The effect of genotypic variability on the yield and yield components of okra (Abelmoschus esculentus L. Moench) in Thailand

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Abstract
This study was conducted on twenty of okra lines (treatments) at the Thaksin University in two farming systems (conventional and organic cultivations). The experiments of conventional and organic cultivations were carried out in a Randomized complete block design (RCBD) with four replications to evaluate the yield, yield components and genetic variations. The results showed significant variability (p≤0.05) in the okra lines for fresh important traits of yield; marketable fruits.plant\(^{-1}\), fruit yields.plant\(^{-1}\), seeds.fruit\(^{-1}\), 100 seed weight, 1000 seed weight and harvest index. The number of marketable fruits.plant\(^{-1}\) of KN-OYV-02 line showed the number of marketable fruits yield approximately 60.85 and 51.91 fruits.plant\(^{-1}\) under the conventional and organic farming systems, respectively. The lowest of marketable fruits.plant\(^{-1}\) were investigated in the OP (Open Pollination) line (30.58 and 26.74 fruits.plant\(^{-1}\) under the conventional and organic farming systems, respectively). KN-OYV-02 line produced the highest yield of two farming system (1,168.37 g.plant\(^{-1}\)). The OP line produced the lowest yield under the organic farming system (505.16 g.plant\(^{-1}\)). There were significant interactions between the cropping system and lines for the two system plantations. So, the results indicated that the KN-OYV-02 line showed the highest potential for okra breeding and production in both systems.

Keywords: Gene interactions, Line, Okra, Yield components

How to cite this:
Benchasri S Simla S and Harakotr B, 2020. The effect of genotypic variability on the yield and yield components of okra (Abelmoschus esculentus L. Moench) in Thailand. Asian J. Agric. Biol. 8(4): 480-490. DOI: https://doi.org/10.35495/ajab.2019.12.597

Introduction
Okra or ladies finger was domesticated in West and Central Africa and is now widely cultivated throughout the tropics primarily for local consumption (Kumar et al., 2010; Chinatu et al., 2014). Okra, the most popular vegetable crop in Asia and Africa (Zeshan et al., 2019), is thought to be a native crop extending from Ethiopia to Sudan. Although the early-history and distribution are not known, okra was apparently introduced to Egypt in the seventh century. Okra is considered to be a prized vegetable due to its high nutrient value (Dabire-Binso et al., 2009). Normally, okra green fruits are rich sources of...
carbohydrate, protein, dietary fiber, calcium, magnesium, potassium, and vitamins A and C etc. [Water 90%, Energy (kcal) 38, Carbohydrate (g) 7.6, Protein(g) 2.0, Fat (g) 0.1, Fiber (g) 0.9, K (mg) 303, Ca (mg) 81, P (mg) 63, Fe (mg) 0.8, Na (mg) 8, Vitamin A (IU) 660, Thiamine (mg) 0.20, Riboflavin (mg) 0.06, Niacin (mg) 1.00, Ascorbic acid (mg) 21.1 and Vitamin B6 (mg) 0.22]. Okra is also an excellent source of iodine, which is useful for the treatment of goiter (Liu et al., 2005; Benchasri, 2015). The green fruits can be boiled, fried or cooked. In Thailand and Asia, this vegetable is usually boiled in water resulting in viscous soups and sauces, which are relished. The fruits also serve as soup thickeners. The leaves buds and flowers are also edible. Okra seeds can be dried, and the dried seed is a nutritious material that can be used to prepare vegetable curds. The seeds can also be roasted and ground and used as a coffee additive or substitute. Okra leaves are often used as cattle feed, but this use is not the primary use of the plant. The powdered root of okra is consumed with sugar as a treatment for leucorrhoea backache. Okra acts as a tonic for both men and women and enables them to increase their vitality and vigor. Mucilage from the stem and roots is used for purifying sugarcane juice in jaggery manufacturing in many countries. Fully ripened fruits and stems containing crude fiber are used in the paper industry. Okra gum obtained from the seedfruits of A. esculentus is an anionic polysaccharide, which can be used as flocculant for the removal of solid wastes from tannery effluent (Moekchantuk and Kumar, 2004; Pendre et al., 2012). Industrially, okra mucilage is typically used to glace certain papers and in confectioneries, among other uses (Markose and Peter, 1990). Over the past 50 years, high agricultural input levels have been used to maximized yields and profits with the aim of feeding the global population. However, these inputs have generated negative impacts on the atmosphere, hydrosphere, and pedosphere (Osma et al., 2012; Arbenz et al., 2017). The increased chemical composition of vegetables and other foodstuffs has become a substantial issue (Manond et al., 2011; Amalraj et al., 2013; Duman et al., 2018). Therefore, organic farming has long been viewed as a sustainable form of management for mitigating the present and potential risks within agro-ecosystems (Pradeepkumar et al., 2017; Suja et al., 2017). Organic farming systems aim to provide a cleaner environment and more fertile soil for future generations via the maintenance of soil organic matter, recycling of carbon, improvement of soil health, reduction of farm nitrogen and phosphorus, increase in biodiversity, reduction in energy use and improvement in energy efficiency (Ghaouti et al., 2008; Aiyelaagbe et al., 2016).

Okra plantation in Thailand, is mostly cultivated in many areas such as Anghthon, Bangkok, Kanchanaburi, Nakornproton, Saraburi, Supanburi, Phatthalung and Phichit provinces, respectively. The area, and productivity of okra in Thailand are approximately 1,996.80 ha and 11,232 tons.ha⁻¹, respectively (Benchasri, 2015). However, okra cultivars with good adaptations to organic farming systems have rarely been reported in Thailand. Thus, comparing the of yield, yield components and variability in genetics under two cropping system of conventional and organic farming are the most important for providing recommendations for okra breeding program and growth in the future. The objectives of this study were to compare the crop performance in difference of okra lines in terms of productivity and reactions of combined analysis of variance after growing in conventional and organic system in Thailand. Finally, selected of suitable genotype of all population with adaptations in both cultivations, identify okra cultivars that exhibit good adaptations to conventional and organic systems. The information data obtained in this study will be useful for providing suggestions for okra breeding program and growth under conventional and organic systems in Thailand.

Material and Methods

Plant materials and experimental conditions

Twenty lines of okra (treatments) including FAK DANG, KN–OYV–01, KN–OYV–02, KN–OYV–03, KN–OYV–04, KN–OYV–11, KN–OYV–12, KN–OYV–13, KN–OYV–14, KN–OYV–16, KN–OYV–25, LUCKYFILE 473, NO–71, OP (Open Pollination, Control line), PC52S5, PI 03, RED FINGER, RED 322, TVRC 064 and TVRC 064, respectively (Table 1) were selected from different areas. Evaluations of the okra lines were carried out in a randomized complete block design with four replicates in conventional and organic systems at the Department of Plant Science, Faculty of Technology and Community Development, Thaksin University Phatthalung Campus, Phatthalung Province, Thailand between January and June 2018.
Table 1. Line information, source of origins and some characteristics of twenty okra germplasm in the experimental research

| No. | Lines/codes  | Sources                  | Original sources      | Flower, Stem color, Pod color       |
|-----|--------------|--------------------------|-----------------------|-------------------------------------|
| 1   | FAK DANG     | Phatthalung Province     | Thailand              | Red, red, yellow                    |
| 2   | KN-OYV-01    | PHRC (India)             | India                 | Light green, green, yellow          |
| 3   | KN-OYV-02    | PHRC                     | India                 | Reddish green, green, yellow        |
| 4   | KN-OYV-03    | PHRC                     | India                 | Dark green, green, yellow           |
| 5   | KN-OYV-04    | PHRC                     | India                 | Light green, green, yellow          |
| 6   | KN-OYV-11    | PHRC                     | India                 | Dark green, green, yellow           |
| 7   | KN-OYV-12    | PHRC                     | India                 | Light green, green, yellow          |
| 8   | KN-OYV-13    | PHRC                     | India                 | Light green, green, yellow          |
| 9   | KN-OYV-14    | PHRC                     | India                 | Dark green, green, yellow           |
| 10  | KN-OYV-16    | PHRC                     | India                 | Light green, green, yellow          |
| 11  | KN-OYV-25    | PHRC                     | India                 | Reddish green, green, yellow        |
| 12  | LUCKY FILE 473 | Bangkok Province       | Japan                 | Light green, white, yellow         |
| 13  | NO 71        | PHRC                     | India                 | Dark green, green, yellow           |
| 14  | OP (CONTROL) | Phatthalung Province     | Thailand              | Dark green, green, yellow           |
| 15  | PC 52S5      | PHRC                     | Thailand              | Light green, green, yellow          |
| 16  | PJ 03        | PHRC                     | Thailand              | Light green, green, yellow          |
| 17  | RED FINGER   | Beijing                  | China                 | Red, red, yellow                    |
| 18  | RED 322      | Pahang                   | Malaysia              | Red, red, yellow                    |
| 19  | TVRC 06      | PHRC                     | India                 | Dark green, green, yellow           |
| 20  | TVRC 064     | PHRC                     | India                 | Dark green, green, yellow           |

PHRC = Phichit Horticulture Research Center

Prior to the start of the experiment, the soil at the two experimental sites was ploughed and sowed with Crotalaria juncea L. as a green manure to improve soil conditions and provide fixed nitrogen for the crops. The soil was ploughed again at the flowering of sun hemp or 60 d after sowing. For both trials, seeds (~3 seeds) were directly planted. The plant to plant and row to row spacing were both maintained at 75 cm. The rows were planted in pairs. Therefore, each plot treatment had maintained 12 plants. One week after planting, only one plant was left in each hole. Conventional fertilizer (N-P-K, formula 15-15-15) was pitched to the conventional trial, and compost manure was pitched to the organic trial, at a rate of 650 kg ha⁻¹ (Benchasri, 2012). The full rates of the fertilizers (organic and conventional) were applied in two rounds at the rate of 325 kg ha⁻¹ at planting and at 28 day after planting. Weeds were eliminated by manually removing them and by conventional hoeing. Insect and disease infestations were treated with pesticides under the conventional farming system and by biological controls under the organic farming system. Okra fruit harvesting was done when the fruits were still fresh. Fresh fruits (at green state) were picked between 3–5 day after flowering (Benchasri, 2012). The meteorological data between planted shows that air temperatures of okra plantings in the two farming systems ranged from 23.60 to 35.70°C. The average air temperature was 28.44°C. The relative humidity values were between 51.00 and 99.00% and the average relative humidity value was 79.13% (Fig. 1A). The number of rain days ranged from 2 to 19 d.mon⁻¹ (Fig. 1B).

Figure 1. Weather conditions during plantation of twenty okra

Data collection

Soil and meteorological conditions

The survival percentage of plant was recorded at 28 day after planting from a total of 48 plants in each treatment. The chemical properties and soil contents were analyzed. The weather conditions for this experiment, including humidity, rainfall, and air temperature (minimum, maximum and average air temperature), were also recorded monthly between planting.
**Yield and important of young fruit trials**

The important morphological characteristics of green okra such as plant height (8\textsuperscript{th} week after planting), first day of flowering, number of branches, plant\textsuperscript{1}, stem diameter, fruit length, fruit circumference, marketable fruits, plant\textsuperscript{1}, seeds, fruit\textsuperscript{1}, 100 seed weight and 1,000 seed weight were manually analyzed of 80 fruits, treatment\textsuperscript{1}. In addition, fresh fruit yield and harvest index were also recorded for the twenty lines. Okra fruit should be harvested at horticulture maturity state or green fruit while still tender, which is usually 3-5 day after flowering. Fresh fruits length around 4-10 cm were harvested in each treatment. Okra should be harvested two to three times a week. Regular picking increases yield.

**Statistical analysis**

Randomized complete block design was investigated in this research (Table 2). Statistical Package for Social Science for Windows were used all analyses. Significant differences between the treatments were applied using the Duncan Multiple Range Test at a 0.05 probability level. Each system (conventional and organic) were statistically analyzed for fruit yield and yield components traits in Table 3. Error of variances were proved for homogeneity with Bartlett’s Test as described by Gomez and Gomez (1984). The variance of combined analysis was investigated for the two environments (production farming systems) using to a statistical model (Freeman, 1973).

**Results**

**Soil content, plant survival and weather conditions**

The soil content for this research is shown in Table 4. Under the conventional farming system, the soil had 1.15\% organic matter, 0.16-0.14\% total nitrogen content, 35.33-36.01 mg.kg\textsuperscript{-1} phosphorus, 81.35-63.01 mg.kg\textsuperscript{-1} potassium, and 0.08 dS.m\textsuperscript{-1} electric conductivity (EC). Under the organic farming, the soil had organic matter, nitrogen contents phosphorus, potassium and electric conductivity before planting of 1.14\%, 0.16\%, 39.58 mg.kg\textsuperscript{-1}, 43.67 mg.kg\textsuperscript{-1} and 0.08 dS.m\textsuperscript{-1}, respectively.

**Table-2. Statistical model of variance in the study**

| Variation source | Degrees of Freedom | Sum of Square | Mean of Square | F  |
|------------------|--------------------|---------------|----------------|----|
| Treatment        | t-1                | SST = \sum_{i=1}^{t} T_i^2 / (b-1) | SST/(t-1) | MST/MSE |
| Block            | b-1                | SSR = \sum_{j=1}^{b} B_j^2 / (t-1) | SSR/(b-1) | MSR/MSE |
| Error            | (t-1)(b-1)         | SSE = Total SS - SST - SSR | SSE/(t-1)(b-1) | |
| Total            | t.b-1              | Total SS = \sum (X_{ij} - CF)^2 | |

**Table-3. Combined analysis of variance for twenty okra lines in conventional and organic cropping system.**

| Source of variences | DF | MS     | Expected Mean Square |
|---------------------|----|--------|----------------------|
| Systems (S)         | s-1| MS (System) | \sigma^2 + \sigma^2 + \sigma^2 |
| Blocks. Within S    | s(r-1)| MS (Blocks within S) | \sigma^2 + \sigma^2 + \sigma^2 |
| Lines (L)           | 1-1 | MS (Line) | \sigma^2 + \sigma^2 + \sigma^2 |
| S x L               | (s-1)(r-1)| MS (System x Line) | \sigma^2 + \sigma^2 + \sigma^2 |
| Pooled error        | s(r-1)(r-1)| MS (Error) | \sigma^2 + \sigma^2 + \sigma^2 |
| Total               | srl-1|         | |
Table 4. Soil chemical properties.

| Soil properties | Conventional | Organic |
|-----------------|--------------|---------|
|                 | Before | After | Before | After |
| Nitrogen (N)    | 0.16%  | 0.14% | 0.16%  | 0.15% |
| Organic matter  | 1.15%  | 1.15% | 1.14%  | 1.16% |
| P<sub>2</sub>O<sub>5</sub> (mg kg<sup>-1</sup>) | 35.33  | 36.01 | 39.58  | 39.98 |
| K (mg kg<sup>-1</sup>) | 81.35  | 63.01 | 43.67  | 37.99 |
| pH (H<sub>2</sub>O) | 4.57   | 4.58  | 4.57   | 4.59  |
| EC (dS.m<sup>-1</sup>) | 0.08   | 0.08  | 0.08   | 0.09  |
| Soil texture    | clay loam | clay loam | clay loam | clay loam |

Twenty lines of okra were evaluated for plant survival 28 days after planting. The survival percentages ranging from 79.97 to 96.17% and 72.01 to 94.12% were recorded under the conventional and organic farming systems, respectively. KN-ONYV-02 had the highest survival percentages with 96.17 and 94.12% under the conventional and organic farming systems, respectively. NO 71 had the lowest survival percentages with 79.97% under conventional farming system and 72.01% under the organic farming system. Other lines are shown in Fig. 2. In general, the conventional farming system had a higher survival percentage than the organic farming system. Because insect pest and disease infestations were treated with pesticides under the conventional farming system, on the other hand biological controls were treated under the organic farming system. NO 71 exhibited the highest difference (7.96%) between the conventional and organic farming systems.

Fruit yield and yield components of okra

The important characteristics of okra lines cultivated in the organic and conventional farming systems were significantly different (p≤0.05) in almost traits. Plant height, first day of flowering, lateral branches.plant<sup>-1</sup>, stem diameter, fruit circumference, marketable fruits.plant<sup>-1</sup>, 100 seed weight, seeds.fruit<sup>-1</sup>, 1,000 seed and fruit harvest index under the conventional farming system are presented in Table 5.

In the organic farming system, okra lines were also significantly different (p≤0.05) for plant height, first day of flowering, lateral branches.plant<sup>-1</sup>, stem diameter, fruit circumference, marketable fruits.plant<sup>-1</sup>, seeds.fruit<sup>-1</sup>, 100 seed weight, 1,000 seed and harvest index. The yield.plant<sup>-1</sup> was also significantly different (p≤0.05). NO 71 had the highest 100 seed weight (8.43 g), white PJ03 had the lowest 100 seed weight (4.47 g) (Table 6). However, middle fruit circumferences were not statistically significantly different between the systems.

![Graphical representation of yield and yield components in 20 okra seed for different cropping](image)

At the termination of the experiment in each system, marketable fruits.plant<sup>-1</sup>, yield.plant<sup>-1</sup>, seeds.fruit<sup>-1</sup>, 100 seed weight, 1,000 seed weight and the harvest index were estimated in each production system. The results showed that the conventional farming system had higher marketable fruits.plant<sup>-1</sup>, yield.plant<sup>-1</sup> and seeds.fruit<sup>-1</sup> than the organic farming system across all lines. The one exception was that the harvest index in the conventional farming system was lower than that in the organic farming system in across all lines. On the other hand, 100 seed weight and 1,000 seed weights were distributed (Fig. 3).
Table 5. Phenotypic traits of 20 okra lines from conventional and organic cropping systems, respectively

| No. Lines | Plant height (cm) | First day flowering (day) | Lateral branches, plant\(^1\) | Stem diameter (cm) | Fruit length (cm) | Fruit circumference (cm) | Mean phenotypic effects from the organic farming system |
|-----------|------------------|--------------------------|-----------------------------|-------------------|------------------|------------------------|---------------------------------------------------|
|           |                  |                          |                             |                   |                  |                        | No. Lines                                           |
| 1 FAKDANG | 154.25bcd        | 42.25bc                  | 5.36bcd                     | 6.16bc            | 8.54bcd          | 4.61def                | 10.25                                            |
| 2 KN-OYV-01 | 171.49ab        | 42.05bc                  | 5.01cd                      | 6.17bc            | 8.40bcd          | 5.14e2                 | 20.91                                            |
| 3 KN-OYV-02 | 150.35bcd       | 40.68cd                  | 5.01cd                      | 6.08bcd           | 8.07bcd          | 5.26cd                 | 20.67                                            |
| 4 KN-OYV-03 | 157.58bcd       | 43.58b                   | 5.31de                      | 6.25bc            | 8.47bcd          | 6.63ab                 | 20.87                                            |
| 5 KN-OYV-04 | 165.58bc        | 40.68ecd                 | 5.61bcd                     | 6.31ab            | 7.40de           | 6.00bc                 | 20.83                                            |
| 6 KN-OYV-11 | 173.59a         | 40.68cd                  | 5.13bcd                     | 6.17bc            | 7.90e2           | 4.60def                | 20.64                                            |
| 7 KN-OYV-12 | 171.59ab        | 40.68ecd                 | 5.33bcd                     | 6.43a             | 8.46bcd          | 4.04d                  | 20.60                                            |
| 8 KN-OYV-13 | 170.36ab        | 40.61c                   | 4.11de                      | 6.19bc            | 8.90bcd          | 4.83e2                 | 20.59                                            |
| 9 KN-OYV-14 | 167.68bc        | 40.68d                   | 3.31f                       | 6.23ab            | 8.83bcd          | 4.85e2                 | 20.58                                            |
| 10 KN-OYV-16 | 171.96ab        | 40.32o                   | 6.14b                       | 6.20bc            | 8.20bcd          | 5.23e2                 | 20.56                                            |
| 11 KN-OYV-25 | 163.39bcd       | 44.63b                   | 6.01b                       | 6.49a             | 9.00ab           | 5.20e2                 | 20.54                                            |
| 12 LUCKYFILE 473 | 187.58a     | 43.36bc                  | 6.18b                       | 6.16bc            | 12.45a           | 6.97a                  | 20.49                                            |
| 13 NO 71     | 151.25bcd       | 41.65cd                  | 4.45cd                      | 6.30ab            | 9.47ab           | 6.23ab                 | 20.45                                            |
| 14 PC 525S   | 134.48de        | 45.68ab                  | 4.78cd                      | 6.48a             | 7.90e2           | 5.00e2                 | 20.37                                            |
| 15 PJ 03     | 69.58f          | 44.58b                   | 5.74bcd                     | 6.21bc            | 9.17ab           | 4.23e2                 | 20.34                                            |
| 16 RED FINGER | 157.18bcd      | 40.28de                  | 5.68cd                      | 6.18bc            | 9.47ab           | 5.20e2                 | 20.32                                            |
| 17 RED 322   | 156.88bcd       | 40.58d                   | 5.78bc                      | 6.20bc            | 9.46ab           | 5.13e2                 | 20.31                                            |
| 18 TVRC 06   | 152.25cd        | 41.69cd                  | 6.11b                       | 6.27ab            | 10.0a            | 4.24e2                 | 20.30                                            |
| 19 TVRC 064  | 99.58e          | 42.25bcd                 | 5.79bcd                     | 6.21ab            | 11.45a           | 6.07abc                | 20.29                                            |
| 20 OP (CONTROL) | 177.35a     | 48.63a                   | 8.88a                       | 6.17bc            | 7.23e2           | 5.13e2                 | 20.28                                            |
| C.V.         | 10.25           | 10.25                    | 9.31                        | 14.02             | 12.47            | 9.67                   | 9.28                                             |

Means in the same column followed by the same letter(s) are not significantly different at P≤0.05 by DMRT.

**Combined analysis of variance in different systems**

The results of combined analysis of variance indicated that the differences between systems (S) and among Lines (L) were significant for marketable fruits, plant\(^1\), yield, plant\(^1\), seeds, fruit\(^1\), 100 seed weight, 1,000 seed weight and the harvest index. There were also significant interactions between the systems and lines (S X L) for the marketable fruits, plant\(^1\), yield, plant\(^1\), seeds, fruit\(^1\), 100 seed weight, 1,000 seed weight and harvest index for the conventional and organic farming systems (Table 7). The variation of replications within the systems for all traits was non-significant. In the results of the okra cultivations at different farming system of; conventional and organic, showed the yield generally of organic treatment lower than conventional system. But the interaction between the farming system and okra germplasms also detected from the experiments. The interactions showed the superior yield of KN-OYV-02 line in conventional farming, of KN-OYV-02 line in organic farming, because of the better marketable fruits, plant\(^1\) and higher yield, plant\(^1\).
Table 6. Mean performance of marketable fruit yield and physical components of 20 okra after cultivated in conventional and organic systems

| No. | Lines          | Marketable fruits.plant⁻¹ (fruit) | Yield.plant⁻¹ (g) | Seeds.fruit⁻¹ (seed) | 100 seed weight (g) | 1000 seed weight (g) | Harvest index(d) |
|-----|----------------|----------------------------------|-------------------|---------------------|---------------------|----------------------|------------------|
| 1   | FAKDANG        | 38.2bfg                          | 741.10ef          | 81.46d              | 6.58def             | 66.86d               | 41.15ab          |
| 2   | KN-OYV-01      | 52.35ab                          | 1013.49ab         | 92.55bc             | 6.68def             | 65.68d               | 43.25ab          |
| 3   | KN-OYV-02      | 60.85a                           | 1168.37a          | 110.21a             | 8.72a               | 74.55cd              | 46.41ab          |
| 4   | KN-OYV-03      | 49.91abc                         | 966.25bc          | 98.21ab             | 8.33bc              | 83.83bc              | 41.12abc         |
| 5   | KN-OYV-04      | 48.81bcd                         | 944.96bc          | 90.25bcd            | 8.45bc              | 85.55abc             | 42.34ab          |
| 6   | KN-OYV-11      | 51.38ab                          | 994.70b           | 86.98cd             | 7.44cd              | 75.74cd              | 40.45bcd         |
| 7   | KN-OYV-12      | 48.25bdc                         | 934.12bc          | 95.47abc            | 8.34bc              | 82.48bc              | 39.15de          |
| 8   | KN-OYV-13      | 52.11ab                          | 999.84bc          | 102.25ab            | 8.65ab              | 87.58ab              | 39.34de          |
| 9   | KN-OYV-14      | 51.75ab                          | 999.88bc          | 99.68ab             | 8.65bc              | 87.35ab              | 42.33ab          |
| 10  | KN-OYV-16      | 44.01def                         | 852.03def         | 85.67dc             | 8.46bc              | 85.12abc             | 40.48bcd         |
| 11  | KN-OYV-25      | 49.68bdc                         | 961.80bc          | 63.12de             | 4.92ef              | 50.94e               | 36.82de          |
| 12  | LUCKYFILE 473  | 60.35a                           | 1158.06a          | 92.48bcd            | 7.79cd              | 80.64bc              | 48.61a           |
| 13  | NO 71          | 50.21ab                          | 972.06bc          | 97.57abc            | 8.74a               | 86.14abc             | 40.08bcd         |
| 14  | PC 5255        | 35.68f                           | 690.76f           | 84.01cd             | 7.45cd              | 73.21cd              | 38.19e           |
| 15  | PJ 03          | 42.01def                         | 813.31def         | 54.34e              | 4.75f               | 46.55e               | 39.12de          |
| 16  | RED FINGER     | 49.35ab                          | 1003.49ab         | 89.68cd             | 6.87df              | 90.75a               | 40.11bcd         |
| 17  | RED 322        | 53.75ab                          | 867.89de          | 98.68ab             | 8.96a               | 68.26d               | 38.57de          |
| 18  | TVRC 06        | 45.01cde                         | 822.99def         | 87.69cd             | 8.67ab              | 86.24abc             | 41.58abcd        |
| 19  | TVRC 064       | 42.51cde                         | 871.39de          | 87.36cd             | 8.17cde             | 82.17bc              | 35.47e           |
| 20  | OP (CONTROL)   | 30.58f                           | 592.03f           | 84.44cd             | 7.78cde             | 76.28cd              | 32.82e           |
| CV  | 8.25           | 12.54                            |                   |                     |                     |                     | 10.24            |

Means in the same column followed by the same letter (s) are not significantly different at P≤0.05 by DMRT.

Table 7. Mean squares for yield and yield component on okra plantation.

| Source of variances | DF | Marketable fruits.plant⁻¹ (fruit) | Yield.plant⁻¹ (plant) | Seeds.fruit⁻¹ (seed) | 100 seed weight (g) | 1000 seed weight (g) | Harvest index(d) |
|---------------------|----|----------------------------------|----------------------|---------------------|---------------------|----------------------|------------------|
| Systems (S)         | 1  | 2,098.49*                        | 26,867.68*           | 4,498.87*           | 2,289.38*           | 2,494.35*           | 3,895.54*        |
| Blocks. Within S    | 6  | 275.27ns                         | 854.15ns             | 209.25ns            | 66.11ns             | 324.10ns            | 305.02 ns        |
| Lines (L)           | 19 | 2,142.51*                        | 28,248.25*           | 4,009.94*           | 1,067.98*           | 2,287.26*           | 3,632.35*        |
| S x L               | 19 | 958.31*                          | 22,454.68*           | 2,915.14*           | 1,537.94*           | 2,032.55*           | 3,438.31*        |
| Pooled error        | 114| 164.63                           | 725.48               | 114.82              | 48.74               | 287.45              | 121.23           |

*significant difference at P ≤ 0.05, ns = not statistically significantly different.
Asian J Agric & Biol. 2020;8(4):480-490. 487

Sorapong Benchasri et al.

Table-8. Comparison fruit components of 20 okra lines grown from conventional and organic farming.

| Systems      | Marketable fruits/plant \(^1\) (fruit) | Yield/plant \(^1\) (plant) | Seeds/fruit \(^1\) (seed) | 100 seed weight (g) | 1000 seed weight (g) | Harvest index(d) |
|--------------|---------------------------------------|----------------------------|---------------------------|---------------------|---------------------|------------------|
| Conventional | 47.84a                                | 918.43a                    | 89.11a                    | 7.72a               | 76.80a              | 40.37b           |
| Organic      | 40.80b                                | 775.51b                    | 81.55b                    | 6.86b               | 69.26b              | 50.45a           |
| Means        | 44.32                                 | 846.97                     | 85.33                     | 7.29                | 73.03               | 45.41            |

Means in the same column followed by the same letter(s) are not significantly different at P≤ 0.05 by DMRT

Mean analysis between systems

Mean analysis of marketable fruits/plant\(^1\), yields/plant\(^1\), seeds/fruit\(^1\), showed significant differences between the conventional and organic farming systems. There were also significant differences in 100 seed weight and 1,000 seed weights under the conventional and organic farming systems, respectively. The conventional farming system generated higher yields than the organic farming system across all lines. However, the harvest index period in the organic farming system was longer than that in the conventional farming system across all okra lines (Table 8).

Discussion

Germination percentage is an estimate of the viability of the population on okra seeds. The present study of germination percentage for okra under the conventional farming system was higher than that under an organic farming system. Abouziena and Haggag (2016) had reported that weed control, disease and pest infestations were treated by chemical pesticides of okra production under the conventional farming systems. On the other hand, the main principle of organic okra production was the avoidance of synthetic pesticides to protect okras from pests and diseases. As a physical control measure and biological control were evaluated under field conditions (Afe and Oluleye, 2017).

The yield components of okra lines cultivated in the organic and conventional farming systems were significantly different (P≤0.05) in almost traits. The conventional farming system had higher the plant height, first day of flowering, lateral branches/plant\(^1\), stem diameter and fruit circumference than the organic farming system across all lines. The one exception was that the harvest index in the conventional farming system was lower than that in the organic farming system in across all lines. The harvest index might be attributed to the variation environmental factors, the genetic potential of the lines, or the differential ability of the lines to absorb nutrients (Yadav et al., 2013).

The results of this study are consistent with work by Shivaramegowda et al. (2016), who reported significant differences in plant height, leaf length, canopy and yield/plant\(^1\) in okra crops due to genetic factors and environmental conditions. All data information, farmers can able to decide the production system according to their needs in the future (Benchasri, 2015).

Okra lines grown through organic agricultural system had lower important morphological characteristics of green okra such as marketable fruits/plant\(^1\) and yield/plant\(^1\). This difference most likely, arises because the okra production under the conventional farming system was protected by pesticides, which prevented damage by fungal pathogens and insects, while the unprotected system of organic agricultural production reduced the ability of plants to growth (Döring et al., 2012). These results were similar to those reported by Benchasri and Pruthikane (2018). Average yield and yield components of plants tested under the inorganic and organic systems were significantly different (Narkhede et al., 2011). Total yields revealed that production under the inorganic agricultural system was approximately 20-65% higher than that under the organic agricultural system. However, Yadav et al. (2013) observed that the costs of organic manure and chemical fertilizers were different. When profits between conventional and organic farming are compared, plants grown under an organic agricultural system were more profitable than those grown under a conventional (inorganic) agricultural system (Naik et al., 2012). Moreover, organic agricultural systems are also safe to consumers and the environment (Campiglia et al., 2015).

The analysis of variance revealed that the lines under study were significant for all characteristics. Generally, the significant differences revealed among the morphological traits may be diverse source of materials and also the result of environmental influence affecting okra lines this corroborates findings of Chaukhande et al. (2011) and Kumar et al. (2019) who mentioned the role of environmental factors as well as differences in the genetic makeup of
different varieties in yield determination of okra. While, the significant interaction effects between system×line indicated that the lines responded differently to changes in the farming system (conventional versus organic). High variation in yield and yield components was detected for different lines. Thus, more testing sites, environments, or locations are in need of evaluation (Gurung et al., 2012). Many scientists have reported that yield and yield components were affected by genetic and environmental conditions (Benchasri and Simla, 2017). Prakash and Pitchaimuthu (2010) reported that the environment had a stronger effect on yield relative to line. In contrast, Gurung et al. (2012) found that line played a major role in yield contents, as more than 70% of total variation in yield was due to the effect of cultivar, although the SxL effects were significant. A large source of variation due to genotype was also reported by Yadav et al. (2016).

**Conclusion**

The current research found that okra line grown through the organic farming system had marketable fruits.plant⁻¹, yield.plant⁻¹, seeds.fruit⁻¹, 100 seed weight and 1,000 seed weight less than okra grown through the conventional farming system. Total yields showed that production under the inorganic agricultural system were approximately 20-65% higher than under the organic agricultural system. The significant interaction effects between system x line indicated that lines responded differently to changes in the environment (production system). There was a strong effect of line on the variation in yield and yield components. Therefore, even with diverse environments, lines had a larger effect on yield than the production system. KN-OYV-02, LUCKYFILE 473, KN-OYV-01 and RED FINGER lines should also be used for further breeding or planting as commercial genotypes under field conditions. The outcome of this study should be used to guide okra breeding in Thailand.

**Acknowledgement**

We are grateful to the PHRC for okra seeds used in this experiment.

**Disclaimer**: None.

**Conflicts of Interest**: None.

**Source of Funding**: Research and Development Institute Thaksin University and National Research Council of Thailand (NRCT).

**References**

Abouziena HF and Haggag MW, 2016. Weed control in clean agriculture: a review. Planta daninha. 34(2): 377-392.

Afe AI and Oluleye F, 2017. Response of okra (Abelmoschus esculentus L. Moench) to combined organic and inorganic foliar fertilizers. Int. J. Recycl. Org. Waste Agric. 6:189-193.

Aiyelaagbe IOO, Harris PJC and Olowe VIO, 2016. Skills gaps in organic agriculture and SWOT analysis in higher educational institutions (HEIs) in anglophone West Africa. Org. Agric. 16(2):109–118.

Amalraj ELD, Kumar GP, Ahmed SKMH, Abdul R and Kishore N, 2013. Microbiological analysis of panchagavya, vermicompost, and FYM and their effect on plant growth promotion of pigeon pea (Cajanus cajan L.) in India. Org Agric. 3(1):23–29.

Arbenz M, Gould D and Stopes C, 2017. Organic 3.0—the vision of the global organic movement and the need for scientific support. Org Agric. 7(3):199–207.

Benchasri S, 2012. Okra (Abelmoschus esculentus L.) as a valuable vegetable of the world. Field Veg. Crop Res. 49(2):105–112.

Benchasri S, 2015. Effects of chemical and organic agricultural systems for okra (Abelmoschus esculentus L. Moench) production in Thailand. Aust. J. Crop Sci. 9(10): 968–975.

Benchasri S and Simla S, 2017. Potential of chilli varieties under chemical and organic agricultural systems in Thailand. Bulg. J. Agric. Sci. 23(1):58–70.

Benchasri S and Pruthikanee P, 2018. Genetic variability for yield and yield components of Thai chilli (Capsicum spp.) landraces under inorganic and organic agricultural systems. Aust. J. Crop Sci. 12(1):126-134.

Campiglia E, Mancinelli R, De Stefanis R, Pucciarmati S and Radicetti E, 2015. The long-term effects of conventional and organic cropping systems, tillage managements and weather conditions on yield and grain quality of durum wheat (Triticum durum Desf.) in the Mediterranean environment of central Italy. Field Crops Res. 176:34–44.
Chaukhande P, Chaukhande PB and Dod VN, 2011. Genetic variability in okra (Abelmoschus esculentus (L.) Moench). Asian J. Hort. 6(1):241-246.

Chinatu L, Okocha P and Mathias EKA, 2014. Ontogenesis of West African okra (Abelmoschus Caillei (A. Chev) and conventional okra (Abelmoschus. esculentus (L. Moench) varieties and its effects on fresh pod yield in Umudike in south eastern Nigeria in 2009 and 2010 cropping Seasons. J. Biol. Agric. Healthcare. 4(13):56-63.

Dabire-Binso CL, Ba MN, Some K and Sanon A, 2009. Preliminary studies on incidence of insect pest on okra, Abelmoschus esculentus (L.) Moench in central Burkina Faso. Afr. J. Agric. Res. 4(12):1488-1492.

Döring TF, Bocci R, Hitchings R, Howlett S, Bueren ETL, Pautasso M, Raaijmakers M, Rey F, Stubsgaard A, Weinhappel M, Wilbois KP, Winkler LR and Wolfe MS, 2012. The organic seed regulations framework in Europe—current status and recommendations for future development. Org. Agric. 2(3-4):173–183.

Duman U, Uygun K, Altundişli A and Elmacı OL, 2018. A long-term trial to determine variations in the yield and quality of a processing type pepper (Capsicum annuum L. cv. Yalova yağlık-28) in organic and conventional farming systems. Org Agric. 8(1):69-77.

Freeman GH, 1973. Statistical methods for the analysis of genotype environments. Heredity. 31:339–354.

Ghaouti L, Vogt-Kaute W and Link W, 2008. Development of locally-adapted faba bean cultivars for organic conditions in Germany through a participatory breeding approach. Euphytica. 162(2):257–268.

Gomez KA and Gomez AA, 1984. Statistical Procedure for Agricultural Research. 2nd ed. John Wiley and Sons, New York. p. 680.

Gurung T, Techawongstien S, Surihan B and Techwongstien S, 2012. Stability analysis of yield and capsaicinoids content in chili (Capsicum spp.) grown across six environments. Euphytica. 187(1):11-18.

Kumar A, Kumar M, Sharma VR, Singh MK, Singh B and Chand P, 2019. Genetic variability, heritability and genetic advance studies in genotypes of okra [(Abelmoschus esculentus (L.) Moench]. J Pharmacogn. Phytochem. 8(1):1285-1290.

Kumar S, Dagnoko S, Haougui A, Ratnadass A, Pasternak D and Kouame C, 2010. Okra (Abelmoschus spp.) in west and central Africa: potential and progress on its improvement. Afr. J. Agr. Res. 5(25):3590-3598.

Liu IM, Liou SS, Lan TW, Hsu FL and Cheng JT, 2005. Myricetin as the active principle of Abelmoschus moschatus to lower plasma glucosein streptozotocin induced diabetic rats. Planta Medica. 71(7):617-621.

Manond T, Jomduang J and Varamit A, 2011. Strategies for disease and insect pest control on chili planting by farmers participating: implication for increase income and food security. Thaksin J. 14(3):30-39.

Markose BL and Peter KV, 1990. Okra review of research on vegetable and tuber crops. Kerala Agricultural University Press, Kerala, India. p. 109.

Moechchantuk T and Kumar P, 2004. Export okra production in Thailand. Inter-country programme for vegetable IPM in South & SE Asia phase II Food & Agriculture Organization of the United Nations, Bangkok. p. 48.

Nair VR, Kunnal LB, Patil SS and Gulegdudda SS, 2012. Organic and inorganic cultivation of chilli and its marketing—an economic analysis. Karnatuka J. Agric. Sci. 25(2):203-207.

Narkhede SD, Attarde SB and Ingle ST, 2011. Study on effect of chemical fertilizer and vermicompost on growth of chilli pepper plant (Capsicum annuum). J. Appl. Sci. Environ. Sanit. 6(3):327–332.

Oasma E, Serin M, Leblebici Z and Aksoy A, 2012. Heavy metals accumulation in some vegetables and soils in Istanbul. Ecol. 21(82):1–8.

Pradeepkumar T, Bonny BP, Midhila R, John J, Divya MR and Roch CV, 2017. Effect of organic and inorganic nutrient sources on the yield of selected tropical vegetables. Sci. Hortic. 224:84–92.

Prakash K and Pitchaimuthu M, 2010. Nature and magnitude of genetic variability and diversity studies in okra. Electr. J. Plant Breed. 1(6):1426-1430.

Pendre NK, Nema PK, Sharma HP, Rathore SS and Kushwah SS, 2012. Effect of drying temperature and slice size on quality of dried okra (Abelmoschus esculentus (L.) Moench). J. Food Sci. Tech. Mys. 49(3):378–381.

Sorapong Benchasri et al.
Shivaramegowda KD, Krishnan A, Jayaramu YK, Kumar V, Yashoda and Koh HJ, 2016. Genotypic variation among okra (*Abelmoschus esculentus* (L.) Moench) germplasms in South India. Plant Breed. Biotechnol. 4(2):234-241.

Suja G, Byju G, Jyothi AN, Veena SS and Sreekumar J, 2017. Yield, quality and soil health under organic vs conventional farming in taro. Sci. Hortic-Amsterdam. 218: 334–343.

Yadav SK, Babu S, Yadav MK, Singh K, Yadav GS and Pal S, 2013. A review of organic farming for sustainable agriculture in northern India. Int. J. Agron. 2013:1–8.

Yadav RK, Syamal MM, Pandiyaraj P, Nagarajan K, Nimbolakar PK and Kumar M, 2016. Evaluation of genetic variation, heritability and genetic advance for various traits in okra [*Abelmoschus esculentus* (L.) Moench] under north Gangetic Plains of Uttar Pradesh. Int. J. Agric. Environ. Biotechnol. 9(2):175-180.

Zeshan MA, Iftikhar Y, Ali S, Yousaf M, Ahmed N and Ghani MU, 2019. Impact of okra yellow vein mosaic virus on the physiology of okra crop and its management. Asian J. Agric. Biol. 7(1):69-73.

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Benchasri S: Conceived idea, designed research methodology, literature review, data collection, data interpretation, manuscript writing and final approbation of the version to be published.

Simla S: Data collection and data interpretation.

Harakotr B: Literature review and data interpretation.