Project Number	VIE36 IF01		
Project Title	**Design and implementation and scientific and financial analysis of 12 Sunflower trials in Vietnam**		
Vietnamese Institution	Oil Palm Research Institute		
Australian Institution	The University Queensland (UQ)		
Commencement Date	November 2005	**Completion Date**	June 2006

Objectives

1. To improve cultural techniques of growing sunflower in the highlands of South Viet Nam to transfer to farmers.
2. To introduce sunflower into South Central Coast and Mekong Delta to enlarge oil seed material areas.

Activities

1. Study the effect of phosphorus dose on sunflower yield in Ferralsols (in Bao Loc, Lam Dong province). (1 experiment)
2. Study the effect of lime dose on sunflower yield in Ferralsols (in Bao Loc, Lam Dong province). (1 experiment)
3. Study the effect of farmyard manure dose (organic fertilizer) on sunflower yield in Ferralsols (in Bao Loc, Lam Dong province). (1 experiment)
4. Study the adaptability of potential sunflower hybrids in the highlands. (2 experiments, one in Bao Loc and one in Duc Trong Lam Dong province)
5. Study the suitable watering regime for sunflower in the rainfed area. (2 experiments, one in Duc Trong and one in Di Linh district, Lam Dong province).
6. Conduct the improve package for sunflower (1 trial in Di Linh district, Lam Dong province)
7. Study the adaptability of some potential sunflower in Mekong Delta (1)
8. Study the financial return of sunflower compared to Maize/ mungbean in South central coast in rainfed area (1 experiment).
9. Study the financial return of sunflower compared to Maize, soybean and rice in Mekong Delta (1 experiment).
10. Study the effect of Nitrogen dose on sunflower yield in Mekong Delta (1 experiments)

Milestones

Nbr	***Milestone Description***	***Deliverables***	***Expected Date***
1	CARD Contract Signed	• Research Agreement signed. Milestones and payment schedules in place	Nov. 2006
2	Research Report	• a summary report of all trial results, together with an evaluation of the potential for financial benefits for smallholder farmers in Vietnam. This report is expected to outline issues and options for further development of a sunflower industry in Vietnam.	June 2005

PROJECT COMPLETION REPOT

AN ASSESSMENT OF THE PROFITABILITY OF SUNFLOWER PRODUCTION IN THE MEKONG RIVER DELTA, SOUTH CENTRAL COAST AND CENTRAL HIGHLANDS OF VIET NAM

Introduction

Viet Nam is a developing country and as such has a low level of vegetable oil consumption. Vegetable oils are an important source of calories in the human diet providing 38 kJ/g compared to 17.8 kJ/g for protein and carbohydrate. Vegetable oil consumption in Viet Nam is increasing and calories obtained from vegetable oils is likely to increase from 15-20% of the total diet to 35-45% as incomes increase and as government policies are implemented. Every year Viet Nam must import a large quantity of crude oil for processing. However, Viet Nam is an agricultural country with the potential to produce oilseeds domestically. Consequently, the development of oil seeds to meet the requirement of oil companies is necessary and essential to reduce the levels of oilseed imports.

Besides the traditional oil plants such as groundnut, soybean, coconut and sesame, it is necessary to develop other new oil crops such as sunflower *(Helianthus annuus* L.*).* Since Winter-spring 1999/2000, with the permission of the Ministry of Agriculture, Oil Plant Institute (OPI) has imported sunflower seeds from Australian research institutes and seed companies to study adaptability of imported hybrid sunflower. The primary aim was to develop cultural techniques (Nguyen Thi Lien Hoa et al. 2002) for the plains and highlands of South Viet Nam and to select adapted hybrids with high oil content. In 2004, hybrids Hysun 38 and G101 gained the temporary approval from Ministry of Agriculture and Rural Development for pre commercial release in Viet Nam (Nguyen Thi Lien Hoa et al. 2004). In addition to Hysun 38, a polyunsaturated sunflower type with long duration, hybrids with short duration and monounsaturated type were imported to grow in the highlands of Lam Dong province. In the Australian market, monounsaturated sunflower attracts a higher price (325 US $/mt) than polyunsaturated sunflower (284 US $/mt).

In the Program to develop the vegetable oil sector to the year of 2010 approved by the Minister of Industry on March-08-2004, sunflower research was directed to initially focus on the Central Highlands (Lam Dong) in order to quickly enlarge the sunflower growing area. Consequently, experiments/trials were conducted on acrisols in Lam Dong province to develop cultural techniques for the rapid adoption of sunflower production by small land holders. Australian sunflower hybrids grown in this region have shown excellent adaptation and have yielded two to three times higher than the Australian commercial average of 1 t/ha. However, there are still some soil constraints such as acidity and phosphorus fertility that require further research.

In addition to the Central Highlands, sunflower has enormous potential to be grown in the Mekong River Delta and South Central Coast. The Mekong farming system is dominated by a rice monoculture with 3-4 consecutive crops grown annually. This practise has brought about land degradation and a build up of pests, diseases and toxicities. Sunflower has the potential to be used as a 'break crop' in the farming system to increase the profitability of small land holders. Because sunflower is a non cereal crop it can use its large tap root to

access unused nitrogen stored deep in the soil profile and benefit the following rice crop by reducing the incidence of pests, diseases and toxicities. Some of the poorest farmers in Viet Nam are located in several provinces of the South Central Coast. This region has typically a semi-arid climate and crop production in the autumn season is low because of a lack of water after the summer rains. In these areas farmers have few cropping options usually only maize, cotton or mungbean. None of these crops have the drought tolerance of crops such as sunflower. Therefore, sunflower has excellent potential to increase the profitability of small land holders in the South Central Coast.

This report presents the results of experiments/trials conducted in Mekong River Delta, South Central Coast and Central Highlands in 2005-2006.

Research objectives:

* To assess the adaptability and profitability of sunflower in the Mekong River Delta and South Central Coast.

* To ameliorate soil constraints of acidity and phosphorus by optimising applications of lime and modify the technology package for growing sunflower.

Materials and methods

1. Materials

Varieties:

Hybrid sunflower: Hysun 38, 7802-6201, Hyoleic 41, 7102-6301, 7802-6801 and 7102-6401
Soybean: MTD 176
Rice: OM 1490
Hybrid maize: LVN 10
Cotton: V20
Soybean: MTD 176

Fertilizer: urea, single super phosphate, Chloride potassium, borax, lime, NPK compound fertilizer, organic fertilizer and muck (an organic fertilizer)

2. Methods

- Randomized design (Binh Thuan, Mekong) and Randomized complete block design (Lam Dong). For the experiments on a small scale a plot size of 20 m^2- 40 m^2 was used. For the experiments on a large scale, plot size varied from 200-2000 m^2.
- Season: Spring–Summer 2005 in Mekong River Delta, and autumn 2005 in the Central highlands and in South Central Coast.

3. Location

- Central Highlands: Lam Dong province (Bao Loc town, Di Linh and Duc Trong districts).
- Mekong River Delta: Can Tho City (O Mon district)
- South Central Coast: Binh Thuan province (Ham Thuan Bac district)

4. Cultural technique for sunflower

- Basal application/ha: 50 N + 100 P_2O_5 +100 K_2O potassium + 300 kg lime + 2t muck + 2 Kg Borax.
- Split application: 50 N + 50 K_2O
- Sowing distance: 30 cm x 60 cm and 1 seed/hole
- Herbicide: Ronstar: 1l/ha after sowing
- Fungicide: (for preventing *Alternaria helianthi* disease) Mancozeb
  - First spraying at 20 days after sowing (DAS), @20 g/8l, 1 ha needed 800 g of Mancozeb.
  - Second spraying at 30 DAS @ 20 g/8 l, 1 ha needed 800 g of Mancozeb.
  - Third spraying at 40 DAS @ 40 g/8 l, 1 ha needed 2.4 kg of Mancozeb

- Fungicide: (for controlling *Sclerotium rolfsii*) Validacin Spraying @ 25 cc/8 l and Daconil (Chlorothalonil) @ 10cc/8 l as disease appears.
- An optimum cultural technique for maize and cotton was defined by Binh Thuan Extension Center.
- An optimum cultural technique for rice, maize and mungbean in Mekong River Delta was defined by Cuu Long Delta Rice Research Institute.

Results and discussion

1 Mekong River Delta (Can Tho)

1.1 Study of the financial return of sunflower compared to maize, soybean and rice in the Mekong River Delta

1.1.1 Vegetative growth and development of sunflower

Table 1. Yield and ancillary data of sunflower grown in the Mekong River Delta in Spring–Summer 2005 (Mean of 8 samples)

Mean of 8 samples	Budding time (days)	Maturing time (days)	Plant height (cm)	Head diameter (cm)	Stem diameter (cm)	1000 seed mass (g)	Sound seed (%)	Seed yield (kg/ha)
	42	**98.6**	**172,3**	**19,6**	**3,70**	**52,2**	**91**	**2758**
$S_{d\pm}$	**0,46**	**0,52**	**2,31**	**0,35**	**0,21**	**0,88**	**1,92**	**245**
CV (%)	**1,11**	**0,52**	**1,34**	**1,76**	**5,62**	**1,68**	**2,12**	**8,88**

1.1.2 Vegetative growth and development of maize

Table 2. Vegetative growth of hybrid maize LVN 10 grown in the Mekong River Delta in Spring–Summer 2005

Observation	Mean of 10 samples
Maturing time (days)	96.3
Plant height (cm)	2.13
Height of stem that has corn ear (cm)	1.08

Table 3. Yield and ancillary data of hybrid maize LVN 10 grown in the Mekong River Delta in Spring–Summer 2005

Observations	Mean of 10 sample
Number of plants/ha	53000
Number of corn ears/plant	1.22
Number of seeds/corn ear	405
Corn ear diameter	3.85
100 seed mass(g)	27.2
Potential yield (T/ha)	6.60
Harvested yield(T/ha)	6.15

1.1.3 Vegetative growth and development of soybean

Table 4. Vegetative growth of soybean grown in the Mekong River Delta in Spring–Summer 2005

Observation	Mean of 10 samples
Maturing time (days)	79.5
Plant height (cm)	65.6
Height of stem that has pod (cm)	9.8
No of branch (n+1)	2.0
No of internodes/stem	13.9
No of internodes that have pods	12.5

Table 5. Yield and ancillary data of soybean grown in the Mekong River Delta in Spring–Summer 2005

Observations	Mean of 10 sample
No of pods/plant	30.5
No of pods that have 1seed/plant	4.5
No of pods that have 2 seeds/plant	19.3
No of pods that have 3 seeds/plant	6.8
Total of seeds/plant	63.3
100 seed mass (g)	16.7
Potential yield (T/ha)	3.09
Harvested yield(T/ha)	2.33

1.1.4 Vegetative growth and development of rice

Table 6 Vegetative growth, yield and ancillary data of rice OM 1490

Observation	Mean of 10 samples
Maturing time (days)	85
Plant height (cm)	96
Number of rice ears/m^2	402
Sound grain/ear	40
Empty grain (%)	21.1
1000 seed mass (g)	24.0
Potential yield (T/ha)	3.86
Harvested yield(T/ha)	3.15

Tables 1-6, indicates that during Spring-Summer in the Mekong Delta, that sunflower shows excellent adaptation. The yield of sunflower was 2.75 t/ha compared to maize, soybean and rice yield of 6.15 t/ha, 2.33 t/ha and 3.15 t/ha respectively. In addition sunflower was able to handle periods of dry conditions better than the other crops.

By spraying fungicides such as Vivadamy, the control of *Sclerotium rolfsii* disease was complete; Sclerotium *rolfsii* disease often develops in conditions of high soil moisture.

1.1.5 Economic analysis

Table 7. Economic analysis of sunflower, maize, soybean and rice grown in the Mekong River Delta during Spring-Summer season 2005

Crop	Yield (t/ha)	Price/kg (VN dong)	Input (1000 VN dong/ha)	Output (1000 VN dong/ha)	Benefit (1000 VN dong/ha)	Ratio Output/ Input
Sunflower	2.75	4000	11000	6407	4593	1.7
Maize	6.15	2000	12300	7707	4593	1.6
Soybean	2.33	4500	10485	6332	4153	1.7
Rice	3.15	2200	6930	5475	1455	1.3

The result in table 7 showed that among 4 crops (sunflower, maize, soybean and rice), sunflower and maize returned the greatest benefit (4,593,000 VN dong/ha).

1.2 Effect of Nitrogen dose on sunflower yield in Mekong River Delta

1.2.1 Vegetative growth and development

Table 8: Effect of nitrogen on plant height, stem diameter and head diameter of Hysun 38 grown in the Mekong River Delta during Spring-Summer 2005.

Treatment (kg/ha)	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)
0N (control)	141,8a	2,16a	15,5c
40N	159,6b	2,87b	17,7b
80N	169,4c	3,49c	18,9a
120N	179,4d	3,39c	19,3a
160N	190,8e	3,02b	18,9a
F	*	**	**
CV (%)	1,4	5,6	2,0

General application: 100 P_2O_5 + 100 K_2O + 2 kg B

There was a strong positive correlation between the rate of N applied and plant height (Table 8). Generally, stem and head diameter were greatest at levels greater than 40 kg/ha.

These results show that only moderate levels of nitrogen 40-80 N kg/ha may be necessary to achieve good plant growth of sunflower.

Table 9: Effect of nitrogen on sound seed percentage, yield and oil content

Treatment (kg/ha)	Sound seed (%)	Seed yield (t/ha)	Oil content at 9% moisture (%)
ON	81a	1,792 a	37,24 b
40N	89b	1,976 ab	37,93 b
80N	91b	2,304 c	41,31 a
120N	90b	2,344 c	40,20 a
160N	80a	2,156 bc	38,19 b
F	**	**	*
CV (%)	3,4	8,8	*3,19*

Despite yield losses of 15-25% due to field-rats excellent seed yields of about 2.3 t/ha and oil content over 40% were obtained with moderate levels of N application (80 kg/ha). Interestingly, sunflower plant grown under the highest rate of N (160 kg/ha) were highly sensitive to *Sclerotium rolfsii* disease (the damage was about 15%).

1.2.2 Economic analysis

The economic analysis (Table 10) shows that the greatest profitability to farmers is achieved with applications of 80 kg N/ha. The ration of benefit to nitrogen input was also highest with the 80 kg N/ha treatment.

Table 10. Economic analysis of N application on sunflower profitability in the Mekong River Delta

N dose (kg N/ha)	Seed yield (t/ha)	Output (VN dong/ha)	Input of N fertilizer (VN dong/ha)	Benefit from N fertilizer (VN dong)	Ratio of benefit to nitrogen input (VN dong)
0	1.792	7,168,000			
40	1.976	7,904,000	434,783	301,217	1.69
80	2.304	9,216,000	869,565	1,178,435	2.36
120	2.344	9,376,000	1,304,348	903,652	1.69
160	2.156	8,624,000	1,739,130	-283,130	0.84

Sunflower seed price/kg: 4000 VN dong

(-) indicates loss of income

2 South Central Coast (Binh Thuan)

2.1. Soil analysis

pH_{H2O}	Organic matter %	Available N (mg/kg)	Available P (mg/kg)	Available K (mg/kg	Exchangeable Ca (meq/100g)
5.74	1.46	237	297	286	1.89

This field is owned by the Chairman of the Farmer's organization of Hong Liem village, Ham Thuan Bac district. The on-farm trial was located on an Acrisol soil, and the previous crop was onion. The soil was acid, organic matter content medium, available N, P and K content very high and exchangeable Ca was low. Based on the soil result the suggested dose for sunflower /ha was 50N- 50 P_2O_5 – 50 K_2O + 300 lime + 13 borax + 2 t of muck.

2.2 Data of rainfall, temperature and humidity from June to December/2006 in Phan Thiet, Binh Thuan

Month	Temperature (^oC)	Humidity (%)	Rainfall (mm)
June	28.0	78	103.0
July	27.2	82	204.5
August	27.2	81	205.7
September	27.1	85	185.3
October	27.5	82	225.9
November	27.4	80	5.1
December	25.9	82	38.9

Normally rainfall decreases by October, but in 2005 due to the effect of a cyclone and eight storms, rainfall was higher than average.

2.3 Study of the financial return of sunflower compared to maize and cotton in the South Central Coast of Viet Nam

2.3.1 Vegetative growth and development of 3 sunflower hybrids

Table 11. Yield and ancillary data of Hysun 38, Hyoleic 41 and 7802-6801 (mean of 8 samples)

Hybrid	Budding time (days)	Duration (days)	Plant height (cm)	Sound seed (%)	Seed yield (kg/ha)
Hysun 38	46	100	194±16.8	82.09±3.43	2275±169
Hyoleic 41	46	100	191±11.3	83.02±5.60	2106±118
7802-6801	38	91	169±7.6	71.66±3.20	1150±158

Among 3 sunflower hybrids, Hybrid 7802-6801 was the earliest to mature, about 91 days, compared to Hysun 38 and Hyoleic 41 which matured in about 100 days. Duration of these hybrids grown in Binh Thuan was shorter than in Lam Dong province by about 20 days. Vegetative growth of these hybrids was very good.

Due to the effect of consecutive cyclone and storm events in September and October, yield was adversely affected, especially hybrid 7802-6801. This hybrid flowered and set seed during a period of heavy rain over many days affecting pollination and leading to poor seed set in the heads (sound seed rate was 71.66%). Hybrids Hysun 38 and Hyoleic 41 flowered later than hybrid 7802-6801, so at flowering these two hybrids were little affected by the heavy rain (sound seed rate was 82.09% and 83.02% respectively). Hysun 38 was the highest yielding at 2275 kg/ha. Due to the control of *Alternaria helianthi* by the fungicide Mancozeb, this disease was not severe and didn't affect yield.

Table 12. Oil content and oil yield of Hysun 38, Hyoleic 41 and 7802-6801 (mean of 8 samples)

Hybrid	Oil content (at 9% moisture)	Oil yield (kg/ha)
Hysun 38	38.31±1.43	872±76
Hyoleic 41	38.75±1.51	818±75
7802-6801	29.91±3.75	347±89

Hybrids Hysun 38 and Hyoleic 41 had the highest oil content and oil yield (Table 12). Generally we found oil content of these hybrids grown in Binh Thuan in Autumn 2005 was low due to the adverse effect of heavy rain at flowering time. Compared to autumn sunflower grown in Di Linh district, Lam Dong province, Hysun 38, had an oil content of 46.65% and oil yield about 1572 kg oil/ha, Hyoleic 41 oil content was 45.03%- oil yield 1397 kg oil/ha and for 7802-6801 oil content was 46.96% and oil yield 1475 kg/ha.

2.3.2 Yield of maize and cotton

Table 13. Yield of Maize LVN-10 and cotton V-20 (Mean of 8 samples)

Crop	Duration (days)	Yield (kg/ha)
Maize	105	4913 ±385
Cotton	120	1500±196

Maize and cotton grown in Binh Thuan were much longer duration than sunflower. Maize yielded 4913 kg/ha, and this year due to excessive rainfall the cotton yield was also low (1500 kg /ha).

2.3.3 Economic analysis

Table 14. Economical analysis of sunflower, maize, and cotton in Autumn season 2005

Crop	Yield (kg/ha)	Price/kg	Input (1000 VN dong /ha)	Output (1000 VN dong/ha)	Benefit (1000 VN dong/ha)	Ratio Output/Input
Sunflower	2275	4000	5143	9100	3957	1.77
Maize	4913	2000	5797	9826	4029	1.70
Cotton	1500	6000	5880	9000	3120	1.53

The result in table 14 shows that among 3 crops (sunflower, maize, and cotton), the benefit of sunflower (3,957,000 VN dong) and maize (4, 029,000 VN dong) was greater than cotton (3,120,000 VN dong). The ratio output/input was greater for sunflower and maize compared to cotton.

3. Central Highlands (Lam Dong)

3.1. Temperature and rainfall data from two meteorology stations (Bao Loc and Lien Khuong).

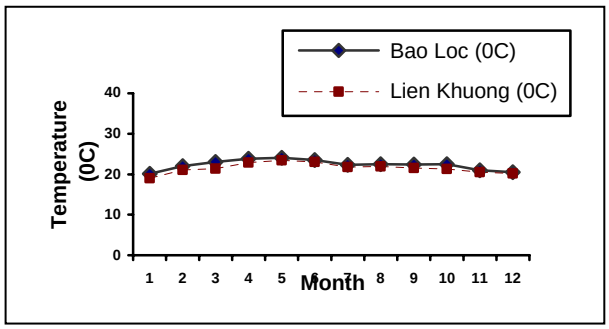

Figure 1: Data of temperature in Bao loc and Lien Khuong station

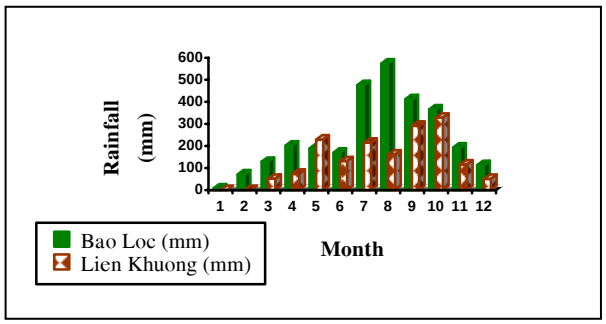

Figure 2: Data of rainfall in Bao loc & Lien Khuong station

Temperature in Bao Loc and Lien Khuong station (near to Di Linh and Duc Trong districts) was ideal for sunflower production. The rainfall measured at Bao Loc station was higher than Lien Khuong station.

3.2. Variety experiments

3.2.1 Vegetative growth of 6 hybrids in Autumn 2005 in 2 locations

Table 15. Vegetative growth of 6 hybrids in Bao Loc and Duc Trong in Autumn 2005.

Hybrid	Maturity (days)		Plant height (cm)	
	Bao Loc	Duc Trong	Bao Loc	Duc Trong
Hysun 38 (control)	119	118	153.7 ab	189.8 a
7202-6201	110	109	138.3 c	151.5 c
Hyoleic 41	119	117	165.0 a	186.8 a
7202-6301	119	115	157.3 ab	185.5 a
7802-6801	110	110	151.0 bc	166.5 b
7102-6401	110	108	146.3 bc	162.5 bc
CV%			***4.44***	***4.46***
LSD (0,05)			***12.3***	***11.7***

Differences in maturity between the 6 hybrids were clear. Hysun 38, Hyoleic 41 and 7202-6301 were late maturing (117-119 days) and 7202-6201, 7802-6801 and 7102-6401 (108-

110 DAS) were early maturing (Table 15). Farmers preferred the early maturing hybrids because of their short plant height.

3.2.2 Yield and ancillary data of 6 hybrids in Autumn 2005 in 2 locations

Table16.Yield and ancillary data of 6 hybrids grown at Bao Loc and Duc Trong in Autumn 2005

Hybrid	Sound seed (%)		Seed yield (kg/ha)		Mean seed yield of two locations (kg /ha)
	BLoc	D.Trong	BLoc	D.Trong	
Hysun 38 (control)	93.30a	96.90 a	3050 ab	3430 a	3240 a
7202-6201	83.91b	93.93 b	2450 b	2570 b	2510 c
Hyoleic 41	84.24b	97.53 a	2470 ab	3160 a	2810 bc
7202-6301	85.01b	97.30 a	2750 ab	3380 a	3060 ab
7802-6801	94.27a	95.92 ab	3100 a	3180 a	3140 a
7102-6401	83.86b	96.95 a	2500 ab	3090 a	2670 c
CV%	***4.92***	***1.53***	***11.85***	***9.84***	***10.11***
LSD (0,05)	***7.83***		***586***	***464***	***300***

The vegetative growth and seed yield of the 6 hybrids was higher in Duc Trong than in Bao Loc because of better soil at Duc Trong. At both locations, 7102-6401 had the highest 1000 seed mass (65.0-76.95 g) (Table 16). Hysun 38 and 7802-6801 had the highest sound seed percentage, at both locations (Table 16). For grain yield there highest yield hybrids averaged across both locations were 7802-6801, Hysun 38 (polyunsaturated sunflowers) and 7202-6301 (a monounsaturated sunflower).

Table 17.Comparison of seed yield in different season and different locations from 2004 to 2005

Hybrid	Seed yield of Duc Trong, Lam Dong (kg/ha)		Seed yield of Duc Trong, Lam Dong (kg/ha)	Seed yield of Bao Loc, Lam Dong (kg/ha)	Seed yield of Mean of 2 years in Lam Dong (kg/ha)	Seed yield of Quang Ninh (kg/ha)*
	Autumn 2004	Winter-spring 04-05	Autumn 2005	Autumn 2005	2004 and 2005	Autumn 2004
Hysun 38 (control)	3240	4020	3430 a	3050 ab	3430 a	1825
7202-6201	2820	3470	2570 b	2450 b	2830 d	1825
Hyoleic 41	3170	3720	3160 a	2470 ab	3130 bc	1840
7202-6301	3020	3910	3380 a	2750 ab	3270 abc	1135
7802-6801	2980	3890	3180 a	3100 a	3290 ab	1500
7102-6401	2960	3640	3090 a	2500 ab	3050 cd	1929
CV%	**11.83**	**7.64**	**9.84**	**11.85**	**4.66**	**14.5**
LSD (0,05)	**NS**	**NS**	**464**	**586**	**222**	**55**

*: Soure; Report of Seed Center and Agricultural Technology 2005.

Averaged over the 6 hybrids, the Winter-Spring seed yield (3770 kg /ha) was higher than in Autumn (3030 kg/ha) by 24.% (Table 17). The grain yield of the 6 sunflower hybrids was lowest in Quang Ninh province of North Viet Nam. Experience from previous years of sunflower trials also suggests that sunflower production is higher in southern parts of Viet Nam compared to the North.

3.2.3. Oil content, oil yield and level of oleic and linoleic acid content of 6 hybrids grown at Duc Trong and Bao Loc in Autumn (A) 2004-5 and Winter-Spring (W-S) 2004-2005

Table 18. Oil content, oil yield and level of oleic and linoleic acid of 6 hybrids

Hybrid	Oil content of Duc Trong (%)*		Oil content of Duc Trong (%)*	Oil content of Bao Loc (%)*	Oil content (Mean of 2 years (%)*	Oil Yield (Mean of 2 years) (%)*	Oleic acid content (%)	Linoleic acid content (%)	O/L
	A. 2004	W-S 04-05	A. 2005	A. 2005	04-05	04-05	A.05	A.05	
Hysun 38 (control)	42.42 bc	38.27	43.57 bc	42.71 bc	41.74	1510 a	56.69	35.09	1.60
7202-6201	44.11 ab	39.94	43.39 c	41.68 c	42.28	1269 d	89.53	3.51	25.5
Hyoleic 41	39.93 c	40.51	43.73 bc	42.56 bc	41.68	1382 bcd	88.93	2.68	33.2
7202-6301	42.85 bc	39.36	44.47 abc	44.17 ab	42.71	1462 abc	87.26	4.24	20.6
7802-6801	47,.42 a	38.95	45.22 ab	43.55 ab	43.69	1499 ab	44.75	45.97	0.97
7102-6401	44.88 ab	38.61	46.06 a	44.89 a	43.61	1367 cd	92.06	2.17	42.4
CV%	***4.94***	***3.57***	***2.48***	***2.41***	***3.44***	***5.54***			
LSD (0,05)	***3,25***	***NS***	***1.66***	***1.57***	***NS***	***118***			

* At 9% moisture

On average oil contents of the 6 hybrids were lower in the Winter-Spring 2004-2005 compared to the Autumn seasons (Table 18) this can be explained by the dry conditions and high temperatures during the seed setting stage of the, Winter-Spring season. Exposure to brief periods of water stress during seed filling reduces oil content in association with increases in the proportion of hull (Hall et al., 1985, 1989). Talha and Osman (1975) reported decreases in oil content in response to preanthesis water stress.

There were differences among the hybrids in terms of fatty acid profile ranging from very high levels of oleic acid combined with low levels of linoleic acid e.g. 7102-6401 to moderate levels of both oleic and linoleic acid e.g. Hysun 38. At this point, the Vietnamese oilseed industry does not distinguish between these fatty acid profile types but it is expected that fatty acid profile of vegetable oils grown in Viet Nam will follow established trends in international markets.

Averaged over two years there were significant differences in oil yield between the 6 hybrids. Hysun 38, 7202-6301 and 7802-6801 had the highest oil yield/ha (1462-1510 kg oil/ha) which is approximately three time the average oil yield of commercial sunflower production in Australia. These results highlight the success of the agronomic package developed by OPI/UQ.

3.3. Fertilizer experiments

3.3.1 Soil results

The Ferralsol soil of Bao Loc was typical of this region. This soil was acid, organic matter was high, available N, P_2O_5, K_2O was very low and exchangeable Ca, K and Mg content were low. Cation exchangeable capacity and the base saturation were both low.

Table 19. Soil analysis of a Ferralsols in Bao Loc

pH $_{H2O}$ (1:5)	Organic matter (%)	Available (mg/kg)			Exchangeable (meq/100g)				CEC Meq/100g	BS (%)
		N-NO_3	P_2O_5	K_2O	Ca^{2+}	Mg^{2+}	K^+	Na^+		
5,73	4,72	6	10	35	1,42	0,32	0,06	0,04	14,0	13,2

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3.3.2 The effect of phosphorus dose on sunflower yield in Ferralsols in Autumn-2005

There was a clear effect of phosphorus application in this experiment with a strong positive correlation between seed yield and the rate of P applied. This result reflects the low availability of phosphorus in these ferralsol soils (10 mg/kg). There was also a clear positive relationship between the amount of applied phosphorus and plant height, head diameter, and ancillary data. There was no significant difference of yield between 50 and 75-100 kg P_2O_5 treatments. Applying phosphorus increased yield by 16-41% over the control, and among the different phosphorus doses, applying 50 kg P_2O_5 was the most efficient (Table 20).

Similar results were observed for trials conducted in Acrisols during Winter-Spring 2004-2005.

Table 20. Effect of phosphorus dose on sunflower vegetative growth, ancillary data, yield and efficiency of 1 kg of P_2O_5 on a ferralsol soil in Bao Loc, Autumn 2005

Treatment (kg P_2O_5/ha)	Plant height (cm)	Head diameter (cm)	Sound seed (%)	Seed yield (kg/ha)	Yield surplus over control (kg/ha)	Efficiency of 1 kg P_2O_5
0P_2O_5 (control)	144.3 b	16.9 b	91.96 b	2300 b *(100)* #		
25 P_2O_5	157.5 a	17.7 b	93.71 ab	2675 b (*116*)	375	15
50 P_2O_5	163.0 a	19.6 a	96.67 a	3125 a (*136*)	825	16.5
75 P_2O_5	167.3 a	19.8 a	96.87 a	3188 a (*139*)	888	11.8
100 P_2O_5	167.5 a	20.9 a	96.58 a	3245 a (*141*)	945	9.45
CV%	***3.83***	***6.01***	***2.25***	***9.80***		
LSD(0.05)	***9.4***	***1.8***	***3.3***	***439***		

General application/ha: 100 kg N + 100 kg K_2O + 2 kg Borax + 300 kg lime + 2 t of muck.
 # % of control shown in italics

3.3.3 The effect of lime dose on sunflower yield in Ferralsols in Autumn-2005

Table 21. Effect of lime dose on sunflower vegetative growth, ancillary data, yield and efficiency of 1 kg lime on Ferralsols in Bao Loc, Autumn 2005.

Treatment (Kg lime /ha)	Plant height(cm)	Sound seed (%)	Seed yield (kg/ha)	Yield surplus over control (kg/ha)	Efficiency of 1 kg lime
0 (control)	161.3	93.24 b	2710 b *(100)#*		
300	163.5	96.48 a	3160 a *(117)*	450	1.5
600	161.3	96.27 a	3150 a *(116)*	440	0.73
900	163.8	96.24 a	3040 a *(112)*	330	0.37
1200	164.8	96.17 a	3070 a *(113)*	360	0.3
CV%	2.31	1.81	5.65		
LSD (0.05)	NS	2.33	263		

General application/ha: 100 N + 100 P_2O_5 + 100 K_2O + 2 kg Borax + 2 t of muck.
 # % of control shown in italics

There was no significant difference of lime application between the rates of 300-1200 kg/ha but these rates gave an increase on sunflowr yield of 12-17% over the control treatment (0 kg/ha). There was no effect of lime rate on plant height . Among lime doses, application of 300 kg/ha lime had the highest efficiency of 1 kg lime (Table 21).

In lime studies conducted on acrisols in 2 crop seasons (Autumn 2004 and Winter-spring 2004-2005) 300 kg lime also increased seed yield over the control by 7-15%.

3.3.4 The effect of muck doses on sunflower yield in Ferralsols in Autumn-2005

In the Central Highlands, farmers often applied muck (an organic fertilizer) to their crops (maize, sweet potatoes) therefore it was necessary to identify optimal application rates for sunflower.

Table 22. Effect of muck dose on yield and vegetative growth of sunflower grown in Bao Loc in autumn 2005

Treatment (t muck/ha)	Plant height (cm)	Sound seed (%)	Seed yield (kg/ha)	Yield surplus over control (kg/ha)
0 t muck (control)	161.5 b	95.13 b	3080 c *(100)#*	
2 t muck	162.5 b	96.41ab	3330 bc *(108)*	250
4 t muck	166.3 b	97.17 a	3460 ab *(112)*	380
6 t muck	174.0 a	97.05 a	3710 a *(120)*	630
CV%	***2.02***	***0.96***	***5.71***	
LSD (0.05)	***5.4***	***1.49***	***310***	

General application/ha: 100 N + 100 P_2O_5 + 100 K_2O + 2 kg Borax + 300 kg lime
#: Italic shows %

There was a positive correlation between the rate of muck applied and seed yield or plant height. Applying 2-6 t muck increased yield over the control by 8-20% (Table 22). Application of 4-6 t muck gave higher levels of sound seed compared to the control.

Table 23. Economic analysis

Treatment (t/ha)	Yield (kg/ha)	Output (1000 VN dong/ha)	Input of muck (1000 VN dong/ha)	Benefit (1000 dong/ha)	Ratio of benefit to muck input (VN dong)
0 t muck	3080	12320		5669	
2 t muck	3330	13320	450	6219	2.2
4 t muck	3460	13840	900	6289	1.7
6 t muck	3710	14840	1350	6840	1.9

Sunflower price: 4000 VNdong/kg

Table 23 shows that the highest benefit to farmers would be achieved with the application of 6 t/ha of muck and the ratio of benefit to muck input was highest with 2t muck/ha treatment.

3.4 Effect of available water on performance of hybrid 7802-6801.

Even within Lam Dong province, there was a large difference in rainfall patterns between districts. E.g Di Linh and Duc Trong districts compared to Bao Loc (Figure 1 and 2). These differences were exploited to study the effect of water availability on sunflower yield.

Treatments:

1/ No irrigation (totally dependant on rain)

2/ Irrigate at four stages (early vegetative stage, budding, flowering and seed filling stage)

3/ Irrigate when the soil is dry

3.4.1 A Study of the suitable watering regime for sunflower in Di Linh district of Lam Dong province, Autumn 2005.

In Di Linh district, the crop lacked water for 10-14 days during vegetative and budding stage. Consequently, it was only necessary to irrigate twice for Treatment 2. For Treatment 3, we also irrigated 2 times because soil was only dry at vegetative and budding stage. During the other stages (flowering and seed filling), the crop had enough water from rainfall for development.

Table 24. Effect of watering regime on vegetative growth, yield and ancillary data of 7802-6801 grown in Autumn 2005, Di Linh district.

Treatment	Plant height (cm)	Sound seed (%)	Seed yield (kg/ha)	Yield surplus over control (kg/ha)
No irrigation	181 b	91.38 b	2890 b *(100)*	
Irrigate at vegetative and budding stage	189 a	94.85 a	3200 a *(111)*	310
Irrigate 2 times	190 a	94.32 a	3240 a *(112)*	350
CV% **LSD (0.05)**	1.47 4.8	1.56 2.53	5.30 285	

General application/ha: 100 N + 100 P_2O_5 + 100 K_2O + 2 kg Borax + 300 kg lime
#: Italic shows % of control

This experiment showed that the lack of water during the vegetative and budding stage adversely affected the yield of 7802-6801 by about 12%. However even without irrigation a yield of 2890 kg/ha was achieved still making sunflower profitable in this district.

3.4.2 Study suitable watering regime for sunflower in Duc Trong Lam Dong, Autumn 2005

In Duc Trong district, dry conditions occurred only at the seed filling stage. Consequently, for Treatment 2 only one irrigation was necessary instead of four For Treatment 3, only one irrigation was necessary at seed filling stage. For Treatment 1, even though the crop didn't received water at seed filling stage, the vegetative growth and development was on par with the other treatments. In fact there were only small differences in yield highlighting the tolerance to dry periods of sunflower in these environments. These results again indicate that sunflower shows excellent adaptation to these regions of Viet Nam.

Table 25. Effect of watering regime on vegetative growth and yield and ancillary data in Autumn 2005 in Duc Trong

Treatment	Plant height (cm)	Sound seed (%)	Seed yield (kg/ha)	Yield surplus over control (kg/ha)
No irrigation	178	95.38	3190 *(100)*	
Irrigate at vegetative and budding stage	181	96.7	3400 *(107)*	210
Irrigate 2 times	180	96.95	3430 *(108)*	240
CV% **LSD (0.05)**	**2.37** **NS**	**1.17** **NS**	**5.30** **285**	

General application/ha: 100 N + 100 P_2O_5 + 100 K_2O + 2 kg Borax + 300 kg lime
#: Italic shows %

3.5 Sunflower demonstration field

3.5.1 Vegetative growth and development of sunflower

Table 26. Vegetative grow, yield and ancillary data and oil content of sunflower demonstration field in Di Linh district of Lam Dong province (Autumn 2005) (Mean of 10 samples)

Hybrid	Plant height (cm)	Sound seed (%)	Yield (kg/ha)	Oil content	Oil yield/ha
7802-6801	181	93.16	3210	45.67	1460
S_d	16	1.27	410	1.37	166
CV(%)	8.86	1.36	12.8	3.0	11.36

In Di Linh district we cooperated with a farmer to conduct a sunflower demonstration field with an area of 2000 m^2. The farmer managed the crop under the guidance of Oil Plant Institute staff. In this demonstration field hybrid 7802-6801 performed very well yielding over 3 t/ha with 46% oil (Table 26). The duration of this hybrid was 110 days and fitted well into the farming system.

3.5.2 Economic analysis of sunflower compared to maize.

In Di Linh district, farmers often grow maize in Summer and in Autumn, with the second maize crop season often yielding less than first maize crop season. Sunflower was grown in the Autumn and compared to the financial benefit of maize in Di Linh district, Lam Dong province

Table 27. Economic analysis of sunflower, maize, in Autumn season

Crop	Yield (kg/ha)	Price/kg	Output (1000đ/ha)	Input (1000đ/ha)	Benefit (1000đ/ha)	Ratio Output/Input
Sunflower	3200	4000	12800	7526	5274	1.7
Maize	6000	2000	12000	7745	4255	1.5

Based on an economic analysis, sunflower was found to give greater benefit than maize in the Autumn season. Importantly, this data confirms previous experiments with sunflower in this region (1999-2004) that sunflower can compete with the second maize crop in Lam Dong province of the Central highlands. Farmers find growing sunflower was not difficult, and is better able to tolerate periods of drought compared to maize. They find there are few insect pests and diseases can be easily controlled by strategic applications of fungicide.

Conclusions

In Mekong River Delta

- Sunflower shows excellent adaptation. The yield of sunflower was 2.75 t/ha compared to maize, soybean and rice yield of 6.15 t/ha, 2.33 t/ha and 3.15 t/ha respectively. In addition, sunflower was able to handle periods of dry conditions better than the other crops. By spraying fungicides such as Vivadamy, the control of *Sclerotium rolfsii* disease was complete.
- The input of maize was the highest (7,707,000 VN dong/ha), sunflower (6,407,000 VN dong/ha), soybean (6,332,000 VN dong/ha) and lowest input was rice (5,475,000 VN dong/ha). Sunflower and soybean had the highest ratio of output to input (1.7 times) and higher than maize (1.6 times) and rice (1.3 times). With yields >2.5 t/ha and with stable price ≥ 4000 VN dong/kg, farmers in the Mekong River Delta can grow sunflower as a profitable option during Spring–Summer season to replace one rice crop season. Sunflower can also out compete soybean and maize to replace Spring–Summer rice.
- The highest yield and oil content were achieved with a nitrogen rate of 80 kg/ha. This N rate would also provide the greatest profits for farmers.

In South Central Coast

- Among 3 sunflower hybrids tested, Hysun 38 and Hyoleic 41 showed excellent adaptation and are suitable to develop during the Autumn season of the South Central Coast. Duration of sunflower in the Autumn season was considerably shorter than for maize and cotton. This feature will be of great benefit to farmers in the region who will then have greater time for preparation and more resources for the following crop season.

  Spraying Mancozeb fungicide gave excellent control *Alternaria helianthi* an important disease of sunflower in Viet Nam.
- Sunflower required the lowest inputs of (5,143,000 VN dong/ha) compared to cotton (5,880,000 VN dong) and maize (5,797,500 VN dong/ha. Growing sunflower and maize gave the highest ratio of output to input (1.7) higher than cotton (1.5).These preliminary field results suggest that, with a sunflower yield of about 2.3 t/ha and a price of 4000 VN dong/kg, and shorter duration, sunflower can out compete cotton and can match maize during the Autumn season in Binh Thuan.

In Central Highlands

- Among 6 sunflower hybrids tested during 2 years, besides Hysun 38, we selected 2 good hybrids with excellent seed yield, 3270-3290 kg /ha and excellent oil yield 1460-1499 kg/ha.
- The optimum dose of phosphorus for sunflower grown on Ferralsols in the Central Highlands was: 50 kg/ha P_2O_5
- The optimum dose of lime for sunflower grown on Ferralsols in the Central Highlands was 300 kg/ha
- The optimum dose of muck (an organic fertilizer) for sunflower grown on Ferralsols in the Central Highlands was 2 t/ha.

- Autumn (Sowing from the middle to the end of August and harvest in November and December) was the optimal season to grow sunflower in Lam Dong province as rainfall was well distributed and irrigation is not needed.
- Sunflower is able to tolerate periods of dry conditions better than maize.

With yield of 3200 kg/ha and price of 4000 VN dong/ha, sunflower can out compete the second maize crop in Lam Dong giving small land owners greater profitability and income.

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References

1. Hall, AJ., C.A. Chimenti, F.Villela, and G.Freier. 1985. *Timing of water stress effects on yield components in sunflower*. P. 131-136. *In* Proc. 11th Int. Sunflower Conf., Mar del Plata, Argentina. 10-13 March. Int. Sunflower Assoc., Toowoomba, Australia.
2. Hall, AJ., D.J.Connor, and D.M.Whitfield. 1989. *Contribution of pre-anthesis assimilates to grain filling in irrigated and water –stressed sunflower crops*. I. Estimates using labelled carbon. Field Crop Res. 20:95-112.
3. Nguyen Thi Lien Hoa, Nguyen Van Minh, Nguyen Xuan Thanh, Luu Quoc Thang, Vinh Nhan, Ngo Thanh Huy, Nguyen Hoang Tam & Nguyen Van Hung, *Study and assess capability of some tropical oil seeds and essential oil plants*, Report presented at the Scientific Council of Ministry Industry, 2002, 54 p.
4. Nguyen Thi Lien Hoa, Ngo Thi Lam Giang, Tran Dinh Long, Le Giang Linh & Ngo Thanh Huy. 2004. *Results of study on hybrid Hysun 38 in South Viet Nam*, Report presented at Scientific Workshop of Ministry of Agriculture and Rural Development, 3/2004, 27 p.
5. Talha, M., and F. Osman. 1975. *Effect of soil water stress on water economy and oil composition in sunflower* (*Helianthus annus L.*) Agric. Sci. (Cambridge) 84: 49-56