed more to the rhizome production than to seed production. In reaction to this concern, the effects of the legumes on the rhizomes mass and viability were studied.

Results of the study showed that cover cropping significantly reduced the mass of cogon rhizome at about two years after planting of kudzu (YAPK) or starting at the time when 80-100% kudzu canopy cover was attained for 6 months (Table 1). The cogon rhizome mass (fresh weight) of 8.46 t/ha in the natural

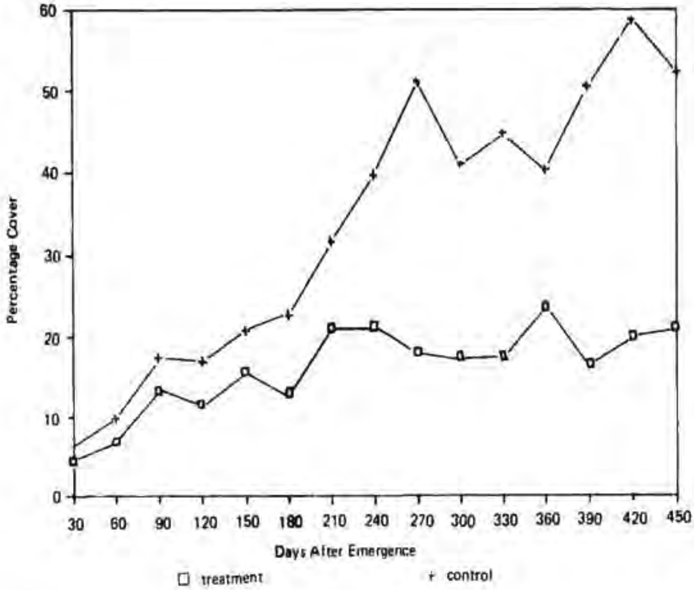

Fig. 6. Effects of centrosema on cogon growth rates. Daro, Jaro, Leyte.

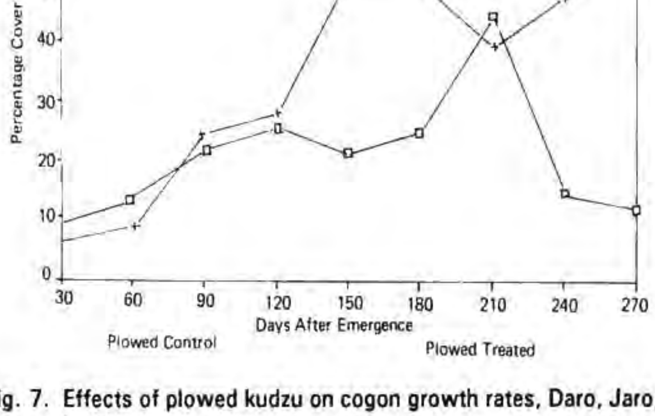

Fig. 7. Effects of plowed kudzu on cogon growth rates, Daro, Jaro, Leyte.

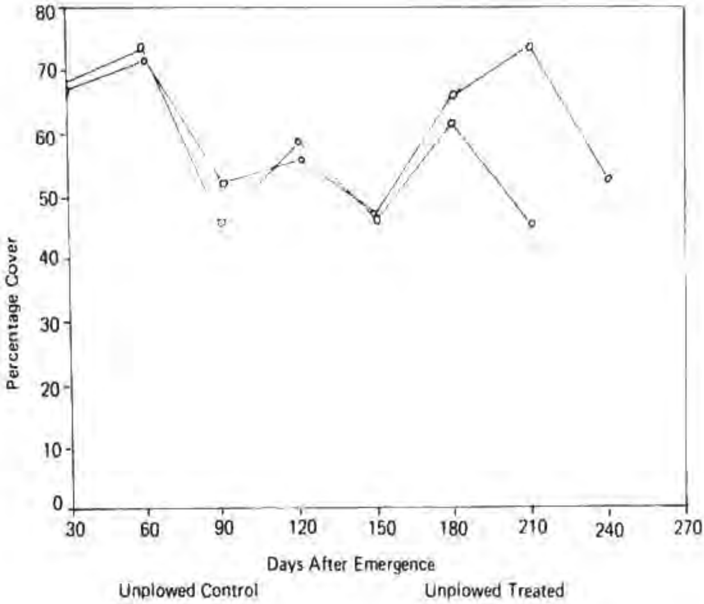

Fig. 8. Effects of unplowed kudzu on cogon growth rates, Daro, Jaro, Leyte.

Table 1. Cogon rhizome mass (t/ha) as affected by cover cropping at a specified length of time after 80-100% canopy cover was attained.

LENGTH OF TIME[a] (Months)	RHIZOME MASS (t/ha)	
	Natural Fallow (Cogon)	Enriched Fallow (Kudzu)
6 (2 YAPK)[b]	8.46	3.25**
12 (2.5 YAPK)	8.43	1.39**
19 (3 YAPK)	8.39	1.29**
24 (3.5 YAPK)	7.95	0.67**

[a]Number of months after attaining 80-100% canopy cover.
[b]Tears after planting kudzu.
**Highly significant at 1% level, t-test.

fallow was significantly reduced to 3.2 t/ha when the area was covered with kudzu. With further lengthening of kudzu canopy cover duration to 24 months, rhizomes mass of 7.95 t/ha of the natural fallows was significantly reduced to 0.67 t/ha when cover cropped.

Consequently cogon viability which were measured by the number of cogon coleoptiles that germinated per unit area, was significantly affected also by cover cropping which decreased with time (Table 2). From 6 to 24 months duration of 80-100% canopy cover, the number of cogon coleoptiles that germinated per unit area, was significantly affected also by cover cropping which decreased with time (Table 2). From 6 to 24 months duration of 80-100% canopy cover, the number of cogon that germinated in the natural fallow dropped from 151 to 135 per square meter while when cover cropped, there was a drastic reduction from 47 to as much as 9 coleoptiles per square meter. A significant reduction in the number of germinated rhizomes was observed in the enriched fallow from 6 to 24 months after an 80-100% canopy cover was attained.

Table 2. Cogon viability (no. of cogon germinated coleoptiles per m² as affected by cover cropping at a specified length of time) after 80-100% canopy cover was attained.

LENGTH OF TIME[a] (Months)	NO. OF COGON COLEOPTILES (per m²)	
	Natural Fallow (Cogon)	Enriched Fallow (Kudzu)
6 (2 YAPK)[b]	151.00	47.88**
12 (2.5 YAPK)	140.62	18.95**
18 (3 YAPK)	137.07	11.60**
24 (3.5 YAPK)	135.66	9.06

[a]Number of months after attaining 80-100% canopy cover.
[b]Years after planting kudzu.
***Highly significant at 1% level, t-test.

Performance of Creeping Legumes in Improving Soil Fertility

Major basis for soil improvement of this study has been the ability of the legume to convert atmospheric nitrogen into usable form. Initially, benefits were banked on decay of nodule and the tissues from physical disturbance of grazing and farm operations, and ultimately from recultivation.

Soil analysis taken at 6 months interval from establishment showed that percent organic matter (OM) increases with the duration of kudzu vegetation (Table 3). Contrary to common knowledge, OM accumulation on the cogon fallow increased at similar rate. Natural fallow vegetations were able to arrive at sufficient 7-8% levels within one year at comparable rate to that of the kudzu vegetations.

Table 3. Effects of creeping legumes on percent of organic matter contents of Guimbaloan soils Daro, Jaro, Leyte.

DAY AFTER EMERGENCE	PERCENT ORGANIC MATTER	
	Enriched Fallow (Kudzu)	Natural Fallow (Cogon)
0	5.37	4.917
180	6.15	5.99
360	6.315	6.52
540	7.73	7.93
720	8.49	9.33

Within 720 days from OM establishment very little disturbance has caused dislodgement of legume parts which hastens mineralization rates. Farmers have been too protective in preventing legume disturbance to the point of even resisting, grazing trials. Furthermore, physiological leafall has occurred only once during that period. Similarly, Abbot as cited by Sherman (1977) claimed that the annual legume production did not enrich the soil when plants are left growing and not incorporated in the soil. He stated further that growing legume does not benefit the soil unless the plant is plowed in as a green manure or fed out in the farm and returned as manure. The N which legumes fix does not remain in the roots where it is fixed, but is turned in the tissues of the entire plant.

Soil analysis collected only from the original trial areas while the kudzu have spread thrice could have resulted in underestimates. It was possible that the kudzu, provided part of the nitrogen contents for the area expansion. Abbot (1817) claimed that legumes accumulate 90% if the nitrogen through the vegetative parts which contain them. To support its vines the legume creeps over the grasses in the periphery. Thus unless they are brought in, back to original area, the OM that could be collected through the tissues from physical disturbance of grazing and farm operations, and ultimately from recultivation.

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To stimulate recultivation, tissues both in the enriched and natural fallows were decayed before soil analysis by soil incorporations of vegetations. As indicated in Table 6, decay of the tissue resulted in increased OM analysis. This further implies that increase of 1.5% due to decay for 60 days from incorporation and recultivation, at 540 days after establishment, the fallows could have actually attained sufficient OM between 360 and 540 days.

Total soil fertility improvement cannot be attributed to increase in nitrogen alone but should, at least, include the macronutrients, phosphorus (P) and potassium (K). However, the enriched fallow showed little discernible improvement on this nutrients, although potassium is already normally sufficient (Table 4 and 5).

Table 4. Effect of creeping legume on Guimbaloan clay soil potassium (K) contents (ppm). Daro, Jaro, Leyte.

DAY AFTER EMERGENCE	PPM OF K	
	Enriched Fallow (Kudzu)	Natural Fallow (Cogon)
0	163	161.24
180	167.2	172
360	197.52	188
540	154.6	154

Table 5. Effect of creeping legumes on phosphorus (P) content of Guimbaloan clay, Daro, Jaro, Leyte.

DAY AFTER EMERGENCE	PPM OF P	
	Enriched Fallow (Legume)	Natural Fallow (Cogon)
0	.95	1.17
180	1.4	1.19
360	1.59	1.50
540	1.49	1.62
720	1.3	1.44

Table 6. Percent soil organic matter of enriched fallows initially incorporated at 720 days after establishment, and its analysis, Daro, Jaro, Leyte.

DAY AFTER INCORPORATION	Enriched Fallow (Kudzu) % OM	Natural Fallow (Cogon)
0	7.94	8.16^{ns}
30	8.77	8.11**
60	9.81	9.77^{ns}

^{ns}Not significant at 1% t-test.
**Highly significant at 1% t-test.

Within 30 days from incorporation, phosphorus generally decreased both in the enriched fallow and natural fallows. However in 60 days, it increased rapidly (Table 7). As noted, this is attributed to multiplication of decay microorganisms that accumulate most of the phosphorus as part of their body tissues within 30 days and releasing it back at 60 days. Soil potassium, on the other hand, is generally sufficient but incorporation increased it at 30 days (Table 8) and drastically decreased at 60 days.

Table 7. Soil phosphorus content of legume enriched fallows initially incorporated at 720 days after establishment, and its analysis, Daro, Jaro, Leyte.

DAY AFTER INCORPORATION	PPM P	
	Enriched Fallow (Kudzu)	Natural Fallow (Cogon)
0	1.49	1.64^{ns}
30	1.4	1.34**
60	1.8	1.77*

^{ns}Not significant at 1% t-test.
**Significant.
**Highly significant at 1% t-test.

Performance of Creeping Legumes on the Pasture Quality of Fallows.

Problem arises in the extension stage if enriched fallow vegetation will not be a good pasture. The enriched fallow thus

Table 8. Soil potassium content of legume enriched fallows initially incorporated at 720 days after establishment and its monthly analysis, Daro, Jaro, Leyte.

DAY AFTER INCORPORATION	PPM K	
	Enriched Fallow (Kudzu)	Natural Fallow (Cogon)
0	191.5	157.9**
30	272.3	234.6*
60	207.6	193.0ns

nsNot significant at % t-test.
*Significant.
**Highly significant at 1% t-test.

included this systems component as a consideration in the selection of the legume vegetation and to measure its role as a pasture vegetation.

Reyes, as cited by Eussien, found that kudzu contained 8.4% fiber and 3.65% protein in green material. Parbem (1967) reported 11.6% protein, and Bermudez, et al. 19.9% protein of dry matter. Centrosema, on the other hand, had 62.4% crude protein and a digestible protein of 65.7%.

Percentage cover of pasture species including pasture grass and the legumes are showing Fig. 9, 10, and 11. Legume-enriched fallow experiment had more pasture vegetation than cogon fallows. Moreover, it increased with the legumes cover due to the increased legumes ``karokawayan'' and ``tanabog'' grasses, and the reduced tough, highly fibrous cogon. In the first year, quality in the natural fallow worsened due to cogon. On the other hand, the legume-enriched fallow offered a better pasture throughout the period.

Farmers, on the other hand, were not sure on the role of kudzu as a pasture vegetation. Consequently, many did not graze their trial to try, however, information on whether their animals eat kudzu was supplied by occasional unwanted grazing demonstrated that somehow, the enriched fallow were actually generally better pasture than the natural cogon bush fallows. Carabaos and goats pick-out young kudzu leaves with grasses mixed with the legumes. On the other hand, kudzu become a dominant vegetation throughout the remote area since its growth is easily retarded by grazing animals (Table 10). Thus, to preserve its botanical composition, kudzu should be leniently grazed.

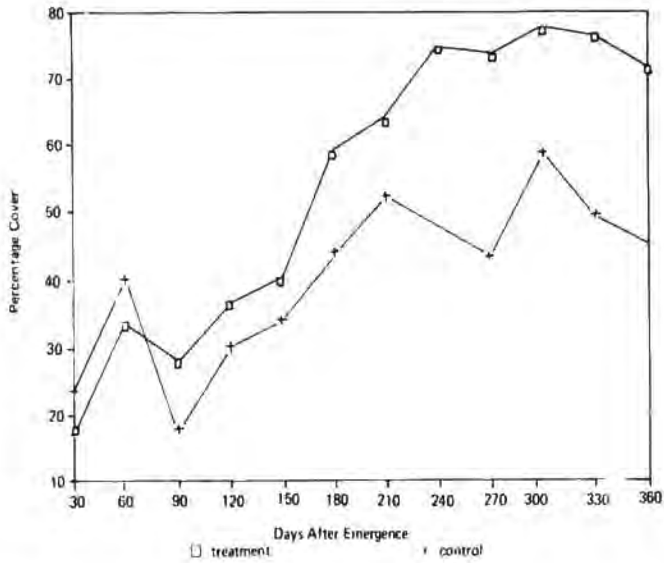

Fig. 9. Effects of plowed/drilled centrosema-kudzu mixture on cover of pasture species, Daro, Jaro, Leyte.

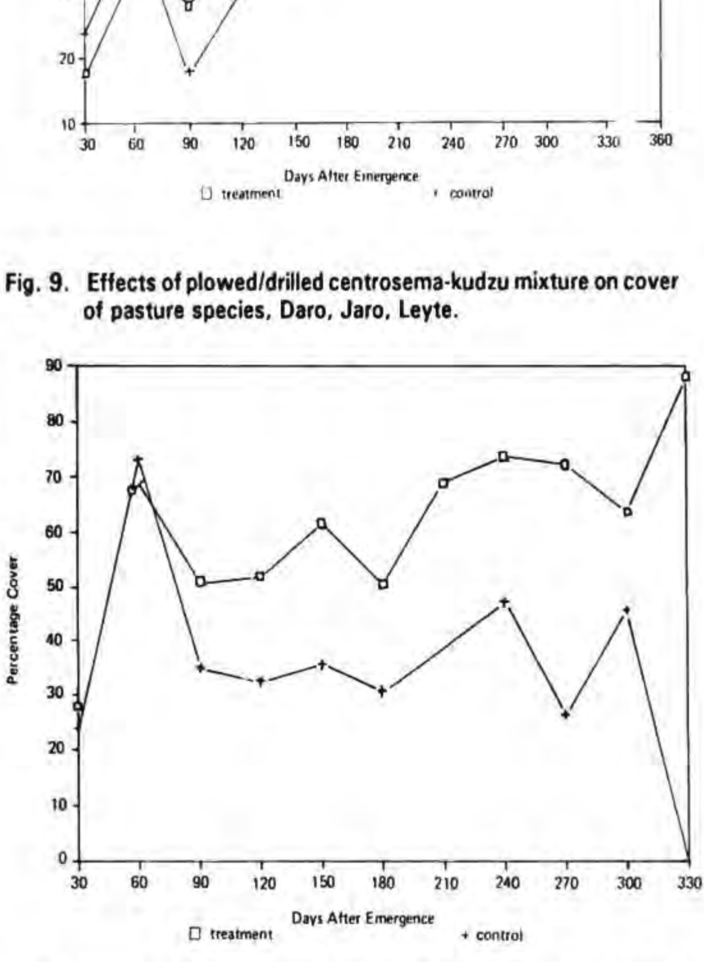

Fig. 10. Effects of plowed/broadcasted kudzu on cover of pasture species Daro, Jaro, Leyte.

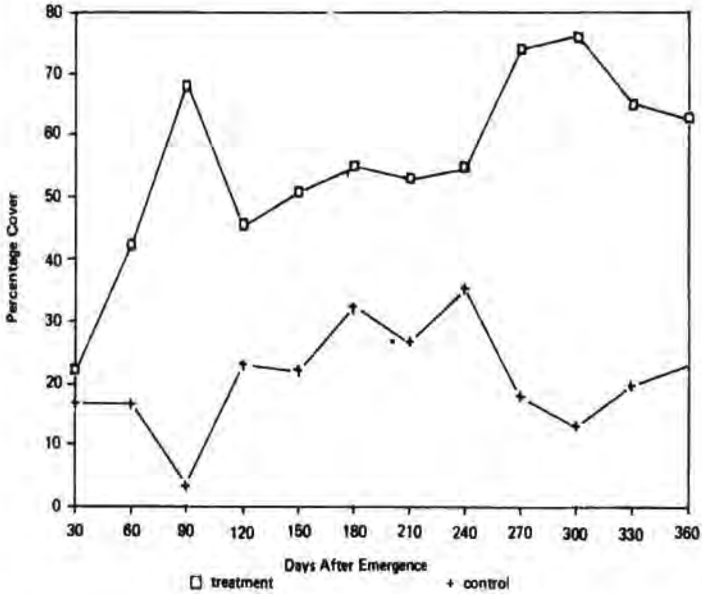

Fig. 11. Effects of plowed/cultivated centrosema on levels of pasture species Daro, Jaro, Leyte.

Table 9. Farmers' Report on carabao grazing of enriched fallows under 16 coconut farmers, Daro, Jaro, Leyte.

REPORT	NO. OF FARMS	PERCENT
Grazed own carabao	6	37.5
Grazed by neighbors carabao	5	31.25
Never tried	5	31.25
Total	16	100%

Total 10. Farmers' comments on consequence of carabao grazing of enriched fallows, 16 farmers, Daro, Jaro, Leyte.

COMMENT	NO. OF FARMS	PERCENT
Retarded legume growth (''rusduk'')	11	68.75
Will retard legume growth	3	18.75
No comment	2	12.5
Total 16	100	

Performance of the Creeping Legumes in Reducing Recultivation Cost

Part of the overall labor reduction in recultivation equation in the cost side is the additional labor requirement to establish legumes. It was hypothesized that the legume-enriched fallow require less labor to recultivate than cogon fallows. Farmers told us and our data showed that plowing cogonal areas for planting kudzu was too laborious (Fig. 12). Planting into the last crop, underbrushing or burning cogon, and direct seeding over the cogon

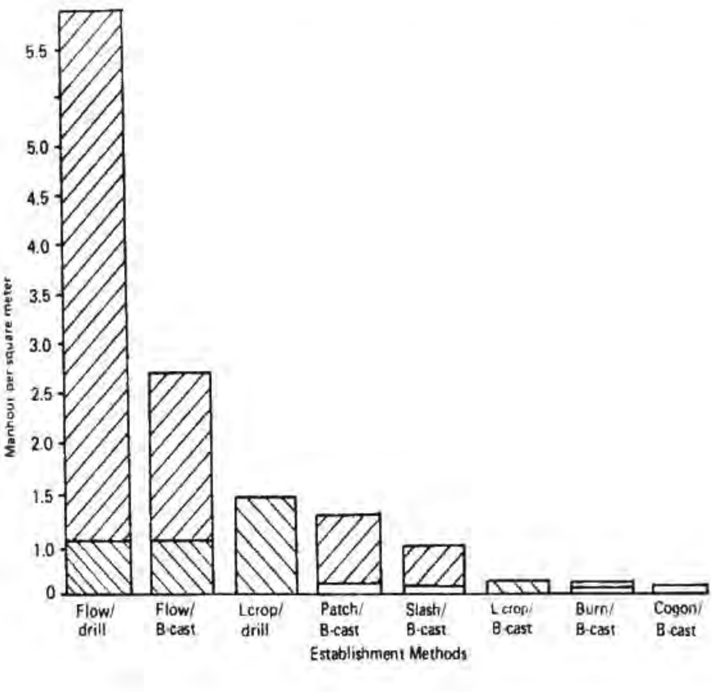

Fig. 12. Labor used in legume establishments, Daro, Jaro, Leyte.

all reduce labor inputs. In addition, the change from hand drilling in rows and broadcast as the planting method reduces labor inputs. In planting adoption trials however, farmers did not select methods with the least labor inputs. Farmers' require higher labor than the broadcast over cogon (Fig. 13) to establish wider kudzu areas from small amounts of seeds.

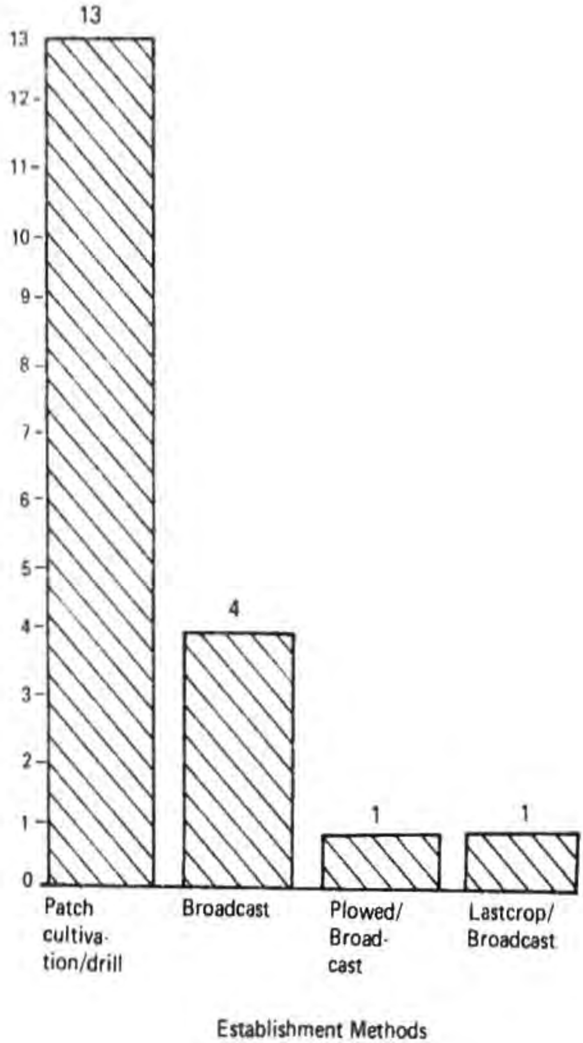

Fig. 13. Establishment methods used by enriched fallow adoptors, Daro, Jaro, Leyte.

Farmers' idea in preserving soil fertility is to decay whatever vegetation is present. In this process, except kaingin, the period by which land is prepared for planting depended on the rate of vegetation decomposition. As a result, enriched fallows being shallow rooted and having lower fiber contents were rapidly decayed resulting in reduction of recultivating periods. Legume enriched fallow land is ready for planting after only 9.5 weeks compared to 28, 12.5 and 10 weeks periods for tigbao, cogon and bush fallow vegetation (Table 11).

Table 11. Comparative periods required for recultivating fallows.

TYPE OF FALLOW	NO. OF WEEKS
Tigbao dominated	28
Cogon	12.5
Bush fallow	10
Legume enriched fallow	9.5

Corollary to this, labor requirements in the recultivation of the enriched fallow is greatly reduced because of the reduction in underbrushing and number of plowings (Table 12). Land preparation for enriched fallow required only 8.68 MD for underbrushing operation plus 26.26 MAD for plowing and harrowing. Consequently, labor values in terms of monitory values is of similar proportions, to a reduction of over or approaching 100% in comparison to costs in recultivating enriched fallows.

Table 12. Average labor costs for cultivating common natural fallows and enriched fallows under coconuts.

TYPE OF FALLOW	LABOR COST		
	Man Days Labor (MD)	Man and Animal Day (MAD)	Value Labor*
Tigbao dominated	31.395	64.455	3,206.10
Cogon dominated	73.33	34.182	2,833.88
Kaingin	115.24	0	2,300.00
Kudzu dominated	8.68	26.26	1,224.00

*Labor cost for labor (MD) = P20.00.
(MAD) = 40.00.

Table 13. Percent cost reduction in recultivating natural fallows over that of legume enriched fallows.

TYPE OF FALLOW	VALUE OF LABOR COST (P)	PERCENT REDUCTION
Tigbao dominated	3,206.10	162
Cogon dominated	2,833.88	132
Kaingin	2,300.00	88
Kudzu dominated	1,224.00	-

CONCLUSION AND RECOMMENDATION

Based on this study, *P. phaseoloides* has been found to be much efficient in creeping over cogon than the *C. pubescens,* the latter being not able to overshade cogon. Moreover, there is no doubt that the cover cropping has positive effects on eradicating cogon. Rhizome mass and cogon viability were significantly reduced by kudzu cover cropping. Reduction of cogon viability was accelerated using kudzu instead of just leaving the area fallowed by natural cogon succession.

The effects of creeping legumes on soil fertility accounted for increases in soil organic matter but did not improve phosphorus levels. Soil organic matter levels are at sufficient 7-8% in over 360 days after emergence provided legume mass is decayed with the soil.

Aside from controlling cogon and improving soil organic matter, the fallows enriched with the creeping legumes did not prejudice pasture quality but rather improved its potential. There is greater pasture species in terms of percent cover throughout the period of fallows. In addition, cultivation of legume mass advantage the farmers in terms of labor costs. The recultivation process is shortened to reduce the number of plow passes, reducing the labor cost incurred in recultivating natural fallows.

The use of *P. phaseoloides* is, therefore, highly recommended to enrich natural fallows especially the cogon dominated ones, for its multipurpose advantages. Moreover, since organic matter is attained earlier, farmers should be cautioned to consider the levels of viable rhizome before reopening to prevent cogon recurrence.

Further studies should be pushed through on the search for a right legume vegetative succession after kudzu to attain desirable potassium and phosphorus level. Consequently, agronomic benefits and grazing trials should be made to supplement the work on enriched fallows.

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