Der Tropenlandwirt, Zeitschrift für die Landwirtschaft in den Tropen und Subtropen
92. Jahrgang. Oktober 1991, S. 127 – 135

The Role of Green Manure for Agricultural Production in the Tropics with Special Reference to *Crotalaria ochroleuca* (MAREJEA)

Die Bedeutung der Gründüngung für die landwirtschaftliche Produktion in den Tropen unter besonderer Berücksichtigung von *Crotalaria ochroleuca* (MAREJEA)

by J.J. Weber[1]

1 Introduction

Agriculture in many developing countries primarily relies on smallholders whose objective is the production of subsistence food and who have very limited access to external inputs.

Traditional farming systems normally rely on a long fallow period to restore soil fertility. Shortening of the fallow period due to land scarcity leads to soil degradation resulting in lower yields. Shortening of the fallow period in combination with a less effective fallow have further declined crop yields (STEINER, 1982).

Bush clearing and land cultivation by hand do not eliminate the original vegetation as effectively as mechanized operations. This implies that traditionally managed fields recover in a shorter fallow period than mechanically cultivated fields (STEINER, 1982).

Efforts made to increase food production by introducing mineral fertilizers have increased crop production. But in years with little rain no extra yield is obtained to recover the fertilizer costs. Fertilizer application may even decrease yields, since fertilizer pellets can burn the crops if they don't dissolve properly due to lack of water. Further it has to be considered that application of artificial fertilizers will not give the lasting improvement in soil fertility which follows organic enrichement and improved physical structure. Another consideration is that

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artificial fertilizers may cause environmental problems and are out of reach of farmers especially those in the poor countries plagued with shortage of foreign exchange.

Soil fertility may be improved by growing certain plants as green manure (SALEMA, 1987).

This fact was stressed in a résumé of four hundred scientists at a recent conference (OUGADOUGOU, 1989) that tropical countries will produce enough food for survival only with the help of biological agriculture.

The objective of this paper is to compile the existing experiences in marejea technology available in Tanzania, in order to give to the smallholder a simple and affordable tool to improve the soils and to grow more food.

2 Potential of green manure

The aim of green manure in traditional framing systems with low capital inputs is to shorten and to better use the fallow period. One year of legume fallow has the same impact as four years of traditional fallow (GEROLD,1988). In comparison to industrial fertilizers very little capital is needed and the application of this technology can rely on traditional farming skills. The potential of green manure is shown by NEUMANN and PIETROWICZ (1983, cfr. Figure 1). They refer to the effects of stable manure, legume fallow and mineral fertilizers on maize yield at Gihisi, Ruanda. In this locality continous maize cropping results in 581 kg/ha grain yield. The yield improves to 1200 kg/ha by application of 15 t of stable manure. After a 10 month legume fallow 2800 kg/ha are achieved. A similar yield is achieved by a mineral fertilizer treatment of 120/100/100 kg/ha NPK. This result can be exceeded by combining legume fallow and stable manure application.

The results highlight the potential of organic agriculture. The loss of one food crop during

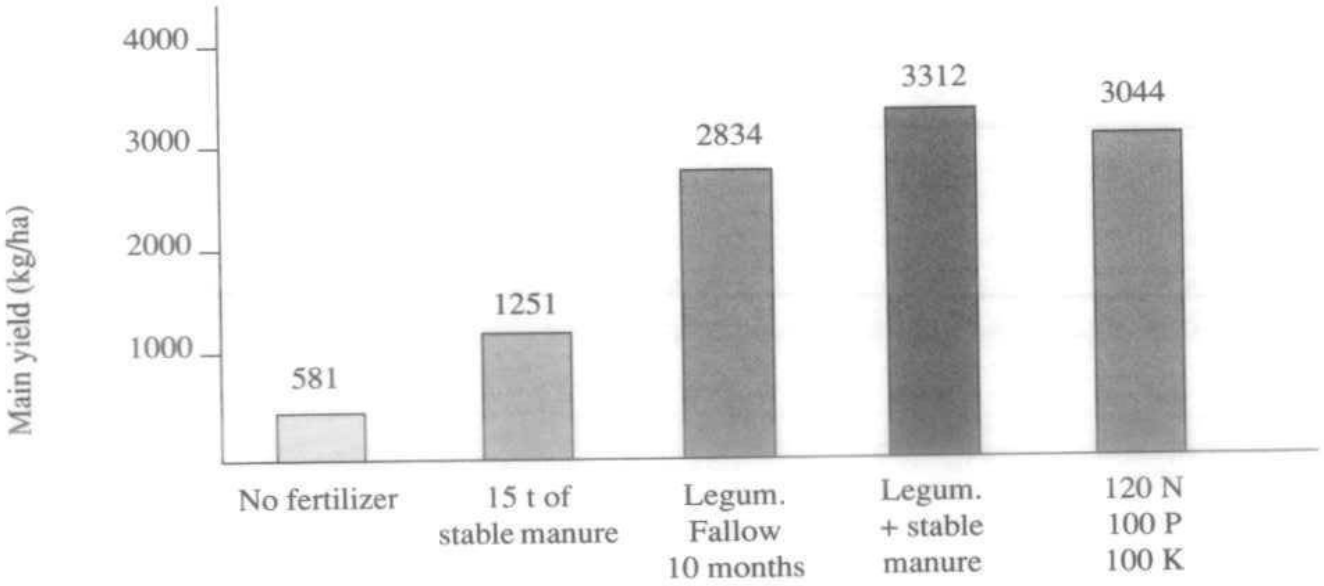

Figure 1: Influence of stable manure, legume fallow and mineral fertilizer on Maize yield at Gihisi, Ruanda

the fallow period is more than compensated by the high yield in the second year. This has been verified in a long term trial over 22 years by RATTRAY and ELLIS (1953, cfr. Table 1).

Table 1: Comparison between continuous maize production and maize in rotation with Green Manure

System	Time	Number of Maize harvests	Maize Yields in Bags/Acre Total	Average
Continuous Maize Growing	1928-50	22	132.2	6.0
Maize in Rotation with Green Manure	1928-50	14	186.9	13.5

Source: RATTRAY and ELLIS, 1953: In WEBSTER and WILSON, 1966

A Farmer who grows maize in rotation with green manure will ultimately produce more maize than the farmer growing maize continously. If we calculate two weedings per maize crop in the above experiment, the total savings are sixteen weedings, mainly done by the women. This experiment implies, that labour will not increase by introducing green manure.

The impact of green manure cannot be sustained long, and it has thus to be applied regularly (cfr. table 2). After two seasons of maize cropping grain yield is almost halved. It is only possible to restore soil fertility to its full potential by using green manure regularly compensating depletion of organic matter over the years (GLIEMEROTH, 1958). According to RATTRAY and ELLIS (1953) maize yields dropped to 36% after four years of continous maize cropping.

Table 2: Average Yields (%) in Different Crop Rotation Systems (Average of Six Years) in Comparison with Alternate Use of Green Manure (GM) and Maize = A = 100%

Crop Rotation of Maize and Green Manure	1	2	3	4
A. GM and Maize Alternating	100			
B. GM Followed by Maize Twice	93.5	52.9		
C. GM Followed by Maize Three Times	95.6	53.5	48.2	
D. GM Followed by Maize Four Times	87.1	51.5	41.2	36.4

Source: RATTRAY and ELLIS, 1953: In WEBSTER and WILSON, 1966

TEMU (1984) gives similar results for three different locations in the south of Tanzania (cfr. tables 3 and 4). The drop in Maize yield in the second year is especially obvious, when the top part of the green manure plant has been removed and less striking, when the whole green manure plant was incorporated in the soil.

These differences can also be observed even when different nitrogen levels are applied. The experiment of TEMU (1984) in Uyole demonstrates that green manure with *Crotalaria*

ploughed under yields the same maize crop as a nitrogen treatment of 160 kg/ha (cfr. table 3). If *Crotalaria* is cut, simulating a situation where *Crotolaria* is fed to livestock, a N-application of 120 kg/ha can be compensated. At other locations the difference in maize yield after *Crotalaria* has been cut and removed is only equivalent to a fertilizer level of 40 kg/ha (cfr. table 4). The difference can be explained by the N-mineralization process depending on climate and soil conditions.

Table 3: Effect of Marejea on Maize Grain Yield (in 100kg/ha) – UYOLE

N-Rates kg/ha	0		40		80		120		160	
Year	82*	83	82	83	82	83	82	83	82	83
Maize after Maize	14.0	14.8	32.6	29.7	40.0	40.3	51.6	43.3	63.1	51.2
Marejea Cut then Maize	53.2	15.5	61.1	28.3	75.8	48.0	82.0	53.1	88.2	54.2
MarejeaPloughed under then Maize	68.0	24.0	63.5	33.2	82.9	49.5	82.8	57.2	90.4	58.4

* 82 = vegetation period 1981/82 and 83 = vegetation period 1982/83
Source: TEMU, 1984

Another effect of green manure is to improve the soil structure and the water storage capacity of the soil, which allows the plant to survive dry spells easier (NOORDWIJK and ANDEL, 1988).

Tabele 4: Effect of Marejea on Maize Grain Yield (in 100 kg/ha) – NBIMBA

N-Rates kg/ha	0		40		80		120		160	
Year	82*	83	82	83	82	83	82	83	82	83
Maize after Maize	7.3	6.9	39.9	29.4	44.1	33.9	45.9	40.5	55.7	34.7
Marejea Cut then Maize	35.5	6.7	58.2	28.2	59.1	40.5	61.4	41.5	64.8	45.4
MarejeaPloughed under then Maize	50.1	14.7	50.6	31.4	58.3	42.4	64.0	40.7	64.3	44.5

* 82 = vegetation period 1981/82 and 83 = vegetation period 1982/83
Source: TEMU, 1984

Green manure also reduces weed infestation. Yield losses due to weeds are considerable and can exceed 50% (STEINER, 1982). Weed infestation increases over time under monoculture.

Further it is reported that green manure with leguminous plants can improve available phosphorus in the soil (AGBOOLA and FAYEMI, 1972; AGBOOLA, 1975; KAHNT, 1983).

3 Conclusions and Recommendations

The potential of Marejea as green manure is considerable. Marejea is the local name for two Crotalaria species. POLHILL (1982) describes fivehundred species of Crotalaria in Afrika. The species of Crotalaria ochroleuca and zansiberica are promoted under the name Marejea by Peramiho Mission, Tanzania.

In Ukara Island, Lake Victoria, the people are traditionally utilizing Crotalaria striata for soil improvement under the name „Maregea". Forty years of experience in Marejea technology are available at Peramiho (GEROLD, 1987; LUPANGA et al., 1987). In recent time Marejea technology has been adopted in other regions.

Large scale adopters are the NAFCO-Farm at Mbozi, Mbeya-Region and a few Prison-Farms. Research has been undertaken by A.E.M. Temu, Uyolo Agricultural Research Centre and by B. Gama, Agricultural Research Institute, Ukiriguru, Mwanza, to determine the value of Crotalaria as a green manure for Maize production. Further research is ongoing at the Sokoine University of Agriculture in Morogoro, Tanzania.

Marejea has most qualities a green manure plant should have according to MÜLLER-SÄMANN (1986) and SALEMA (1987).

Marejea is a high yielding plant. 20 t of fresh material can be produced by the plant (SARWATT, 1987). Exeptional yields of up to 120 t of fresh material per hectare are reported by BOGDAN (1977). Marejea covers the soil fast and suppresses weeds; if it is planted at the same time as Maize, Marejea can suppress the Maize. Therefore Marejea intercropped with Maize has to be controlled or sown after the first weeding of the main crop. Marejea can be controlled easily by cutting it down, since the plant will shoot again.

Marejea has a deep and wide root system. Once developed the plant can survive long dry periods. It cannot survive heatstress during the first weeks after planting. Therefore it is recommended to plant Marejea after the first rains have penetrated the soil by more than 20 cm. This means Marejea should not be broadcast in expectation of rain. For Marejea single stand a seed rate of 25 kg/ha should be used. As a general rule, Marejea can grow, whereever Maize production is possible. Yet it is easier to establish Maize. Marejea once established tolerates more heatstress than Maize.

Marejea is a leguminous plant and can fix nitrogen. Experiments in Peramiho (MORUS and SALEMA, 1989) show that if inoculated with the right Rhizobium[1] strains it establishes itself easier and develops faster. Marejea may not easily grow in fields which have been under intensive inorganic farming technologies for several years as observed by the author. Marejea can grow successfully to its potential only with the help of microorganisms. Depending on the status of the soil it may take several years to restore full microbial activities again. This means, if Marejea did not grow satisfactorily in the first vegetation period,

[1] The Rhizobium was produced by M.P. Salema, Dept. of Soil Science, Sokoine University, Morogoro

Marejea – preferably inoculated – should be planted in the next season again. Only a well established Marejea crop producing nodules contributes effectively to soil fertility.

To develop its potential Marejea needs an annual rainfall of about 800 mm. At this level after a successful Marejea crop a Maize yield of 30 dt/ha can be expected without fertilizer application. For different localities at altitudes of over 1000 m a.s.l and with more than 1000 mm of rainfall TEMU (1984) shows yields up to 6800 kg/ha (cfr. tables 3 and 4).

Marejea cultivation should be succeeded by a cereal crop for maximum benefit. Supplemental inorganic nitrogen is not recommended for the first year. A nitrogen application of about 40 kg/ha is advisable the second year after Marejea cultivation to avoid a drastic drop in Maize yield (TEMU, 1984). Depending on location 20 to 40 kg/ha of Phosphorous may also be applied especially in deep sandy soils. Heavier soils with high clay content and some lighter soils – medium clay and high sandy loam – do not need fertilizers (PRICE et al., 1982). As mentioned before, several authors report that leguminous green manure turns fixed phosphorous to available phosphorous for the plant (AGBOOLA and FAYEMI, 1972, AGBOOLA, 1975; KAHNT, 1983)

If no inorganic fertilizer is available Marejea intercropped with Maize in the second year may stabilize the Maize yield. Some farmers at Peramiho adopted the following crop rotation (LUPANGA et al., 1987).: First year, Marejea single stand; second year, Maize single stand; third year, Maize with Marejea intercropped; fourth year, Maize single stand. This rotation has proved to maintain an average Maize yield above 2700 kg/ha.

These results can only be achieved after a successfull Marejea crop. This depends on good field preparation by ploughing or hoeing, including careful weeding[1]. Only then Marejea broadcast or drilled[2] can prevent the reestablishment of weeds, since it germinates in a moist soil within 24 hours and covers the soil rapidly.

There are observations from Bukoba (BLOMBERG, 1988 and FRIEDRICH, 1988), Tabora and Peramiho (GEROLD, 1988) that Marejea lowers weed infestation. They especially report that Marejea has suppressed Cynodon dactylon, commonly known as „Kweek" or „Couch grass". Heavy weed infestation may need two vegetation periods of Marejea cultivation to be extinguished. Observations show, that Marejea grows as fast as weed. After about two months it starts overgrowing the weed and develops a dense canopy with its side branches. Futher research is needed to determine whether the dominance of Marejea is caused by competition or by allelopathy.

Marejea is a high yielding species with a crude protein content of up to 35% (SARWATT,

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[1] A Peramiho farmer, Mrs. Valerina Mwenta, reports that after a successful Marejea cultivation, the following Maize crop does not need any weeding.

[2] Drilling or raking in is only advisable, if sowing cannot succeed field preparation immediately. Otherwise broadcasting is sufficient and successful if done on the same day of field preparation when the soil surface is still humid.

1989). SARWATT (1989) also reports that the growth rate (g/day) of sheep doubled when fodder grass was supplemented with Marejea ad libitum. Similarly Marejea fed to livestock has improved milk production of cows (Br. HERMANN and Br. MORUS, 1988) and sheep (BWANA SHAMBA, 1989). Due to the presence of three alkaloids (MAKINGE, 1988) which accumulate during flowering the proportion of Marejea fed to livestock should never exceed 40%.

Especially Maize benefits if intercropped or rotated with Marejea, since it sustains yields and contributes to biological crop protection. In the soil Crotalaria lowers the nematode population (ANON, 1961) and in its pods it can host the earwig, a predator of the larvae of the Maize stemborer[3] (SHEPARD, 1986).

4 Summary

We can conclude that Marejea as a green manure plant has an impact on several aspects within the farming system of a small-holder. As a legume it improves the soil, suppresses weeds and complements livestock forage.

Hence Marejea cultivation is an effective and simple technology within the reach of the Small Scale Farmer to secure his food products and to reduce his dependance on chemical inputs.

Zusammenfassung

Der Anbau von Marejea *(Crotalaria ochroleuca)* beeinflußt mehrere Aspekte des Farming Systems von Subsistenzbauern in der tropischen Landwirtschaft. Als Leguminose verbessert sie die Bodenfruchtbarkeit, unterdrückt Unkraut und ergänzt das Viehfutter. Der Kleinbauer erhält dadurch eine preiswerte und wirksame Technologie zur Ernährungssicherung und verringert seine Abhängigkeit von importierten Inputs.

References

1. AGBOOLA, A.A., 1975: Problems of Improving Soil Fertility by the Use of Green Manuring in the Tropical Farming System. FAO Soils Bulletin No. 27, 146-164.
2. AGBOOLA, A.A. and FAYEMI, A.A.A., 1972: Fixation and Excretion of Nitrogen by Tropical Legumes. Agronomy Journal, 64, (4), 409-412.
3. ANON, B., 1961: Use of Mexican Merigold (*Tagetes minuta*) for Control of Nematodes. E.A. Agric. For. J., 3, 63-64.
4. BLOMBERG, B., 1989: Letter Correspodence with the Author. Igabiro Farmers' Training Centre, P.O. Box 98, Bukoba, Tanzania.
5. BOGDAN, A.V., 1977: Tropical Pastures and Fodder Plants. Longman. London. P.336.
6. Br. HERRMANN and Br. MORUS, 1988: Oral Report to the Author. Peramiho, Tanzania.

[3] Shephard reports that the earwig can eat up to 30 larvae per day of the Maize stemborer.

7. BWANA SHAMBA, 1989: Oral Report to the Author. Kibuko, Mgeta, Tanzania.

8. FRIEDRICH, T., 1989: Letter Correspodence with the Author. P.O. Box 474. Bukoba, Tanzania.

9. GEROLD, R., 1987: Cultivation of Marejea: The Experience of Peramiho. In: The Role of Marejea (*Crotalaria ochroleuca*) in Agricultural Production in Tanzania. Hrsg. MINJAS A.N., SALEMA M.P., SARWATT, S.V. and WEBER, J.J., Benedictine Publication Ndanda Peramiho, Tanzania. 9-12.

10. GEROLD, R., 1988: Letter Correspodence of Fr. Gerold, Peramiho, with Fr. Saint Pierre P.A., Tabora, Tanzania. Oral Report from Fr. Gerold to the Author.

11. GLIEMEROTH, G., 1958: Untersuchungen über den Einfluß von organischer Düngung, Pflanzenbestand und Bearbeitung auf Humusgehalt und Aggregateigenschaften eines Lößlehms. Z.f. Acker- u. Pfl.-bau, 105, 353-376.

12. KAHNT, G., 1983: Gründüngung. 2 verb. Auflage. Frankfurt a.M., DLG-Verlag, 146 S.

13. KLAPP, E., 1967: Lehrbuch des Acker- und Pflanzenbaues. Verl. Paul Parey. Berlin.

14. LUPANGA, I.J., MATTEE, A.Z., MVENA, Z.S.K. and WEBER, J.J., 1987: Social-Economic Factors Influencing the Adoption of *Crotalaria ochroleuca* in Farming Communities around Peramiho – A Preliminary Study. In: The Role of Marejea (*Crotalaria ochroleuca*) in Agricultural Production in Tanzania. Hrsg. MINJAS, A.N., SALEMA, M.P., SARWATT, S.V. and WEBER, J.J.. Benedictine Publication Ndanda Peramiho, Tanzania. 48-65.

15. MAKINGE, F.A.M.K., 1988: Preliminary Investigation Leading to the Identification of Pesticidal Compounds in Marejea Seeds. Tanzania Industrial Research and Development Organization (TIRDO).

16. MORUS, T. and SALEMA, M.P., 1989: Unpublished Experiment at Peramiho, Tanzania.

17. MÜLLER-SÄMANN, K.M., 1986: Bodenfruchtbarkeit und Standortgerechte Landwirtschaft. Maßnahmen und Methoden im Tropischen Pflanzenbau. GTZ Headquarter, Eschborn, FRG.

18. NEUMANN, I. and PIETROWICZ, P., 1983: Annual Report of the Research Report of the Research Department in the Project „Agro-Pastoral de Nyabisindu/Rwanda 1982". Unpublished Research Report, GTZ Headoffice, Eschborn, FRG.

19. NOORDWIJK, M., van and ANDEL, J., van, 1988: Reduction of Risk by Diversity. Ileia-Dec. 1988. Vol. 4, No. 4, 8-9.

20. OUGADOUGO, 1989: VII International Scientific Conference: Agricultural Alternatives and Nutritional Self Sufficency for a Sustainable Agricultural System that Respects Man and his Environment. Burkina Faso, January 1989.

21. POLHILL, R.M., 1982: *Crotalaria* in Africa and Madagascar. A.A. Balkema/Rotterdam/1982. 309pp.

22. PRICE, M., MACHANGE, F. and ASENGA, J.A., 1982: Growing Cowpeas in the Morogoro Region. Tanzanian Ministry of Agriculture.

23. RUTHENBERG, H., 1980: Farming Systems in the Tropics. Third Edition. Clarendon Press. Oxford.

24. SALEMA, M.P., 1987: The Potential of *Crotalaria ochroleuca* in Soil Improvement. In: The Role of Marejea (*Crotalaria ochroleuca*) in Agricultural Production in Tanzania. Hrsg. MINJAS, A.N., SALEMA, M.P., SARWATT, S.V. and WEBER, J.J. Benedictine Publication Ndanda Peramiho, Tanzania. 23-31.

25. SARWATT, S.V. and MKIWA, F.E.J., 1987: The Value of *Crotalaria ochroleuca* as a Livestock Feed. In: The Role of Marejea (*Crotalaria ochroleuca*) in Agricultural Production in Tanzania. Hrsg. MINJAS, A.N., SALEMA, M.P., SARWATT, S.V. and WEBER, J.J..Benedictine Publication Ndanda Peramiho, Tanzania. 32-41.

26. SARWATT, S.V., 1989: Potential of *Crotolaria ochroleuca* "Marejea" as a Livestock Feed. Report given in „Workshop on the Experience of Marejea Cultivation (*Crotalaria ochroleuca*) in Tanzania for Research Training and Extension Personnel", held at the Institute of Continuing Education, Sokoine University of Agriculture, Morogoro from 20 to 25th of February 1989.

27. SHEPHARD, B.M., 1986: Helpful Insects, Spiders and Pathogenes. International Rice Research Institute, Manila, Phillipines. 32-33.

28. STEINER, K.G., 1982: Intercropping in Tropical Smallholder Agriculture with Special Reference to West Africa. GTZ Headoffice, Eschborn, FRG.

29. TEMU, A.E.M., 1984: Effect of: *Crotalaria zansiberica* as a Previous Crop in Grain Yield of Maize. Unpublished Paper. Crop Research Department, Uyole Agricultural Centre. P.O. Box 400, Mbeya, Tanzania.

30. WEBSTER, C.L. and WILSON, P.N., 1966: Agriculture in the Tropics. Longman, London. 488p.