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Effects of chemical and organic agricultural systems for okra (*Abelmoschus esculentus* L. Moench) production in Thailand

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Abstract

The objective of this study was to investigate yield and yield components in 15 lines of okra under chemical (inorganic) and organic agricultural systems during two seasons (2011 – 2012). The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. Yield and yield components were subjected to analysis of variance (ANOVA) using the statistical program of SPSS version 16.0. Means were separated using the Duncan's New Multiple Range Test (DMRT). The results showed that there were highly significant ($p \leq 0.01$) pods/plant, yield/plant and 100 seed weight in different lines of okra. The highest number of quality pods was found in Lucky file 473 line: approximately 69.11and 52.46 pods/plant under chemical and organic agricultural systems, respectively. The lowest number of quality pods was observed in OP line: approximately 30.90 pods/plant under the chemical agricultural system and 16.64 pods/plant under the organic agricultural system. Moreover, Lucky file 473 produced the highest yield (49.79 $T.ha^{-1}$) under the chemical agricultural system. OP under the organic agricultural system produced the lowest yield (19.66 $T.ha^{-1}$). However, the number of quality pods/plant and yield/plant under chemical agricultural systems was higher than organic agricultural systems in all lines.

Keywords: *Abelmoschus esculentus* (L.) Moench, Yield, Chemical agricultural system, Organic agricultural system.

Introduction

Okra (*Abelmoschus esculentus* L. Moench), a fast growing annual crop, mainly grown for its tender fruit, is an important warm season vegetable crop grown in tropical and subtropical parts of the world (Aladele et al., 2008 ; Alam and Hossain, 2008; Kumar et al., 2010; Wammanda et al., 2010). Opinions differ among scientists regarding the origin of *A. esculentus* as India, Ethiopia, West Africa, Tropical Asia and Hindustani Centre of Origin chiefly India, Pakistan, and Burma (Benchasri, 2012). Okra is grown commercially in India, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Myanmar, Japan, Malaysia, Thailand, Brazil, Ghana, Ethiopia, Cyprus and the Southern United States (Benjawan et al. 2007; Benchasri, 2012). The economic importance of okra cannot be overemphasized. Okra contains carbohydrate, protein and vitamin C in large quantities (Dilruba et al. 2009). Okra is a surprisingly versatile vegetable for its easily digestible fibre content. It contains essential and nonessential amino acids (Lamont 1999, Arapitsas 2008). And therefore plays a vital role in human diet (Kahlon et al. 2007, Saifullah and Rabbani 2009). Young immature fruits (pods) are important fresh fruit that can be consumed in different forms (Benchasri, 2013). They could be boiled, fried or cooked (Akintoye et al., 2011). Compared to other fleshy fruit vegetables (tomatoes, eggplants), okra is particularly rich in Ca and ascorbic acid (Benchasri, 2012). Carbohydrates are mainly present in the form of mucilage (Lengsfeld et al., 2004; Liu et al., 2005; Kumar et al., 2009). That of young fruits consists of long chain molecules with a molecular weight of approximately 170,000 made, up of sugar units and amino acids. The main components are galactose (25%), rhamnose (22%), galacturonic acid (27%) and amino acids (11%). The mucilage is highly soluble in water. Its solution in water has an intrinsic viscosity value of approximately 30%. Okra seeds contain about 20% protein and 20% oil. Bark fibre is easy to extract. It is white to yellow in colour and strong but rather coarse. Tests conducted in China suggest that an alcohol extract of *Abelmoschus* leaves can eliminate oxygen free radicals, alleviate renal tubular interstitial diseases, improve renal function and reduce proteinuria (Liu et al., 2005; Kumar et al., 2009).

In Thailand, okra is usually boiled in water resulting in the thick soups and sauces, which are relished. The production sources of okra in Thailand are the provinces of Saraburi, Bangkok, Angthong, Nakornpratom, Supanburi, Phichit and Phatthalung. The growing area is approximately 1,996.80 ha. and total productions is 11,232 $tons.ha^{-1}$(Benchasri, 2013). Production output and requirements are currently increasing. Production has been increased in order to meet with the higher demand. Consequently, pesticide has been used in the production process, causing chemical residues in the product and environment (Fajinmi and Fajinmi, 2010). Use of pesticide also hikes up the cost of the production process, making it not worth the investment. At present, consumers are paying much more attention to their health. As a result, vegetable production processes that are safe for both consumers and the environment are even more necessary (Odeleye et al., 2005; Petlamul et al., 2009; Benchasri and Bairaman, 2010; Tiamiyu et al., 2012). Therefore, the main objective of this study was to investigate the effects of chemical (inorganic) and organic agricultural systems on okra production**.** Sine, it is a new concept that is useful in daily farming. The outcome of the study may be used as guidance for okra production in Thailand.

Table 1. Sources and original source of okra plants.

No.	Lines	Sources	Original sources
1	KN-OYV-01	Phichit Horticulture Research Center	India
2	KN-OYV-02	Phichit Horticulture Research Center	India
3	KN-OYV-03	Phichit Horticulture Research Center	India
4	KN-OYV-04	Phichit Horticulture Research Center	India
5	KN-OYV-11	Phichit Horticulture Research Center	India
6	KN-OYV-13	Phichit Horticulture Research Center	India
7	KN-OYV-14	Phichit Horticulture Research Center	India
8	KN-OYV-16	Phichit Horticulture Research Center	India
9	KN-OYV-25	Phichit Horticulture Research Center	India
10	Lucky file 473	Bangkok Province	Japan
11	NO 71	Phichit Horticulture Research Center	India
12	OP	Phatthalung Province	Thailand
13	PC 52S5	Phichit Horticulture Research Center	Thailand
14	PJ 03	Phichit Horticulture Research Center	Thailand
15	TVRC 064	Bangkok Province	Thailand

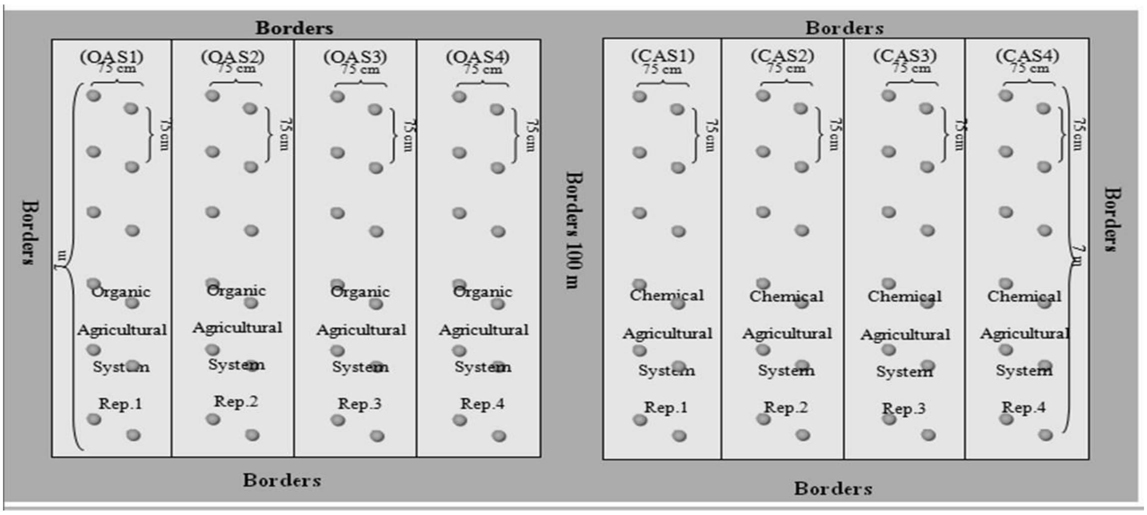

Fig 1. Experimental plotting design.

Results

Physical properties of soil.

The Physio–chemical properties of the soil in 2011 and 2012 is given in Table 3. Total nitrogen value in the soil during the two years was low (0.13 % and 0.14 %). Similarly, the soil had a medium level of phosphorus (5.61 ppm and 5.62 ppm) with a corresponding low level of potassium (0.21 % and 0.24 %) respectively in 2011 and 2012. Relatively moderate amounts of exchangeable bases (Ca and Mg) were presented in all the soil units. During the aforementioned years, organic matter was low (2.51 % and 2.58 %), while the pH in water was near neutral about 6.31 and 6.45 in the first and the second season, respectively.

Yield components of okra under the chemical and organic agricultural system during the first season.

In the present study of yield and yield components of okra under the chemical agricultural system during the first season between June and October 2011, it was shown that marketable pods, unmarketable pods, marketable yields, unmarketable yields, seeds/pod and 100 seed weight were significantly different in all lines. Lucky file 473 had the highest marketable pods: approximately 66.67±2.69 pods/plant. A number of unmarketable pods were infested by insects and diseases and it was found that KN – OYV – 02 had the highest number of unmarketable pods at 30.33±0.69 pods/plant. The other lines were also infested on KN-OYV-16, KN-OYV-13, KN-OYV-25, KN-OYV-11, TVRC 064, PJ 03, PC 52S5, KN-OYV-14, NO 71, OP, KN-OYV-03, KN-OYV-04, KN-OYV-01 and Lucky file 473 with the number of unmarketable pods/plant being approximately 29.45±0.98, 29.00±1.32, 28.67±1.38, 28.67±1.06, 28.67±0.74, 28.33±1.68, 28.33±1.35, 28.00±0.79, 27.67±2.06, 27.00±1.52, 27.00±0.99, 26.33±0.79, 26.00±0.98 and 23.12±2.03 pods/plant, respectively. Lucky file 473 had the highest average number of marketable yields of approximately 1,330.73±14.35 grams/plant, whereas the minimum pod yields of okra were recorded in a control line (OP) of approximately 616.76±12.03 grams/plant (Table 4). While, the results of the yield and yield parameters of okra lines planted and managed under the organic agricultural system during the first season (2011) showed that yield parameters (marketable pods, unmarketable pods, marketable yields, unmarketable yields, seeds/pod and 100 seed weight) were significantly different in all lines. The highest marketable pods and marketable yields were found in Lucky file 473: approximately 52.41±2.22 pods/plant and 821.79±9.28 grams/plant, respectively. The control line (OP) produced the lowest number of marketable pods and yields about 16.64±1.21 pods/plant and 260.92±12.68 grams/plant, respectively. The other lines produced an average pod number and yield distributed between Lucky file 473 and (OP) lines (Table 4).

Table 2. Analysis of variance model (ANOVA)

Source	DF	SS	MS	F
Treatments	t-1	SSTr =$(T_1^2+T_2^2+\ldots+T_t^2)$/r-CF	SSTr/ (t-1)	MSTr/MSE
Rep or Blocks	r-1	SSR = $(R_1^2+R_2^2+\ldots R_r^2)$/t-CF	SSR/ (r-1)	MSR/MSE
Error	(t-1)(r-1)	SSE = Total SS – SSTr – SSR	SSE/(t – 1)(r – 1)	
Total	t.r-1	Total SS = $\sum(X_{ij}^2)$ - CF		

Table 3. Physio-chemical properties of the soil (0-30 cm) of the experimental site in the first and second seasons.

Parameters	First season	Second season	Method of analysis
Organic matter	2.51%	2.58%	Walkley-Black method
Nitrogen	0.13%	0.14%	McKenzie method
P_2O_5	5.61 ppm	5.62 ppm	Flame photometric
K	0.21%	0.24%	Oxidation
Ca	4.56meq/100g	4.65meq/100g	A.A.S
Mg	3.41meq/100g	3.52meq/100g	A.A.S.
pH (H_2O)	6.31	6.45	pH meter method
pH ($CaCl_2$)	6.49	6.48	pH meter method

A.A.S: Atomic absorption Spectrometer Experimental set up.

Yield components of okra under the chemical and organic agricultural system during the second season.

Table 5 shows yield and yield components of okra under the chemical agricultural system during the second season. Marketable pods, unmarketable pods, marketable yields, unmarketable yields, seeds/pod and 100 seed weight were also significantly different in all lines which is the same as the first season. Lucky file 473 had the highest marketable pods of approximately 69.11±1.58 pods/plant while the lowest marketable pods were recorded on OP at approximately 33.22±2.03 pods/plant. The other lines were of average marketability, distributed between Lucky file 473 and (OP) lines. Yield and yield components of okra lines planted and practiced under organic the agricultural system during the second season (2012) showed that marketable pods, unmarketable pods, marketable yields, unmarketable yields, seeds/pod and 100 seeds weight were significantly different in all lines which is the same as the first season under the organic agricultural system. The highest marketable pods and marketable yields were found in Lucky file 473: approximately 52.64±1.09 pods/plant and 821.90±10.68 grams/plant, respectively. The lowest marketable pods and marketable yields were recorded in the control line about 16.87±1.06 pods/plant and 261.03±9.98 grams/plant, respectively (Table 5).

Comparison of the number of pods in the two systems

The number of pods/plant was significantly affected ($P \leq 0.01$) by different combinations of chemical (inorganic) and organic agricultural production (Table 6). The highest number of quality pods (94.56±1.68 pods/plant) was produced by adding the chemical agricultural system during the second season. The other lines produced an average number of pods distributed between Lucky file 473 and the OP lines. However, the number of pods/plant under chemical agricultural systems was higher than organic agricultural systems in all lines.

Comparison of okra yields in the two systems.

As for yield evaluation and components of okra under chemical and organic agricultural systems for comparison with the OP line (local market line) for two seasons, it was found that all types were statistically significant. Lucky file 473 had the highest yield during the first season: 47.41±0.58 $T.ha^{-1}$. The next lowest rates included lines KN-OYV-02, KN-OYV-25 and KN-OYV-01, which produced 46.70±1.02, 45.35±0.39 and 44.96±1.21 $T.ha^{-1}$ respectively. The lowest yield was recorded in OP: approximately 28.65±1.45 $T.ha^{-1}$ under the chemical agricultural system and 20.11±1.05 $T.ha^{-1}$ under the organic agricultural system. As for the other lines, yields were distributed between Lucky file 473 and OP. Moreover, all lines of okras produced and managed under the chemical agricultural system produced a higher yield than the organic agricultural system regarding to the numbers of pod (Table 7).

Meteorological data between planting

The present study quantitatively compares the influence of temperature, the level of relative humidity and rain on the development times of fifteen okra lines during two years. It was found that rainfall occurred from the months of June to April for two years of the study. The month of December recorded the highest amount of rainfall and also the highest number of rainy days. The average monthly temperature for the two years ranged between 26.45°C and 29.39°C, while the average relative humidity ranged from 75.75 % to 86.50 % for the two years. The average monthly temperature and relative humidity range were considered optimal for the growth and development of okra (Table 8).

Materials and Methods

Plant materials

Fifteen lines of okra were selected from someplace in Thailand and other countries. (Table 1)

Preparation of the planting

The preparation of plots and the planting of okra were carried out according to the regulations of Organic Agriculture Certification Thailand (ACT, 2012) and the International Federation Organic Movement, IFOAM (International Federation Organic Movement, 2009). All lines of okra were sown under field trial conditions at the Department of Plant Science, Faculty of Technology and Community Development Thaksin University Phatthalung Campus, Phatthalung Thailand (The latitude and longitude of Phatthalung, Thailand is 7° 37' 0" N / 100° 5' 0" E) during

Table 4. Yield and yield components of okra during the first season.

Lines	Chemical agricultural system in 1st season				Organic agricultural system in 1st season			
	Marketable pods/plant	Unmarketable pods/plant	Marketable yields/plant (g)	Unmarketable yields/plant(g)	Marketable pods/plant	Unmarketable pods/plant	Marketable yields/plant(g)	Unmarketable yields/plant(g)
KN-OYV-01	60.23±1.02ab	26.00±0.98bc	1,202.19±12.35ab	371.54±3.35a	45.97±1.42ab	27.27±0.68c	720.81±10.25b	397.54±1.36cd
KN-OYV-02	60.17±0.98ab	30.33±0.69a	1,200.99±14.35ab	433.42±3.65a	45.91±0.98ab	31.35±1.20b	719.87±11.10b	403.75±1.35c
KN-OYV-03	49.67±1.21b	27.00±0.99bc	991.41±13.69b	385.83±4.25a	35.41±1.85bc	28.27±0.82bc	555.23±10.58d	412.83±2.25bc
KN-OYV-04	47.13±2.03b	26.33±0.79bc	940.71±11.65cd	376.26±4.36a	32.87±2.40c	27.60±0.09c	515.40±9.68de	402.59±1.58c
KN-OYV-11	52.70±1.26ab	28.67±1.06ab	1,051.89±11.58bc	409.69±3.58a	38.44±2.07ab	29.94±1.06bc	602.74±7.58c	438.36±2.98ab
KN-OYV-13	50.43±0.89ab	29.00±1.32ab	1,006.58±17.69cd	414.41±2.69a	36.17±1.61bc	30.27±0.74bc	567.15±7.35cd	423.41±3.28b
KN-OYV-14	52.07±3.02ab	28.00±0.79b	1,039.32±14.35bc	400.12±3.69a	37.81±1.38abc	29.27±0.36bc	592.86±12.36cd	428.12±2.67b
KN-OYV-16	46.33±2.98b	29.45±0.98ab	924.75±14.26cd	414.41±2.69a	32.07±4.01cd	31.27±1.01b	502.86±8.06e	443.41±3.19a
KN-OYV-25	59.00±1.78ab	28.67±1.38ab	1,177.64±13.69b	409.69±4.30a	44.74±3.05ab	29.94±2.02bc	701.52±7.69b	438.36±2.52ab
Lucky file 473	66.67±2.69a	23.12±2.03c	1,330.73±14.35a	328.67±1.09b	52.41±2.22a	24.27±0.98d	821.79±9.28a	351.67±1.68d
NO 71	50.53±1.35ab	27.67±2.06bc	1,008.58±14.02cd	395.40±1.98a	36.27±2.41bc	28.94±0.29bc	568.71±10.68cd	412.83±3.57bc
OP	30.90±2.07c	27.00±1.52bc	616.76±12.03e	385.83±2.68a	16.64±1.21e	35.21±0.57a	260.92±12.68g	443.07±3.29a
PC 52S5	40.00±1.06b	28.33±1.35ab	798.40±12.30cde	404.84±3.68a	25.74±1.58cd	29.60±0.46bc	403.60±12.68f	433.17±2.68ab
PJ 03	51.33±1.38ab	28.33±1.68ab	1,024.55±14.36cd	404.84±7.58a	37.07±2.07abc	29.60±0.58bc	581.26±11.25cd	433.17±2.35ab
TVRC 064	48.37±1.98b	28.67±0.74ab	965.47±12.35cd	409.69±2.38a	34.11±1.21bc	29.94±1.10bc	534.84±8.68d	438.36±4.06ab
CV	14.03	3.55	8.20	14.30	14.21	3.15	7.51	12.57

Means followed by asterisks in the same column differ significantly from complete at 1% probability by DMRT test.

Table 5. Yield and yield components of okra during the second season.

Lines	Chemical agricultural system in 2nd season				Organic agricultural system in 2nd season			
	Marketable pods/plant	Unmarketable pods/plant	Marketable yields/plant (g)	Unmarketable yields/plant(g)	Marketable pods/plant	Unmarketable pods/plant	Marketable yields/plant (g)	Unmarketable yields/plant(g)
KN-OYV-01	62.49±1.25a	27.65±0.68cd	1,284.50±11.35ab	395.01±1.35bc	46.14±2.15b	27.61±2.36c	720.98±7.58ab	468.55±1.39a
KN-OYV-02	61.48±2.35a	32.01±0.47a	1,226.83±10.24b	457.29±2.85a	46.20±1.68b	31.69±2.31b	719.92±12.02ab	458.98±2.35a
KN-OYV-03	51.92±1.39ab	29.65±1.02ab	1,036.06±14.25bcd	423.58±3.02ab	35.64±1.68cd	28.61±3.25c	555.34±8.64d	439.98±2.35ab
KN-OYV-04	49.58±1.58bc	27.33±0.25cd	989.37±11.58cd	390.44±2.35c	33.10±2.30cd	27.94±2.35c	515.52±10.32de	423.64±1.58c
KN-OYV-11	54.67±2.36ab	30.22±0.58ab	1,090.94±9.58bc	431.72±1.25ab	38.67±1.98bc	30.28±1.35bc	602.85±11.09c	448.98±1.57a
KN-OYV-13	51.99±3.25ab	29.99±0.98ab	1,037.46±14.25bcd	428.44±4.25ab	36.40±2.06c	30.61±2.36bc	567.26±9.58d	437.22±4.36bc
KN-OYV-14	54.13±1.25bc	30.50±0.78a	1,080.16±12.35bc	435.72±1.67a	38.04±1.25bc	29.61±1.39bc	592.98±6.69d	447.72±3.63a
KN-OYV-16	48.59±1.78bc	29.95±1.02ab	969.61±13.54cd	427.87±2.03ab	32.30±1.06cd	31.61±3.29b	502.97±9.68de	439.87±3.41ab
KN-OYV-25	61.26±0.98a	30.32±1.36a	1,222.44±12.01b	433.15±1.25ab	44.97±2.06bc	30.28±2.87bc	701.64±11.43b	445.15±4.05ab
Lucky file 473	69.11±1.58a	25.45±1.36d	1,379.09±11.36a	363.51±1.41d	52.64±1.09a	24.61±2.19d	821.90±10.68a	375.51±1.39d
NO 71	53.03±1.75ab	29.22±2.08abc	1,058.21±14.25bc	417.44±1.36ab	36.50±2.46c	29.28±1.81bc	568.83±12.28d	429.44±1.55bc
OP	33.22±2.03d	29.06±0.52bc	662.91±12.98e	415.15±2.56bc	16.87±1.06e	35.55±2.04a	261.03±9.98f	427.15±2.98bc
PC 52S5	42.31±2.35c	30.64±0.68a	844.30±10.98d	437.72±2.98a	25.97±1.09d	29.94±2.06bc	403.72±8.67e	449.72±4.39a
PJ 03	53.46±2.05ab	30.49±0.25a	1,066.79±10.58bc	435.58±3.89a	37.30±3.05bc	29.94±2.67bc	581.37±13.35d	447.58±3.68a
TVRC 064	50.53±0.87ab	31.17±1.32a	1,008.33±10.36bcd	445.29±3.36a	34.34±2.97cd	30.28±4.01bc	534.96±12.68d	457.29±2.89a
CV	13.03	3.46	8.65	12.55	11.58	4.68	7.68	12.58

Means followed by asterisks in the same column differ significantly from complete at 1% probability by DMRT test.

Table 6. Number of pods produced in two seasons under the chemical and organic agricultural systems.

Lines	No. of pods/plant (pod) in 1st season		No. of pods/plant (pod) in 2nd season	
	chemical agricultural system	organic agricultural system	chemical agricultural system	organic agricultural system
KN-OYV-01	90.50±2.21a	73.24±1.33b	90.14±2.35ab	73.75±1.35ab
KN-OYV-02	86.23±2.02a	77.26±2.35a	93.49±2.24a	77.89±2.50a
KN-OYV-03	76.67±2.68b	63.68±2.34cd	81.57±3.15c	64.25±2.68bc
KN-OYV-04	73.46±1.68bc	60.47±2.10d	76.91±2.65d	61.04±2.36bc
KN-OYV-11	81.37±2.06ab	68.38±3.26c	84.89±2.45bc	68.95±4.06bc
KN-OYV-13	79.43±1.62b	66.44±3.02c	81.98±1.95c	67.01±3.05bc
KN-OYV-14	80.07±2.00ab	67.08±1.16c	84.63±2.06bc	67.65±1.28bc
KN-OYV-16	75.78±1.71bc	63.34±1.05cd	78.54±2.34d	63.91±1.58c
KN-OYV-25	87.67±2.71a	74.68±0.85b	91.58±3.05ab	75.25±0.98a
Lucky file 473	89.79±1.06a	76.68±0.26a	94.56±1.68a	77.25±0.29a
NO 71	78.20±1.02b	65.21±1.50cd	82.25±1.25c	65.78±1.55bc
OP	57.90±1.01d	51.85±1.09f	62.28±1.06e	52.42±1.58d
PC 52S5	68.33±1.20c	55.34±2.60e	72.95±1.58de	55.91±2.68d
PJ 03	79.66±0.92ab	66.67±3.21c	83.95±0.98bc	67.24±3.23bc
TVRC 064	77.04±1.36b	64.05±2.68cd	81.70±2.39c	64.62±3.26bc
CV	10.67	9.68	8.66	11.64

Means followed by asterisks in the same column differ significantly from complete at 1% probability by DMRT test.

Table 7. Comparison of total yield between two systems.

Lines	Total yields in 1st season		Different yields chemical(+)/ organic(-)	Total yields in 2nd season		Different yields chemical(+)/ organic(-)
	under chemical agricultural system ($T.ha^{-1}$)	organic agricultural system($T.ha^{-1}$)		under chemical agricultural system ($T.ha^{-1}$)	organic agricultural system ($T.ha^{-1}$)	
KN-OYV-01	44.96±1.21ab	31.95±0.98ab	+13.01	47.99±1.20ab	33.99±0.96ab	+14.00
KN-OYV-02	46.70±1.02ab	32.10±1.02ab	+14.59	48.12±0.96a	33.68±1.02ab	+14.43
KN-OYV-03	39.35±0.98c	27.66±1.05c	+11.69	41.70±1.10bc	28.44±2.02b	+13.27
KN-OYV-04	37.63±0.98cd	26.23±1.41cd	+11.40	39.42±0.58c	26.83±1.25bc	+12.59
KN-OYV-11	41.76±1.32b	29.75±0.85ab	+12.01	43.50±1.36b	30.05±1.36ab	+13.45
KN-OYV-13	40.60±1.04bc	28.30±0.96bc	+12.30	41.88±0.82bc	28.70±1.05b	+13.18
KN-OYV-14	41.13±0.95b	29.17±0.85abc	+11.96	43.31±0.76b	29.73±1.25b	+13.58
KN-OYV-16	38.26±0.78c	27.04±0.74c	+11.23	39.93±0.92c	26.94±0.91bc	+12.99
KN-OYV-25	45.35±0.39ab	32.57±1.05a	+12.78	47.30±1.21ab	32.77±2.01ab	+14.54
Lucky file 473	47.41±0.58a	33.53±1.11ba	+13.88	49.79±1.02a	34.21±1.25ab	+15.58
NO 71	40.11±1.35bc	28.04±1.98bc	+12.07	42.16±2.58bc	28.52±2.06b	+13.64
OP	28.65±1.45e	20.11±1.05d	+8.53	30.80±1.25e	19.66±1.25d	+11.14
PC 52S5	34.38±0.15cd	23.91±1.05cd	+10.47	36.63±2.35d	24.38±1.02c	+12.25
PJ 03	40.84±2.30bc	28.98±1.68bc	+11.86	42.92±1.68bc	29.40±0.36b	+13.53
TVRC 064	39.29±2.21c	27.81±1.38c	11.48	41.53±1.14bc	28.35±0.87b	+13.18
CV	7.02	9.25		9.36	7.98	

Means followed by asterisks in the same column differ significantly from complete at 1 % probability by DMRT test.

Table 8. Meteorological information in Phatthalung province Thailand.

The first season	Temperature/Month (°C)			Relative Humidity (RH) (%)			Rain	
	Maximum	Minimum	Averages	Maximum	Minimum	Averages	water	Day
June	33.83	24.95	29.39	93.20	58.30	75.75	130.20	13.00
July	32.89	24.15	28.52	93.87	59.97	76.92	74.30	12.00
August	32.40	23.90	28.15	93.87	62.16	78.02	173.20	11.00
September	32.00	24.40	28.20	93.00	63.00	78.00	178.70	14.00
October	31.00	24.10	27.55	94.00	70.00	82.00	333.00	22.00
The second season	Temperature/Month (°C)			Relative Humidity (RH) (%)			Rain	
	Maximum	Minimum	Averages	Maximum	Minimum	Averages	water	Day
December	28.90	24.00	26.45	95.00	78.00	86.50	631.90	26.00
January	29.90	24.10	27.00	95.00	74.00	84.50	435.10	19.00
February	32.00	24.40	28.20	90.00	65.00	77.50	22.50	6.00
March	32.70	24.40	28.55	93.00	65.00	79.00	83.30	13.00
April	33.20	24.80	29.00	93.00	64.00	78.50	121.30	18.00

two seasons. The first season was conducted between June and October 2011 and the second season was planted between December 2011 and April 2012. Before planting, sunhemps (*Crotalaria juncea* L.) were planted and practiced out by thoroughly ploughing for soil improvement for one season. The plot was sized 1 x 7 m (7 m^2). Three okra seeds were dropped in each hole. Plant to plant and row to row spacing was maintained at 75 cm and 75 cm, respectively. The rows were planted in pairs (Fig. 1). Seven days after planting, they were separated and only one plant was left in the hole. The experimental design was a Randomized Complete Block Design (RCBD) with four replications and eighteen plants/replication. Afterwards, the full rate of NPK (inorganic agricultural system) 15-15-15 (650 $kg\cdot ha^{-1}$) and the full rate of compost manure (organic agricultural system) were applied at 650 $kg\cdot ha^{-1}$. Two types of fertilizers (inorganic and organic) were applied twice. The first time, fertilizer would be put in the bottom of the hole after the soil had already been prepared. The second time, fertilizer would be filled around the hole again, approximately 28 days after planting. Conventional agronomic practices were followed to keep the crop in good condition. Weeds could be eliminated by pulling them out and using a hoe to dig them out. Disease and insects infestations were protected by pesticides under the inorganic agricultural system and by biological control under the organic agricultural system. Okra harvesting was carried out when the pods were still fresh. Fresh pods were collected 3 – 5 days after flowering.

Data records

Important morphological characteristics of pod including marketable pods/plant (pod length between 4 and 9 cm), unmarketable (pods were destroyed by diseases and insects) pods/plant, yields/plant were measured for 50 pods/treatment. In addition, the height at 50% flowering, the first date flowering, number of branches, leaf area, pod length, pod diameter, seeds/pod and 100 seeds weight were also measured.

Statistical analysis

All measurements in this study were subjected to analysis of variance (ANOVA) using the statistical program of SPSS (Statistical Package for the Social Science for Windows) version 16.0. Means were separated using the Duncan's New multiple Range Test (DMRT) at 1% probability level (Table 2).

Discussions

Experiments to evaluate the yield and yield components of 15 okra lines under agro-chemicals at Thaksin University, Thailand, in 2011 and 2012, showed the height at 50% flowering, first date flowering, number of branches, leaf area, pod length and pod diameter marketable pods, unmarketable pods, marketable yields, unmarketable yields, seeds/plant and 100 seed weight showed differences statistically significant in all lines (some data not shown). This is consistent with the report of Benjawan et al., 2007. In addition, Saifullah and Rabbani (2009) reported similar experimental results. However, the yield components tested are different in term of terrain and climate (Fajinmi and Fajinmi, 2010; Benchasri, 2011). Abbas et al. (2011) reported that chemical agricultural production plants can utilize advantage nutrients faster and better than the organic farming system. However, the preliminary data showed that 15 okra lines can be grown commercially because a higher than average yield of okra worldwide is 6.6 tons per hectare (Varmudy, 2011). An evaluation of yield and yield components of 15 okra lines under organic farming during both seasons showed that high first flowering branches, pod number against number of sheaths, pod weight, best weight sheath, weighs 100 seeds/pod, height at 50% flowering, leaf areas, pod length and pod diameter (some data not shown) showed different statistical significance when tested under the same cultivation agriculture in the same inorganic agricultural system. However, it was found that the yield and yield tested with different out method under organic agricultural system were less than yield and yield components under chemical agricultural system (Okwuagwu et al., 2003; Odeleye et al., 2005; Akande et al., 2010; Tiamiyu et al., 2012). This result corresponds to the test crops planted during the growing season, under regular (chemical) and under organic fertilizer. It was found that the average yield and yield components under test cultivated under chemical rather than organic (Anant and Manohar, 2001; Gundopant, 2001; Attigah et al., 2013) or comparing the yield of green beans is the same effect (Naeem et al., 2006). Abbas et al. (2011) reported that some of plant nutrients, when added to the soil in the inorganic form have low efficiency when comparing to the effect of inorganic fertilizers (Olusegun, 2014). However, the yield and yield components of okra produced and managed under organic agricultural system were less than that under the organic agricultural system, and under organic useful for soil improvement and environment conservation (Tiamiyu et al., 2012).

The present study quantitatively compares the influence of temperature, the level of relative humidity and rain on development times. The average monthly temperature for the two years ranged from 26.45°C to 29.39°C, while the average relative humidity ranged between 75.75% and 86.50%. The average monthly temperature and relative humidity ranges were considered optimal for the growth and development of okra. Katung (2007) reported optimum growth and development for okra at a temperature of 32°C, while Benchasri (2013) observed an improvement in the performance of okra with the relative humidity range of 70 to 85%. Similar results were reported by Ijoyah et al. (2010) and Chinatu et al. (2014). Moreover, soil treatments affect the release of elements (Akande et al, 2003; Owolarafe and Shotonde, 2004), day photoperiod (Dilruba et al., 2009; Udengwu, 2009) and rainy season impact on the okra yields (Olasotan, 2001).

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