Volume 13 Number 1, June 2007

Journal of ISSAAS

The International Society for Southeast Asian Agricultural Sciences

CONTENTS

J. ISSAAS Vol. 13, No 1. pp.1-9 (2007)

SALT TOLERANCE IN *ANDROGRAPHIS PANICULATA* ACCESSIONS

I. Rajpar[1], Y. M. Khanif[1] and M. S. Saad[2]

[1]Department of Land Management, [2]Department of Crop Sciences,
Faculty of Agriculture, Universiti Putra Malaysia,
43400 UPM, Serdang, Selangor, Malaysia

(Received: January 5, 2006; Accepted: May 11, 2007)

ABSTRACT

Andrographis paniculata, commonly known as Kalmegh is an important source of phytochemicals (andrographolide and neo-andrographolide) that have hepatoprotection, hypoglycemic, anti-bacterial, analgesic, anti-inflammatory, vermicidal, anti-acene, anti-typhoid and anti-malarial effects. In addition, *A. paniculata* can grow well on wide range of soils even on lands with low fertility status. The growth and herbage yield depend on the environmental and genetic consistency, and the information on the salt-tolerance of *A. paniculata* accessions may be of great importance. These plants may or may not tolerate salts stress or there may be inter-accessions variability for salt-tolerance. Seven accessions (Acc. 11225, Acc. 11228, Acc. 11234, Acc. 11316, Acc. 11345, Acc. 11348 and Acc. 11349) of *A. paniculata* were evaluated for salt-tolerance. Seedlings were grown for 4 weeks in artificially salinized soil with 4, 8 and 12 conductivity (EC_e dS m^{-1}) levels in polyethylene bags. The results of the study revealed that increasing soil EC_e decreased significantly plant height, number of fully expanded leaves on the main-stem and herbage yield. At soil EC_e of 4, 8 and 12 dSm^{-1}, the dry herbage yield was decreased by 35, 63 and 91%, respectively. The adverse effect of salinity was greater at 8 and 12 EC_e (dSm^{-1}) level. With the exception of Acc. 11345, all accessions could not survive at the highest EC_e level (12 dSm^{-1}). The Acc. 11228 appeared to be the most sensitive to all EC_e levels than the other accessions tested. Despite having lower response at EC_e 4 dSm^{-1}, the Acc. 11345 showed some tolerance to salinity followed by Acc. 11225. The seedlings grown at EC_e 4 and 8 (dSm^{-1}) had higher Na^+ and lower K^+ content and showed lower K^+/Na^+ ratio in tissues. The sensitive accessions like Acc. 11228 with smaller height and low herbage yield had higher Na^+ and lower K^+ in tissues. The sodium/potassium ratio was generally higher in those accessions (Acc. 11345 and Acc. 11225) which exhibited some tolerance to salinity.

Key words: Salinity, medicinal herb, growth, yield

INTRODUCTION

Land salinization is a major cause of desert formation (Qureshi and Barret-Lennard, 1998) in several countries of the world. About one-third of the world's irrigated land is subjected to degradation and loss of production (Rowell, 1994). Soil degradation due to salinity results in the loss of biodiversity with the reduction in vegetation cover. This negative development reduces the capacity of both natural and agro ecosystems to assimilate CO_2 from the atmosphere by their photosynthesis activities and thus contributes to global warming; an increase of 3 ^{0}C temperature by 2030 has been predicted by this process (NIAB, 2003).

The existence of salt-tolerant plants (halophytes) and differences in salt-tolerance between genotypes within salt-sensitive plant species (glycophytes) indicates that there is a genetic basis to salt response (Blumwald, 1987). Scientists have identified and introduced several plant species/cultivars, which remain productive at high salinities. World bibliographies list more than 1500 species with

high levels of salt tolerance (Mudie, 1974; Aronson, 1989). However, the field of saline agriculture is in its infancy; most species with potential have not yet been tested (Qureshi and Barret-Lennard, 1998). It is common challenge today for researchers to evaluate cereal and non-cereal conventional crops for salt-tolerance. The report of Dagar and Tomar (2002) indicates that there are many aromatic and medicinal valued plant species (*Plantago ovata, Vertiveria zizanioides, Aloe barbadensis*) which have tremendous potential for cultivation with saline waters having EC_i up to 10 (dSm^{-1}). This suggests that understanding of the adaptation, propagation and management of medicinal and aromatic plants on salt-affected soils will be useful to allow increased productivity in saline conditions.

A. paniculata, used in this study is an excellent annual-branched, erect-running 0.5 to 1 meter height medicinal herb (Chadha, 1985). It is a member of the plant family Acanthaceae and is commonly known as "King of bitters" (Bhan et al., 2005). It has been used for centuries in Asia for the treatment of several diseases including, upper respiratory infections, (Tipakorn, 2002), fever, herpes, sore throat (Handa and Sharma, 1990; Saxena et al., 2000), human cancer (Kumar *et al*., 2004) and HIV (Otake et al., 1995). The therapeutic activities of this plant are attributed to andrographolide and related diterpens, i.e. deoxyandrographolide, 14-deoxy-11, 12-didehydroandrographolide and neo-andrographolide (Bhan et al., 2005). It is also evident from various research reports that andrographolide protects the liver and gallbladder (Saraswat et al., 1995) and neo-andrographolide is effective against malaria (Misra et al., 1992).

There are several reports showing that this plant can grow on a variety of soils, including heavy to medium textured soils and on soils with low fertility status. However, the growth of plant, quality and quantity of industrial phytochemicals may depend on the environment where it grows and on the genetic variability among the accessions (Bhan et al., 2005). The aim of this experiment was to evaluate plant growth, herbage yield and Na^+ and K^+ contents of different *A. paniculata* accessions in salt-affected soils at early growth stage.

MATERIALS AND METHODS

The present investigation was carried out on heavy textured clay soil of the Munchong series (Tropeptic Haplorthox) with 73% clay, 10.23% silt and 16.23% sand. The soil had 3.7% organic carbon, 0.29% total N, 0.8 dSm^{-1} EC_e and 5.6 pH. The soil collected from the field was air-dried and sieved through ¼ inches garden sieve. To create 4, 8 and 12 dSm^{-1} EC_e level, NaCl at 48, 96 and 144 $mmol_c$ $saltl^{-1}$ was calculated respectively and thoroughly mixed with air-dried soil following the method described by Rowell (1994). Addition of salt resulted in EC_e of 4.2, 8.96 and 11.0 dSm^{-1}. A liming material dolomite was applied to soil at 2 tons ha^{-1} one week before transplantation. The experiment was conducted in a glass-house at the Department of Land Management, University Putra Malaysia, during the period of October to November 2005. In the present study, seven germplasm accessions (Acc. 11225, Acc. 11228, Acc. 11234, Acc. 11316, Acc. 11345, Acc. 11348 and Acc. 11349) of *Andrographis paniculata* were used. These accessions were provided from the germplasm conserved by the Faculty of Agriculture (UPM). The plants were established by transplanting of 30 day old seedlings with good root system into polyethylene bags of 1.5kg capacity with drainage holes. There were three replicate bags of each of 4 soil treatments per accession. To prevent loss of drainage water containing soluble salts, each bag was placed on plastic saucer (Rowell, 1994). A NPK (20:20:20) fertilizer was used to apply nitrogen, phosphorus and potassium at 40kgN, 40kg P_2O_5 and 40kg K_2O ha^{-1} before transplanting. The plants were irrigated with tap water whenever needed.

At 30 days after transplanting (DAT) all plants from each treatment were harvested by cutting at soil level. The harvested plants were used to record height (cm), number of fully expanded leaves on the main-stem. Dry herbage yield was determined after oven drying fresh plants at 63 ^{0}C for 48 hr. The dry matter of seedlings from 3 soil treatments viz., control, EC_e 4 and EC_e 8 (dSm^{-1})

was used for Na^+ and K^+ analysis following the dry-ash method. The concentrations of Na^+ and K^+ were determined by atomic absorption spectrophotometer. The soil at sowing was analysed for particle size distribution by international pipette method, EC_e and pH by digital meters and organic carbon by Walkley-Black method.

RESULTS AND DISCUSSION

Effect of salinity on seedling survival

All of these accessions had high percentages of survivors at 4 and 8 EC_e level. However, at 12 EC_e (dSm^{-1}) level, the survival was observed only in Acc. 11345 plants (data not shown). This indicates some tolerance in Acc. 11345 for high soil salinity. Salt-tolerance is a complex trait involving the function of many genes (Yamaguchi and Blumwald, 2005). Hence, the difference in accessions for salt-tolerance could be largely genetic inconsistency and accumulation of organic acids. It is also evident from the reports of several research workers (Hajar et al., 1996; Zidan and Elewa, 1995; Ashraf and Orooj, 2006; Bohnert and Jensen, 1996; Chen and Murata, 2000; Chenusamy et al., 2005) that many plants including traditional medicinal herbs accumulate organic (proline, betaine, polyoles, sugar alcohols and soluble sugars) osmolytes (osmoprotectants) to tolerate osmotic stress.

Effect of salinity on growth and dry herbage yield

Increasing soil salinity significantly ($P < 0.005$) decreased seedling height (Fig. 1); number of main-stem leaves (Fig. 2) and dry herbage yield (Fig. 3). Compared to the control, seedlings grown at 4 EC_e level were 25% shorter in height, developed 28% fewer leaves on their main-stem and had 35% lower dry herbage yield. Similarly the seedlings grown at 8 EC_e (dSm^{-1}) level were 47% shorter in height, developed 57% fewer leaves and produced 63% lower dry herbage yield. The effect of high EC_e (12 dSm^{-1}) level for almost all agronomical variables recorded remained greater than 90%. The adverse effect of soil salinity on plants was possibly due to the physiological drought and ionic toxicity caused by addition of NaCl to soil. Although Na^+ is required in some plants, particularly halophytes, a high concentration of NaCl is toxic and affects plant growth (Glenn et al., 1999).

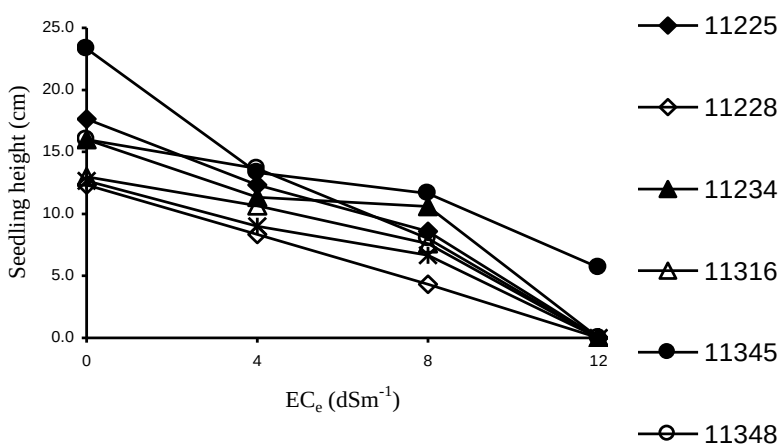


Fig. 1. Effect of soil salinity on the height of *A. paniculata* seedlings at 30 DAT.

	S. E. D.	L. S.D.
Salinity	0.545	1.095***
Accessions	0.721	1.449***
Salinity*Accessions	1.440	2.890***

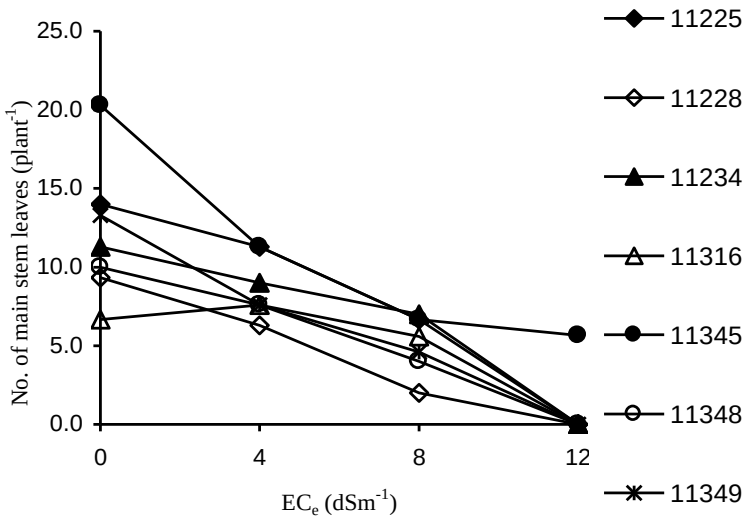


Fig. 2. Effect of soil salinity on the number of main stem leaves per plant at 30 DAT.

	S. E. D.	L. S. D.
Salinity	0.3417	0.6860***
Accessions	0.2040	0.4107***
Salinity*Accessions	0.9038	1.8167***

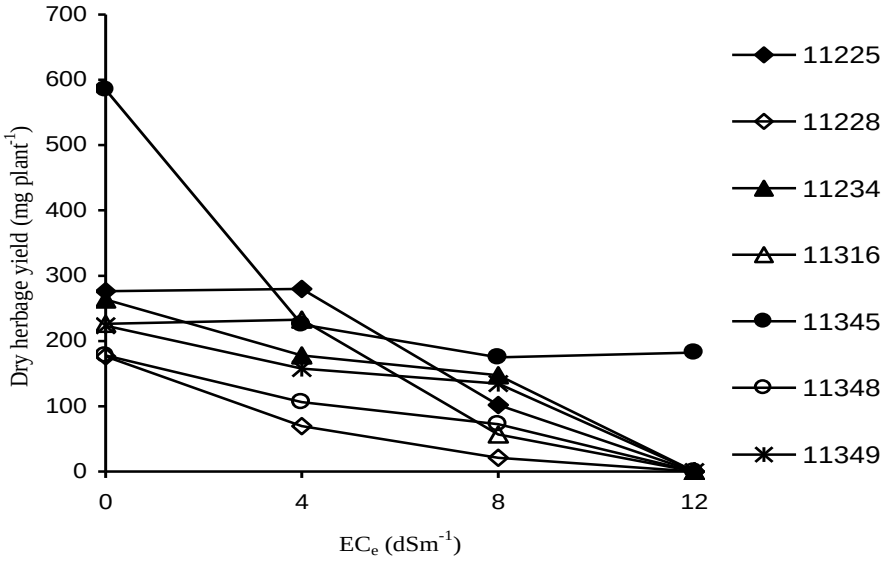


Fig. 3. Effect of soil salinity on dry herbage yield, of *A. paniculata* accessions at 30 DAT.

	S. E. D.	L. S.D.
Salinity	27.104	54.4800***
Accessions	35.856	72.0700***
Salinity*Accessions	71.712	N. S.

On average over salinity levels, the difference between accessions for height, number of main-stem leaves and herbage yield was also significant ($P < 0.005$). The accession with the tallest plants and highest herbage yield was Acc. 11345. The Acc. 11228 appeared to be the poor test accessions with shortest plants, fewer leaves and lowest herbage yield. The effect of interaction of salinity*accessions for height and number of leaves was significant ($P < 0.005$). The Acc. 11345 and Acc. 11225 showed slightly better tolerance to salinity, these had taller plants, more leaves and higher herbage yield.

The adverse effect of salinity on plants was related (Table 1) to the higher concentration of Na^+ (Fig. 4) and lower concentration of K^+ (Fig. 5).

Table 1. Linear correlation co-efficient between Na^+, K^+ and K^+/Na^+ ratio determined in plant tissues and plant height, no. of main-stem leaves and dry herbage yield.

Ion	**Observation**		
	Plant height (cm)	**No. of main-stem leaves ($plant^{-1}$)**	**Dry herbage yield ($mg\ plant^{-1}$)**
Na^+	-0.514***	-0.548***	-0.445***
K^+	0.500***	0.539***	0.328***
K^+/Na^+	0.328**	0.426***	0.204

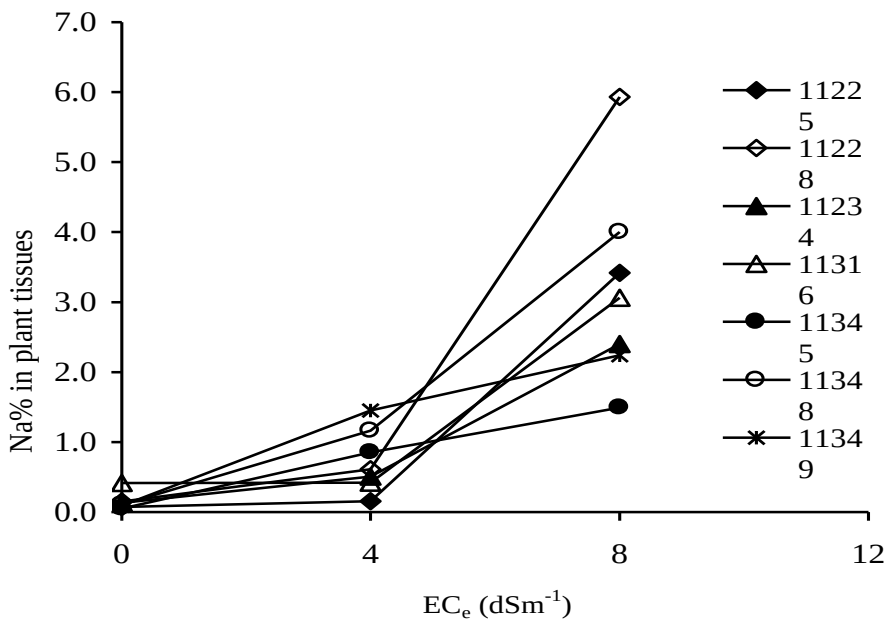


Fig. 4. Effect of soil salinity on Na% in plant tissues.

	S. E. D.	L. S.D.
Salinity	0.1139	0.2291***
Accessions	0.1732	0.3500***
Salinity*Accessions	0.3000	0.6063***

The seedlings of *A. paniculata* grown under saline conditions had higher concentration of Na^+ (Fig. 4), lower concentration of K^+ (Fig. 5) and lower K^+/Na^+ ratio (Table 2) in plant tissues. In terms of Na^+ and K^+ contents, the Acc. 11345 had lower concentration of Na^+, higher concentration of K^+ and maintained high K^+/Na^+ ratio than poor accessions in saline soil treatments.

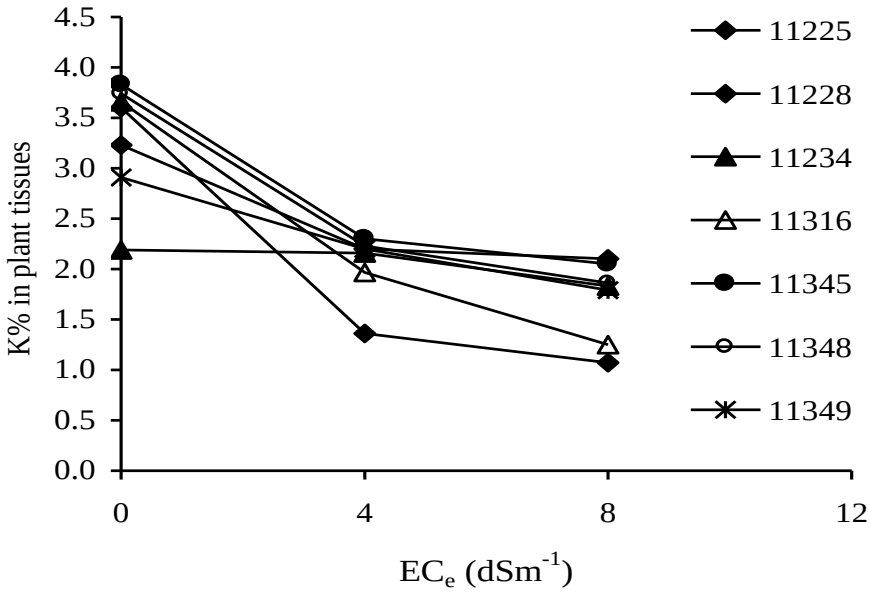


Fig. 5. Effect of soil salinity on K% in plant tissues

	S. E. D.	L. S.D.
Salinity	0.1299	0.2630***
Accessions	0.1985	0.4013**
Salinity*Accessions	0.3438	0.6950**

Table 2. Effect of soil salinity on K^+/Na^+ ratio in plant tissue

Accessions	**Treatment (EC_e dSm^{-1})**				
	Control	**4.0**	**8.0**	**12**	**Mean**
Acc. 11225	43.87	27.72	0.66	No survival	24.082
Acc. 11228	26.95	3.16	0.18	------	10.098
Acc. 11234	26.60	4.35	0.76	------	10.564
Acc. 11316	10.22	7.70	0.42	------	6.114
Acc. 11345	88.69	2.76	1.51	------	30.989
Acc. 11348	35.76	2.40	0.47	------	12.875
Acc. 11349	33.23	1.50	0.79	------	11.849
Mean	37.902	7.087	0.685	------	
	Salinity	Acc.	Sal*Acc.		
S. E. D.	3.464	5.29	9.15		
L. S. D.	7.009***	10.69***	18.52***		

This indicates that under saline conditions, the sensitivity of some accessions to salt stress was due to accumulation of low K^+ and high Na^+ concentration in tissues. The alteration of ion ratios in plants was possibly due to the influx of Na^+ through pathways that function in the acquisition K^+ (Blumwald, 1987). Maintenance of a high cytosolic K^+/Na^+ concentration ratio is a key requirement for plant growth in soils with a high concentration of salt (Glenn et al., 1999).

CONCLUSION

Addition of NaCl to soil increased electrical conductivity (salinity). Increasing soil salinity decreased plant height, number of main-stem leaves and herbage yield of *A. paniculata*. The adverse effect of salinity on *A. paniculata* was associated with higher Na^+, lower K^+ and lower K^+/Na^+ ratio in the plant tissues. Accessions No. 11345 and .11225 showed some tolerance to salinity while Accession No. 11228 proved to be the most sensitive of the accessions tested.

ACKNOWLEDGEMENT

The authors would like to thank the Islamic Development Bank (IDB), which funded the post-doctoral tenure awarded to the main author of the article. Thanks are also due to the Department of Land Management, Faculty of Agriculture, University Putra Malaysia for providing computer, glass-house and analytical facilities to conduct this research. The authors are also highly thankful to Ms. U. K. Asmaon and Mr. Ab. Aziz Abdullah (lab. assist.), Mr. Alias Tahar (field assist.), Mr. A. Rahim Utar (A.S.O) and S.H. Chia (post-graduate) for the technical support.

REFERENCES

Aronson, J. A. 1989. HALOPH: Salt-tolerant plants of the world. Office of Arid Lands Studies. The University of Arizona, Tucson, Arizona, A database. pp. 77.

Ashraf, M., Orooj, A., 2006. Salt stress effects on growth, ion accumulation and seed oil concentration in an arid zone traditional medicinal plant ajwain (*Trachyspermum ammi* [L.] Sprague). Journal of Arid Environment 64 (2): 209-220.

Bhan, M. K., A. K. Dhar, S. Khan, S. K. Latto, K. K. Gupta and D. K. Choudhary. 2005. Screening and optimization of Andrographis apniculata (Burm.f.) Nees for total andrographolide content, yield and its components. Scientia Horticulturae, 107 (4):386-39.

Blumwald, E. 1987. Tonoplast vesicles for the study of ion transport in plant vacuoles. Plant. Physiol.. 69: 731-734.

Bohnert, H. J., and R.G. Jensen, 1996. Strategies for engineering water stress tolerance in plants. Trends in Biotechnology. 14:89-97.

Chadha, Y. R. 1985. The Wealth of India. Council of Scientific and Industrial Research, New Delhi, India. Report. Vol. 1 A. 265 p.

Chen, T. H. H., and N. Murata, 2000. Enhancement of tolerance of abiotic stress by metabolic engineering of betaines and other compatible solutes. Current Opinion in Plant Biology, 5: 250-257.

Chinnusamy, V., Jagendorf, A., and Zhu, Jian-Kang. 2005. Understanding and improving salt-tolerance in plants. Crop Science, 45: 437-448.

Dagar, J.C and O.S. Tomar. 2002. Utilization of salt-affected soils and poor quality waters for sustainable bio-saline agriculture in arid and semi-arid regions of India. pp. 340-350. In Proc. 12th ISCO Conference, Beijing, China,

Glenn, E. P., J. J. Brown and E. J. Blumwald. 1999. Salt-tolerance and crop potential of halophytes, Crit. Rev. Plant. Sci. 18: 227-255.

Hajar, A.S., M.A. Zidan and H.S. Al-Zahrani. 1996. Effect of salinity stress on the germination, growth and some physiological activities of black cumin (*Nigella sativa* L.), Arab Gulf Journal of Scientific Research 14: 445–454.

Handa, S. S. and A. Sharma. 1990. Hepatoprotective activity of andrographolide from *Andrographis paniculata* against carbontetrachloride, Indian. J. Med. Res. 92 (B): 276-283.

Kumar, R. A., K. Sridevi, N.V. Kumar, S. Nanduri and S. Rajagopal. 2004. Anticancer and immunostimulatory compounds from *Andrographis paniculata*. J. Ethanopharmacol, 29 (2-3): 291-295.

Misra, P., N.L. Paul, P.Y. Guru, J.C. Katiyar, V. Srivastava and J. S. Tandon. 1992. Anti-malarial activity of *Andrographis paniculata* (Kalmegh) against plasmodium berghei NK 65 in Mastomys natatensis. Int. J. Pharmacogenomics, 30: 263-274.

Mudie, P. J. 1974. The potential economic uses of halophytes. pp 565-597. In Remold, R. J and Queen, W. H (ed.). Ecology of halophytes. Acad. Press, New York,

NIAB. 2003. Salinity problem and what to do about. In Salinity and Environment. Saline Agriculture Farmer Participatory Development Project in Pakistan. Quart. 1 (1): 2-3.

Otake, T., H. Mori, L.T. Morimoto, M. Hattori and T. Namba. 1995. Screening of Indonesian plant extracts for anti-human immunodeficiency virus-type 1 (HIV-1) activity, Phytother. Res. 9: 6-10.

Qureshi, R. H. and E. D. Barret-Lennard. 1998. Saline agriculture for Irrigated Land in Pakistan. A Handbook. ACIAR, Canberra, Australia.

Rowell, D.L. 1994. The preparation of saturation extracts and the analysis of soil salinity and sodicity. pp 287. In Rowell, D. L. (ed.). Soil Science Methods and applications. Longman Group, UK.

Saraswat, B., P. Visen, G.K. Patanik and B.N. Dhawan. 1995. Effect of Andrographolide against galaetosamine-induced hepatotoxicity. Fitoterapia. 66:415-420.

Saxena, S., D.C. Jain, M.M. Gupta, R.S. Bhakuni, H.O. Mishra and R.P. Sharma 2000. HPLC analysis of hepatoprotective dilerpenoids from *Andrographis paniculata*. Phytochem Anal. 11: 34-36.

Tipakorn, N. 2002. Effects of *Andrographis paniculata* (Burm. F.) Nees on performance, mortality and coccidiosis in broiler chickens. PhD. Thesis Inst. of Animal Physiology and Animal Nutrition. George-August-Universitat, Gottingen.

Yamaguchi, T. and E. Blumwald. 2005. Developing salt-tolerant crop plants: Challenges and opportunities. Trends in Plant Sci. 10 (12): 615-620.

Zidan, M.A. and M.A. Elewa. 1995. Effect of salinity on germination, seeding growth and some metabolic changes in four plant species (Umbelliferae), Indian Journal of Plant Physiology 38**:** pp. 57–61.

J. ISSAAS Vol. 13, No 1. pp.10-17 (2007)

TRANSMISSION OF PEPPER YELLOW LEAF CURL VIRUS BY THE INSECT VECTOR *Bemisia tabaci* Genn. (HEMIPTERA : ALEYRODIDAE)

Sri Sulandari[1], Sri Hendrastuti Hidayat[2], Rusmilah Suseno[2], Jumanto Harjosudarmo[3] and Soemartono Sosromarsono[2]

[1)] Department of Plant Pests and Diseases, Gadjah Mada University, Bulaksumur, Yogyakarta 55281, Indonesia
[2)] Department of Plant Protection, Bogor Agricultural University, Jalan Kamper – Darmaga Campus, Bogor 16680, Indonesia
[3)] Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development, Jalan Tentara Pelajar 3A, Bogor 16111, Indonesia

(Received: June 16, 2006; Accepted: November 16, 2006)

ABSTRACT

The yellow leaf curl disease caused by a geminivirus is a serious problem to the pepper plantations in Indonesia. The epidemic of the disease which started in 2000 is assumed to have a relationship with the vector activities, that is, tobacco whitefly (*Bemisia tabaci* Genn.). Basic studies was carried out to elucidate the characteristics of pepper yellow leaf curl virus (PYLCV) transmission by its vector, *B. tabaci*. It was found that a single whitefly was able to transmit the virus to chili pepper. The insect vector could transmit the virus in a persistent manner, but it is not transovarially transmitted. Acquisition and inoculation feeding period of the whitefly to transmit the virus was identified to be optimum in the range of 3 to 6 hours. The virus needs at least 9 hours in the vector to complete latent period, while the retention period is until the insect dies. The transmission efficiency will increase with longer acquisition and inoculation feeding period of the insect and a higher number of insects per plant. The female tobacco whitefly is more effective in transmitting the virus compared to the males.

Key words: geminivirus, whitefly

INTRODUCTION

The geminivirus is a group of plant viruses with distinct morphological characters. Its twinned isometric particles consist of circular single-stranded (ss) DNA genomes (Bock,1982). Geminiviruses are subdivided into three genera on the basis of host range, insect vector, and genome organization. The genus Begomovirus (sub group III) consists of viruses that are transmitted by whiteflies to dicotyledonous plants with a monopartite or bipartite arrangement (Harrison, 1985). The first geminivirus which originated from Indonesia was reported by Thung in 1932 (Trisusilowati et al., 1990) and caused leaf curling in tobacco plants. In 1984, tobacco leaf curl virus (TLCV) caused serious damage in Bojonegoro, East Java, with up to 30% disease incidence (Poerbokoesoemo 1984 cited in Trisusilowati et al., 1990). A virus infection causing yellow mosaic, upward leaf curling, and stunting has been observed infecting chili pepper throughout the production area of Bogor, West Java since 1998 and in Central Java and Jogyakarta since 2000. Geminivirus association with this disease was confirmed using polymerase chain reaction method, and the virus is named Pepper yellow leaf curl virus (PYLCV) (Sulandari et al., 2006).

An earlier study conducted by Rusli et al. (1999) and Sulandari et al. (2006) showed that PYLCV was not seed- neither mechanically- transmitted although the virus was easily transmitted through grafting and through direct feeding by the whitefly. *Bemisia tabaci* Genn. (Hemiptera: Aleyrodidae). *Bemisia tabaci* (Genn.) is known as one of the most economically important pests in many tropical and subtropical regions (Bock, 1982). The pest can cause extensive damage on more than 500 species of crops (Greathead, 1986) through direct feeding and through its ability to transmit viruses, including geminiviruses. Based on our observation on the incidence of PYLCV during the last 5 years, we can conclude that the severity and incidence of the disease is highly correlated with the high population of whitefly in the field.

In response to the increasing incidence of PYLCV in important pepper-producing regions of Indonesia, and because of the close association that exist between this disease and the presence of the whitefly in affected chili pepper growing areas, the investigation needs to be undertaken to study the relationship between the insect vector and the virus. In this paper we reported characteristic relationship between PYLCV and its insect vector *B. tabaci*.

MATERIALS AND METHODS

Maintenance of Virus Source, *B. tabaci*, and Plants. Leaves showing PYLCV symptom were collected from chili pepper field at Segunung, West Java. The virus was maintained on tomato plants (*Lycopersicon esculentum*) by insect transmission. Tomato plants were grown in a whitefly-proof screenhouse. Adult *B. tabaci* were obtained from broccoli plants in Bogor, West Java and identified using the identification key of Martin (1987). The insects were reared on broccoli (*Brassica oleareceae* var. *Italica*) plants in whitefly-proof cages.

Virus-Vector Relationship. PYLCV transmission experiments with *B. tabaci* were conducted using cylindrical cages with mesh tops which were inverted over individual leaves . Adult *B. tabaci* were introduced into the cage through a hole which then was sealed. The insects were given access to PYLCV-infected tomato plants in separate whitefly–proof cages. After the acquisition access period the whiteflies were re-collected individually using an aspirator and transferred to separately caged healthy tomato plants (2 weeks after sowing) for the inoculation access periods. After inoculation access period, the whiteflies were removed, and the plants were sprayed with insecticides and held for symptom development in an insect-proof screen house.

The minimum acquisition-access period required for transmission of PYLCV was determined by allowing *B. tabaci* adults access to PYLCV-infected tomato plants for `0.5, 1, 3, 6, 12 and 24 h before transferring them to healthy tomato plants for a 24- h inoculation access period. Ten *B. tabaci* adults per plant were used for each acquisition access period. Five plants were used for each acquisition access period and percentage of virus infection was calculated from plants showing PYLCV symptoms after 10-25 days.

To determine the minimum inoculation access period, *B. tabaci* adults were given a 48- h acquisition access period on PYLCV-infected tomato plants and inoculation access periods of 0.5, 1, 3, 6, 12, and 24 h on healthy tomato plants. Ten *B. tabaci* adults per plant were used for each acquisition access period. Five plants were used for each acquisition-access period and percentage of virus infection was calculated from plants showing PYLCV symptoms after 10-25 days.

The effect of vector number on the relative efficiency of virus transmission was determined by allowing 1, 3, 5, 10, 15, and 20 *B. tabaci* adults a 24-h inoculation access period on healthy tomato plants after a 48-h acquisition access period on PYLCV-infected tomato plants. Five plants were used for each treatment unit.

Serial transmission was conducted to determine persistence of the virus on its insect vector. One *B. tabaci* adults was given a 48-h acquisition access period on PYLCV-infected tomato plants and viruliferous insects were transferred serially every 24 h to healthy tomato plants. Serial transmission was conducted until the insects die.

The ability of the virus to be transovarially transmitted was determined by placing whiteflies in infected-tomato plants for 48 h in insect-proof screen cages. Female whiteflies were then removed and allowed to lay eggs on healthy broccoli plants, which are not a host of PYLCV, for seven days before removing them off the cages. The eggs were maintained until they hatched, then the adults were allowed to feed on healthy chili pepper plants for 24 h. Virus infection was calculated from plants showing PYLCV symptoms after 10-25 d.

Transmission efficiency of females and males of tobacco whitefly was tested following transmission procedure explained above. The females and males were first separated based on their body size, where the females usually are larger than the males. Each group was then subjected to a 48-h acquisition feeding period and a 24-h inoculation feeding period with 10 insects per plant. Ten plants were used for each group and percentage of virus infection was calculated from plants showing PYLCV symptoms after 10-25 d.

RESULTS

Acquisition Feeding Period

After a 30- min acquisition access period, ten *B. tabaci* adults were able to cause 40% transmission of PYLCV (Table 1). The transmission rate increased as the acquisition-access period was lengthened and reached a maximum at 3 to 24 -h acquisition access period. The PYLCV symptoms developed faster when the whitefly was given a longer acquisition feeding period.

Table 1. The effect of various acquisition feeding period of *B. tabaci* (ten adults per plant) on transmission and incubation period of pepper yellow leaf curl virus on tomato plants after a 24-h inoculation feeding period.

Acquisition feeding period (hour)	Number of infected plants (%)	Incubation period (days)
0.5	40	8 - 12
1	80	6 - 16
3	100	6 - 10
6	100	6 - 12
12	100	6 - 10
24	100	4 - 10

Inoculation Feeding Period

Thirty minutes inoculation access period following a 48-h acquisition-access period was sufficient to cause 80% transmission by ten *B. tabaci* adults. The number of infected tobacco decreased when the whitefly was given 1-h and 3 –h inoculation feeding period but the number increased as the inoculation-access period was lengthened (Table 2).

Latent period of the virus in *B. tabaci*

Transmission efficiency of acquisition feeding period treatment was cross listed with those of inoculation feeding period treatment to estimate latent period of the virus in the insect body. It was

observed that transmission occurred when the insect was given a combination of minimum 3-h acquisition feeding period and 6-h inoculation feeding period (Table 3).

Table 2. The effect of various inoculation feeding period of *B. tabaci* (ten adults per plant) on transmission and incubation period of pepper yellow leaf curl virus on tomato plants following a 48-h acquisition feeding period.

Inoculation feeding period (hour)	Number of infected plants (%)	Incubation period (days)
0.5	80	6 - 10
1	60	6 - 8
3	60	6 - 10
6	100	6 - 8
12	100	6 - 10
24	100	6 - 8

Table 3. Latent period of pepper yellow leaf curl virus in *B. Tabaci*

Inoculation feeding period (hour)	Number of infected plants (%) per acquisition feeding period (hour)					
	0.5	1	3	6	12	24
0.5	0	0	0	0	100	100
1	0	0	0	0	100	80
3	0	0	0	0	100	80
6	0	0	60	60	100	60
12	100	80	100	100	80	100
24	80	40	80	60	60	100

Transmission efficiency

Given a 48- h acquisition access period and a 24- h inoculation access period, a single *B. tabaci* adult was able to cause 40% transmission. The efficiency of transmission increased as the number of *B. tabaci* adults increased and reached maximum (100% transmission) when 10, 15, and 20 *B. tabaci* adults were used. The incubation period of PYLCV on infected tomato plants tended to be shorter as the number of *B. tabaci* adult increased (Table 4).

Table 4. The effect of number of *B. tabaci* on transmission and incubation period of pepper yellow leaf curl virus on tomato plants after a 48-h acquisition feeding period and a 24-h inoculation feeding period.

Number of insects	Number of infected plants (%)	Incubation period (days)
1	40	8 – 14
3	80	8 – 14
5	80	8 – 12
10	100	8 – 10
15	100	6 – 8
20	100	6 – 8

Transovarial Transmission and Persistence of PYLCV on *B. tabaci*

Adult progenies of viruliferous *B. tabaci* were unable to transmit PYLCV after they emerged from the eggs. None of the test plants developed symptoms up to 35 d after introduction of the whiteflies. This result proved that PYLCV could not be transmitted through eggs of whiteflies.

Serial transmission with single *B. tabaci*, given a 24- h acquisition access period and transmission interval of 24- h, showed that PYLCV was persistent in the insect vector up to the end of their life cycle which was 6 days in this experiment (Table 5).

Table 5. Persistence of pepper yellow leaf curl virus on *B. tabaci* after a 48-h acquisition feeding period and a 24-h inoculation feeding period

Serial transmission (day)	***B. tabaci*[1)]**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	+	+	+	+	+	+	+	+	+
2	+	+	+	+	+	+	+	+	D
3	+	+	+	+	+	+	+	D	
4	+	+	+	+	+	M	+		
5	D	+	M	+	D		+		
6		D		+			+		
7				D			D		

[1)] + = successful transmission; M = insect is missing; D = death of insect

Effect of sex of whitefly on virus transmission.

Transmission by female and male whiteflies was tested under identical environmental conditions, but the levels of virus transmission were different. When 10 batches of 10 females and 10 males each were given 48 h aqcuisition feeding period and 24 h inoculation feeding period, the females and males gave 100% and 60% transmission of PYLCV, respectively (Table 6). The effect of sex of whitefly on virus transmission was analyzed by Fisher's exact test.

Table 6. The effect of sex of *B. tabaci* on the transmission of pepper yellow leaf curl virus with a 48-h acquisition feeding period and a 24-h inoculation feeding period

Sex of *B. tabaci*	**Number of infected plants (%)**	**Incubation period (days)**
Female	100 *)	6 - 8
Male	60	10 - 18

*) Transmission potential was significantly different between female and male (Fisher's exact test, P=0.043)

DISCUSSION

Virus acquisition by insect vectors may depend on the virus titer in the infected plant, the ability of insect to ingest the virus, and the passage of the virus through the midgut wall and subsequent survival in the insect vector. The probability of subsequent transmission of circulative viruses by insect vectors generally increases with increasing acquisition access period until all insects that are able to do so have acquired the virus (Swenson, 1967). The higher levels of PYLCV transmission efficiency after extended acquisition access in our study are supportive of a circulative mode of transmission. A similar result was reported by Rosell et al. (1999) for tomato yellow leaf curl virus (TYLCV). Transmission of TYLCV increased from 10% to 90% when the whiteflies were given 0.5 h and 12 h acquisition feeding period, respectively. Samretwanich et al. (2000) concluded that 1 h feeding period of the whiteflies on infected plants was an optimum acquisition feeding period

for pepper yellow leaf curl virus (PepYLCV)-Thailand, whereas our study showed that the optimum acquisition feeding period for PYLCV was 3 h.

The ability of the insect vector to transmit PYLCV is affected by the inoculation access period. Percent transmission increased as the inoculation access period was lengthened and reached a maximum (100%) after a 6-h inoculation access period. Longer inoculation access period i.e. 12 h, was achieved with TYLCV(Mehta et al., 1994), and chino del tomate virus (Brown & Nelson 1988), and 24 h for tobacco leaf curl virus (TLCV) (Aidawati et al. 2002).

The above study on acquisition and inoculation feeding period showed that PYLCV needs a minimum 9-h latent period in insect body to become infective (Table 3). The whiteflies required a minimum 6-h acquisition feeding period followed by a minimum 3-h inoculation feeding to become viruliferous. These findings support earlier an statement regarding circulative transmission of PYLCV.

Transmission of PYLCV was observed with one adult *B. tabaci*, but the efficiency of transmission increased almost twofold as the number of adults was increased to three per plant. Transmission of geminivirus by single whitefly has been reported earlier for TLCV on tobacco (Aidawati et al., 2002), squash leaf curl virus (SLCV) on squash (Cohen et al., 1983), Texas pepper virus (TPV) on chili pepper (Lotrakul et al., 2000), and Sinaloa tomato leaf curl virus (STLCV) on tomato (Idris and Brown, 1998). Maximum transmission efficiency of PYLCV (100%) reached with at least 10 adults per plant was used in the transmission experiment. According to Aidawati et al. (2002) maximum efficiency of TLCV was reached with at least 20 adult whiteflies per plant. This fact may be the indicator of the high concentration of PYLCV in virus source plant or the isolate of PYLCV used in this study has a high virulence.

PYLCV is not transmitted through the eggs. Adult *B. tabaci* emerging from eggs of viruliferous insects were not able to cause infection. The same results were reported by Butter and Rattaul (1977), Mehta et al. (1994), Idris and Brown (1998), and Aidawati et al. (2002) with tomato leaf curl virus, TYLCV, STLCV, and TLCV. Earlier, Costa (1969) stated that virus transmitted by *B. tabaci* is not transovarial.

Transmission of PYLCV by female whiteflies was relatively higher than those by male whiteflies. When female whiteflies were introduced to all test plants, they showed symptom of PYLCV infection within relatively shorter incubation period, i.e. 6 – 8 d. These findings were in line with those of Cohen and Nitzany (1966), Rathi and Nene (1974), and Varma (1963). Transmission efficiency of female whiteflies is assumed to be correlated to their feeding behaviour. Female whiteflies tend to feed more actively to support their reproduction role.

Symptom development of PYLCV on tomato plants inoculated serially via viruliferous *B. tabaci* showed that PYLCV persisted in the insect body up to the end of the insect's life cycle. Persistence of the virus in the insect body varies, for example 1 -15 d for TYLCV (Cohen and Nitzany, 1966), 8 – 55 d for tomato leaf curl virus (Butter and Rattaul 1977), 9 d for STLCV (Idris and Brown 1998) and the whole life cycle for zinnia yellow net disease (Srivastava et al., 1977) and TLCV (Aidawati et al., 2002).

The results obtained in this study indicate that tobacco whitefly, *B. tabaci*, is able to transmit PYLCV efficiently. Pepper yellow leaf curl disease is now widely distributed in pepper production region in Indonesia, partly due to the increment of pepper growing area in recent time which stimulates the whitefly to reach its highest populations, especially during the dry season. Basic information on the virus-vector relationship might be useful in developing suitable control measures against the disease.

REFERENCES

Aidawati, N., S.H. Hidayat, R. Suseno, and S. Sosromarsono. 2002. Transmission of an Indonesian isolate of Tobacco leaf curl virus by *Bemisia tabaci* Genn. (Hemiptera: Aleyrodidae). Plant Pathol. J. 18(5):231 - 236.

Bock, K. R. 1982. Geminivirus diseases in tropical crops. Plant Dis. 66(33) : 266-271.

Brown, J. K., and R. Nelson. 1988. Transmission, host range, and virus-vector relationships of Chino del tomate virus, a whitefly-transmitted geminivirus from Sinaloa, Mexico. Plant Dis. 72 : 866 - 869.

Butter, N. S., and H. S. Rataul. 1977. The virus-vector relationship of the tomato leafcurl virus (TLCV) and its vector, *Bemisia tabaci* Gennadius (Homoptera;Aleyrodidae). Phytoparasitica 5(3) : 173 - 186.

Cohen, S., J.E. Duffus, R.C. Larsen, H.Y. Liu, and R.A. Flock. 1983. Purification, serology, and vector relationships of Squash leaf curl virus, a whitefly transmitted geminivirus. Phytopathol. 73:1669 – 1673.

Cohen, S., and F.E. Nitzany. 1966. Transmission and host range of the tomato yellow leaf curl virus. Phytopathol. 56:1127 – 1131.

Costa, A. S. 1969. Whiteflies as virus vectors. pp: 95-119. In K. Marasmorosch (ed.). Viruses, Vectors, and Vegetation. John Wiley and Sons (Interscience), New York. 659p.

Greathead, A. H. 1986. Host plants, pp. 17 – 25. In M. J. W. Cock (ed.), Bemisia tabaci – A literature Survey on the Cotton Whitefly with an annotated Bibliography. CAB. International. Institute of Biological Control. Ascot, Berks, U.K.

Harrison, B.D. 1985. Advances in geminivirus research. Ann. Rev. Phytopathol.23: 55 – 82.

Idris, A. M., and J. K. Brown. 1998. Sinaloa tomato leaf curl geminivirus : Biological and molecular evidence for a new subgroup III virus. Phytopathol. 88: 648 - 657.

Lotrakul, P., R.A. Valverde, R. De La Torre, J. Sim, and A. Gomez. 2000. Occurrence of a strain of Texas pepper virus in Tabasco and Habanero pepper in Costa Rica. Plant Dis. 84:168 – 172.

Martin, J. H. 1987. An Identification guide to common whitefly pest species of the world (Homoptera : Aleyrodidae). Trop. Pest Manag. 33(4):298 – 322.

Mehta, P, J. A. Wayman, M. K. Nakhla, and D. P. Maxwell. 1994. Transmission of tomato yellow leaf curl geminivirus by *Bemisia tabaci* (Homoptera : Aleyrodidae). J. Econ. Entomol. 87(5) : 1291-1297.

Rathi, Y.P.S., and Y.L. Nene. 1974. Sex of *Bemisia tabaci* Genn. In relation to the transmission of mung bean yellow mosaic virus. Acta Bot. Indica 2:74 – 76.

Rosell, R.C., I. Torres-Jerez, and J.K. Brown. 1999. Tracing the geminivirus-whitefly transmission pathway by polymerase chain reaction in whitefly extract, saliva, hemolymph, and honeydew. Phytopathol. 89:239 – 246.

Rusli, E.S., S.H. Hidayat, R. Suseno, and B. Tjahjono. 1999. Geminivirus on pepper : Symptom variation and transmission study. Bul. HPT 11(1): 126 – 131.

Samretwanich, K., P. Chiemsombat, K. Kittipakorn,, and M. Ikegami. 2000. A new geminivirus associated with a yellow leaf curl disease of pepper in Thailand. Plant Dis. 84:1047.

Srivastava, K. M., B.P. Singh, V.C. Dwadash – Shreni, and B.N. Srivastava. 1977. Zinnia yellow net disease-transmission, host range, and agent-vector relationship. Plant Dis. Rep. 61(7): 550-554.

Sulandari, S., R. Suseno, S.H. Hidayat, J. Harjosudarmo, and S. Sosromarsono. 2006. Detection and host range study of virus associated with pepper yellow leaf curl disease. Hayati 13(1): 1 – 6.

Swenson, K. G. 1967. Plant virus transmission by insect. pp. 267-307. In K. Maramorosch & H. Koprowski (Eds.). Methods in Virology. Academic, New York.

Trisusilowati, E.B., R. Suseno, S. Sosromarsono, Barizi, Soedarmadi; and M.A. Nur.. 1990. Transmission, serological aspects and morphology of the tobacco krupuk virus. Indon. J. Agric. (2): 75-79.

Varma, P. M. 1963. Transmission of plant viruses by whiteflies. Nat. Inst. Sci. India Bull. 24: 11-33.

J. ISSAAS Vol. 13, No 1. pp.18-25 (2007)

ACTIVITIES OF SOIL ENZYMES IN CORN FIELDS ENRICHED WITH MANURE

Sri Yusnaini[1], Abdul Kadir Salam[1], Masanori Nonaka[2]

[1]Department of Soil Science, Faculty of Agriculture University of Lampung
Address: Jl. Prof. Sumantri Brojonegoro No. 1
Bandar Lampung 35145, Indonesia e-mail : yusnaini@unila.ac.id

[2] Laboratory of Soil Biochemistry Faculty of Agriculture, Niigata University,
Ikarashi Niigata Japan e-mail : nonaka@agr niigta-u.ac.jp

(Received: January 5, 2006; Accepted: March 28, 2007)

ABSTRACT

Elevated enzyme activities in soils have been reported to be associated with enhanced contents of organic matter and total nitrogen (N). This research sought to evaluate the changes in enzymatic activities in cornfield soil enriched with organic matter. Corn field plots had been treated for 8 seasons with increasing amounts of green manure or barnyard manure (0 – 100% of 20 ton ha^{-1}) and decreasing amount of chemical fertilizers (100 – 0% of 300 kg Urea + 200 kg SP-36 + 100 kg KCl ha^{-1}). Soil samples were taken at the maximum vegetative stage and at harvest time, and analyzed for enzymatic and chemical properties. The results clearly showed that enrichment with barnyard manure significantly increased alkaline phosphatase activity. Both manures did not affect the activities of acid phosphatase, arylsulfatase and β-glucosidase. The greater effect of barnyard manure on alkaline phosphatase was closely related with increases in soil pH, available P, and microbial activities. Barnyard manure also significantly increased organic C and total N content. The activities of acid and alkaline phosphatase, arylsulfatase, and β -glucosidase showed high and significant correlations with soil pH, organic C, total N, and available P. Acid phosphatase showed a significant correlation with corn yield.

Key words: barnyard manure, chemical fertilizers, green manure

INTRODUCTION

Switching from the use of chemical fertilizers to more environmentally sound sources of plant nutrients is one of the most central issues in current agricultural system, particularly related to the use of indigenous and cheaper materials. Organic matter in the form of manure such as barnyard manure of domesticated animals and green manures are among the indigenous sources of plant nutrients available in agricultural environments. The use of these materials may lower the need for chemical fertilizers that has become very expensive. The use of these materials may also lower the emission of toxic materials such as heavy metals brought about by the application of chemical fertilizers into the soil system.

The use of organic matter in agricultural soils may, of course, change some soil properties, of which soil enzymatic property is of utmost importance. Soil enzymes are very important in accelerating the decomposition of organic matter and making available plant nutrients from organic sources in the soil system (Tabatabai, 1982; Tate III, 1987). Some accessible experimental data show that the activities of soil enzymes are well-correlated with changes in organic matter content, organic C, and total N (Nannipieri et al., 1980; Frankenberger and Dick, 1983; Baruah and Mishra, 1984; Tate III, 1984; Baligar et al., 1988; Salam et al.,1998; 1999a; 1999b). This indicates that addition of

organic matter to the soil will increase soil enzyme activities, which eventually increases the decomposition of structural plant nutrients of organic materials into available nutrients. Some researchers argue that the structural C and N may increase the soil microbial population and activities responsible for the production of enzymes released into soil system (Tate III, 1984). Soil microorganisms are the most important producers of soil enzymes (Duxbury and Tate III, 1981; Ross and Cairns, 1982; Frankenberger, Jr. and Dick, 1983; Vinotha et al., 2000), probably more important than plant roots and soil mesofauna such as earthworms (Satchell and Martin, 1984).

The decreasing amounts of chemical fertilizers added into the soil system may also change the soil enzymatic properties. For example, the soluble P from P-fertilizers such as TSP, SP-36, and rock phosphates may inhibit the action of phosphatases in accelerating the detachment of phosphates from organic structures and their release into the soil solution. Some researchers report that addition of inorganic P through chemical fertilizers even decreases phosphatase activities (Pang and Kolenko, 1986; Fox and Commerford, 1992). Lower activity of phosphatases and higher soluble P in soil solution will slow the decomposition reaction and decrease the concentration of P of organic matter origin. Since the addition of organic matter usually changes the soil pH, the changes in soluble P may be lower because the activities of soil phosphatases are pH-dependent. The activities of phosphatases in general increase with soil pH at pH lower than their optimum pHs and decrease with soil pH at pH higher than their optimum pHs (Frankenberger, Jr. and Johanson, 1982; Malcolm, 1983; Rojo et al., 1990; Salam et al., 1998).

This research sought to evaluate the changes in corn-field soil enzymatic properties as affected by addition of organic matter of barnyard manure (chicken dung) and green manure (*Glyricidium* sp.) with decreasing amount of added chemical fertilizers.

MATERIALS AND METHODS

Study site and experimental design

Soil samples were taken from experimental plots designed for a long-term evaluation set up in Tamanbogo experimental farm at Purbolinggo, East Lampung. Experimental treatments were arranged in randomized block design with three replicates. Treatments were Control = no manure and chemical fertilizers, 0% M = 100% chemical fertilizers, 50% GM or 50% BM = 50% green manure (*Glyricidium* sp.) or 50% barnyard manure (chicken dung) and 50% chemical fertilizers, 75% GM or 75% BM = 75% green manure or 75% barnyard manure and 25% chemical fertilizers, and 100% GM or 100% BM = 100% green manure or 100% barnyard manure. A 100% barnyard manure or green manure was equivalent to 20 ton ha^{-1}. A 100% chemicals fertilizers was equivalent to 300 kg Urea + 200 kg SP-36 + 100 kg KCl ha^{-1}. Selected properties of barnyard and green manures are listed below (Table 1).

Table 1. Properties of barnyard manure and green manure.

Manure	pH	C/N	C	N	P	Na	K	Ca	Mg	WC
						mg kg^{-1}				(%)
1. BM	7.01	5.83	81.0	13.9	19.8	0.80	8.80	75.4	4.60	77.3
2. GM	5.77	3.27	115	35.0	2.00	1.70	20.6	6.00	2.70	62.9

Note: BM = barnyard manure; GM = green manure; after Afriyani (2003)

The experimental plots were consecutively planted with different crops and left to fallow between seasons from the time it was set up in March 2001 (Table 2).

Table 2. Cropping history of experimental field.

Season	Time of Planting	Crop Plants	Fallow period
1	March 2001	Corn var Bisma	
2	August 2001	Corn var Bisma	2 weeks
3	November 2001	Upland paddy var Limboto	1 month
4	April 2002	Upland paddy var Limboto	3 months
5	November 2002	Upland paddy var Limboto	1 month
6	April 2003	Corn var Bisma	1 season*
7	-	-	
8	April 2004	*Corn var Bisma*	

* from August 2003 – April 2004

During the very first season, treatments were applied after plowing and plotting. Each plot measured 6 m x 3 m, 0.8 m between plots and 1 m between blocks. Organic matter was mixed to 20-cm depth. In the 8th season, the experimental plots were plowed and treatment materials were applied to 20-cm depth. Chemical fertilizers were injected beside corn seedlings which had a planting distance of 25 cm x 25 cm. SP-36 and KCl were applied once at the beginning of corn growth (7 DAP, days after planting). Urea was applied twice, at the beginning of corn growth (7 DAP) and at 30 DAP.

Soil samples were taken twice from three random sites in each experimental plot. The first sampling was at maximum vegetative stage (t-1 = 60 DAP) and the second sampling was at the harvest time (t-2). Soil samples were taken from the corn plant rooting zones. After a thorough mixing, one part of the soil samples was stored in a cold room for soil enzymatic analyses and another part was air-dried for determination of pH, organic C, total N, and available P.

Analyses included soil enzymatic properties (acid and alkaline phosphatases, arylsulfatase, and β-glucosidase) using modified Tabatabai method (Tabatabai, 1982); some soil chemical properties (soil pH using pH-electrode, organic C using Walkey and Black method, total N using Kjeldahl method, and available P using Bray I method) and soil microbial biomass C using chloroform fumigation-extraction (CFE) method (Wu et al., 1990). Data were analyzed using ANOVA. Differences among treatments were analyzed with Least Significant Difference (LSD) at the 5% level.

Soil Enzymatic assay

Phosphatase Activity. After stopping the soil microbial activities with toluene, 4 mL of a modified universal buffer (MUB), pH 6.5 (for acid phosphatase measurement) or pH 11 (for alkaline phosphatae) and 1 mL of 0.025 ρ- nitrophenyl phosphatase (ρ-NPP) dissolved in MUB solution with the corresponding pH were added to 1 g of soil sample and incubated at 3 ^{o}C for 60 min. The enzymatic reaction was stopped by the addition of 2 ml of 0.5 M NaOH solution, followed by 0.5 ml of 0.5 M $CaCl_2$ to extract ρ- nitrophenol. The concentration of ρ- nitrophenol was determined with a Shimadzu UV-2200 UV-VIS Recording Spectrophotometer at 400 rpm for 5 min. Controls were made in the same way, although the substrate was added before the $CaCl_2$ and NaOH (Tabatabai and Bremner, 1969).

β-glucosidase Activity. The activity *β-glucosidase* was determined by the above method but ρ- nitrophenyl β- D- glucopyranoside (ρ- NGP) was added as a substrate instead of ρ- nitrophenol (ρ-NPP), and a MUB solution pH 6 was employed. The rest of the method was the same as phosphatase

activity but to stop the reaction, tris-hydroxymethyl aminomethane (THAM) was used, as suggested by Tabatabai (1982).

Arylsulfatase Activity. Arylsufatase activity was measured by the following method. A 1 g aliquot of soil sample (< 2mm, oven dry equivalent) was put into a 50-mL Erlenmeyer flask. The microbial activity was stopped by the addition of 0.25 mL toluene, followed by 4 mL acetate buffer 0.5 M (pH 5.8) and 1 mL *ρ*- nitrophenyl sulfate solution 0.025 M (ca. 3.5 mg of *ρ*- nitrophenol equivalent). After gentle swirling, the mixture was incubated for 60 min. A 1 mL aliquot of 0.5 M $CaCl_2$ and 4 mL aliquot of 0.5 M NaOH solution were then added. The *ρ*- nitrophenol concentration in the solution phase was determined with aspectrophotometer at 400 nm wavelength after filtering through a Whatman No. 42 paper (Tabatabai, 1982). Activity of each enzyme was determined at 30^oC.

RESULTS AND DISCUSSION

Changes in Soil Chemical and Biological Properties

Addition of organic matter (barnyard manure and green manure) into the soil system was observed to significantly change the soil chemical (Table 3) and biological properties (Table 4).

Table 3. Changes in some soil chemical characteristics as affected by enrichment with organic matter.

Treatment	pH		Organic C		Total N		Available P	
	Maximum Vegetative	Harvest Time	Maximum Vegetative	Harvest Time	Maximum Vegetative	Harvest Time	Maximum Vegetative	Harvest Time
			g kg^{-1}				mg kg^{-1}	
Control	4.66 ab	4.63 b	10.2 a	10.2 a	1.2 a	1.2 a	20.1 a	15.4 a
0% M	4.54 a	4.37 a	13.3 b	13.2 b	1.6 bc	1.2 a	59.8 d	64.7 b
50% GM	4.61 ab	4.60 b	12.6 b	12.4 b	1.7 c	1.3 b	49.2 c	49.1 ab
75% GM	4.75 b	4.59 b	12.3 b	12.1 b	1.5 b	1.3 b	38.6 b	38.6 ab
100% GM	4.73 b	4.79 c	12.8 b	12.6 b	1.6 bc	1.3 b	30.0 b	27.0 ab
50% BM	6.16 c	6.33 d	17.3 d	16.3 c	2.2 e	1.6 c	170 e	228 c
75% BM	6.54 d	6.37 d	15.1 c	15.0 c	1.9 d	1.7 d	213 f	270 d
100% BM	6.55 d	6.61 e	19.7 e	19.5 d	2.5 f	1.9 e	241 g	300 d

Table 4. Changes in soil microbial biomass C as affected by enrichment with organic matter.

Treatment	Maximum Vegetative	Harvest time
	mg CO_2-C kg^{-1}	
Control	22 a	81 a
0% M	154 b	210 c
50% GM	61 a	141 b
75% GM	161 b	149 b
100% GM	190 b	154 b
50% BM	290 c	293 d
75% BM	368 d	268 d
100% BM	583 e	412 e

Barnyard manure increased significantly the soil pH, organic C, total N, and available P (Table 3). Green manure, however, increased significantly only the soil pH to a lower extent and significantly decreased the soil available P. Sampling time (maximum vegetative period and harvest time) did not change the soil chemical properties except the available P in barnyard-manure treated plots; available P in soils sampled at harvest time was significantly greater that those sampled at maximum vegetative period.

The greater effect of barnyard manure compared to green manure in affecting the soil chemical properties was associated with the greater population and activities of microorganisms in barnyard treatment plots. Microbial population was more active in barnyard manure treated plots. Observations confirmed that microbial population activities increased with barnyard manure treatment and, conversely, decreased with green manure treatment (Table 4).

Application of barnyard manure increased the soil pH; higher than with green manure both exclusively or in combination with inorganic fertilizer (Table 3). The increases in soil pH were probably caused by the fact that barnyard manures contained high Ca (7.5 %) (Table 1). Calcium is a liming cation that can increase soil pH. The same results have been reported by Simex et al. (1999); soil pH was increased by the addition of organic plus inorganic fertilizer applied in conjunction with lime, but was decreased in the absence of liming. Green manure showed a lower Ca content (0.6 %).

The soil organic C and total N contents were all higher in all fertilized treatments compared to the control treatment (Table 3). The greatest amounts of both organic C and total N were observed in soils treated with barnyard manure and the least amount organic C and total N were in unfertilized treatments, except for total N, lowest plots fertilized with inorganic fertilizer. The increases in soil C were probably due to the combined effects of C addition in the manure and increased plant productivity as a result of both manure and organic fertilizer additions. Soil organic C and total N provide a measure of soil organic matter level. In this study, the aboveground crop biomass was removed and not incorporated into the soil. The increase in soil organic matter with the application of inorganic fertilizer was probably because of the greater input of root biomass due to better crop growth (Goyal et al., 1992).

Changes in Soil Enzymatic Properties

Changes in the activities of soil enzymes as affected by increasing manure and decreasing chemical fertilizers are shown in Table 5.

Table 5. Changes in soil enzymatic activities as affected by enrichment with organic matter.

Treatment	Acid Phosphatase		Alk. Phosphatase		Arylsulfatase		*β*-Glucosidase	
	Maximum Vegetative	Harvest Time	Maximum Vegetative	Harvest Time	Maximum Vegetative	Harvest Time	Maximum Vegetative	Harvest Time
	microgram p-nitrophenol g^{-1} h^{-1}							
Control	266 a	371 a	43.1 a	50.9 a	1380 a	1420 a	208 a	189 b
0% M	216 a	543 a	46.4 a	39.8 a	1480 a	1370 a	200 a	228 c
50% GM	221 a	627 a	38.7 a	42.0 a	1380 a	1440 a	216 a	230 c
75% GM	304 a	560 a	52.0 a	46.5 a	1380 a	1440 a	230 a	231 c
100% GM	293 a	632 a	56.5 a	47.6 a	1320 a	1520 a	205 a	234 c
50% BM	366 a	693 a	83.1 b	189 b	1460 a	1310 a	208 a	164 a
75% BM	305 a	777 a	170 c	218 c	1410 a	1400 a	230 a	331 d
100% BM	321 a	738 a	257 d	239 d	1510 a	1500 a	357 a	225 c

Note: Different characters in one column indicates a significant difference by LSD= 0.05.

Dick (1992) has noted that numerous researchers have found that soil enzyme activity increases with the addition of organic material. However, our experiment showed that both barnyard manure and green manure did not give consistent effect on the activities of acid phosphatase, arylsulfatase, and *β*-glucosidase, except for the alkaline phosphatase activity which was observed to increase significantly with increasing barnyard manure treatment. Time of sampling (maximum vegetative period and harvest time) generally did not affect the soil enzymatic properties, except for acid phosphatase, which was higher at harvest time, and closely associated with the more available P observed at harvest time (Table 3).

Activities of acid and alkaline phosphatases, arylsulfatase, and *β*-glucosidase at maximum vegetative period were all significantly well-correlated with soil pH, organic C, total N, and available P. At harvest time, only acid and alkaline phosphatase activities were significantly well-correlated with soil pH, organic C, total N, and available P. Only acid phosphatase activity was well correlated with corn yield (Table 6).

Table 6. Coefficient correlations between soil enzymatic activities and selected chemical properties and plant yield.

Properties	Acid Phosphatase		Alk. Phosphatase		Arylsulfatase		*β*-Glucosidase	
	t-1	t-2	t-1	t-2	t-1	t-2	t-1	t-2
Soil pH	0.71**	0.77**	0.87**	0.99**	0.57*	- 0.14	0.60*	0.18
Organic C	0.61*	0.79**	0.83**	0.88**	0.76**	- 0.02	0.72**	0.07
Total N	0.58*	0.87**	0.83**	0.97**	0.68**	0.03	0.72*	0.25
Avail P	0.59*	0.80**	0.90**	0.98**	0.69**	- 0.19	0.67**	0.28
Yield	-	0.87**	-	0.43	-	- 0.02	-	0.40

Note: *significant at 0.05 and **at 0.01

All plots showed similar values of *β*-glucosidase activities in the maximum vegetative phase (T1), although at harvest time (T2) different results were observed. *β*-glucosidase activity was higher in plots with barnyard manure than the other plots. The lowest activities of *β*-glucosidase was observed in the control plot.

Inorganic fertilizer and barnyard manures significantly affected soil microbial biomass carbon (Table 4). Microbial biomass C was greatest with the barnyard manure amendment and lowest in unfertilized soil. Soil microbial biomass and soil enzyme activities show a more quick response to the changes in soil management practices compared to total soil organic matter (Dick, 1992; Doran et al., 1996). The increased levels of microbial biomass in the barnyard manure treatment (Table 4) reflect high annual inputs of organic matter in the form of barnyard manure. Several studies have been focused on the shifts in microbial population and activity in soil as related to the change in C inputs. In some studies these were attributed to amount and diversity of organic inputs (Powlson et al., 1987). The microbial biomass and extracellular enzyme activity in assessment of soil quality were established by the essential role of soil microorganisms in nutrient cycling within agriculture ecosystems (Rice et al., 1986).

ACKNOWLEDGEMENT

This research was done within the frame work of the sub-project" Basic Research on Developing the Techniques for Sustainable Biological Production in the Regions of Red Acid Soils" under the main project "Basic Research on Environmentally Sound Biological Production Technology Development in Eastern Asia" Grant-in-Aid for Creative Basic Science from the Ministry of Education, Science, Sports and Culture of Japan. The authors would like to express special thanks to Loraseli and Suhaedi for conducting part of the research for their final *skripsi*.

REFERENCES

Afriyani R. 2003. Pengaruh pemberian pupuk organik dan inorganik serta kombinasinya terhadap pupulasi AMF pada pertanaman padi gogo di Ultisols Taman Bogo. (In Indonesian).

Baligar, V.C., R.J. Wright and M.D. Smedley. 1988. Acid phosphatase activity in soils of the Appalachian region. Soil Sci. Soc. Am. J., 52:1612-1616.

Baruah, M. and P.R. Mishra. 1984. Dehydrogenase and urease activities in rice-field soils. Soil Biol. Biochem., 16:423-424.

Doran, J.W., M..Sarantonio and M.A Liebig,. 1996. Soil health and sustainability. Adv. Agron.,56: 1-54.

Dick, R.P. 1992. Long term effects of agricultural systems on soil biochemical and microbial parameters. A Reviewe Agric. Ecosyst. Environ. 40: 25-36.

Duxbury, J.M. and R.L. Tate III. 1981. The effect of soil depth and crop cover on enzyme activities in Pahokee Muck. Soil Sci. Soc. Am. J., 45: 322-328.

Fox, T.R. and N.B. Commerford. 1992. Rhizosphere phosphatase activity and phosphatase hydrolysable organic phosphorus in two forested Spodosols. Soil Biol. Biochem., 24:579-583.

Frankenberger, Jr., W.T. and J.B. Johanson. 1982. Effect of pH on enzyme stability in soils. Soil Biol. Biochem., 14:433-437.

Frankenberger, Jr., W.T. and W.A. Dick. 1983. Relationship between enzyme activities and microbial growth and activities indices in soils. Soil Sci. Soc. Am. J., 47: 945-951.

Goyal, S., M.M Mishra,., I.S., Honda, Singh, R., 1992. Organic matter microbial biomass relationship in field experiment under tropical conditions: Effects of inorganic fertilization and organic amendments. Soil. Biol. Biochem. 24: 1081-1084.

Malcolm, R.E. 1983. Assessment of phosphatase activity in soils. Soil Biol. Biochem., 15:403-408.

Martens, D.A., J.B. Johanson and W.T. Frankenberger, Jr. 1992. Production and persistence of soil enzymes with repeated addition of organic residues. Soil Sci., 153:53-61.

Nannipieri, P., B. Ceccanti, S. Cervelli and E. Matarese. 1980. Extraction of phosphartase, urease, protease, organic carbon, and nitrogen from soil. Soil Sci. Soc. Am. J., 44:1011-1016.

Pang, P.C.K. and H. Kolenko. 1986. Phosphomonoesterase activity in forest soils. Soil Biol. Biochem., 18:35-40.

Powlson, D.S., P.C. Brookes and B.T. Christensen. 1987. Measurement of soil microbial biomass provides on early indication of changes in total soil organic mater due to straw incorporation. Soil Biol. Biochem., 19: 159-164.

Rice, C.W., M.S. Smith and R.L. Blevins. 1986. Soil nitrogen availability after long-term continuous no-tillage and conventional tillage corn production. Soil Sci. Soc. Am.J., 50:1206-1210.

Rojo, M.J., S.G. Carcedo and M.P. Mateos. 1990. Distribution and characterization of phosphatase and organic phosphorus in soil fractions. Soil Biol. Biochem., 22:169-174.

Ross, D.J. and A. Cairns. 1982. Effect of earthworms and ryegrass on respiratory and enzyme activities of soil. Soil. Boil. Biochem., 14: 583-587.

Salam, A.K., A. Katayama, and M. Kimura. 1998. Activities of some soil enzymes in different land use system after deforestation in hilly areas of West Lampung, South Sumatra, Indonesia. Soil Sci. Plant Nutr., 44(1):93-103.

Salam, A.K., Y. Desvia, E. Sutanto, T. Syam, S.G. Nugroho and M. Kimura. 1999a. Activities of soil enzymes in different land-use system in middle terrace areas of Lampung Province, South Sumatra, Indonesia. Soil Sci. Plant Nutr., 45(1):89-99.

Salam, A.K., E. Sutanto, Y. Desvia, A. Niswati, Dermiyati and M. Kimura. 1999b. Activities of soil enzymes in fields continuously cultivated with cassava, sugarcane, and pineapple in middle terrace areas of Lampung Province, South Sumatra, Indonesia. Soil Sci. Plant Nutr., 45(4):803-809.

Satchell, J.E. and K. Martin. 1984. Phosphatase activity in earthworm feaces. Soil Biol. Biochem., 16: 191-194.

Simex, M., D.W. Hopkins, J.Kalcik, T. Ricek, H. Santruckova, J. Stana and K.Travnik. 1999. Biological and chemical properties of arable soils affected by long-term organic and inorganic fertilizer applications. Biol. Fertil. Soils, 29: 300-308.

Tabatabai, M.A. 1982. Soil Enzymes. pp. 903-817. *In* A.L. Page, R.H. Miller, and D.R. Keeney (Eds.). Method of Soil Analysis Part 2. Chemical and Microbiological Properties. 2nd ed. SSSA Inc., Madison.

Tabatabai, M.A.and Bremner, J.M. 1969. Use of ρ- nitrophenol phosphate in assay of soil phosphatase activity. Soil Biol. Biochem., 1: 301-307.

Tate III, R.L. 1984. Function of protease and phosphatase activities in subsidence of Pahokee muck. Soil Sci., 138:271-278.

Tate III, R.L. 1987. Soil Organic Matter, Biological and Ecological Effects. John Wiley & Sons, Inc., New York.

Vinotha, S.P., K. Parthasarathi and L.S. Ranganathan. 2000. Enhanced phosphatase activity in earthworm casts is more of microbial origin. Current Sci., 79: 1158-1159.

Wu, J., Joegensen, R.G. Pommerening, R. Chaossod and P.C. Brooks. 1990. Measurement of Soil microbial biomass C an automated procedure. Soil Biol. Biochem, 22: 1167-1169.

J. ISSAAS Vol. 13, No 1. pp .26-32 (2007)

EFFECTS OF SOIL WATER DEFICIENCY ON SEED GERMINABILITY AND VIGOUR DURING SEED MATURATION IN PEANUT

Takashi Shinohara[1] and Akihiro Isoda[2]

[1]Tokyo University of Agriculture, Faculty of International Agriculture
and Food Studies, Sakuragaoka 1-1-1, Setagaya, Tokyo, Japan
[2]Chiba University, Faculty of Horticulture,
Matsudo 648, Matsudo, Chiba, Japan

(Received Nov. 6, 2006; Accepted May 30, 2007)

ABSTRACT

Poor seed quality causes low field emergence in general, but relatively few reports about effects of abiotic factors on peanut (*Arachis hypogaea* L.) seed quality have been documented. This study was initiated to collect information about the relationship between peanut seed germinability and seed vigour, and soil water deficit during maturation using a major Japanese peanut cultivar 'Chibahandachi' grown in the Kanto district. Seeds which matured in drought condition (T_2) did not lose viability, but had a lower germination at 15 ^{o}C and more cations leaked from seeds to water than seeds which matured in the absence of moisture stress (T_1). Nearly 25% of seeds produced from T_2 had dark plumules, whereas less than 5% were found in the seed lots from T_1. Field emergence of seeds from T_2 did not differ from that from T_1, but about a quarter percentage of seeds developed abnormal seedlings characterised as missing foliage leaves. These results suggest that peanut seed vigour is reduced by soil water deficit during maturation stage. Hypothesis that this vigour reduction may be associated with calcium deficiency is discussed.

Key words: *Arachis hypogaea* L., drought stress, seed quality

INTRODUCTION

Producing high quality seed is one of an important aim of seed industry. Traditionally, information of seed quality for planting value is obtained via germination testing. However, it is now internationally recognised that seed lots, which do not have differences in germination, may differ significantly in field emergence even when sown at the same time (Dornbos, 1995). This performance difference in field conditions is ascribed to different vigour among seed lots (Hampton and TeKrony, 1995).

Seed vigour is defined as an index of the extent of physiological deterioration and/or mechanical integrity of a high germinating seed lot which governs its ability to perform in a wide range of environments (Hampton, 1998). There are a number of factors influencing seed vigour. Environmental stress (e.g. drought and high temperature) during seed development and/or maturation is one factor that can strongly reduce seed vigour (Hampton, 1998).

Peanut (*Arachis hypogaea* L.), having the subterranean fruiting habit, is cultivated around the world in semiarid tropics and warm temperate climates. Isleib et al. (1994) pointed out that the productivity of peanut is relatively low in Southern Asia due to a combination of several factors, and poor seed quality is one contributing the low productivity. The peanut plant is highly drought tolerant, but its fruiting habit makes the reproductive growth sensitive to water stress. It has been reported that water deficit at the fruiting zone (4-5 cm from the soil surface) delays the rate of seed and pod development (Sexton et al., 1997), causes a yield reduction (Wright, 1989), and also

decreases germination (Cox et al., 1976: Pallas et al., 1977: Pallas et al., 1979). Despite of this, information of effects of this stress on seed vigour is limited.

In the Kanto district in Japan, where just under 90% of Japanese peanuts are produced, the average annual precipitation is around 1500 mm (National Astronomical Observatory, 2002). However, rainfall distribution is not even through the year: the amount of evaporation exceeds rainfall in mid-summer (Hatachi Nougyo Kenkyukai, 1988) at which time peanuts develop their seeds underneath the soil surface. Therefore, it is possible even in Japan that soil water deficits during summer season may decrease peanut seed quality, particularly vigour. This study was conducted to examine the relationship between seed quality (germinability and vigour) and soil water deficit during seed development in peanut.

MATERIALS AND METHODS

A peanut cultivar 'Chibahandachi' (Virginia type) was used in this experiment. This is the most commonly grown cultivar in Japan. Seeds were sown in the experimental farm of the faculty of Horticulture, Chiba University on May 11, 2000. Planting distance was 20 cm within rows and 50 cm between rows. Fertilizer in the ratio 30:100:100 kg ha^{-1} of N, P_2O_5 and K_2O was applied just before sowing. Flowering started on June 28. Each plot size was four rows by 11 m long. Plots were arranged in a randomised block design with two replications. After flowering had started (July 28), a rain shelter was placed over the trial area to apply treatments. Treatments were as follows: plants were watered to keep the surface 20 cm moist (pF <2.4) until harvest (T_1): plants were not watered until harvest (T_2).

Pods were dug up, excluding pods matured in border rows, from T_1 and T_2 by hand on October 8 (102 days after flowering). Takeuchi et al. (1964) reported that 'Chibahandachi' increased dry seed weight by 100 days after flowering, and it is considered that a seed attains its maximum vigour potential at this time, i.e. physiological maturity (Coolbear, 1994). Seeds were thereafter ambient air dried to approximately 7% seed moisture content.

Seed germination percentages were measured at two temperatures (25 and 15°C) using 25 seeds with four replicates. Each seed was placed into vermiculite in a plastic-cup. Germination was determined at 72 and 120 hours after sowing for 25 and 15°C, respectively. Seeds were considered to have germinated by the observation of the radicle emergence.

To determine field emergence, seeds from T_1 and T_2 were sown in a field of the experimental farm on May 14, 2001 (the standard sowing time), using 6 replicates of 50 seeds. The number of emerged seedlings was counted daily, and field emergence percentage was calculated at 14 days after the sowing. After the determination of field emergence percentage, 10 seedlings from each replicate were sampled and dried to measure seedling dry weight.

Measurements of solute leakage from seeds to water were used to evaluate seed vigour. Thirty seeds with three replicates were soaked in 50 ml deionised water, and shaken at 20°C for 2 hours. The amount of cations (K^+, Na^+, NH_4^+, Ca^{2+} and Mg^{2+}) leaked into the water was measured with a Multichannel Capillary Electrophoresis Measuring System (Otsuka Electronics Co. Ltd.: CAPI-3300).

RESULTS

Soil water condition in the plots, irrigation treatment was applied (T_1), fluctuated between 2.0 and 2.5 pF during the irrigation treatment, whereas pF value was kept around 2.7 in the plots, not watered (T_2) (Fig. 1).

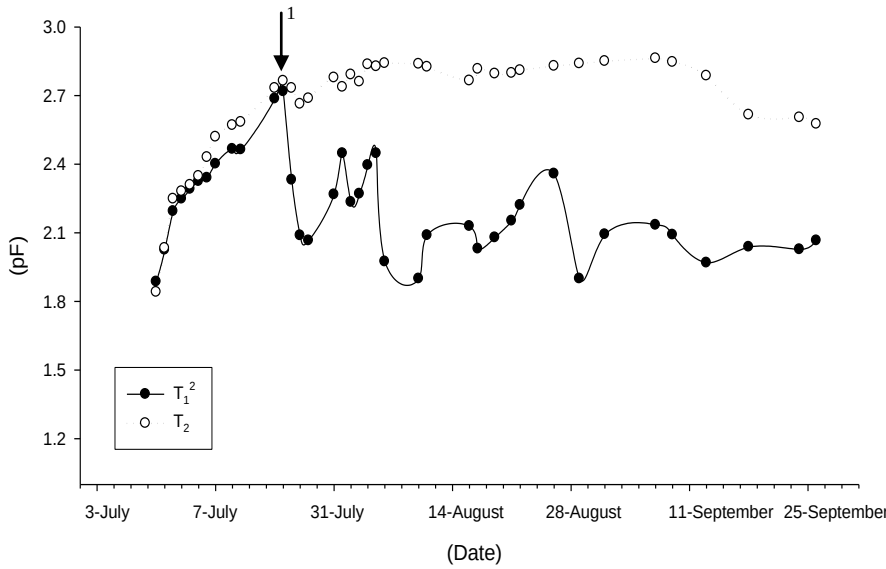
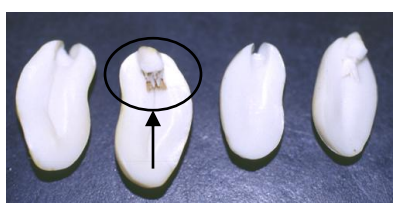


Fig. 1 Changes of soil water condition during the experiment.

[1] The arrow indicates the date when treatment began.
[2] T_1: plants were watered to keep the surface 20 cm moist until harvest.
T_2: plants were not watered until harvest.

The 100-grain weight did not differ between seeds matured at T_1 and T_2 (Table 1). Seed lots produced in T_2 had 23% of seeds with a dark plumule (Fig. 2). At 25°C, germination was over 95% for both seed groups. However, there was a significant difference in germination percentage tested at 15°C: the germination of seed lots from T_2 was only 71%, while that from T_1 stayed at 99%.



Dark plumule Normal plumule

Abnormal seedling Normal seedling

Fig 2. Seed with dark plumule and with normal plumule (above), and normal and abnormal seedlings emerged in the experimental field 12 days after sowing.

Field emergence of seed lots from T_2 and T_1 was 94% and 99% respectively (Table 1). However, 25% abnormal seedlings (Fig. 2) were observed among the seed lots from T_2, while only 5% of the T_1 seedlings were abnormal. For seedling dry weight 14 days after sowing, leaf parts of T_2 seedlings were significantly lighter than T_1 (Fig. 3). In contrast, root and cotyledon parts of T_2 seedlings were heavier than those of T_1.

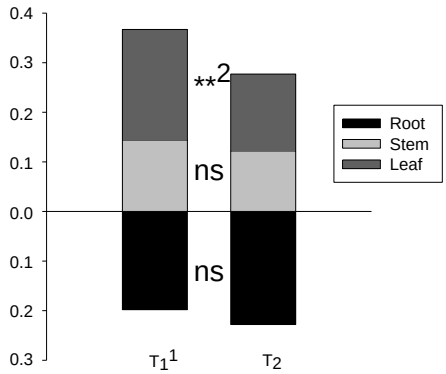


Fig. 3 Dry matter weight of organs of seedlings 14 days after sowing.
[1] T_1: plants were watered to keep the surface 20 cm moist until harvest.
T_2: plants were not watered until harvest.
[2] ** and ns = 1% and not significant level of significance according to t-test, respectively.

Table 1. Effects of soil water deficiency during seed development on seed quality and field emergence.

		T_1[1]	T_2
100-seed weight (g)		77.8	74.2
		ns[2]	
Dark plumule seeds (%)		0.0	23.0
		**	
Germination (%)	25°C	99	95
		Ns	
	15°C	99	71
		**	
Field emergence (%)		99	94
		*	
Abnormal seedlings (%)		5	25
		**	

[1] T_1: plants were watered to keep the surface 20 cm moist until harvest.
T_2: plants were not watered until harvest.
[2] *, **, ns = 5%, 1% and not significant level of significance according to t-test, respectively.

Of the cations leaked from seeds to water, most was potassium in both seeds from T_1 and T_2 (Table 2). Seeds produced from T_2 leaked significantly more potassium than seeds from T_1. Seeds produced from T_1 leaked more magnesium into water than seeds from T_2.

Table 2. The amount of cations leaked from soaked seeds.

	T_1[1]	T_2
K^+ (µg/seed)	43.8	64.0
	**[2]	
Na^+ (µg/seed)	4.4	2.8
	Ns	
NH_4^+ (µg/seed)	2.2	1.8
	Ns	
Ca^{2+} (µg/seed)	1.1	0.6
	Ns	
Mg^{2+}) (µg/seed	0.5	0.3
	**	

[1] T_1: plants were watered to keep the surface 20 cm moist until harvest.
T_2: plants were not watered until harvest.
[2] **, ns = 1% and not significant level according to t-test, respectively.

DISCUSSION

The environment during seed production is a major determinant of seed quality (Delouche, 1980), particularly seed vigour (Hampton, 1998). In peas (*Pisum sativum* L.), high air temperature conditions during seed maturation did not affect germination, but decreased seed vigour significantly (Castillo et al., 1994). For peanut seed quality, soil moisture around the fruiting zone is a known factor influencing seed quality (Coolbear, 1994), but its effects on seed vigour were not clearly documented.

Cox et al. (1976) and Pallas et al. (1977: 1979) confirmed that soil water deficit significantly decreased seed germination. In this experiment, soil water deficit did not reduce germination at an optimum condition (25°C), but did decrease germination at lower temperature (15°C). The drought stress also produced significantly more abnormal seedlings, which developed from seeds with dark plumules. These results indicate that the seeds produced under the drought condition were reduced their quality for planting value (i.e. low seed vigour).

Low seed vigour is associated with reduced cell membrane integrity (McDonald, 1999). For peanut, it is well known that calcium (Ca) is directly absorbed by fruits (Skelton and Shear, 1971). Water stress in the pod zone induced a reduction in the seeds' Ca accumulation (Wright, 1989). Since Ca stabilizes cell membranes by bridging phosphate and carboxylate groups of phospholipids (Caldwell and Haung, 1981), Ca deficiency due to water deficit in the pod zone may lead reduced cell membrane integrity. In this study, the increased leakage of cations, especially potassium, from seeds matured under the high pF soil condition supported this hypothesis.

Moreover, seeds with the dark plumules may also be an evidence that the seeds matured under drought condition suffered from Ca deficiency. As widely agreed, symptoms of Ca deficiency readily appear at low-transpiration organs (e.g. developing young leaves or/and fruits) (Marschner,

1986). Thus, the dark plumule symptom may be 'tip necrosis' induced by insufficient Ca accumulation due to water deficit in the pod zone.

In conclusion, this study showed a slight water deficit (about pF 2.7) in the podding zone reduces the peanut sowing value, which is not detected by an assessment of the physiological germination under an optimum condition. Therefore, vigour tests (such as a germination test under cold conditions), the electrical conductivity test or at least the germination test defined by ISTA (2006), which defines germination as normal seedlings, should be employed for the evaluation of peanut seed quality. These findings suggest that irrigation treatments during seed maturation are required to obtain sound field establishment, and this may lead to increased productivity of peanut in Asian countries.

ACKNOWLEDGEMENT

The authors are thankful to Professor M.J. Hill, Seed Technology Institute Australia Pty Ltd, and Professor J.G. Hampton, Bio-Protection and Ecology Division, Lincoln University, for their assistance in editing this paper.

REFERENCES

Caldwell, C.R. and A. Haung. 1981. Temperature dependence of the barley root plasma membrane-bound Ca^{2+} and Mg^{2+} -dependent ATPase. Pysiolo. Plant 53: 117-124.

Castillo, A.G., J.G. Hampton and P. Coolbear. 1994. Effect of sowing date and harvest timing on seed vigour in garden pea (*Pisum sativum* L.). New Zealand J. Crop Hort. Sci. 22: 91-95.

Coolbear P. 1994. Reproductive biology and development. pp.138-172. In J. Smartt (ed.). The Groundnut Crop: A scientific basis for improvement. Chapman & Hall, London.

Cox, F.F., G.A. Sullivan and C.K. Martin. 1976. Effect of calcium and irrigation treatments on peanut yield, grade and seed quality. Peanut Sci. 3: 81-85.

Delouche, J.C. 1980. Environmental effects on seed development and seed quality. HortScience 15: 775-780.

Dornbos, D.L.Jr. 1995. Seed Vigor, p. 45-80, In A. S. Basra (ed.). Seed Quality- Basic Mechanisms and Agricultural Implications. Food Products Press, London.

Hampton, J.G. 1998. Report of the vigour test committee 1995-1998. Seed Sci. Technolo. 26: 265-269.

Hampton, J.G., and D.M. TeKrony. 1995. Definition and concept of seed vigour, p. 8-9, In J. G. Hampton and D. M. TeKrony (eds.). Handbook of Vigour Test Methods (3rd edition). International Seed Testing Association, Zurich.

Hatachi Nougyo Kenkyukai. 1988. Ninon No Hatachi Kiban- Sono Genjyo To Doukou- Hatachi Nougyo Shinkokai. [Basis of Japanese upland Agriculture- current situations and trends]. Tokyo. 493p.

Isleib, T.G., J.C. Wynne and S.N. Nigam. 1994. Groundnut breeding. pp. 552-623. In J. Smartt (ed.). The groundnut crop: a scientific basis for improvement. Chapman and Hall, London.

ISTA. 2006. International rules for seed testing. International Seed Testing Association, Zurich.

McDonald, M.B. 1999. Seed deterioration: physiology, repair and assessment. Seed Sci. Technolo. 27: 177-237.

National Astronomical Observatory. 2002. Chronological Scientific Tables 2003. Maruzen Co., Ltd. Tokyo. 183p.

Pallas, J.E., Jr, J.R. Stansell and R.R. Bruce. 1977. Peanut seed germination as related to soil water regime during pod development. Agronomy J. 69: 381-383.

Pallas, J.E., Jr, J.R. Stansell and T.J. Koske. 1979. Effect of drought on Florunner peanuts. Agronomy J. 71: 853-858.

Sexton, P.J., J.M. Bennet, and K.J. Boot. 1997. The Effect of Dry Pegging Zone Soil on Pod Formation of Florunner Peanut. Peanut Sci. 24: 19-24.

Skelton, B.J. and G.M. Shear. 1971. Calcium translocation in the peanut. Agronomy J. 63: 409-412.

Takeuchi, S., O. Ashiya and H. Kamekura. 1964. Varietal differences of the fruit development process of peanut. Chiba Province Agr. Inst. Report 5: 122-130.

Wright, D.C. 1989. Effect of pod zone moisture content on reproductive growth in three cultivars of peanut (*Arachis hypogaea*). Plant and Soil 116: 111-114.

J. ISSAAS Vol. 13, No 1. pp.33-38 (2007)

IDENTIFICATION OF POTATO CYST NEMATODE POPULATIONS PREVAILING IN EAST AND CENTRAL JAVA, INDONESIA, BASED ON MORPHOMETRIC AND MORPHOLOGICAL CHARACTERISTICS

Lisnawita[1], Meity S Sinaga[2], GA Wattimena[3], Supramana[2] and Gede Suastika[2]

[1] Doctoral student, Post Graduate School, Bogor Agricultural University
(Email: itamuis@yahoo.com),
[2] Lecturer, Department of Plant Protection, Faculty of Agriculture, Bogor Agricultural University
[3] Lecturer, Department of Agronomy and Horticulture, Faculty of Agriculture,
Bogor Agricultural University, Indonesia

(Received: October 5, 2006; Accepted: December 1, 2006)

ABSTRACT

Potato cyst nematodes (PCN), *Globodera* spp., are worldwide important pathogens and have become one of the main obstacles to potato production in Indonesia. Since the first detection of PCN in East Java in 2003, the nematodes have caused significant losses in three main potato production areas in Indonesia, Sumber Brantas, Kota Batu, in East Java (1,600 – 1,800 m above sea level) and Karang Tengah, Banjarnegara in Central Java (1,700 m above sea level). As the nematodes were newly introduced into Indonesia, little was known about their characteristics. To manage the parasite effectively it is very important to identify the species and the pathotype of the nematode populations. Morphometric observations and morphological characterization were conducted including the measurement of Granek's ratio for randomly sampled cysts , second stage juveniles (J2) , females , males, and eggs. All specimens collected from abovementioned areas were identified as golden potato cyst nematode, *Globodera rostochiensis*.

Key words: *Globodera rostochiensis*, cyst, second stage juveniles (J2), females, males, eggs

INTRODUCTION

Potato cyst nematode (PCN) is a major pest of potato and has currently become one of the main constraints of potato production in Indonesia. The nematode is a newly introduced parasite and information on its species and pathotypes is hardly available. PCN was first detected in a potato plantation in Sumber Brantas, Kota Batu, East Java in 2003 (Daryanto, 2003), and recently occurred in several areas in Central and West Java. PCN has been reported to cause significant losses in several countries, particularly in Europe and may become a potential threat for the potato industry in Indonesia.

Two *Globodera* species, golden potato cyst nematode (*G. rostochiensis*) and pale potato cyst nematode (*G. pallida*) are reported to infect potato (Berg *et al.* 2000). Each species have several pathotypes that exhibit different pathologic responses to resistance genes of potato cultivars (Kort *et al*. 1977). Information on species and pathotypes as well as the pathogenic characteristic of Indonesian PCN are not available. This information is required to design an effective control method. Identification based on the morphometric and morphological characters together with molecular techniques are still a reliable tool to determine PCN species (Baldwin & Mundo-Ocampo, 1991).

Slight differences between *G. rostochiensis* and *G. pallida* were noted based on their morphometric and morphological characters (Stone, 1973a & 1973b). For that reason, observation

on selected characters of cyst and second stage juvenile / J2 are crucial for conventional species identification, since both stages of PCN are always found on infested soil. Hence, this study sought to identify Indonesian PCN species based on their morphometric and morphological characters.

MATERIALS AND METHODS

PCN sources

PCN samples were taken from infested potato plantations in Sumber Brantas, Kota Batu, East Java and Karang Tengah, Banjarnegara, Central Java. Soil and potato root from Sumber Brantas were collected from three locations (1600 to 1800 m, above sea level), while only one location (1700 m, a. s. l.) was sampled from Karang Tengah. Cysts were extracted using the sieving method (Shepherd, 1985), and were collected for observation.

Morphometric and morphology observation

Observations were conducted on cysts (25 cysts per population), females (25), second stage juveniles / J2 (50), males (50), and eggs (50), selected randomly from the field population, using stereoscopic and compound microscopes. Morphological characters, such as cyst form, stylet type and perineal pattern, were observed from semipermanent specimens prepared by a modified method as described by Golden (1990) and Hooper (1970). All measurements are in micrometers and were prepared by computerized tpsDig Program with Olympus 11D digital camera. Species confirmation were characterized according to species determination by Fleming and Powers (1998) and Stone (1973a & 1973b).

RESULTS AND DISCUSSION

The cyst was spheroid, slightly elliptical or ovoid (Figure 1B). Cysts contained eggs, the progeny for the next generation, and were formed from the hardened dead cuticle of the female. The newly developed cyst was golden yellow, turning to light brown and eventually dark brown, and showed an intact vulval / fenestral basin. Fenestral basin is one of the important morphological characters on species identification of PCN (Fleming & Powers, 1998).

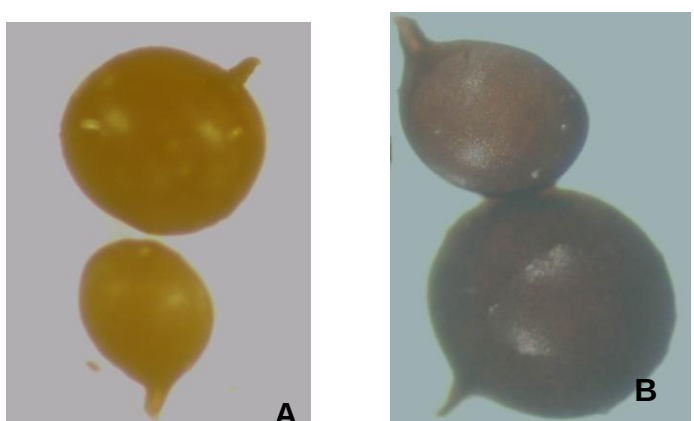


Fig. 1. Morphology of Indonesian Potato Cyst Nematode: mature female (A) and cyst (B).

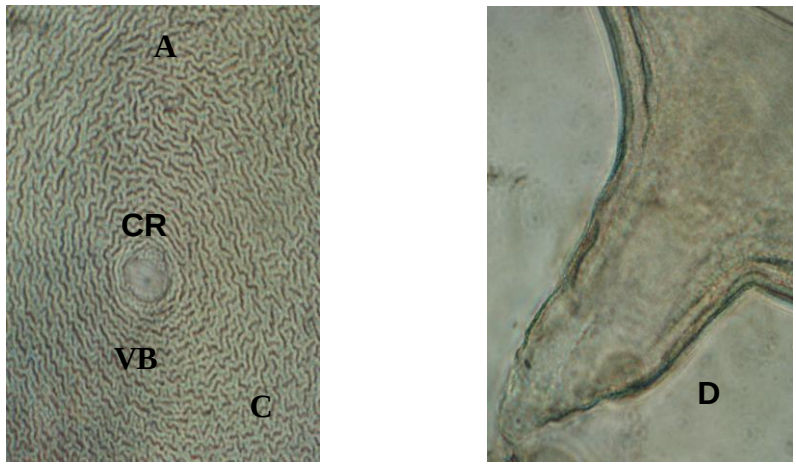


Fig. 2. Morphology of Indonesian Potato Cyst Nematode: mature female perineal pattern of *G. rostochiensis* (C), and female anterior (D), VB = vulva basin, CR = cuticular ridges, A = anus, GR >3.2.

The second-stage juvenile / J2 hatched from the egg and became an infective phase of PCN. The juvenile was vermiform with a rounded head and finely tapered tail (Figure 3A, B and C). The hyaline portion of the tail represented about two thirds of its length. The head was slightly offset and bore four to six annules. The stylet was strong, the conus being about 45% of the total length. The stylet knobs are an important diagnostic feature and typically slope backwards.

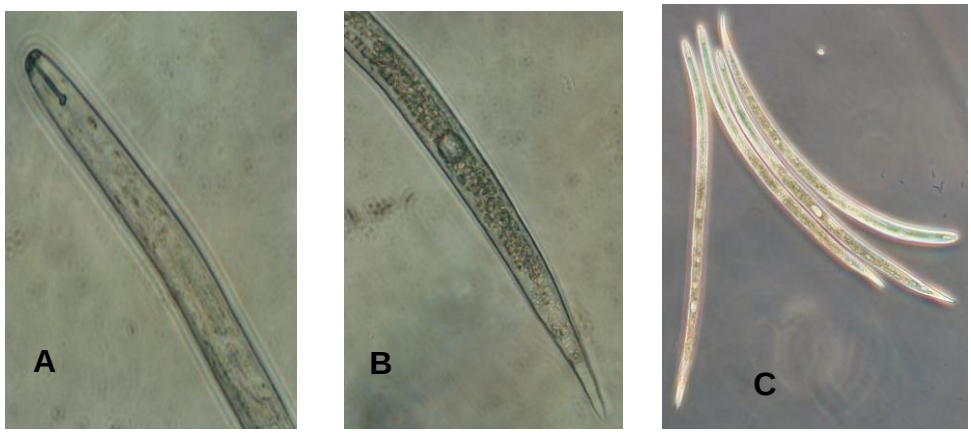


Fig. 3. Morphology of Indonesian Potato Cyst Nematode: anterior with stylet (A) and posterior (B) of J2 or second-stage juvenile (C).

The females emerged from the root cortex about one month to six weeks after invasion by the second-stage juveniles. Female was spheroid, slightly elliptical or ovoid, with hexaradiate head skeleton (Figure 2D). Mature females were pure white initially, turning golden yellow on maturation (Figure 1A). The posterior of the female bore the vulval basin / fenestra where the vulval slit was located. The anus was distinct and often seen at the point in the cuticle where the 'V' shape tapers to an end. The number of cuticular ridges found in the area between the anus and the edge of the fenestra was counted as an aid to the identification of *Globodera* species (Figure 3C).

Table 1. Measurement (µm) of Indonesian PCN: cysts, juveniles, females, males, and eggs

No.	Characters	PCN samples */			
		East Java, location 1	East Java, location 2	East Java, location 3	Central Java
Cysts					
1.	Width	371.0 ± 103.7a	380.0 ± 96.5a	378.0 ± 95.0a	374.0 ± 66.5a
2.	Length	456.0 ± 31.8a	457.0 ± 33.4a	470.0 ± 44.3a	450.0 ± 37.1a
3.	Fenestra diameter	19.4 ± 4.8a	19.0 ± 4.6a	20.0 ± 4.2a	19.0 ± 4.6a
4.	Distance(anus-fenestra)	65.0 ± 10.6a	66.0 ± 8.3a	65.0 ± 7.0a	66.0 ± 8.3a
5.	Neck length	104.0 ± 79.2a	104.0 ± 79.2a	110.0 ± 75.7a	105.0 ± 47.8a
6.	Granek's ratio	4.4 ± 1.8a	3.8 ± 1.1a	3.6 ± 0.9a	3.9 ± 0.9a
7.	Number cuticular ridges (average)	16.0 – 28.0a (22.0)	15.0 – 30.0a (20.0)	16.0 – 32.0a (21.0)	14.0 – 30.0a (23.0)
Second-stage juveniles (J2)					
8.	Body length	460.0 ± 81.5a	462.0 ± 90.5a	452.0 ±96.9a	457.0 ± 97.9a
9.	Width at excretory pore	17.7 ± 0.6ab	17.8 ± 0.9b	17.2 ± 0.9a	17.5 ± 1.1a
10.	Stylet length	22.0 ± 1.4a	23.0 ± 1.7b	23.0 ± 1.3b	24.2 ± 1.1c
11.	Tail length	45.0 ± 4.6a	45.0 ± 4.3a	44.0 ± 5.2a	45.4 ± 4.5a
12.	Tail width at anus	11.8 ± 1.4 a	12.0 ± 1.1a	11.7 ± 1.4a	11.5 ± 1.4a
13.	Head width at base	4.7 ± 0.9a	4.5 ± 0.5a	4.3 ± 1.2a	4.3 ± 1.2a
14.	Hyaline tail length	27.0 ± 3.9a	27.0 ± 4.2a	28.0 ± 3.5a	27.6 ± 4.1a
15.	Knob stylet	Round	Round	Round	Round
Females					
16.	Diameter of vulval basin	21.0 ± 4.0a	20.0 ± 3.4a	22.0 ± 3.1a	21.0 ± 3.8a
Males					
17.	Body length	1038.0±124.0b	1064.0±124.0b	1042.0±144.0ab	1044.0±116.0a
18.	Width at excretory pore	27.39 ± 3.03a	27.85 ± 3.06a	27.22 ± 2.74a	27.97± 2.65a
19.	Stylet length	25.65 ± 2.14b	25.34 ±2.28ab	25.44 ± 2.14a	24.36± 1.51a
20.	Tail length	5.57 ± 0.82a	5.48 ± 0.52a	5.81 ± 0.68a	5.69 ±0.52a
21.	Head length	7.31 ± 0.84b	6.53± 0.88b	6.80 ± 0.62b	6.51± 0.88a
22.	Head width at base	12.24 ± 1.39b	11.72 ± 1.54b	13.06 ± 1.35a	12.00 ±1.53b
23.	Spicule length	31.0 ± 5.53a	32.36 ± 4.32b	30.02 ± 5.66b	36.04 ±2.11b
Eggs					
24	Length	100.3-108.0a	90.8-109.9a	101.0-105.0b	102.1-105.9a
25	Width	40.2 -57.0bc	41.0 - 49.5c	50.0 - 53.9a	47.0- 50.9a

***/** Mean of 25 (cyst), 50 (J2), 25 (female), 50 (male), and 50 (egg) individuals

The male was vermiform in shape with a short tail and had no bursa. On fixation, the body assumed a C or S shape with the posterior region twisted at a 90 degree angle to the remainder of the body. The rounded head was offset and bore 6-7 annules. The head was strongly developed having a hexaradiate skeleton. The stylet was strong and had backward sloping knobs. The tail tip was rounded with a pairs of terminal spicules. The eggs of *G. rostochiensis* are always retained within the cyst body. Each cyst contains 300 – 500 eggs that will develop to juveniles. The eggshell surface was smooth and microvilli were not present.

Morphometric and morphological observation showed less variable characters and measurement of each sampled population. Characterization of cysts and J2 is the most important step in a conventional species identification of PCN, with additional information of males, females, and eggs. Miller and Gray (1972) used the fenestral – anus region to determine *Heterodera tabacum*, *H. Virginiae*, and *H. Solanacearum*. The similar procedure was also employed by Fleming & Powers (1998) that used the cuticular ridges pattern in the area between anus and vulval basin to distinguish *Globodera* species. Characterization on all cyst samples in this study showed the character of cuticular ridges as follow: average number of ridges was above 19, arranged in a parallel pattern, and had Granek's ratio of more than 3. According to Fleming and Powers (1998), those characters lead to *G. rostochiensis*. Other observations on morphometric and morphological characters, such as knob stylet and stylet length of J2, supported the result. All measurements are in micrometers, and listed in Table 1.

CONCLUSION

Indonesian PCN populations collected from three locations at Sumber Brantas, Kota Batu (1,600 – 1,800 m, a. s. l.) were identified as a single species, *Globodera rostochiensis* (golden potato cyst nematode) based on their morphometric and morphological characters . The same result was shown in the population collected from Karang Tengah, Banjarnegara, Central Java (1,700 m, a. s. l.).

ACKNOWLEDGEMENT

This paper is part of the doctoral research of the first author; "Identification, Bioecology study, and resistance of selected potato cultivars to potato cyst nematode (*Globodera* spp.)", under the supervision of the co-authors. The research was partly financed by a scholarship from BPPS (Directorate of Higher Education, Indonesia) which allowed the author to pursue her doctoral degree at the Post Graduate School, Bogor Agricultural University.

REFERENCES

Baldwin JG and M Mundo-Ocampo. 1991. Heteroderinae, cyst and non cyts forming nematodes. pp. 275-362. *In.* WR Nickle (eds.). Manual of Agricultural Nematology. New York, Basel, Hongkong: Marcel-Dekker.

Berg G, Russell S, Peter M. 2000. Developing a better way of managing PCN in Australia. IHD at Potatoes 2000 "Linking research to practice".

Daryanto. 2003. Status penyebaran dan kerugian nematoda sista kentang pada tanaman kentang. Disampaikan pada Lokakarya Nematoda sista kentang 11-12 Desember 2003, Yogyakarta. 8 hal.

Fleming CC and TO Powers. 1998. Potato Cyst Nematode Diagnostics: Morphology, Differential Host and Biochemical Technique. pp. 91-114. *In* Potato Cyst Nematode-Biology, Distribution and Control. Marks, R.J & Brodie, B.B (eds.). Publ. CAB International.

Golden AM. 1990. Preparation and mounting nematodes for microscopic observations. Pp. 197-205. *In* B. M. Zuckerman, W. F. Mai, and L. R. Krusberg (eds.). Plant Nematology Laboratory Manual. Amherst, MA : University of Massachusetts Agricultural Experiment Station.

Hooper DJ. 1970. Handling, fixing, staining, and mounting nematodes. Pp. 39-54. *In* J. F. Southey. Laboratory Methods for Work with Plant and Soil Nematodes. Ministry of Agriculture, Fisheries & Food, London.

Kort J, Ross H, Rumpenhorst HJ, Stone AR. 1977. An international scheme for identifying and classifying pathotypes of potato cyst-nematodes *Globodera rostochiensis* and *G. pallida*. Nematologica23: 333-339.

Miller LI and BJ.Gray. 1972. *Heterodera solanacearum* sp., a parasite of solanaceous plants. Nematologica 18 : 404-413.

Stone AR. 1973a. *Heterodera pallida*. C.I.H. Descriptions of Plant Parasitic Nematodes. Set 2, No. 17.

Stone AR. 1973b. *Heterodera rostochiensis*. C.I.H. Descriptions of Plant Parasitic Nematodes. Set 2, No. 16.

Shepherd AM. 1985. Extraction and estimation of cyst nematodes. pp. 31-49. *In* J. F. Southey. Laboratory Methods for Work with Plant and Soil Nematodes. Ministry of Agriculture, Fisheries & Food, London.

J. ISSAAS Vol. 13 No1. pp.39-52 (2007)

ECONOMIC ANALYSIS OF HIGHLAND VEGETABLE CULTIVATION IN BENGUET AND LAGUNA, PHILIPPINES

Ma. Eden S. Piadozo[1] and Akimi Fujimoto[2]

[1] College of Economics and Management, University of the Philippines at Los Banos
[2] Faculty of International Agriculture and Food Studies, Tokyo University of Agriculture

(Received: October 17, 2006; Accepted: November 11, 2006)

ABSTRACT

This paper attempts to clarify differences in economic performance of vegetable cultivation between the long established and newly established vegetable growing areas in the Philippines, based on a questionnaire survey of 50 farmers each in the highlands of Benguet and Laguna. Temperate vegetables such as cabbage, carrot and potato were grown in Benguet, while tomato, sweet potato, chayote, cabbage and beans were the major crops grown in the Laguna village. The former was a long established vegetable area in the country, whereas the latter was a relatively new area. Benguet farmers were market-oriented, and generated higher income and profit levels from vegetable production, whereas in Laguna temperate crops were not profitable, especially during the rainy season, but functioned to provide employment for the farmers. In well established areas, land area and fertilizer were the main determinants of vegetable income, and in the case of new areas, land and labor were more important in income determination

Key words: temperate vegetables, cultivation practice, cropping patterns, profitability, farm business analysis, income function

INTRODUCTION

A large part of the forest in tropical highlands has been converted to temperate vegetable fields in recent decades in Southeast Asia, but the conditions do not always assure a high level of production due to many constraints such as rugged topography, lack of water and the distance from the farm to the market. Often highland vegetable growers suffer from low income, which presents a serious challenge to agricultural policy in the area (Fujimoto and Miyaura 1996). A farm management study of 50 farmers each in Benguet and Laguna Provinces in the Philippines was conducted in order to clarify their economic conditions and consider ways to improve their production mechanism. Initially a questionnaire survey was conducted in 1999 and a follow-up survey and interviews were made in 2003-2004.

The study sought to identify the kinds of vegetables grown and the cultivation practices for major crops, and to analyze the production performance and profitability of vegetable farming in the study areas. Focus will be given to the impact of farm size, and farm experience and education on the farmers' income. This paper depends heavily on data obtained from the initial questionnaire survey for quantitative analysis, while qualitative analysis is derived from more recent information.

RESEARCH METHODOLOGY

Areas and Farmers Studied

The study was conducted in two major vegetable producing areas: Benguet and Laguna, Philippines (Fig. 1). Benguet has long been known as the salad bowl of the Philippines, where temperate vegetables such as carrots, cabbage, potatoes, Chinese cabbage, and celery are popularly grown. This province is considered the largest vegetable producing area in the Cordillera Autonomous Region (CAR). Laguna province is also known as a major vegetable growing area especially in Southern Luzon. In fact, it is the highest producer of vegetables in all the 11 provinces in the Southern Tagalog region.

Fig. 1

The questionnaire survey was conducted in two villages in these two provinces: Barangay Nutubleng in the Municipality of Buguias, Benguet, and Barangay Bukal in the Municipality of Nagcarlan, Laguna. The former village is located at 2,500 m above sea level and the latter at 400-700 m above sea level. Reflecting the high altitude, the temperature ranged from 13.6 to 22.8^{o}C in the study village in Benguet, while the range was from 20 to 24°C in the Laguna village.

It should be clearly noted here that Benguet is a well established temperate vegetable area in Luzon in that it has been supplying vegetables to Manila and other areas in Luzon for as long as six decades. In this sense, Benguet exemplifies an open economy where farmers have access to production technologies, production programs, market and technical assistance and information from the government. In contrast, temperate vegetable production in Laguna is only a recent phenomenon. There is only a single road to Bukal, going up the hill from Nagcarlan town center, and all goods, services and information have to rely on this road, which goes through forests and housing areas. Although this may present protection for the local community, it also typifies the closed nature of the community of farmers in that entry into the village is easily checked and farmers' access to technology and information is limited. In addition, the relatively small size of the production capacity of the area restricts

competitive activities by market agents, resulting in limited sources of inputs and information as well as number of outlets.

RESULTS AND DISCUSSION

The frequency distribution of farmers studied according to vegetable land area owned and operated in the two study areas are shown in Table 1. More farmers in Benguet tended to own and operate a larger area than those in Laguna. In fact, as many as 30% of the farmers cultivated an area larger than 2.0 ha in Benguet, whereas only 4% did so in Laguna. In contrast, 74% of farmers in Laguna operated an area less than 1.0 ha, whereas only 24% did so in Benguet.

Table 1. Number of farmers by size of land owned and operated**.**

Farm size (ha)	Benguet		Laguna	
	Owned area	Operated area	Owned area	Operated area
0.10-0.49	1	1	12	17
0.50-0.99	14	13	21	20
1.00-1.49	15	15	10	8
1.50-1.99	7	6	4	3
2.00-2.49	9	8	3	2
2.50-2.99	0	1	0	0
> 3.0	4	6	0	0
	50	50	50	50

The different numbers of the farmers who owned and operated areas in each size category implies that there were cases of tenancy transactions. Table 2 shows the number of farmers and average farm size by tenurial status in the two study areas. It is confirmed that average farm size was much larger in Benguet (1.37 ha) than in Laguna (0.68 ha). The owned lands were actually covered by a land title or property declaration, thus guaranteeing their legal land ownership status. However, as many as 36% and 50% of the farmers in Benguet and Laguna appeared to cultivate some area of land rented in from others.

Pure tenant farmers accounted for 8% in Benguet and 14% in Laguna. The predominant tenancy form was a sharing contract in Benguet and fixed rent in Laguna, but most of the tenant farmers in Laguna were renting the land from hacienda owners with a rental free arrangement.

Table 2. Number of farmers and average farm size by tenurial status.

Tenure	Benguet		Laguna	
	No.	Average farm size (ha)	No.	Average farm size (ha)
Owner farmers	32	1.21	25	0.71
Owner-tenant farmers	14	1.75	18	0.79
Tenant farmers	4	1.38	7	0.32
Overall	50	1.37	50	0.68

Cultivation Practices of the Major Crops

In the Benguet village, cabbage, potatoes and carrots are the major crops, grown by 84%, 50% and 36% of the farmers respectively (Table 3). Only a few farmers (6%) were planting other crops like Chinese cabbage, radish and shasta daisy. Actually, the village of Natubleng gained prestige among dealers and buyers at the La Trinidad Trading Post for producing high quality cabbage (Robles, 1998). As such the area devoted to cabbage production was the largest.

In contrast, tomato was the most popular crop grown by 96% of the farmers in our Laguna village. This was followed by cabbage, grown by 42% of the farmers, beans (34%), chayote (24%) and sweet potato (22%). Other crops grown included Chinese cabbage, radish, bitter gourd and eggplant. It is clearly seen that some traditional crops alongside the temperate crops were grown in this area, reflecting the nature of middle level altitude where a mixture of tropical and temperate vegetables could be observed. Tomato growing was usually limited to the dry season, while the rest of the crops could be planted during the rainy season as well.

Table 3. Number of farmers and area planted to specific vegetables.

Crops Grown	No. of farmers	Planted area (ha)
Benguet		
Cabbage	42	0.65
Potato	25	0.75
Carrot	18	0.75
Chinese cabbage	1	0.20
Radish	1	0.25
Shasta daisy	1	0.25
Laguna		
Tomato	48	0.45
Cabbage	21	0.26
Beans	17	0.17
Chayote	12	0.18
Sweet potato	11	0.29
Chinese cabbage	2	0.25
Radish	3	0.36
Bitter gourd	1	1.00
Eggplant	1	0.25

Farmers generally planted vegetables twice a year in both study areas. This cropping intensity seemed to be much lower than a similar temperate vegetable area in Indonesia (Suryadi 2000). In both Benguet and Laguna, the farmers seemed to have difficulty in maximizing the use of their vegetable fields because their plots were situated on steep slopes at a distance from the housing area or were within a forest. These conditions prevented them from increasing the intensity of their cultivation.

About 28% of the farmers grew the same vegetables twice a year during both rainy and dry seasons: cabbage (14%), carrot (10%), potato (2%) or Chinese pechay (2%) (Table 4). Another 60% of the farmers alternated vegetables grown in both seasons, the common patterns being cabbage-carrot (18%), potato-cabbage (16%), cabbage-potato (8%) and carrot-cabbage (8%). In other words, three kinds of vegetables, cabbage, potato and carrot, appeared to be planted throughout the year under various cropping patterns. Unfortunately, whether or not these vegetables constituted a part of an

established crop rotation system could not be ascertained. According to the farmers interviewed, however, crop rotation system was not properly established in this area, and the choice of vegetables to be planted were largely influenced by the on-going price levels rather than technical considerations regarding soil fertility and soil borne diseases. In fact, as mentioned earlier, there were some farmers who continuously planted cabbage in spite of the emergence of club root disease. The need for a sustainable cropping system with the introduction of crop rotation was also pointed out by an earlier study in the area (Fujimoto and Miyaura 1996).

Table 4. Number of farmers and area planted by the number of crops planted in Benguet

Cropping patterns	No. of farmers	Planted area (ha)
Same crops twice		
Cabbage-cabbage	7	0.32
Carrot-carrot	5	0.49
Potato-potato	1	0.28
Chinese pechay - Chinese pechay	1	0.20
Two different crops		
Cabbage-carrot	9	1.28
Cabbage-potato	4	0.72
Cabbage-radish	1	0.25
Cabbage-shasta daisy	1	0.63
Potato-cabbage	8	0.68
Potato-carrot	2	0.25
Carrot-cabbage	4	0.86
Carrot-potato	1	1.00
Three crops		
[Cabbage + potato] –[carrot]	1	0.33
[Cabbage] – [potato + carrot]	1	0.50
Four crops		
[Cabbage + potato] – [potato + cabbage]	1	0.50
[Cabbage + carrot] – [cabbage + carrot]	2	0.45
Six crops		
[Cabbage + carrot + potato] – [cabbage+ carrot + potato]	1	0.33
TOTAL	50	

Economic Analysis of Vegetable Growing

Profitability of the Major Vegetables

The profitability of some of the major vegetables grown in the study areas on a per 0.1 hectare basis was analyzed. Costs have been classified into variable costs such as seeds, fertilizers, pesticides, labor and transportation, and fixed costs such as depreciation, interest on capital and payment made to the credit supplier for the land cultivated. Gross returns refer to the total revenue received by the farmers for the vegetables they disposed of in the market. Profitability measures are the farmers' profit after their total cost had been deducted from their gross returns and net income which is equivalent to their profit plus the returns to land and capital.

In Benguet, contract farming was a common practice and the trader-credit supplier provided all the material inputs needed in crop production (Table 5). The trader sometimes provided even the food required for the farmer's family, such as rice, sugar and lard. After the crop had been sold, all the trader's expenses were deducted from the gross sale, and the remaining sale was divided between the farmer and the trader according to their agreed sharing rate. The sharing arrangement usually depended on the amount loaned out to the farmer. If the farmer was given a loan of P50,000 and the land belonged to the trader, the sharing arrangement was 50-50.

Table 5. Profitability of contract and non-contract farming per 0.1 ha in Benguet, 1999**.**

Unit: peso

ITEM	Rainy Season		Dry Season	
	Contract (n=8)	No Contract (n=20)	Contract (n=6)	No Contract (n=20)
Cabbage				
Total Variable Cost	15,854	6,629	17,029	7,963
Total Fixed Cost	1,337	1,527	1,048	3,349
Total Cost (A)	17,191	8,156	18,077	11,313
Saleable Production (kg)	2,920	2,214	4,559	2,018
Gross revenue (B)	32,000	16,439	58,834	13,342
Profit (B-A)	14,809	8,283	40,758	2,029
Net income	15,078	9,786	40,758	4,074
Carrot				
Total Variable Cost	14,055	6,615	13,339	5,108
Total Fixed Cost	1,206	318	3,192	313
Total Cost (A)	15,261	6,933	16,532	5,421
Saleable Production (kg)	3,331	1,044	1,527	783
Gross revenue (B)	38,050	20,829	26,643	13,503
Profit (B-A)	22,789	13,896	10,111	8,082
Net income	22,789	15,105	10,387	9,207
Potato				
Total Variable Cost	16,453	5,070	19,425	6,631
Total Fixed Cost	5,632	1,030	701	1,274
Total Cost (A)	22,084	6,100	20,126	7,905
Saleable Production (kg)	1,731	1,042	1,385	868
Gross revenue (B)	21,112	10,441	19,250	9,089
Profit (B-A)	(972)	4,341	(876)	1,184
Net income	4,294	4,956	(517)	3,358

It is clear that the vegetable farmers on contractual arrangement had a higher variable cost, indicating that more inputs were used in their vegetable production, compared to those farmers under own management. The financing provided by the traders enabled the contract farmers to buy a larger quantity of necessary farm inputs. For instance, material input cost for potato cultivation was as much as P10,604 and P15,175 for the contract farmers in rainy and dry seasons respectively, while the corresponding figures for the non-contract farmers were a mere P3,582 and P3,966 respectively. As a result, the saleable production was 1,731 kg in the rainy season and 1,385 kg in the dry season for the contract farmers, whereas the non-contract farmers sold 1,042 kg and 868 kg only respectively.

However, due to higher cost and lower price under contract farming, the farmers received a negative profit and low net income, compared to the non-contract farmers who obtained a profit of P4,341 and P1,184 in the rainy and dry seasons respectively.

However, it was more profitable for the contract farmers to grow carrot and cabbage. The profit per 0.1 ha of cabbage appeared to be P14,809 in the rainy season and P40,758 in the dry season under contract farming, whereas the corresponding figures for carrot were P22,789 and P10,111. It must be noted that these profit and net income were the total before sharing between the two parties. In other words, the contract farmers received a lower income than the non-contract farmers except for cabbage farming in the dry season.

As shown in Table 6, among the crops grown in Laguna, temperate vegetables such as cabbage and Chinese cabbage recorded a negative profit due to high occurrence of pests and diseases, resulting in a low level of production. Even chayote and radish also recorded a negative profit during the rainy season. However, if family labor cost and interest on own capital investment were excluded from the cost calculation, the net income of the farmers would be positive, pointing to the existence of the simple reproduction mechanism. Needless to say, should they have paid a rental to the hacienda owners, many of them would likely go bankrupt. Since these farmers were considered to have almost zero opportunity cost for their labor, one may say that growing these crops provided them the necessary employment and income.

Farm Business Analysis

The average annual costs and profit per farm in both study areas are shown in Table 7. In Benguet, material cost, transportation cost and rental payment accounted for about 84% of their gross expenditure. Since vegetable farmers in the area have a contractual arrangement with their credit supplier, payment for this purpose accounted for 30% of the total cost. The rugged terrain of the uplands makes transporting of the products difficult. On the average, they paid P1.00 per kg for transporting their produce to the market as most of these farmers delivered their produce to the vegetable trading post in La Trinidad, 84 km away from the production site. About one third of their production cost went to material inputs. Pesticide and chemical fertilizer accounted for 67% of this production cost. Labor cost, however, only accounted for about 10% of their total cost implying that these farmers had learned how to economize on this resource knowing that labor was relatively scarce in the area.

On the other hand, Laguna farmers spent more on labor input where family labor alone accounted for about 53% of their total cost, followed by material inputs at 37%. As is the case in Benguet, expenditure on pesticide was also high in Laguna.

It is clear that an average farmer received a profit of more than P200,000 in Benguet, while it was a mere P10,000 in Laguna. In terms of net income, the former recorded about P260,000 per year, while the latter about P35,000. The huge differences in profit and net income between the two study areas reflected different farm size, production costs, productivity and price levels. Due to the higher returns received in Benguet, a higher profit and net income were realized despite the high cost they incurred.

Table 7. Average production cost and profit per farm per year by location, Philippines, 1999**.**

ITEM	BENGUET		LAGUNA	
	Pesos	%	Pesos	%
Gross Returns (A)	390,188		57,974	
Material Cost				
Seeds	10,250	5.7	5,488	11.6
Chicken Manure	18,053	10.0	226	0.5
Chemical fertilizer	8,027	4.4	3,476	7.3
Pesticide	18,497	10.2	6,597	13.9
Others	-		1,906	
Sub-total	54,827	30.3	17,693	37.4
Transportation cost	41,713	23.1	100	0.2
Hired Labor Cost	9,625	5.3	3,380	7.1
Family Labor Cost (a)	6,534	3.6	25,082	53.0
Rental paid	54,712	30.3	-	-
Interest paid ((b)	4,708	2.6	571	1.2
Depreciation (c)	8,553	4.7	536	1.1
Total Variable Cost	167,411		46,255	
Total Fixed Cost (b+c)	13,261		1,107	
Total Cost (B)	180,671		47,362	
Profit (A-B)	209,516		10,613	
Net income (C=A-B+a)	261,051		35,695	
Net income ratio (C/A) (%)	55.4		61.6	
B/C ratio (A/B)	2.2		1.2	

Note: Rental in Benguet was calculated as a proportion of gross sale, and as such was not included in fixed cost.

The breakdown of annual production costs and profit by farm size in both study areas are shown in Table 8. The size of farm was hypothesized to play an important role in farm success because it reflects availability of capital, access to credit and even managerial capability. In the case of Benguet, the larger the farm, the higher the farmers' gross returns. In fact, the highest average gross return was obtained by the largest farms which were more than 3.0 ha in size. The net profit was P1,478,200 during the production year. The benefit cost ratio was also high at 3.24. Smaller farms (less than 1.0 ha) had a lower profit and net income; the benefit cost ratio was also low.

However, Laguna farmers showed a different trend. Those farmers operating less than 0.5 ha of land earned a profit of P5,590 per year, and those operating between 0.5 and 0.9 ha earned P8,687. Farmers with farm size of 1.0 ha or larger recorded a negative profit on the average, but in terms of net income, including the return to family labor, the larger the farm size, the higher the net income, indicating that the income of the vegetable farmers largely comes from their unpaid family labor. In fact this is regarded as a way of providing employment to the unemployed sector of the village economy.

In addition, both farming experience and education were considered to be determinants of successful performance in vegetable farming. Experience would allow farmers to adjust to changing economic conditions and adopt the most efficient cultural practice. Higher educational attainment implies that farmers are more knowledgeable and have a better access to technologies and information.

Table 8. Average production cost and profit per farm per year by farm size and by location, 1999.

Item	Farm s	
	0.01 - 0.49	**0.50 - 0.99**
Benguet		
Gross Returns (A)	40,750	96,266
Total Variable Cost	28,182	60,880
Total Fixed Cost	1,380	9,652
Total Cost (B)	29,562	70,532
Profit (A-B)	11,188	25,734
Net income	17,089	32,180
Laguna		
Gross Returns (A)	42,486	50,909
Total Variable Cost	36,361	41,754
Total Fixed Cost	535	469
Total Cost (B)	36,895	42,222
Profit (A-B)	5,590	8,687
Net income	23,073	29,238

Table 9. Average production cost and profit per farm per year by farming experience and by location, 1999.

Item	Farming experience (years)					
	5 ~ 10	**11 ~ 20**	**21 ~ 30**	**31 ~ 40**	**41 ~ 50**	**More than 50**
Benguet						
Gross Returns (A)	247,808	189,823	616,001	619,971	161,350	
Total Variable Cost	167,891	134,616	229,839	125,671	171,933	
Total Fixed Cost	6,643	13,533	14,342	8,284	19,027	
Total Cost (B)	174,534	148,149	244,181	133,955	190,960	
Profit (A-B)	73,274	41,674	371,820	486,017	(29,610)	
Net income	78,241	48,003	377,684	494,762	(17,844)	
Laguna						
Gross Returns (A)	55,003	36,593	34,553	75,877	50,350	68,600
Total Variable Cost	36,470	82,007	54,875	64,552	59,204	20,175
Total Fixed Cost	980	808	750	1,182	729	269
Total Cost (B)	37,450	82,815	55,625	65,734	59,933	20,444
Profit (A-B)	17,553	(46,222)	(21,072)	10,143	(9,584)	48,156
Net income	32,821	(27,479)	10,387	46,173	22,863	60,624

Except for very young and old farmers, the longer experience in vegetable growing, the more successful the farming would become in Benguet (Table 9). They had an increasingly higher profit and net income, with increasing years of experience. In contrast, there was no clear correlation between experience and farm performance in the case of Laguna. Although those farmers with more than 50 years of experience earned the highest profit of P21,489, those with 11-20, 21-30 and 41-50 years experience suffered losses from their production due to low production, gross returns and high cost incurred.

It is interesting to note that those farmers with college education received the lowest profit in Benguet but showed the best performance in Laguna (Table 10). In Benguet, farming experience was a positive determinant of successful performance, and it is likely that the college educated farmers had a shorter experience at the time of this study. In Laguna, those farmers with primary school education also recorded a positive profit but their net income appeared to depend largely on family labor. In contrast, those farmers with college education obtained a much larger profit and net income.

In short, the analysis of farming experience and education seems to indicate the following realities. In Benguet, where vegetable farming had long been established and various technologies and information were somehow available to the farmers through the existing institutions, farming experience of the farmers had been a good determinant of successful business operation. In contrast, in Laguna which was a relatively new vegetable producing area and support systems had been largely limited, there was more room for a greater role for education in successful farming, in addition to family labor and farm experience which were the traditional determinants of net income in small farming.

Income Function Analysis

In order to clarify quantitatively the mechanism of vegetable income determination, the Cobb-Douglas production function was used. Since the farmers were producing different kinds of vegetables in a year, the gross value derived from the sale of their vegetables represented their output. The variables taken into the analysis are as follows. The dependent variable is the gross sale per farm in the year under study, expressed in terms of pesos. The independent variables included the following. X_1 is the area planted to vegetables in terms of hectares, X_2 the total labor input, both family and hired labor, expressed in terms of peso, and X_3 the material input in peso. This material input is subdivided in order to examine the contribution of fertilizer and pesticide separately: X_4 refers to fertilizer cost in peso, and X_5 pesticide cost in peso.

Table 10. Average production cost and profit per farm per year by education and by location, 1999.

Item	Educational attainment		
	Elementary	**High school**	**College**
Benguet			
Gross Returns (A)	428,235	355,942	320,070
Total Variable Cost	182,829	131,406	263,046
Total Fixed Cost	14,132	10,890	17,304
Total Cost (B)	142,961	142,296	280,351
Profit (A-B)	285,274	213,645	39,719
Net income	292,252	219,303	48,660
Net income ratio (%)	68.3	61.6	15.2
B/C ratio (A/B)	3.0	2.5	1.1
Laguna			
Gross Returns (A)	59,152	42,675	77,940
Total Variable Cost	55,730	42,766	45,320
Total Fixed Cost	817	652	1,123
Total Cost (B)	56,546	43,418	46,443
Profit (A-B)	2,606	(743)	31,497
Net income	31,088	20,292	46,347
Net income ratio (%)	52.6	47.6	59.5
B/C ratio (A/B)	1.1	1.0	1.6

The coefficients of multiple determination (R^2) ranged between 43% and 45% for Benguet, and 34% and 42% for Laguna, indicating that more variables are needed to improve the explanatory power of the models (Table 11). However, at least two regression coefficients are significant and provide interesting insights as follows. First, the planted area was a significant factor in determining total income from vegetable farming in both areas. It seems that 10% increase in the planted area would result in 4.8 to 5.7% increase in income in Benguet, but the contribution is smaller in Laguna, 2.3 to 3.4% increase. Second, a larger contribution is expected from labor input rather than land area in the case of Laguna, which is consistent with our earlier discussion in that vegetable income was largely determined by the amount of labor input. Actually the regression coefficient for labor input in Benguet was not significant even at the 10% probability level.

Third, in Benguet, the material input, especially fertilizers, appeared to be the more important factor. This is again consistent with our earlier discussion that the contract farmers with higher inputs obtained a higher income, except for potato. The importance of fertilizers was also true for Laguna where yield of vegetables was generally low, resulting in a low level of income from vegetable farming. Lastly, it must be clearly mentioned that the regression coefficient for pesticide use was not significant in both areas, and it has a negative sign in Benguet. It is widely known that vegetable farmers tended to apply pesticide at an excessive level, often disregarding the seriousness of pest and disease outbreaks, causing a critical problem of pesticide residue and environment degradation. Our analysis also confirms the urgent need for reducing pesticide application.

Table 11. Estimates of income function in Benguet and Laguna**.**

Variables	**Model I**		**Model II**	
	Regression coefficients	**t-values**	**Regression coefficients**	**t-values**
Benguet				
Constant,a	6.273**	1.931	6.066**	1.882
Planted area,b1	0.569**	2.053	0.479**	1.674
Labor, b2	0.300	0.976	0.254	0.814
Material input b3	0.263***	2.440		
Fertilizer, b4			0.403*	1.763
Pesticide, b5			-0.050	-0.314
R2	0.428		0.451	
F value	11.475		9.232	
N	50		50	
Laguna				
Constant,a	4.992*	2.128	5.365***	2.449
Planted area,b1	0.226*	1.222	0.342**	1.863
Labor, b2	0.483**	1.889	0.173	0.671
Material input b3	0.096	0.498		
Fertilizer, b4			0.356**	2.036
Pesticide, b5			0.085	0.542
R2	0.336		0.414	
F value	7.474		7.959	
N	50		50	

***Denotes significance at the 1% probability level.
**Denotes significance at the 5% probability level.
*Denotes significance at the 10% probability level.

CONCLUSION

Based on a detailed questionnaire survey of vegetable farmers in Benguet and Laguna Provinces in the Philippines, the study clarified the cultivation practices of the major vegetables and their economic performance. It became clear that in Benguet which is the long established vegetable bowl of the country, three kinds of vegetables, cabbage, carrot and potato, predominated in the area throughout the year. They were grown in both rainy and dry seasons, but no proper crop rotation system appeared to exist. In contrast, Laguna is a rather new area for vegetable production and support systems were rather limited. Due to a middle altitude, both traditional and temperate vegetables were grown, but yield levels were generally low.

Farm business analysis clearly indicated a high profitability of vegetable growing in Benguet, where contract farming system was a common practice. The larger the farm size, and the longer the farming experience, the higher was the profit and net income. Education appeared to play a minimum role in Benguet, where the clearly established tradition of vegetable farming resulted in experience being a significant factor. In contrast, in Laguna where vegetable growing was still a new enterprise, education seemed to play a more significant role.

Income function analysis revealed that in addition to the area planted, fertilizer made a large contribution to income determination in both areas, but pesticides did not seem to be a significant determinant of income. It was also interesting to note that income was largely determined by labor use in Laguna, whereas the contribution of increased labor would not affect income level in Benguet. However, for better clarification of income determination and suggestions for improved vegetable farming, further studies are needed especially in relation to cropping system, fertility maintenance, pest control technology, and marketing practices.

REFERENCES

Ayeras, Q. 1992. Vegetable Crop Production in the Benguet State University Farm, La Trinidad, Benguet. Major Practice Report, UPLB.

Boquiren, R. 1989. The History and Political Economy of the Vegetable Industry in Benguet. Working Paper 14. Cordillera Studies Center, University of the Philippines Baguio.

Cruz, A. 2005. Enterprise Study on Vegetable Production in Barangay Silangan Lazaan, Nagcarlan, Laguna. Special Problem Report, UPLB.

Fujimoto, A. and R. Miyaura, 1996, An Ecological and Economic Assessment of Vegetable Cultivation in Highland Areas in Southeast Asia*, J of Agricultural Science, Tokyo Nogyo Daigaku*, Vol.40, No.4

Miyaura, R., A.M. Suryadi and A. Fujimoto. 1998. Vegetable Cultivation Practices and Costs in Tropical Highland: A Case Study of Highland Bali, Indonesia. J Agricultural Development Studies, Vol 9, No 1.

Ranola R Jr. 1984. Cropping Systems and Determinants: Factors Influencing Cropping Patterns, Fertilizer Use and Resource Use Efficiency, PhD Thesis, University of Minnesota.

Tandang, L., R. Colting and P. Alipit. 2001. Overview of Vegetable Farming in Natublelng. Mimeographed.

Tapawan, Z. 1987. Economics of Farming Systems in the Upland Areas of Hamtic, Antique, Philippines. PhD Thesis, UPLB.

J. ISSAAS Vol. 13 No1. pp. 53-69 (2007)

INDUSTRY GROWTH AND INSTITUTIONAL CAPACITY BUILDING IN PHILIPPINE MICROFINANCE: AN OVERVIEW

Alessandro A. Manilay

Department of Agricultural Economics, College of Economics and Management
University of the Philippines Los Banos, College, Laguna, Philippines 4031

(Received: February 19, 2007; Accepted: June 10, 2007)

ABSTRACT

The continuing growth of the microfinance industry in the Philippines resulted in an increased demand for microfinance professionals. Building the capability to train personnel is a concern that requires serious attention for the sustainability of the industry. This paper reviews past capability-building efforts of the microfinance industry; evaluates the training resources that have been developed; and proposes an approach to further strengthen capability-building. Data utilized were gathered through mailed questionnaires and interviews of key informants. Secondary data were obtained from the People's Credit and Finance Corporation and from a previous study published by the Asian Institute of Management, Philippines.

Funds for microfinance training were mostly provided by international development agencies and training service providers were established to train personnel of microfinance institutions (MFIs). Later on, some MFIs conducted in-house training after developing the expertise. Most of the training resources are concentrated in the Metro Manila Area. Facilities are limited for outlying provinces in Luzon, Visayas and Mindanao. As a recommendation, the paper proposes that linkages between service providers and selected academic institutions strategically located across the country be established to hasten capability-building in other areas of the country.

Key words: Microfinance institutions, sustainability, training institutions, institutional linkages

INTRODUCTION

Microfinance is the "provision of a broad range of financial services such as loans, deposits, insurance, payment services, and money transfers to poor and low-income households"(Charitonenko, Campion & Fernando, 2004). According to Conroy (2003), the intended beneficiaries of such services often do not have access to formal financial institutions.

Microfinance is currently the Philippine's focal program in reducing poverty which affects 25.4 million Filipinos or 33% of the population in 2002 (NSCB, 2000). The beneficiaries of microfinance are small farmers, fisherfolks and other rural and urban microentrepreneurs (Llanto, 2004). The statement of the Governor of the Bangko Sentral ng Pilipinas (Central Bank of the Philippines), in addressing a stakeholders' forum on microfinance encapsulates the significance of microfinance in the nation's effort towards poverty alleviation when he declared:

"… there is an urgent need for microfinance to provide them [the poor] with opportunities to increase their economic activity, foster their spirit of entrepreneurship, facilitate employment and improve the quality of their lives… On our part, we at the Bangko Sentral ng Pilipinas will continue to be an active advocate of microfinance in our country." (Tetangco, A. M., 2005)

To stimulate industry growth, the government has provided an enabling policy environment that promotes the "development of sustainable microfinance institutions" (Daley and Sautet, 2005). In tandem with the active participation of international donor agencies, the country gained considerable mileage in poverty alleviation and growth towards a sustainable microfinance industry (Lllanto, 2004; Llanto, 2005 and ADB, 2005).

The rapid growth of the microfinance industry is a positive indicator for the country's agenda on poverty alleviation. However, it could create a vacuum in the industry's requirements for qualified and competent human resource as more banks open windows and establish new branches for microfinance; as other MFIs such as NGOs and credit cooperatives are set up; and as clients' needs develop from the mere provision of microcredit to bigger loans and other related financial services such as savings accounts, health and life insurance, fund remittances and the like.

Thus, the industry's capability to train its personnel becomes an essential element to ensure a sustainable microfinance industry. Charitonenko (2003) underscored this concern when she emphasized the need for "donors to focus on increasing the domestic availability of microfinance training courses and programmes" to build institutional capacity. In the same manner, Llanto (1997) recommended that MFIs continue "staff training and development of career paths for capable workers, upgrade pay scales and incentive schemes" to increase the attractiveness of the profession.

Given the above scenario, the following questions logically emerge which require some amount of elucidation: Where does the Philippine microfinance stand to address this likely concern on human resource development? Is the industry equipped to face the challenge?

Objectives

This paper presents an overview of the resources available to the Philippine microfinance industry for capability-building. Specifically, it documents statistics on industry growth and highlights achievements in capability-building in response to the demands of the market. It also proposes an approach to strengthen microfinance training in the country.

Sources of Data

The study benefited from previously written publications on Philippine microfinance. Information regarding training was largely based on the paper entitled, "The First Decade of Philippine Microfinance: 1992-2002", by M.F. Miranda and R. T. Chua which was published by the Asian Institute of Management (AIM). Data were also obtained through key informant interviews. Personal interviews were granted by PJ Bombeta of TSPI Development Corporation, Ma. Cecilia Tanael of Rural Bank of Mabitac, Raquel Castro of People's Credit and Finance Corporation (PCFC), Christopher Lomboy of Punla sa Tao Foundation and Generoso Octavio, a rural finance international consultant and founder of Ahon Sa Hirap, Inc. The TSPI Development Corporation is one of the oldest microfinance NGOs with several branches in the country while the Rural Bank of Mabitac is a formal financial institution that diversified into microfinance services with several branches in the province of Laguna. The PCFC serves as a major conduit for government and international development funds which are lent to microfinance institutions. Punla Sa Tao Foundation, on the other hand, is an organization geared at developing microfinance capability and business entrpreneurship. Additional information were gathered through questionnaires that were sent to 10 selected microfinance institutions located across the country. However, only nine of these organizations responded. The list of MFI respondents including the key informants appear as Table 1. Secondary data on industry growth were provided by the People's Credit and Finance Corporation (PCFC).

Table 1. List of respondents, microfinance institutions (MFI), Philippines, 2006

	Microfinance Institution	Location	Contact Person
1	Alalay sa Kaunlaran Sa Gitnang Luzon, Inc.	Cabanatuan City, Nueva Ecija	Rolando Victoria, Exec. Director
2	Rural Bank of Mabalacat	Dau, Mabalacat, Pampanga	Joynard Dizon, Analyst
3	Bangko Kabayan	Ibaan, Batangas	Norma P. Cometa Microfinance Program Head
4	Bangko Mabuhay (Rural Bank of Tanza Cavite)	Tanza, Cavite	Imelda Montenegro Microfinance Unit Head
5	Agricultural & Rural Development for Catanduanes, Inc.	Virac, Catanduanes	Jose Blas Henson Jr. HR Training Head
6	Center for Agriculture and Rural Development	San Pablo City, Laguna	Dr. Jaime Aristotle Alip Managing Director
7	CCT Credit Cooperative	Manila	Ruth Callenta, President
8	MILAMDEC Development Foundation	Cagayan de Oro City, Misamis Occ.	Fr. Emeterio Barcelon, SJ. Exec. Director
9	Bukidnon Integrated Network of Home Industries, Inc.	Calanawan, Bukidnon	Ma. Nemia Bornidor Project Manager
10	Rural Bank of Mabitac*	Mabitac, Laguna	Ma. Cecilia Tanael, Vice Pres.
11	TSPI Development Corp.*	Makati City, Metro Manila	Ruben de Lara, Exec. Director
12	Punla sa Tao Foundation*	Manila	Christopher Lomboy, Exec. Director
13	Generoso Octavio*	Alabang, Metro Manila	
14	PCFC*	Makati City, Metro Manila	Raquel Castro, Manager, MIS

* Key informant

RESULTS AND DISCUSSION

Growth Statistics in Philippine Microfinance

Non-collateralized money lending has existed among the ranks of the poor and the small entrepreneurs in the Philippines for a long time. However, it was not until 1989 when microfinancing as we now understand it was formally introduced in the country with the establishment of the Ahon sa Hirap, Inc. ASHI, as it is popularly known, is the first replication of the Grameen Bank of Bangladesh (Octavio, 2006). Since then, growth in the number of microfinance institutions (MFIs) has been significant. The Asia Resource Centre for Microfinance of Australia (2005) estimated that 500 non-government organizations (NGOs), 4,579 savings and credit cooperatives and 195 banks are already engaged in microfinance in the Philippines in 2005. In terms of geographical coverage, MFIs are present in all of the 80 provinces of the country (Castro, 2006, personal interview). Specifically, MFIs are found in all of the 117 cities around the nation and in 1,413 (94%) of its 1,500 towns. MFI clients served, classified by sector, are: farmers (34%), fisherfolk (29%), workers in informal sector (20%), urban poor (15%), indigenous people (1%) and the youth (1%) (PCFC, 2005).

Sustainability of microfinance institutions

The issue of sustainability of the microfinance institutions was raised as the industry grew. To be sustainable, MFIs ought to operate like business entities (Charitonenko, Campion and Fernando, 2004). Commercialization is the application of business oriented approaches to MFI operation which includes, among others, the following: developing diversified, demand-driven microfinance products and services; applying cost-recovery interest rates; use of commercial sources of funds (wholesale lending institutions) or commercial banks' mobilization of voluntary savings, or other market-based funding sources; and "operation as a for-profit, formal financial institution that is subject to prudential regulation and supervision and able to attract equity investment" (Charitonenko *et al.*, 2004).

According to Almario (2002), many MFIs in the Philippines associate commercialization with the "adoption of market-based principles" in their operations. This is an indication that the Philippine microfinance industry is developing along this direction. Charitonenko *et al*. (2004) mentioned Tulay Sa Pagunlad, Inc. (TSPI) and the Center for Agriculture and Rural Development (CARD) as examples of microfinance NGOs that have achieved financial self-sufficiency and have efficient operations. The authors reported that "despite the increase in the number of microfinance NGOs, the highest growth in commercial microfinance provision comes from formal financial institutions employing a commercial approach to microfinance such as NGOs that have transformed into regulated rural banks or thrift banks, *i.e.*, CARD Bank, Opportunity Microfinance Bank, ARDCI's Vision Bank, and Banco ng Masa, as well as existing cooperatives and rural banks that have adopted microfinance operations".

Growth in PCFC Conduits (1998-2006)

The People's Credit and Finance Corporation (PCFC) was empowered by Republic Act No. 8425 to be the lead government entity "specifically tasked to mobilize financial resources from both local and international funding sources for microfinance services for the exclusive use of the poor".[1] The PCFC started operations in 1998 as a wholesale lending institution. Funds are made available to accredited MFIs that act as retail conduits for onlending to poor households. To safeguard the resources lent to MFIs, PCFC requires the conduits to adhere to "appropriate accounting and reporting standards and operational methods" (Charitonenko, 2003).

Number of active conduits

Six types of MFIs deal with the PCFC, namely: cooperatives, NGOs, cooperative banks, rural banks, thrift/development banks and lending investors. The total number of conduits increased from 94 in 1998 to 202 in July 2006 at an average growth rate of 11% (Table 2). Growth was highly significant during the early years of operation. MFI conduits grew at a rate of 52% from 1998 to 1999 and 24% the following year. During this period, PCFC did not only engage in wholesale lending but also in "setting up retail outlets where there was minimal MFI activity". The conduits with significant increases between 1999 to 2000 were the cooperatives, rural banks and NGOs. The increase in the number of MFI borrowers started to stabilize thereafter. According to PCFC, the increase in the availability of funds for microfinancing from other sources (donor agencies, private sector) is a limiting factor in the continued increase in number of PCFC-accredited MFIs (Castro, 2006, personal communication). By July 2006, the PCFC reported that there were 202 conduits that were actively borrowing funds from them. The updated count by type of conduits is as follows: Rural Banks - 82, Cooperatives - 54, NGOs - 40, Cooperative Banks - 21, Thrift Banks - 3 and Lending Investors - 2. Despite the halt in the growth of PCFC conduits, lateral organizational expansion in terms of

[1] Sec. 14, R. A. No. 8425.

increases in the number of branches could be observed during the period 2002 to 2006. PCFC reported that, including branches, there are a total of 390 active conduits affiliated to their organization in 2006. CARD, for instance, indicated that its branches grew to a total of 127 as of December 31, 2005. Similarly, MILAMDEC Development Foundation, an NGO whose main office is located in Cagayan de Oro City, Misamis Oriental and Bangko Kabayan, a rural bank in Ibaan, Batangas, reported that they have 16 and 8 branches, respectively, as of June 2006.[2]

Table 2. Growth rate of PCFC conduits, by type of MFIs, Philippines, 1998 to July 2006

Type of MFI/ Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	Ave. Growth
Cooperatives	25	42	56	63	63	60	54	53	54	12.39%
NGOs	18	24	27	30	33	32	34	38	40	10.90%
Lending investor	0	1	1	1	1	1	1	2	2	25.00%
Coop banks	18	23	24	26	27	25	24	21	21	2.55%
Rural banks	31	51	66	68	76	83	83	82	82	14.59%
Thrift/Dev't banks	2	2	4	5	2	2	3	3	3	14.38%
Total no. of MFIs	94	143	178	193	202	203	199	199	202	
Growth rate (%)										
Total MFIs		**52%**	**24%**	**8%**	**5%**	**0%**	**-2%**	**0%**	**2%**	**11%**

Source: PCFC

Amount of loan releases to PCFC conduits and number of active clients served

In 1998, the PCFC released PhP 1.09 Billion to its conduits for microfinancing. By July 2006, this amount has increased to PhP 8.56 Billion, a 30.44% growth within the eight year period, according to Castro (2006). Initially, more than 40% of the available funds were absorbed by NGOs. The rural banks, however, became more aggressive in borrowing funds in the latter years as they became more confident in managing their microfinance programs and as their client outreach expanded. By July 2006, their percentage share of the total funds amounted to 43% while the share of NGOs went down to 27%.

About 47% of the total loan releases in 2006 were utilized in Central Luzon (15%), Western Visayas (13%), CALABARZON (10%) and Cagayan Valley (9%) (Table 3). The aggregate share of Mindanao of the PCFC loans was 23% as of July 2006.

The loan releases from PCFC were made available to poor households through the MFIs. The number of active household clients increased at an average rate of 46% from 1998 to July 2006 (Table 4). A significant decline in the number of clients is evident in 2004 (-0.2% growth rate) which was a result of the decrease in the number of PCFC conduits during the same year. More moderate growth rates, 18% and 12%, respectively, were demonstrated in 2005 and the first half of 2006.

The impact of microfinance under PCFC may be gauged by comparing the number of active clients to the number of poor household population of the country.[3] The 2006 data show that there were 1,844,533 households that benefited from the PCFC conduits representing 43.6% of the

[2] The figures were obtained directly from CARD, MILAMDEC and Bangko Kabayan through the mailed questionnaires.

[3] Poor households are those living below the poverty level. According to the National Statistics Coordinating Board (NSCB), the annual per capita poverty threshold for the Year 2000 was estimated at PhP 11, 605.00. A total of 4,234, 193 households or one third of the Philippine population in 2000 live below the poverty line.

population of poor households. This magnitude of outreach may be considered significant when compared to the performance that was reported in 2000, *i.e.*, 324,108 households or 7.65% of Filipino families living below the poverty line. On the other hand, others might view this as a poor performance considering that microfinance is a major poverty reduction program of the government. A higher percentage should have been achieved by now. This seemingly slow pace may be attributed to the fact that most MFIs have been conservative in their approaches in order to minimize loan defaults. For instance, there is a tendency to favor poor households that are already engaged in microenterprises than first-time borrowers.

Table 3. Total loan releases to PCFC conduits, by Region, Philippines, 2005-July 2006 (PCFC)

Region	2005	%	July-2006	%
CAR	123,449,390	2%	140,893,390	2%
Ilocos Region	410,947,477	5%	464,950,477	5%
Cagayan Valley	712,662,098	9%	763,007,098	9%
Central Luzon	1,150,606,011	14%	1,251,425,610	15%
CALABARZON	815,561,189	10%	867,646,189	10%
MIMAROPA	248,809,792	3%	252,909,792	3%
Bicol Region	402,496,676	5%	406,496,676	5%
Western Visayas	1,092,574,301	13%	1,145,574,301	13%
Central Visayas	604,516,584	7%	618,716,584	7%
Eastern Visayas	238,101,163	3%	277,071,163	3%
Zamboanga Peninsula	144,463,515	2%	153,088,329	2%
Northern Mindanao	451,216,281	6%	457,216,281	5%
Caraga	714,404,335	9%	722,214,335	8%
Davao Region	350,966,545	4%	386,638,998	5%
SOCCSKSARGEN	161,965,241	2%	166,965,241	2%
ARMM	49,645,240	1%	49,645,240	1%
NCR	428,709,264	5%	441,935,484	5%
TOTAL	8,101,095,102	100%	8,566,395,188	100%

Table 4. Total loan releases by number of poor households, PCFC, Philippines, 1998-2006

Type of conduit	1998	1999	2000	2001	2002	2003	2004	2005	2006
Cooperatives	10,278	25,612	44,488	62,570	98,008	142,159	139,515	223,610	246,867
NGOs	53,607	62,557	79,299	128,488	261,662	571,443	624,499	841,192	979,769
Lending investor	0	0	3,594	5,603	4,149	4,149	0	0	0
Coop banks	31,610	66,829	80,782	97,367	142,334	171,152	138,455	121,469	123,515
Rural banks	13,270	60,355	94,671	152,320	264,987	487,162	468,672	443,165	469,024
Thrift/Dev't banks	390	491	1,132	8,873	19,959	26,373	25,185	19,319	21,965
Others (PMU/CECAP)	0	1,395	20,142	27,022	0	0	3,393	3,393	3,393
Total loan releases	109,155	217,239	324,108	482,243	791,099	1,402,438	1,399,719	1,652,148	1,844,533
Growth rate (%) Total No. of Clients		**99%**	**49%**	**49%**	**64%**	**77%**	**-0.2%**	**18%**	**12%**
Ave. Growth Rate									46%

Capability – Building of Microfinance Institutions

Growth and development of the Philippine microfinance industry necessitated capability-building among MFIs for efficient and sustainable operations. Training and technology transfer played a major role in support of the development of the industry particularly in the following areas (Miranda and Chua, 2003):

1. Transfer of microfinance approaches or methodologies
2. Training of managers in general management skills and in understanding the concept of microfinance
3. Training of field/account officers
4. Training on specific technical skills such as, but not limited to financial analysis, market research and product development, delinquency management, and risk management
5. Training of trainers
6. Network activities such as seminars and conferences
7. Development or adoption of performance standards

During the first decade of Philippine microfinance, majority of the resources for capability building were provided by international development agencies (Miranda. and Chua, 2003). The donors that actively contributed to capability building from 1997 to the present are, among others, the Asian Development Bank (ADB), United States Agency for International Development (USAID), United Nations Development Programme (UNDP), and the European Union (EU).

Efforts in Capability-Building

Donor-initiated capability-building programs were implemented in collaboration with local government agencies or private institutions. Some donor-supported programs conducted in the past were:

1. ADB loan granted to PCFC to provide training on Grameen banking methodology, credit discipline, management information systems and financial management;
2. Microfinance Support Project and the Microfinance Sector Strengthening Project of UNDP which promoted the transfer of the Association for Social Advancement (ASA) methodology to Philippine MFIs;
3. PCFC training supported by Cooperacion al Desarollo y Promocion de Actividades Asistenciales (CODESPA) of Spain to improve "customer service, credit discipline, scaling up, financial and strategic planning";
4. Microenterprise Access to Banking Services (MABS) Project of the USAID in collaboration with the Rural Bankers Association of the Philippines (RBAP) which provided trainings and technical assistance programs to develop the capability of banks to "profitably serve the microenterprise sector", and develop the capability of the RBAP to continuously assist its members in upgrading its services, *e.g.*, in the area of product development/market research, financial analysis;
5. Research and Capacity Building for Product Development in Microfinance Project of the Inter-Church Organization for Development Cooperation (ICCO) of the Netherlands in cooperation with the Microfinance Council of the Philippines to design and develop new and improved financial products for poor clients (Dingcong, 2005); and
6. Technical skills courses supported by the Consultative Group to Assist the Poorest (CGAP) provided through the Punla sa Tao Foundation. The training courses included the following topics: delinquency measurement, interest rate setting, accounting for non-

accountants, financial analysis, business planning, product development, and internal control.

To support the capability-building of MFIs, the Philippine government has established the People's Development and Trust Fund (PDTF) through Republic Act No. 8425, also known as the Social Reform and Poverty Alleviation Act , approved in December 1997. It would be progressively funded up to PhP 4.5 Billion. The PDTF remains unfunded until now.

Institutions involved in microfinance training

Training institutions were set up to provide microfinance-focused courses to MFIs. In addition, a few academic institutions responded by offering general management courses for microfinance managers (Miranda and Chua, 2003). The institutions that extend specialized microfinance training courses are presented in Table 5.

Table 5. List of microfinance training institutions and their geographical location, 2006

Name of Institution	Location
Luzon	
Mallig Plains Rural Bank	Isabela
Producers Rural Bank	Nueva Ecija
Asian Institute of Management (AIM)	Metro Manila
Ateneo de Manila University	Metro Manila
Ahon Sa Hirap, Inc.	Metro Manila
Alliance of Philippine Partners for Enterprise Development (APPEND)	Metro Manila
Credit Union Empowerment and Strengthening (CUES)	Metro Manila
Punla Sa Tao Foundation	Laguna
CARD Training Center	Laguna
Visayas	
Agricultural & Rural Development for Catanduanes, Inc.	Catanduanes
Negros Women for Tomorrow Foundation (NWTF)	Bacolod
Taytay sa Kauswagan, Inc.	Iloilo
Mindanao	
Enterprise Bank	Surigao del Sur
Peoples Bank of Caraga	Davao del Sur
Highlands Bank Inc.	Compostella Valley

Aside from AIM and Ateneo de Manila which are established academic institutions, the other service providers are either microfinance organizations that expanded their services to include training (*e.g.*, CARD) or NGOs and network organizations that were founded to assist in capability-building (*e.g.*, Punla Sa Tao Foundation and MABS). Punla sa Tao Foundation recently instituted a Microfinance Management Development Course in cooperation with the De La Salle University (Miranda and Chua, 2003). It is also initiating a linkage with the University of the Philippines Los Banos on rural finance which will include research, training and extension activities (Lomboy, 2006, personal communication).

AIM, on the other hand, recently concluded its 2nd Microfinance Training of Trainers, a distance learning course which started in October 2005 and ended January 2006. Seven graduates of the course were accredited as microfinance trainers (www.aim.edu/home/announcement, n.d.). CARD, NWTF, ARDCI, Mallig Plains Rural Bank, Producers' Rural Bank, Taytay sa Kauswagan, Inc., Enterprise Bank and People's Bank of Caraga are accredited training centers of PCFC (Castro,

2006, personal communication). General and financial management training courses were conducted by the University of Asia and the Pacific, the Ateneo de Manila, and the University of the Philippines (Miranda and Chua, 2003).

Some MFIs have the capability for in-house training (Table 6). Based on the author's survey, facilities range from a conference hall to a training complex with provisions for lodging. Most of these facilities employ their own training staff. Training courses vary from the basic principles and methodologies of microfinance to specialized technical topics pertaining to market research, financial analysis, risk management and the like. Examples of MFIs that conduct their own staff training are: TSPI Development Foundation, Inc. (Metro Manila), Rural Bank of Mabitac (Laguna), Agricultural and Rural Development for Catanduanes, Inc. (ARDCI) (Catanduanes), Alay Sa Kaunlaran, Inc. (Nueva Ecija), Bangko Kabayan (Batangas), Bukidnon Integrated Network of Home Industries, Inc. (BINHI) (Bukidnon), Bangko Mabuhay (Cavite), Rural Bank of Mabalacat (Pampanga).

Table 6. In-house training capability of selected MFIs, Philippines, 2006

Institution	Training Facilities	Training Staff	Courses Offered
CARD Training Center	Training rooms & equipment Lodging facilities	Currently enrolled in Masteral Programs at AIM & Southern New Hampshire University	Technical Officers Ready-To-Go Branch/Asst. Managers Ready-To-Go MA Organizational Development major in Microfinance Mgmt
Alay Sa Kaunlaran, Inc.	Training rooms & equipment	Trained under Citibank, AIM, UNDP	Designed & developed based on needs. Patterned after modules of other training institutions
Rural Bank of Mabalacat	Training room & equipment	MABS-trained	Cashflow analysis, Portfolio at risk computation Loan monitoring & delinquency management, Business plan Internal control, Risk management, Market research, MIS
Rural Bank of Tanza, Cavite, Inc.	Training room & equipment	MABS-trained	Cashflow analysis, Portfolio at risk computation Loan monitoring & delinquency management, Business plan Internal control, Risk management, Mkt research, MIS
Rural Bank of Mabitac	Training room & equipment	MABS-trained	Cashflow analysis, Portfolio at risk computation, Loan monitoring & delinquency management, Internal control, Risk management, Mkt research, MIS, Business plan
BINHI	Training room & equipment	Trainers are contracted	Grammen banking, programs and services, policies of BINHI
TSPI Development	Training room & equipment	12 training personnel	Basics of microfinance, entrepreneurship, Value

Institution	Training Facilities	Training Staff	Courses Offered
Corp.			formation
Agricultural & Rural Development for Catanduanes, Inc.	Training room & equipment	3 training personnel	
Center for Community Transformation	Training room & equipment	2 training personnel Hire assistance of AIM for training managers	Basic training for new recruits Proper selection of group members
MILAMDEC Development Foundation	Training room & equipment	With training staff	Basics of microfinance, management principles

A limited search revealed that there are three institutions that are currently offering degree courses in Microfinance. These are the CARD Training Center, AIM Center for Development Management and the Philippine Christian University (PCU)[4]. CARD has a Master's degree course in Organizational Development major in Microfinance Management. Similarly, AIM's Master in Development Management Program offers a specialization in Microfinance. PCU, on the other hand, offers a Masters in Business Administration major in Microfinance as well as a Bachelor of Business Administration major in Microfinance.

Geographical location of training institutions

Majority of the specialized training institutions are located in Luzon particularly in the Metro Manila area. Punla Sa Tao Foundation, however, plans to move to Los Banos, Laguna by 2007. These institutions conduct on-site trainings for MFIs located in the Visayas and Mindanao as well as the MFIs in northern Luzon. This is in addition to the services offered by the training institutions located nearer these areas such as the NWTF in Bacolod, Taytay sa Kauswagan, Inc. in Iloilo and the Mallig Plains Rural Bank training center in Isabela. In the case of the MABS, rural banks are trained by their accredited service providers, Punla sa Tao Foundation and ARMDEV (Lomboy, 2006, personal interview). The banks are likewise encouraged to establish training units within their organization and bank personnel are trained to become trainers to support their expansion program.

Common practices in training microfinance personnel

Information on the practices of MFIs regarding the training of newly hired Field/Account Officers and Managers was generated in this study. Field or Account Officers are non-supervisory personnel who are in constant contact with the organization's clients. They move around the community to collect loan repayments[5], identify potential microfinance clients, organize client groups and conduct orientation courses on-site, as well as participate in regular group meetings of members. Managers, on the other hand, refer to Area Managers, Branch Managers, Assistant Branch Managers, and Department Managers at head offices.

All of the MFI respondents and the MFI key informants reported that Field/Account Officers undergo training upon entry into the organization (Table 7). The interview of Bombeta (2006) and Tanael (2006) revealed that majority of the Field/Account Officers being recruited by their organization do not have any academic background or previous work experience related to

[4] A more intensive search is required to check the course offerings of other academic institutions.
[5] Some MFIs require clients to pay directly at their offices, not through the Account Officers.

microfinance. This necessitates the conduct of basic microfinance training courses prior to any field assignment. For most NGOs, these training activities include sessions in value transformation so that these frontliners would "imbibe a sense of mission and commitment to endure the very demanding conditions of working in rural or urban poor environments" (Miranda and Chua, 2003). Similarly, 100.00% of the MFI respondents reported that they also train their newly hired or promoted managers. A training course for either managers or field officers lasts from 5 days to 3 months.

Table 7. Number of MFIs that train newly hired managers and field officers, Philippines, 2006

	MFI	Newly hired FOs are trained			Newly hired managers are trained		
		No	Yes	Duration	No	Yes	Duration
1	Alalay sa Kaunlaran Sa Gitnang Luzon, Inc.		X	5 days		X	1 month
2	Rural Bank of Mabalacat		X	1 month		X	1 month
3	Bangko Kabayan		X	1 month		X	3 months
4	Bangko Mabuhay (Rural Bank of Tanza Cavite)		X	2 months		X	2 months
5	Agricultural & Rural Development For Catanduanes, Inc.		X	7 days		X	7 days
6	Rural Bank of Mabitac		X			X	
7	Center for Agriculture and Rural Development		X	1 month		X	
8	TSPI Development Corp.		X	2 weeks		X	
9	CCT Credit Cooperative		OJT*	2 months		OJT*	2 months
10	MILAMDEC Development Foundation		X	2 months		X	1 month
11	Bukidnon Integrated Network of Home Industries, Inc.		X	3 months		X	2 months
	Percent responding yes		100			100	

* On-the-job-training

Promoting high performing field personnel to a management position is also a common practice among MFIs (Tanael, 2006, personal interview). Previous performance, however, is not an insurance that the individual could equally handle a managerial responsibility. This method proved costly to NWTF in 1991 because the new managers were not given proper training on decision making and other tools required by a microfinance manager (Miranda and Chua, 2003). Thus, managers still undergo training on the basics of microfinance management (Bombeta, 2006 and Tanael, 2006, personal interview).

MFIs that have a larger budget for developing their managers professionally should shoulder the cost of a graduate degree in management or a continuing education program.

Cost of training microfinance personnel

Between 1998 to 2002, the cost of the foreign-assisted capability-building projects in the Philippines was estimated to be PhP 1.91 Billion (Miranda and Chua, 2003). No data were available that would indicate the average cost per trainee for these projects. However, the survey conducted on selected MFIs revealed that the cost of training a new recruit ranges from PhP 2,750.00 to PhP 95,000.00 or an average of about PhP 20,156.00 (Table 8). Undoubtedly, the cost of personnel training is high. However, investing in human resource development has been proven to result in better operational efficiency and contributes to the sustainability of MFIs.

Table 8. Cost of training, selected MFIs, Pesos/person, 2006

Microfinance Institution	Cost of training		
	Managers	Field/Account Officers	Average Cost
CARD			9,000.00
TSPI Development Corp.			20,000.00
Bangko Kabayan	130,000.00	60,000.00	95,000.00
Alay Sa Kaunlaran, Inc.			2,750.00
Rural Bank of Mabalacat			7,000.00
BINHI	10,000.00	15,000.00	12,500.00
ARDCI			3,000.00
MILAMDEC Development Foundation			12,000.00
Average of all institutions			**20,156.25**

There is, however, a negative side on donor-subsidized training courses. In certain cases, dependence on donor assistance causes reluctance of MFIs to invest in capacity building to the extent that training of personnel is not given a substantial allocation in their annual budget. Lomboy (2006, personal interview) estimated that only 1% of the total budget of some MFIs are devoted to training and education.

Analysis of training needs

In the study conducted by Miranda and Chua (2003), focus groups were asked to identify training areas that still require attention within their respective organizations. While previous efforts for capability-building benefited the microfinance industry, the focus groups indicated that training would still be necessary under the following concerns:

1) General management skills and systems needed to run a financial institution;
2) Microfinance technology or methodology specific topics; and
3) Institutional type (ie., NGO, Coop, Rural Bank) specific topics.

The first category include the following topics: credit risk and delinquency management; risk management; financial management; information management; accounting and financial reporting; performance monitoring; internal control; assets and liabilities management; human resource management; business planning/strategic planning; strategic management; leadership; operations management; and product development and marketing.

The topics that fall under the second set of training needs are: center management for group lending; and microfinance principles and technologies. The third category include concerns pertaining to "skills, systems and topics that may be peculiar to a specific institutional type" such as membership development for coops and transformation into formal financial institutions for NGOs (Miranda and Chua, 2003).

The above topics were covered by training programs implemented in the past. By still including them as part of the training needs of MFIs indicates that more managers and other personnel are being hired and, therefore, would require instruction in these areas. What is missing is the information whether the MFIs have the capability within their organization to provide the training from previously trained personnel. It may also be worth conducting an update on the training needs

because it has been three years since Miranda's study was implemented. A new set of concerns may have emerged.

Projection of demand for microfinance personnel

The MFI respondents were asked to project the number of Field/Account Officers and Managers that they will need from 2006 to 2008. Based on the number of branches that they plan to open during that period of time, the MFIs reported that they will require a total of 326 managers and 1,236 Field/Account Officers (Table 9). Though these projections are based on a limited number of respondents, the figures are indicative of the expansion of the industry within the near future.

Table 9. Projected number of personnel, selected MFIs, 2006 to 2008.

Microfinance Institution	2006		2007		2008		Total	
	Managers	Field Offcr	Managers	Field Offcr	Managers	Field Offcr	Managers	Field Offcr
Bangko Kabayan	0	9	0	0	0	0	0	9
MILAMDEC Development Foundation	4	12	5	15	6	18	15	45
Agricultural & Rural Dev. for Catanduanes, Inc.	0	10	6	10	6	10	12	30
Bangko Mabuhay (Rural Bank of Tanza Cavite)	0	3	0	0	0	0	0	3
Rural Bank of Mabitac	0	0	0	0	4	12	4	12
Center for Agriculture & Rural Development	218	778	0	0	0	0	218	778
TSPI Development Corp.	0	0	16	112	0	0	16	112
CCT Credit Cooperative	5	20	15	40	25	80	45	140
Alalay sa Kaunlaran Sa Gitnang Luzon, Inc.	7	49	4	35	4	21	15	105
Rural Bank of Mabalacat	0	0	1	2	0	0	1	2
Total	234	881	47	214	45	141	326	1,236

SUMMARY AND CONCLUSIONS

The capability-building programs in the past provided the knowledge, methods, systems and services required by the Philippine microfinance industry to cope with the growing demands of the market and the expansion of the industry as a whole. The foundations to support industry growth were laid down through the collaborative efforts of donor agencies, government units and the private

sector. Concrete outputs which could partly or wholly be attributed to past efforts in capability-building, can be identified to include, among others, the following:

Application of microfinance methodologies: Several microfinance methodologies have been successfully adopted by various MFIs as a result of past programs aimed at transferring the technologies to the Philippines. Aside from the Grameen Banking Approach, other methodologies such as the ASA Model, MABS Approach, CUES, Solidarity, and APPEND Scale-Up Model were introduced. A description of the methodologies appear as Table 10.

Table 10. Microfinance methodologies, Philippines, 2002

Methodology	Key Features	Replicators
Grammen Bank	1. Small loan amounts that gradually increase from one cycle to the next 2. Weekly loan repayments 3. Mandatory weekly center meetings where educational inputs are usually provided 4. Formation of homogeneous groups by borrowers themselves 5. Close monitoring & supervision of borrowers 6. Non-collateralized loans secured through group guarantees 7. Staggered loan releases, depending on repayment performance of the 1st two borrowers 8. Compulsory weekly savings	PCFC MFIs Philippine Network for the Hardcore Poor (PHILNET)
ASA Model	1. Formation of homogeneous groups for credit and collection 2. A simple standardized structure with only one branch manager and four account officers 3. Loans paid on a weekly basis 4. Delinquency controlled by the sit-down or doorstep approach 5. No group liability on loans; past dues considered individual obligations 6. Increased loan amounts in succeeding cycles depending on repayment performance 7. Fast expansion through cost-minimized operations	Microfinance Support Project Partners
MABS Approach	1. Cashflow-based lending to individuals without collateral 2. Loan amount based on capacity to pay 3. Zero tolerance of delinquent borrowers 4. Technical assistance to rural banks on best practices	Rural Banks
Credit Union Empowerment and Strengthening (CUES) Approach	1. Focus on economically disadvantaged women 2. Formation of savings and credit associations 3. Financial services with education on topics such as health and nutrition, and better business development 4. Non-collateralized lending with group guarantees 5. Regular weekly meetings 6. Mandatory and voluntary savings	Cooperatives
Solidarity	1. Group formation where members self-select	NGOs

Methodology	Key Features	Replicators
	2. Amount of loan is determined based on member needs 3. On-time repayment requirement	
APPEND Scale-Up Model	4. Borrower and lender accountability & mutual respect 5. Savings for emergency needs 1. Targets economically active but poor women 2. Self-selection of group members 3. Weekly meetings where social, economic 7 spiritual goals are pursued 4. Simultaneous release of loans 5. Weekly loan payments 6. Uncollateralized lending; members co-guarantee all loans	NGOs

Source: IMCC ADB Study on Philippine Microfinance, 2002, cited by Miranda and Chua, AIM-CDM, 2003.

New products offered by MFIs: The microfinance industry started by offering microcredit to poor households. Their services expanded to include savings accounts, life/health insurance and money transfer. These new products were developed with the help of training courses in market research.

Human resources trained in microfinance operations: A cadre of managers and field personnel trained in microfinance operations now exists among the MFIs across the country. There is management expertise in strategic and business planning, risk management, financial analysis, business performance evaluation, and other management tools. Field/Account Officers, on the other hand, have been trained in areas such as delinquency management, market research, and group/center coordination. Other personnel have knowledge in MIS, bookkeeping and accounting, human resource management and other support functions. A portion of these personnel are also capable of providing training on specific areas of microfinance.

Availability of training institutions: The services of training institutions, albeit still limited in number, are available to MFIs. Experienced training staff ensures that knowledge and techniques are imparted in a relevant manner. Training courses for standardized topics have been documented and are available for replication in future training activities. In addition, several MFIs have a training unit within their organization to upgrade the knowledge and skills of their own personnel.

RECOMMENDATIONS

With the foundations already in place, the industry would not find much difficulty in future capability-building efforts. Monetary resources, for instance, can now be channeled to upgrading knowledge and skills instead of facilitating adoption of methodologies and developing or setting up operating systems.

However, the study also revealed that majority of the available training resources (*i.e.*, trainers and physical facilities) are found in Metro Manila. Thus, MFIs in the Visayas and Mindanao as well as those in the northern, central and southern part of Luzon have lesser access to these resources due to geographical location. There is also a noticeable deficiency in the number of schools offering degree courses in microfinance. While the microfinance industry has been in existence for more than a decade, the Philippine educational system, except for a few institutions, appears to be slow in perceiving the market potential in offering microfinance courses. The projected requirements for microfinance managers and field/account officers obtained from a selected number

of MFIs show that there is a demand for graduates with a microfinance background. Even greater demand could arise as MFIs realize that duration of training and, therefore, training cost could be reduced by hiring graduates possessing basic knowledge in microfinance. Understandably, current number of enrollees may not justify simultaneous offering of courses for microfinance degrees. While demand exists, this is dispersed geographically.

One approach in making microfinance training available to a broader clientele is to consolidate available resources among existing microfinance training providers and academic institutions located in strategic areas across the Philippines. Microfinance Centers can be established within the selected schools wherein short term training courses in microfinance could be offered. In the medium and long term perspective, a course in microfinance can be developed and incorporated in the schools' academic curricula while degree courses (*e.g.*, Bachelor of Arts/Science or a Masteral degree) can be offered when sufficient demand is attained. Research projects in microfinance (or rural finance, to address a broader field of study) can also be conducted by the Centers. The existing service providers will transfer their knowledge base in the area of microfinance to the selected academic institutions. On the other hand, the teaching and research expertise as well as the facilities of the schools will be tapped.

REFERENCES

Almario, Joselito. 2003. Reaction paper on the Country Study, "Commercialization of Microfinance - Philippines" by Charitonenko, S., in Charitonenko, S., A. Campion and N. Fernando. 2004. Commercialization of Microfinance: Perspectives from South and Southeast Asia, Asian Development Bank, Pasig City, Philippines.

Asia Resource Center for Microfinance. 2005. Country Profile on Microfinance: Philippines, The Foundation for Development Cooperation, Queensland, Australia.

Asian Development Bank and International Fund for Agricultural Development. 2002. Interim Evaluation Report, Rural Micro-Enterprise Finance Project, Asian Development Bank, Pasig City, Philippines.

Charitonenko, S., A. Campion, and N. Fernando. 2004. Commercialization of Microfinance: Perspectives from South and Southeast Asia, Asian Development Bank, Pasig City, Philippines.

Charitonenko, S. 2003. Commercialization of Microfinance –Philippines, Asian Development Bank, Pasig City, Philippines.

Chowdury, M. Jahangir Alam. 2006. Poverty and Microfinance in the Philippines, University of Dhaka, Bangladesh.

Conroy, John D. 2003. The Challenges of Microfinancing in Southeast Asia, The Foundation for Development Cooperation, Brisbane, Australia.

Daley, S. and F. Sautet. 2005. Microfinance in Action: The Philippine Experience, Mercatus Center, George Mason University, Virginia, USA.

Dingcong, Clarence. 2005. Assessment of the Research and Capacity Building for Product Development in Microfinance Project, Microfinance Council of the Philippines, Inc., Manila, Philippines.

Goldberg, Nathanael. 2005. Measuring the Impact of Microfinance: Taking Stock of What We Know, Grameen Foundation, Washington D.C., USA.

Llanto, G. M. 1997. Using Microfinance Institutions in Poverty Alleviation: A Case of the Blind Leading the Blind?, Policy Notes No. 97-09, Philippine Institute for Development Studies, Makati, Philippines.

Llanto, G. M. 2004. Microfinance in the Philippines: Status, issues, and challenges, Policy Notes No. 2004-10, Philippine Institute for Development Studies, Makati, Philippines.

Miranda, M. and R. Chua. 2003. The First Decade of Philippine Microfinance: 1992- 2002, in Delivering to the Poor: A Search for Successful Practices in Philippine Microfinance, United Nations Development Programme, National Anti-Poverty Commission, People's Credit and Finance Corporation and the Asian Institute of Management, Makati, Philippines.

National Statistical Coordinating Board, National Census 2000, Quezon City, Philippines.

Tetangco, Jr., A. M. 2005. "Stimulating the Growth of Microfinance in the Philippines", Speech delivered at the National Capital Region Stakeholders' Forum on Microfinance, Manila, 19 September 2005, unpublished.

Torres, T. P. November 25, 2003. "PCFC Loan Portfolio Hits P2.4B", The Philippine Star, Manila. Philippines

J. ISSAAS Vol. 13, No 1. pp.70-79 (2007)

ACCOUNTING SYSTEMS OF SMALL-SCALE AGRIBUSINESS FIRMS IN THE MUNICI PALITY OF NAGCARLAN, LAGUNA, PHILIPPINES

Tricia C. Ascan

Department of Agribusiness Management, College of Economics and Management
University of the Philippines Los Baños
College, Laguna, Philippines

(Received: January 26, 2007; Accepted: June 14, 2007)

ABSTRACT

The study sought to provide a general overview of the accounting systems of small-scale agribusiness firms particularly in the Municipality of Nagcarlan, Laguna, Philippines. It seeks to determine the nature and extent of the systems being used by these firms, the internal control practices, and the strengths and weaknesses of the existing systems. Majority of the firms have crude and almost non-existent accounting systems. One of the identified problems is that most owners lack the necessary skills to set up and maintain an accounting system. Another is the cost involved in the set up and maintenance. Internal control appears to be weak in some of cash control, inventory, sales, purchases, and property valuation. Small firms, given personnel and financial constraints, cannot justify many of the accounting system features and control procedures found in larger companies. The strength lies in the personal involvement of the owners in their business in which the owner acts as the internal control feature of the firm. Based on the findings of the study, the firms must first recognize the need of an accounting system and the benefits that could be derived from it.

Key words: internal control practices, financial statements, inventory, property valuation, cash control

INTRODUCTION

In the Philippines, the use of accounting systems in small-scale businesses is usually crude if not non-existent. Though most businesses have some form of record keeping, the more formal accounting systems are usually absent. While the country is replete with undergraduate accountancy courses and accounting graduates, not to mention thousands of Certified Public Accountants (CPAs) board passers every year, it is interesting that accounting practices are not fully appreciated in the small-scale business level. The study provides an empirical view of the nature and extent of the use of accounting systems of small-scale agribusiness firms. It seeks to understand the usefulness (or non-usefulness) of the accounting systems on such firms. The study hopes to know the reasons for the absence, if it is indeed true, and what measures can be done to make the system work for these firms. The town of Nagcarlan in the province of Laguna, was chosen for the study because most of the firms here are agriculture-related such as coconut processing, coconut trading, cassava processing, poultry and pig raising, and rice milling, among others. The study covers only the more general view of the accounting systems being maintained and used by the small-scale agribusiness firms. It is limited to financial reporting purposes, procedures being followed, and the basic internal control practices by the firms.

REVIEW OF LITERATURE

There have been limited studies covering accounting systems and its usefulness with business enterprises. In fact, most studies are descriptive in nature and are not really stand-alone

researches. Most literature cover only the basics such as classification of accounts, procedures on recording transactions, adherence to generally accepted accounting principles, and preparation and contents of different financial reports. It seems that though systems are an integral part of effective business management, it is often a neglected case. Whereas the systems can often "make or break" a company, few have identified this as a threat to sustainability of an enterprise (Chico,1987). Albert (1981) discussed that a typical small business has inadequate records. Almost half of marginal or failed businesses had poor records, while the majority of thriving small businesses had accurate and thorough records. A study made by Salazar et. al. (1986) showed that less than half of small enterprises kept a complete set of accounting books, only about a third kept either a cash book or a record of accounts receivable, and about one-fifth kept both cash and accounts receivable books. Moreover, businesses that are family-owned have no records to separate the family and business finances (Haynes, 1999). A study by Aguilar (2001) showed that the financial statements of a business do not reflect accurately the true earnings and financial condition of an enterprise due to intermingling of family and business finances. The apparent lack of knowledge on accounting systems has resulted yet to more constraints – that of receiving financial assistance. Aside from lack of collateral and high interest burden, a small business simply would not be granted loans if its financial reports are inaccurate and unreliable. The initial impulse of most small company owners/managers is to think that systems are a tool for large businesses only. The necessary paperwork and equipment make them costly to develop, and the time required for the development and introduction in the company makes the costly to use (Krentzman, 1981). One should recognize that, once a system is introduced and working, the added expense will be balanced by more efficient production, cost savings, and better customer service, which translates into a profitable business.

CONCEPTUAL FRAMEWORK

This study used the conceptual framework presented in Figure 1. The organizational environment revolves around the nature of the organization under study, the size, and the type of their operation. Once the environment is established, documentation of the existing systems follows. This includes the preparation of financial reports, use of book of accounts, use of business forms, and internal control practices. Tools that were used to document are questionnaires, personal interviews, personal observations of business operation, and inspection of accounting and management reports if available. The results are then summarized into major findings, identifying problems and gaps, defining the strengths and pointing out the weaknesses of the existing accounting systems of small-scale agribusiness firms.

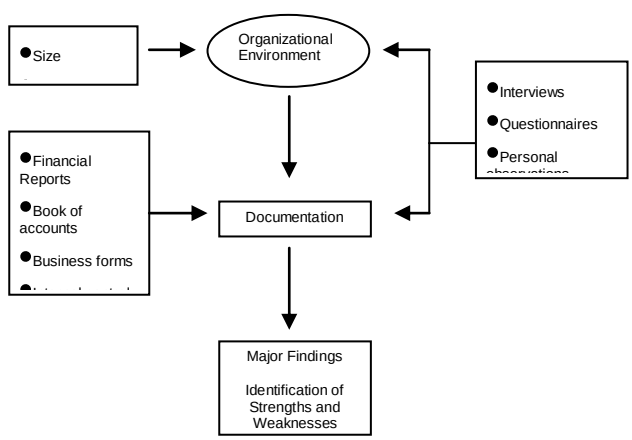


Fig. 1 Conceptual Framework

METHODOLOGY

A list of small-scale agribusiness enterprises was obtained from the municipal record through the Municipal Licensing Officer. The list was grouped into three categories, namely: production, processing, and trading. From the said list, purposive sampling was used to determine the number of respondents based on the premise that the firm is relatively organized in terms of basic business structure, compliance with registration and other government requirements, and with substantial capital outlay to warrant a bookkeeping system and keep track of operations as a whole. A total of 70 respondents from the different categories were interviewed. Since it is the culture of Filipino businessmen to be very confidential about their financial activities, most of the respondents are only those who are willing to participate and cooperate to give financial data. Primary data were gathered through the use of questionnaire and personal interviews

Questionnaires were analyzed using descriptive analysis and frequency counts/cross tabulations where applicable. Secondary data about the area were obtained in the Municipal Office. Others were sourced from existing literatures and publications.

RESULTS AND DISCUSSION

The town of Nagcarlan in the province of Laguna has a total land area of 11,489.4 hectares with 3 urban barangays and 49 rural barangays comprising the whole town. It is an inland town that is about 99 kilometers from Manila through San Pablo City. The terrain of the municipality consist of rolling hills extending from the base of Mt. Banahaw and Mt. San Cristobal downward north towards Laguna de Bay. The municipality is agriculturally dominant with a total agricultural area of 10,015 hectares of 87.17% of the total land area. Its major crop is coconut covering almost 91% of the total agricultural area or a total of 9,075.24 hectares. It has also been tagged as the "Little Baguio" of Laguna since the weather, especially in the upland barangays, permits cultivation of vegetable crops grown in Baguio, a province in the northern part of the Philippines. Other sources of livelihood are livestock and poultry raising though majority are backyard raisers.

Of the total registered businesses in the municipality, 182 are engaged in agriculture-related businesses. While the town is essentially agricultural, most of those engaged in farming are not registered and may be classified only as subsistence level farming. The 182 registered businesses were classified as trading, production, and processing (Table 1).

Those engaged in trading include coconut dealership with which is the major trading business in the area. Sale food products, feeds and agro-vet products follow. The processing sector is composed of bakeries, processors of homemade candies, oils, fiber, and rice milling. The production sector is divided into piggery and poultry farms wherein some owners have 2 – 3 farms located in different barangays (Table 2). Seventy firms were taken as sample from the total registered agribusiness firms.

Table 1. Number of firms engaged in agribusiness

Sector	Count	Percent (%)
Trading	78	43
Processing	87	48
Production	17	9
Total	182	100

Table 2. Businesses engaged in each sector

Trading Sector	Count	Percent (%)
Coconut dealer	39	21
Food products	25	14
Agro-veterinary products	9	5
Others	5	3
Processing Sector		
Bakery	36	20
Homemade candies	29	16
Essential oils	2	1
Rice mill	1	0.5
Fiber processing	1	0.5
Other food products	18	10
Production Sector		
Poultry Farm	8	4
Livestock (piggery) Farm	9	5
Total	182	100

The Nature and Extent of the Present Accounting Systems

Of the total respondents, only about 40% or 28 firms prepare Income Statement. This is mostly used for submission and filing of income tax return. Ten firms or about 14% also prepare Balance Sheet. Preparation of Cash Flow Statement, which is a mandatory requirement in the country, is very minimal with only 5 firms or 7% doing it (Table 3). Most of the respondents argue that these statements are not necessary since their gross sales is less than Php60,000. Those whose earnings are Php60,000 and below are exempted from filing tax return. For those fresh produce vendors, gross sales are assigned by the Municipal Assessor that become the basis for sales tax. This procedure diminishes the importance of maintaining books and preparing financial statements.

Table 3. Number of Firms Preparing Financial Statements

Type of Financial Statement	Count	Percent (%)
Balance Sheet	10	14
Income Statement	28	40
Statement of Cash Flows	5	7
Others	3	4

Note: Percentage in proportion to total respondents (n=70)

Table 4. Number of Firms Using Book of Accounts

Book of Accounts	Count	Percent (%)
General Journal	22	31
General Ledger	18	26
Sales Book	6	9
Purchases Book	5	7
Cash Collections Book	3	4
Cash Disbursements Book	4	6
Accounts Receivable Ledger	4	6
Accounts Payable Ledger	3	4
Others	6	9

Note: Percentage in proportion to total respondents (n=70)

Only 22 firms or 31% record transactions in general journal while only 18 firms or 26% maintain general ledger. Low usage affirms that most firms do not keep a record of financial transactions (Table 4). It is also interesting to note that respondents use only a piece of paper in recording purchases while they never bother to record their sales transactions.

The official receipt is the most commonly used business form with 23 firms maintaining such business form. Check/cash voucher (21%) follows which is common in firms issuing checks. Sales invoice and delivery receipt are also used by about 14% (Table 5). Minimal usage of the forms attest that majority of the firms do not keep an adequate accounting system to keep track of their operations as well as their finances.

Table 5. Number of firms using business forms

Business Forms	Count	Percent (%)
Official Receipt	23	33
Delivery Receipt	9	13
Sales Invoice	10	14
Purchase Order	8	11
Petty Cash Voucher	4	6
Journal Voucher	0	0
Cash/Check Voucher	15	21
Others	7	10

Note: Percentage in proportion to total respondents (n=70)

Internal Control

Internal control is divided into six categories, namely: general accounting control, control of cash receipts and disbursements, sales, property, purchases, and payroll (Table 6). General accounting control tackles the area of bookkeeping and reporting preparations as well as the involvement of the owner in the financial activities of the business. Control of cash encompasses the implementation and recording of cash transactions particularly on cash receipts and disbursements. Internal control for sales, purchases, property, and payroll is about responsibility, accountability, recording, and execution of these transactions.

General Accounting Control

Of the total respondents, 5 firms have fulltime accountant and another 5 hire part time accountants or retainers. Most of these retainers work only during the tax season to prepare the financial statements. Only 9 respondents prepare monthly financial statements, 3 prepare quarterly, and 10 prepare annually. Monthly updating of books is also minimal with only 11 respondents doing it regularly. For others, 3 firms update their books daily, 2 weekly, 1 quarterly, and 2 annually. This affirm that notion that small-scale businesses do not give much attention to bookkeeping and financial reporting. Most of the respondents regard accounting as cumbersome and eats up a lot of their time which should be focused on operations. However, 83% of the respondents claim that they have a system for determining their income and expenses and only 10% has no system whatsoever. For most of the firms, they use their weekly revolving capital as the basis. The said capital is used to purchase materials and whatever they collected at the end of the week less labor and other credit payments, they claim to be their income. Some also claim that based on the material things that they accumulated overtime, they know their business is profitable.

One strong point is the personal and direct involvement of the owners. Almost all of them (99%) directly oversee the operations particularly the financial aspect of the business. The only one

that do not have personal involvement is a cooperative, which has a different management style and structure.

Table 6. Internal Control

Internal Control	Count			Percent (%)		
	Yes	**No**	**N/A**	**Yes**	**No**	**N/A**
General Accounting Control						
Presence of Accountant	10	54	6	14	77	9
Monthly Financial Statements	9	48	13	13	69	19
Monthly Updating of Books	11	43	16	16	61	23
System of Income & Expenses	58	7	5	83	10	7
Direct control of owner	69		1	99		1
Legal entity	32	31	7	46	44	10
Cash Control						
Daily deposit of collections	5	58	7	7	83	10
Issuance of check by owner	48	18	4	69	26	6
Owner signs/approves checks	45	3	22	64	4	31
Bank reconciliation	8	36	26	11	51	37
Sales Control						
Issuance of Sales Invoice	9	42	19	13	60	27
Approval of sales invoice by owner	8	27	35	11	39	50
Approval of credit sales by owner	54	8	8	77	11	11
Holding of inventory count	43	21	6	61	30	9
Recording of inventory in books	34	35	1	49	50	1
Property/Fixed Asset Control						
6 Listing of assets in books	20	41	9	29	59	13
Purchases Control						
Use of purchase order	9	37	24	13	53	34
Purchase of goods done by owner	63	5	2	90	7	3
Recording of purchases in books	30	35	5	43	50	7
Payroll Control						
Hiring of personnel done by owner	65	4	1	93	6	1
Awareness of absenteeism by owner	57	5	8	81	7	11
Owner's signature in payroll sheet	49	3	18	70	4	26
Payment of salaries done by owner	66	4		93	7	

In terms of separation of personal assets and income from the company assets and income, only 32 firms apply the legal entity concept. Others claim that separation is impractical because they use them as supplement to their day-to-day subsistence particularly those whose main source of income is the business itself.

Cash control consists of depositing the collections as it is received, and proper disbursements through the use of checks or voucher system. Only 5 firms deposit their collections daily, 10 weekly, 15 monthly, and 17 others occasionally. The rest do not make deposits as some of them do not have bank accounts or some use the collections for personal purposes. About 48 firms issue checks to pay

for their expenses. However, only 8 firms perform regular reconciliation between the book balance and bank balance.

Sales Control

Only 9 firms use sales invoice in sales transactions. Inventory is done by majority and inventory counts are done monthly by 3 firms and annually by 2 firms. Most of the respondents do an inventory count on a daily basis. While they do perform inventory count, only 39 firms record those that were sold. Eleven record the inventory taken out on a daily basis, 8 on a weekly basis, and 12 intermittently.

Property Control

Majority of the firms (59%) do not have a listing of assets particularly the fixed assets. No proper valuation has ever been made on the assets. While most of them knew their capital expenditures at the time of incurrence, they do not know the present valuation. This also implies that no depreciation has ever been computed or recorded in the books.

Purchase Control

Only 9 firms use a purchase order in buying materials. About 30 firms record their expenses in the books and more than half do not list expenses even in a simple notebook. Most of them only use a piece of paper that are usually misplaced or torn after payment of such expense. For others, they collect the official receipts issued to them for references. Of those that record expenses, 14 firms record them on a weekly basis, 8 monthly, and other at irregular intervals. A strong control regarding purchases is seen on the personal involvement of the owners. The owners themselves inspect the materials delivered in terms of quality and quantity and they prepare the payment themselves.

Payroll Control

This is another strong trait in internal control. By standards, the duties of hiring, payroll computation, and payment of salaries should be separated. However, the involvement of owner in dealing with these transactions is enough control to ensure proper hiring and minimize fraud on payroll computation and payment. 93% of the respondents have owners personally interviewing and hiring workers/employees; 83% record the absenteeism of the workers, 70% personally approve and sign the payroll of the employees, and 93% personally hand out the salaries of workers/employees.

Major Findings

The results of the study can be summarized as follows:

1. Majority of the companies under study has crude and almost non-existent accounting systems. Most of the respondents are not aware of the importance of accounting and rely only on memory to keep track of their business operations. They are not interested in setting up or maintaining an accounting system partly because they have the mentality that an accounting system is only useful to big establishments. Another reason is that they do not have the skills to set up one. Further, maintaining a system involves time, energy and money that these small firms could not afford.

2. Financial statements are prepared only for the purpose of conforming to government requirements such as filing of taxes. An independent accountant who is not necessarily a Certified Public Accountant does most of the statements. These statements are not used for decision-making so its purpose as a tool for making financial decisions is defeated.

3. Internal control appears to be weak in some areas of cash control, inventory, sales, purchases, and property valuation. However, it is compensated by the fact that most of the owners have a direct hand in the business operations and in essence acts as internal auditor.

The strength and weaknesses of the existing systems are:

Strength

The only strength identified was the Personal involvement of the owners in the business operations. The owner becomes the control feature of the business and oversees most of the critical areas of the business such as purchasing of materials, payment of expenses, depositing of collections, computation and payment of wages, as well as other cash transactions. The possibility therefore of error, fraud or mishandling of funds is minimized.

Weaknesses

1. Poor bookkeeping and accounting system.

While most of the respondents claim they have as system for determining their income, it was not made clear how they compute it. Most of the firms hire an independent accountant during the tax season to prepare their statements because this is perceived to be more reasonable and practical.

2. No separation of personal and business transactions.

The true value or worth of the business could not be determined because personal and business transactions of the owners are not separated.

3. No proper valuation of business assets.

As no book of accounts is maintained and no separation of personal and business transactions are made, business assets especially fixed assets are not properly recorded and valued or even that depreciation expenses on these assets are not properly computed and recorded.

4. Inadequate inventory recording.

While some claim that they hold an inventory count, the true cost of goods sold and inventory on hand could not be determined. Even the spoils are not accounted and most rely only on what the workers tell them.

5. Poor recording of purchases and expenses.

Firms seldom use of purchase order so there is no basis for counterchecking the purchases made. It is also difficult to determine the correct amount of expenses incurred during a given period.

6. No reconciliation between cash bank balance and book balance.

Most rely only on their bank balance as they made their deposits or withdrawals. Those who use checks seldom perform bank reconciliation because they don’t know how.

CONCLUSION

From the discussion and analysis above, it can be concluded that small-scale firms have poor and almost non-existent accounting systems. These small-scale firms belong to the production, processing, and trading sectors. It was found out that no particular sector maintains a good accounting system. Most of the firms under study do not even keep a simple book of accounts to keep track of their financial condition as well as results of operation. Financial statements are prepared solely for the purpose of tax compliance and not used for decision-making. Accounting and business forms that are used to document transactions and as audit trail are used minimally. Internal control is weak in some areas of cash control, purchasing, inventory, and valuation of business assets. Only the personal involvement of the owners who act as managers appear to be the strong element present in the internal control.

The problem lies with the perception of the owners of the firm on establishing and maintaining an accounting system. They see no immediate benefits from having such system. Lack of proper skills, financial, and personnel constraints are also factors that add to the lack of interest in putting up an accounting system. It is imperative that small-scale business owners recognize the need of an accounting system that will help them in making useful financial decisions and not just comply with the legal requirements.

The presence of an accounting system in agribusiness firms particularly in small-scale enterprises will assist owners in decision making since they are provided with more reliable and accurate data regarding their revenues, expenses, and cash flows. It will allow them to know the true costs of their products and therefore help them to price their products more effectively and competitively. An accounting system with a built-in internal control will facilitate the identification of discrepancies between the recorded amounts and the actual amounts, thereby preventing possible theft or fraud. It will also give the owners the ability to generate more cash flows since banks and other financial institutions are more likely to approve loans to businesses with a good accounting system.

ACKNOWLEDGEMENT

The author wishes to acknowledge the business owners/managers who participated in this study.

REFERENCES

Aguilar, A.F. 2001. A Study on the Intermingling of Business and Family-owned Enterprises in Selected Areas in Cavite from 1995 to 1999. Unpublished B.S. Thesis, De La Salle University, Philippines.

Albert, K.J. 1981. Straight Talk About Small Business. McGraw Hill Book Co.

Chico, L.V. 1987. Enterprise Development for Small & Medium Industries in the Philippines. University of the Philippines Institute of Small-Scale Industries (UPISSI).

Clapham. R. 1985. Small & Medium Entrepreneurs in Southeast Asia. Institute of Southeast Asian Studies. ASEAN Economic Research Unit. Research Notes & Discussion Paper No. 49.

Compilation of Statements of Financial Accounting Standards Nos. 1-23. Accounting Standards Council. 1995.

Haynes, G.W. et. al. 1999. The Intermingling of Business & Family Finances in Family-owned Business. Family Business Review. 12(3).

Krentzman, H.C. 1981. Successful Management Strategies for Small Business. Pp. 45-62. Prentice Hall Inc., Englewood Cliff, New Jersey.

Lee, V.S. 1986. Major Shortcomings and an Improvement Direction of the Financial Monetary Assistance System for a New SME Foundation. Workshop in Enterprise Development for Small-Scale Entrepreneurs. Kuala Lumpur, Malaysia.

Mckeran, D. 1990. Planning for Growth. p.36.Mercury Books. Gold Arrow Publications, Ltd. London.

Newman, B. 1980. Forms Manual for the CPA for Audit, Review & Compilation of Financial Statements. p. 162. Ronald Press Publications.

Salazar, M.S.Jr. 1986. Small and Medium Business Importance in the ASEAN Region Financial Factors (Philippines). Edited by Kenneth James & Narongchai Arkanase. Field Report Series No. 16. Institute of Southeast Asian Studies.

J. ISSAAS Vol. 13, No 1. pp. 80-87 (2007)

EFFECT OF CUTTING DATE AND CUTTING HEIGHT ON SUBSEQUENT GROWTH AND YIELD OF DRY DIRECT-SEEDED RICE

Anan Polthanee and Arunee Promkhambut

Department of Agronomy, Faculty of Agriculture,
Khon Kaen University, Thailand

(Received: November 5, 2005; Accepted: June 4, 2007)

ABSTRACT

This study sought to investigate the effect of cutting date and cutting height on subsequent growth and yield of dry direct-seeded rice under greenhouse conditions. A factorial combination of three cutting dates at 30, 45 and 60 days after seeding, two cutting heights at 5 and 10 cm above ground surface and three rice cultivars KDML105, RD15 and RD23 were used in this experiment. Early cutting at 30 days after seeding (DAS) gave the maximum grain yield from the regrowth, but did not show any significant difference with cutting at 45 DAS. The crops, cut at 5 and 10 cm above ground surface, did not show any significant difference on grain yield from the regrowth. KDML105 and RD15 cultivars gave similar grain yield and both cultivars produced a significant greater grain yield than that of RD23 cultivar. Grain yield was not dependent on total soluble sugar and starch in the stem at various cutting dates.

Key words: regrowth, total soluble sugar, starch, grain production

INTRODUCTION

Weed control is more critical and difficult in rice grown from dry direct-seeded of broadcasting rice than in transplanted rice. Weeders cannot move through broadcast rice to weed by hand without destroying some rice plants. Also, they cannot distinguish between young grassy weeds and young rice (De Datta, 1981). Weed control method by cutting weed and rice in dry direct-seeded of broadcasting seems to be practical to the farmers since grain yields from the regrowth of cutting plots were higher than that of uncut-unweeded plots (Polthanee et al., 2004). Although main crop cultural practices are known to have significant influences on the subsequent crop performance, little information is available on the effect of cutting height and cutting date on growth and yield of the regrowth crop. In general, most of the research is focused on ratoon cropping. The ratoon cropping of rice is the practice of obtaining a second crop from the stubble of a previously harvested (main) crop. The length of the stubble left after harvest determine the number of buds available for regrowth (Chauhan et al., 1985) and ratoon tiller origin (Vergara et al., 1988). Reddy et al., (1979) did not find differences in ratoon yields when the main crop was cut at 0.03, 0.13 and 0.18 m above ground level. Balasubramanian et al. (1970) also did not find any ratoon yield differences at cutting height of 0.10, 0.20 and 0.30 m. Bahar and De Datta (1977), however, found consistently better ratoon yields at 0.15 and 0.20 m than at 0.05 m cutting heights. Turner and Jund (1993) found that total nonstructural carbohydrate in the culm and leaves of the main crop at harvest had a significant effect on ratoon crop performance. Main crop plants with high total nonstructural carbohydrate level in culm and leaves produced ratoon yields higher than the plants with low total nonstructural carbohydrate at main crop harvest. Some consider the culm to be the priority source of reserve energy for regrowth in grasses (Deregibus et al., 1982; Anderson et al., 1989). The objectives of this study were to investigate the effect of cutting date and cutting height on subsequent growth and yield of three rice cultivars in dry direct-seeded rice.

MATERIALS AND METHODS

Pot experiments were conducted at the Agronomy Department greenhouse, Faculty of Agriculture, Khon Kaen University, Thailand from June 2004 to December 2005. The soil used was collected from 0-to-20 cm soil depth from Ban Muangyai village. The soil was sandy loam with pH 4.50, total N 0.020%, available P 5.62 ppm and extractable K 20.02 ppm. The soils were dried, ground and filled into vegetable oil cans, 24 cm long, 24 cm wide and 35 cm deep; and leveled off 5 cm below the can's lip surface. A factorial combination of three cultivars (KDML 105, photoperiodic sensitivity; RD15, photoperiodic sensitivity; RD7, non-photoperiodic sensitivity), and two cutting height (5 cm and 10 cm) with four replications were used. Three rice seeds were seeded at 2.5 cm soil depth. Rice seedlings were thinned to 1 plant/pot at 10 days after seeding. Fertilizer grade 16-16-8 (N-P_2O_5-K_2O) was applied as basal at rate of 94 kg/ha with incorporated into the soil and again at rate of 94 kg/ha at any cutting date. Urea fertilizer (46%N) was applied at rate of 30 kg/ha at panicle initiation. Water was applied at field capacity by bucket shower for optimum crop growth until desirable cutting date. Then, standing water was remained at 3 cm depth above ground surface. Water was drained out from the cans one week before harvest. Two hand-weedings were done at 15 and 30 days after seeding. Insecticides and fungicides were not used in this study. For cutting height, the culms were cut by sickle at desirable depth 5 and 10 cm above ground surface.

The number of days to heading and maturity were recorded in the present experiment. The tiller number, plant height and top dry weight (not include grain) were measured at harvest. The yield components such as panicle number, grain per panicle, filled grain number and 1000 grains weight were determined at harvest. Grain yield (gm/pot) was measured at harvest and calculated at 14% seed moisture content.

The total soluble sugar and starch concentration were determined according to the method outlined by Conocono et al. (1988).

RESULTS

Day to heading and maturity

Cutting date had a significant effect on days to heading and maturity. Days to heading and days to maturity were longer when cutting at 60 DAS, in comparison with 30 DAS and 45 DAS cutting date (Table 1). This indicates that late cutting tends to delay heading and maturity. Cutting height had no effect on days to flowering and maturity, while cultivars differed considerably for days to flowering and maturity (Table 1). KDML 105 had the longest number of days to heading and maturity. There was an interaction between cutting date and cultivar on days to maturity (Table 1). KDML105 and RD15 cultivars did not show any significant difference on days to maturity at 60 DAS. On the other hand, RD23 cultivar had significant effect on days to maturity. The crop were cut at 60 DAS, which delayed maturity by 18 days in comparison with early cutting at 30 DAS (Table 2).

Growth

Cutting date had no effect on tiller number at panicle initiation growth stage while, cutting date affected significantly plant height and top dry weight (not include grain) at harvest (Table 1). The plant height and top dry weight were greatest at the first cutting dates 30 DAS, in comparison with 45 DAS and 60 DAS cutting dates (Table 1).

Cutting height had no effect on tiller number, plant height and top dry weight while, cultivars differed considerably for tiller number, plant height and top dry weight (Table 1). RD23 cultivar

produced the maximum tiller number, RD15 cultivar gave the highest plant height and KDML 105 cultivar produced the greatest top dry weight.

There was an interaction between cutting date and cultivar on plant height and top dry weight (Table 2). The three rice cultivars had a significant effect on plant height at three cutting dates. KDML105 cultivar was cut at 45 and 60 DAS had reduced plant height by 8 and 17 cm, respectively in comparison with early cutting at 30 DAS. RD15 cultivar which was cut at 45 and 60 DAS had decreased plant height by 9 and 9 cm, respectively as compared with early cutting at 30 DAS. RD23 cultivar which was cut at 45 and 60 DAS had reduced plant height by 14 and 32 cm, respectively in comparison with early cutting at 30 DAS. For above ground part dry weight, three rice cultivars had significant effect on top dry weight at three cutting dates. KDML105 cultivar which was cut at 45 and 60 DAS had decreased above ground part dry weight 6 and 16 gm per pot, respectively as compared to early cutting at 30 DAS. RD15 cultivar was cut at 45 and 60 DAS reduced above ground part dry weight 17 and 24 gm per pot, respectively in comparison with early cutting at 30 DAS. RD23 was cut at 45 and 60 DAS decreased top dry weight 7 and 12 gm per pot, respectively in comparison with early cutting at 30 DAS (Table 2).

Table 1 Main effects of treatments on day to heading and maturity, tiller number at panicle initiation, plant height and top dry weight (not include grain) at harvest.

Treatments	Days to heading	Days to maturity	Tiller (no./pot)	Plant height (cm.)	Top dry weight (g/pot).
Cutting date (D)					
30 DAS	106.6 b	140.0 b	4.3	123.0 a	17.2 a
45 DAS	109.4 ab	143.6 ab	4.8	113.5 b	11.8 b
60 DAS	112.0 a	148.7 a	4.7	101.5 c	7.7 c
Cutting height (H)					
5 cm	109.9	144.8	4.7	111.9	24.2
10 cm	108.8	143.3	4.5	113.8	26.3
Cultivar (C)					
KDML105	122.3 a	156.0 a	4.5ab	120.1 a	16.3 a
RD15	113.8 b	145.8 b	3.7 b	120.4 a	12.5 b
RD23	91.9 c	130.4 c	5.6 a	98.1 b	7.9 c
F-value					
Cutting date (D)	5.02*	7.08**	0.79NS	54.05**	41.79*
Cutting height (H)	0.63NS	0.61NS	0.36NS	1.14NS	1.76NS
Cultivar (C)	1.66.67**	62.08**	9.30**	72.26**	35.95**
D x H	2.35NS	2.22NS	0.93NS	0.15NS	1.68NS
D x C	2.81NS	3.95*	1.16NS	2.83*	2.68*
H x C	2.51NS	0.97NS	0.27NS	2.60NS	1.84NS
D x H x C	1.74NS	1.02NS	2.11NS	0.35NS	1.22NS

Yield components and grain yield

Cutting date had no effect on panicle number and 1,000 grain weight, but there was significant difference in the number of grains per panicle, filled grains per panicle and grains yield (Table 3). The maximum grains per panicle, filled grain per panicle and grain yield were obtained when the crops were cut at 30 DAS (Table 3).

Table 2 Interactions between cutting date and cultivar on days to maturity, plant height and top dry weight.

Treatments	Days to maturity	Plant height (cm)	Top dry weight (g/pot)
30 DAS x KDML105	155.5 a	128.3 a	39.4 ab
30 DAS x RD15	140.5 b	129.0 a	41.0 a
30 DAS x RD23	124.0 c	113.3 bc	22.7 cd
45 DAS x KDML105	156.5 a	120.7 b	33.8 b
45 DAS x RD15	148.8 ab	120.2 b	23.6 c
45 DAS x RD23	125.3 c	99.7 d	15.6 e
60 DAS x KDML105	156.0 a	111.2 c	23.4 cd
60 DAS x RD15	148.2 ab	120.2 b	16.9 de
60 DAS x RD23	141.8 b	81.3 e	10.8 e

Cutting height had no effect on yield components and grain yield (Table 3). Cultivars had a significant effect on number of grains per panicle, filled grains per panicle, 1,000 grains and grains yield, but did not show any significant difference on panicle number (Table 3). KDML 105 cultivar gave maximum filled grain per panicle and grain yield. RD15 cultivar produced the highest number of grains per panicle. RD23 cultivar gave the highest 1,000 grains weight. However, the grain yield was not statistically significant difference between KDML105 and RD15 cultivars.

Table 3 Main effects of treatments on yield components and grain yield.

Treatments	Panicle (no./pot)	Filled grain (no./panicle)	Grain per/panicle (no.)	Grain weight (gm/1000)	Grain yield (gm/pot)
Cutting date (D)					
30 DAS	7.0	78.5 a	92.3 a	26.7	14.4 a
45 DAS	8.1	65.5 ab	76.2 ab	25.9	13.2 ab
60 DAS	7.7	57.3 b	67.7 b	26.0	11.3 b
Cutting height (H)					
5 cm	7.7	66.5	79.2	26.3	12.9
10 cm	7.5	67.7	78.2	26.1	13.0
Cultivar (C)					
KDML105	7.8	79.5 a	86.9 a	25.5 b	15.5 a
RD15	7.5	76.3 a	88.0 a	26.2 ab	14.4 a
RD23	7.4	45.5 b	61.2 b	26.8 a	9.0 b
F-value					
Cutting date (D)	1.25NS	8.47**	7.58**	1.94NS	3.40*
Cutting height (H)	0.20NS	0.08NS	0.04NS	0.33NS	0.01NS
Cultivar (C)	0.16NS	26.06**	11.22**	4.86*	15.79**
D x H	2.84NS	1.27NS	3.01NS	0.79NS	1.09NS
D x C	1.06NS	0.40NS	1.43NS	1.79NS	1.23NS
H x C	1.72NS	0.79NS	0.18NS	1.24NS	1.89NS
D x H x C	2.17NS	0.88NS	1.34NS	0.63NS	0.71NS

Total soluble sugar and starch concentration

Cutting date had a significant effect on total soluble sugar (TSS) and starch concentration in the stem among cutting dates of 30, 45 and 60 DAS (Table 4). The maximum TSS and starch concentration were obtained when the crop were cut at second cutting date of 45 DAS.

Cutting height had no effect on TSS and starch concentration in the stem among cutting dates of 30, 45 and 60 DAS. Cultivar had no effect on TSS, but there was a significant difference on starch in the stem among cutting dates of 30, 45 and 60 DAS (Table 4). RD23 cultivar produced the highest starch concentration in the stem among cutting dates of 30, 45 and 60 DAS.

Table 4. Main effects of treatments on total soluble sugar (TSS) and starch concentration in the stem.

Treatments	Concentration in stem (mg/g)	
	TSS	Starch
Cutting date (D)		
30 DAS	38.6 b	74.3 c
45 DAS	57.1 a	276.1 a
60 DAS	32.5 b	120.2 b
Cutting height (H)		
5 cm	43.9	153.6
10 cm	41.6	160.1
Cultivar (C)		
KDML105	43.3	144.9 b
RD15	42.8	145.9 b
RD23	42.2	179.9 a
Cutting date (D)	44.44**	188.22**
Cutting height (H)	1.15NS	0.53NS
Cultivar (C)	0.09NS	6.69**
D x H	2.22NS	0.71NS
D x C	1.80NS	0.68NS
H x C	2.04NS	2.43NS
D x H x C	1.03NS	0.21NS

Influence of total soluble sugar and starch on crop yield

Stem TSS of cutting height at 5 cm and 10 cm above ground surface of three cultivars plotted against crop yields produced a non significant positive linear relationship, R^2 values of 0.0128 (Fig. 1). While, stem starch of cutting height at 5 cm and 10 cm of three cultivars plotted against crop yields gave a non significant negative linear relationship, R^2 values of 0.0311 (Fig. 2). Results indicating that grain yield was not depend on TSS and starch concentration in the stem at various cutting date.

DISCUSSION

Early cutting at 30 DAS gave the maximum grain yield as early cutting produced the highest number of filled grains per panicle. However, there was not significant difference on grain yield when the crops were cut at 30 and 45 DAS, but significant increase in grain yield in comparison with cutting at 60 DAS. In the experiment, cutting date had a significant effect on plant height at harvest, indicating that the maximum number of grain per panicle was obtained when the crops were cut early due to greater panicle length in comparison with late cutting. These findings are in agreement with the work by Osnishi and Horie (1990) reported that as the cutting time delayed the herbage yield linearly increased but the grain yield of rice from the regrowth linearly decreased.

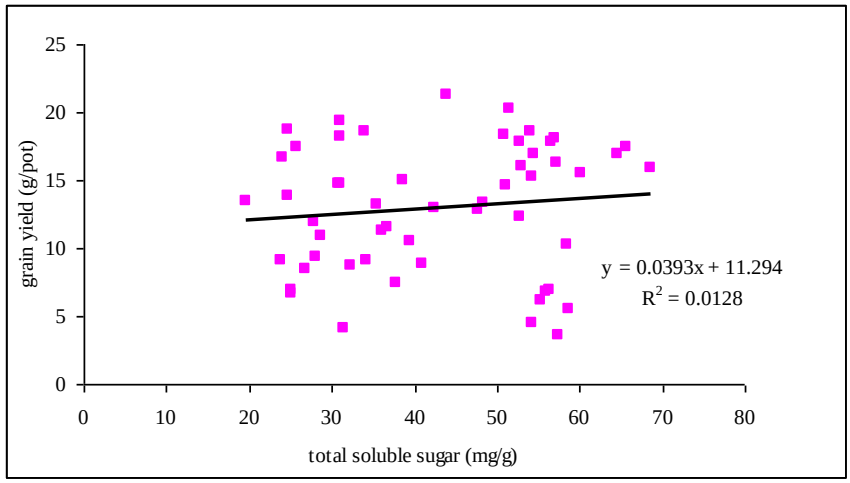


Fig. 1. Relationship between total soluble sugar and grain yield in the stem.

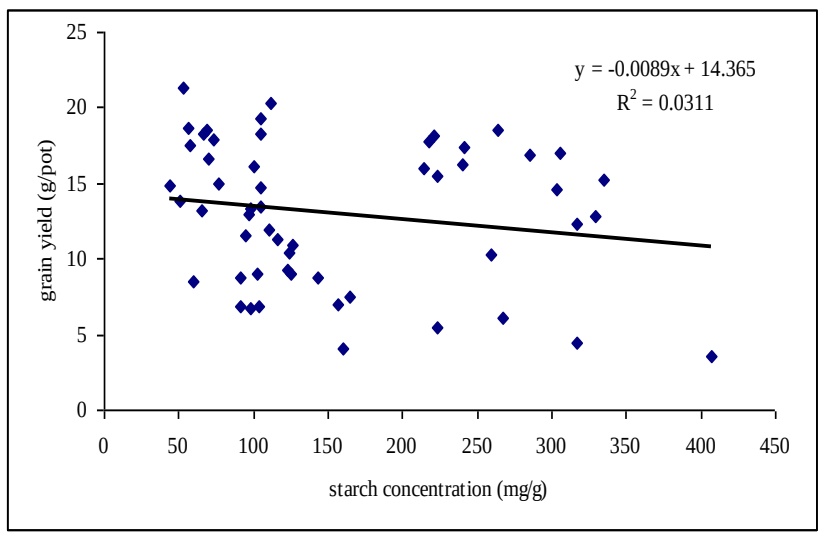


Fig. 2. Relationship between starch and grain yield in the stem.

In this experiment, delaying cutting at 60 DAS decreased the number of grain per panicle and filled grain per panicle. Muldoon (1985) reported that winter cereals crops; barley, wheat, rye and triticale, were cut for forage at 8 days, 80 and 122 days, or 80, 122 and 164 days from sowing. Grain yields following cutting were linearly decreased. With later cutting, the rate of decrease in the grain yield was: wheat and rye > tritical and barley > oats. Grain yields decreased because of reduced number of heads (in wheat), fewer grains per head (barley, wheat and triticale) and lower 1,000 – grain weights (wheat, rye and triticale). Cutting height at 5 and 10 cm above ground surface had no effect on grain yield from the regrowth. This finding disagrees with the work by Ohnishi and Horie (1990) which stated that cutting height at 5 cm above ground surface reduced the grain yield of the regrowth as compared with cutting at 10 cm, especially at the late transplanting.

KDML105 and RD15 cultivars produced similarly in grain yield and both cultivars gave a significantly greater grain yield than that of RD23 cultivar. This was due to both cultivars had a longer vegetative growing period. Then, the crops provided greater in plant height, top dry weight, number of filled grains per panicle than that of RD23 cultivar.

There was no interaction on grain yield between cutting date x cutting height, cutting date x cultivar, cutting height x cultivar and cutting date x cutting height x cultivar in this experiment. The number of days to maturity, plant height and top dry weight had a significant ($P<0.05$) cutting date x cultivar interaction, indicating that subsequent crop performance just as in the main crop are influenced by an individual cultivar.

Total soluble sugar (TSS) and starch in the stem was significant increase when the crop was cut at 45 DAS as compared with cutting at 30 DAS. However, grain yield has no significant linearly relationship with TSS and starch in the stem. This result indicates that TSS and starch in the stem of the main crop at cutting date had no significant effect on grain yield from the regrowth. Thus, factors that influence TSS and starch in the stems of the main crop at cutting date may not influence the subsequence crop performance such as the ability of tillering (data not shown). The capacity of the plant for regrowth seems to be based on apical meristems at cutting date. The culms were cut at 30, 45 and 60 DAS during the vegetative growth stage. The growth apices had not yet been elevated above cutting height, so regrowth can start from already existing tiller. This contrasts with ratoon cropping of rice which obtains a second crop from the stubble of a previously harvested (main) crop. In general, total nonstructural carbohydrate of the main crop food reserve increased ratoon crop yields (Turner and Jund, 1993; Samson, 1980).

Dry direct-seeded of broadcast rice as practiced by the farmers tend to increase in Thailand due to less labour requirements as compared to transplanted rice. In addition, dry direct-seeded rice can be broadcasted even when soil moisture is low at planting time where rainfall is erratic in rainfed ricelands. However, weed infestation is a major factor limiting grain yield in dry direct-seeded of broadcasting rice. Weed control method by cutting weed and rice in dry direct-seeded rice proved to be practical for farmers and increased grain yield (Polthanee et al., 2004). This study suggests that rice and weeds should be cut not later than 60 days after seeding with cutting height 5-10 cm above soil surface to improve grain yield. Rice and weed stover removed from the paddy fields by this weed control method can be used for cattle feed.

REFERENCES

Anderson, B., Matches, A.G. and Nelson, C.J. 1989. Carbohydrate reserves and tillering of switchgrass following clipping. Agron. J. 81: 13-16.

Bahar, F.A. and De Datta, S.K. 1977. Prospects of increasing tropical rice production through ratooning. Agron. J. 69: 536-540.

Balasubramanian, B., Morachan, Y.B. and Kaliappa. 1971. Studies on ratooning in rice : I. Growth attributes and yield. Madras Agric. J. 57: 565-570.

Chauhan, J.S., Vergara, B.S. and Loper, F.S.S. 1985. Rice ratooning. IRRI Res. Pap. Ser. 102. International Rice Research Institute, Los Banos, Philippines.

Conocono, E.A., Egdane, J.A. and Setter, T.L. 1998. Estimation of canopy photosynthesis in rice by mean of daily increases in leaf carbohydrate concentrations. J. Crop Sci. 38 : 987-995.

Deregibus, V.A., Trlica, M.J. and Jameson, D.A. 1982. Organic reserves in herbage plants : Their relationship to grassland management. p. 315-344. *In* M. Rechcigl, Jr. (ed.) CRC handbook of agricultural productivity. Vol. I. Plant productivity. CRC Press, Boca Raton, FL.

Muldoon, D.K. 1985. Simulation of the effect of forage cutting on subsequent grain yields of temperate cereals. Agricultural Systems 17: 231-242.

Ohmishi, M. and Horie, t. 1990. Effects of cropping season and soiling time and height on herbage and grain yeilds and feeding value. Japan. Jour. Crop. Sci. 59(3): 419-425.

Polthanee, A., Gonkhamdee, S. and Phoemsana, K. 2005. The effect of rice and weed cutting on subsequent weed growth and grain yield of dry direct-seeded rice. J. ISSAAS. 12(?) ??

Reddy, T.G., Mahadevappa, M. Kand Kulkarni, K.R. 1979. Rice ratoon crop management in hilly regions of karnatake, India. Int. Rice. Res. Newsl. 4(6): 22-23.

Samsan, B.T. 1980. Rice ratooning effects of variety type and some cultural management practices. MS thesis. Univ. of Philippines at Los Banos, Laguna, Philippines.

Turner, F.T. and Jund, M.F. 1993. Rice ratoon crop yield linked to main crop stem carbohydrates. Crop Sci. 33: 150-153.

Vergara, B.S., Lopez, F.S.S. and Chauhan, J.S. 1988. Morphology and physiology of ratoon rice. P.31-41. *In* W.H. Smith and V. Kumble (ed.). Rice ratooning. Proc. Workshop IRRI, Indian Counc. Agric. Res., and Univ. of Agric. Sci., Bangalore, India. 21-24 Apr. 1986. IRRI, Los Banos, Philippines.

The International Society for Southeast Asian Agricultural Sciences