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Comparisons of Production Costs and Profit of Three Different Technology Levels of Papaya Production in Tabasco, Mexico

E. Guzmán-Ramón [*1], **R. Gómez Álvarez** [1], **H. A. J. Pohlan** [2], **J. C. Alvarez-Rivero** [3], **J. Pat-Fernández** [4] and **V. Geissen** [1]

Abstract

The survey was carried out from September 2006 to January 2007 in three papaya production sites located in main papaya production zones in Tabasco; SE Mexico. There are differences in size of the cultivated area, in the yield of the papaya as well as in production costs and profit, according to the different technology levels in the farming systems: low, medium and high technology cultivation level. The financial evaluations were carried out in three sites with different productive technologies. The comparison of the agronomic and economic traits results for low technology level in: VAN of 2359.00 USD, BCR in 1.9 and an equilibrium point of 3750.00 USD, TIR of 0.25. In order to avoid loses, a quantity of 10714 kg papaya should be sold. In medium technology VAN is 1605.10 USD, BCR is 1.7, TIR 0.20 and the equilibrium point is 12800.00 USD. 36571 kg of papaya should be yearly sold. In high technology level VAN is 11749.40, BCR is 2.73, TIR 0.43 and the equilibrium point is 12187.50 USD, 34821 kg papaya should be sold yearly. The indicators showed that all three levels are profitable and economically viable.

Keywords: investment, yield, production costs, benefit - cost - ratio, equilibrium point

Resumen

La investigación se llevó a cabo en 3 unidades de producción de papaya ubicadas en las principales zonas agroecológicas productoras de papaya en el Estado de Tabasco entre Septiembre 2006 a Enero de 2007. Existen diferencias en el tamaño del área cultivada, en rendimientos de la papaya así como en costos de producción y rentabilidad, de acuerdo a las diferentes tecnologías utilizadas en las unidades de producción: alto, mediano y bajo nivel de tecnificación del proceso productivo). Las evaluaciones financieras fueron realizadas en tres unidades de producción ubicadas en Cunduacán, Teapa y Balancán. La comparación de los aspectos agronómicos y económicos resultó en tecnología baja: VAN es de USD 2359.20; RB/C es 1.9 y el punto de equilibrio es de USD 3750.00 y

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TIR es 0.25; para no tener pérdidas se debe vender 10714 kg de papaya. En tecnología media: VAN es de USD 1605.10; RB/C es 1.7, TIR 0.20 y el punto de equilibrio que es de USD 12800.00 y 36571 kg. En tecnología alta: VAN es de USD 11749.40; RB/C es 2.73, TIR 0.43 y el punto de equilibrio que es de USD 12187.50 y 34821 kg. Los indicadores demostraron que todos los niveles son rentables.

Palabras clave: inversión, rendimiento, costos de producción, beneficio-costo, punto de equilibrio.

1 Introduction

Mexico is immersed in a deep changing process. Thousands of big agro exporting enterprises are successful while an outstanding proportion of commercial producers are in bankrupt. Small farms are impoverished; however they do not disappear due to the lack of employment alternatives. It is necessary to rethink about the rural concept when the agricultures produce only for self consumption without the possibility to develop their market production subsisting on incomes gotten thanks to complex temporary migratory processes. It is imperative for Mexican farmers to become managers taking advantage on their experience and the needed implications for the organization of the production, education, training, product organization, commerce transformation, supplying of own personnel or use of technology (Pohlan *et al.*, 2007; Plata, 2000). In a great number of cases farmers in the tropics have the same social economical and financial problems, such as the lack of technology, substructure for the production and commercialization, training and technical assistance, organization to produce and commercialize in a proper way, productive chain articulation, subsidies and lack of strategies to develop human factor (Wander *et al.*, 2007; Méndez Garrido, 2005, p.9).

Nation wide, Tabasco occupied the eighth position of Mexican papaya producers with 662 ha, with a total production of 214,679 tons per year (SAGARPA, 2005). Tabasco has a humid tropical climate where the growth of papaya (*Carica papaya* L.) is propitiated. Papaya cultivating areas have increased between 1991 (187 ha) and 2001 (2126 ha) (SAGARPA, 2001). During the last years papaya production has reached a rise in sown land surface, the Maradol and Zapote varieties are the most commercialized species at the moment with yields of more than 27 t ha^{-1} which has sustained as a profitable product for the small farmers of the Centro and Chontalpa regions of Tabasco. For most producers the Maradol variety is sown in an 80% and the rest are the varieties Zapote and Tabasco 95. The main problem in fruit production is the presence of the fruit annular rotting caused by a virus (Mirafuentes Hernandez, 2001). Because of this, Tabasco is making an update of the producers' census list with the support of their districts and the integration of the product System State Council to organize producers on the getting, post-harvest handling and commercialization of this papaya fruit. The papaya production and commercialization is a challenge for each of the municipalities in the state, due to structural and fundamental problems starting with the handling of crops, the application of proper technology, infrastructure, training, technical assistance, meteorological phenomena, pests and diseases until the aggregated value chains and commercialization as well as the investment needed to get a greater income.

2 Methods and Materials

2.1 Study area

Tabasco is located in south east of Mexico; it extends from the Gulf of Mexico plain coast to the north of Chiapas' Sierra. Tabasco soils are mainly alluvial soils on flat and lowlands, excepting for the limiting zone with Chiapas which is mountainous. The climate is humid and hot distinguished by high temperatures quite uniform with an annual mean of 26° C. There are three important papaya producing sub regions, Chontalpa, Centro-Sierra and Los Rios, each one with different features. Most of the low technology farmers are found in the Chontalpa and Centro sub regions, mainly in the municipalities of Cunduacan, Huimanguillo and Cardenas, which represents the 88% of the total shown land among 1-5 ha. The medium technology farmer are found in Cunduacan, Huimanguillo and Teapa which represent 7.5 % of papaya area with plantations between 5 to 10 ha. The high technology farmers are located in Balancan representing only 4.5 % of the total, with plantations of more than 10 ha in size. According to the data of SAGARPA (2005), in Tabasco are 189 Maradol papaya temporary producers (610 ha) and 10 farmers with 33 ha irrigated papaya cropping. In Chontalpa the greatest number of low technology producers (175 farmer) is concentrated with surfaces between 1 to 2 hectares (manual and temporary crops), 24 medium technology producers in Chontalpa and Centro-Sierra. The high technology producers are located in Balancan, in Los Rios region where there is a small number of producers and great areas of high technologies (irrigation and mechanization) with sown areas between 10 and 40 ha. with a total of 199 producers (SAGARPA, 2006).

This study was carried out in six main papaya producing municipalities in Tabasco: Huimanguillo, Cardenas, Cunduacan, Centro, Teapa and Balancan (Figure 1).

By stratified sampling, 67 surveys were applied in these 6 municipalities. For the data analysis of the survey, the DYANE statistical software (Santesmases, 2005) was used. For the economical analysis we determined the yields obtained in the field, carrying out interviews with producers and own observation.
For each technology level (low, medium and high) we selected three production units to be studied in their handling of the product and their costs/profits ratios.

For the comparison between the different technology levels were analyzed the following economical indicators:

Net present value (VAN):
$VAN = -p + (F_1/(1+i)^1 + F_2/(1+I)^2 + F_3/(1+i)^3 + \cdots + F_n/(1+i)^n$

Benefit – cost – ratio (BCR):
$BCR = profit/total\ costs$

Point of equilibrium (PE):
$PE = fixed\ costs/(1 - variable\ costs/net\ sales)$;
$PE = TIR$ being $VAN = 0$

Discount rate (TIR):
$TIR=$ by which the VAN is equal to zero, and it is defined as the I (its determined by rough calculation) that is made with the discounted flows being equal to the initial investment. Once the information was obtained, it was organized and systemized according to the fix and variable costs, determining the total papaya production costs in the three levels of technology to calculate the profitability product indicators at the price in January 2006. The aspects analyzed were the fixed costs and the production costs, in the papaya production process, during the first 12 months with a 5 year projection to obtain financial indicators: net present value (VAN), benefit/cost ratio (RB/C), TIR and point of equilibrium (PE).

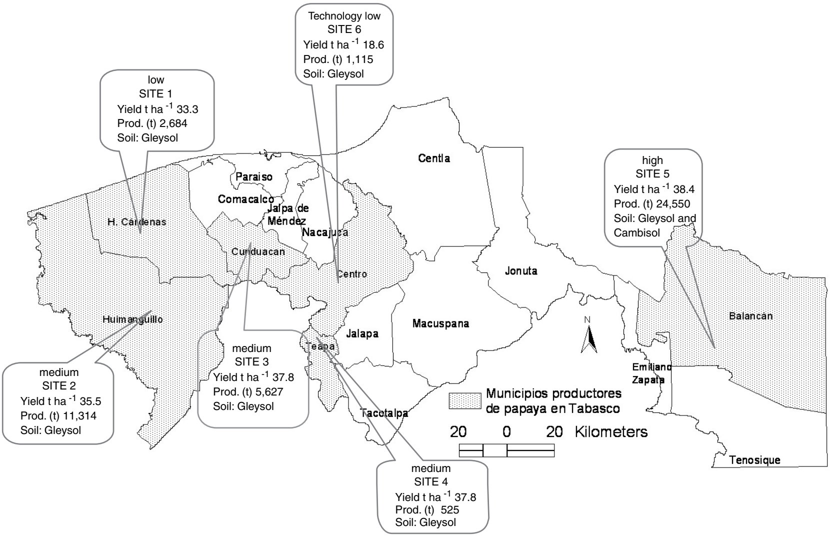
The VAN is defined as the result of the difference between the updated incomes (positive values) and updated costs (negative values) to a determinate discount rate (Coss Bu, 2001, p. 61). This discount rate allows making comparable the flow either incomes or costs. When the VAN is positive to a higher rate tax than 15% annual, it is considered that the project profitability is acceptable and thus financially convenient. Depreciation is the diminution of the price or value that suffers to a product as a consequence of the use and time. It is only applied to the fix actives; all the enterprises should base their calculations of their depreciations in the Financial Law (art. 37 of the LISR). This is calculated only for medium and high technology levels.

The different technological papaya production levels were determined by the main factors such as cultivation density, crop size, use of irrigation, use of agrochemicals, agro ecological handling, rank of crop significance, harvest method and post harvest handling (Table 1). The main elements to differentiate the level of technology were the cultivating system and the use of materials and agricultural implements such as tractors, irrigation system and transportation means.

Table 1: Papaya production technologies in Tabasco (classification based in SAGARPA (2005); Silva Torres (2002).

Concept	*Technology level*		
	Low	*Medium*	*High*
Crop density per ha	1100 plants	1600 plants	2200 plants
Size of plantation (ha)	1 to 4	5 to 10	10 or more
Use of irrigation	no	tubes or drops	drops or tubes
Use of agrochemicals	low	medium	high
Agro ecological handlings	low	low	low
Productive Structure (Rank of crop importance)	10% or less with papaya	30% of the area is papaya	more than 50% is papaya
Harvest method	manual	manual & with equipment	with equipment
Post Harvest handling	manual	medium technician	highly process technician

Figure 1: Sites of the papaya cultivation areas in Tabasco, Mexico.



3 Situation of the papaya cultivation in Tabasco

The papaya production in Tabasco is mainly characterized economically and socially of low production technology, for which is the main economical activity and its main familiar source of income for the producers by selling their produce in the local and national market by intermediaries. In contrast to them, the producers with medium and high technologies have a high income potential in the national and international markets due to the great demand of this fruit.

Based in the project carried out by Semillas del Caribe (2000), the production cost per hectare of Maradol papaya, under average conditions in Mexico, and considering a cycle of 18 months (2 months in nursery, 7 in crop growing and 9 in fructification and harvest) it was determined in a total of \$105,548.50 Mexican pesos, (1 USD≈\$10.00 Mexican pesos) with partial costs for tillage \$3,190.00; \$4,647.50 for the planting preparation, sowing \$1,540.00; irrigation \$3,400.00; weed control \$3,100.00; pest management \$24,987.00; fertilization \$26,244.00; cultivating handling \$9,940.00 and harvest \$28,500.00 (Semillas del Caribe, 2000).

The price paid to the producer per kilogram of fruit in 1999 varied from \$2.00 to \$6.00 (0.20 USD to 0.60 USD), depending on the fruit quality, the season and the market to it was sent. In the year 2006 the price paid to the producer by the intermediary in Tabasco was the same as 6 years ago.

Silva Torres (2002) reported that the average income obtained by the small producers in a two year producing cycle is \$181,260 pesos ha^{-1}, harvesting 95.4 t ha^{-1} with a price of 1.90 pesos ha^{-1} of fruit. In contrast, the medium producers have an average income of \$529,332 pesos ha^{-1}, and the high technology producers have incomes of \$618,800 pesos ha^{-1} selling at 3.4 pesos ha^{-1} (Table 2).

Table 2: Comparison of production costs (Mexican pesos ha^{-1}) in a 2 year cycle in San Pedro, Balancan (Silva Torres, 2002).

Concept	*Small holding farmers*	*Medium size farmers*	*Big size farmers*
Land Acquisition	0	0	3750
Machinery and Equipments	6477	16179	50375
Land conditioning	2044	1368	4041
Nursery	5465	2565	1011
Transplanting	522	801	486
Irrigation	11435	4022	2231
Pest management	15315	31482	31131
Weed control	1258	3166	1697
Fertilization	6441	20139	34075
Cultivating labours	390	468	477
Harvest an post harvest	15743	19432	38549
Transport	0	64633	79762
Total costs	65090	164255	247585
Income ha^{-1}	181260	529332	618800
Profit ha^{-1}	116170	374581	371214

4 Results and Discussion

4.1 Agro ecological parameters in the different production sites

The Zapote Variety is only cultivated by the low technological level farmers. The Maradol variety is the most predominant in the high and medium levels. These farmers buy the plants in specialized nurseries. The harvest of Maradol starts at six months and the Zapote variety seven months after transplanting. The productive period varies between 5 and 7 months with harvest cuts in an 8 day rhythm. The harvest must be realized when the fruits present a maturation point of 25 to 35 % yellow to be sent to the local market. For external market the fruit should show a trace of yellow color. Both varieties present five productive months, considering that it shouldn't be affected by pests and diseases. In the medium and high level technologies farmers calculate 15 t per cut and hectare, which fills a truck with 9000 fruits with an average weight of 1.7 kg approximately.

The evaluation of the agro ecological features in the six producing units presented a very heterogeneous scenario among the producing units (Table 3). The cultivated density according to the technology level varies between 1000 and 2140 plants ha^{-1}.

Table 3: Agro ecological parameters in the different production sites.

Agro ecological parameters	*Cárdenas*	*Centro*	*Huimanguillo*	*Cunduacán*	*Teapa*	*Balancán*
Level of technology	low	low	medium	medium	medium	high
Density (plants per hectare)	1800	1000	1400	2000	2140	2140
Sown surface area (ha)	2	1	3	3.5 to 5	6	20 to 40
Water quality	low	medium	medium	medium	medium	high
Cropping System	temporary	temporal	temporary	irrigation	irrigation	irrigation
Use of agrochemicals	medium	low	medium	high	medium	high

Water quality was analyzed in each site. Irrigation systems only exist in medium and high production level units. The use of agrochemicals in reference to the interviews done is according to the technology level.

The economical aspects (Table 4, Figure 1) vary in the production units shown mainly by the technology level. The use of irrigation in the units of high and medium technology has an influence in the yield of these units. The economic incomes are higher in the high technology level. The production costs are significantly higher caused by machinery and equipment investment such as tractors and modern systems of fertirrigation, which allow a more precise application of fertilizers. The interviews showed average yields of 40 t ha^{-1} for the low technology level, 60 t ha^{-1} for the medium technology level and 80 t ha^{-1} for the high level. The production costs per hectare vary from \$25,000 to \$40,000; \$60,000 to \$80,000 and \$80,000 to \$100,000 Mexican pesos, respectively.

Table 4: Economical parameters of papaya crops in different municipalities of Tabasco.

Economical parameters	*Cárdenas*	*Centro*	*Huimanguillo*	*Cunduacán*	*Teapa*	*Balancán*
Type of Technology	low	low	medium	medium	medium	high
Cropping System	temporary	temporary	temporary	irrigation	irrigation	irrigation
Cultivated surface with papaya	10%	10%	> 50%	30%	> 50%	> 50%
Post harvest	manual	manual	manual	manual	manual	manual
Yield (t* ha^{-1})	28	28	60	60	60	84
Production costs (Mex. pesos ha^{-1})	40,000	40,000	120,000	120,000	120,000	160,000

The low technology farmers represent 88% in Tabasco, according to the information obtained from the surveys and it was also confirmed that the average plant density that are sown in the low technology surfaces is of 1100 plants per hectare, 1600 in the medium technology lands and 2200 in the high technology surfaces (Table 5). Height of the plants, size of the stem and yield were strongly related to fertilization.

Table 5: Agro economical characteristics according to the applied technology.

Concept	*Technology level*		
	Low	*Medium*	*High*
Plant density per hectare	1100 plants	1600	2200
Size of the plantation (ha)	1 to 5	5 to 10	10 or more
Type of cropping system	Temporary	Irrigation	irrigation
Distance between plants (m)	3×3	3×2.5	2×2.5
Drainage	Low	Medium	high
Height of the plants (m)	1.87	1.94	2.05
Stem diameter (cm)	30	44	46
Harvest calendar	each 10 days	each 8 days	each 8 days
Harvest period	5 months	7 months	8 months or more
No. of harvest cuts/month	3 cuts	4 cuts	4 cuts
No. of harvest cuts/year	15	20	28
No. fruits/plant/cut	1 to 5	8 to 10	8 to 10
Average weight/fruit (kg)	2.5	2.00 to 3.00	2.00 to 3.00
Yield (t/ha)	28	60	84

4.2 Production costs

The concepts that build up the cost structure are variable and fix costs. The total cost is the sum of the total variable cost (CVT) and the total fixed cost (CFT) (Baca Urbina, 2006) (Table 6).

Table 6: Comparative costs in the different technological levels (Mexican pesos per ha).

Concept	*Technology level*		
	Low	*Medium*	*High*
Land preparation	3500	5000	5000
Tools and equipments	2260	44410	54490
Plants	1650	8000	11000
Sowing	2850	10500	13500
Irrigation	0	10000	20000
Fertilization	7325	7500	10220
Pests and disease control	24318	40863	44034
Weed control	0	3800	7200
Harvest	500	8925	9425
Total costs	42403	138998	174939

The finality of this feature is to determine the profitability for the producer comparing the costs and benefits considering all the incomes and expenses, the money relative value in time and interest rate. The differences among the levels of costs for the productive cycle are influenced mainly by the acquisition of the plants (amount and variety) and the agrochemical materials (fertilizers, fungicides and herbicides). The raw material costs in the plantations with low technology level are 13193 pesos ha^{-1}, following by the medium level with 29101 and high level with 37369 pesos ha^{-1} (Table 7). It's important to say that the mentioned products are applied in a revolving way as preventions and in some cases of more incidences. The prices for the agrochemicals are base to the brokers of these products in March 2007.

Table 7: Raw material costs in the different technological levels (Mexican pesos per ha).

Concept	*Technology level*		
	Low	*Medium*	*High*
Plants	1650	10500	13600
Fertilizers	7325	7500	10620
Fungicides	3318	9051	11099
Herbicides	600	800	800
Paper for fruit packing	300	1250	1250
Total cost	13193	29101	37369

The variable costs are the only directly affecting production costs. In contrary, the total fixed fabrication costs remain constant at any production volume. The total variable costs increase in a direct proportion with the change that occurs in the production. Table 8 presents the variable and fixed costs for the papaya production.

Table 8: Total costs in the different technological levels (Mexican pesos/ha).

Concept	*Technology level*		
	Low	*Medium*	*High*
Variable costs	38133	59061	104829
Raw material	13193	29101	37369
Labor	24700	29600	63500
Water	240	360	360
Fuel	0	0	2400
Electricity	0	0	1200
Fix costs	18000	96000	78000
Rent	18000	18000	0
Administration	0	36000	36000
Sale costs (15 tons truck) $ 7000 x 6 months	0	42000	42000
Total costs	56133	155061	182829

The marginal contribution percentages characterizing the productivity level is 48% in the lower level, 72% in the medium and 59% in the high. Each peso per sale is designated to the fixed costs being of 52, 28 and 41% remaining, designated for the variable costs.

The security margin (SM) is the percentage in which the sales can be reduced before possible loses.

SM (low technology) = (70000-37500)/70000 = 0.46 ≘ 46%
SM (medium technology) = (210000-128000)/210000 = 0.39 ≘ 39%
SM (high technology) = (294000-121875)/2940000 = 0.58 ≘ 58%.

In the case of high technology, the security Margin of 58% indicates that the papaya sales could be reduced to 58 % without financial loss. The neutral point of the enterprise is 42% of the total sales volume. That is, if it is sold at a neutral point its security margin is zero.

Table 9: Marginal contribution of the different technological levels (Mexican pesos/ha).

Concept	*Technology level*		
	Low	*Medium*	*High*
Yield (t ha^{-1})	28	60	84
Price (Mexican pesos / kg)	2.50	3.50	3.50
Net sales	70000	210000	294000
Variable costs	38133	59061	104829
Marginal contributions	31867	150939	189171
Contribution percentage	48	72	59
Security margin (%)	46	39	58

4.3 Profitability of the different production levels

The initial investment varied from $44323.00 in low technology and $148670 in high technology. The cash flows for five years ranged from $84481.00 in medium technology to $406069.00 in high technology (Table 10).This was the case in the three levels that presented values from $16,051 in the medium level to $117,494 Mexican pesos in the high level (Table 10).

The relation profit/cost (BCR) ranged from 1.7 to 2.7 in the different technology is an positive economic income, and so production is profitable (Table 10).

Our study shows that there's a financial profitability in the three different production levels. Most of low producers are located in Chontalpa and Centro sub regions mainly in Cunduacan, Huimanguillo and Cardenas and represent 88.06% with 1-5 has cultivated. This temporary system presents 6 months from sow time (1100 plants 3.00×3.00m apart) to harvest and 5 or 6 of harvest as high average production. (1.85 per cut each 10 days are 3 cuts per month, total 15 cuts = 28 tons a year. Market price is 2.50 kg., and incomes per sales are $70,000.00, considering that disease and plague problems have a 50% influence. It's transplanted from June to August for the harvest between

Table 10: Investments effective flow and profitability indicators in the different technological levels (10 Mexican pesos = 1 USD).

Concept	*Technology level*		
	Low	*Medium*	*High*
Fix investment	2420	86630	103430
Deferred investment	1500	1500	1500
Labour capital	36483	40476	43740
Total investment	44323	1286806	148670
Effective flow	84481	219483	406069
VAN	23592	16051	117494
BCR	1.9	1.7	2.73
TIR	0.253773	0.200580	0.430864
Point of Equilibrium	Sales should be 37,500 Pesos to have no losses, therefore it must be sold a minimum of 10,714 kg at $2.50/kg	Sales should be 128,000 Pesos to have no losses, therefore it must be sold a minimum of 36,571 kg at $3.5/kg	Sales should be 121,875 Pesos to have no losses, therefore it must be sold a minimum of 34,821 kg at $3.5/kg

February and June taking into account that in cold seasons the papaya consumption lowers from December to January. The results give: VAN is 2359.20 USD, BCR is 1.9 and the equilibrium point is 3750.00 USD in order to avoid loses, it should be sold at 10714 kg ant TIR is 0.253773 and this indicators show that the system is profitable.

Most of medium technology producers cultivated papaya in Cunduacan, Huimaguillo and Teapa. This producers harvest each 8 days, 1 to 5 t ha^{-1} in an average of 3 t per cut and 4 cuts per month with a yield of 60 t ha^{-1}. In medium technology VAN is 1605.10 USD, BCR is 1.7, TIR 0.20 and the equilibrium point is 12800.60 USD and 36571 kg and indicators have shown that also this system is very profitable.

High technology producers grew their papaya in Balancan. These big producers sell directly their products in a price of $3.50 per kg. The transplanting time in risk conditions is March, April to harvest in September-February. It's a cut each 8 days with an average of 3t/ha during 7 months which is an average of 28 cuts per year with a yield of 84 t ha^{-1} (Table 10). In high technology level VAN is 11749.40 USD, BCR is 2.73, TIR 0.430869 and the equilibrium point is 12187.50 USD with a minimum commerce of 34821 kg. The indicators showed that all three levels are profitable and economically viable.

4.4 Pro-form results

The aim of the analysis of the results or the loses or benefits is to calculate the real net profit and net cash flow, which is the real benefit and it is obtained extracting the incomes from all the cost that happen during the cropping season (Table 11). In

México, it's paid in 2007 (Based in IRS) the 28% of taxes. It's called pro-farm because this means projecting (normally 5 years) the economic results the producer will have. We assume that the need of 5 year projection is necessary to have a good profit margin, as well as crop rotation.

Table 11: Pro-form results in different technological levels.

Variables	*Year*				
	1	*2*	*3*	*4*	*5*
Low level					
Yield (t ha^{-1})	28	28	28	28	28
Income (Mex pesos ha^{-1})	70000	77000	84700	93170	102487
Production costs (Cv+Cf)	56133	61746	67920	74713	82184
Net cash flow	13867	15254	16780	18457	20303
Medium level					
Yield (t ha^{-1})	60	60	60	60	60
Income (Mex pesos ha^{-1})	210000	231000	254100	276210	303831
Production costs (Cv+Cf)	155061	170567	187624	206386	227025
Profit before taxes	54939	60433	66476	69824	76806
Taxes 28%	15383	16921	18613	19551	21506
Profit after taxes	39556	43512	47863	50273	55300
Services 26%	10285	11313	12444	13071	14378
INFINAVIT 5% IMSS 19.75+1.255 ceasing and retiring and salaries 2007					
Profit after tax	29271	32199	35419	37202	40922
Profit after benefits	8894	8894	8894	8894	8894
Depreciation					
Net cash flow	38165	41093	44313	46096	49816
High level					
Yield (t ha^{-1})	84	84	84	84	84
Income (Mex pesos ha^{-1})	294000	323400	355740	391314	430445
Production costs (Cv+Cf)	104829	115311	126842	139526	153479
Profit before taxes	111171	122289	134518	147970	162766
Taxes 28%	31128	34241	37665	41432	45574
Profit after taxes	80043	88048	96853	106538	117192
Services 26%	20811	22892	25182	27700	30470
INFINAVIT 5% IMSS 19.75+1.255 ceasing and retiring and salaries 2007					
Profit after tax	59232	65156	71671	78838	86702
Profit after benefits	8894	8894	8894	8894	8894
Depreciation					
Net cash flow	68126	74050	80565	87732	95596

Papaya production is profitable based on economic indicators considering pros and cons of the troubles that the producers face in their crops. Therefore, it should be considered a systematic planning of the investment program. From the small producers point of view, from income and expenses control to training and technical assistance as well as having a soil analysis before sowing, a good production process control, good farming practices including a complete control of plagues and diseases so that the ecological equilibrium of the environmental ecosystem can be kept. With few investments, profitability can be achieved. If more productive and profitable systems are to be installed, it will be necessary to have more investment.

5 Outlooks

In the last years papaya production was drastically reduced nation wide especially in Tabasco. This is the result of the high level of disease and plagues indexes in the crops, reducing the prices of the fruit, increasing the costs of materials and the low level of technology that makes a low profit in the papaya production in Tabasco. The application of low technology is profitable for the producers who crop 1-4 ha, even considering the pest and diseases problems and dryness and water flooding. Their incomes can be raised by adequate training and the use of good culture practices with an adapted technological level which allows them to produce with higher yield and better quality more profit. It's possible to organize sustainable growing, harvest and commercializing structures based in best culture practices, transparent fruit handling and high income for all papaya producers in Tabasco.

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Plant Genetic Resources: Selected Issues from Genetic Erosion to Genetic Engineering

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Abstract

Plant Genetic Resources (PGR) continue to play an important role in the development of agriculture. The following aspects receive a special consideration:
1. *Definition*. The term was coined in 1970. The genepool concept served as an important tool in the further development. Different approaches are discussed.
2. *Values of Genetic Resources*. A short introduction is highlighting this problem and stressing the economic usfulness of PGR.
3. *Genetic Erosion*. Already observed by E. Baur in 1914, this is now a key issue within PGR. The case studies cited include Ethiopia, Italy, China, S Korea, Greece and S. Africa. Modern approaches concentrate on allelic changes in varieties over time but neglect the landraces. The causes and consequences of genetic erosion are discussed.
4. *Genetic Resources Conservation*. Because of genetic erosion there is a need for conservation. PGR should be consigned to the appropriate method of conservation (*ex situ*, *in situ*, on-farm) according to the scientific basis of biodiversity (genetic diversity, species diversity, ecosystem diversity) and the evolutionary status of plants (cultivated plants, weeds, related wild plants (crop wild relatives)).
5. *GMO*. The impact of genetically engineered plants on genetic diversity is discussed.
6. The *Conclusions and Recommendations* stress the importance of PGR. Their conservation and use are urgent necessities for the present development and future survival of mankind.

Keywords: Plant Genetic Resources (PGR), crop plants, genetic erosion, genetic resources conservation, GMO

1 Introduction

World population is expected to increase by 2.6 billion over the next 45 years, from 6.5 billion today to 9.1 billion in 2050. The world needs astonishing increase in food production to feed this population. Plant genetic resources (PGR) constitute the foundation upon which agriculture and world food securities are based and the genetic diversity in

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the germplasm collections is critical to the world's fight against hunger. They are the raw material for breeding new plant varieties and are a reservoir of genetic diversity. Genetic adaptation and the rate of evolutionary response to selective forces depend on inherent levels of genetic diversity present at the time a species experiences a threat to its survival. Genetic diversity gives species the ability to adapt to changing environments, including new pests and diseases and new climatic conditions.

Over the millennia, traditional farmers have given us an invaluable heritage of thousands of locally adapted genotypes of major and minor crops that have evolved because of natural and artificial selection forces (MYERS, 1994). The genetic base of landraces, wild and weedy relatives in which future breeding is based have been threatened by various factors of genetic erosion. Erosion of these genetic resources along with accompanying practices and knowledge that farmers use to develop, utilize and conserve crop genetic resources could pose a severe threat to the world's food security in the long term. Loss of genetic variation may decrease the potential of species to persist in the face of abiotic and biotic environmental change as well alter the ability of a population to cope with short-term challenges such as pathogens and herbivores. Detecting and assessing genetic erosion has been suggested as the first priority in any major effort to arrest loss of genetic diversity. Generally, nevertheless, many national programs have not regarded quantification of genetic erosion as a high priority, as apparent from the paucity of information in the State of the World Report (FAO, 1996b).

With the further development of scientific and technical possibilities, the need for various plant genetic resources will increase. Therefore, the results of unabated gene erosion must by all means be reversed. Urgent action is needed to collect and preserve irreplaceable genetic resources (FRANKEL, 1974). All effort should be made to cover this future need by utilizing both *in situ* as well as *ex situ* maintenance. In situ means the setting aside of natural reserves, where the species are allowed to remain in their ecosystems within a natural or properly managed ecological continuum. This method of conservation is of significance to the wild relatives of crop plants and a number of other crops, especially tree crops and forest species where there are limitations on the effectiveness of *ex situ* methods of conservation. The *ex situ* form of conservation includes, in a broad sense, the botanic gardens and storage of seed or vegetative material in gene banks. Biotechnology has generated new opportunities for genetic resources conservation. Techniques like *in vitro* culture and cryopreservation have made it possible to collect and conserve genetic resources, especially of species that are difficult to conserve as seeds. DNA and pollen storage also contribute to *ex situ* conservation. No single conservation technique can adequately conserve the full range of genetic diversity of a target species or gene pool. Greater biodiversity security results from the application of a range of *ex situ* and *in situ* techniques applied in a complementary manner, one technique acting as a backup to the other techniques.

Advances in biotechnology have offered a new arsenal of methods to effectively utilize genetic resources. Gene technology increased the possible use of distantly related trait carriers as donors for the desired characteristics. However, the movement of genes across species boundaries presents many opportunities for both expected and unexpected risks.

In addition to food safety, other concerns involve ecological risks, such as new or increased resistance to insecticides and weed resistance to herbicides due to hybridization or excessive selection pressure, changes in the ecological competitiveness of crops, and the possible loss of genetic diversity in areas of crop origin (St Amand *et al.*, 2000). Transgenes conferring novel traits that enhance survival and reproduction may inadvertently disperse from cultivated plants to wild or weedy populations that lack these traits and might generate similar but unwanted effects in their weedy relatives through gene flow.

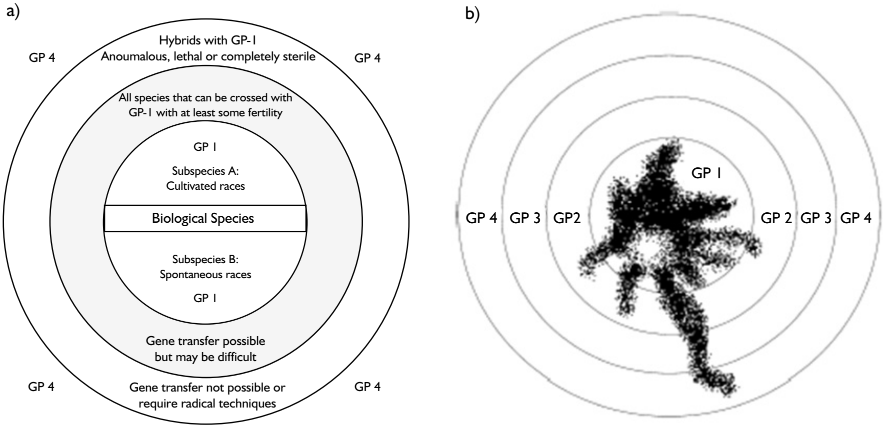
2 Plant Genetic Resources

2.1 Definition of Plant Genetic Resources

The term "genetic resources" was first used at a conference which took place under the International Biological Program (Hawkes, 1997). The conference papers were published in 1970 (Frankel and Bennett, 1970). Since then various attempts were made to define plant genetic resources. According to the revised International Undertaking 1983 of the FAO, plant genetic resources were defined as the entire generative and vegetative reproductive material of species with economical and/or social value, especially for the agriculture of the present and the future, with special emphasis on nutritional plants. Brockhaus and Oetmann (1996) defined PGR as "plant material with a current or potential value for food, agriculture and forestry". A correlated definition that appends a value of aggregation to PGR was given by FAO (1989). According to this definition, plant genetic resources refer to the economic, scientific or societal value of the heritable materials contained within and among species. They include materials used in cytogenetic, evolutionary, physiological, biochemical, pathological or ecological research on one hand, accessions evaluated for their agronomic or breeding propensities on the other.

The work of Harlan and de Wet (1971) that starts with gene pools (Figure 1) has formed a valid scientific basis for the definition of plant genetic resources. Plant breeders recognized three major gene pools based on the degree of sexual compatibility (Harlan and de Wet, 1971; Gepts, 2000). All crop species belong to a primary gene pool together with such material with which they produce completely fertile crosses through hybridisation. In contrast, all those plant groups that contain certain barriers against crossing belong to the secondary gene pool. The tertiary gene pool includes groups that can only be crossed with the help of radical new techniques. Plant breeders have traditionally emphasized closely related, well-adapted domesticated materials within the primary gene pool as sources of genetic diversity (Kelly *et al.*, 1998). More recently, however, plant transformation and genomics have led to a new quality which has been defined by Hammer (1998) and Gepts and Papa (2003) as a fourth gene pool, whereas Gladis and Hammer (2002) concluded that information and genes from other species should be a special case for the third gene pool. The fourth gene pool should contain any synthetic strain shown with nucleic acid frequencies, DNA and RNA, that do not occur in nature (Figure 1). Transgenesis allows us to bypass sexual incompatibility barriers altogether and introduce new genes into existing cultivars. It should be emphasized here that the major function of transgenic technologies is not the creation of new cultivars but the generation of new gene combinations that can be used in breeding programs (GEPTS, 2002).

Figure 1: The gene pool concept, established by HARLAN and DE WET (1971) and an example of an organismoid or a hypothetically designed crop.



a) The gene pool concept, established by HARLAN and DE WET (1971), modified. GP 1 The biological species, including wild, weedy and cultivated races. GP 2 All species that can be crossed with GP 1, with some fertility in individuals of the F1 generation; gene transfer is possible but may be difficult. GP 3 Hybrids with GP 1 do not occur in nature; they are anomalous, lethal, or completely sterile; gene transfer is not possible without applying radical techniques. Information from other genes refers to comparative genomic information on gene order and DNA sequence of homologous genes. GP 4 Any synthetic strains with nucleic acid frequencies (DNA or RNA) that do not occur in nature.

b) Example of an organismoid or a hypothetically designed crop with a genome composed of different gene pools and synthetic genes [for the explanation of this complicated matter, see GLADIS and HAMMER (2002)].

2.2 Values of Genetic Resources

Human civilizations have benefited greatly from the domestication, conservation and use of plants species used for agriculture and food production. For thousands of years, farmers have used the genetic variation in wild and cultivated plants to develop their crops. Genetic diversity is the basic factor of evolution in species. It is the foundation of sustainability because it provides raw material for adaptation, evolution, and survival of species and individuals, especially under changed environmental, disease and social conditions (HAMMER, 2004), and it will allow them to respond to the challenges of the next century (HAMMER *et al.*, 1999). The future food supply of all societies depends on the exploitation of genetic recombination and allelic diversity for crop improvement, and many of the world's farmers depend directly on the harvests of the genetic diversity they sow for food and fodder as well as the next seasons seed (SMALE *et al.*, 2004).

The considerable genetic diversity of traditional varieties of crops is the most immediately useful and economically valuable part of global biodiversity. Subsistence farmers use landraces as a key component of their cropping systems. Such farmers account for about 60% of agricultural land use and provide approximately 15-20% of the world's food (Francis, 1986). In addition, landraces are the basic raw materials used by plant breeders for developing modern varieties.

Over the last few decades, awareness of the rich diversity of exotic or wild germplasm has increased. This has lead to a more intensive use of this germplasm in breeding and thereby yields of many crops increased dramatically. Domesticated tomato plants are commonly bred with wild tomatoes of a different species to introduce improved resistance to pathogens, nematodes and fungi. Resistance to at least 32 major tomato diseases have been discovered in wild relatives of the cultivated tomato. Genes responsible for promoting resistance to 16 of these have been bred into commercial cultivars, allowing tomato production in areas where they could not otherwise have grown. Lodging was one of the major constraints limiting further increases in yields in wheat production since it prohibits the application of high amount of fertilizer. A search was therefore made among wheat from different areas of the world to locate a suitable source of genetic dwarfness to overcome this barrier. Norin 10, an extremely dwarf wheat landrace from Korea found in Japan's collections, proved to be a suitable source because of two genes, Rht1 and Rht2, that caused dwarfing. Norman Borlaug speculated that by breeding these genes into Mexican wheat lodging would be reduced and the plants would respond to fertilizer application. As it turns out, these genes not only reduce lodging through reduced height, they have direct effects on yield as a result of more efficient nutrient uptake and enhanced tillering. Despite decades of active efforts by plant breeders to control potato late blight, the disease continued to cause the loss of billions of dollars for growers each year (Kamoun, 2001). The exploitation of genetic resistance remains the most promising approach for the long-term control of late blight. The wild potato species *Solanum bulbocastanum* is a source of genes for potent late blight resistance. Similarly, the use of landraces and wild species in rice breeding has had an enormous impact on rice productivity in many countries. For example, of the 6723 accessions of cultivated rice and several wild species of *Oryza* screened for resistance, only one accession of wild species *O. nivara* was found to be resistant and used to introduce resistance to grassy stunt virus into cultivated rice (Ling *et al.*, 1970). The use of Turkish wheat to develop genetic resistance to diseases in western wheat crops is valued in 1995 at US $ 50 million per year. Ethiopian barley has been used to protect Californian barley from dwarf yellow virus, saving damage estimated at $160 million per year. Mexican beans have been used to improve resistance to the Mexican bean weevil, which destroys as much as 25% of stored beans in Africa and 15% in South America (Perrings, 1998). The diversity of plants in different ecosystems brings a lot of pleasure and inspiration to people with cultural and/or religious significance and the potential for income generation through eco-tourism. Thus, it is important to appreciate the contribution to human welfare and environmental sustainability made by all the three levels of biodiversity: (i) ecosystems, (ii) species, and (iii) genetic diversity (IPGRI, 1993).

3 Genetic Erosion

From the beginning of agriculture, farmers have domesticated hundreds of plant species and within them genetic variability has increased owing to migration, natural mutations and crosses, and unconscious or conscious selection. This gradual and continuous expansion of genetic diversity within crops went on for several millennia, until scientific principles and techniques influenced the development of agriculture (Scarascia-Mugnozza and Perrino, 2002). The impact of humans upon biodiversity has gradually increased with growing technology, population, production and consumption rates. The quest for increasing food production and the ensuing success achieved in several crops has begun to replace landraces by uniform, true-breeding cultivars. N.I. Vavilov and even Jack Harlan are sometimes proposed as the first researchers that became aware of genetic erosion in the 1920s and 1930s (Scarascia-Mugnozza and Perrino, 2002). In fact, this phenomenon was postulated for the first time by Baur (1914, pp. 104-109), see also Flittner (1995) and Hammer and Teklu (2006). So far, the American plant breeders H. V. Harlan and M. L. Martini (Harlan and Martini, 1938) have been credited with first recognizing the problem of genetic erosion in crops (Brush, 1999). The concept emerged forcefully between 1965 and 1970, in a period when crop improvement had clearly demonstrated its power to transform local crop populations in industrialized countries and in certain less developed regions (Brush, 1999) and the term gene erosion was coined (Bennett, 1968). Brush (1999) defined genetic erosion in crops as the loss of variability from crop populations. Variability refers to heterogeneity of alleles and genotypes with their attendant morphotypes and phenotypes. Genetic erosion implies that the normal addition and disappearance of genetic variability in a population is altered so that the net change in diversity is negative.

3.1 Cases Studies

Several approaches have been employed to estimate the degree of genetic erosion that a particular taxon faces in a certain region over a given time. Methods usually rely on either the analysis of molecular data (Provan *et al.*, 1999) and allozyme analysis (Akimoto *et al.*, 1999), or comparison between the number of species/cultivars still in use by farmers at present time to those found in previous studies (Hammer *et al.*, 1996) or using the genetic assessment model presented by Guarino (1999) or using a checklist of risk factors (de Oliveira and Martins, 2002). The most widely used figures in estimating genetic erosion are indirect, i.e., the diffusion of modern crop varieties released from crop breeding programs. The two case studies conducted by Hammer *et al.* (1996) to estimate genetic erosion in landraces revealed that genetic erosion was found to be 72.4% in Albania and 72.8% in South Italy. Genetic erosion up to 100% was detected in *T. durum* and *T. dicoccon* in some districts of Ethiopia (Teklu and Hammer, 2006). Hammer and Laghetti (2005) used temporal comparison method to examine the loss of genetic diversity in Italy. In the early years (from the 1920s to the 1950s), a relatively high genetic erosion was observed (13.2% p.a.). From the 1950s until the 1980s erosion rates between 0.48 and 4% p.a. were estimated. In the little island of Favignana there was an erosion rate of 12.2% p.a. leading to the extinction of the last wheat landraces of this island. The study of 220 land races with 147 forms in South Korea (Ahn *et al.*, 1996) showed a medium gene erosion of 74%. Akimoto *et al.* (1999) evaluated the threat of genetic erosion faced by Asian wild rice in Thailand and reported that the wild rice population was seriously destroyed and fragmented. Between 1949 and 1970, the number of wheat varieties cultivated in China dropped from 10000 to only 1000 (Thrupp, 1998). The upland rice varieties in the Jinuo community of southern Yunnan have been decreased from over 100 before 1980 to 65 in 1994. Recent statistics have shown that variety numbers of crops in Swidden agro ecosystems in the community have dropped since several improved varieties were introduced to the area within the past 10 years (Long *et al.*, 1995). In India rice varieties have declined from an estimated 40,0000 before colonialism to 30,000 in the mid-19th century with several thousand more lost after the green revolution in the 1960s. Also Greece is estimated to have lost 95% of its broad genetic stock of traditional wheat varieties after being encouraged to replace local seeds with modern varieties developed by CIMMYT (Lopez, 1994). The widespread adoption of high-yielding rice varieties has led to biological impoverty of rice germplasm, as local rice varieties are abandoned for modern varieties (Gao, 2003). IUCN has developed a system of categories of conservation status, the so-called IUCN Red Data List Categories (IUCN, 1994). A review of the situation in southern Africa using this system revealed that of the 23,000 species in the flora, 58 were extinct, 250 endangered, 423 vulnerable, and 1141 rare (Hilton Taylor, 1996). Hammer and Khoshbakht (2005) have also used Mansfeld's Encyclopedia (2001) and the IUCN Red List of threatened plants (2001) to document the current genetic resources status of agricultural and horticultural plants (excluding ornamentals) in Iran. About 200 threatened cultivated plants are considered and presented in the respective lists, among them completely extinct crop plants such as *Anacyclus officinarum* and *Bromus mango*. According to their report, there is even loss in crop plants on the species level.

In an attempt to determine the changes produced on genetic diversity as a result of modern plant breeding, Khlestkina *et al.* (2004) compared the diversity of cultivated wheat (*Triticum aestivum*) gene bank accessions collected up to 80 years ago in four divergent geographical regions with materials that entered the gene bank about 50 years later but originating from the same areas. They used a set of microsatellite markers and reported a non-significant difference in both the total number of alleles per locus and in the polymorphic information content when the material collected in the repeated collection missions in all four regions were compared. They reported that an allele flow took place during the adaptation of traditional agriculture to modern systems, whereas the level of genetic diversity was not significantly influenced. Khlestkina *et al.* (2004) only investigated the allelic changes occurred, over time, in the conserved materials. Hence, their studies couldn't fully address the actual genetic erosion occurred in the field.

3.2 Major Causes of Genetic Erosion

The manifest cause of genetic erosion is the diffusion of modern varieties from crop improvement programs (Brush, 1999). Much of the evidence for genetic erosion presented in the 1970/71 FAO survey (Frankel, 1973) is data on the diffusion of modern cultivars (Kjellqvist, 1973). Landraces adapted to optimal local agronomic conditions are probably the crop plant genetic resources that are most at risk of future loss through habitat destruction or by replacement by introduced elite germplasm (Brush, 1995). With the development of scientific plant breeding, high-quality and homogenous new varieties were quickly and widely distributed suppressing landraces. Yield (or yield potential), which is the characteristics of most modern varieties, is the most important criterion for the choice of a variety by a farmer (Heisey and Brennan, 1991). The "Green Revolution" contributed and still undoubtedly contributes to the loss of genetic diversity, even if the issue is not as cut and dried asWood and Lenné (1997) state it in the equation "Green revolution = Loss of genetic diversity". Population growth, urbanization, developmental pressures on the land resources, deforestation, changes in land use patterns and natural disasters are contributing to abundant habitat fragmentation and destruction of the crops and their wild relatives. The famine of the mid-1980s seriously threatened Ethiopia's biological resources (Worede and Mekbib, 1993). The study of Stephen *et al.* (2002) showed a marked reduction in rice diversity in the northeastern Philippines from 1996 to 1998 as a result of drought due to the El Niño phenomenon in 1997 and flooding due to two successive typhoons in 1998. According to Erskine and Muehlbauer (1990), droughts of just a single season could result in people consuming seed stocks, while successive years of drought can prompt changes in cropping patterns and the geographic distribution of crops. Social disruptions or wars also pose a constant threat of genetic wipeout of such promising diversity. Overexploitation and also the introduction of invasive alien species are the other factors contributing to the loss of genetic resources. More recently, global warming and a high degree of pollution have also been recognized as further causes for the loss of biodiversity (Myers, 1994).

The modern world is placing a range of pressures on wild areas and on traditional agricultural communities, and external interests (often dominated by economic or political issues) strongly impinge (Tunstall *et al.*, 2001). The major external forces advocate the introduction of high-yield varieties, accompanied by mechanization and major chemical inputs, as the means to increase total production and economic return. These forces change the nature of the decision-making process dramatically; the farmer is encouraged to grow high-yield varieties in monoculture using inputs of fertilizer and pesticides. In many parts of the world, farmers were given several socio-economic incentives to replace varieties that evolved within their agro-ecosystem with improved/introduced varieties (Louette *et al.*, 1997; Teklu and Hammer, 2006).

Often there are relationships of substitution between ecological functions of agrobiodiversity and external input (for example fertilizer or pesticides) (Hammer, 2004). That means that external inputs can take over functions of agrobiodiversity and vice versa. In homogenous, high-input agricultural systems, ecosystem functions that are missing because of low agrobiodiversity are replaced with intensive management and external inputs. Because of this, those components of agrobiodiversity whose functions can be substituted at lower cost are particularly endangered. For example, in former years many different fodder plants were grown in German fields (oats, barley, beans, clover, Leucerne, fodder beets and potatoes). Now, corn is usually the only fodder plant, possibly supplemented by soybean meal as a protein component. Each of the species has lost the race in its own fashion. Indigenous crops are adapted to the conditions of less developed agriculture such as "crude land preparation and low soil fertility" (HARLAN, 1975). As these conditions change with improved traction and fertilizer, the existing adaptation of landraces turns from asset to liability. TUNSTALL *et al.* (2001) described that landraces, which are grown because of their high resistance to pests during seed storage, may become less important if improved storage systems are introduced.

Two types of genetic erosion can be distinguished in wild rice: the extinction of populations and the drastic change of genetic structure of populations (GAO *et al.*, 2001). The first type means the total loss of genetic resources, which results from complete destruction of habitats, and all genotypes and/or alleles being lost, while the second one originates from isolated local populations due to the deterioration of habitats. For plants and some animals, area measurements of habitat patch sizes will provide a reasonable basis to estimate population size (BROWN *et al.*, 1997), an important factor determining survival of individuals. HAWKES (1983) reported that smaller area in traditional crops reduces diversity. The frequency distribution of the sizes of individual populations is likely to reflect the way in which genetic variation is partitioned within and among populations, with small populations being at increased risk of loss of alleles, reduced heterozygosity, increased uniformity, enhanced inbreeding or possible extinction. BROWN *et al.* (1997) also indicated that the size and number of individual populations are related to their ability to cope with both random (stochastic) fluctuations in the environment and steady (systematic) long-term change. In some cases the loss of particular crop varieties is not complete, but instead reduces surviving members of a landrace to a few isolated populations (VAN TREUREN *et al.*, 1990). In such cases there is significant risk of the ultimate loss of diversity, because smaller populations are vulnerable to demographic and environmental stochasticity and the decline in fitness associated with genetic drift and inbreeding (FRANKEL and SOULÉ, 1981). Allozyme genetic diversity, inversions and visible mutations all declined more rapidly in smaller than large populations (MONTGOMERY *et al.*, 2000). Two genetic consequences of small population size are increased genetic drift and inbreeding. Genetic drift is the random change in allele frequency that occurs because gametes transmitted from one generation to the next carry only a sample of the alleles present in the parental generation. Genetic drift changes the distribution of genetic variation in two ways: (i) the decrease of variation within populations (loss of heterozygosity and eventual fixation of alleles), and (ii) the increase of differentiation among populations. Every finite population experiences genetic drift, but the effects become more pronounced as population size decreases (FALCONER, 1989).

The problem of genetic erosion through inappropriate maintenance of *ex situ* collections is widely recognized. Genetic erosion can occur at many stages in the preparation, sub-sampling, exchange, storage and regeneration of seed (SACKVILLE HAMILTON and CHORLTON, 1997). They also highlighted loss of diversity through genetic shifts and convergent selection during regeneration as a potentially severe and often underacknowledged problem. In the world collection, beyond the problem of duplication among accessions, the security of *ex situ* conservation as a whole is endangered. About half of all gene bank accessions urgently require rejuvenation, and in several countries the percentage is even higher (Hammer, 2004). However, the different institutes are suffering from financial problems, lack of staff and shortage of farms. The long-term storage strongly reduces the metabolism and therefore highly limits viability and seed vigor. According to Tsehaye (2002), durum wheat materials from the Ethiopian gene bank have showed poor germination potential and vigor in the field, which is an indicator of genetic erosion. Considerable evidence indicated that damage to chromosomes, some of it resulting in heritable changes, takes place as seeds loose their viability. Studies in barley and wheat showed that as storage age increases, chromosome aberrations (per cell) increase (Gunthardt *et al.*, 1953). Changes in the properties of DNA associated with loss of viability in rye seeds, namely the loss of DNA-template activity (Holden and Williams, 1984) and decreases in the molecular size of extractable DNA (Cheah and Osborne, 1978), also have been observed.

Genetic erosion can also be caused by limited support for gene banks and in appropriate focus or change in institutional policies. The work of gene banks in Eastern Europe towards the end of the last century was reduced due to lack of money and employees. Only international help was able to prevent catastrophic breakdowns (Frison and Hammer, 1992). New technological developments allow us to change agricultural products during the processing phase so much that only a few basic raw materials are necessary. It is possible, for example, with the aid of biotechnological methods to produce iso-glucose from starch. In the USA, a large part of the present demand for sugar is met with iso-glucose made from cornstarch. This has led to a strong decrease in the importance of cane sugar (Knerr, 1991). Another approach attempts to supply widely differing quality products with a regionally well- adapted variety. For example, different oil qualities are produced from canola (rapeseed, *Brassica napus*) in order to avoid importing oils or growing other oil plants. Transgenic canola with high laurin acid oil content can be used to substitute coconut or palm oil (Sovero, 1996), and reduce the demand for these oils in the industrial countries. Buerkert *et al.* (2006) have reported genetic erosion in *T. turgidum* L. and *T. aestivum* L. (including *T. compactum* Host) in Afghanistan because of 23 years of war. They reached to this conclusion after they compared their survey studies conducted in 2002 with the survey results of Vavilov (1997) and Vavilov and Bukinich (1929). Other prominent causes of genetic erosion include the market preferences of consumers for uniform grains, vegetables or foods (Myers, 1994), pest and disease outbreaks, urbanization, population pressure, lack of recognition of current or future value of genetic resources; poor monitoring and management, and lack of sustainable breeding program.

3.3 Consequences of Genetic Erosion

Genetic uniformity leaves a species vulnerable to new environmental and biotic challenges and causes heavy damage to the society. The Irish Potato famine was a dramatic example of the dangers of genetic uniformity. The Irish population had reached about

8.5 million by 1845. Potatoes were the only significant source of food for about one third of the Irish population. Farmers came to rely almost entirely on one very fertile and productive variety known as 'Aran Banner'. Unfortunately, this particular variety was highly sensitive to the fungal disease late blight (*Phytophthora infestans*), which had spread from North America to Europe. The blight destroyed the potato crop of 1845. Consequently, the Irish Famine of 1846-50 took as many as one million lives from hunger and disease, and changed the social and cultural structure of Ireland in profound ways. The famine also caused emigration of between 1.5 and 2.0 Million Irish.

By 1970 roughly three-quarters of the corn acreage in the US was planted in "Texas T cytoplasm" corn. The Texas T cytoplasm results in individuals that are male-sterile. This makes production of hybrid corn far less labor intensive, as there is no need of detassleing. However, this maize is highly sensitive to host selective toxin (T toxin) produced by race T of *Cochliobolus heterostrophus*, the casual organism of southern corn leaf blight (Hooker *et al.*, 1970). In 1970 this blight swept through fields of "Texas T cytoplasm" corn and yield was reduced by approximately 710 billion bushels. The cost to farmers was about $1 billion (Ullstrup, 1972). Browning (1988) argued that the epidemic was "the greatest biomass loss of any biological catastrophe" and that it was "a man-made epidemic caused by excessive homogeneity of the USA's tremendous maize hectarage.' The loss of a significant fraction of the Asian rice crop to grassy stunt virus also illustrates the same point. The catastrophic outbreak of coffee rust in 1970 caused great losses in Brazil with higher coffee world market prices as a consequence. In 1916 a rust fungus destroyed about 3 million bushels of wheat in the United States, roughly one-third of the crop. Other examples include the coffee rust epidemic in Ceylon in the 1870s, the tropical maize rust epidemic in Africa in the 1950s and the blue mould epidemic on tobacco in the USA and Europe in the 1960s (Marshall, 1977).

The loss of one species is estimated at being worth $203 million (Farnsworth and Soejarto, 1985). These authors have calculated a total financial loss for the USA through the loss of plant species at $3,248 billion dollars up to the year 2000. Presently, 33,730 plant species are characterized as being extinct or strongly endangered (Lucas and Synge, 1996).

4 Genetic Resources Conservation

4.1 The Need for Conservation

Many species and varieties are becoming extinct and many others are threatened and endangered. To reverse these unabated gene erosion, conservation of genetic diversity is a fundamental concern in conservation and evolutionary biology, as genetic variation is the raw material for evolutionary change within populations (Frankel and Soulé, 1981). Conservation is the process that actively retains the diversity of the gene pool with a view to actual or potential utilization Maxted *et al.* (2002). Utilization is the human exploitation of that genetic diversity. The aim of conservation is to collect and conserve adaptive gene complexes. Collection can be seen as a subject in its own right and is not reviewed here – recently a first review appeared in this respect on one of Vavilov's gene centres (Vavilov, 1997) -– the Mediterranean (see Laghetti and HAMMER (2004). The raw materials of plant genetic resource conservation are genes within gene pools, the total genetic diversity of the particular plant taxon being conserved (MAXTED *et al.*, 2002). The product of gene pool conservation is utilised or potentially utilisable genetic diversity.

The conservation of plant diversity is of critical importance because of the direct benefits to humanity that can arise from its exploitation in improved agricultural and horticultural crops, because of the potential for development of new medicinal and other products and because of the pivotal role played by plants in the functioning of all natural ecosystems. A great diversity of plants is indeed to keep the various natural ecosystems functioning stably. No organism exists alone but all depend on a magnitude of interactions that relate them together such as pollination and depend on a multitude of interactions that relate them together (PRANCE, 1997). No doubt that primitive and wild gene pools will continue to serve as important sources of genes for resistance to parasites or for characteristics indicated by advances in science or technology or by changing demands of the consumer. In the case of species, which are already used by human beings as crops, it is very important to have a broad genetic base, to improve existing genotypes when necessary.

4.2 A methodology for plant genetic resource conservation

Methods for germplasm conservation are determined by a number of factors. MAXTED *et al.* (1997a) proposed a model of plant genetic conservation, which summaries the entire process of plant genetic conservation from selection of a target crop gene pool through to its utilization (Figure 2). One of the first factors to be considered when conserving botanical diversity is the efficient and effective selection of the target taxa. The decision must have been taken that the target taxon is of sufficient importance to warrant active conservation and that the gene pool is not currently adequately conserved MAXTED *et al.* (1997b). A practical approach to select target species could be the use of the gene pool concept of HARLAN and DE WET (1971). This concept is based on the ease with which species hybridize with each other. The availability of information on different gene pools enables the priority setting of target species to be incorporated into the different conservation strategies. After selecting a taxa, a form of commission in a form of formal statement containing the actual conservation activities including the objectives of the conservation and justification for selection, how the material is to be utilized, where the conserved material is to be safely duplicated, etc., and perhaps indicating which conservation technique is to be employed should be formulated. A clear and concise commission statement will help to focus subsequent conservation activities MAXTED *et al.* (1997a).

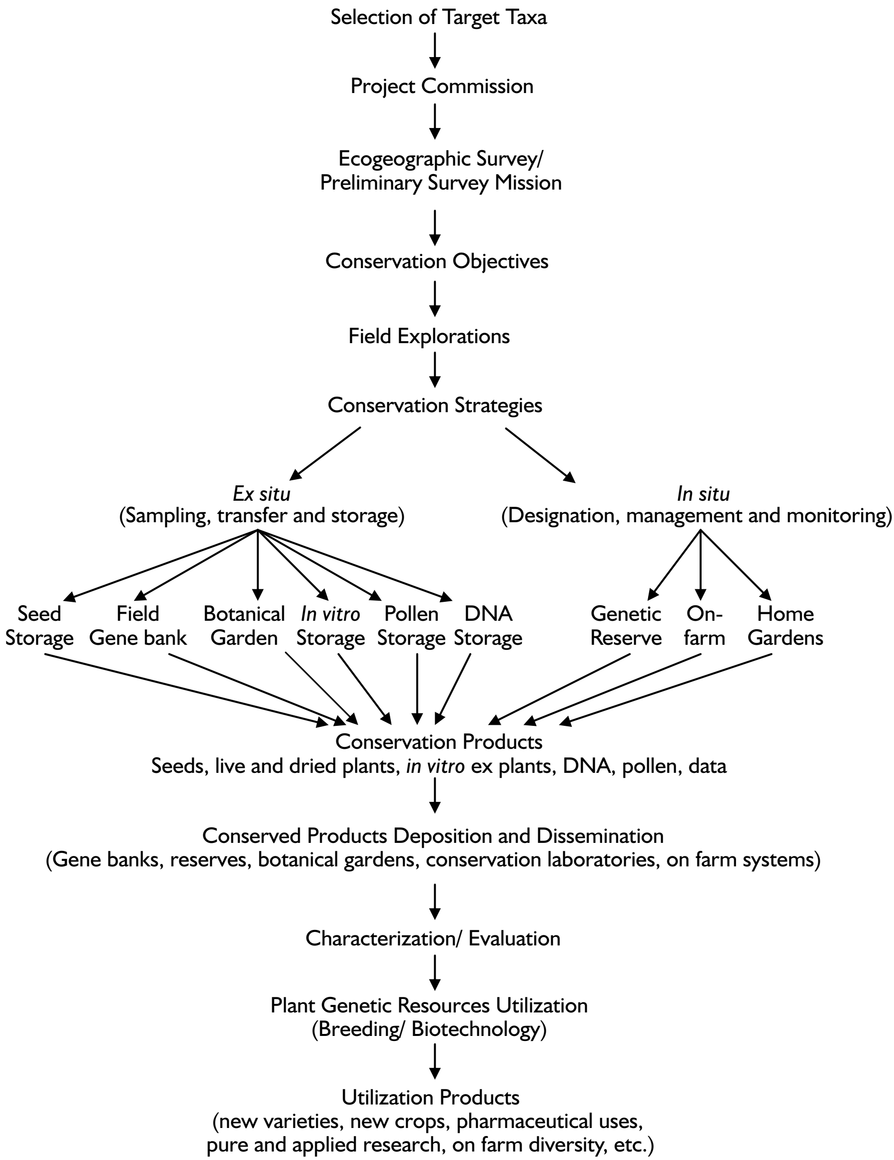
In formulating strategies for the conservation of any crop, it is essential to know its areas of distribution, and identify regions where both collecting for conservation activities could usefully be initiated. This will be due to a combination of high levels of genetic diversity at the site(s), interest the user community in the specific genetic diversity found at or believed to be found at the site, lack of previous conservation activities, and imminent threat of genetic erosion (MAXTED *et al.*, 1997a). Hence, an ecogeographic survey has to be undertaken to define the most appropriate conservation strategy (Maxted et al., 1995), and specific conservation objectives should be formulated, involving both *ex situ* and *in situ* components. The synthesis and analysis of ecogeographic data enable conservationist to make vital decisions concerning, for example, which taxa to be included in the target group, where to find these taxa, which combination of *ex situ* and *in situ* conservation to use, what sampling strategy to adapt, and where to store the germplasm or site the reserve (Maxted *et al.*, 1995). Because the ecogeographic data will rarely be sufficiently comprehensive to locate actual populations precisely; the preparatory element of conservation activities should be followed by field exploration, during which the actual populations are located (Maxted *et al.*, 1997a). There are two primary complementary conservation strategies, *ex situ* and *in situ*, each of which includes a range of different techniques that can be implemented to achieve the aim of the strategy. The products of conservation activities are primarily conserved germplasm, live and dried plants, cultures, and conservation data. The conservation products are either maintained in their original environment or deposited in a range of *ex situ* storage facilities. To ensure safety, conservation products should be duplicated more than one location.

4.2.1 *Ex situ* conservation

Ex-situ conservation is defined as the conservation of components of biological diversity outside their natural habitat. In a broad sense, *ex situ* conservation of germplasm is a practice that humans have used since the beginning of agriculture, to expand cultivation and/or to colonize new lands and to ensure the spread of agriculture around the world plants have traveled, during human migrations and along the ancient caravan routes, from continent to continent. Moving from the Old to the New World and vice versa, PGR have made many important contributions to agricultural production, diversification and eating habits around the planet (FAO, 1959). Starting from the beginning of agriculture, man has stored plants and seeds from one cycle of cultivation to the next in different ways. Storage of germplasm also took place during migration.

The great genetic diversity to be found in the traditional stocks of peasant agriculture in the centres of genetic diversity, where the wild or weedy relatives of crop species can be found, were called gene centres or centres of diversity (Vavilov, 1926). Wild and primary gene pools constitute the genetic resources available for the adaptation of present-day cultivars, or for initiating new and potentially valuable pathways of crop evolution (Frankel, 1974). As agriculture progressed with the beginning of scientific plant breeding and human population increased, modern varieties were widely distributed displacing landraces from cultivation. This increased the need to formally store plants and seeds *ex situ*. Land races were then gathered together, which resulted in fairly large collections, above all in the USA and in Russia (Plucknett *et al.*, 1987). In particular, the Russian scientist N. I. Vavilov amassed an unbelievable collection of diversity in a Leningrad Institute (now St. Petersburg) by systematically collecting material. With the rapid advancement of biotechnology in recent years, the ex-situ conservation of living and genetic resources has increased in importance. At present, over 6 million accessions are stored *ex situ* throughout the world (Plucknett *et al.*,

Figure 2: Proposed model of plant genetic resources conservation (taken from MAXTED *et al.* (1997a)

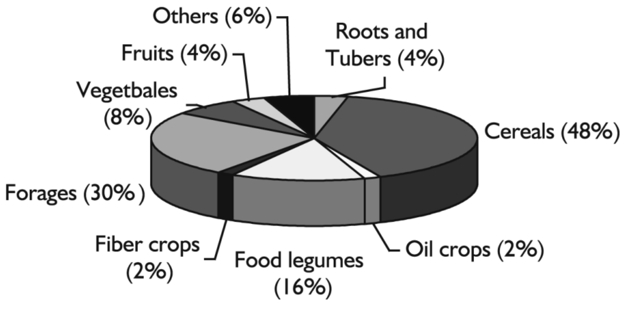


1987). Of these, some 600,000 samples are maintained within the Consultative Group on International Agricultural Research (CGIAR), the remaining 5.4 million accessions are stored in national or regional gene banks (Table 1). Figure 3 shows the representation of different crops in gene banks.

Table 1: Number of worldwide *ex situ* collections and their material (according to FAO (1996b))

Region	*Number of gene banks*	*% world*	*Number of accessions*	*% world*
Africa	124	10	353,523	6
Asia	293	22	1,533,979	28
Europe	496	38	1,934,574	35
Near East	67	5	327,963	6
North America	101	8	762,061	14
Latin America and Caribbean	227	17	642,405	12
Sum	1,308	100	5,554,505	100
CGIAR system			593,191	
Total sum			6,147,696	

Figure 3: Major crop groups in *ex situ* gene banks (Source: HAMMER (2004))



Only 30 crops make up the major part of the conserved plant material indicating that most of the remaining 7,000 species of cultivated plants and many other valuable genetic resources species have only been included on a limited scale in the gene bank collections (HAMMER, 2004)

4.2.1.1 Ex situ conservation techniques

Among the various *ex situ* conservation methods, seed storage is the most convenient for long-term conservation of plant genetic resources. Traditionally, many crops are conserved as seed in gene banks. This involves desiccation of seeds to low moisture contents and storage at low temperatures (KAMESWARA RAO, 2004). However, there is a large number of important tropical and sub-tropical tree species, which produce recalcitrant seeds that quickly lose viability and do not survive desiccation, hence conventional seed storage strategies are not possible (ROBERTS, 1973). For vegetatively propagated and recalcitrant seed species, living plants can be stored in field gene banks and/or botanical gardens. Major disadvantages of field gene banks, such as high maintenance costs, the limited amount of genetic variation that can be stored and vulnerability to natural and human disasters have led to efforts to develop *in vitro* conservation methods. *In vitro* conservation is also used by botanical gardens for the reproduction of rare species. It guarantees freedom from pest infestation and diseases. However, it is extremely labor and cost intensive and can therefore only be used for special material as a long-term storage possibility. The rapid developments in the field of biotechnology have opened up new avenues for the conservation of germplasm in the form of tissue culture, cryopreservation, pollen storage and DNA banks (CALLOW *et al.*, 1997). Cryo-conservation (storage in extreme deep freeze situations) is accomplished with liquid nitrogen at -196 °Celsius (HAMMER and HONDELMANN, 1997). It is also suitable for seeds and leads to a dramatic prolongation of germination rates. It allows for an extremely long storage of many species. For *in vitro* maintenance cultures, it is the choice of preference because somaclonal variation can be prevented. The problem with cryo-conservation is its high cost, especially for technical equipment. A constant supply of liquid nitrogen also has to be available at all times (HAMMER, 2004). The methods of *ex situ* conservation have been summarized in Table 2.

The *ex situ* conservation of large numbers of cultivated plants depends on the longevity of the seeds. Most species belong to the orthodox seed type with a logarithmical progression of shelf life as humidity and storage temperature are reduced (HAMMER and HONDELMANN, 1997). The duration of seed viability can be estimated fairly precisely by taking these aspects into account (ELLIS and ROBERTS, 1980). The life expectancy is determined through genotype. Care should be taken that viability not sink under 85% (if the original rate is set at 100%), so that gene mutations will not occur in the seed during storage.

4.2.2 *In situ* conservation

Storing genetic resources in collections as back-up seed stocks in *ex situ* collections does not substitute for the evolution of crop plants in the fields of farmers. Plant populations on farms have the capacity to support a greater number of rare alleles and different genotypes than accessions in gene banks (BROWN, 2000). As a result, *in situ* approach was proposed in the early 1970's for strictly agricultural purposes (KUCKUCK, 1974), but it has been scarcely utilized in the international crop germplasm system. *In situ* conservation is defined as the conservation of ecosystems and natural habitats, and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they

Table 2: Methods of *ex situ* conservation for various plant genetic resources (according to FAO (1996a))

Storage technology	*Storage material*	*Function*
Low temperature (-18°C), 3-7% moisture content	Orthodox seeds	Long-term storage (basic collection), working collection
Dried seeds at cool temperatures	Orthodox seeds	Active and working collections, medium-term storage
Ultra-dried seeds at room temperature	Orthodox seeds with long-term viability	Medium to long-term storage (active and working collections)
Field gene banks	Vegetatively-reproduced species, species with recalcitrant seeds, species with long reproduction cycles and minimal seed production	Short or medium-term storage, active collections
In-vitro culture under slow-growth conditions	Vegetatively-reproduced species, some species with recalcitrant seeds	Medium-term storage, active collections
Cryo-conservation at -196°C with liquid nitrogen	Seeds, pollen, tissue or embryos that are suitable for in-vitro regeneration after freeze drying	Long-term storage

have developed their distinctive properties (UNEP, 1992). This definition encompasses two distinct concepts (and techniques), which may be distinguished as "genetic reserve conservation" and "on-farm conservation." Both involve the maintenance of genetic diversity in the locations where it is encountered (i.e., *in situ*), but the former primarily deal with wild species in natural habitats/ecosystems and the latter with domesticated species in traditional farming systems. Maxted *et al.* (1997a) provide the following working definitions for the two activities. Genetic reserve conservation is the location, management and monitoring of genetic diversity in natural wild populations within defined areas designated for active, long-term conservation. On-farm conservation is the sustainable management of genetic diversity of locally developed crop varieties (land races), with associated wild and weedy species or forms, by farmers within traditional agricultural, horticultural or agricultural systems.

On-farm conservation is dynamic and is aimed at maintaining the evolutionary processes that continue to shape genetic diversity. It is based on the recognition that farmers have improved and grown genetic diversity and that this process still continues among many farmers in spite of socio-economic and technical changes. Farmers play a big role through their selection of plant material which influences the evolutionary process and through their decisions to continue with a certain landrace or not (Bellon, 1996). Each season the farmers keep a proportion of harvested seed for resowing in the following year. The farmer makes a conscious decision about which sample to retain for seed. For a successful implementation of on-farm conservation, a fuller understanding of both crop populations on the farming systems that produce them is needed to create active co-operation between farmers and conservationists (Brush, 1995). On-farm conservation assumes planned conservation in the framework of agricultural or garden production; conservation must therefore take place during agricultural production. Modern varieties, which often are more productive than the landraces, compete for this space with landraces or wild plants. Therefore, financial or other incentives have to be built into the system to safeguard future conservation. These requirements can be more easily attained in developing countries. Subsistence farming tolerates a multitude of cultivated plant species and forms in mixed culture and should be considered a living conservation reservoir (Esquivel and Hammer, 1988).

Table 3: Number of species of wild plants, plant genetic resources (PGR) and cultivated plants in the world (after Hammer (2004))

	Higher plants	*PGR among higher plants*	*Cultivated plants among higher plants*
Number	250,000	115,000	7,000

Wild plant material is usually conserved in its natural habitat. Compared with the relatively small number of cultivated plant species, the plant genetic resources of wild plants are quite numerous (Hammer, 2004, see Table 3). General protective measures can therefore be of great importance to a large number of plant genetic resources. Protected areas include national parks, biosphere reserves and Nature parks, which can be divided into areas of varying protection, as well as riparian or wetland areas (Schlosser *et al.*, 1991). Policy strengthening, establishment of nature reserves and protected areas with rich wild populations, management promotion, environmental education and training (especially in local communities), adoption of indigenous knowledge, and local peoples' participation can strongly support *in situ* conservation of agro-biodiversity (Long *et al.*, 2003).

4.3 Comparison of the different conservation measures

Conservation measures have often been critically evaluated. Many supporters of the *in situ* strategy consider *ex situ* methods to be at best a transitional method leading to further *in situ* maintenance (Lande, 1988). The differing standpoints have been formulated in various international documents and treaties.

It is important that criticism of *ex situ* maintenance includes the limited possibilities of evolution available with this method. In gene banks, conservation of the material is handled in such a manner as to exclude natural evolution. This has to do with long-term seed storage on the one hand, which strongly reduces the metabolism and therefore strongly limits evolution. On the other hand, gene banks often have to grow the plant material in areas that are far away from its place of origin, and this can easily result in changes in population composition. Additional points of criticism are that insufficient equipment and facilities are available to gene banks, that long-term storage is overrated, and that the necessity of reproduction is underrated. *Ex situ* collections are not going to be the universal means of preventing the results of gene erosion. The collections will always be limited and gene banks will only be able to include a portion of all genetic resources (Hammer, 2004).

The advantages of *in situ* conservation are undisputed in order to maintain a large wealth of species, at the same time guaranteeing further evolutionary adaptation. The possibilities of easily gaining access to the material are positive aspects of *ex situ* maintenance. Also, a vast amount of material of the most important plant groups, mostly in the infraspecific area, can be safely conserved. Above and beyond this, systematic documentation and characterization can be carried out more easily. From the side of the user, the major criticism of *in situ* conservation lies in the difficulty of obtaining access to the material for basic and breeding research. Furthermore, in many cases, it is easier to conserve a viable population *in situ* than *ex situ*. This is certainly true of tree species. Further comparison of the advantages and disadvantages of the different conservation methods is presented in Table 4.

Table 4: Advantages and disadvantages of the different conservation methods (Kjaer *et al.*, 2001).

Maintenance method	*Advantages*	*Disadvantages*
In situ	• Interactions with other species and organisms are possible • Interspecific and infraspecific variations can be combined • Can also be used for vegetatively reproducible species or those with recalcitrant seeds	• Requires large area for maintenance • Only a small number of genotypes can be managed this way. Does not protect against epidemics, diseases, etc., possible losses • Access to the material is difficult
In situ or On-farm	• Further evolution through natural evolution and choice of varieties is possible	• No conservation of the status quo, selection • Gene erosion is possible

(Table 4 continuation)

Maintenance method	*Advantages*	*Disadvantages*
Ex situ Seed banks	• Genetic status quo of the stored seeds can be maintained with appropriate reproduction strategy • Propagules ready for use (although the amount of seed typically is too limited to serve as input to commercial use) • Little space required (at least for species with small seeds) • Intra- and inter-population can be easily conserved provided species range adequately sampled • Seed can be conserved far away from the *in situ* environment if requested	• No further evolutionary development dependent on the surrounding environment • Problems with the maintenance of recalcitrant and vegetatively reproducible species • Facilities and large amount of space necessary for storage (large seeds) • The original surrounding flora is not conserved as well • Regeneration needs space and is money and labor intensive • Only a limited portion of the variability is collected and maintained • Change of population structure through reproduction of populations that are too small • 'Short term storage rather than conservation' for the majority of species
Field Gene banks	• Can conserve genetic resources in the habitats of expected use • Can develop into multiple population conservation programmes where new intrapopulation variation is developed as response to different conditions of growth or selection criteria • Can be combined with utilization • Can function as seed sources allowing rapid procurement of seed in commercial scale in early domestication	• Many areas required • Spatial isolation to conserve population identity required • Lack of pollinators may cause problems • Relatively expensive if not combined with utilization
Botanical gardens and arboreta	• Botanical gardens are often part of very stable institutions and likely to be continuously maintained by trained staff • Can be combined with demonstration and education.	• Suitable site(s) required • Difficult to collect seed due to hybridization • In general not apt for conservation of inter and intra- population variation (requires a larger number of individuals than usually planted in botanical gardens/arboreta).
Tissue culture	• Little space needed • Good for vegetative material and recalcitrant species • Aseptic conservation (minimizes disease risk) • Short time required to produce propagules for use	• High technical outlay • Expensive facilities required • Sampling problems (representative individuals and within individual) • Difficult to conserve adequate number of genotypes • Protocols are specific for species and often even for genotypes • Problems of soma-clonal variation and early maturation

(Table 4 continuation)

Maintenance method	*Advantages*	*Disadvantages*
DNA	• Little space needed • Can be used anywhere • Future method of last resort in isolated cases	• Is not a germplasm conservation method *per se*

From the viewpoint of plant genetic diversity for food and agriculture, the diversity of (1) cultivated plants, (2) wild relatives of cultivated plants, (3) introgressions between cultivated plants and their relatives, and (4) weeds should be differentiated. Although a different conservation strategy may be the most appropriate modus operandi for each of these categories and for each specific group within these categories, the integrated use of the different methods for conservation is necessary depending on the categories of diversity and diversity groups. It is also necessary to consider different economics of the countries. The argumentation scheme, which was based on is based on the methods of conservation (*ex situ*, *on-farm*, *in situ*) as well as on the type of diversity, species diversity and diversity of the ecosystem, has been proposed by Hammer *et al.* (2003) (Table 5).

Table 5: Conservation methods for different categories of diversity rated by their importance for specific groups of diversity (Hammer *et al.*, 2003).

Category of diversity	*Method of conservation*			
	ex situ (genebanks)	*on-farm (agro-ecosystems)*		*in situ* (other ecosystems)
		Developing countries	*Developed countries*	
Infraspecific diversity	C** R* W**	C*** R*** W***	C** R* W*	C° R*** W*
Diversity of species	C* R* W**	C*** R*** W***	C** R* W**	C° R** W*
Diversity of ecosystems	C° R° W°	C*** R*** W***	C* R** W***	C° R** W*

The number of stars indicates the relative importance of the methods for the various diversity groups. C= Crop species, R = Wild Relatives of Crop Species, W = Weeds
° = no importance, * = low importance, ** = important, *** = very important

4.4 The economics of plant genetic resources conservation

It looks much different when we talk about costs. The high costs for *ex situ* maintenance are visible, and it is possible to obtain an overall picture from the concrete figures for material and equipment listed in the global report. According to Plän *et al.* (1994), the conservation of one seed sample costs approximately 0.50 German marks a year (calculated according to Smith (1984) and Parez (1984). The entire volume of finances for the gene bank Gatersleben in the year 1992 (payroll, investment costs, overhead) came to 4,790,800 German marks (Thoroe and Henrichsmeyer, 1994). Taking 100,000 samples into account, the costs for the maintenance of one sample comes to approximately 50 German marks. Included in this estimation are not only the costs for the maintenance of the material, but also research, without which the collection cannot be vitally maintained over a longer period. The case studies made to estimate annual cost of maintaining different crops is given in Table 6.

The economics of plant genetic resources, with relation to gene banks, is going to establish itself as new research area (Virchow, 1999). The basis for these considerations is usually the search for larger budget-cutting possibilities. But since gene banks have often already been degraded to the role of harvest silos, such examples are highly unsuited for a general estimate of costs. The economic conclusions reached by such studies could further burden the already unstable situation of global *ex situ* conservation.

Table 6: Annual costs of maintaining cassava, wheat and maize germplasm in field gene bank, *in vitro* and seed conservation.

Conservation Technique	*Crop*	*CG Centre*	*Total cost/accession (US $)*
Field	Cassava	CIAT	17.09
In vitro	Cassava	CIAT	26.22
Seed	Wheat	CIMMYT	0.05
Seed	Maize	CIMMYT	0.33

Source: Epperson *et al.* (1997).

5 The Impact of Genetically Engineered Plants on Genetic Diversity

Genetic engineering has potential to solve problems that have proved intractable using conventional breeding approaches, such as developing crop varieties with in-built resistance to key pests and diseases and tolerance to stresses such as drought. Genetically modified (GM), or transgenic, organisms are created through genetic engineering techniques that allow genetic material to be moved between similar or vastly different organisms with the aim of changing their characteristics for a purpose. In developing an engineered plants, genes are introduced into a genome using *Agrobacterium tumefaciens*, a pathogenic bacterium that naturally transfers DNA to plants during the disease process (Gelvin, 2000) and using biolistics or a variant, particle discharge (Birch, 1997). Another method associated with transgenic technology is the process of nuclear transfer, which is a cloning technique. Since the birth of the first successful transgenic plant in the beginning of 1980's, tremendous accomplishments associated with transgenic biotechnology have been achieved and rapid application of the biotechnology in agriculture has substantially benefited crop genetic improvements. As a consequence, a great number of genetically modified crops (GMC) have been released and commercialised (e.g. Huang *et al.* (2002). New cultivars of maize (*Zea mays* L.), soybean (*Glycine max*), cotton (*Gossypium* spp.), papaya (*Carica papaya*), tomatoes (*Lycopersicon esculentum*), canola (*Brassica napus*), and others have been developed that carry additional genes conditioning traits as herbicide tolerance, insect resistance, or virus tolerance. From 1996 to 2004, the global area of biotech crops increased more than 47 fold, from 1.7 million hectares in 1996 to 81.0 million hectares in 2004, with an increasing proportion grown by developing countries. More than one-third (34%) of the global biotech crop area of 81 million hectares in 2004, equivalent to 27.6 million hectares, was grown in developing countries where growth continued to be strong. The estimated global area of approved biotech crops for 2004 was 81.0 million hectares up from 67.7 million hectares in 2003. Approximately 8.25 million farmers in 17 countries grew biotech crops in 2004 (James, 2005).

Domesticated plants and their wild relatives usually belong to the same biological species and they often hybridize and give rise to viable and fertile progenies (Harlan and de Wet, 1971; Ellstrand *et al.*, 1999), if wild and domesticated forms are sexually compatible, grow within pollinator flight distance (in the case of insect-pollinated species), and their flowering times overlap at least partially. Such hybridization may lead to gene flow: 'the incorporation of genes into the gene pool of one population from one or more populations' (Futuyma, 1998). Many cultivated plants hybridize spontaneously with wild or weedy relatives (Small, 1984; Ellstrand *et al.*, 1999). For example, cultivated rice and its wild relatives *O. rufipogon* have sympatric distribution and overlapping flowering times, which meets the spatial and temporal conditions for transgene escape from cultivated rice to its wild relatives (Lu *et al.*, 2003). Though cultivated sorghum is largely self-pollinated with outcrossing rate of 2-30% (Schmidt and Bothma, 2006), analyses of progeny segregation, allozymes, and RFLPs reveal crop-specific alleles in wild S. bicolor when it co-occurs with the crop in Africa, suggesting that intraspecific hybridization and introgression are common (Aldrich and Doebley, 1992). Studies carried out to measure spontaneous hybridisation between wild radish (*Raphanus sativus*) and cultivated one (Klinger *et al.*, 1991) and with *Sorghum bicolor* and *Sorghum halepense* (a widespread weed) (Arriola and Ellstrand, 1996) demonstrated that spontaneous hybridisation does take place (for a recent review see Ellstrand (2003). With transgenic plants, the problem of gene flow, which may ultimately cause possible ecological risks, has acquired special significance.

5.1 Consequences of gene flow

Transgenes coding for novel traits such as resistance to biotic and abiotic stresses could have the potential to enhance ecological fitness of wild and weedy genotypes (Ellstrand and Elam, 1993; Snow, 2003) and thus cause ecological problems. For example, wild sunflower populations host many of the same herbivores and diseases as cultivated ones (Seiler, 1992) and crop genes can easily backcross into wild sunflower populations (Whitton *et al.*, 1997). Snow (2003) studied a crop-developed *Bacillus thuringiensis* (Bt) transgene, *cry1Ac*, in backcrossed wild sunflower populations and found that a transgene derived from a crop has the potential to increase the fitness of wild plants, and an increase in frequency in wild populations. The spread of transgenic herbicide resistance is likely to pose challenges for controlling weeds and unwanted "volunteer" crop plants (Snow *et al.*, 1999). Other possible risks are that transgenic phenotypes with altered fitness could change in abundance in the ecosystem, with unwanted effects on other species and on ecosystem integrity, or that the ecosystems are affected indirectly by the transgenic plants (Jorgensen *et al.*, 1999).

Both genetic and geographic barriers to gene flow from crop to wild sunflower are minimal (Snow *et al.*, 2002). Hence, simple co-existence of GE and non-GE crops might be impossible. For instance, there are now scientific evidences for cultivated rice outcrossing to non-GE rice (Lu *et al.*, 2003; Gealy *et al.*, 2003; Chen *et al.*, 2004). Cultivation of GE rice will therefore cause weedy strains of *O. sativa* such as "red rice" and the wild relative, *O. rufipogon* to become contaminated with the GE transgenes (the GE DNA insert). There are concerns that if red rice becomes tolerant to the herbicide used in conjunction with a GE herbicide-tolerant rice, it will become more difficult to control (Gealy *et al.*, 2003; Chen *et al.*, 2004). The GE contaminated populations of wild and weedy species of rice are likely to be persistent, becoming reservoirs of GE transgenes for further contamination. A loss of genetic diversity of domesticated and wild relatives is cited among the potential drawbacks of the introduction of transgenic crops (Berthaud and Gepts, 2004). When alien transgenes escape to and express normally in wild relatives and weedy species, the transgenes will persist and disseminate within the wild or weedy populations. This will lead to contamination of the original populations of the wild relatives, and even to the extinction of endangered populations of the wild relatives in local ecosystems (Ellstrand and Elam, 1993). Examples of genetic assimilation or extinction by displacement of native allelic diversity are provided in date palm (*Phoenix dactylifera*), olive (*Olea europaea*), and coconut (*Cocos nucifera*) (Bronzini *et al.*, 2002). Furthermore, natural hybridisation with cultivated rice has been implicated in the near extinction of the endemic Taiwanese taxon, *O. rufipogon* ssp. *formosana* (Small, 1984). Small-scale farmers generally maintain a range of genetic diversity on their farm to meet their various needs and to be self-reliant. Genetic assimilation and displacement of genetic diversity may constrain the livelihood of subsistence farmers. The presence of transgenic volunteers in crop fields would contaminate harvest with transgenic seeds and prevent the farmer from obtaining a 'non-genetically modified crop' label for this product. Transgene contamination has been found in local traditional varieties of maize in Mexico (Quist and Chapela, 2001). The escape and persistence of transgenes in environment will also make effective *in situ* conservation of wild genetic resources more difficult. Genetically modified crops cause much trouble particularly in centres of diversity where crops are grown along with their wild relatives.

Most alien genes carried by genetically modified agricultural products are not from crops, instead, they are from other organisms or microorganisms, even from an artificially synthesized origin. These genes may completely alter the natural habit of crop species and significantly change wild relatives of the crop species when transgene escape happens. As a consequence, the environmental safety, particularly the agricultural ecosystems might be under their negative influence (ELLSTRAND *et al.*, 1999). The insertion of transgenic DNA may bring about small-scale rearrangements of the transgene and native DNA sequences at the insertion site (WINDELS *et al.*, 2001). The interactions of transgene with other genes in the genome ("background effect") may affect the overall level of expression of the trait. Through recombination, genes belonging to a specific variety can migrate into new genetic backgrounds where new linkages and gene interactions may modify the expression of transgenes in an unpredictable fashion (BERTHAUD and GEPTS, 2004). When more than one sequence is introduced or if a transgene is similar to a native sequence in the genome, then gene silencing can take place (COMAI, 2000).

Some crop plants have been genetically engineered to produce pharmaceuticals and industrial chemicals (GE "pharm" crops). These pharm crops are not intended to be eaten by humans and animals, but to be used by drug companies or in industrial processes. The compounds produced by these plants are often biologically active chemicals and all are potentially toxic to animals and humans.

Apart from the specific problems with GMOs, there is a more general effect. The use of GMOs speeds up the breeding process and consequently leads to high in the agricultural production, which results in a high genetic erosion. But this is the consequence of all modern technology.

6 Conclusions and Recommendations

Thousands of genetically distinct varieties of our major food crops owe their existence to years of evolution and to careful selection and improvement by our farmer ancestors. Nevertheless, processes that once took hundreds or thousands of years to develop could then be carried out within decades or even years under human influence (HAMMER, 2004). There has been a significant loss of genetic diversity during the last l00 years and the process of gene-erosion continues (HAMMER *et al.*, 2003). With genetic erosion it is not only genetic resources that are under threat of disappearance but also the indigenous knowledge of selecting, utilizing, and conserving these materials that has been accumulated for thousands of years. Erosion of crop genetic resources could pose a severe threat to the world's food security in the long term since loss of genetic variation may decrease the potential for a species to persist in the face of abiotic and biotic environmental change as well alter the ability of a population to cope with short-term challenges such as pathogens and herbivores. It is also threatening the genetic base of many important crops in which future breeding is based. As a result, the loss of biodiversity belongs to one of the central problems of mankind, next to other important matters such as climate change and securing an adequate supply of drinking water. Paradoxically, in many parts of the world, although it is generally accepted that significant amount of genetic erosion has occurred and is still occurring, there is little data on its amount and extent. Without remedial action, genetic erosion will inevitably increase, and the costs of replacement of diversity needed in the future by the community will be much greater (Hammer, 2004). Future progress in the improvement of crops largely depends on immediate conservation of genetic resources for their effective and sustainable utilization. It is widely agreed that the primary solution to the genetic impoverishment of crop germplasm is genetic conservation and utilization in breeding of the vast genetic variation found in populations of the wild progenitors and landraces of cultivated plants (Frankel and Bennett, 1970; Tanksley and McCouch, 1997). The discovery, collection, and conservation of potentially valuable but endangered plant genetic resources is a primary obligation of all countries and institutions adhering to the FAO international undertaking on plant genetic resources (Hammer *et al.*, 2003). A better characterization and understanding of genetic diversity and its distribution is essential to efficiently exploit the available resources in more valuable ways. It is crucial to efficiently design collecting trips and conservation projects (Teklu and Hammer, 2006). The value of diversity is in its use (Gao, 2003).

Since the beginning of the 70s of the last century an effective program has been developed for collecting, conserving and using of plant genetic resources, which was called "plant genetic resources movement" (Pistorius, 1997). But step by step parts of this program have become outdated. Recently, a paradigm shift in the discipline of plant genetic resources has been observed (Hammer, 2003) which includes 1) the maintenance of material (*in situ* instead of *ex situ*), 2) the enforced inclusion of neglected and underutilized cultivated plants, 3) the methods of quantifying genetic diversity between different cultivated plant taxa, 4) the methods of analyzing genetic diversity among the different cultivated plant taxa, 5) their evaluation and 6) their reproduction.

The best method of conservation is the use of complementary approach of the different *ex situ* and *in situ* conservation techniques. Since part of the worldwide *ex situ* collections is endangered, priority should be placed on securing and providing financial support for existing collections. The regular regeneration of material is essential and must be made possible (Hammer, 2004). The expansion of strong national programs should be supported as an important basis for a functional global plan. Support for networks of cooperation in the area of plant genetic resources must also be improved. It is always necessary to conserve a large number of collections of a particular taxon. The classic example of this was the screening for resistance against the grassy stunt virus of rice at the International Rice Research Institute in the Philippines. Under the 6723 accessions of cultivated rice and several wild species of *Oryza* screened for resistance, only one accession of wild species *O. nivara* was found to be resistant and used to introduce resistance to grassy stunt virus into cultivated rice (Ling *et al.*, 1970). The principle of prevention (Noah's Ark principle) tells us to maintain as much material as possible. There is presently no scientific method, except the identification of duplicates, which can give us a secure assessment as to which parts of the collections are expendable. Apart from conservation, creation of sustainable agricultural systems that actively use as much biodiversity as possible must remain the major goal. Only in use can diversity be appreciated enough to be saved, only in use it can continue to evolve, and thus retain its value (Partap, 1996). Hence, there should be an ultimate linkage between conservation and utilization.

Biotechnology offers us a new arsenal of methods for the study of genetic resources, but also for certain conservation techniques. Gene technology increases the possible use of distantly related trait carriers as donors for the desired characteristics. Most of the crop cultivars that are developed are compatible *inter se* but they are also compatible with related wild or weedy relatives, suggesting that gene flow has always taken place. The possibility of transgene flow from engineered crops to other varieties, to their wild relatives or to associated weeds is one of the major concerns in relation to the ecological risks of the commercial release of transgenic plants (Messeguer, 2003). It is currently impossible to prevent gene flow between sexually compatible species in the same area. Pollen and seeds disperse too easily and too far to make containment practical (Snow, 2002). It is therefore necessary to understand genetic relationships and actual gene flow frequencies between the transegenic crop and wild/weedy relatives or landraces, to know geographic distribution patterns and flowering habits of cultivated and wild crop species, and to understand other factors influencing the gene flow. This will facilitate the effective prediction of transgene escape and its potential ecological risks, and the development of strategies to minimize the escape of alien transgenes. Empirical research is also needed to evaluate the persistence of transgenes in the recipient populations and its effect on fitness should be measured to fully assess the impact of gene flow of transgenes.

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Factors Influencing Irrigation Technology Adoption and its Impact on Household Poverty in Ghana

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Abstract

The treadle pump technology was promoted and disseminated as an alternative to traditional rope and bucket for irrigation in Ghana by the International Non-Governmental Organization, Enterprise Works. The aim is to improve output, increase incomes and consequently reduce poverty among farm households. The paper employed the Heckman two-stage and the Ordinary Least Square procedures to identify the factors that influence adoption of the technology and the impact of adoption on the poverty status of farm households. Farm and household level data were obtained from 108 farmers consisting of 52 adopters and 58 non-adopters. The results demonstrated that availability of labor and increases in number of extension visits per year are factors that increase the probability of adoption. The results also showed that increase in irrigated area has the highest impact on poverty followed by adoption of treadle pump and literacy level of farmers.

Keywords: Irrigation technology, treadle pump adoption, poverty, Ghana

1 Introduction

The occurrence of erratic rainfall have created uncertainty for agricultural production and emphasized the need for irrigation in Africa. The traditional system of irrigation comprises of the use of either rope and buckets to lift and distribute water from shallow open wells or watering cans to lift water from streams. Although the low capital requirement of these traditional technologies makes them advantageous and affordable, their low delivery capacity and labor intensive nature make them highly unfavorable to African production conditions (Kamara *et al.*, 2004). Improved water lifting technologies, with relatively high efficiencies such as motorized pumps, have been tried but have been found to be favorable mostly to large-scale farmers. For small-scale farmers, who usually irrigate relatively small plots of land and operate relatively small capital, such technologies are unaffordable. This lack of simple, affordable and well adapted water development technologies, suitable to the production conditions and needs of smallholder farmers in sub-Sahara Africa, among others, is a serious handicap to efforts for achieving food security in the continent (Hyman *et al.*, 1995; Brabben and Kay, 2000).Today a substantial variety of low-cost, affordable water development options exist, including

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treadle pumps (TP [1]). The TP is a low-lift, high capacity, human powered water lifting pump. It is suitable for irrigating agricultural land of less than one hectare and are considerably less expensive than motorized pumps. Also, it cost much less to operate , having no fuel and only limited repair and maintenance costs. Its water lifting capacity of five to seven cubic meters per hour meets the irrigation requirements of most African farmers, the majority of whom cultivate less than one hectare of land. The pump is fabricated entirely from locally-available materials can be manufactured using welding equipment and simple hand tools in the metal workshops commonly found in Africa .The manufacturing, marketing and distribution campaigns of the treadle pump is carried out through development organizations. In Ghana, an international non-governmental organization, Enterprise Works promoted the use of treadle pumps to assist farmers improve their productivity and incomes. Treadle pump (TP) technology is widely believed to be a pro-poor, poverty alleviating technology due to its demonstrated potential for low cost irrigation, and suitability for small scale farming. The objective of this study is to identify the factors that influence the adoption of TP. It also explores the links between the adoption of TP and poverty status of small scale farmers.

2 Methodology

2.1 The Study Areas

The study was conducted in two Ghanaian regions of Ashanti and Volta. These regions were selected because they are known to have recorded the highest rates of treadle pump sales in Ghana. The Ashanti region recorded approximately 38% of total treadle pump sales while the Volta region recorded 15% of the total treadle pump sales in Ghana (EnterpriseWorks, 2004). The Ashanti Region lies in the south-central part of Ghana occupying an area of 24,389 km^2. The region falls within the Equatorial Monsoon belt, which is characterized by two main seasons, wet and dry. The wet season is associated with a double maxima rainfall regime from April to July (MAR=1270 mm) and September to October (MAR=1778 mm)[2]. The region is well endowed with rivers and lakes including man-made ones. Rainfed agriculture is predominantly practiced, and is associated with the cultivation of major staples such as maize, cassava, plantain, yam and some vegetables. Informal irrigation with the use of watering cans and buckets is extensively practiced in the dry season for the cultivation of both exotic and indigenous vegetables. In and around the capital city, however, vegetables are cultivated throughout the year, particularly exotic vegetables. These include lettuce, cabbage, carrot, spring onion, garden egg and green pepper.

The Volta Region is located in the eastern part of Ghana sharing the eastern border with the Republic of Togo. It is the fourth largest region in Ghana, covering a surface area of about 20,570 km^2. (Ghana Statistical Services, 2002). It has a mean annual rainfall of between 140 mm and 165 mm. The southern part of the region is located in the dry equatorial zone, which according to Dickson (1977, p.27) is the driest climatic zone in Ghana. Temperatures are generally high (between 26°C and 28°C) throughout

[1] Treadle Pump (TP)

[2] MAR: Mean Annual Rainfall

the year. The region's main river is the Volta, and is also served by several smaller rivers and streams. Farming is the dominant form of land use and the main source of income for most households in this region Duncan and Brants (2004). This is related to the predominantly rural character of the region and the fact that the region is moderately endowed with natural resources and fertile soils. Dry season vegetable cultivation is widely practiced and some districts cultivate vegetables throughout the year. Rainfed agriculture involves the cultivation of major staples including cassava, maize, rice and yam. Cocoa and coffee are important export crops cultivated in the forest zones. Fishing is another important income-generating activity, especially for communities along the coastline and Lake Volta. Both exotic and indigenous vegetables are irrigated and these include shallots, onions, okra, pepper and tomatoes.

2.2 Study Design and Data

The study was carried out primarily through a survey of 108 farmers comprising 52 adopters and 56 non-adopters of TP in the months of August and September 2005. In obtaining the sample for the survey, a multistage sampling technique was used. First, the districts in each of the regions with more adopters of TP were sampled using the sales list provided by EW. In all, five districts were selected in the Volta region and seven in the Ashanti region. Second, farmers in each selected district were stratified into two, namely adopters of TP and non-adopters. Adopters were identified by using the sales list and through assistance from sales agents. In some cases, farmers assisted in identifying other users. The non-adopters of TP were distributed throughout the selected districts. These were farmers who irrigated using the traditional water lifting devices such as rope and bucket and/or watering cans. Third, all TP adopters who were available in these districts were interviewed. Those who had stopped the use of the pump were also interviewed. In sampling non-adopters, a simple random sampling technique was used. A questionnaire was used to obtain farm and household level information from adopters and non-adopters. The data collected from the survey was supplemented by interviews with TP manufacturers and sales agents to distill information on the level of local capacity for the manufacture and dissemination of the TP. It is to be noted that the promotion of TP by EW in Ghana was only for a period of two years, only occurred between 2002-2004; hence, because the study was conducted in 2005, it was only able to assess the short-term impact of TP adoption in Ghana.

The data were analyzed using descriptive statistics and the Heckman's two-stage model. The T statistic and and chi-square statistic were used to test for significance in differences in the socio-economic characteristics of adopters and non-adopters.

3 Analytical Framework

3.1 Factors that influence adoption of TP

The decision to adopt an agricultural technology depends on a variety of factors (Nowak and Korsching, 1983; Wiersum, 1994; Mendola, 2005; Calatrava-Leyva *et al.*, 2005), including farm households' asset bundles and socio-economic characteristics, characteristics of the technology proposed, perception of need, and the risk bearing capacity of the household. An 'asset bundle' comprises physical, natural, human, social and financial assets. In this study, we hypothesize that the factors affecting treadle pump adoption are as follows:

Physical/natural assets – The area of land under irrigation is expected to affect the adoption decision. Farmers with less than a hectare of irrigated farm are expected to be willing to adopt the technology since the area is within the pump's capacity to irrigate. The size of irrigated land cultivated depends on availability and the financial capacity of the farm household for cultivation. It is therefore used as a proxy of the family's wealth status. Reliable access to water throughout the year is also considered a factor in whether or not the TP will be adopted.

Human assets – The quality and quantity of household labor are expected to affect adoption decisions. The quality of household labor is captured by the capacity to work proxied by the age of farm household head, and the capacity to adopt proxied by the level of education of household head. The quantity of household labor is captured by the household size and the ratio of family members that are not earning an income to those who earn (dependency ratio) and the number of household members who can assist in operating the treadle pump (those of 15 years and above). TP adoption is expected to have a negative relationship with the age of household head and dependency ratio; TP adoption is expected to have a positive relationship with the level of education of household head, household size, and household members above 15 years of age. The gender of the household head is included to examine its impact on adoption decisions, although no negative or positive relationships are hypothesized for this relationship.

Social assets – These are represented by membership in the farmers' cooperative society and frequency of extension visits. It is expected that membership in the cooperative society and high frequency of extension visits will increase adoption. These variables are expected to improve the adequacy of the information obtained about the pump, which will have an impact on the adoption decision..

Financial assets – This is proxied by the farm household access to formal or informal credit. Access to credit has remained a constraint to adopting improved technologies in developing countries and it is expected that access to credit will affect the adoption decision positively.

The adoption of TP technology can be analyzed by employing the logit or probit model. To assist in testing for selectivity bias in the outcome equation, however, the Heckman selection model was used to estimate both the adoption model and the poverty impact model (outcome equation). The explanatory variables in the adoption model are age of household head, years of schooling of household head, household size, household members above 15 years, dependency ratio, irrigated land area, membership of association, number of extension visits per year, gender, accessibility to credit, reliability of water and region.

3.2 Impact on poverty status of adopters

In order to further investigate the impact of treadle pump (TP) adoption on the poverty status of adopters, a multivariate analysis was done. To isolate the impact of TP adoption from other intervening factors, the establishment of a counterfactual outcome is required, as is the ability to overcome selection bias. According to HECKMAN and SMITH (1999), the establishment of a counterfactual outcome represents what would have happened in the absence of project intervention. ZAINI (2000) asserts that these problems become more complicated when participants self select into the project. Due to the difficulty of establishing an effective counterfactual situation, a control group was used. The control group comprises non-adopters of TP. To allow for selection bias in the assessment of the poverty impact of TP adoption, the identification variable approach following the Heckman two stage procedure was adopted to analyze the data. Selection bias relates to the unobservable factors which may bias the outcome on poverty due to TP adoption. An appropriate identification variable for this two step procedure needs to be found for the analysis. This variable has to influence adoption but not poverty. Moreover, even if an appropriate identification variable were found, the results from the procedure can be sensitive to the choice of this variable. Due to this limitation, the results from the procedure need to be checked for 'robustness' (ZAMAN, 2000). This paper adopted the 'number of extension visits per year' as the identification variable that influences adoption but not poverty. The choice is dictated by the fact that an increase in the number of extension visits increases farmers' knowledge about the TP and helps farmers make an informed decision as to whether or not to adopt. The impact of extension visit on poverty will depend not only on the number of extension visits per year but also on the quality of extension services rendered. The impact of this variable was tested in the adoption and poverty models to verify its choice as an identification variable.

The Heckman two stage procedure involves, first, the estimation of the adoption process and second, the estimation of the poverty outcome. Following ZAMAN (2000), the adoption equation (the first stage of the Heckman model) estimated is:

$$Y_i^* = \sigma + \delta X_i + \mu_i \tag{1}$$

Y_i^* is a latent variable representing the propensity of a farm household i to adopt TP, X_i is the vector of farm households' asset endowments, household characteristics and location variable that influence the adoption decision.
Prior to the analysis, pair wise correlation was conducted for the variables in the model and it was found that some of the variables were highly correlated. One of each pair of the highly correlated variables was dropped.

Employing the maximum likelihood estimation procedure, the probability of adoption is obtained from the first stage of the Heckman two-step technique. This involves employing a probit regression to predict the probability of adoption. Using these estimates, a variable known as the Mills ratio is obtained as follows:

$$\lambda_i = \frac{\phi(\rho + \delta X_i)}{\varphi(\rho + \delta X_i)} \tag{2}$$

Where ϕ is the density function of a standard normal variable,
φ is the cumulative distribution function of a standard normal distribution and
λ_i is the Mills ratio term

The second stage involves adding the Mills ratio to the poverty equation. The factors that determine poverty are explicit in the literature and they include household and community characteristics. Lack of household ownership and access to assets that can be put to productive use are important determinants of poverty (Ellis and Mdoe, 2003; World Bank, 2000). The specific factors identified in the literature that determine poverty include demography or human factors (e.g. household size, age and gender, education and health) and social capital (membership in mutual support organizations); physical capital (ownership of livestock and other productive assets); community factors (access to infrastructure and services, population density, urban-rural or regional location; and external factors (civil strife, climate) (Benin and Mugarura, 1999).

The household and community characteristics with institutional factors hypothesized to affect poverty are similar to those hypothesized to affect adoption. They are the age of the household head, household size, dependency ratio, number of years of schooling of household head, irrigated area, membership of water user or cooperative association, the geographical location of the study area and the household TP adoption status. The poverty status of the household is represented by its per capita income. The household per capita income was obtained by dividing the total household income by the number of adult equivalent in the household. The household income includes income from irrigated farming, rainfed farming, livestock production, off-farm activities, non-farm activities and remittances.

The poverty equation is estimated as:

$$P_i = \beta_0 + \beta_1 W_i + \beta_2 Y_i + \beta_3 \lambda_i + \xi_i \tag{3}$$

Where
$E(\xi_i) = 0$
P_i is the *per capita* income of household i in US Dollars
W_i is a vector of farm households asset endowments, household characteristics and location variable
Y_i = is a dummy variable which is 1 for adopters and 0 for non-adopters

4 Results and Discussion

4.1 Socio-Economic Characteristics of TP Adopters and Non-adopters

The summary statistics of the socio-economic characteristics of adopters and non-adopters of TP are given in Table 1. It reveals that irrigated farming is male dominated with the percentage of males generally high in the study areas. The result also show that the age of household head was not significantly different for adopters and non-adopters.

There is a small but significant difference in the years of schooling of the household heads among adopters and non-adopters, with the former being more educated. The

Table 1: Characteristics of Adopters and Non-adopters of TP.

Characteristics	*Adopters*	*Non-adopters*	*% Difference*	*T-test / χ^2 value*
Age of Household head	41.38	43.32	4.68	1.041
Gender of Household head Male (%)	94.23	98.21	3.98	1.200†
Years of schooling of Household head	10.63	9.30	12.51	1.801*
Household size	5.97	6.78	13.56	1.693*
Adult male above 15yrs	2.14	1.98	7.48	1.042†
Adult female above 15yrs	2.12	2.21	4.25	0.358†
Dependency ratio	0.67	0.77	14.93	1.810*
Irrigated area	0.66	0.58	1.12	1.440
Member of Association (%)	48.07	55.35	7.28	0.572†
Number of extension visits per year	4.31	2.07	51.97	2.456***
Access to credit (%)	5.76	1.78	3.98	1.091*

*** significant at 1%, * significant at 10%, † chi-square (χ^2) values

mean household size of adopters is significantly lower than that of non-adopters. There is also higher numbers of adult males, and lower numbers of adult females in adopter households, but these differences were not significant. The dependency ratio of non-adopters is higher and significantly different at 10% from that of adopters. This implies that the ratio of non-working members to those working is higher in non-adopter households. Therefore, labor availability is lower in these households when compared with those of adopters. Adopters had higher number of extension visits per year (4.31) than non-adopters (2.07) and the difference is significant at 1%.

4.2 Factors that influence TP adoption

The explanatory variables and summary statistics used in the adoption model are presented in Table 2.

Table 3 presents the estimated parameters and the statistically significant variables explaining the adoption decision.

Diagnostic statistics (Table 3) showed that the model had a good fit to these variables with chi-square test statistics significant at 1%. This shows that the explanatory variables are relevant in explaining the adoption decision. The signs of the variables also agrees with *a priori* expectations, except the variable for age of the household head. The Z test statistics reveal that three of the variables were statistically significant. These were the dependency ratio, number of extension visits per year, and the regional dummy. Dependency ratio has a negative relationship with the probability of adoption and is significant at 1%. Increase in the number of non-working household members as compared to those working infers lower labor availability for productive economic activities. This apparently discouraged TP adoption, which requires labor for pedaling. Also, increase in

Table 2: Summary Statistics of the Explanatory Variables for Adoption Model.

Variables	*Explanation*	*Mean*	*Std. dev.*
Age of household head in years	Age of the household member responsible for final decisions on farm operations and investments	42.30	1.80
Year of schooling	Years of formal education of the household head	9.94	3.89
Household[3] size	Total number of members of the household	6.30	0.19
Household members above 15 years	The total number of household members above 15 years representing the adult workers in the household	4.23	2.26
Dependency Ratio	Ratio of non-income earning members of the household to income earning members of the household	0.72	0.01
Irrigated area	The area of land cultivated under irrigation before adoption	0.59	0.41
Membership of association	Dummy variable for membership of Water User Association, Farmer Cooperative Society; 1 for members, 0 for non-members		
Number of extension visit	Number of visits from MoFA and EW per year	3.10	1.83
Gender	Dummy variable for gender; 1 for male, 0 for female		
Accessibility to credit	Dummy for accessibility of credit from formal and/or informal sources: 1 for accessibility and 0 otherwise		
Reliability of water	Dummy variable for availability and accessibility of water all the year round; 1 for reliability of water, 0 otherwise		
Region	Dummy variable for region; 1 for Volta, 0 for Ashanti		

[3] A household is taken as members who eat from the same pot over a 12 month period

the number of dependants in the household may reduce the household income available for investments, thus discouraging adoption. The number of extension visits per year is positive and significant at 5% showing that the more frequent the number of visits, the higher the probability TP adoption. The regional dummy is significant at 5% and with a negative sign, implying that Ashanti region has a higher probability of adoption than

Table 3: Factors that influence Adoption of TP using Heckman Two-Stage Model.

Variable	*Coefficient*	*Standard Error*	*Z*	*P-value*
Constant	-0.261	0.724	0.361	0.717
Age	0.009	0.016	0.567	0.571
Years of schooling	0.050	0.041	1.211	0.226
Household size	-0.025	0.055	-0.464	0.642
Dependency ratio	-0.808***	0.280	-2.880	0.004
Irrigated area	0.248	0.363	0.683	0.495
Membership of association	-0.109	0.296	-0.370	0.711
Number of extension	0.067**	0.336	1.999	0.045
Reliability of water	0.358	0.309	1.159	0.274
Region	-0.766**	0.316	-2.421	0.015
Log- likelihood	-60.572			
χ^2	28.428			
Probability of χ^2	0.0081			
N	108			

*** significant at 1%, ** significant at 5%

the Volta region. In the Ashanti Region, there is easy access to big commercial markets particularly for exotic vegetables, which serves as an incentive for farmers.

This study shows that the age of the household head, years of schooling, irrigated area, and water supply reliability have positive relationships with the probability of adoption, but are not significant. Similarly, household size and membership in associations have negative relationships with the probability of adoption but are not significant. On the whole, this result revealed that availability of labor and increases in number of extension visits per year will increase the probability of adoption. In addition, there was a higher probability of TP adoption in Ashanti as compared to the Volta region

4.2.1 Impact on poverty status

A multivariate analysis was undertaken to assess the impact of TP adoption on poverty using the Heckman two-step procedure. Essentially, the explanatory variables include the same household and community characteristics, as well as institutional factors, as in the adoption model. The second step of the Heckman two-step procedure estimates the determinants of poverty and tests for selectivity bias by incorporating the Lambda into a linear regression. The Lambda is the inverse Mills ratio saved from the probit equation describing adoption. The dependent variable is the log of the household per capita income. The selection of the identification variable was tested by estimating the determinants of poverty. The model was estimated using the number of extension visits per year as the identification variable. Table 4 presents the coefficients in the poverty model from both the second step of the Heckman two-step and the OLS (Ordinary Least Squares) estimation procedures. The Lambda coefficient is negative and is not significantly different from zero which indicates the absence of selectivity bias in the sample. This means that the error terms of the adoption and poverty models are not correlated. The robustness of the identification variable was tested using the "identification on functional form" method. This involves including the identification variable in the model. Again, the Lambda coefficient was not significant. The identification variable was also not significant, which implies that it does not influence the per capita income of farm households in the study area. Therefore, it is possible to judge the variable appropriate for an identification variable. Since the results from the estimation can, however, be sensitive to the choice of the identification variable and in the two models the Lambda is not significant, the model can be estimated using an OLS.

Table 4: Determinants of Poverty.

	Heckman second step with number of extensions as identification variable		*Heckman second step and identifying on functional form*		*OLS estimation*	
Age	-0.001	(p=0.87)	-0.001	(p=0.89)	-0.001	(p=0.83)
Years of schooling	0.073***	(p=0.00)	0.073***	(p=0.00)	0.072***	(p=0.00)
Household size	-0.005	(p=0.78)	-0.005	(p=0.77)	-0.005	(p=0.78)
Dependency ratio	0.016	(p=0.85)	0.016	(p=0.86)	0.027	(p=0.76)
Irrigated area	0.739***	(p=0.00)	0.742***	(p=0.00)	0.749***	(p=0.00)
Membership of association	-0.031	(p=0.74)	-0.035	(p=0.71)	-0.036	(p=0.71)
Number of extensions			0.002	(p=0.87)	0.001	(p=0.91)
Reliability of water	-0.001	(p=0.98)	-0.002	(p=0.98)	0.007	(p=0.93)
Adoption of TP	0.247**	(p=0.04)	0.243**	(p=0.03)	0.281***	(p=0.00)
Region	-0.205*	(p=0.06)	-0.205*	(p=0.06)	-0.194*	(p=0.07)
Lambda	-0.012	(p=0.45)	-0.011	(p=0.44)		

*** significant at 1%; ** significant at 5%; * significant at 10%

The result from the OLS estimation is used to explain the model. The p values reveal that four of the variables are statistically significant and affect household poverty. Three of these have positive relationship with household poverty. They are; years of schooling, irrigated area and TP adoption. The regional dummy has a negative sign. The years of schooling of the household head is significant at 1 percent. The per capita income will increase by 7 percent for each additional year of schooling. This implies that the education of the household head had an impact on poverty. This is not surprising because literacy enhances the capacity to adapt to change, understand new practices and technologies, and improving a household's productivity and income. The size of irrigated area is positive and significant at 1 percent. A unit increase in irrigated area leads to about 74.9 percent increase in per capita income. Increase in irrigated area will increase farm output and incomes and thereby improve household per capita income. The adoption of the TP is significant at 1 percent. The result shows that the TP adoption increases per capita income by 28.1 percent relative to that of a non-adopter. This shows that the adoption of a TP reduces poverty. This is consistent with findings in a similar study in Malawi (Mangisoni, 2006).The regional dummy is significant at 10 percent and this implies that the per capita income of farm households in the Volta region was 19.4 percent lower than the per capita income of those in the Ashanti region. In sum, the increase in irrigated area has the highest impact on poverty followed by TP adoption, and lastly the number of years of schooling. The higher per capita income of farm households in Ashanti as compared to Volta is partly due to its better access to markets.

4.3 Conclusion

The paper examined the factors influencing the adoption of treadle pump technology for irrigation in two regions with the highest adoption rates in Ghana. The socio-economic analysis reveal that irrigated farming is practiced mostly by men irrespective of adoption status. There is no significant age differential between adopters and non-adopters of the technology. However, there are significant differences in the number of years of schooling, household size, dependency ratio and the number of extension visits per year between the adopters and non-adopters. The factors influencing the probability of adoption are the availability of labor and increase in the number of extension visits. The probability of adoption also differed between regions. The impact of treadle pump adoption on poverty revealed that the area cultivated under irrigation has the highest impact on household poverty. Others are the adoption of treadle pump and the number of years of schooling of the farmer. The impact on poverty also differed between regions due to access to markets.

The implication of these findings is that extension visits are important to technology adoption. Increased collaboration of private initiatives with local institutions such as extension service could improve the reach of the technology to farmers. Increasing the area cultivated under irrigation will reduce poverty: this suggests that assisting farmers gain access to land close to sources of water or drilling of tubewells to improve access to ground water will have significant impact on poverty reduction among poor farming households. It is also important to stress that due to the capital requirement for acquisition of treadle pump, targeted credit programs by formal financial institutions will ameliorate the financial constraint. This also will improve farmers access to the treadle pump because more farmers will be able to purchase the pump. The study shows the need for public-private partnership in the promotion and dissemination of agricultural technology to improve adoption rates.

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Vernacular Languages and Cultures in Rural Development: Theoretical Discourse and Some Examples

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Abstract
The role of language and culture in rural development projects is investigated. Examples taken from the context of Northern Iran, the significance of which is not confined to its agricultural and forestry resources and extends beyond national borders, are presented. A starting point of the analysis is an appreciation of diversity, not only in the biological, but also in the cultural sense, as an asset and viewing development endeavors as sense making acts. It is further argued that new intangible forms of capital are increasingly gaining in importance in the contemporary world. Capital is considered not merely as an asset, but as a relation having accumulation moment as well, and impact on the regeneration of cultural and economic divides. A central concern is enhancing social inclusion and promoting conditions for making voices of otherness heard. It is deemed that vernacular voices encompass valuable indigenous knowledge and modes of perception, the negligence of which can undermine the success of rural development projects.

Keywords: language, culture, social inclusion, rural development, Iran

1 Framework

The role of language in development, despite its obvious relevance, even centrality considering its species- specific place and its role in communication process, has so far remained a neglected area and largely escaped scientific investigation and theorization (Bearth, 2000). Among the studies that have constituted an exception to this rule and have considered language as a primary topic in development research, many have been carried out from a dominant- centric position. A major problematic in those studies has been the language as a problem in itself: how to deal with the question of linguistic diversity and lack of competence in a major language that can serve as the means for common discourse and social interaction. A World Bank publication (Chiswick *et al.*, 1996) devoted to the economics of language exemplifies this approach. One of the consequences of linguistic heterogeneity, according to the analysis presented in that

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study, is a reduction in communication among segments of the population. This is the equivalent of an increase in transaction costs or the costs of exchange. It presents a mathematical model of an economy and demonstrates that linguistic divisions in the population retard economic development and exacerbate other often vexing problems, namely, inequality, poverty and inequity in the society. Further analysis demonstrates how microdata on individuals and households can be used to study issues related to the determinants and labor market consequences of dominant language fluency. The obvious conclusion is that majority language education is not only economically necessary, but also socially desirable. It is desirable especially from the minority point of view, because it is they who suffer from linguistic disadvantage. The study introduces the concept of language capital; but only as a subset of human capital satisfying the triple requirements of being embodied in the person, costly to create, and productive. The viewpoint elaborated in the mentioned study shows the stances common to several other studies. Not only are the recent sociolinguistic works discussing the advantages of multilingualism and linguistic diversity not taken into account, but the newer trends in development research appreciating diversity are also not considered. The latter trends can be seen, for example, in recent UNESCO studies e.g. the Universal Declaration on Cultural Diversity, adopted by the UNESCO General Conference (2001). Explicit in the declaration is that cultural diversity is as important a factor for development as biological diversity. In terms of intangible and oral heritage, it has been argued, the world is experiencing the rapid disappearance of local languages and of traditional cultures and their underlying spirituality, and of knowledge traded over generations, which is profoundly relevant for sustainability.

Exoglossic language and educational policies inherited from the colonial era have contributed to perpetuating a conceptualization where access to innovative knowledge and hence to social and economic development and to full participation in processes of democratization and decision-making, is considered linked to proficiency, if not in English or some colonial language, at least in a nationally or regionally dominant language. That there is a one- way communication of innovative ideas from the developed states and institutions to the underdeveloped or developing countries, regions, and nations, which still carry the "burden of traditionalism", is a common supposition reinforced by the correlation of innovation and development with modernization and industrialization, which are ultimately identified with westernization and the fact that funding flows from the former to the latter. Even critical studies of rural development otherwise trying to adopt minority- centric points of view and consider the role of indigenous languages in development communication, often start from the presupposition of a development source language, DSL, as opposed to a development target language, DTL. Outright majority-centric stances are, of course, becoming discredited. Much emphasis is now put on notions of participatory and endogenous development projects. That target community should assume control over its development and orient the development plan around local resources has become an important goal not only for progressive non- governmental organizations, NGO's, formed to promote that idea, but also for donor institutions as well. The two main motivations cited are enhanced sustainability and better use of indigenous knowledge (Bearth and Fan, 2003). However, important as the emphasis on local control may be in many respects, it is claimed that it does not go far enough, and endogenous control of rural development does not yet guarantee a break from dominant-centrism. In fact, whether the target economy is completely market- based, or if it still has remnants of traditionalism, relations of dominance are often no less pronounced; and neither is the tendency to innovate and experience helping identify the best development path necessarily stronger. Good intentions and promising approaches may also fail to lead to better implementations due to inadvertent methodological defects. It has been pointed out that in many pluridisciplinary and practical research works where sociological approaches to economic and linguistic problems are adopted, little attention is paid to philosophical and methodological issues, and by default, the sociological analysis is conducted within the theoretical confines of the dominant paradigms. Functionalist biases are inevitable results (Nercissians, 1988b, 2002). In particular, uncritical consideration of target communities as total entities and lack of regard for the heterogeneity and internal conflicts and contradictions are important drawbacks. Another shortcoming to be avoided is the notion of overadapted agencies and the consequent social determinism. A new concept of glocal development has found currency in the contemporary integrated world. Both exogenous and endogenous factors are important for rural development and it is their interaction that leads to the selection of the proper route. Our stances are that we should go beyond target community control of the development process and study conditions under which social inclusion is enhanced and those voices that were kept silent can now be heard in development communication. Even beyond that, it is not enough to hold that increased participation, not only by the target community as a whole, but also by its different strata, is an important condition for successful and sustainable rural development. Social inclusion, it should be emphasized, is not a precondition but an end for rural development projects. It is also important to overcome the forces hindering development. The iron grip of dependency cannot be broken unless raised vernacular voices other than those sustaining it are heeded.

It has been posited as a starting point for consideration of language as the missing link in development studies, that it is not the mere comprehension of, and collective action response to the idea of development, presumably emanating from some exogenous source, by the target community, that should constitute the objective of development communication. The more important question is its internalization and endogenous reproducibility through negotiation and argumentation processes. In other words, it is conjectured that communicative sustainability is a prerequisite to sustainability in development. Again, this paper purports to go beyond that premise. Of course, it is important to penetrate communal discourses on development issues, something that is impossible unless the idea is expressed in a language that is understood by them, even if it were true that their vernacular, and the very fact of linguistic heterogeneity, had a detrimental impact upon the development project. But the latter supposition, even if it could be considered true in the past, can no longer be supported by the facts in the contemporary world. We should take several steps beyond the stance/current status, stressing the importance of expressing the development message in the target language even though it could be costly. Firstly, heterogeneity and diversity can be an asset rather than liability. Furthermore, social creativity can enhance the value of diversity. In sociolinguistic studies, the concept of additive multilingualism has been elaborated for examining the conditions under which maximum benefit can be obtained from societal plurilingualism (Nercissians, 1988a, 2002, 2004). Secondly, even if it had no advantage, vernacular development, through being an objective of the endeavor, should be pursued. And finally, vernacular expression of the development project, and not its mere translation, is essential for overcoming the real obstacles hindering it.

What has been said about language is also true for culture (Hannerz, 1992). Closely related to languages and cultures are mental structures, ideologies, norms and values, customs and behavioral patterns, and identities. Their correspondence, however, need not always be one to one (Nercissians, 2002; Nercissians and Lucas, 2005). Our approach to development stems from the belief that it is closely related to the process of sense making. Our sense of self is always correlative to our sense of an external, constraining reality. Biological organisms are both an embodiment and a source of meaning: communities of fate becoming communities of will that are discursively constituted and oriented towards freedom, transcending the intrinsic drives of the organic life towards a future shaped by an ideal. A main concern is how ideal types or standards are formed. The concept of multiglossia refers to the existence of several different standards, differentially endowed with social prestige. Each standard is considered proper in a certain domain. A two dimensional approach to the scientific conceptualization of diglossia suggests that the standards are compared along different axes. The prestige or status dimension gives rise to an overt standard that is formed from above, while the solidarity or identity dimension also leads to a covert standard formed from below. The first standard is proper in domains that are more formal, and therefore does not include the intimate and family domains, and is thus superposed, that is, obtained through a process of formal education. It has also been argued that the ability to compartmentalize the domains, and freely switch between different standards is an index of social dominance. Others find themselves in a situation where there are contradictory expectations always co-present. They have to carry out an act of balancing. Thus they always underachieve because if they pursue one ideal too far they fall too far behind alongside the other ideal axis. This extended model can be as easily applied to the spheres of cultures, social norms, and identities (Nercissians, 1988a, 1992, 2000, 2001, 2004).

The rest of the paper is organized as follows. The concept of language capital, cultural capital, and other symbolic and intangible capitals and their role in rural development projects is analyzed in the next section. Examples illustrating the role of vernacular languages and cultures are provided afterwards. Concluding remarks constitute the final section of the paper.

2 New Capitals

Rapid technological progress especially during the past decade and the advent of disruptive technologies like infotech and biotech has led to radical shifts in social and economic paradigms. An important aspect of the shift is the ascent to hegemonic position of a new economic sector. The sector, which at least in some respects includes quite traditional spheres of economic activities, but in contemporary world can be called the (newly recognized) sector of intangibles, incorporates most of the economic activities used to denote as service sector, as well as newer activities producing knowledge and other goods related to culture and consciousness. This new sector is growing very rapidly, employs a large part of the workforce, is generally more productive, and exerts its influence upon the older sectors: agriculture and industry. Computer networks and economic activities in virtual space are reinforcing the trend towards the information- based digital economy. Success in the new economy no longer depends only on workforce and machinery. In the new economy knowledge and the ability to mobilize and coordinate efforts and find best ways of dealing with physical and environmental constraints are more important factors for increasing productivity (LUCAS and NERCISSIANS, 1987, 2003).

Social and economic changes in the contemporary world are associated with changes in anthropological and cognitive- behavioral spheres. A major expression of those transformations is the increased importance attached to representation and signification. In a rapidly changing world where flexibility and adaptability are crucial, functions and meanings are not considered fixed and total any more. Everything becomes a subject for re-use, re-deployment, re-interpretation, and re-signification through denotation as well as connotation. Cultural items, through becoming commodities, become economic categories. But use values are no longer primary aspects of economic commodities. Rather, goods and articles are consumed mainly because of their semiotic attributes. Their use marks consumers' identities. This fusion of culture and economy intensifies the sense making process. Development plans become first and foremost endeavors to endow community life with new meanings. Language is the most important tool for this process of semiosis. To carry out the development plan, the community must first accept it as its major discourse.

The construct of a learning organization (SENGE, 1990) has been proposed as a suitable tool for the conceptualization of rural development projects. Success in development, it has been argued, will depend on organizational competencies and developmental potential of the rural community. Drawing upon past and ongoing theorizations on organizational development and learning, SENGE (1990) has elaborated five core disciplines for building a learning organization. The first, personal mastery, refers to individual community members' learning. Organizations learn, in part, through the synergy of the learning processes of individuals constituting them. ARGYRIS (1993) holds that many people and organizations practice defensive reasoning, i,e, act so as to avoid embarrassment or threat. But to avoid embarrassment and threat, they also avoid learning. Effective learning, therefore, becomes possible when the flaws in mental models are discovered and corrected. Team learning constitutes the third core discipline. It begins with dialogue and builds up the capacity of individual members to suspend assumptions and think together genuinely. Next comes shared vision. The latter can be built by finding good compromises between individual visions and developing those visions in a common direction. The fifth discipline is denoted as system thinking. It most of all refers to the primacy of the whole. A learning organization is thus an entity which individuals "would truly like to work within and which can thrive in a world of increasing interdependency and change" (Senge, 1990).

The concepts of knowledge capital and social capital have in recent times been widely used both in theoretical works and in practical feasibility analysis for development projects (Coleman, 1988; Dasgupta and Serageldin, 2000; Putnam, 2000; Buckman, 2004). Closely related are the concepts of symbolic capital, language capital, and cultural capital (Bourdieu, 1986). These constructs are somewhat more suitable for our purposes because the term capital does not carry the implied functionalistic connotation of being free of conflicts. The concept of knowledge capital draws upon theories on intellectual capital and knowledge management. With the advent of the digital economy and the leading role of the economic sector of intangibles, there can be no doubt about the importance of leveraging knowledge for creating value. Knowledge here is viewed as a resource and capital refers to the value creating process. Intellectual capital theory, according to this view, discusses intellectual endowments as the stock or content of knowledge, while knowledge management theory is about the flow of that resource. Unlike the activity- based view of an enterprise, which focuses on particular tasks people carry out in the course of doing their work, the knowledge- based view elaborates the functioning of a more responsive, learning, and intelligent enterprise in a more rapidly changing world. A knowledge-based organization is thus closely related to a learning organization (DiBella and Nevis, 1998; Fremerey, 2000, 2005). Both are models of intelligent organization in a sense more general and holistic than the sum total of intelligences of the people forming it. The main method for creating knowledge capital is said to be through conversation. These are structured interactions during which the leaders, practitioners, and stakeholders reflect upon their experiences, share understandings, and explore the different dimensions of knowledge creation.

The construct of social capital also refers to the potential of leveraging one's social support for material gain. Poor and disadvantaged communities, both in urban and rural settings, often have rich and close knit social networks, upon whose solidarity and assistance they can count to confront poverty, hardship, and crisis, and which could be utilized to reduce vulnerabilities, resolve disputes, share knowledge, etc. Social capital is, therefore, a main asset for rural communities that lack other assets available to more affluent entities. Social capital thus refers to the civic virtue embedded in a sense network of reciprocal relations; it consists of the trust, mutual understanding and shared norms, values and behaviors that binds members of the community together and make cooperative action possible. The conjecture proposed in this paper is that even social capital does not always mean homogeneity and total harmony. Diversity can also be an enriching aspect in many cases that can be leveraged for more effective development. But it does involve understanding, tolerance, and trust: that which motivates people to commit themselves to goals and courses of action. The lack of it may not only lead to frictions and inefficiencies that hinder development, but also to wars, massacres and genocides that modern history of rural developments has, unfortunately, registered so very often. When ethnicities are suppressed, expelled, or exterminated, then the knowledge capital embodied in their cultures, languages, and customs are lost as well.

In many cases, ethnicities constitute the organizing principle for division of labor, and ethnic conflicts disrupt human resource utilization processes for decades to come. There are many examples from different times and places, including those from conflict areas surrounding Iran. The successive massacres and genocides of Armenians, Kurds, and other ethnicities, in eastern Anatolia, for example, has left that area undeveloped despite favorable conditions, and is leading to larger scale, intra- state conflicts on utilization of water resources. The Hutu-Tutsi conflicts in sub-Saharan Africa leading to the recent genocide in Rwanda provides yet another example (Uvin, 1998; Pons-Vignon and Solignac Lecomte, 2004). Degradation of lands and forests, destruction of wetlands and frequent flooding, loss of habitat for wildlife and sedimentation, and economic collapse has been the result of massive suppressions, resettlements and massacres. Indonesia provides ample examples how hegemonic and centralized rule undermines and finally destroys locally grown modes of rural production and natural resources management which have proved to be appropriate and sustainable (Sunito, 2003). Conflicts are also instigated by colonialist and imperialist interests, and these can be circumvented only by attitudes of tolerance and comradeship arising from conflict-long history of living together and strong consciousness of community of interests.

We propose to distinguish between bonding capital and bridging capital. The former refers to inter- group ties like kinship and language. The latter refers to strategies promoting social inclusion. Bridging social capital refers to propensities to transcend various social divides. A third construct, linking capital, has also been elaborated to account for non- equal divides. Linking social capital refers to reaching out across power and class divides. The constructs of knowledge capital and social capital have found very wide acceptance among not only radical theoreticians but also international donor organizations. Various means for their operationalization and quantitative assessment have also been proposed. On the other hand, their contradictory conceptualizations and functionalist biases have also been widely criticized. Bourdieu's conceptualization of social capital, however, includes a critique of functionalism. It expounds the problem of struggle for dominance as well as the dialectic between the objective and subjective. But even there, capital is understood mostly as a resource. Bourdieu distinguishes economic, social, symbolic, and cultural capitals. The latter forms are capitals since they are interchangeable with and transformable into economic capital. Central to his theory is the concept of habitus (Bourdieu, 1986). It refers to the system of acquired dispositions that are both categories of perception and organizing principles of action. It functions as a regulating element in reproduction and reconstruction of social relations and status within social space through making ideologies, and senses of social dynamism appear self evident, masking their representational essence. Structures of dominance are not maintained through complete functional fits or challenged due to lack of a complete fit. Break in prevailing order, rather, can happen through removal of veils of misrecognition. Legitimacy is conferred to social structure in the form of symbolic capital. The social world presents itself as a symbolic system organized through the logic of difference. Consumption of certain products and occupation of certain places, for example, signify differences that construct social positions. It is indeed through signs and signals that sense making is negotiated and meanings are constructed. Thus class appropriation of symbols, like class appropriation of material means of production, can lead to social divisions and reproduction of power relations. Consciousness is not mere reflection of objective conditions, even allowing for miscognition due to distortions caused by social interest. Production of meaning, rather, is like production of material goods. Through symbolic capital, it is possible to engage in reconstruction of the social space within the plurality of its possible structurings. Culture and education are the central factors in ordering the social space and affirming class differences. The educational system reproduces cultural division of the society. Cultural capital refers to collection of forces that influence social status. Through acquiring cultural competence, one can obtain social distinction. Finally language, through being the most important semiotic system, and the most direct and species- specific means of communication, is in the center of attention in this paper. Like the other forms of new capitals, it can be leveraged and is an important factor in reproduction of social relations. This raises the question of social commitment: Do we try to reaffirm our status and power? Or shouldn't we feel challenged to take a meta-position, which means to resort to a language which serves as a link rather than a divide between different groups and strata?

Before elaborating examples on the role of language in rural development, let us briefly point out three important aspects. Firstly, language constitutes a holistic mode of conceptualization as demonstrated by different interpretations of the Sapir-Whorf hypothesis (Nercissians, 2000). Secondly, language embodies local knowledge. The latter concept has been the focus of much attention in recent research on rural development. It advocates the inclusion of local voices and priorities, and promises empowerment through participation in the process – though it rarely escaped the dominant-centrism bias. Thirdly and most importantly, language constitutes access key to the corresponding imagined community. Furthermore, research on the interface of languages can reveal the extent of communicative reciprocity.

It was argued that capital should be differentiated from asset or factor of production. Viewed as a process rather than an entity, it incorporates the accumulation moment. With accumulation come social stratification, exploitation, and dominance. New capitals are no exceptions. Their role in reproduction of existing social divides as well as creation of new divides is as important as their potential for being leveraged for achieving better models of rural development.

3 Examples

To illustrate the topics discussed in the previous sections, let us consider rural development projects in north Iran. The importance of that region stems from several considerations (UNIDO, 1998; Shakoori, 2001; Plusquellec, 2002; I.R. Iran, 2001, Gilan Regional Committee on Irrigation & Drainage). Firstly, it includes the southern coast of the Caspian Lake. The geopolitical importance of the Caspian is far greater in scale than regional or even continental. It is the largest inland water body in the world. Despite its long distance from the open waters, it has many characteristics for which it is designated as the Caspian Sea. It accounts for more than 40 percent of the overall volume of the world's lacustrine waters. Its moderating role for the harsh climate of Western Asia cannot be overestimated. The Caspian region includes steppe land in the north, cold, continental deserts and semi-deserts in the northeast and east, and warmer mountain and highland systems in the south and southwest. It supports very rich biodiversity. Over 400 species are unique to the Caspian. Its native sturgeon accounts for approximately 90% of the world's caviar industry. Secondly, Northern Iran is important for its environmental conditions and economic situation. The striking contrast between the extremely favorable climate in the coastal area in the northern parts of the country, and the mostly desert central and southern parts is obvious to every visitor. The geological depression of the Caspian Lake is a result of the rise of the Alborz Mountains in the Cenozoic. With an approximate area of 60,000 square kilometers, the thinly stretched coastal areas between Alborz Mountain range and Caspian Lake occupy 3.7 percent of the country. In 1986, the Guilan and Mazandaran counties constituting that area had a population of about 5.5 million, or 11 percent of the country's total population. The diverse topography endows the region with a beautiful natural landscape. Its forests are the only ones in the country that have been commercially explored/exploited. It holds 40 percent of Iran's pastures and 8.5 percent of agricultural lands. Rural development in the coastal region is particularly important in Iran. The area is the main source of growing rice and tea for the country, the most important attraction point for internal as well as international tourism, historically the center of Iran's fishing industry, as well as many other rural activities, some also unique to that area. Another very important factor is the existence of dense forests, unique in the country and especially important for the very high level of air pollution that has become a major problem in recent times. On the other side of the Alborz, the climate changes abruptly. However, the rivers flowing from the mountains still furnish favorable conditions. Historically, the area has always been important for the trade routes that connect Asia to the West, and for the large cities that have served as the capital of the country in different times. Tehran, the capital of contemporary Iran, is situated in the southwest of Damavand, the highest peak in the country; and has been attracting migrant populations from every side of the country. But the eastern half, which was economically very active before the Mongolian conquests, has remained underdeveloped and under-populated; leading to the danger of desertification. The rapid development in the rest of the region under consideration during the past few decades, on the other hand, have inflicted severe damage to the already very fragile and vulnerable environment; and will continue to inflict even more disastrous damages, unless a carefully studied change of development course is attempted. We shall especially focus on the more favorable environmental conditions of the southwestern coast of the Caspian, although the danger in continuation of the extensive trends in the development projects is more or less the same in the whole region under consideration.

The dangers posed by continuation of the present course of development are indeed great (Farvar and Milton, 1972; Messer, 2001; Cambers, 1998; Plusquellec, 2002; Kashani, 2003). With the region's geographical diversity and abundance of natural resources, unique patterns of population settlement and spheres of business activity have resulted. Its vast economic possibilities have served as a magnet for people and the area has become quite congested with a density of 90 persons per square kilometers, three times the national average. The absence of town planning and the exploitation of any available property to accommodate settlers, the invasion of the natural plateau, and congestion generated inadequacy and disruption in the activities of towns constitute some of the main problems in those areas. A case in point is the development of tourist facilities. Townships and private villas were hastily built along the coast between Ramsar and Babolsar in order to accommodate more tourists. This development scenario exposes the sensitive natural environment to misuse, misappropriation and damage, and also creates insufficiencies and disruptions in the region. Statistics show that forest areas which have been converted into farm lands and orchards have increased ten-fold compared to 60 years ago and the decline in jungle coverage definitely has environmental repercussions. Compared to figures in 1963, the total forest area has been cut down to half, and each year, about fifty thousand hectares more are ruined.

The geographical territory of the region is characterized by a delicate balance between marine, aquatic, and terrestrial ecosystems. The growth of populations and cities with the inevitable increase of traffic, agriculture and industries is one of the culprits of desertification in the Caspian Lake. Another hazard is soil erosion. This deterioration of fertile soil results from overgrazing by sheep, cows and horses in farms and households and from the fact that forests are cut down. Frequent sea water flooding, poor irrigation practices and high rates of water evaporation leads to salination. Both land and water animals and plants are adversely affected. Entire breeds are destroyed or replaced. Migrating birds lose valuable habitat and are forced to find alternative places to feed and breed. A build up of salts in soil, eventually to toxic levels for plants, is the process of salination of groundwater. Salination increases risks to human health because there are few alternative drinking water sources. Damage to coastal habitat alters land use patterns, especially in cases of recreational activity. It reduces the aesthetic and economic value of the land. In Iran, the rapid urbanization and industrialization of coastal areas has not been followed by adequate construction of sanitary and solid waste infrastructure. The resulting deficiencies are most clearly noticeable in relation to water pollution in coastal areas, especially rivers that pass through populated and industrial areas. The most conspicuous example of this phenomenon is the Zarjab River that enters Anzali lagoon and carries the pollution load of numerous factories and towns into this water body.

The main vulnerabilities identified in a study conducted by the Caspian Environment Programme, were categorized in the following aspects. Fishstock, including sturgeon is declining drastically. The coastal landscapes and habitats are damaged by a variety of natural and man-made factors. Natural factors include water level fluctuations (on both storm and decadal scales), earthquakes, and climate change. Some of the man-made causes of the degradation of coastal landscapes and damage to coastal habitats are: deforestation, regulation of rivers, urbanization/ industrial development, inadequate agricultural/ aquaculture development, inadequate recreational development, and land-based and sea-based pollution. Caspian species biodiversity across nearly all phyla is low compared to that of other more open seas. Decline in environmental quality includes the decline in air, water and sediment quality, damage to ecosystems due to human activities, loss of aesthetic appeal, and related issues. UNDP, EU, World Bank, WHO, and other health data sources in the region show high levels of infant mortality, relatively short life spans compared to developed countries, and incidence of certain types of diseases in certain areas. Water level fluctuation is a major threat to coastal infrastructure. Wind-induced or storm-induced surges cause considerable flooding or exposure of coastal areas. Lack of planning at all levels has led to construction practices that ignore water level fluctuations. Desertification may push urbanization closer to the water, further increasing pressure on coastal infrastructure. Significant portions of the coasts are located in seismic zones of magnitude ranging from 6 to 7. Earthquakes may cause hazards due to the strong tectonic activity in the middle and southern sections of the region. Introduction of exotic species is a recurring phenomenon in the Caspian Lake, as much of the ecosystem arises from flora and fauna transported from other bodies of water. More recently, man has introduced foreign species both purposely and accidentally. Certain mollusks have been introduced into the North Caspian Lake in the past, for instance, in response to changes in river hydrological regimes. Plant species have been introduced to coastal wetlands in Iran. Some of these species have unexpectedly caused anoxia in lagoons as a result of decreasing light penetration. A main threat is the contamination caused by offshore oil and gas activities. Besides extraction, downstream activities such as oil refining, transport, and related industries also increase the environmental pressures in the sea, in the sediments, and in air.

Rural development projects, during the past decades, have been planned and executed with the support of a number of Iranian and international organizations. Some of the official institutions as well as non-governmental organizations, NGO's, are very progressive in their outlook. Jahad is an example of a governmental body, though initially set up after the Iranian revolution as a semi- official organization composed of volunteer workers who wanted to further revolutionary goals by helping the rural population (Kashani, 2003). The Center for Sustainable Development, CENESTA, on the other hand, is a non-governmental, non-profit organisation dedicated to promoting sustainable community- and culture-based development. CENESTA works with a variety of partners, from local communities in Iran and other countries to local and national governmental agencies, from universities and research organizations to national and international NGOs. The UN bodies with which CENESTA and its experts entertain on-going collaboration include UNDP, FAO, UNICEF, UNSO, IFAD, UNCCD and the UN Secretariat. CENESTA is the first non-governmental Organization born in Iran just after the Iranian Revolution in 1979. Before the Revolution, it was next to impossible to register a not-for-profit Organization in Iran even though the law gave the citizens the right to do so. Any one who dared think of something not-for-profit was suspect. A group of citizens getting together dedicated to a social aim? That was considered outright dangerous! CENESTA was thus born out of the concern of a group of activist scientists and citizens who were concerned that development in Iran as well as other parts of the Third World needed its own patterns and models that should not be based on imitation of the West.

Indeed this would have been anathema to the state operating on the fundamental precept that development was Westernization itself. Both organizations have been involved in rural development projects in the region under consideration in this paper. Among supporters and partners are well known international donor bodies like the World Bank, FAO, and UN; various ministries and governmental bodies from Iran and other countries; and, especially in the case of CENESTA, other international progressive NGO's with an indigenous and participatory approach to development with special emphasis on local knowledge and biodiversity.

"Integrated Participatory Production and Pest Management" is the designation of a rural development project being carried out in North Iran by CENESTA in collaboration with UNDP and GEF. This project addresses the rice crop production and pest management in fourth northern provinces. At present rice yield is estimated at 4000 kg/hectare and potential yield can achieve 5000 kg/hectare under the Integrated Participatory Production and Pest management (IPPPM) approach. The overall objective of the project has been to improve food production strategies through greater farmers' participation in problems identification, planning, implementation and monitoring to ensure sustainable farming system using Farmer Field School (FFS) as major tool. It can be seen by examining the proposal as well as progress reports of the project that the whole effort is directed towards increasing the productivity of the crops and combating pests through educating a limited number of farmers in the course of fieldwork, with the help of community animators and government extensions, and a larger number of secondary farmers' adopters directly exposed. The larger economic and environmental issues like the reason why productivity is not high to begin with and whether increasing the production of rice or other specific crops is desirable at all remains outside the scope of the project. It can be argued, for example, that replacing wheat by rice as the main diet in Iran is perhaps not so wise; and market liberalization through allowing the export of more expensive Iranian rice and import of cheaper foreign rice may be a more effective way of motivating farmers to increase their productivity and achieving higher levels of self sufficiency at the same time. These and similar other issues are left to be taken into consideration implicitly through the absorption of local knowledge of the farmers via the "learning by doing" method adopted in the project. It is here that the problems of language and culture, and the more general question of new capitals come into the picture. In the 1^{st} IPPPM Workshop where CENESTA experts and Jahad staff were participating, the facilitators and participants narrated their initial hesitation to participate in classes they did not consider relevant, their motivation to continue to participate in order not to miss the opportunity to become experts, and their enthusiasm for the project realizing its respect of the farmers and the real possibility of gaining control over the project instead of following government directives and advices. It becomes at once clear that language and cultural capitals, paving the way for being the chosen participants and facilitators, can be leveraged for gaining social control. Some speakers actually expressed their main motivation as gaining that social control rather than achieving the project goals.

In order to illustrate some of the other issues associated with the role of language and culture in rural development, let us consider the Taleshi and Tati ethnicities, which are, in fact, the aboriginal people speaking dialects once spoken in the north, but are now confined to few villages (Samadzade, 2002; Chizari *et al.*, 1999; Mohseni, 2002; Ramazani, 2002; Wijayaratna, 2004). In fact, the very name of the once widely spoken language and the corresponding ethnicity, Tat, marks otherness; since it has been derived from the Turkish stem meaning one whose identity is other. The choice of these ethnicities does not mean that similar analysis cannot be carried out in the very multiethnic context of northern Iran. In fact, it is to be noted that ethnic diversity is a characteristic of the northern part of the country. There are many different languages spoken in that area, both aboriginal and newer ones formed as a result of migrations especially from Central Asia that have become native languages, and the corresponding ethnicities have been forged as a result of assimilation of aboriginals into the migrant population. During the course of the history, the influence of invading cultures and dynasties has reached northern areas with more difficulty and time lag and has been successful only through assimilating the locals. Whether or not those languages are structurally close to Farsi, the dominant language in Iran, they are all considered vernacular and the prestige associated with any particular language reflects mainly the dominance pattern of the corresponding ethnicity in local or regional sense. However, the more aboriginal languages enjoy stronger support for ethnolinguistic vitality from the solidarity dimension. The less dominant a language is, the more its speakers are excluded from the development communication. In the case of Taleshis, they are still concentrated in towns and villages in the very thin coastal area between Talesh Mountain range and the Caspian Lake. Their local influence has vanished especially after the constitutional revolution and modernization of Iran.

Taleshi identity is threatened not only by the dominance as well as direct migration of Farsi speakers, but also, and even more so, by Guilaks from the southeast and Azerbeijanis from the northeast. Both of these ethnic groups have been very active in the constitutional movement and modernization of the country. In fact, their sociocultural participation is resented by the less active Farsi speaking majority, and they are negatively stereotyped especially through cruel ethnic jokes. The economic influence of the Taleshis, as well as their nomadic culture and way of life, has taken a severe blow especially following the curtailment of the political influence of their khans. There have been massive immigrations into their homeland too. Those Taleshis that live in lowlands have learned rice growing from the Guilaks and are now predominantly farmers. Animal husbandry is, however, the main occupation of the Taleshis of the mountains. Taties, on the other hand, are more scattered than Taleshis. Their villages are in the vicinity of towns and villages of other ethnic and national groups in a larger area. Unlike Taleshis, they are less hesitant to engage in trade and generally to urbanize. It can be seen that the division of labor is an important aspect of ethnocultural maintenance.

Under the pressure of increasing population, and migration, as well as changing the land use pattern, there is ample ground for ethnocultural conflict. Much of the friction remains latent. But judged by the abusive language evident in ethnic web pages, mutual antagonism is very strong. The environment, especially the forests, becomes the easiest victim. For example, the conflict between farmers and nomads, which has become the conflict between various ethnic groups, and has been made more acute by demographic and economic pressures and natural and artificial environmental degradations, always leads to deforestation by both farmers and nomads; not to mention migrants who cut down trees for economic profit. This process is always evident whenever one studies Taleshi- Tati, Taleshi- Azerbeijani, Tati- Azerbeijani, Taleshi- Guilak, Tati- Taleshi-Azerbeijani- Guilak- Kurdish, as well as other inter-ethnic conflicts in the region.

When a language is excluded from the development communication, the outcome is not always zero- sum, with one party gaining and the other losing. With the language come the knowledge, and historically shaped modes of perceptualization and conceptualization, which are lost to the detriment of all sides, as a result of not being leveraged and utilized. The exclusion of the Taleshis, especially their more socioeconomically disadvantaged strata, from development communication, for example, deprive the planners of the possibility of viewing the development project from the mindset of aboriginal nomads. The latter tend to seek not an optimal steady state, but continual adaptation. Sustainability assumes altogether new meaning from that outlook. Even without human intervention, the region has very fragile environmental conditions. There is the threat of natural disasters like flooding and earthquake, which has been responsible for taking many lives in recent past. Being native, Taties and Taleshies have not only accumulated much indigenous knowledge in their linguistic and cultural capitals, but also indirect and implicit memories, unconscious codes of behavior, even emotions, about where to build houses, what to cultivate and where, what to avoid, etc. that escape the consideration of non- aboriginal planners. The interested researcher cannot fail to take note of the immanent threat latent in the continuation of the present course of development, and the very valuable insights on dealing with those threats contained in those vernacular cultures and languages. Like a body that is already fragile, the environment cannot take in and must reject foreign elements like very fast growth of rice plantations and tourism. There are many published works and analyses documenting the implications of careless use of technologies, many commissioned by the very donor organizations that are responsible for approving development projects. But when it comes to specific practices, old mistakes tend to be repeated.

The problem of earthquakes, floods, and landslides is very important in the region under consideration. Already the tectonic activities and the geomorphology of the region pose serious problems. So does the balance between the marine, aquatic, and terrestrial ecosystems, which has already been mentioned. The steepness of the coastal land makes the situation more critical. There are many rivers and rich underground water resources. Rice plantation is associated with high water consumption and irrigation requirements. Rapid urbanization, construction of townships alongside highways, villas for the tourists and summer retreat for the rich, pose additional problems associated with the waste. Deforestation, overutilization of land, overconsumption of water resources, and changing the land use patterns all increase these dangers. These problems are all present in the region under consideration. Main environmental risks can be categorized into the impact of natural disasters, increasing land erosion and salination, and limited availability of healthy drinking water. The area is subject to earthquakes, landslides, mudslides and floods. Often these natural disasters are worsened by human activities such as the use of the mountainous areas and lowland plains for cattle grazing, deforestation, small-scale agriculture, mining and road building. Landslides are very common where the surface is not covered with dense vegetation. In drainage basins in the northern part of Iran, a combination of natural and human factors has caused numerous landslides with a lot of damage. Naturally effective factors in landslide occurrence are slope, altitude, aspect, rainfall, land use, geology, and distance from faults, distance from old and new roads and distance from main drainages. Careless development projects can increase these dangers. This discourse, however, is carried out in vernaculars like Taleshi that are not heard in the development communications. The outcome is much more serious than not having mobilized the whole population because communicative and cognitive sustainability is a prerequisite to economic and sociopolitical sustainability. Failing to hear vernacular voices leads to the failure of the development planners to avail themselves of their latent wisdom, and cosmovisions.

4 Conclusions

It has been conjectured that disregarding vernacular languages and cultures condemns rural development projects to impoverishment. The arguments presented in this paper attempt to go beyond the premise that it is important to deal with the problem of cultural and linguistic diversity in order to achieve sustainability. It is held that diversity is to be viewed as blessing and not as a problem. The central role of language and culture can be seen when development is viewed as a sense making activity. The paper stresses the role of new capitals in contemporary development process and discusses the role of linguistic and cultural capitals not only as important assets to be leveraged in rural development projects, but as social relations especially in the capital accumulation process. Communication is a very important part of implementing the modernization process both linguistically (the national language is not normally used at the village level) and cognitively (dissimilar awareness). It has become evident that communication problems, and difficulties concerning consensus-building at community level, will inevitably include disagreement among actors located at different levels of the communal networks responsible for the promotion of development.

Research and practice provide ample evidence of the importance of human linguistic and cultural diversity, on the one hand, and biological diversity, on the other. They also point to the complexity of human-environment relationships on earth, and suggest fundamental links between human languages and cultures, non-human species, and the earth's ecosystems. In particular, evidence is accumulating of remarkable overlaps between areas of largest biological and greatest linguistic- cultural diversity around the world. It has been noted that models of development have been profoundly Eurocentric, conflating development, modernization and westernization, and promoting particular worldviews, cultures and technology- oriented rationalism. Participatory and indigenous models of rural development are advocated instead. The notion of sustainability has become an important consideration. But there is a contradiction between the modernist progressivism of development discourse and the postmodern particularism of aspects of sustainability. The question to be asked is what is to be developed and what is to be sustained. This question is value ridden and answers can vary in accordance to ideology. Vernacular languages and cultures, it is argued, encompass ideologies, modes of perception, and implicit knowledge that are neglected in contemporary rural development projects.

Interest in the contribution of indigenous knowledge to a better understanding of sustainable development has been catalyzed by UN Conference on Environment and Development. UNCED highlighted the urgent need to develop mechanisms to protect the earth's biological diversity. An ever-growing body of research on vanishing cultures, language endangerment, shift, and death, biodiversity loss and environment destruction has emerged in recent years. As different worldviews and knowledge systems collide, however, the bottom-up formula of participation will not easily marry the essentially top-down framework of development and modernization. It will lead to a confrontation of social actors with different epistemologies. Areas of biological diversity, such as the earth's remaining rain forests, are both the most poorly known to science, and those in which biodiversity loss is most dramatic. These same areas host the world's highest concentrations of linguistically and culturally diverse human groups, who have traditionally lived in close contact with their ecological niches. The oral, rural and powerless nature of indigenous knowledge has made it largely invisible to the development community and to global science. Throughout the recent past, for example, women's knowledge of forestry, trees and firewood have been ignored. The WORLD CONFERENCE ON SCIENCE (1999, Budapest) recommended that scientific and traditional knowledge should be integrated into interdisciplinary projects dealing with links between culture, environment and development in areas as the conservation of biological diversity, management of natural resources, understanding of natural hazards an mitigation of their impact. Local communities and other relevant players should be involved in these projects.

Yet, due to a mix of historical, cultural and socio-political circumstances, the social capital embodied in traditional community leaders should sometimes be tapped only with great care, as much of that capital, although grounded in traditional networks of mutual assistance and solidarity is also nested in clientelistic relations among kinship groups of unequal social status. Women's knowledge of their environment, for instance, often thrives within the gendered spaces of work and gets little acknowledgement either in modernistic or traditionalistic development discourse. Many feminist researchers have reported on gender differences in access issues: land tenure, tree tenure; who plants what tree or bush where and when; marital status, age of woman, types of by-product or product utilization, the source of the seedling or planting and for commercial, cash or household use.

A major aspect of the role of the new capitals in rural development, it is argued in this paper, is their leveraging for reproduction of power relations in a community or creation of new socioeconomic divides. The emergence and consolidation of small-scale, local initiatives has been placed at the core of many current development programs, like the examples discussed in the previous section, and has led to a much more important role for intermediaries, facilitators and brokers of development. These actors, mediating between the rural population and project staff, are typically people who comprehend the "project language". Often, they are relatively younger persons who have migrated, learnt the national language well, are functionally literate, but have lost touch with the community resource base and, especially, the norms and institutions that govern it.

The issue of the relationship between the rise of the new type of intermediary and the traditional community leaders, structures and institutions, is particularly interesting and complex. Historically, the latter performed the role of facilitators and assured the mediation between the state and the local population. The problem has also been discussed in an FAO publication (1997), which finds that in the project framework, the mismatch between the system of reasoning of the "development world", imported through the project-language, and the rural (peasant) world brings about a productive misunderstanding which manifests itself in the emergence of intermediaries, whose competence acquired in terms of mastering the project-language makes them real development brokers, who may enter into competition with politically dominant actors at the local level.

Besides redefining power relations, languages and cultures, it has been argued in this paper, encompass modes of thinking and understanding. This role, it is to be pointed out, is not always conscious and explicit. It is often to be found in linguistic and cultural routines, dominant discourses, plays, sayings, slight differences in the meanings, even connotations of words, grammatical structures, rituals, ceremonials, and generally what might be called the memetic pool of the community of practice. A nice illustration is furnished by the Tati word for key money used in Taleshi bazaar. It has been argued that the meaning of the term, due to the fact that Taleshi landlords are reluctant to engage in trade or even construct shops in the land they lease out, is different from the meaning commonly understood elsewhere in the country. The difference not only reflects different communal understandings of ownership, land tenure, and appropriation, indeed indicating differences in the whole economic and financial category of key money, but also provides an example of legal technicality according to which the law of the country is to be contradicted if local "orf" (common practice) so dictates; a point often neglected by the courts.

The argument presented in this paper is that any move to take greater account of local participation will nevertheless still continue with many of the great exclusions that marked modernist development discourse. Social inclusion is the key to leveraging local and global knowledge systems, promoting the notion of language as postcolonial performative, of culture as difference, of sustainable development being about creating the possibilities for being more. The advocated development paradigm is to re-contextualize the idea of progress and the use of more advanced technologies coming from national and international donors, and the systems of local knowledge implicit in vernacular languages and cultures, in a more inclusive framework created in the sense making process of interaction with the environment.

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Interaction between Coffee (*Coffea arabica* L.) and Intercropped Herbs under Field Conditions in the Sierra Norte of Puebla, Mexico

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Abstract

Caffeine released from decaying seeds and leaves accumulates in a soluble form in the soil. The compound is known to inhibit mitosis, reduce the access of nutrients and water to surrounding plants which is one of limiting problems in intercropped coffee plantations. The allelopathic interactions between coffee (*Coffea arabica* L.) and mint (*Mentha piperita* L.), basil (*Ocimum basilicum* L.), oregano (*Origanum vulgare* L.) and sage (*Salvia officinalis* L.) could be a diversification alternative and extra income activity for coffee growers outside the harvest period that could cope with high levels of caffeine in the soil. We tested the interaction of the proposed system (2004 – 2005) in rural area of Puebla State, Mexico. The results demonstrate that intercropping sage, spearmint, basil and oregano stimulate the plagiotropic growth of *Coffea arabica* plants most effectively in young production systems, through volatile essential oils. Intercropping basil, sage, spearmint and oregano in coffee plantations seems to be a promising approach for higher income and increasing yield and quality production in coffee farms.

Keywords: Allelopathy, herbs, caffeine uptake, intercropping systems, mint, oregano, sage, basil

1 Introduction

Coffee production and industry is a significant source of revenue and a source of job in rural communities for many countries. The coffee price crisis like present day, create social unbalances, instability and migration accelerated to urban areas (Cardenas, 2003; Pohlan, 2002, p. 386). If crisis continues, coffee growers in Latin America will be forced to abandon their cultivations and to look for alternative activities, like illegal crops (Torrico *et al.*, 2005; Pohlan, 2001). Some coffee growers, that confront the crisis, have begun to diversify with cultivation of medicinal and aromatic plants as intercrops. Intercropped aromatic plants provide some advantages like control of weeds, recycling of nutrients, use of unproductive areas and extra income.

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Wide arrays of natural products that cause allelopathy are secondary compounds synthesized by plants and microorganisms. The compounds belong to different chemical classes such as, phenolic acids, tannins, flavonoids, terpenoids, alkaloids, steroids, and quinons (Duke *et al.*, 2000; Phippen and Simon, 2000; Einhellig and Leather, 1988; Chou and Waller, 1980b). Phenolics and other secondary products, including flavonoids and antocyanins are common constituents of aromatic plants.

On the other hand, caffeine is a biologically active compound found in members of the Rubiaceae family, e.g. *Coffea arabica* that contribute to allelopathic and auto toxic effects appearing in coffee plantations (Anaya *et al.*, 2002). Friedman and Waller (1983) showed that caffeine inhibits mitosis in lettuce (*Lactuca sativa* L.) roots. As a consequence of restricted development of young roots the access of nutrients and water is reduced. The inhibitory effect is thought to be finally due to the ability of caffeine to destabilize nucleic acids by intercalation. The researchers indicated that caffeine released from decaying seeds and leaves accumulates in a soluble form in the soil and is the major reason of auto-toxicity, one of the principal problems in coffee plantations. Only 150-200 g of coffee dry matter has the potential to liberate 1-2 g caffeine/m^2/year in addition to other components, originating limitations in production. Waller *et al.* (1986) demonstrated that caffeine applied externally was absorbed and translocated by the root system of coffee (*Coffea arabica*, Bourbon variety).

The interest in aromatic plants has been generated in the last years among the planter's community and the actual demand of these profitable products in the international market. Aromatic plants are profitable crops and the possibility to introduce them to environmental conditions under coffee systems is high. In order to appraise this new alternative and this possible interrelation with coffee, must be consider that allopathic effects are produced by both crops and plant-plant interaction need to be defined.

The investigation included the following objectives:

- Establishment of suitable species for intercropping in a commercial production under different seasons and determines if caffeine and other compounds released by coffee may have a negative effect on aromatic plants.

- To evaluate if factors like long period of establishment, density, moisture, nutrients availability, management of coffee plantations, age of the production system, seasonality affect the plant- plant relationship when aromatic plants and coffee are intercropped.

- To evaluate the participation of volatile essential oils in plant-plant relationships and possible targets in plant physiology as growth stimulant.

2 Materials and Methods

Four species of aromatic plants and one control without herbs were tested as intercrops in three different age coffee systems at two ecological conditions. The first named "Providencia", located at 20° 16' 295 N and 97° 50' 456 W with an altitude of 900 m above sea level and the second named "Orquidea" located at 20° 16', 887 N and 97°

45' 600 W with an altitude of 550 m above sea level, both in rural area from Xicotepec de Juarez, Puebla, Mexico.

The treatments were planted in-between the coffee rows. Randomized complete block design with four repetitions of treatment per plot were established. An area of $12m^2$ ($6m\times2m$) were demarked as experimental units leaving a free space among treatments of $8m^2$ ($4m\times2m$) without influence of aromatic herbs. Four weeks old plants of the proposed species sown and propagated under homogeneous conditions were planted with a density of 4 plants per m^2, as treatments. For sampling growth variables on coffee, four plants per treatment were marked. Two primary plagiotropic branches (10^{th} and 20^{th}) from the upper third of the plant canopies were tagged in each treatment unit for periodical length measurements and number of leaves evaluation. Physiological variables on coffee were evaluated every 2 months. Samples of coffee beans from experimental units were collected separately and after processed dried to 10 to 12% moisture content. No specific agronomical management was required for the herbs. Five fertilizations were applied, the first with 500g/plant of compost (no nutritional data available) when transplanting and after every harvest 50 g/plant of soluble commercial fertilizer (18-18-18 Hydro). No controls on pest or diseases were made on the treatments. The coffee plants were pruned after the first harvest (as traditional management) and fertilized two times per year with soluble commercial product (46-15-15 Hydro). No agronomical management was made and the control of *Hypothenemus hampei* Ferr., was made by using pheromones tramps wit a density of 17 tramps/ ha.

Two factors were analyzed in the experiment:
Factor A: Influence of aromatic plants in physiological development of coffee

The following treatments were evaluated:
A1: coffee without aromatic plants
A2: coffee with Genovese basil
A3: coffee with spearmint
A4: coffee with sage
A5: coffee with oregano

Factor B: Effects of different age coffee systems on yield of aromatic plants

B1: New plot (5 years of establishment)
B2: Medium plot (10 years of establishment)
B3: Old plot (over 20 year of establishment)
Variables analyzed:
Plagiotropic growth (cm)
Vegetative growth (cm)
Appearance of new leaves

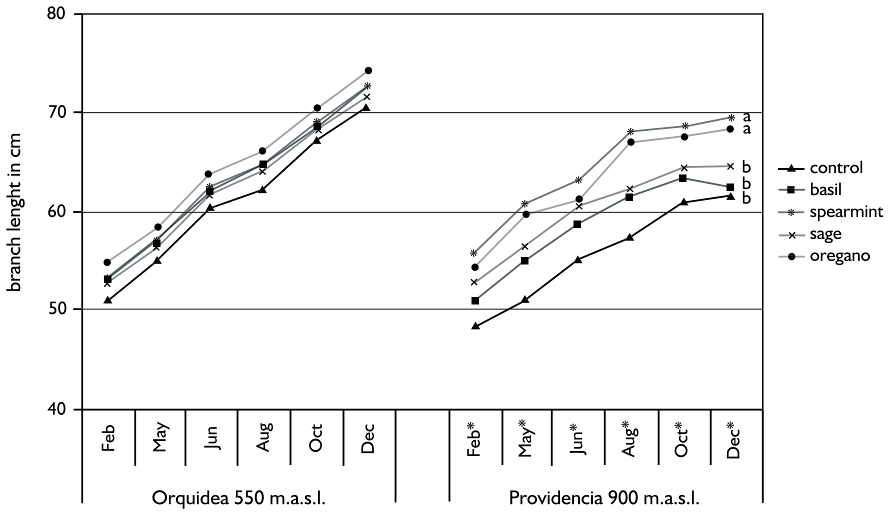
For the statistical analysis of data, SPSS, 11.0 was used. The data were subjected to ANOVA and, when test F is significant, the means were compared using Tukey's test at 95% probability.

3 Results and Discussion

In every allelopathic relation exists a plant (donor) that frees to the environment (atmosphere or rhizosphere) by a specific way, volatilization, leaching, decomposition of residues, and root exudation (Chou, 1986) chemical compounds which are absorbed by another plant (receptor) causing a damage or beneficial effect. The growth habit and physiological properties of plants can differ markedly under different influence of neighbour plants, in this case of study, growth stimulation in coffee due to volatilization of essential oils of intercropped aromatic plants.

For the variables of plagiotropic growth in coffee under different ecological conditions an increase in branch length when aromatics plants were intercropped was found (Figure 1).

Figure 1: Increasing of branch length in coffee (*Coffea arabica* L.) when intercropping aromatic herbs.



A significant difference between control and treatments was found in Providencia farm, during the whole year, with higher growth rate when mint, oregano, sage and basil were intercropped. No significance difference in Orquidea farm for this variable was observed but higher means of branch growth in coffee when oregano was intercropped elucidated a positive stimulation of this treatment.

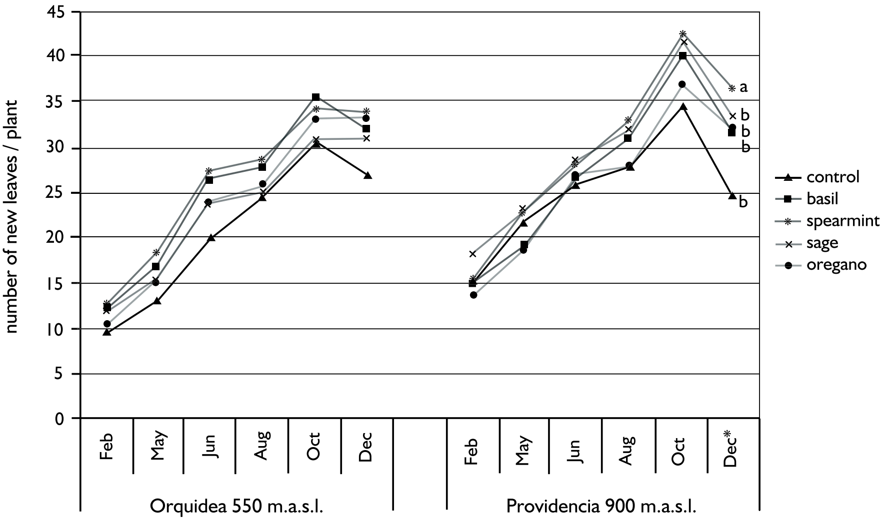
Stress in plants causes various physiological and biological changes, one of which is the accumulation of reactive oxygen species in the cell. The reactive oxygen radicals are toxic and may result in a series of injuries to plant metabolism. It damages photosynthetic components, inactivates protein and enzymes, destroys cell membrane structure and permeability by causing lipid peroxidation (Price and Hendry, 1989, 1991; Winston, 1990). Other authors suggest that many environmental stresses such as drought, salinity, low temperature, herbicide application and cultural management (pruning), damage plants directly or indirectly and suppress their vegetative growth (Larson, 1988; Price and Hendry, 1989; Smirnoff, 1995; Thompson *et al.*, 1987).

The effect on growth stimulation in *C. arabica* close to the intercropped herbs could be related to the important role of volatilization of monoterpens from herb oils into the environment and its effects on neighbour plants.

The importance of aromatic plants as natural antioxidants is well established (Dapkevicious *et al.*, 1998). As reported by Aruoma *et al.* (1992) rosemary and sage have highly antioxidant properties due to the carnosic acid in their leaves. Carnosic acid is lipophilic antioxidant that scavenges singlet oxygen, hydroxyl radicals, and lipid peroxyl radicals, thus preventing lipid peroxidation and disruption on biological membranes. Antioxidant activities of polyphenols from sage (*Salvia officinalis* L.) have been reported by Lu and Foo (2001). In herbs like rosemary, thyme, and basil similar concentrations of phenolic compounds were found (Zheng and Wang, 2001) supporting the hypothesis that aromatic plants are good sources of natural antioxidants. Preliminary results clearly indicate that antioxidant capacity of volatile essential oils and plants extracts are closely related to the total growth of the coffee and the vegetative stage of the plants.

A significant difference for the number of new leaf was found in December 2005 in Providencia farm for the treatments with basil, sage and oregano (Figure 2).

Figure 2: Increasing of leaf number in coffee (*Coffea arabica* L.) when intercropping aromatic herbs.

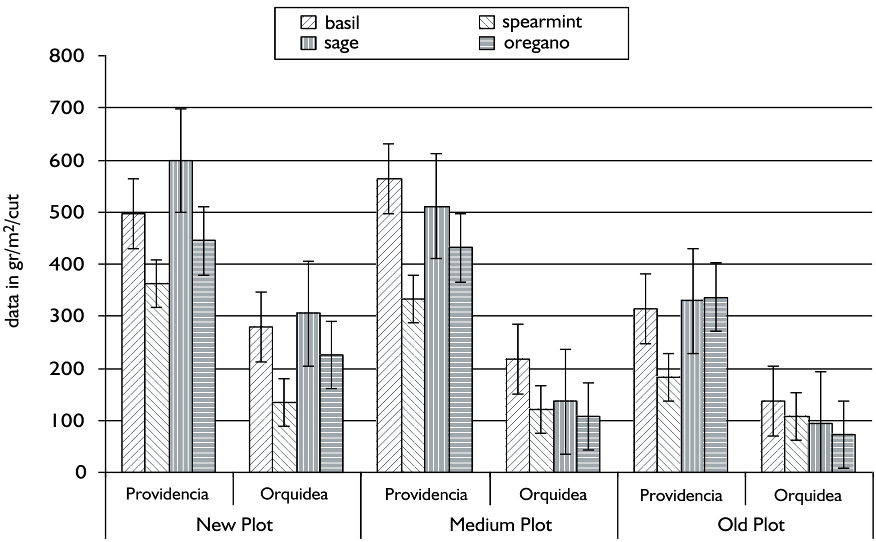


Thus no difference were found in the other experimental unit, the average of new leaf appearance in coffee were better for the treatments with aromatic herbs intercalated in comparison with the control. A decrease in the development of new leaves was observed in October in both experimental units, it coincides with the start of fructification and constrain of nutrient availability for the vegetative growth.

The relationships between vegetative and reproductive growth in coffee are rather complex and poorly understood. In most regions, rapid vegetative growth and fruit development appear to take place at different times. Nevertheless, the positive effect on appearance of new coffee leaves and an increase in branch length when intercropped with aromatic species is of considerable relevance because flower buds in *Arabica* coffee are initiated on the same wood only once (Rena *et al.*, 1994), thus the amount of growth produced in the current season will determine the crop yield of the following growing season. Therefore, additional studies have to be performed to compare the yield of coffee plants intercropped with aromatic species to that of control plants growing in the absence of aromatic plants.

Experiment results and field observations show negative influence of caffeine accumulation in soil on the production yield of basil, oregano, spearmint and sage. Sage, oregano and basil revealed to be the less affected species in the three production systems evaluated and high altitude conditions. Under plots of 10 year of coffee establishment, basil and sage show better average of yield production in comparison with the other two crops, thus demonstrating that they can adapt well to coffee plantations by the means of a tolerance mechanism to the potentiality toxic effects of caffeine (Figure 3).

Figure 3: Yield production of herbs under different age coffee systems in Puebla, Mexico



The negative interaction in soils with more than ten years of coffee monoculture has been previously reported by Weinberg and Bealer (2001), due to accumulation of soluble form of caffeine in the soil. Under old coffee system the yield production of all species decrease and demonstrate that thus a involved mechanism to tolerate certain levels of caffeine, higher amounts of the alkaloid in the soil can be toxic, limiting the tested crops development. A notorious general result for all species is that they grow better on younger fields and at higher altitudes.

Data demonstrates that caffeine acts as a negative allelochemical to aromatic plants. Although there is a high potential of intercropping basil, sage, spearmint and oregano between coffees rows in order to obtain extra income for the idle area, evidence on this study indicates that age of the plots and accumulation of caffeine in the soil are limiting factors in the yield of aromatic plants.

According to the available data, an estimation of production for the three different systems shows a decrease in yield with increasing age of the plot. Low altitude conditions are not suitable for sage, oregano, basil and mint. A possible ability of the aromatic plants to grow better under high altitude conditions may be associated with the temperature and water availability.

For coffee production systems between 5 and 10 years of establishment, an extra income of 400-500 kg of basil, sage and oregano can be obtained per cut. Three cuts during no harvest period can be done, obtaining 1500 kg/ ha^{-1} as extra income for coffee growers in crisis. The production of spearmint is not significant, and cannot compete with commercial production, but competition with weeds and coverage in between coffee rows open an interesting sustainable alternative for weed management in coffee production systems.

4 Conclusions

Intercropping sage, spearmint, basil and oregano stimulate the plagiotropic growth of *Coffea arabica* plants most effectively in young production systems. Coffee growers can stabilize their income and their social condition by offering aromatic plants produced during the no-harvest period of coffee to the local markets and using idle space of their farms. Therefore, additional studies have to be performed to compare yields of aromatic species under different coffee production systems. There are indications that these herbs cope with high caffeine levels and are even able to stimulate coffee growth. Further research of the biochemical nature of this interaction is promising and needed.

On the basis that stimulatory effect of the constituents of the evaluated volatile essential oils acts as growth stimulants, it might be necessary to define from the qualitative and quantitative composition the effect of each compound.

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Decomposition of Organic Substrates and their Effect on Mungbean Growth in Two Soils of the Mekong Delta

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Abstract
Agricultural land use in the Mekong Delta of Vietnam is dominated by intensive irrigated rice cropping systems on both alluvial and acid sulfate soils. A stagnating and occasionally declining productivity may be linked on the alluvial soils to low N use efficiency and low soil organic matter content while on acid sulfate soils to acidity, Al toxicity and P deficiency. For economic reasons, farmers increasingly diversify their cropping system by replacing the dry season rice by high-value horticultural crops grown under upland conditions. However, upland cropping is likely to further exacerbate the soil-related problems. Organic substrates from decentralized waste and waste water management are widely available and may help to alleviate the reported soil problems. During the dry season of 2003/2004, the effect of the application of various types and rates of locally available waste products on crop performance was evaluated at both an alluvial and an acid sulfate soil site. The C and N mineralization dynamics of nine organic substrates from waste and waste water treatment were determined by anaerobic (N) and aerobic (C) incubation in the laboratory. The response of 12 week-old mungbean (dry matter accumulation) to substrate application (1.5 – 6.0 Mg ha^{-1}) was evaluated on a degraded alluvial and on an acid sulfate soil. In the alluvial soil, largest mineralization rates were observed from anaerobic sludge. Biomass increases in 12 week-old mungbean ranged from 25-98% above the unfertilized control. In the acid sulfate soil, highest net-N release rates were observed from aerobic composts with high P content. Mungbean biomass was related to soil pH and exchangeable Al^{3+} and was highest with the application of aerobic composts. We conclude that the use of organic substrates in the rice-based systems of the Mekong Delta needs to be soil specific.

Keywords: acid sulfate soil, Al toxicity, N mineralization, Vietnam, *Vigna radiata*

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1 Introduction

In Vietnam, the area planted to rice increased from 5.6 Mha in 1980 to 7.7 Mha in 2000, with >90% of the production occurring in lowland ecosystems (MACLEAN *et al.*, 2002; CAN, 2003). Nearly half of this lowland rice is produced in the Mekong Delta, where the area cultivated with rice has been substantially increasing as a result of infrastructure development and recent demographic growth (CHIEM, 1994). Being the key component of agricultural land use, rice is used in diverse production systems and cropping patterns. This diversity is largely determined by soil type with acid sulfate soils and alluvial soils covering each about 40% of the land area (VAN BO *et al.*, 2002).

Rice triple cropping systems are mainly found in areas with alluvial soils with a limited influence of the late season flood (nearly 0.9 Mha). Fields are fully irrigated, rice is direct wet-seeded, and production is based on high external input use. Main problems in this production system are associated with pollution of the environment by agrochemicals and a relatively low productivity, probably linked to near-permanent soil flooding, increased incidence of soil-born diseases, a low N use efficiency and, in some instances, a low soil nutrient supply and declining soil organic matter content (DOBERMANN *et al.*, 2002). With the rapid economic development in the Mekong Delta, farmers tend to diversify their cropping system. The most prominent strategy is the replacement of the dry season rice by high-value horticultural crops grown under upland conditions (e.g.; the rice - rice - field vegetable rotation). While short-term economic benefits are obvious, upland cropping is likely to further accelerate the mineralization of soil organic matter and hence to exacerbate the problems of low soil nutrient supply and the physical degradation of the soil structure, related to low soil organic matter content.

The rice double cropping system dominates on the acid sulfate soils and is concentrated in areas where seasonal floods occur (about 0.7 Mha). During the period of intense flooding in October-November, a 2-3 months fallow period follows a crop of transplanted wet season rice. Another irrigated rice crop is grown after flood recession during the dry season (NI, 2000). Rice production is constraint by soil-related nutrient imbalances such as iron toxicity and P and Zn deficiencies (TINH *et al.*, 2001). During intermittent soil aeration phases, the acidification of the aerobic soil can result in severe Al toxicity and further exacerbate the problem of P deficiency (HUSSON *et al.*, 2000). The geochemistry of the acid sulfate soils tends to limit the choice of crops to be grown during the aerobic soil phase to the relatively acidity-tolerant species and cultivars (MINH, 1996). However, as in the triple cropping system, mixed production of wet season rice with diverse dry season upland crops on raised beds are emerging, particularly in the peri-urban areas.

Organic substrates from decentralized waste or wastewater treatment are widely available in South Vietnam (WATANABE, 2003). Their use in agriculture can recycle substantial amounts of nutrients, thus improving soil fertility and increasing rice yield (CLEMENS and MINH, 2005). However, high transport costs and an unfavorable cost-benefit ratio are limiting the use of organic substrates to lowland rice. In addition, the application of organic waste to flooded fields may lead to increased water pollution and microbial contamination from the substrates (RECHENBURG and HERBST, 2006). When applied to an upland crop grown in rotation with rice, the use of organic substrates may be environmentally safer than in lowland fields, and the substrates may contribute to alleviate the prevailing soil-related problems.

We hypothesize that in the rice triple cropping systems on alluvial soils, the replacement of the dry season rice with an upland crop combined with the application of organic substrates can overcome the problem of declining soil fertility and may improve the system's productivity. In the rice double cropping system on acid sulfate soils, the application of organic substrates to upland crops may counteract negative effects of low pH and excess Al^{3+} and permit the cultivation of more acidity-sensitive higher-value crops such as mungbean (*Vigna radiata* L.). Direct and residual effects of organic amendments are likely to depend on the quality and quantity of the substrate applied as well as on the type of upland crop. Accordingly, the following objectives were addressed in both degraded alluvial and acid sulfate soils:

(1) Physico-chemical and mineralization characteristics of major organic substrates of the Mekong Delta;

(2) Quantification of substrate effects on the biomass accumulation of mungbean grown in rotation with rice.

2 Material and Methods

2.1 Study sites

All experiments were conducted in Cantho province of the central Mekong Delta. The area is characterized by a monsoon climate. The length of the growing period for rainfed crops is in excess of 320 days. According to the FAO (1978), the area is classified as a humid forest agroecological zone. The mean annual rainfall ranges from 1,900 to 2,300 mm, falling mainly during the 6 months of summer monsoon (May-October). Three farmers' fields representing the triple cropping situation were selected close to the village of An Binh (105°43'40" – 105°43'45" E latitude and 10°00'05" – 10°00'10" N longitude). Three further farms, representing the rice double cropping pattern, were selected close to the village of Hoa An (108°0'00" – 108°5'00" E latitude and 10°65'00" – 10°70'00" N longitude). While An Binh was characterized by an alluvial clay soil with low organic carbon and total N contents, the Hoa An site was characterized by a typical acid sulfate soil with low available P and a high acidification potential under aerobic conditions. Selected physico-chemical properties of the experimental soils are shown in Table 1.

2.2 Crop plants

The widely grown improved semi-dwarf lowland rice (*Oryza sativa* L.) variety VD 20 with 105-day growth duration was obtained from Cuu Long Rice Research Station, Omon, Vietnam. For homogenizing the field sites, it was pre-germinated for two days and broadcast-seeded at a rate of 120 kg ha^{-1} into the water-saturated lowland field (An Binh) or seeded into a wet bed and transplanted at 21 days after seeding at two seedlings per hill at a 20×20 cm spacing (Hoa An). Mungbean (*Vigna radiata* L.) is commonly

Table 1: Selected physico-chemical properties of the experimental soils (0-20 cm)

Parameter	*Alluvial soil (An Binh)*	*Acid sulfate soil (An Binh)*
Soil type (USDA)	Tropaquept	Sulphaquent
Texture	Silty clay	Clay Loam
Clay (%)	57	44
Silt (%)	34	55
Sand (%)	9	1
pH (H_2O)	5.0	3.4
org. C (%) *	1.52	4.59
Exch. Al^{3+} (mg $100g^{-1}$) †	–	37.2
Tot. N (%) ‡	0.16	0.26
Avail. P (mg kg^{-1}) §	5.81	1.90
Exch. K (mg kg^{-1}) ¶	7.58	38.9

* Walkley-Black, † NaF titration, ‡ Kjeldahl, § Bray-I, ¶ NH_4O-Ac extraction

cultivated in the Mekong Delta and was selected as a substitute of the dry season rice crop. Seeds were obtained from the College of Agriculture, Cantho University. The material was seeded at a 20×40cm spacing onto 10 cm high raised soil beds of 1×5 m, that were constructed in the lowland plots after the harvest of wet season rice.

2.3 Substrates

Organic substrates from decentralized waste and wastewater treatment, commonly applied to field and garden crops in the Mekong Delta, were collected from farms in the study area. These organic amendments included five aerobic substrates (vermicompost from pig and goat manure, pig manure – rice straw compost, biogas sludge compost, rice straw compost, and rice mushroom compost) and three anaerobic substrates (young biogas sludge [<4 months], old biogas sludge [>12 months], and fish pond residue [30 – 50 mm depth of deposit]). The substrates differed widely in their N content (1.6 – 3%), C/N ratio (12 - 23), and P (0.15 – 1.65%) and K content (0.28–1.98‰). Selected physico-chemical parameters of the organic amendments are presented in Table 2.

2.4 Chemical analyses

The C mineralization was determined by weight loss from litterbags containing 3 g substrates. The organic substrates were placed into Nylon mesh bags (0.2 mm) and incubated in the dark in three replicates per soil type (about 30 g substrate kg^{-1} soil) for a period of 12 weeks (Okalembo *et al.*, 2002). Soils were kept under aerobic conditions at about 75% field capacity. The weight loss of the substrate in the litter bags (dry matter) was recorded after removal, careful washing in distilled water and oven drying for 48 hours at 70°C.

Table 2: Selected physico-chemical properties of the organic substrates used in the field experiments on alluvial and acid sulfate soils in the Mekong Delta in 2003/2004.

Substrate	*Moisture cont. (%)*	NH_4^+*-N (mg kg^{-1})*	NO_3^-*-N (mg kg^{-1})*	*Total* N *(%)*	C/N *ratio*	*Total* P *(%)*	C/P *ratio*	*Total* K *(‰)*	C/K *ratio*
Aerobic Substrates									
Vermicompost (pig / goat)	60.4	1.40	844	2.20	19	1.39	30	0.92	454
Pig manure straw compost	56.0	1.84	940	2.60	16	1.65	25	1.98	209
Biogas sludge compost	38.7	2.68	1832	1.95	20	0.60	71	0.57	737
Rice straw compost	68,7	4.28	19	1.95	22	0.15	274	0.57	732
Mushroom compost	70.1	4.84	575	2.45	17	0.22	190	1.54	273
Anaerobic substrates									
Biogas sludge (> 12 months)	82.5	1.23	t	2.55	12	0.68	53	0.65	470
Biogas sludge (< 4 months)	86.3	1.56	t	2.38	14	0.80	42	0.31	397
Fishpond residue (3 – 5 cm)	78.9	1.76	t	1.35	18	0.40	48	1.81	106

t: traces

The N mineralization potential of substrates applied to the two soils was determined by net ammonium-N release during two weeks of anaerobic incubation (Stanford and Smith, 1972). Substrates were applied at 100 mg N kg^{-1} soil and 20 g of soil-substrate mixture were placed in 50mL test tubes, filled with 30mL of distilled water. Three replicates of each organic substrate and soil type (2 soils $\times$ 11 treatments $\times$ 2 extraction times $\times$ 3 replications = 132 tubes) were incubated in the dark at 30 – 32 °C for 21 days and extracted with 2 N KCl after 7 days (initial value) and after two further weeks of anaerobic incubation. The ammonium content in the extract was determined colorimetrically via flow injection analysis. The net-N mineralization was computed as (Nmin after 1 and 2 weeks of incubation) – (Nmin in the initial sample). Substrate mineralization was calculated as the net-N release in amended minus that in unamended sample tubes.

The total N in soil samples and in the biomass of 12 week-old mungbean was determined by Kjeldahl method. Soil exchangeable K was extracted with NH_4O-Ac, followed by flame photometer determination. Soil P was determined according to the Bray-I procedure and determined spectrophotometerically after vanadate coloration. Soil pH, total acidity, and exchangeable Al^{+3} were based on a soil: extractant ratio of 1:5 (pH-H_2O). Soil total acidity and exchangeable Al^{+3} were determined only in the acid sulfate soil. Soil samples (0-10 cm) were taken from individual planting holes of the test crops extracted with 2N KCl and subsequently titrated with $NaOH$ and NaF for total acidity and exchangeable Al^{3+}, respectively (McLean, 1965).

2.5 Treatment application

Dry season field experiments were conducted at each of the two study sites during the dry season of 2003/2004, following the field homogenization with an unfertilized crop of lowland rice during the 2003 wet season. In addition, experiments were conducted under controlled conditions in the laboratory of the Institute of Technology at Cantho University (substrate C and N mineralization). The field experiments were established at both the Hoa An (acid sulfate soil) and An Binh (alluvial soil) sites. Three adjacent farms were used as replications at each site with treatments being randomized within the farms (Randomized Complete Block Design - RCBD). The experimental area at each site was 1500 m^2 (500 m^2 per farm), on which 10cm high soil ridges of 5.0 $\times$ 1.0 m were built after the harvest of wet season rice in November 2003 for the cultivation of upland crops.

Field experiments studied (1) the response of mungbean to different substrates at one substrate application rate and (2) the response of mungbean to one substrate at different application rates. Twelve weeks after seeding of mungbeans, the dry matter accumulation was determined from 1$\times$3m harvest areas (alluvial soil) or from individual plants (acid sulfate soil) after oven drying at 70°C for 48 hours. *Experiment 1*: The differential effect of organic amendments on a test crop of mungbean (involved the application and manual incorporation (0-0.1 m) of eight substrates (Table 2) at a rate of 3 Mg ha^{-1} (dry matter basis) in comparison to an unamended control. *Experiment 2*: The effect of different application rates on a test crop of mungbean focused solely on the “old” biogas sludge, applied at rates of 0, 1.5, 3.0, 4.5, and 6.0 Mg ha^{-1} (dry matter basis).

2.6 Data analysis

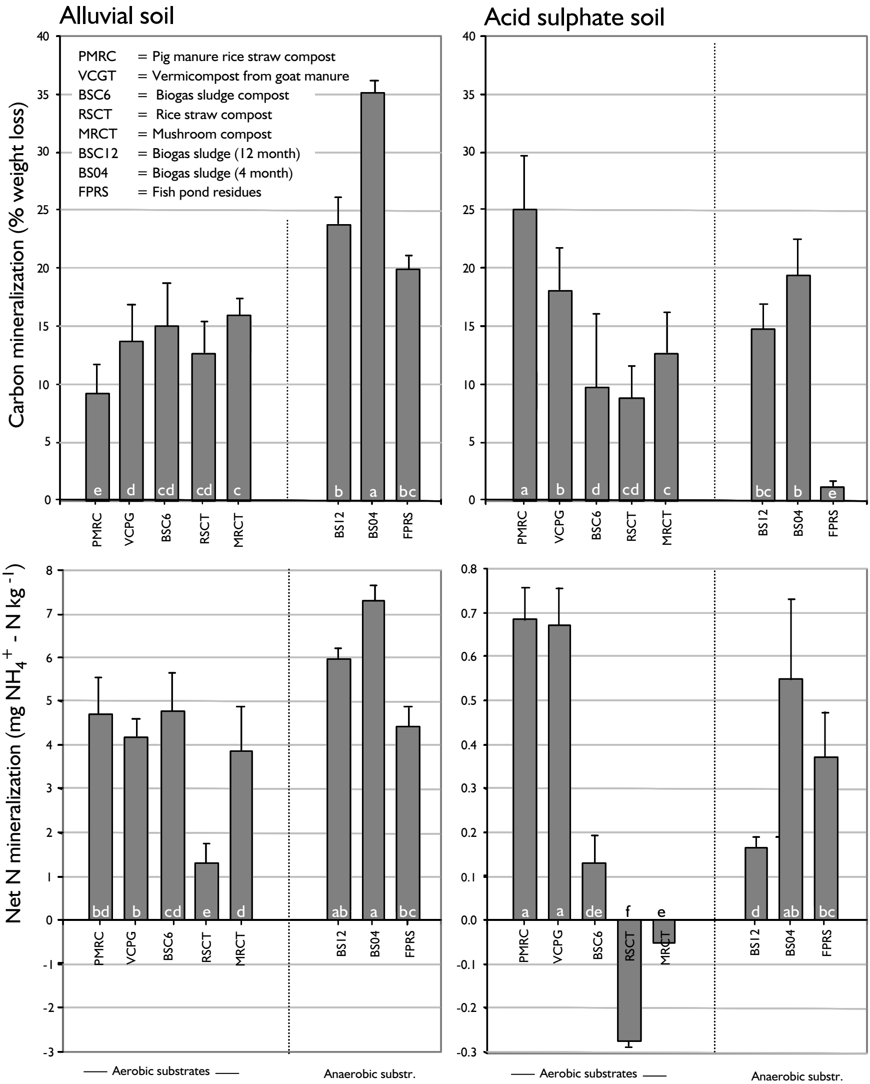
Data were analyzed for basic statistics (means and standard errors) by Microsoft EXCEL and subsequently subjected to ANOVA using SPSS 11.5. Mean separation was done by Tuckey Test at 5% error probability. Graphical presentations were made with SIGMAPLOT 5.3.

3 Results

3.1 Substrate mineralization

The substrates from waste and wastewater treatment were characterized based on physico-chemical parameters (Table 2) and on their C and N mineralization characteristics in both experimental soils (Figure 1). The C mineralization (weight loss) of soil-applied substrates tended to be generally lower in the acid sulfate than in the alluvial soil. In general, larger mineralization rates were observed from anaerobic sludge than from the aerobic composts. In the alluvial soil, the aerobic C mineralization varied between 8 and 35% weight loss. Rice straw compost showed the lowest (9-15%), young biogas sludge the highest C mineralization (24-35% weight loss). Vice versa, the sub-

Figure 1: Carbon mineralization (% weight loss in litterbags during 12 weeks of aerobic incubation – upper graph) and net-N mineralization (NH_4-N in amended minus unamended soil during 2 weeks of anaerobic incubation – lower graph) of organic substrates applied to an alluvial soil – left side, and an acid sulfate soil – right side (incubation experiments under controlled conditions). Bars present standard errors of the mean (n=3); value bars with the same letter are not significantly different by Tuckey Test (0.05).



strates with highest P content tended to mineralize more rapidly than the substrates low in P in the acid sulfate soil (up to 25% weight loss in pig manure-rice straw compost).

In the alluvial soil, anaerobic net-N mineralization varied between 1.2 and 7.2 mg N kg^{-1} soil. It followed a similar pattern as the aerobic C mineralization, whereby rice straw compost showed the lowest, young biogas sludge the highest net-N mineralization. In contrast to the alluvial soil, substrate N mineralization in the acid sulfate soil was by one order of magnitude lower. Highest net-N release was observed from aerobic substrates, particularly those with high P content (e.g., vermicompost and pig manure compost). Lowest N mineralization was observed with rice straw compost with –2.8 mg kg^{-1} soil (net-N immobilization).

3.2 Effects of substrates application to an alluvial soil

In *experiment 1*, all substrates were applied at 3 Mg ha^{-1} to soil ridges build in the paddy fields after the harvest of wet season rice. The biomass accumulation of mungbean after 12 weeks of growth responded differentially to substrate application (Table 3). Incorporation of biogas sludge resulted in the largest mungbean biomass (3.9 - 4.8 Mg ha^{-1}). The low-quality substrates, such as the aerobic rice straw compost, the compost from rice mushroom production and the anaerobic fishpond residue resulted in a low and not significant mungbean response (dry matter of 1.6-2 Mg ha^{-1}). Biomass response and crop nutrient uptake correlated significantly with the amount of added P ($P<0.01$) and N ($P<0.05$) but showed little apparent relation to other substrate attributes. Increasing the application rates of young biogas sludge (*experiment 2*), resulted in N additions of 0 - 144 kg ha^{-1}, corresponding to P additions of 0 - 48 kg ha^{-1}. While N and P accumulation in the biomass increased nearly linearly with increasing substrate application rates, no significant differences were observed in the dry biomass accumulation of mungbean at application rates beyond 3.0 Mg ha^{-1}.

3.3 Effects of substrate application on the acid sulfate soil

During the aerobic soil phase (dry season), the field site was characterized by a large and small-scale heterogeneity in soil pH (2.8-4.3), total acidity (3-23 cmol kg^{-1}) and exchangeable Al^{3+} (7-18 cmol kg^{-1}). Based on the analysis of 264 individual soil samples, significant linear correlations were observed between pH and total acidity ($r^2=0.64^{***}$) and between total acidity and exchangeable Al^{3+} ($r^2=0.59^{***}$) (date not shown). As crop growth strongly responded to aluminum, the soil exchangeable Al^{3+} was used as a covariate in the statistical analysis and data are presented as dry matter per plant in relation to the exchangeable Al^{3+} in the rhizosphere soil (soil collected from the individual planting holes before treatment application).

In *experiment 1*, eight aerobic and three anaerobic substrates were applied to mungbean at a rate of 3 Mg ha^{-1}. Mean biomass accumulation did not differ between treatments. However when using soil Al^{3+} as a covariant, the application of the aerobically composted substrates resulted in significantly more biomass than the unamended control. Anaerobic substrates produced an intermediate response, which was not significantly different from either the unamended control or the application of aerobic substrates

Table 3: Nutrient addition by substrates and the response in dry matter accumulation and nutrient uptake of 12 week-old mungbean plants to the application of organic substrates at 3 Mg ha^{-1} and to increasing application rates of biogas sludge on an alluvial soil (An Binh, Vietnam, 2004).

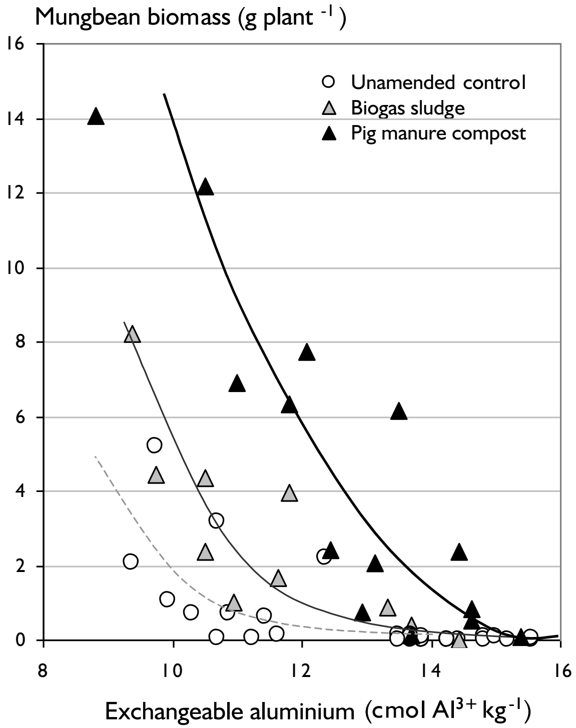
Substrate	*Amount of nutrient added (kg ha-1)*			*Mungbean dry matter (Mg ha-1)*	*Mungbean nutrient content at harvest (%)*		
	N	*P*	*K*		*N*	*P*	*K*
Unamended control	0	0	0	1.58^{e}	1.40^{d}	0.31^{e}	1.74a
Aerobic substrates							
Vermicompost	88.5	9.0	4.1	4.01^{c}	1.28^{e}	0.38^{c}	1.31^{c}
Pig manure compost	78.0	49.5	5.9	4.81^{ab}	1.20^{g}	0.49^{a}	1.33^{c}
Biogas sludge compost	55.5	18.0	1.7	3.92^{d}	1.24^{e}	0.40^{bc}	1.28^{d}
Rice straw compost	62.5	4.8	1.8	2.50^{e}	1.02^{fg}	0.27^{f}	1.34^{c}
Mushroom compost	53.5	6.6	4.4	2.04^{e}	1.34^{de}	0.41^{a}	1.27^{d}
Anaerobic substrates							
Biogas sludge (<4 months)	86.5	20.4	1.5	4.81^{a}	1.62^{d}	0.47^{b}	1.79^{a}
Biogas sludge (>12 months)	72.0	24.0	1.1	3.68^{cd}	2.18^{a}	0.46^{b}	1.58^{b}
Fishpond residue	48.0	12.0	5.4	1.57^{e}	1.06^{fg}	0.47^{b}	1.52^{b}
Increasing rates of biogas sludge							
0 Mg ha^{-1}	0	0	0	1.58^{e}	1.42^{d}	0.31^{e}	1.74^{a}
1.5 Mg ha^{-1}	36.0	12.0	0.4	3.11^{d}	1.06^{f}	0.33^{d}	1.12^{d}
3.0 Mg ha^{-1}	72.0	24.0	0.8	3.68^{cd}	1.52^{b}	0.35^{cd}	1.08^{f}
4.5 Mg ha^{-1}	108.0	36.0	1.3	4.21^{bc}	1.60^{b}	0.33^{de}	0.97^{f}
6.0 Mg ha^{-1}	144.0	48.0	1.7	4.40^{bc}	1.55^{f}	0.38^{cd}	1.19^{de}

Values followed by the same letter in a column are not significantly different by Tuckey Test (0.05)

(Figure 2). In the absence of substrate application (control treatment), the mungbean did not grow when the soil exchangeable Al^{3+} exceeded 11 cmol kg^{-1}, and a maximum biomass of 6 g plant-1 was observed with Al^{3+}concentrations of <9 cmol kg^{-1}. With the addition of 3 Mg ha^{-1} of aerobically composted organic substrates, the critical Al^{3+} value for mungbean growth increased from 11 up to 15 cmol kg^{-1} and the dry matter accumulation reached a maximum of 14 g plant-1 at 9 cmol Al^{3+} (Figure 2). The strongest growth response (and highest Al^{3+} tolerance) was observed with the application of well-rotten substrates with a wide C/N-ratio and high P concentrations (e.g., pig manure compost).

The growth of mungbean responded to increasing application rates of biogas sludge (test substrate in *experiment 2*) and shifted the critical aluminum concentration for mungbean growth from 11 (control) over 13 (3 Mg sludge ha^{-1}) to 15 cmol kg^{-1} (6 Mg sludge ha^{-1}), while increasing the maximal plant biomass at 10 cmol Al^{3+} kg^{-1} from 2 g (unamended control) to 12 g (data not shown). A comparison of the regression equations showed no significant differences of the slopes, while the X-axis intercept (critical Al concentration) shifted from 11 to 15 cmol Al^{3+} kg^{-1} with substrate amendments.

Figure 2: Mungbean response (dry matter accumulation of 12 week-old plants) to the application of 3 Mg ha^{-1} of biogas sludge or of of pig manure compost in relation to soil exchangeable Al^{3+} on an acid sulfate soil (dry season, Hoa An, Vietnam, 2004).



4 Discussion

Stagnating long-term yield trends in intensified rice-based cropping systems have been reported throughout Asia (Cassman *et al.*, 1997; Dawe *et al.*, 2000; Regmi *et al.*, 2002) and changes in soil organic matter quality under constant soil anaerobiosis and a declining soil N and P supplying capacity have been identified as the main culprits (Dobermann *et al.*, 2000; Ladha *et al.*, 2003). Breaking the cycle of permanent soil flooding by replacement of dry season rice with upland crops and in increased addition of organic substrates have been hypothesized to counteract the yield decline (Dawe *et al.*, 2003; Ladha *et al.*, 2003). The present work focused solely on the effect of substrate application on mungbean grown in rotation with rice. Nevertheless, the alleviating effects of various substrates on soil-related problems may also have positive carry-over effects on the subsequent crop of rice and the cropping system at large. In this context, the following chapters will discuss the decomposition dynamics and yield effects of organic amendments.

4.1 Substrate mineralization

Organic substrates contain besides a range of C sources, variable quantities of essential nutrient elements, salts, and heavy metals. However, the organic amendments need to undergo microbial decomposition before these elements can become plant available. Mineralization processes and rates are affected by temperature and moisture, microbial activity, soil texture, and substrates properties such as C/N ratio, content of lignin and polyphenols, and the lignin-to-N ratio (Palm and Sanchez, 1991; Becker and Ladha, 1997; Dendooven *et al.*, 1998; Calderón *et al.*, 2004). In the present study, soil texture and moisture conditions among the study sites were similar, while pH and the availability of P strongly differed between the alluvial and the acid sulphate soil. Hence, soil acidity and P limitations were likely to have been responsible for lower C and N mineralization at the Hoa An than the An Binh site. This appears to be confirmed by the observed high substrate mineralization rates of the P-rich pig manure-based substrates at Hoa An. In this acid sulphate soil, substrate decomposition may have been inhibited by soil acidity and possibly by P precipitation with soluble Al^{3+} and Fe. Consequently, the N mineralization of substrates was apparently related to the C/P rather than to the C/N ratio, as previously reported by Whalen *et al.* (2000). From the present data we conclude that the C/N and the C/P ratio may be the key drivers of substrate mineralization in the alluvial and the acid sulphate soil, respectively.

4.2 Soil and crop effects of organic amendments

Irrespective of the site, soil type or substrate, organic amendments generally improved the performance of mungbean. This may have been related to the direct addition of limiting plant nutrients and/or to a possible indirect effect via an alleviation of (H^+ and Al^{3+}) toxicities. On the acid sulphate soil, acidification and Al toxicity are likely to have further exacerbated the prevailing problem of P deficiency (Ren *et al.*, 2004). The extent of the ameliorative effects of organic amendments on P deficiency and Al toxicity depended on both the amount and the quality of the substrate. Similar to the substrate mineralization patterns, direct effects on crop biomass were related to N additions in the alluvial and to P addition and Al toxicity alleviation in the acid sulphate soil. The latter effects were much more pronounced with aerobic (compost) than with anaerobic (sludge) substrates. This may be related to a larger share of stable, non-soluble C-compounds in the composts, which can reportedly immobilise toxic Al^{3+} by forming non-toxic Al–DOM complexes (Hue and Licudine, 1999) or humic complexes with Al and Fe ions (Iyamuremye *et al.*, 1996). While the application of lime can rapidly correct the prevailing soil pH-related constraints, lime is currently hardly available in the Mekong Delta and not affordable to low-input farmers. Organic substrates on the other hand are widely available on farm and may thus provide a short-term alternative to alleviate Al toxicity and nutrient deficiency problems.

On the alluvial soil, the pronounced effect of substrate application on the biomass yield of mungbean was not only related to P but also to the amount of added N ($P<0.01$), which may surprise in the light of mungbean being a nitrogen-fixing legume. Nevertheless, fixation rates were probably very low and few effective (red) nodules were found, possibly related to the heavy soil texture, high bulk density and low plant-available P and exchangeable K in the soil.

The inclusion of an aerobic soil phase by growing an upland crop has been shown to obtain substantial yields of crops that tend to have a much higher market value than rice. The application of the organic substrates not only stimulated the performance of these high-value crops, but may also result in significant residual effects on the subsequent crop of wet season rice (Becker and Ladha, 1997; Eghball *et al.*, 2004). Such longer-term effects of substrate application on soil parameters may include enhanced soil P dynamics, increasing availability of P, Mg, Zn, Fe, and Cu, as well as improving soil biological and chemical properties (Kirk, 2004, pp. 135-164). It may thus be assumed that the effects of substrate application reported in this paper are likely to contribute to longer-term improvements of these production systems. While presenting a promising option, the organic substrates need to be matched with soil-specific needs.

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General information

The annual Conference on Tropical and Subtropical Agricultural and Natural Resource Management (TROPENTAG) is jointly organised by the universities of Bonn, Göttingen, Hohenheim, Kassel-Witzenhausen, Hamburg (2009), Zürich (2010) as well as by the Council for Tropical and Subtropical Research (ATSAF e.V.) in co-operation with the GTZ Advisory Service on Agricultural Research for Development (BEAF).

Tropentag 2008 will be held in Hohenheim. All students, Ph.D. students, scientists, extensionists, decision makers, politicians and practical farmers, interested and engaged in Agricultural Research and Rural Development in the Tropics and Subtropics are invited to participate and to contribute.

Target of the conference

The Tropentag is a development-oriented and interdisciplinary conference. It addresses issues of resource-, environmental-, agricultural-, forestry-, fisheries-, food-, nutrition and related sciences in the context of international rural development, sustainable resource use and poverty alleviation worldwide.

Plenary session

The growing demand for food for a still rapidly increasing population in the South, an alarming decrease in available arable land, increasing impact of climate change and the emergence of bioenergy production as a new powerful and competitive player enhance the competition for resources in a changing World.

Invited international speakers will present their view on these recent trends and analyse who will actually benefit from the new drive for rural development.

Eiselen award plenary session

On the occasion of this conference a special plenary session will be devoted to the presentation of the **"Hans H. Ruthenberg-Graduate-Award"** and the **"Josef G. Knoll European Science Award 2008"** by the "Eiselen Foundation", Ulm.

Oral and poster presentations

The Tropentag 2008 entitled "Competition for Resources in a Changing World - New Drive for Rural Development" particularly welcomes contributions pertaining to rural development, hunger and poverty alleviation, climate change issues, the conflicting field of food vs. bioenergy production, and their environmental repercussions and influences of globalisation on these topics. The Tropentag will be organised in four sessions of five parallel thematic groups. Each session will be opened by an invited keynote lecture, to be followed by four original papers.

Posters contributing to the different topics will be introduced during a plenary session on the first day at early evening time. On the second day there will be two parallel guided poster sessions around lunch time.

Local organising committee

- Prof. Dr. Georg Cadisch
- Prof. Dr. Folkard Asch
- Dr. Ludwig Kammesheidt
- Bärbel Sagi, MSc

Further Information:

http://www.tropentag.de
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Notes to authors

The Journal of Agriculture in the Tropics and Subtropics publishes papers and short communications dealing with original research in the fields of rural economy and farm management, plant production, soil science, animal nutrition and animal husbandry, veterinary hygiene and protection against epidemics, forestry and forest economy.
The sole responsibility for the contents rests with the author. The papers must not have been submitted elsewhere for publication. If accepted, they may not be published elsewhere without the permission of the editors.
Manuscripts are accepted in German, English, French, and Spanish. Papers may not be published in the order of receipt, those that require minor amendments, only are likely to appear earlier. Authors are advised to retain one copy of the manuscript themselves as the editors cannot accept any responsibility for damage or loss of manuscripts.

1. *Contents of the manuscripts*

Findings should be presented as brief as possible. Publication of a paper in consecutive parts will be considered in exceptional cases.
The following set-up is recommended:
The introduction should be as brief as possible and should concentrate on the main topics of the paper. Reference should be made to recent and important literature on the subject, only.
Materials used and methods applied should be explained briefly. Well-known or established methods and procedures should not be described. New or important methods should be explained. With all its brevity, this part should enable the reader to assess the findings adequately.
Tables and Figures should be used to effectively present the results. Explanations and other remarks on the results can be included in the text.
Discussion of results should also refer to relevant literature on the topic and lead to clear conclusions. Recommendations with respect to further research needed on the respective subject will increase the value of the paper.
The summary should concentrate on the main results and conclusions to highlight the author's contribution. It should be suitable for information storage and retrieval.

2. *Form of the manuscripts*

Manuscripts should be typed double-spaced with a wide margin.
Documents should be submitted as standard word processing formats: OpenDocument Format (OpenOffice.org .odf), LaTeX or Microsoft Word (97-2003 .doc). Alternatively, the manuscript can be submitted as a simple text/rtf file together with a printed version or PDF file of the original format.

Please do not use automated or manual hyphenation.
Title, headings and references (names of authors) should *not* be in capitals.
Tables and figures should be attached at the end of the document or separately.
The preferred position for the insertion of tables and figures should be marked on the margin of the text.

The manuscript should not be longer than 15 typed pages including tables, figures and references.
The title of the paper is followed by the name(s) and address(es) of the author(s).
The abstract should be followed by a list of keywords (up to eight).
For each paper, a summary must be submitted in the same language (not more than 20 lines) and in English, if the paper is written in an other language.

Tables should not be prepared with blanks and should fit on a DIN A5 page
(max. width: 12cm (landscape: 18.5cm) with a minimum font-size of 7pt.).
All tables should have captions and should be numbered consecutively.

Figures should be black&white/greyscaled and suitable for reproduction (if possible, vector formats: svg or postscript). Photos should be high-gloss prints of good contrast, maximum size 13 by 18 cm, line drawings with Chinese ink on white or transparent paper. All figures should be numbered consecutively. A separate list of captions for illustrations has to be added.

S.I. (System International) units have to be used throughout.
References in the text should be made by the name of the author and the year.
Each paper should have an alphabetical list of references giving name and abbreviated first name of the author(s), title of the paper, name of the journal, number of the volume, year, page numbers; for books: title, place of publication, and year.
On publication, each author will receive two copy of the Journal

Manuscripts and communication should be addressed to:
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