

INTERCROPPING IN CASSAVA – A REVIEW

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ABSTRACT

Cassava, a long season wide spaced crop is slow in its initial growth and development and therefore, intercropping of a short duration crop may increase the biological efficiency as a whole. Intercropping in cassava is a widely followed practice in the humid and sub-humid tropics. In Latin America and Africa, cassava is most commonly associated with an early maturing grain crop such as maize or legumes. Normally, green covers are planted with cassava for a variety of purposes such as cultural weed control, fertility management and moisture conservation and forage production. Results have shown that intercropping in cassava did not affect the growth and yield of tubers significantly, but increased the biological efficiency of the intercropping system as a whole by way of better nutrient efficiency and better weed control. Intercropping in cassava could also fetch additional income and since cassava being a wide spaced and initial slow growing crop, could provide ways to

Cassava (*Manihot esculenta* Crantz.), commonly known as tapioca in India, is a staple food of more than 300 million people all over the world and is grown in as many as 90 countries. It also serves as an important raw material for several industries. Among cassava growing countries, India ranks fifteenth in area, but it is the ninth largest producer of cassava with a production capacity of 6.7 million tonnes from an area of 0.24 million hectares (2005). However, India tops in productivity with 27.9 t ha⁻¹, which is the highest in the world (Unnikrishnan et al, 2006). In India, Kerala is the state accounting for 43.6 per cent of the cultivated area and 36.4 per cent of production. Tamil Nadu is the second largest in area (95,000 ha) but, first in production (3.22 million tonnes) accounting for 40.0 and 48.7 per cent of states share, respectively, but tops in productivity (33.6 t ha⁻¹).

Cassava, a long season wide spaced crop is slow in its initial growth and development and therefore, intercropping a short duration crop may increase the biological efficiency as a whole. Intercropping in cassava is a widely followed practice in the humid and sub-humid tropics. In Latin America and Africa, cassava is most commonly associated with an early maturing grain crop such as maize or

legumes. Normally, green covers are planted with cassava for a variety of purposes such as cultural weed control, fertility management and moisture conservation and forage production (Leihner, 1980). But, the area under intercropping of cassava is negligible especially in India and research work on intercropping is also scanty.

Importance of intercropping

Intercropping of two or more crop species with contrasting growth habits is a time-honoured practice and the potential advantages recognized are summarized by Mutsaers et al. (1993). According to them intercropping leads to better use of physical resources (solar radiation, mineral nutrients and water), provide high labour productivity than sole cropping and reduces risk as compared with sole cropping.

Light use efficiency in intercropping can be expected when crops with differential response to light are grown together. Efficient use of light by intercrop canopy has been recorded in intercropping experiments (Natarajan and Willey, 1980). They also observed a high water use efficiency in intercropping, attributable to the reduction in evaporation loss from inter-row space by intercrop canopy. There is also better weed

control in intercropping; often assignable to the high population pressure of the component crops (Shetty and Rao, 1981).

Last, but not the least is the yield advantage in intercropping, which could be considered as a consequence of greater uptake and utilization of nutrients as observed by Natarajan and Willey (1980). In legume and non-legume association, the nutrient use efficiency is greater because of the ability of the legume to fix atmospheric N and made available later to associated non-legume, thus resulting in higher yield of non-legume than its sole crop yield (Nair et al., 1992).

Intercropping in cassava

Intercropping in cassava is gaining importance in most of the countries of developing world, where the pressure on scarce cultivable land is ever increasing. In addition to the increased productivity there were many more reasons to practice intercropping systems in different parts of the world (Andrews and Kassam, 1976; Willey, 1979). Intercropping cassava with short duration crops was found feasible (Okigbo and Greenland, 1976; Prabhakar and Nair, 1984). They have attempted to grow various leguminous (groundnut, cowpea, soybean etc.) and non-leguminous (maize, sunflower, upland rice etc.) crops besides vegetable crops (onion, french bean etc.).

According to Kawano and Thung (1982), cassava can be planted in association with short duration crops like faba beans, cowpea etc, and that cassava genotypes of less vegetative vigour could be preferred for such associations. Leihner (1984) estimated that approximately 40 per cent of cassava cultivated in Latin America and 50 per cent in Africa is intercropped. In Africa, about 50 per cent of cassava is reported to be under mixed cropping (Okigbo and Greenland, 1976). After surveying two cassava-growing states of India, namely,

Tamil Nadu and Kerala, Ramanathan et al. (1990) reported that intercropping in cassava was a common practice in Tamil Nadu, where-as, mixed cropping involving tuber crops and this crop rotation was widely followed in Kerala.

Being a long duration crop, tapioca offered scope for accommodating intercrops in between rows, reduced the risk of dependence on a single crop, provided early and additional income and hence useful for small and subsistence farmers (Thamburaj, 1991). Cassava, a long duration crop has slow initial growth and during this phase utilization of light, nutrients, moisture etc. by cassava is meagre. Therefore to increase the efficiency of utilization of resources i.e. land, water and solar radiation, intercropping system are suggested (Mutsaers et al., 1993).

Intercropping cassava with maize

Cassava / maize intercropping seemed to be the most popular and productive bispecific mixture grown in Tropical Africa, Asia and Latin America. In Nigeria, Ikeorgu and Odu-rukwe (1990) opined that cassava / maize intercrops were highly productive, and this could further be improved by inclusion of groundnut. Hartojo and Widodo (1991) reported that hybrid maize could be intercropped with cassava without affecting the cassava yield in Indonesia. Olasantan et al. (1994) concluded that intercropping cassava with early maturing maize under optimum availability of soil nutrients, particularly N can maintain high mixture productivity.

Intercropping cassava with legumes

Several grain legumes like Cowpea (*Vigna unguiculata*), Mung bean (*Vigna radiata*), Soybean (*Glycine max*), Groundnut (*Arachis hypogaea*) and Pigeonpea (*Cajanus cajan*) have been tried as intercrops in cassava by several workers (Sasidhar and Sadanandan, 1976; Pillai et al., 1986). The inclusion of a

legume in the multiple cropping systems with cassava was suggested out of two important considerations. First, being a legume crop it will fix atmospheric N and thereby promote soil fertility. Secondly, cassava tuber is very low in protein and inclusion of a pulse crop is quite significant from the point of view of balanced nutrition (Sasidhar and Sadanandan, 1976).

Leihner (1983) reported that cassava a long duration tuber crop is commonly intercropped with legumes in the tropics. Two rows of intercrops were considered the best system (Charoenrath, 1983). Pillai *et al.* (1986) reported that cassava could be inter-cropped with cowpea, greengram, blackgram or groundnut in the early stages. Though different cassava based intercropping systems are prevalent among farmers, cassava legume association has the advantage of improving the nutrient status of the farm family, enriching the soil by means of legume effect adding to fertilizer use efficiency (Bhattacharya and Singh, 1988).

According to Tsay *et al.* (1988) and Fukai *et al.* (1990) cassava/legume intercropping could be more productive than sole cropping of individual species particularly when wide row cassava was intercropped with a short duration crop, as the associated legume matured before competition developed between the two species and that cassava had time to recover from the adverse effect of legume. According to Thamburaj (1991) suitable intercrops identified in cassava for Tamil Nadu conditions have been bellary onion, groundnut, cowpea and blackgram. Nair *et al.* (1992) reported that intercropping cassava with groundnut, french bean and vegetable cowpea were found to be most promising in Kerala, while onion, tomato were most profitable in Tamil Nadu.

Effect of intercropping on growth attributes

Higher plant height and more number of leaves were observed by Sheela and

Mohammed Kunju (1988), Thamburaj and Muthukrishnan (1991) and Prabhakar and Nair (1992) in sole crop than in inter-cropped cassava. Ramanujam and Lakshmi (1984) and Prabhakar and Nair (1992) noticed that at the harvest stage, leaves, stem and tuber accounted for about 16, 25 and 59 per cent of total DMP, respectively, both in sole and intercropped cassava. Increase in plant height after second, third and fourth month after planting was reported by Anilkumar and Sasidhar (1987) in cassava when intercropped with groundnut. However, when intercropped with cowpea maximum reduction in plant height of cassava was noticed, due to the smothering effect of the luxuriant vegetative growth of cowpea before the fifth month, after which this effect was lessened. Kunuvilla Varughese *et al.* (1988) observed that the height of the main crop was reduced by cowpea and groundnut throughout the growth period. These two crops were also casual in reducing number of leaves of cassava, but the effect reached significant only during the early stage of the growth.

Total dry matter of intercropped cassava was always lesser than that of sole cassava (Tsay and Wilson, 1989). As intercrop, yam affected cassava lesser than maize (Moreno, 1990). Thamburaj (1991) found that the growth of tapioca picked up after three and half months and after five months there was no difference in the growth of sole or intercropped cassava.

According to Prabhakar and Nair (1992), the setback in cassava growth during its early stage was due to competition with associated groundnut for light and applied nutrients. However, there was no difference in biomass production between sole cassava and cassava + groundnut under irrigated conditions. In another study, Balakrishnan and Thamburaj (1993) recorded the maximum height of cassava when intercropped with blackgram suggesting that the plant height of cassava was also influenced by the intercrop.

Olasantan *et al.* (1995) reported that inclusion of maize with cassava increased plant height, reduced LAI and decreased nutrient uptake in cassava. Intercropping of cassava with *Flemingia* led to an increase in quantity of drymatter. The highest dry matter yield was obtained when cassava intercropped with *Flemingia* (Nago Tien Dung *et al.*, 2005).

Anilkumar and Sasidhar (1987) observed lower values of LAI, when intercropped with cowpea. According to them, the smothering effect of cowpea which was evident in the form of yellowing of older leaves of cassava in intercropped plots. Intercropping might have reduced the leaf area duration in addition to the number of functional leaves thereby causing a reduction in leaf area index. However, such significant difference in LAI was not observed by them after fifth month of planting. According to Ghosh *et al.* (1989) intercropping influenced the mean LAI of cassava and the effect was more pronounced in intercropped stands of cassava with groundnut and cowpea. Ayyasamy (1994) reported that LAI of cassava, groundnut and sesamum increased with increase in number of irrigation and it was not altered due to sole or comrade crop in groundnut and sesame.

Yield of tubers

Intercropping with maize

Abit (1979) found that intercropping sorghum or maize did not affect the yield of cassava when both crops were planted at the same time or when the cereals were planted one or two weeks later. In case of cassava + maize, high N status stimulated maize growth, which might reduce the cassava yield if maize vigour exceeded a threshold level (Kang and Wilson, 1981).

Villamayor Junior and Destriza (1982) found that one hill of sweet maize between cassavas did not significantly affect the yield of cassava. In Costa Rico, Ikeorgu *et al.* (1989)

reported that cassava / maize intercropping system yielded highest calories $\text{ha}^{-1} \text{day}^{-1}$. Ikeorgu and Odunukwe (1990) reported that cassava yields were not reduced in cassava/maize and cassava/groundnut bispecific mixture. According to Ezumah (1990), a maize population of 40 to 80 per cent did not significantly reduce the yield of intercropped cassava. Ezumah *et al.* (1990) reported a decline in cassava root yield under intercropping with maize at high population ($1,00,000 \text{ plants ha}^{-1}$). Hartojo and Widodo (1991) opined that hybrid maize could be intercropped with cassava without affecting cassava yield. Olasantan *et al.* (1997) concluded that the main factor limiting the total yield in a cassava-maize intercropping system is the depression of the early cassava growth by vigorous maize component, which reduces the amount of assimilate allocated to cassava roots.

Intercropping with legumes

Yield aspects

In India, intercropping cassava with groundnut was found more lucrative than monocropping, but resulted in reduction of cassava yields (Thamburaj and Muthukrishnan, 1991; Mohankumar and Hrishi, 1979; Prabhakar and Nair, 1984).

Sheela (1981) concluded that the yield was not affected by growing groundnut as intercrop in cassava. Leihner (1980) reported that planting stylo between cassava, produced root yields similar to or higher than those obtained without stylo undersowing. Anilkumar *et al.* (1990) recorded higher tuber yield under paired row cassava + fodder cowpea intercropping system compared to pure stand of cassava at normal planting. Mestra (1990) reported that the highest tuber yield was obtained in sole cassava and the lowest in associated cropping. Thamburaj and Muthukrishnan (1991) observed that the yield

of tapioca tubers was not affected comparatively when bellary onion was raised as an inter-crop, the reduction in yield was negligible. Neither spatial arrangement of cassava nor change in plant density of intercropped groundnut had any substantial effect on tuber yield of cassava (Prabhakar and Nair, 1992).

According to Villamayor Junior *et al.* (1992), the long-term trial with legume intercropping showed significant yield differences in the first crop; highest and lowest yields were obtained when cassava was monocropped and intercropped with *Cajanus cajan*, respectively. Kamik *et al.* (1993) experimented and found that monoculture of cassava gave significantly higher tuber yield followed by cassava + cowpea. No significant difference in yield of cassava was reported when intercropped with cowpea (Savithri and Alexander, 1995).

Nago Tien Dung *et al.* (2005) reported that intercropping with *Flemingia* reduced the yield of foliar and root in the first year, but increased in the second year. This agrees with the findings of Nguyen Phuc Tien *et al.* (2003).

Weed control

Leihner (1980) postulated that cassava with legume, ensured better coverage of soil surface, which diminished light penetration, thus reduced weed growth without other weed control measures. The sole practice of intercropping beans with cassava reduced the total weed dry weights to 47 per cent at 90 DAP.

In maize + cassava intercropping system, Akobundu (1980) obtained the highest total food energy and the lowest weed dry weight with a total plant density of 30,000 ha⁻¹. However, according to Ossom (1986), a total plant density of 50,000 ha⁻¹ markedly reduced the weed infestation. Zuofa *et al.* (1992) also suggested the use of groundnut or

cowpea or melon as smother crop in cassava + maize intercropping system wherein the best weed control, highest yields and LER were recorded with a total plant density of 50,000 ha⁻¹. Olsantan *et al.* (1994) concluded that intercropping cassava and early-maturing maize under optimum availability of soil nutrients, particularly N, could give good weed control and maintain high mixture productivity.

Land equivalent ratio (LER)

Kang and Wilson (1981) reported an LER of 1.42 to 1.79 in cassava + maize intercropping. LER increased with increased N levels at 20,000/40,000 plants ha⁻¹. Higher LER of cassava + maize intercropping was reported by many workers. An LER of 1.36 to 1.84 by Ezumah and Lawson (1983), 1.73 to 2.11 by Ikeorgu *et al.* (1984), 1.63 to 1.91 by Ezumah (1988) and 1.16 to 1.69 by Osiru and Hahn (1988) were recorded.

In cassava + cowpea combination higher LER values were also reported by many investigators. Mason *et al.* (1986) reported an LER of 1.48 to 1.56 at 9,300/1,11,100 plants ha⁻¹; 1.50 to 1.73 by Mba and Ezumah (1985), 2.02 by Ezumah (1986) at different densities and row patterns. A small but real biological advantage of growing cassava in association with maize or grain legumes, with an average mean LER of 1.19 and 1.11, respectively, was reported by Mutsaers *et al.* (1993).

Yield differences between mono and intercropped cassava depended on time of harvest. They were large at the beginning and zone at final harvest. Land equivalent ratios were mostly > 1.5 indicating that a maize / cassava mixed crop protected or unprotected, considerably increased the productivity per unit area of land.

Economic aspects

Intercropping is considered as an income augmenting measure from cassava field. Even though intercrops reduced the yield

of cassava, the reduction was compensated by the intercrop yield and further increased the net profit to the farmer (Mohankumar and Hrishii, 1974). According to Andrews and Kassam (1976) and Okigbo and Greenland (1976), higher gross return and dietary requirements were achieved under intercropping than sole cropping.

The economic analysis of various intercropping systems in tapioca has revealed that the performance of groundnut as intercrop was the most profitable one (Singh and Mandal, 1970; Sintupra-ma *et al.*, 1973; Sheela, 1981; Anilkumar and Sasidhar, 1987 and CTCRI, 1988). Evengelio and Posas (1983) found that under intercropping system maximum economic benefits were obtained when root crops and legumes were planted at the same time. According to Asokan *et al.* (1985), in a cassava + legume intercropping, cowpea might be the most remunerative intercrop in high rainfall oxisol of central Kerala. Ghosh *et al.* (1987) obtained the highest net return from the crop combination of cassava plus french bean or cowpea.

Asokan and Sreedharan (1987) observed the highest income under cassava + groundnut + red gram (BCR-1.94) followed by cassava + groundnut (BCR-1.86) and cassava + cowpea (BCR-1.83) than sole cassava. Intercrops like greengram, cowpea, blackgram or groundnut gave an additional income without adversely affecting the yield of main crop and also recorded higher profit than sole cassava (Kunuvilla Varughese *et al.*, 1988). Ghosh *et al.*, (1989) reported that cassava in combination with seasonal intercrops provided the highest net returns than as a pure crop; cowpea as a ground tier crop was more profitable when compared with groundnut. Sheela and Mohammed Kunju (1990) found that groundnut intercrop was found to be significantly superior to cowpea giving the mean net return of Rs.11, 863 ha⁻¹.

Meera bai *et al.* (1992) reported that paired row planting of cassava+ cowpea recorded the highest net income of Rs.11,335 ha⁻¹ followed by uniform planting of cassava + cowpea (Rs.10,433 ha⁻¹). The corresponding cost benefit ratio (BCR) was Rs.1.65 and 1.60, respectively, per rupee invested suggesting that cassava cowpea intercropping was more efficient than cassava groundnut association.

Interplanting cassava with other crops such as upland rice, maize and legumes increased the gross income by 33 per cent compared to monoculture cassava (Wargiono *et al.*, 1992). The study conducted by Prabhakar and Nair (1992) revealed that by practicing cassava groundnut intercropping system it was possible to achieve 27 to 32 per cent more monetary benefit under rainfed condition and 15 to 60 per cent with supplementary irrigation than sole cropping of cassava.

Soil fertility: Searle *et al.* (1981) have reported that intercropping with groundnut was beneficial to soil. According to Burgos (1980) advantages of intercropping cassava with other crops were felt in many ways like reduction in run off and soil losses, and conservation of physical properties and maintenance of soil fertility. Leihner (1980) reported that stylo, as a companion crop in cassava besides smothering the weeds, was able to supply N equivalent to 20 kg urea ha⁻¹ for unfertilized stylo and 160 kg urea ha⁻¹ for fertilized stylo. Prabhakar and Pillai (1984) found that intercropping helped to reduce soil erosion, leaching nutrient, depletion of soil fertility and check the growth of weeds than pure crop of cassava.

Swaify *et al.* (1988) found that the use of legumes as ground cover reduced runoff and soil losses in maize. Similar beneficial effects were also gained from intercropping legumes

with cassa-va. Besides providing protection against runoff and erosion, legume intercropping also enhanced grain yields in succeeding crops due to nutritional contributions from their residues.

Intercrops produced large amount of residues which, when returned to the soil as mulch, would improve crop production and soil productivity (Wargiono and Tuherkin, 1987). The NPK content of soil was improved due to raising of legumes (Thamburaj, 1991). Olsantan *et al.* (1995) reported that soil fertility especially N was lower in cassava + maize intercropping than in cassava grown alone. Compared with monoculture of cassava or Flemingia intercropping them resulted in

decreased soil erosion was reported by Nago Tien Dung *et al.* (2005). Similar findings were reported by Dung (2002) who showed that the root yield of cassava intercropped with two and three rows of peanut compared to cassava in monoculture. In Flemingia + cassava intercropping system (Nago Tien Dung *et al.* 2005) recorded decrease in organic matter and nitrogen in the plots with cassava for roots and cassava for foliage.

The foregoing review brings out that intercropping in cassa-va could fetch additional income and since cassava being a wide spaced and initial slow growing crop, could provide ways to accommodate certain specific intercrop for yield and economic advantages.

REFERENCES

- Abit, S.E. (1979). In: Progress Report, CRIC 1979. *Annual Report*, Vol. 11. pp. 130-134.
- Akobundu, I.O. (1980). *Trop pest Mgmt.*, **26**: 420-426.
- Andrews, D. and Kassam, A.H. (1976). In: Multiple cropping. (Papendick *et al.* Eds.) American Society of Agronomy. Special Publications, 27: 1-10
- Anilkumar, A.S. and Sasidhar, V.K. (1987). *J. Root crops*, **13**: 59-60.
- Anilkumar, A.S. *et al.* (1990). *J. Root Crops*, ISRC Nat. Symp. 1990, Special issue - pp 147-150.
- Asokan, P.K. and Sreedharan, C. (1987). *Agric. Res. J. Kera-la*, **25**(5): 15-16.
- Asokan, P.K. *et al.* (1985). *Trop. Agric (Trinidad)*, **62**(4): 313-318.
- Ayyasamy, M. (1994). Ph.D. Thesis. Tamil Nadu Agric. Univ., Coimbatore, India. Pp 126
- Balakrishnan, S. and Thamburaj, S. (1993). *South Indian Hort.*, **42**: 273-277.
- Bhattacharya, B. and Singh, R.P. (1988). In: Proc. of the Second International Symp. on Food-Energy Nexus and Ecosystems held in New Delhi, 12-14 February 1986. Mouluk, T.K. Ed. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi. pp.315.
- Burgos, C.F. (1980). In: Proc. International Development Re-search Centre, Ottawa, Canada. Series IDRC-151e. pp. 75-81.
- Charoenrath, S. (1983). In: Intern Sem Root Crops in South East Asia (ISRC-SEA). VISCA and UPLB, Philippines, November 8-16, 1983. p.17.
- CTCRI. (1988). *Annual Report*, Central Tuber Crops Research Institute, Trivandrum, India.
- Dung T.T. (2002). In: 7th Regional Cassava Workshop, 28th October to 1st November 2002. Bangkok, Thailand pp: 196-198.
- Ezumah, H.C. (1986 & 1988). In: *IITA Annual Report*, Ibadan, Nigeria, pp.50-55; 78-80.
- Ezumah, H.C. (1990). *Discovery and Innovation* **2**(2): 65-72.
- Ezumah, H.C. and Lawson, T.L. (1983). *International Institute of Tropical Agriculture Annual Report*, Ibadan, Nigeria, pp.141-143.
- Ezumah, H.C. *et al.* (1990). *Discovery and Innovation*, **2**(2): 73-82.
- Fukai, S. *et al.* (1990). In: Proc. of 8th Symp. Int. Soc. Tropical Root Crops. Bangkok, (Howeler, R.H. Ed.) Thailand. pp. 293-300.
- Ghosh, S.P. *et al.* (1989). *Cassava Newsl.*, **13**(1): 6-8.
- Ghosh, S.P. *et al.* (1987). *Tropic. Agric (Trinidad)*, **64**: 233-236.
- Hartojo, K. and Widodo, Y. (1991). In: Malang Research Institute for Food Crops. Indonesia. pp. 11-13.
- Ikeorgu, J.E.G. and Odurukwe, S.O. (1990). *Tropic. Agric (Trinidad)*, **67**(2): 164-168.
- Ikeorgu, J.E.G. *et al.* (1989). *Field Crop Res.*, **21**(1): 1-7.

- Ikeorgu, J.E.G. et al. (1984). In: Tropical Root Crops: Production and uses in Africa. Terry, E.R. et al. Ed.) In: Proc. 2nd Triennial Symp. ISTRC, Africa Branch, Douala, Cameroon, 14-19th August, 1983. Ottawa, Ont., IDRC. pp.63-66.
- Kang, B.T. and Wilson, G.F. (1981). In: (Terry, E.R et al. Ed.) Tropi-cal Root Crops. Research strategies for the 1980's. IDRC, Ottawa. pp. 129-133.
- Kamuk, A.R. et al. (1993). *Indian J. Agric. Sci.*, **63**: 265-267.
- Kawano, K. and Thung, M.D. (1982). *Crop Sci.*, **22**: 59-63.
- Kurivilla Varughese. et al. (1988). *Agric. Res. J. Kerala*, **24**: 179-184.
- Leihner, D.E. (1980). In: Proc. Int. Workshop on cassava cultural practices. (Weber, E.J. Ed) IDRC, Ottawa, Canada. Series 151 e: pp.107-111.
- Leihner, D.E. (1984). In: Proc. Symp. the Int. Soc. Tropical root crops. 1983. Lima, pp. 247-255.
- Mason, S.C. et al. (1986). *Agron. J.*, **78**(1): 43-46.
- Moa, A. and Ezumah, H.C. (1985). Int. Inst. Tropic. Agric. Annual Report for 1984, Ibadan, Nigeria. pp. 175-176.
- Meera Bai, M. et al. (1992). *Eng. systems*, **8**: 12-17.
- Mestra, M., A. (1990). In: Yvea Y culti-vars asociados. Cali, Columbia, Centro Internacional de Agricultura Tropical. Documento de Trabajo no. 02. pp. 79-83. Es. 4 Ref.
- Mohankumar, C.R. and Hrisi, N. (1974). Annual Report, Central Tuber Crops Research Insti-tute, Trivandrum. pp. 67-69.
- Mohankumar, C.R. and Hrisi, N. (1979). In: Proc. Int. Workshop on Intercropping with Cassava. Trivandrum, India. 27 Nov. - 1 Dec., 1978. pp.31-34.
- Moreno, B.A. (1990). In: Yvea cultivos asociados. Cali, Colombia, Centro Internacional de Agricul-ture Tropical. Documento de Trabajo no. 02. pp.51-59.
- Mutsaers, H.J.W. et al. (1993). *Field Crops Res.*, **34**: 431-457.
- Nago Tien Dung et al. (2005). *Livestock Research for Rural Development*, **17** (1): 25-35.
- Nair, P.G. et al. (1992). In: (Howeler, R.H., Ed.) Regional Workshop on Cassava Breeding Agronomy and utiliza-tion Research in Asia. 3rd, Malang, Indonesia, 1990. Pro-ceedings Bangkok, Thailand, Centro Internacional de Agricul-ture Tropical. Regional Centro Program for Asia. pp. 224-244. En., Sum. en., 18 Ref., 11. I.C. Classification : SB. 211. C3C 452.
- Natarajan, M. and Willey, R.W. (1980). *J. Agric. Sci.*, **96**: 51.
- Okigbo, B.N. and Green land, D.J. (1976). In: Multiple Cropping. (Papendick, R.I. Eds) American Society of Agronomy, Spl. Publication, 27: 63-101.
- Olasantan, F.O. et al. (1994). *Field crops Res.*, **39**: 63-69.
- Olasantan, F.O. et al. (1995). *Agric. Ecosystems Environment*, **57**(2-3): 149-158.
- Olasantan, F.O., et al. (1997). *Nutrient Cycling in Agro ecosystems*, **46**: 215 -223.
- Osiru, P.S.O. and Hahn, S.K. (1988). Annual Report for 1987, IITA, Ibadan, Nigeria, pp.15-18.
- Ossom, E.M. (1986). *J. Agric. Sci.*, **56**: 732-734.
- Pillai, G.R. et al. (1986). In: Proc. Australian Centre for Intemation-al Agricultural Research, Canberra, Australia. No. 18. pp. 240-241.
- Prabhakar, M. and. Nair, G.M. (1984). *Indian Eng.*, **34**(1): 9-10.
- Prabhakar, M. and Nair, G.M. (1992). *J. Root crops*, **18**(1): 26-31.
- Ramanathan, S. et al. (1990). *J. Root crops*, **16**(2): 83-86.
- Ramanujam, T. and Lakshmi, K.R. (1984). *Indian J. Pl. Physiol.*, **27**: 138-144.
- Sasidhar, V.K. and Sadanandan, N. (1976). *Indian Eng.*, **26**(6): 23.
- Savithri, K.E. and Alexander, D. (1995). *Legume Res.*, **18**:59-60.
- Searle, P.G.E. et al. (1981). *Field Crops Res.*, **4**: 135-145.
- Sheela, K.R. and Mohammed Kunju, U. (1988). *J. Root Crops*, **14**(1): 67-69.
- Sheela, K. R. and Mohammed Kunju, U. (1990). *J. Root Crops*, **16**(1): 53-55.
- Shetty, S.V.R. and Rao, M.R. (1981). In: Proc. International Workshop on Intercropping, Jan. 1979. ICRISAT, Hyderabad, India, pp. 238-248.
- Singh, K.D. and Mandal, R.C. (1970). Annual Report, CTCRI, Trivandrum p.25.
- Sintuprama, S. et al. (1973). Annual Report, Thailand Ministry of Agriculture, Field Crops Division, Bangkok, pp.2-6.
- Swaify, S.A. et al. (1988). *Soil Technology*, **1**(1): 1-12.
- Thamburaj, S. and Muthukrishnan, C.R. (1991). *Madras Agric. J.*, **63**(3): 198-199.
- Tsay, J.S. and Wilson, G.S. (1989). *Field crops Res.*, **21**(2): 83-94.
- Tsay, J.S. et al. (1988). *Field Crops Res.*, **19**: 211-225.

- Unnikrishnan, et al. (2006). *Kissan World.*, **33**(11):11
- Villamayor Junior, F.G. and Destrizza, T.T. (1982). *The Radix*, **4**(2): 4-5.
- Wargiono, J. and Tuherkin, E. (1987). In: *Central Research Inst., Food Crops*, Bogor. p. 13.
- Wargiono, J. et al. (1992). In: *Regional Workshop in Cassava Breeding, Agronomy and Utilization Research in Asia*, 3rd, Malang, Indonesia, 1990. (Howeler, R.H Ed) *Proceedings Bangkok, Thailand, Centro Internacional de Agricultura Tropical*, Sum. en. 11. I.C. Classification: S.B. 211.C3C 452.
- Willey, R.W. (1979). *Field Crops Abstr.*, **32**(1): 1-10.
- Zuofa, K. et al. (1992). *Field crops Res.*, **28**(4): 309-314.