GROWTH AND ESTABLISHMENT OF CACAO SEEDLINGS UNDER INTERCROP WITH PLANTAIN AT DIFFERENT TRANSPLANTING POSITIONS

ABSTRACT

An investigation was carried out in Cocoa Research Institute of Nigeria (CRIN), Uhonmora Station, Edo State to evaluate the effect of transplanting positions of cacao (*Theobroma cacao* L) seedlings with plantains under field condition. Four treatments were evaluated: Plantain suckers on top of cacao seedlings at transplanting (PTCT), Cacao seedlings on top of plantain suckers at transplanting (CTPT), Cacao seedlings transplanted 30 cm apart from plantain suckers (CT30P) and Cacao seedlings transplanted 150 cm apart from plantain suckers (CT150P) as control. The experiment was arranged in Randomized Complete Block Design (RCBD) with three replications. Plantain suckers were planted at 3 x 3m spacing as shade crop while cacao seedlings (hybrid) were planted on treatment basis. The experiment was monitored for 22 months after transplanting. Data were collected on plant height, number of leaves, stem diameter, number of branches and leaf area at 3, 4, 5, 12, 13, 14 and 15 Months After Transplanting (MAT), and on Survival count (%) at 10 and 22 MAT. The data were analyzed with analysis of variance (ANOVA) as well as descriptive statistics, and significant means separated by Duncan multiple range test ($P<0.05$). The result showed that cacao seedlings on top of plantain (CTPT) at transplanting had the highest percentage of 91.67 and 75.00 survival count at 10 and 22 MAT, respectively, closely followed by plantain on top of cacao seedlings at transplanting (89.00 % and 72.00%). When compared with CT150P, CTPT increased the plant height, number of leaves, stem diameter, number of branches and leaf area at 4 MAT, at 15 MAT, at 3, 13, 14, 15 MAT, at 3, 15 MAT and at 13, 14,15 MAT, respectively by 1%, 10%, 61%, 2%, 3%, 8%,46%, 11%, 5%, 3% and 13%, respectively. Therefore, cacao seedlings transplanted on top of plantain was the most effective treatment for improving cacao seedling establishment and growth under field condition.

Keywords: Cacao seedlings, Plantain, Transplanting position, Seedling establishment, Growth,

INTRODUCTION

Cocoa (*Theobroma cacao* L.) is a tropical woody species which belongs to the family Malvaceace [1]. Under natural condition, the tree can attain a height of 20 -25 m [2], whereas under cultivation, plant height varies from 3 to 5 m. The geographical origin of cacao is South America [3]. It is considered as one of the most important perennial crops with an estimated world output of 4.2 million tonnes in 2018 [4], while FAO [5] reported an estimated annual yield of 3.2 million tonnes in 2009. It is cultivated in the Humid tropics of the world [6] with more than 70% production coming from Africa as source of income for producing countries [7]. Cocoa production is dominated by small-scale farmers who live and work in the cocoa belt providing them employment and income [8; 9]. Cocoa is the most prominent export crop in Nigeria in terms of its production and export capacities.

Traditionally, cacao farmers in Nigeria established their farms with plantains or other food crops, either sown directly at stake or seedlings are transplanted from the nursery in to the field [10; 11; 12]. Conventionally, cacao seedlings are planted or transplanted in between the plantain suckers [13]. The temporary shade provided by plantain supplies direct shade to the cacao seedlings for 2 to 3 years after transplanting. Moreover, despite the provision of shade by plantain for transplanted young cacao seedlings, it is a known fact that the highest percentage of these seedlings die between the first and second dry seasons as a result of soil moisture deficit during the peak of dry seasons [14]. It is also established that plantains that are planted to provide shade during the dry period do shed most of their leaves as a result of limited soil moisture in order to survive [14]. In Nigeria, cocoa production is limited to the rainforest and savanna transition zones. Presently, the level of cocoa production stands at 350,000 tonnes per annum [15], in spite of the fact that Nigeria is endowed with vast land areas suitable for its cultivation. Adoption of good management practices can bring about increased bean production of up to 100-300% [16]. According to [17], the major reason attributed to low productivity despite the huge effort of the government were limited access to modern production technology, limited access to input and credit facilities, low percentage of survival (less than 35%) of transplanted seedlings at the end of the second dry season due to soil moisture stress and poor field management. There are also concerns that the projected global temperature rise and subsequent increase in potential evapo-transpiration and demand for plant water may lead to further drought stress during the dry season and deterioration of cocoa climate condition [18; 19]. To solve the above mentioned problems, more robust farm management strategies are therefore needed.

Effective management of cacao seedlings on the field using agronomic practices like dry season irrigation and optimum shading regime to enhance root development could improve plantation establishment and cacao productivity. However, research efforts that would ensure cocoa sustainable production at the early stage of establishment are seen as steps in the right direction which remains sacrosanct for the survival of young cocoa in the field and the improvement of farmers' income [20]. Moreover, it is a known fact that cacao cultivation in Nigeria is predominantly in the hand of peasant farmers who cannot afford irrigation facilities. Due to climate change, rainfall and humidity have been on a decline progressively since mid-1970s [21], while global warming has been on steady increase. Given the increasing global demand for cocoa and quest for obtaining sustainable production systems, it is imperative to understand the effects of some agronomic practices on the responses of cacao seedlings to dry season environmental conditions especially the hydrothermal stresses [22]. Improved insights would be valuable towards the attainment of optimum seedlings establishment and vigor on the field [23]. Much of success of intercrops in cacao establishment depends on understanding the role each component plays in the system: cacao/plantain farming system has been recommended [24] but the transplanting arrangement in the face of global warming and climate change is a gap in research. Therefore, the objective of this work was to evaluate effect of different planting positions of cacao and plantain on survival and morphological growth of cacao on the field.

MATERIALS AND METHODS

Study area

Field experiment was carried out at the experimental farm of Cocoa Research Institute of Nigeria (CRIN), Uhonmora Station in Edo State between 2018 and 2020 covering two consecutive rainy seasons and two dry seasons. The location, a derived savanna zone of Nigeria, lies on latitude 6º5′N and longitude 5º50′E. The rain fall is between 1000 – 1500 mm per annum. The maximum temperature ranges between 26 to 35 ^{0}C with an average of about 30 ^{0}C while minimum temperature ranges from 15 to 25^{0}C with an average of 20 ^{0}C. Relative humidity is high during the raining season, ranges from 50 to 85 % with an average of 75%. There are seasonal variations in the values of relative humidity, which varies from 65 to 89% during the rainy season and 46 – 70% during the dry season. The rainy season which runs from April to October is characterized by heavy rains, low ambient temperature and high humidity; while the dry season runs from November to March and is characterized by little or no rain, high ambient temperature and very low humidity.

Acquisition and preparation of experimental materials

Seedlings of hybrid CRIN TC genotype were collected from CRIN, Uhonmora nursery, while plantain suckers were collected from experimental plots in the station. Experimental plot of 50 by 30 m was mapped out and the experiment was laid out in rows of 3 x 3 m.

Treatments and experimental design.

The field experiment comprised four treatments (four different transplanting positions of cacao seedlings and plantain suckers): Plantain suckers on top of cacao seedlings at transplanting (PTCT), Cacao seedlings on top of plantain suckers at transplanting (CTPT), Cacao seedlings transplanted 30 cm (between 2 plantain stands) apart from plantain suckers at transplanting (CT30P) and Cacao seedlings transplanted 150 cm (between 2 plantain stands) apart from plantain suckers at transplanting (CT150P) as control. The experiment was laid in Randomized Complete Block Design (RCBD) with three replications. Layout of the experimental site (Measurement, pegging, and holing) was carried out. One hundred and forty-four (144) plantain suckers were planted at 3 x 3m spacing as shade crop. The same number of five months old cacao seedlings (Hybrid) of average height of 50 cm (raised in the nursery) were transplanted on treatment basis. The experiment was monitored for 22 months after transplanting (MAT).

Data collection

Data collected included growth parameters of cacao seedlings (Plant height, Number of leaves, Stem diameter, Leaf area, Number of branches) and their Survival counts. The growth parameters were taken on monthly basis for 22 months commencing from 3 months after transplanting (3 MAT). Plant height (cm)was measured using a meter rule from the ground surface to the tip of the main stem. Stem diameter (cm) was measured with Vernier Caliper 30 cm above the ground level. Number of leaves, Number of branches and Survival count were determined by visual count. Leaf area was also measured. The growth parameters were taken monthly for 22 months commencing from 3 MAT. Survival counts were carried out at 10 and 22 MAT

Data collected were subjected to statistical analysis using analysis of variance (ANOVA) as well as descriptive statistics, and significant means were separated by Duncan Multiple Range Test (DMRT) ($P<0.05$)

RESULTS AND DISCUSSION

Effects of transplanting positions of cacao seedlings on survival count are represented in Figure 1. Cacao seedlings on top of plantain suckers at transplanting (CTPT) and Plantain suckers on top of cacao seedlings at transplanting (PTCT) significantly ($P<0.05$) enhanced the survival count of cacao seedlings relative to other treatments at 10 and 22 MAT, while cacao seedlings on top of plantain at transplanting gave the highest survival count in both 10 and 22 MAT (Figure 1). The highest seedlings survival count recorded in 10 and 22 MAT under Cacao seedlings on top of plantain suckers at transplanting (CTPT) could be as a result of commensalism relationship between the transplanted cacao seedlings on top of the plantain suckers in which both shared the same environment and the cacao benefitted from the water and cooler weather around the biosphere especially during the dry season, yet the plantain was not adversely affected. The relationship is called table fellowship. This result also confirmed that the survival of transplanted cacao seedlings did not depend on the spacing adopted but the arrangement of cacao with the plantain. This result was corroborated by [25] and [23] who reported that the reduction in stand mortality under moderate and dense shaded plots was traced to improved microclimate conditions occasioned by shade plants that aided reduced air and soil temperature, reduced moisture loss through evaporation and increased activities of microbial organism under shaded microclimate. It was also observed that the same CTPT treatment had the lowest percentage mortality rate of 18% after the end of the first dry season; this was closely followed by PTCT (19%) (Figure 1).

Effect of transplanting position of cacao seedlings on growth parameters of cacao seedlings is presented in tables 1 - 5. The CTPT also gave the highest plant height, number of leaves, stem diameter, number of branches and leaf area at 4 MAT, at 15 MAT, at 13, 14, 15 MAT, at 15 MAT and 15 MAT, respectively. When compared with the conventional transplanting of cacao seedlings in between the plantains (CT150P), CTPT increased the plant height, number of leaves, stem diameter, number of branches and leaf area at 4 MAT, at 15 MAT, at 3, 13, 14, 15 MAT, at 3, 15 MAT and at 13, 14, 15 MAT respectively by 1%, 10%, 61%, 2%, 3%, 8%, 46%, 11%, 5%, 3% and 13%, respectively; while CT150P treatment significantly enhanced cacao seedlings, number of leaves, number of branches and leaf area at 4 MAT, 4 and 13 MAT, 3, 4, 5 MAT, respectively, when compared with the other treatments. This finding could be due to the fact that the cacao seedlings which could have been suppressed by plantain shade were not directly positioned under the plantain suckers but in between which is 150 cm apart. This discovery is in agreement with the reports of [26] that, due to the competition that exists among them, closely spaced cacao seedlings produced smaller morphological parameters than well-spaced ones. Shipat [27] as well as Famuagun and Agele [16] also established that the leaves and circumference of plants are among the main factors that determine the vigour needed for the growth of cacao seedlings after transplanting.

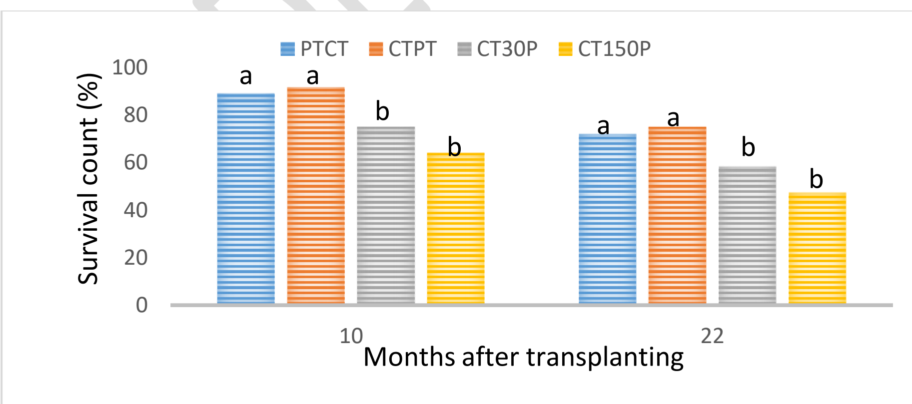

Figure 1: Effect of transplanting positions on survival count (%) of cocoa seedlings

Means followed by the same letters in each composite bars are not significantly different by DMRT (P<0.05)
PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30P: Cacao transplanted 30 cm apart from plantain; CT150P; Cacao transplanted 150 cm apart from plantain

Table 1: Effect of transplanting positions on plant height (cm) of cocoa seedlings

Treatments	3 MAT	4 MAT	5 MAT	12 MAT	13 MAT	14 MAT	15 MAT
PTCT	74.33b	98.33c	124.00c	175.67a	179.67a	182.67a	187.00a
CTPT	94.33ab	147.00a	157.67ab	159.33a	173.00a	178.67a	195.33a
CT30P	92.00ab	134.00b	146.33b	162.33a	169.67a	182.00a	191.33a
CT150P	112.67a	145.67a	164.67a	177.00a	179.67a	186.67a	200.67a
Mean	93.33	131.25	148.17	168.58	175.50	182.50	193.58

Means followed by the same letters along each column are not significantly different by DMRT (P<0.05)
PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30P: Cacao transplanted 30 cm apart from plantain; CT150P: Cacao transplanted 150 cm apart from plantain

Table 2: Effect of transplanting positions on number of leaves of cocoa seedlings

Treatments	3 MAT	4 MAT	5 MAT	12 MAT	13 MAT	14 MAT	15 MAT
PTCT	23.00a	45.67b	64.33ab	92.33a	111.00a	114.33a	132.33a
CTPT	9.00c	48.00b	83.33a	91.33a	110.67a	112.67a	137.67a
CT30P	13.33b	31.00c	55.67b	90.00a	109.00a	109.00a	121.33a
CT150P	11.33bc	87.33a	87.33a	92.33a	127.00a	116.00a	123.67a
Mean	14.17	53.00	72.67	92.00	114.42	113.00	128.75

Means followed by the same letters along each column are not significantly different by DMRT (P<0.05)
PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30P: Cacao transplanted 30 cm apart from plantain; CT150P: Cacao transplanted 150 cm apart from plantain

Table 3: Effect of transplanting positions on stem diameter (cm) of cocoa seedlings

Treatments	3 MAT	4 MAT	5 MAT	12 MAT	13 MAT	14 MAT	15 MAT
PTCT	0.63a	1.57ab	1.83b	3.27a	3.33a	3.70a	3.67b
CTPT	0.43ab	1.60ab	2.23ab	3.03a	3.73a	3.83a	4.07a
CT30P	0.73a	1.20b	2.30ab	3.20a	3.47a	3.43a	3.77ab
CT150P	0.17b	1.83a	2.67a	3.37a	3.67a	3.73a	3.73b
Mean	0.49	1.55	2.26	3.22	3.55	3.81	3.68

Means followed by the same letters along each column are not significantly different by DMRT (P<0.05)
PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30P: Cacao transplanted 30 cm apart from plantain; CT150P: Cacao transplanted 150 cm apart from plantain

Table 4: Effect of transplanting positions on number of branches of cocoa seedlings

Treatments	3 MAT	4 MAT	5 MAT	12 MAT	13 MAT	14 MAT	15 MAT
PTCT	0.47a	2.00b	5.67ab	3.50b	4.17b	5.67ab	5.33a
CTPT	0.37a	3.33b	5.00bc	3.60ab	4.20b	5.00bc	6.00a
CT30P	0.57a	1.33b	4.00c	4.37a	4.17b	4.00c	4.33b
CT150P	0.20b	6.67a	6.67a	4.00ab	6.67a	6.67a	5.33a
Mean	0.40	3.33	5.33	3.89	4.80	5.33	5.25

Means followed by the same letters along each column are not significantly different by DMRT (P<0.05)
PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30P: Cacao transplanted 30 cm apart from plantain; CT150P: Cacao transplanted 150 cm apart from plantain

Table 5: Effect of transplanting positions on leaf area (cm^2) of cocoa seedlings

Treatments	3 MAT	4 MAT	5 MAT	12 MAT	13 MAT	14 MAT	15 MAT
PTCT	70.33bc	84.00b	95.33b	308.33a	306.33a	308.67a	327.00b
CTPT	76.33c	74.33c	86.67b	164.67b	292.33a	302.67a	362.67a
CT30P	77.33b	82.00b	93.00b	153.33b	165.00b	206.33b	232.00a
CT150P	101.33a	110.33a	119.67a	241.33a	279.00a	292.67a	316.67b
Mean	79.08	87.67	98.67	215.12	260.27	277.58	309.58

Means followed by the same letters along each column are not significantly different by DMRT ($P<0.05$)
PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30P: Cacao transplanted 30 cm apart from plantain; CT150P: Cacao transplanted 150 cm apart from plantain

CONCLUSION AND RECOMMENDATION

Much of success of intercrops in cacao establishment depends on understanding the role each component plays in the system, cacao/plantain farming system has been recommended, but the transplanting arrangement in the face of global warming and climate change is a gap in research which this work has filled. Furthermore, the long dry season and the wind – storms early March to April in the study area usually devastate the plantains so that effective shade is not actually provided for the cacao in the later part of the dry season when the shade is needed most. According to this work, Cacao transplanting on top of plantain (CTPT) enhanced the best performance of cacao seedlings when compared to other treatments because cacao seedlings would have benefited from the soil moisture available at the base of plantain for survival and morphological growth.

REFERENCES

[1] Alverson W. S., Whitelock, B. A., Nyffeler R., Bayer C., Baum D. A. Phylogeny of the core Malvales: Evidence from sequence data. *American Journal of Botany, 1999;* 86:1474-1486.

[2] Lachenaud P., Mooleedhar V., Couturier C. Les cacaoyers spontanes de Guyane. Nouvelles prospections. *Plant, Rech. Develop, 1997; 4: 25-30.*

[3] Oluwalade I. A. Sustainable cocoa production and certification. In: A hand book on Cocoa Production Akure, Nigeria: Stebak Publisher. 2018. Pp 100-116

[4] ICCO. International Cocoa Organization Annual Report. 2007. Pp. 23-25.

[5] FAO. FAOSTAT Online Database. Rome, Italy: The food and Agriculture Organization of the United Nation; 2011. Available from : http://faostat.fao.org (Accessed: June 2011). P1.

[6] Yanelis, A., Hernandez-Rodriguez, A., Heydrich-Perez, M., EI Jaziri, M. & Hernandez-Lauzardo, A.N. Management of black pod rot in cacao (*Theobroma cacao* L). *Fruit, 2012; 67, 41-48.https//doi.org/10.1051/fruits/2011065.*

[7] Simo, C., Djocgoue, P. F., Minyaka, E. and Omokolo, N. D. Guaiacol Peroxidase heritability in tolerance of cocoa (*Theobroma cacao* L) to *Phytophthora magakarya*,agent of cocoa black pod disease. *International Journal of Agricultural Policy and Research, 2018; 6 (2), 7-20.*

[8] Minimol, J. S., Suma. B., Mahiya, U. and Chithira, P. G. Genetic Improvement of cocoa by developing superior hybrid. *Journal of Tropical Agriculture, 2015; 53 (2), 157-165.*

[9] Ngoh, J. P., Ambang, Z., Ndongo, B., Kuate Tueguem W.N., Heu, A and Ntsomboh Ntsefong, G. Development of Cocoa Black Pod Disease (Caused by *Phytophthora megakarya*) in Cameroon when treated with extracts of *Thevetia peruviana* of Ridomil. *International Journal of Current Research in Bioscience and Plant Biology, 2015; 2(3) 47-59.*

[10] La Anyane, S. Ghana Agriculture: Economic development from early time to the middle of the 20th Century. London. Oxford University Press. 1963. Pp 11,222.

[11] Benneh, G. Land tenure and agro forestry land use in Ghana. In: *Proceedings of International Workshop on Tenure Issues in Agro forestry. May 27-31, 1987 (ed.J.B. Raintree) Nairobi, Kenya. Pp 163-168*

[12] Opeke, L. K. Tropical Commodity Crops. Spectrum Books Ltd. PMB 5612, Ibadan, Nigeria. 2005. Pp.181, 247.

[13] Owusu-Bempah, K. (1988) The role of women in species selection for agroforestry farming systems in rural areas of Ghana. In: Gender issues in farming systems research and extension (ed. S.V. Poats, M. Schmink and. Spring). Colorado, USA: Westview Press.

[14] Babadele F. I. Effects of shade regimes and varying seasons of irrigation on survival, developmental pattern and yield of field grown cacao (*Theobroma cacao* L) *International Journal of Plant &Soil Science, 2018; 22 (3) :1-12. Article no. IJPSS.37339. ISSN:2320-7035.*

[15] ICCO, Monthly review of the Market August 2015, UK, 2015 August. Available: http://www.icco.org/ about us //international cocoa /agreement.//doc-download 1789-icco-monthly review-august-2015. P1.

[16] Famuagun I. B. and Agele, S. O. Cacao developmental pattern, soil temperature and moisture variation as affected by shade and dry season drip irrigation. *American Journal of Experimental Agriculture, 2016; 12 (3) :1-6. Article no: AJEA.22628. Available from: www.scie ncedomain.org.*

[17] Famuagun I. B. and Agele, S. O. Effects of sowing methods and plant population densities on root development of cacao (*Theobroma cacao* L) seedlings in the nursery. *International Journal of Agricultural Research., 2010; 6(11): 445-452.*

[18] Laderach. P., Matinez, A., Schroth, G. and Castro, N. Predicting the future climate suitability for cocoa farming of the world's leading producer countries, Ghana and Cote d'Ivoire. *Climate Change, 2013; 119, 841-854. https//doi.org/10.1007/s10584-013-0774-8.*

[19] Schroch, G., Laderach, P., Martinez-Valle, A. L., Bunn, C. and Jassogne, L. Vulnerability to climate change of cocoa in West Africa: Patterns, Opportunities and limits to adaptation. *Science of the total Environment, 2016; 556, 231-241. https//doi/org/10 .1016/j.scittenv.2016.03.024.*

[20] Agbongiarhuoyi, A. E., Ayegboyin, K. O., Ogunlade, M. O. and Orisajo, S. B. Farmers' Banana instead of plantain as shade crop in cacao establishment: A case study of Cross Rivers State, Nigeria. *World Rural Observation*, 2016; *8(1): 14-22.*

[21] Omotosho, J. B., Balogun, A. A. and Ogunjobi, K. O. Predicting monthly and seasonal rainfall, onset and cessation of the rainy season in West Africa using only surface data. *International Journal of climatology, 2000; 20:865-880*

[22] Daymond, A. J. and Hadley, P. The effects of temperature and light integral on early vegetative growth and chlorophyll fluorescence of four contrasting genotypes of cacao (*Theobroma cacao* L). *Annals of Applied Biology, 2004; 145: 257-262.*

[23] Famuagun, I B and Agele, S O. Cacao growth and development under different nursery and field conditions. *DOI: http://dx.doi.org/10/55772./intechopen, 2019; 82680*

[24] Manu, M. and Tetteh, J. K. A guide to cocoa cultivating. 1988. P. 11.

[25] Ayegboyin, K.O, Famaye, A.O, Adeosun, S.A, Idrisu,M. Osasogie,A.P and Okunade, F.A. Effect of high density on the viguor and yield of Theobroma cacao L in southwest of Nigeria. *World journal of advanced research and review, 2020; 08(01), 217-223 e-ISSN: 2581-9615, Cross Ref DOI: 10.3057/wjarr. Journal homepage: https://www:wjarr.com.*

[26] Famaye, A.O. Evaluation of physiological changes in coffee seedlings intercropped with maize, cassava and plantain in Nigeria. *Moor Journal of Agricultural Research, 2003*; *Vol. 4 No. 2 pp221-224*

[27] Shipat, C. Yield and disease incidence on Trinidad Selected hybrid (TSH) seedlings. A preliminary report. *Proceedings of 13th International Cocoa Research Conference, Cocoa Producers Alliance, London. United Kingdom Kota Kinabalu, Sabah, Malaysia. October 9-14, 2001: 247-253.*