SUNFLOWER PRODUCTION AND RESEARCH IN THAILAND

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Abstract

Sunflower is expected to be a new oilseed crop of Thailand. In 1988, it was grown in about 1,200 ha producing 670 tons of seed yield. The area planted to this crop increased about 20 folds to 21,000 ha in 1994 with the seed production of 8,548 tons. Hundreds of sunflower varieties were introduced into the country for yield tests during 1973-1986 but none of them were promising. After 1986, extensive yield trials were concentrated on hybrid varieties which showed good potential in other countries. After 1990, a hybrid variety Hysun 33 is recommended to farmers. The development of synthetic or composite varieties which enable the farmers to save their own seed is being undertaken. Most investigators found that application of N and P is necessary for the crop grown in all regions of the country. *Alternaria* spp. and *Heliothis armigera* are the most important disease and pest, respectively. The utilization of sunflower oilseed meal as animal feed was also investigated showing that sunflower oilseed meal can constitute 10-20% of the diets without adverse effects.

Introduction

Sunflower (*Helianthus annus* L.) is one of the most important oilseed crops of the world and adapted well for seed production where corn production is successful. There are two types of sunflower, oilseed and confectionery types. In recent years, sunflower oil is becoming increasingly popular for human consumption due to its high contents of poly-unsaturated fatty acids which make it attractive as an edible oil. Oilseed meal, after extraction of oil, can be utilized as animal feed.

Sunflower is well known as a drought tolerant crop and adapted well in varieties of climate. It is not a new crop in Thailand as it has been grown for birdseeds and confectionery for more that three decades. However, the crop was not popular due to its low yield and low demand. In recent years, new hybrid varieties are developed with a marked increase in yield and oil percentage. These result in the rapid expansion of sunflower production in Thailand.

The objective of this paper is to review research reports appeared in Thai literatures to be used as basic information for further research on this crop.

Sunflower Breeding

An extensive review on sunflower breeding in Thailand prior to 1988 was made by Laosuwan (1988) (Table 1). The earliest attempt to improve sunflower varieties was made in 1973 when the Field Crop Division compared 18 introduced varieties and found that Saratovskij was the best yielder. Many more yield trials were made during 1976-1978 but the yield levels were not attractive and the performance of these accessions were not consistent. In 1986, a sunflower hybrid, Hysun 33, was first included in sunflower yield trial at Chiang Mai Field Crop Research Center and showed very outstanding performance. This hybrid was later included in many other yield

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Table 1. Yield trial of sunflower conducted in Thailand 1973-1987.

Year	No. of entries	Location	Best Yielder
1973	18	Maha Sarakham Chiang Mai	Saratovskij
1976	13	Maha Sarakham	Saratovskij
1978	29	Kalasin	Saratovskij
1979	37	Kalasin	Saratovskij
1981	(1) 36	Kalasin Phisanulok	NS-H-11
	(2) 6	Chiang Mai Phisanulok Kalasin Sakon Nakhon	KC. NO.19
1983	60	Kalasin, Phisanulok	-
1984	4	Ubon Ratchathani	Synthetic 3
1985	4	Ubon Ratchathani	Synthetic 3
1986	(1) 27	Chiang Mai	Fransonal
	(2) 4	Chiang Mai	Hysun 33
1987	(1) 8	Chiang Mai	As 450
	(2) 8	Ubon Ratchthani	4-E-5
	(3) 46	Chiang Mai	Hysun 33
	(4) 5	8 locations	Hysun 33

Adapted from Laosuwan (1988).

trials throughout the country and exhibited acceptable yield potential (Julsrigival and Gypmantasiri, 1991; Siripongse and Vichukit, 1989; Siripongse *et al.*, 1990; Sarobol *et al.*, 1990b). These attempts led to the extension of sunflower hybrid Hysun 33 to farmers in Thailand.

Sunflower is an open-pollinated crop and the yield reduction due to inbreeding is expected if farmers use seeds from F_1 crops for planting. A study was made to compare F_1 and S_1, S_2 seeds of Hysun 33 and S 101 and found that the yield reduction due to inbreeding depression was about 20% (Siripongse *et al.*, 1990). Attempts also were made independently by investigators at Department of Agriculture (DOA), Chiang Mai University and Kasetsart University beginning in 1986 to develop synthetic or composite varieties. Sunflower lines were developed by DOA and tested for general combining ability by topcrossing to Hysun 33 (Kaewmeechai *et al.*, 1989, 1990, 1991) and eight lines were identified for their superiority (Kaewmeechai, 1992). At Kasetsart University, 36 entries were selected from open-crosses among 67 varieties of sunflower and were recombined for five generations to form a composite variety (Table 2) (Yothasiri, 1990, 1991, 1992). At Chiang Mai, sunflower lines were extracted for the development of composite and open-pollinated varieties. Yield test and testing for combining ability showed that some materials possessed desirable potential for variety development (Julsrigival and Gypmantasin; 1991). In 1989, a yield trial was conducted to compare Chiang Mai Composite-1 (CMU-1) with Hysun 33 from which the latter outyielded CMU-1 16-31%

The effort is being made to develop synthetic varieties so that farmers can use their own seed for planting rather than depending on expensive hybrid seed. However, sunflower breeding program need to be given a higher priority over a longer span before success can be achieved. This program at some institutes was discontinued due to the short of support.

Table 2. Mean values of different characters of recombined populations of cycles I-V from breeding program at Kasetsart University. [1]

Character	Cycle I	Cycle II	Cycle III	Cycle IV	Cycle V
Plant height at harvest (cm)	157.16	215.50	182.80	202.56	184.39
Head diameter (cm)	14.91	16.70	24.04	22.59	31.11
Head weight (g)	56.83	53.18	68.50	54.71	164.76
Seed weight/head (g)	35.87	29.95	31.60	35.95	111.50
100 seed weight (g)	5.34	7.36	7.88	7.12	7.30
oil %	32.93	33.14	33.59	34.97	28.46
Day to 50% flowering	64.10	62.45	62.19	61.34	59.31

[1] *Adapted from Yothasiri (1992)*

Agronomy

The first report on nutrient requirement of sunflower in Thailand made by the Department of Agriculture (DOA) in 1973 was that sunflower responded to N and K application but not P (Laosuwan, 1988). Many experiments conducted later at various locations gave the same conclusion that N application was necessary for sunflower regardless of locations and soil types (Sanmaneedchai and Ratanapanich, 1990; Sampet, 1990; Serepong, 1990). These findings agree with other research experience worldwide. At Chiang Mai in the North of Thailand, studies on major and minor element requirements have identified boron deficiency in sandy loam soils as a limiting factor, although readily remedied by foliar sprays or broadcasting with borax (Sanmaneechai and Sirinant, 1989; Gypmantasiri *et al.*, 1990). Although more field experiments have yet to be made to gather more information on sunflower production, Department of Agricultural Extension (DOAE), based on above findings, has suggested that fertilizer formula 15-15-15 or 16-16-8 (N, P_2O_5, K_2O) should be applied to sunflower 200 kg/ha (DOAE, 1994).

Planting densities and spacings of sunflower were investigated by many workers (Vichukit *et al.*, 1990, Siripongse *et al.*, 1 990). They gave similar conclusion that spacing 50-75 cm between rows and 35-45 cm between plants were suitable for all varieties. However, for the ease of field operation, either 75x35 cm or 75x45 cm spacings were recommended. In case of over planting, thinning should be made prior to V10 or 21 days after emergence leaving 1 but not more than 2 plants per hill.

Harmful and Beneficial Insects

Insect Pests. Charoenying (1989 a, b, c) carried out intensive surveys on kinds and number of insects found or feed on sunflower and found that more than 20 kinds of insects many of which were serious pests such as *Heliothis armigera, Ostrinia furnacalis* etc. Yield reduction due to *O. furnacalis* was linearly related to the degrees of damage caused by the insect (Charoenying, 1989d)

Studies on insect control were made intensively by projects support financially by OCDP during 1987-1990. Insecticides such as synthetic pyrethroids, monocrotophos triazophos, malathion, endosulfan, cypermetrin, decemetrin, cyhalothrin, chloropyriphos, carbosulfan etc. were studied at different rates. The effects of these insecticides are somewhat selective. For example, monocrotophos and endusulfan gave satisfactory control for *Trialeurodes* sp. and *Heliothis armigera*, respectively (Charoenying, 1989d). Similar results were obtained from subsequent experiments that endosulfan gave satifactory control on *Heliothis armigera* (Charoenying, 1990 a, b, c). Detailed life cycle and the importance of certain insect pests are given by DOAE (1994).

Beneficial insects. Although sunflower is an open-pollinated crop, good seed set of the crop is usually ensured by insect pollinators. Insect pollinator surveys carried out on different

varieties of sunflower showed that various types of bees are major pollinators (Table 3) (Waikakul *et al.*, 1989; 1990; Malaipan *et al.*, 1990). They were Europeon honey bee (*Apis mellifera*), little honey bee (*A. florea*), stingless bee (*Trigona* sp.), giant honey bee (*Apis dorsata*), eastern honey bee (*A. cerana*), digger wasp (*Campsomeris* sp.), carpenter bee (*Xylocopa* sp.) and allodapine bee (*Ceratina* spp., *Pithitis smaragdula*, *Brausapis* spp.). The importance of insect pollinators were confirmed by two experiments that higher seed set was obtained from sunflower visiting by pollinators than the control (Malaipan *et al.*, 1989, 1990; Budharugsa *et al.*, 1990). These studies gave an evidence that honey bees are the most important pollinators without which the sunflower seed set was affected. It was shown also that certain varieties may attract the insect better than others (Malaipan *et al.*, 1989).

Diseases

Diseases are important limiting factors for sunflower. Many diseases were reported to attack sunflowers in Thailand such as rust (*Puccinia helianthii*), stem rot (*Sclerotium rolfsii*), wilt (*Verticillium alboatrum*), downy mildew (*Plasmopora halstedii*), leaf and stem blight (*Alternaria spp. Septoria* sp.), head rot (*Cleadosporium* sp.) Prathuangwong *et al.*, 1989). Among these, *Alternaria* spp. is the most destructive disease (Prathungwong *et al.*, 1990). Studies on disease control by chemicals showing that iprodione (Rovral 50% WP) and mancozeb (Azimag 40% WP) was more effective in controlling *Alternaria* spp. than others (Prathungwong, 1990). Importance of certain diseases, their symptoms and methods of control are given by DOAE (1994)

Production System

Most of the upland areas in Thailand are planted to corn, soybean, groundnut, etc. Therefore, new systems of cropping must be developed to introduce new crop such as sunflower into the

Table 3. Major insect pests and beneficial insects of sunflower. [1]

Stages of Development of Crop	Major Insect Pests	Beneficial Insects
Seeding	1. Aphids	1. Spiders (*Tetragnatha* sp.)
	2. Thrips	2. Big-eyed bugs (*Geocoris* sp.)
	3. Leaf webbers (*Antigastra* sp.)	3. Ladybird beetles (F. Coccinellidae)
Vegetative	1. Aphids	1. Spiders (*Tetagnatha* sp.)
	2. Leaf webbers (*Antigastra* sp.)	2. Ladybird beetles (F. Coccinellidae)
	3. Tobacco capsids (*Engytatus tenuis*)	3. Tachinid flies (*Argyrophylax nigritibialis*)
Flowering	1. Aphids	1. Spiders (*Tetragnatha* sp.)
	2. Leaf webbers (*Antigastra* sp.)	2. Ladybird beetles (F. Coccinellidae)
	3. Thrips	
	4. Tobacco capsids (*Engytatus tenuis*)	
	5. Whiteflies capsids (*Engytatus tenuis*)	
	6. Leaf eating caterpillars (*Acherontia styx*)	
Podding	1. Aphids	1. Spiders (*Tetragnatha* sp.)
	2. Tobacco capsids (*Engytatus tenuis*)	2. Ladybird beetles (F. Coccinellidae)
		3. Tachinis flies (*Argyrophylax nigritibialis*)

[1] *Adapted from Waikakul et al. (1990a)*

already accepted system. A cropping system involving relay intercropping of mungbean/corn/sunflower was tested against monocropping of corn (Table 4). The relay intercropping system such as this resulted in a greater net income than the traditional system (Sarobol *et al.*, 1990a.)

Land preparation constitutes the main input of most crop production systems. Tillage and no-tillage system for sunflower production conducted on-farm at Chiang Mai showed that the yield of tilled plot was about twice that of the no-tilled plot (Sarobol,1990c). On the other hand, an experiment conducted at Si Sa Ket in the Northeast Thailand showed that mininum tillage involving only one ploughing gave the higher net return than conventional tillage (Visuttipitakul, 1991). Pacific Seeds have developed a complex package of practices for cultivating hybrid sunflower (Hysun 33 or Pacific 33). The package comprises seed rate (0.8 kg/rai), row spacing (75 cm), plant spacing (25-35 cm), seedbed fertilizer (N16 : P11 : K14), pre-emergence herbicide (alachlor), urea application before ridging, insecticide and fungicide applications as needed. These practices are likely to be too complex and too costly for farmers, but the Pacific Seeds aim at progressive farmers who expect moderate to high seed yield.

Yield gap analysis, first used in soybean (Sarobol *et al.*, 1989), was applied to identify major constraints affecting sunflower production (Sarobol *et al.*, 1991). Yield gap may be defined as the gap between the potential yield (obtained from researcher yield trials) in farmers environments and the actual farm's yield in such a location. This reveals possibility for yield improvement if adequate inputs are applied. This study showed that climatic conditions, soil characteristics, cultural practices, application of inputs such as fertilizers, insecticide, fungicide, and certain socio-economic factors were of major constraints.

Utilization of Sunflower Meal as Animal Feeds

Sunflower seeds and oilmeal have long been used as protein supplements in ruminant feeds in the major producing countries such as USA and Canada. Sunflower seed and oilmeal contain high level of crude protein. Khajarern *et al.*, (1990b) conducted chemical analyses using sunflower seeds and meal obtained from local central market of Thailand. The analyses of samples were carried out according to the A.O.A.C method. The chemical composition of whole sunflower seed and sunflower meal were shown in Table 5.

A series of experiments was conducted to explore the utilization of sunflower seeds and meal in animal feeds in Thailand. When 0, 5, 10, 15, 20 and 25% sunflower seeds were used to replace soybean and corn in broiler diets on an isonitrogenous basis, weight gain was maximized when diets contained 10% sunflower seed. It was concluded that in corn-soybean-fish meal broiler diets, sunflower seed can constitute at least 20% of the diet without any adverse effect

Table 4. Net income per rai of farmer at Ban Nangsai, Tambon Wangmung, Muaklek district, Saraburi Province in 1987/88 crop year. [1]

Item	Existing Cropping System		Relay Cropping System		
	1st crop corn	2nd crop corn	Mungbean	Corn	Sunflower
Growing period	Mar.15-Jun.15	Jun.15-Sep.30	Apr.15-Jun.15	Jul.1-Oct.15	Oct.1-Jan.13
Grain yield (kg/rai)	280	400	100-110	400	150
Gross income (baht)	770	1,122	1,080	1,200	750
Cost (baht)	447	447	745	447	285
Profit (baht)	323	675	335	675	465
net income (baht)	**988**			**1,475**	

[1] *1 rai = 0.16 hai*
From Sarobol (1990a)

on weight gain and feed efficiency. However, when sunflower seed was used in laying hen diets, hen-day egg production was slightly depressed with the increasing sunflower seed in the diet (Khajarern, 1990d). However, feed effeciency was found to increase at the 10% level. The utilization of sunflower seed in swine diet was also investigated by replacing soybean meal. The results from this experiment indicated that up to 10% sunflower seed can be used in growing-finishing swine diets (Khajarern, 1990e).

Production of Oil Meal and Cake

At present there is no information available in Thailand regarding the potential of production, extraction, process and the return on investment of sunflower oil production. The production process for pre-feasibility testing was designed and organized by Thailand Institute of Scientific and Technological Research (TISTR) with cooperation of the Pacific Seeds vegetable oil extraction mill (Kamol Kit Co.Ltd) and a refining factory (Rural Agro-Industry Co Ltd.). The testing process, underaken under the supervision of TISTR chemical laboratory, showed that the extraction and refining of sunflower seed oil can be successfully carried out in existing plants producing edible oil from rice bran. The quality of RBD oil was comparable with the standard of edible oils and fats (Srikumlaithong *et al.*, 1991).

Discussion and Conclusion

Sunflower breeding. There was an evidence of progressive success in the breeding program of sunflower at the Department of Agriculture, Chiang Mai University and Kasetsart University during 1987-91. Some of these efforts were discontinued due to the cease of support by Thai-EC OCDP. However, it seems that DOAE policy for promoting the uptake of sunflower by farmers has not been upset by this incidence. It turns out that the cost of hybrid seed per unit area is about 10-15% of production input. Which is very insignificant for farmers. This is not high as expected if all characteristics of hybrid varieties are taken into consideration. However, the national sunflower breeding program should be undertaken by DOA aiming at the development of synthetic or composite varieties adapted to low or moderate production inputs.

Soils, fertilizers, pests and diseases. Although a number of experiments on input technology for sunflower production was carried out in the past 20 years but the objectives were not clear. They were quite fragmented and cannot be formulated into a production system. At present, the promoting effort of DOAE is at accelerated rate

Table 5. Chemical composition of whole sunflower seeds.

Composition as Feed Basis (%)	Types of Sunflower Seed		
	High oil	Medium oil	Low oil
Moisture	7.8 ± 0.46	7.4 ± 0.82	6.9 ± 0.61
Crude protein	16.8 ± 0.85	17.1 ± 0.63	15.2 ± 0.63
Crude fiber	14.2 ± 0.11	14.5 ± 0.21	14.9 ± 0.30
Ether extract	39.4 ± 2.20	34.1 ± 1.80	13.9 ± 1.60
Ash	3.4 ± 0.42	3.6 ± 0.52	3.8 ± 0.40
Nitrogen free extract	18.2 ± 0.72	23.3 ± 1.20	45.5 ± 0.63
GE, MJ/kg DM	26.1 ± 0.90	25.0 ± 1.10	21.3 ± 1.30
Calcium	0.2 ± 0.05	0.3 ± 0.10	0.3 ± 0.08
Phosphorus	0.0 ± 0.05	0.5 ± 0.16	0.4 ± 0.11

GE = Gross energy; DM = Dry matter
1/ No. of each sample = 12
From Khajarern (1990b)

aiming at farmers in the central and Northeast. Therefore, on-farm research on all inputs, the integration of these, and the study of socio-economic status of farmers should be made at the target areas. Yield gap of sunflower is large. Thus, the possibilities to improve sunflower yield are attractive. In the long run, the research effort has to be taken up by existing research agencies and universities and the results should be rountinely transferred to DOAE for further application. The DOAE personnel should not or unable to carry out complicated research on-farm.

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References

Budharugsa, S., Titayawan, M. and Sukumolanan, P. 1990. Insect pollination of sunflower growing in Northern Thailand. OCDP Research Report for 1988. p.154-155.

Charoenying, S., Amornsak, W., Isichaikul, S. and Surakarn, R. 1988. Pest management of sunflower in central Thailand. Paper presented at the second Oilseed Crop Development Project Seminar, Chiang Mai Will, August 13-16, 1988.

Charoenying, S., Isichaikul, S. and Amornsak, W. 1989a. Comparision of sampling methods to estimate population of sunflower insect pests. OCDP Research Report for 1987. p.81-87.

Charoenying, S., Isichaikul, S., Amornsak, W. and Surakarn, R. 1989b. Population dynamics of insect pests in sunflower growth stages. OCDP Research Report for 1987. p.88-91.

Charoenying, S., Isichaikul, S., Amornsak, W. and Surakarn, R. 1989c. Population densities estimation of sunflower insects during harvesting stage. OCDP Research Report for 1987. p.92-94.

Charoenying, S., Isichaikul, S., Amornsak, W. and Surakarn, R. 1989d. Yield reduction in sunflower due to the disc flower borer, *Ostrinia furnacalis* Guen. OCDP Research Report for 1987. p.95-98.

Charoenying, S., Isichaikul, S., Amornsak, R. and Surakarn, R. 1989e. Comparative efficacy of synthetic pyrethriods and other insecticides against sunflower insect pests. OCDP Research Report for 1987. p.99-113.

Charoenying, S., S. Isichaikul, S., Amornsak, W. and Surakarn, R. 1990a. Efficacy of synthetic pyrethroids and other insecticides against the American bollworm, *Heliothis armigera* Hbn. on sunflower. OCDP Research Report for 1988. p.174-176.

Charoenying, S., Isichaikul, S. and Petchlom, R. 1990b. Interaction of five insecticides against the Americal bollworm, *Heliothis armigera* Hbn. in two varieties of sunflower. OCDP Research Report for 1988. p.177-178.

Charoenying, S., Isichaikul, S. and Kovitvadhi, K. 1990c. Evaluation of toxicity of ten insecticides against the American bollworm. OCDP Research Report for 1988. p.182-184.

Department of Agricultural Extension. n.d. Sunflower Production.

Department of Agricultural Extension, 1994. Important diseases and pests of sunflower.

Gypmantasiri, P., Insomphun, S. and Sriwattanapongse, V. 1990. On- farm research of sunflower production technology. OCDP Research Report for 1988. p.15-25.

Julsrigival, S. and Gypmantasiri, P. 1991. Development of sunflower production technology : Improvement of sunflower for Northern Thailand cropping system. OCDP Research Report for 1989. p.170-179.

Kaewmechai, S., Na Lampang A., Dangprodub, S. and Kachonmalee, V. 1989. Production of synthetic sunflower varieties (extraction of inbred lines). OCDP Research Report for 1987. p.34-38.

Kaewmechai, S., Na Lampang A., Potan, N., Dangpradub, S., Kachonmalee, V. and Pumklom, M. 1990. Production of synthetic sunflower varieties. OCDP Research Report for 1989. p.10-14.

Keawmechai, S., Na Lampang A., Kachonmalee, V., Dangpradub, S., Potan, N. and Pumklom, M. 1991. Sunflower varietal improvement. OCDP Research Report for 1989. p.180-189.

Kaewmechai, S., Pudhanon, P. and Dangpradub, S., 1992. Sunflower breeding : Line performance testing. OCDP Research Report for 1989. p.79-86.

Khajarern, J., Khajarern, S., Sripraya, P., Chaiput, S., Sakiya, P., Thammabat, B. and Saingarm, Y. 1990a. Utilization of sunflower by productions as animal feed. OCDP Research Report for 1998. p.206-207.

Khajarern, J., Khajarern, S., and Sakiya, P. 1990b. Chemical composition and digestibility of sunflower products by chemical and *in vitro* estimation. OCDP Research Report for 1988. p.208-216.

Khajarern, J., Khajarern, S., Sripraya, P., Chaiput, S. and Sakiya, P. 1990c. The utilization of sunflower seed in broiler diets. OCDP Research Report for 1988. p.217-221.

Khajarern, J., Khajarern, S., Sripraya, P., Chaiput, S., Sakiya, P. and Sainagarm, Y. 1990d. The utilization of sunflower seed in laying hen diets. OCDP Research Report for 1988. p.222-227.

Khajarern, S., Khajarern, J., Chaiput, S., Thammabut, B. and Tiabsri, S. 1990e. The digestibility and utilization of sunflower seed in swine diets. OCDP Research Report for 1988. p.228-238.

Laosuwan, P., 1989. Present status of research on sunflower breeding and input technology (in Thailand). OCDP Consultant Report. p.18-25.

Malaipan, S., Kongpitak, P. and Orotrairat, O. 1989. A role of *Apis mellifera* L. in seed set of sunflower. OCDP Research Report for 1987. p.130-170.

Malaipan, S., Kongpitak, P. and Orotrairat, O. 1990. Wild bee mass rearing and honey bee attractant for sunflower pollination. OCDP Research Report for 1988. p.140-153.

Prathauangwong, S., Charleepraom, W. and Sommartya, T. 1989. Sunflower diseases in some growing areas of Thailand. OCDP Research Report for 1987. p. 184-216.

Prathauangwong, S., Wongkao, S., Sommartya, T. and Simchaisri, P. 1990. Role of four *Alternaria* spp. causing leaf and stem blight of sunflowering Thailand and their chemical control. OCDP Research Report for 1988. p. 185-204.

Sampet, C. 1990. Effects of rates and times of N supply on growth and yield of sunflower cv. Hysun 33. OCDP Research Report for 1988. p.87-100.

Sanmeechai, M. and Sirinant, P. 1989. The status and management of boron for sunflower production in Northern Thailand. OCDP Research Report for 1987. p. 52-64.

Sanmeechai, M. and Ratanapanitch, N. 1990. Inorganic nutrition of sunflower response to nitrogen and phosphorus. OCDP Research Report for 1988. p.75-86.

Sarobol, N., Vichukit, V., Apiboonyopas, J. and Sarobol, N. 1991. Yield gap analysis of sunflower. OCDP Research Report for 1989. p.124-136.

Sarobol, E., Worasan, T., Tachasan, S., Chainuvati, C. and Sukontasing, S. 1990a. Relay-intercropping systems and farmer income. OCDP Research Report for 1988. p.101-103.

Sarobol, N., Worasan, T., Tachasan, S., Chainuvati, C. and Sukontasing, S. 1990b. Yield trials of sunflower at different locations. OCDP Research Report for 1988. p.104-107.

Sarobol, N., Worasan, T., Tachasan, S., Chainuvati, C. and Sukontasing, S. 1990c. Tillage trials on sunflower production at Chiang Mai. OCDP Research Report for 1990. p.108-109.

Sarobol, N., Virakul., P., Potan, N., Benjasil, V., Setarath, P. and Dechates, S. 1989. Preliminary survey on soybean yield gap analysis in Thailand. CGRRT. Center, Bogor, Indonesia. 57 p.

Serepong, S. 1990. Studies on the effects of various levels of nitrogen and phosphorus on growth, nutrient uptake and seed yield of sunflower. OCDP Research Report for 1988. p.63-74.

Siripongse. D. and Vichukit, V. 1989. Improvement of sunflower for central Thailand. OCDP Research Report for 1987. p.39-51.

Siripongse, D., Vichukit, V. and Sarabol., E. 1990a. Response of hybrid sunflower to plant population, OCDP Research Report for 1988. p.46-53.

Siripongse. D., Vichukit. V. and Sarobol, E. 1990b. Yield performance and some agronomic traits of F_2 seeds collected form F_1 sunflo wer hybrids. OCDP Research Report for 1988. p.40-45.

Srikumlaithong, S., Jenvanitpanjakul, P., Numchaiseewatana, S., Ranghirunruk, K. and Munsakul, S. 1991. Production of sunflower oil meal and cake on factory scale. OCDP Research Report for 1989. p.198-214.

Vichukit, V., Sarobol, E. and Siripongse, D. 1990. Response of sunflower to time of thimming and number of plants per hill. OCDP Research Report for 1988. p.30-35.

Visuttipitakul, S., Unvichian, I., Kaviraves, P., Vilairatana, P. and Chalermglin, P. 1991. Investment of low input technology for optimizing return on sunflower cultivation. OCDP Research Report for 1989. p.191-197.

Waikakul, Y., Waikakul, P., Soda, S. and Theansuponpong, T. 1989. Insect pollination of sunflower and populations of insects pollinators of sunflower in Northeastern Thailand. OCDP Research Report for 1987. p.114-129.

Waikakul, Y., Waikakul, P. and Wannakan, S. 1990a. Sunflower pollination in Northeastern Thailand. OCDP Research Report for 1988. p.120-139.

Waikakul, Y., Adam, V., Kamroob, S. and Yimyam, S. 1990b. Pest management of sunflower and sesame in Northeastern Thailand. OCDP Research Report for 1988. p.162-168.

Yothasiri, A. 1990. Sunflower breeding. OCDP Research Report for 1988. p.7-9.

Yothasiri, A. 1990. Sunflower breeding. OCDP Research Report for 1989. p.120-123.

Yothasiri, A. 1992. Sunflower breeding. OCDP Research Report for 1990. p.74-78.