Australian Journal of Crop Science AJCS

AJCS 11(05):585-595 (2017) ISSN:1835-2707
doi: 10.21475/ajcs.17.11.05.p410

Investigation of inorganic and organic agricultural systems for *Vigna* spp. production in Thailand

Duangjai Chanapan[1], Sorapong Benchasri[1*] and Sakunkan Simla[2]

[1]Department of Plant Science, Faculty of Technology and Community Development, Thaksin University, Pa Phayom, Phatthalung Thailand P.O. 93210
[2]Department of Agricultural Technology, Faculty of Technology, Mahasarakham University, Khamriang, Kantarawichai Maha Sarakham Thailand P.O. 44150

[*]Corresponding author: benchasri@gmail.com

Abstract

Yield, yield components, antioxidant activity and genetic variation of fifty genotypes on *Vigna* spp. were evaluated under two production systems (inorganic and organic agricultural systems) at the field trails in the Kingdom of Thailand. The experimental design was a Randomized Complete Block Design with four replications and twenty plants in blocks. It was found that pod length, fresh pod weight, number of seeds, number of pods, fresh pod yield, 100 seed weight and harvest index showed significant difference ($p \leq 0.05$). The highest quality number of pods was found on Fakdang 71.75 and 55.25 pod.plant^{-1} under inorganic and organic agricultural system, respectively. The Kangkragan produced the highest quality yield 1,385.20 and 1,135.30 g.plant^{-1} under inorganic agricultural system and organic agricultural system, respectively. Suarpran had the lowest quality yield 208.10 g.plant^{-1} under organic agricultural system. The highest values for trolox equivalent antioxidant capacity (TEAC) and 2,2-diphenyl-1-picrylhydrazyl radical scavenging ability (DPPH) were obtained from Panomsarakram and Fakdang (95.36 and 35.61% of inhibition, respectively). The outcome of this study can be used as guidance for *Vigna* spp. production in Thailand.

Keywords: Yield, Yield Components, Antioxidant, Genetic.

Introduction

Vigna unguiculata subsp. *sesquipedalis* L., yardlong bean, is a common vegetable in Asian markets (Benchasri et al., 2012), is characterized by its very long (30–90 cm in length) pods with seeds usually 8–12 mm long. It is also known as asparagus bean, string bean, snakebean and sitao (Kongjaimun et al., 2012). Yardlong bean originated from West Africa (Madukwe et al., 2008). It is cultivated extensively in many countries in Southeast Asia such as Malaysia, Philippines, Indonesia, Myanmar and Thailand (Win and Oo, 2015). This crop is also widely grown in Southern China, India and Pakistan. Yardlong bean could be boiled, fried or cooked (Kongjaimun et al., 2012). The composition of mature seeds per 100 g edible portion is: energy 47 Kcal, carbohydrates 8.35 g, protein 2.8 g, total fat 0.40 g, folates 62 µg, niacin 0.41 mg, pantothenic acid 0.06 mg, pyridoxine 0.02 mg, riboflavin 0.11 mg, thiamin 0.11 mg, vitamin C 18.8 mg, vitamin A 865 IU, sodium 4 mg, potassium 240 mg, calcium50 mg, copper 0.05 µg, iron 0.47 mg, magnesium 44 mg, manganese 0.21 mg, phosphorus 59 mg, selenium 1.5 µg and zinc 0.37 mg.

Vigna unguiculata subsp. *unguiculata* (L.) Walp, cowpea, is classified as belonging to the same group of yardlong bean (Phansak et al., 2005), is one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times (Shevkani et al., 2015). Cowpea is grown extensively in many countries (Singh et al., 2003; Win and Oo, 2015). Cowpea is a tropical grain legume which plays an important nutritional role in developing countries of the tropics and subtropics, namely sub-Saharan Africa, Asia, Central and South America (Fang et al., 2007; Odedeji and Oyeleke, 2011; Badiane et al., 2012; Masvodza et al., 2014). Cowpea is often termed the poor man's meat because the seed protein contents range from 23 to 32% of seed weight and are rich in lysine and tryptophan, and substantial amount of mineral and vitamins, folic acid and vitamin B (Chinma et al, 2008, Huaqiang et al., 2012; Peyrano et al, 2016). The crop serves as food, animal feed, cash and manure (Henry and Chinedu, 2014). Cowpea can be regarded as a pivot of sustainable farming in regions characterized by systems of farming that make limited use of purchased inputs like inorganic fertilizer (Hamid et al, 2016). The crop can fix about 240 kg.ha^{-1}of atmospheric nitrogen and make available about 60-70 kg.ha^{-1} nitrogen for succeeding crops grown in rotation with it (Aikins and Afuakwa, 2008). Cowpea is well adapted to environmental conditions that affect crop production such as drought, high temperatures and other biotic stresses compared with other crops (Agyeman et al., 2014). Cowpea can be grown on a wide variety of soils ranging from predominantly sandy to predominantly clay and pH range between 4.5 and 8.5.

In Thailand, yardlong bean and cowpea are usually boiled in water resulting in the thick soups and sauces, which are relished. The production sources of *Vigna* spp. in Thailand are the provinces of Angthong, Nakornpratom, Supanburi, Phichit and Phatthalung (Benchasri et al., 2012). Thailand production areas of yardlong bean and cowpea were estimated at 18,560 – 20,160 ha annually (Sarutayophat et al., 2007). Production output and requirements are currently increasing. Production has been increased in order to meet with the higher demand (Benchasri and Bairaman, 2010). Consequently, pesticide has been used in the production process, causing chemical residues in the product and environment (Petlamul et al., 2009; Adeoye et al., 2011; Farahvash and Mirshekari, 2011). Use of pesticide also hikes up the cost of the production process, making it not worth the investment. Nowadays, consumers are paying much more attention to their health (Benchasri, 2015). As a result, vegetable production processes that are safe for both consumers and the environment are even more necessary (Win et al., 2015).

Organic agriculture was established in many countries such as England, Germany, Japan, Thailand and the America (Benchasri, 2015). Organic agricultural emerged in the 1930's and 40's as an alternative to the increasing intensification of agriculture, particularly the use of synthetic nitrogen (N) fertilizers. Sustained high rates of growth in sales of certified organic products in worldwide, averaging 20–25% per year since 1980, have spurred concomitant growth and activities in production, processing, research, regulation and trade agreements, and exports. The global organic agricultural market value is near 1% in Thailand, 2% in the US and 1–5% in EU countries. Processed organic agricultural have shown particularly rapid growth, often over 100%. Nowadays, commercial certified organic agriculture has spread to over 130 countries worldwide (Lotter, 2003; Reganold and Wachter, 2016). Therefore, the main objectives of this study were to investigate the effects of inorganic and organic agricultural systems in terms of yield, yield components, antioxidant activity and combined analysis gene of *Vigna* spp. production**.** The outcome of this study may be used as guidance for yardlong bean and cowpea production. Moreover, we can recommend novelty of work that right varieties should be used for further breeding, physiological as well as antioxidant studies in many countries.

Results

Physical properties of soil and meteorological data between planting

The Physio–chemical properties of the soil are given in Table 1. Total nitrogen value in the soil before planting of two systems was low (0.12 % and 0.12 %). Similarly, the soil had a medium level of phosphorus (33.34 and 37.33 mg.kg^{-1}) with a corresponding level of potassium 41.35 and 42.67 mg.kg^{-1} for before planting under inorganic and organic agricultural systems, respectively. The pH after planting in water was near neutral about 5.66 and 5.68 in the inorganic and organic agricultural systems, respectively. The present study quantitatively compares the influence of temperature, the level of relative humidity and rainfall on the development times of fifty *Vigna* spp. genotypes. The meteorological data were shown in Fig 1. air temperatures between January and June 2015 (from 23.14°C to 34.80°C). Average air temperature was 28.53°C. The relative humidity values were between 60.48% and 95.17% and the average relative humidity value was 79.06%. Rain day ranged from 3 to 13 days, while the lowest rainfall was recorded in February 5.70 mm.

Fresh pod yield and yield components of Vigna **spp.**

Data presented in Table 2 show that the effect of different production was significant of pod length, fresh pod weight, number of seeds.pod^{-1}, number of pods.plant^{-1} and fresh pod yield.plant^{-1}. Inorganic agricultural system had higher pod number and fresh pod yield than organic agricultural system for all genotypes. The highest number of pods.plant^{-1} was obtained from Fakdang (71.75±7.27), while the lowest belonged to Taydang (20.00±3.37). The highest fresh pod yield was recorded from Kangkragan (1,385.20±14.40). While, yield components on organic agricultural production systems showed that Fakdang was recorded the highest number of pods.plant^{-1} (55.25±5.41). Kangkragan was observed the highest fresh pod yield.plant^{-1} (1,135.30±17.47).

Comparison of pod weight, seed numbers, 100 seed weight and harvest index of Vigna **spp.**

Figure 2 showed that inorganic agricultural system had higher fresh pod weight, number of seeds, 100 seed weight than organic agricultural system in many genotypes. The most different between production systems for fresh pod weight was Suarpran (11.96 g) (Fig 2A). The number of seeds.pod^{-1} differed production systems between 0.00 g in Maping and 3.53 g in Lumtakong (Fig 2B), whereas the differences between production systems for 100 seed weight were between 0.08 g in Pechkagi and 11.88 g in Mung 3A (Fig 2C). The final harvest index time was greatly affected by system production. However, many genotypes of *Vigna* spp. planted under organic agricultural system had time of harvest index more than inorganic agricultural system. The differences between production systems for harvest index were between 0.00 g in Sansuwan and 18.75 g in Dawdang (Fig 2D).

Total anthocyanin content (TAC)

Yardlong bean and cowpea were harvested at edible stage. Dawdang (organic agricultural system) had the highest TAC (603.83±12.76 mg CGE.100g^{-1} of FW) followed by Kangkragan (480.59±9.71 mg CGE.100g^{-1} of FW) and Tuypum (480.43±11.65 mg CGE.100g^{-1} of FW), respectively, whereas, Lumnumpong (inorganic agricultural system) had the lowest TAC (30.80±6.14 mg CGE.100g^{-1} of FW) (Table 3). Significant differences ($P \leq 0.05$) among pod components were observed for TAC.

Total phenolic compound (TPC)

Significant differences ($P \leq 0.05$) among bean genotypes were founded for TPC under inorganic and organic agricultural systems (Table 3). Tuypum (organic agricultural system) had the highest TPC (6.50±2.34 mg GAE.100g^{-1} of FW) followed by Fakdang (6.42±0.24 mg GAE.100g^{-1} of FW) and Dawdang (6.18±0.40 mg GAE.100g^{-1} of FW), respectively, whereas Lumnumpong had the lowest TPC (2.47±0.30 mg GAE.100g^{-1} of FW) under organic agricultural system.

Antioxidant capacity

Differences among yardlong bean and cowpea genotypes planted under inorganic and organic agricultural system were significant ($P \leq 0.05$) for parameters related to antioxidant capacity (DPPH, TEAC). The lowest values for TEAC and DPPH were obtained from Taydang and mudkaw 3A (36.16±1.51 and 2.98±0.10% of inhibition, respectively), whereas the highest values were obtained from Panomsarakram and Fakdang (95.36±0.29 and 35.61±1.46% of inhibition, respectively) (Table 3).

Table 1. Physio-chemical properties of the soil (0-30 cm) of the experimental site.

Parameters	Inorganic system		Organic system		Method of analysis
	Before planting	After planting	Before planting	After planting	
Organic matter (%)	1.13	1.08	1.12	1.28	Walkley-Black method
Nitrogen (%)	0.12	0.11	0.12	0.14	McKenzie method
P_2O_5(mg.kg^{-1})	33.34	37.21	37.33	39.33	Flame photometric
K(mg.kg^{-1})	41.35	41.01	42.67	44.68	Oxidation
pH (H_2O)	5.67	5.66	5.67	5.68	pH meter method
EC (dS.m^{-1})	0.06	0.07	0.08	0.07	

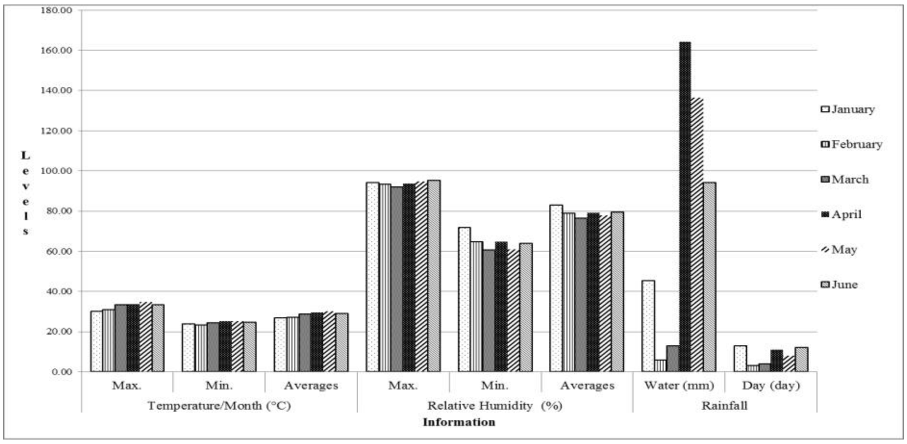

Fig 1. Meteorological data in Phatthalung province, Thailand.

Interaction effect of production systems

Combined analysis of variance indicated that differences systems (S) and among genotypes (G) were significant of fresh pod length, fresh pod weight, number of pods, fresh pod yield, 100 seed weight and harvest index. There were also significant interactions between system and genotypes (S x G) for fresh pod length, fresh pod weight, number of pods, fresh pod yield, 100 seed weight and harvest index for two system plantations. While, the variation of blocks within system for all traits were not significant (Table 4).

Mean comparison

The mean analysis of fresh pod weights, number of pods, fresh pod yield, 100 seed weight and harvest index are shown that significant differences between system productions in 5 probability level, while pod length and number of seeds were not significant difference (Table 5).

Discussions

The average monthly temperature ranged from 23.14°C to 34.80°C, while the average relative humidity ranged between 60.48% and 95.17%. The average monthly temperature, relative humidity and rainfall ranges were considered optimal for the growth and development of *Vigna* spp. According to Bastos et al. (2002) reported optimum growth and development for *Vigna* spp. at the temperature of 25–30°C, while Benchasri and Bairaman (2010) observed an improvement in the performance of yardlong bean with the relative humidity range from 70% to 85%. Similar results were reported by Ntare (1991). Moreover, soil treatments affect the release of elements (Farahvash and Mirshekari, 2011; Nkaa et al., 2014), day photoperiod, hormone growth and rainy season were also impact on yield and yield components of *Vigna* spp. (Mukhtar and Singh, 2006).

Yield and yield components of fifty genotypes of *Vigna* spp. were carried out under agro-chemicals at Thaksin University between January and June 2015, showed differences statistically significant in all genotypes. This is consistent with the reported of Adeoye et al.. (2011). In addition, Nirmal et al. (2001), Magani and Kuchinda (2009), Adeyanju et al. (2012), and Agyeman (2014) reported similar experimental results. However, yield and yield components tested are different in term of terrain and climate (Connell et al., 2015; Karikari et al., 2015). Comparison of fifty *Vigna* spp. under inorganic and organic farming showed that pod length, number of pods.plant^{-1}, number of seeds.pod^{-1}, fresh pod yield, 100 seed weight and harvest index showed different statistical significance when tested under the same cultivation agriculture system. Moreover, Fresh pod weight, number of pods.plant^{-1}, 100 seed weight, harvest index and fresh pod yield.plant^{-1} were higher under inorganic agricultural system than under organic agricultural system. Similar results were reported by Benchasri (2015). This results, corresponds to the test crops planted under regular (chemical) and under organic fertilizer. It was found that the average yield and yield components test cultivated under inorganic (chemical) rather than organic farming (Attigah et al., 2013) or comparing the yield of green beans is the same effect (Naeem et al., 2006). Moreover, Abbas et al. (2011) reported that some of plant nutrients, when added to the soil in the organic form have low efficiency when comparing to the effect of inorganic fertilizers (Farahvash and Mirshekari, 2011; Olusegun, 2014). In contrast, pod length and number of seeds.pod^{-1} were not significant between systems. Although, yield and yield components of *Vigna* spp. managed under organic agricultural system were less than inorganic agricultural system, but planting under organic agricultural system was useful for soil improvement and environment conservation (Drinkwater, 2002; Mahoney et al., 2004;

Table 2. Yield and yield components of *Vigna* spp. (Mean±SE)

Genotypes	Pod length (cm)		Fresh pod weight.pod-1(g)		Number of seeds.pod-1(seed)		Number of pods.plant-1 (pod)		Fresh pod yield.plant-1(g)	
	Inorganic	Organic	Inorganic	Organic	Inorganic	organic	Inorganic	Organic	Inorganic	Organic
28-2	53.06 ±4.96c-f	48.19±10.92f-m	21.37±0.41 fg	21.37±1.12cd	14.60±1.30d-i	12.23±1.12k-o	41.00±3.74b-i	33.75±7.50b-e	876.20±29.96e-q	721.20±10.28d-k
901	64.14 ±14.08a	66.63±10.10a	24.25±0.16d-e	24.25±1.67bc	15.78±4.77a-c	13.18±1.67f-m	41.00±6.98b-i	35.75±1.56b-d	994.30±19.17c-m	866.90±20.28a-h
Big 1	48.39 ±9.91d-k	47.94±4.91g-m	19.93±0.35f-h	19.93±0.65de	13.58±5.80h-m	14.85±2.65b-f	38.25±7.27b-i	39.00±6.48a-d	762.30±14.98i-r	777.30±19.16b-j
Dawdang	52.84 ±5.52c-f	45.52±6.71h-o	16.33±0.05h	14.72±0.20h	13.95±4.04d-l	14.45±4.20d-h	36.75±6.02d-j	31.25±7.80b-e	600.10±98.32q-u	460.00±19.82j-m
Dokkrong 10	41.80 ±10.01i-n	45.79±7.61h-n	10.72±0.21l	10.6±0.85i	14.33±5.90d-j	13.65±2.85e-l	30.75±1.12g-k	24.00±5.48d-g	329.60±55.48v	254.40±14.41n
Ero 6	46.30 ±5.59e-m	60.33±10.80a-d	22.71±0.52e-g	22.71±1.11c-d	13.38±3.34i-m	12.58±4.11k-n	51.50±2.07b-d	42.50±3.70a-d	1169.60±24.09a-f	965.20±83.96a-c
Fakdang*	26.91 ±1.73pq	24.80±2.71s	12.38±0.42k	12.38±0.84 hi	14.25±6.45d-j	15.23±4.84b-e	71.75±7.27a	55.25±5.41a	888.30±36.51e-q	684.00±90.06e-k
Fakkeal*	40.11 ±6.25l-n	37.20±5.47n-q	19.06±0.63f-h	19.06±0.74de	16.25±4.05ab	14.88±5.74b-f	35.00±4.24e-k	30.00±5.94b-f	667.10±80.86m-s	571.80±13.3g-m
Green aro	47.29 ±9.33e-l	47.25±5.36h-m	23.63±0.82ef	23.52±0.31b-d	13.68±2.69g-m	13.83±3.30e-k	43.50±8.77b-h	40.00±7.02a-d	1027.70±26.01b-k	940.60±16.32a-f
Green aro 692*	50.56 ±8.48d-h	42.95±11.16k-p	14.34±0.18j	12.9±0.57hi	15.38±3.59a-f	13.45±5.57f-l	49.25±3.86b-e	46.50±3.11ab	706.40±78.54k-s	799.80±53.48b-i
Hero*	44.94 ±7.78g-n	41.40±9.00l-p	16.08±0.33hi	13.7±0.07hi	13.48±5.91h-m	11.45±1.07n-p	41.00±5.48b-i	34.00±6.27b-e	659.10±14.73n-s	465.80±18.06i-n
Jawsamran	47.96 ±11.54d-k	47.09±10.93h-m	25.98±0.64c-e	25.98±0.13b	12.68±1.84k-m	13.88±6.13d-k	44.25±6.50b-h	31.25±2.25b-e	1149.60±18.87a-g	811.90±20.34a-i
Jiandou	58.97 ±5.23a-c	49.70±9.57e-l	24.42±0.87de	24.42±0.05bc	14.70±4.29d-i	13.88±1.44d-k	51.50±6.24b-d	42.50±5.69a-d	1257.60±12.50a-d	1037.90±18.86a-d
Jin 6	59.02 ±10.61a-c	63.18±11.95a-c	28.03±0.10bc	28.03±0.50a	15.68±3.68a-c	15.73±3.50bc	44.75±8.77b-h	39.00±4.83a-d	1254.30±25.83a-d	1093.20±15.40a-b
Jin 8	64.81 ±10.02a	63.64±7.81ab	21.04±0.25fg	18.2±0.79eg	15.28±3.13a-f	16.30±2.79ab	48.50±8.06b-f	30.50±8.58b-e	1020.50±10.41b-l	555.10±13.93g-n
Jong ang	46.18 ±8.65f-m	52.46±9.28d-j	12.16±0.09k	12.68±0.38hi	14.35±2.59d-j	12.38±5.38ko	39.50±9.88b-i	36.75±3.77b-d	559.30±89.04q-u	466.00±58.13i-n
Kangkragan	48.39 ±6.56d-k	36.74±6.23o-q	28.56±0.08bc	28.56±0.24a	14.73±2.66b-i	14.35±2.24d-h	48.50±6.81b-f	39.75±4.11a-d	1385.20±14.40a	1135.30±17.47a
Kaset 135*	41.31 ±6.85j-n	54.38±10.17d-i	18.15±0.07f-h	16.2±0.14fg	13.68±4.19g-m	13.18±3.14f-m	40.75±3.82b-i	32.50±1.66b-e	739.60±26.09j-s	526.60±25.55i-n
keawdok 4	55.34 ±10.25b-d	57.58±12.75b-e	21.25±0.40fg	21.25±0.65c-e	14.98±2.56b-h	12.70±3.65i-n	40.50±2.01b-i	38.75±7.80a-d	860.60±25.29f-q	823.40±65.85a-i
Longgo 5	63.75 ±10.29a	60.85±7.86a-d	24.59±0.05de	24.28±0.40bc	14.08±4.86d-k	14.35±1.47d-i	36.50±3.32d-j	29.50±3.70b-f	897.50±81.56e-p	716.40±87.76d-k
Lumnumchee	41.47 ±5.60i-n	50.54±10.86e-l	22.27±0.32eg	22.13±0.51c-e	14.28±4.36d-j	14.55±4.51d-g	36.01±8.40d-j	20.50±2.08d-g	801.90±19.84h-r	453.60±6.44j-m
Lumnumpong	48.97 ±4.20d-i	51.14±7.48e-k	27.93±0.29bd	24.86±0.24bc	12.93±5.12j-m	13.83±3.50d-k	40.50±1.90b-i	34.00±5.60b-e	1131.10±20.66a-h	845.20±39.16a-h
Lumtakong	25.44 ±6.40pq	26.24±5.49s	15.5±0.28i	10.83±0.21i	14.08±3.59d-k	10.55±1.20q	39.25±2.09b-i	36.25±7.72b-d	608.30±12.19p-u	392.60±83.6k-n
Maping	37.54 ±14.93no	49.64±9.87e-l	25.48±0.64c-e	19.70±0.65de	14.30±3.65d-j	14.30±3.65d-j	41.50±1.33b-i	37.35±7.09b-d	1057.40±18.07a-j	735.70±40d-k
MMS1*	53.84 ±10.52b-e	42.96±7.76k-p	16.71±0.40h	14.01±0.92hi	12.53±1.5l-n	14.75±1.92b-f	43.50±4.42b-h	36.01±9.49b-d	727.00±15.49j-s	504.40±59.28i-n
mudkaw 3A*	46.69 ±7.60e-m	50.40±7.85e-l	21.45±0.37fg	16.78±0.28fg	11.05±6.55no	12.50±2.28k-n	36.50±8.27d-j	40.75±7.80a-d	782.90±17.31i-r	683.60±67.42e-k
Mung 3A	43.38 ±8.16h-n	41.72±7.02l-p	22.03±0.21e-g	21.99±0.27c-e	15.13±5.74b-h	14.33±4.27d-j	37.25±7.63d-i	32.05±9.06b-e	820.60±18.14g-r	704.90±19.51d-k
mungsitid	37.94 ±5.44no	48.52±5.04f-m	17.48±0.58gh	16.25±0.34fg	13.35±4.58i-m	12.48±2.34k-n	39.50±7.51b-i	20.00±3.48d-g	69.40±11.57l-s	325.02 ±36.28l-n
Neu	28.95 ±3.24p	45.74±11.09h-n	26.03±0.28cd	25.93±0.26b	13.93±5.91e-l	13.00±1.26g-n	29.25±0.21h-k	12.05±3.16g	761.40±25.77i-r	312.40±82.31l-n
Nhongsau	48.56 ±11.11d-j	42.97±8.76k-p	25.19±0.18c-e	25.26±0.04b	16.55±6.35a	15.58±2.04b-d	53.50±5.45bc	37.25±9.57b-d	1347.70±34.58ab	940.90±41.74a-f
Nigro	55.18 ±5.29b-d	54.64±10.60c-h	18.73±0.87fh	18.73±0.68e-g	13.70±6.06g-m	11.48±5.68m-p	38.75±3.82b-i	36.50±7.10b-d	725.80±28.80j-s	683.60±30.24e-k
Nuangtong9	48.39 ±4.57d-k	45.56±10.64h-o	22.63±0.60eg	22.60±0.80c-e	14.40±4.90d-j	14.53±6.80d-g	37.75±1.05c-i	32.05±1.36b-e	854.30±27.33f-q	724.20±34.45d-k
Panomsarakram	42.27 ±12.42i-n	49.81±7.61e-l	21.17±0.30fg	21.17±1.75c-e	12.63±8.50k-m	13.65±1.75e-l	32.50±7.42f-k	29.25±8.18c-f	688.00±57.10l-s	619.20±98.35f-m
Pechkagi	44.46 ±6.91g-n	43.23±7.93j-p	18.00±0.53fh	16.48±0.46fg	13.53±4.19h-m	13.58±3.46e-l	38.25±7.10b-i	32.00±8.41b-e	688.60±13.33l-s	527.40±38.54h-n
Pechpimai*	28.19 ±3.08p	23.53±3.41s	17.78±0.38gh	17.49±0.74e-g	14.98±3.50b-h	17.48±5.74a	42.25±3.77b-h	35.00±7.44b-d	751.20±67.12j-s	612.30±32.26f-m
Raya	39.39 ±16.59mn	56.57±7.94b-g	23.38±0.62ef	23.38±1.04b-d	12.30±4.97mn	13.40±4.04f-l	46.00±1.61b-g	40.25±5.85a-d	1075.50±48.17a-i	941.00±36.83a-f
Samchuk	60.77 ±7.46a	57.23±11.19b-f	21.64± 0.16fg	21.62±0.67c-e	14.05±4.06d-l	12.63±1.67j-n	45.50±1.08b-g	25.00±2.96d-g	984.40±37.19d-n	543.80±31.43g-n
Sansuwan	58.86 ±5.75a-c	60.54±11.65a-d	26.65±0.41cd	25.18±0.33b	15.48±4.89a-d	12.78±3.30h-n	49.75±4.43b-e	37.75±1.05b-d	1325.60±21.87a-c	950.60±79.55a-c
Sayrung	39.77 ±7.04l-n	47.33±8.40h-m	9.66±0.58m	9.05±0.38j	13.78±4.03f-m	11.58±3.38m-p	44.00±8.33b-h	38.75±4.57a-d	425.10±30.97s-u	350.50±68.51l-n
Saytan	44.99 ±5.23g-n	50.59±7.09e-l	22.18±0.28eg	18.96±0.31e-g	14.43±3.74d-j	12.55±2.26k-n	45.75±4.99b-g	41.00±1.39a-d	1014.80±10.32b-l	777.40±17.04b-j
Saytara	53.56 ±8.27b-e	49.80±7.11e-l	24.32±0.59de	24.32±0.65bc	10.75±2.71o	13.00±3.65f-m	26.25±7.27i-k	26.75±1.34d-g	638.40±76.91o-u	650.60±51.47e-l
Saytip	43.02 ±9.91h-n	45.88±10.06h-n	8.45±0.89n	8.28±0.42k	14.70±5.34d-i	13.50±1.42f-l	49.25±5.97b-e	42.00±4.39a-d	416.20±67.40tu	347.80±57.51l-n
Suarpran*	19.77 ±4.93q	22.36±3.57s	31.78±1.58bc	19.82±0.80de	13.38±3.59i-m	10.75±2.80o-q	21.00±8.45jk	10.50±3.11g	667.40±94.64m-s	208.10±61.62o
Taydang*	28.93 ±9.87p	34.91±1.59p-r	33.57±1.48a	28.17±0.54a	13.88±2.96e-l	13.58±2.54e-l	20.00±3.37k	17.25±5.32e-g	671.40±13.64m-s	486.00±88.12i-n
Tuy ngu	31.41 ±7.96op	30.73±4.87q-r	23.28±0.18ef	23.28±1.47b-d	8.77±4.36p	9.65±1.47q	21.25±2.06jk	13.00±3.92f-g	494.70±47.99r-u	302.60±91.61mn
Tuypum*	30.69 ±4.53op	27.48±5.28rs	16.75±0.27h	16.4±0.80fg	13.43±3.38i-m	13.38±2.80f-l	39.75±1.69b-i	38.05±2.73b-d	665.80±79.04m-s	624.20±34.21el
Tuysan	51.79 ±7.81c-g	53.77±8.60d-i	20.3±0.13fh	17.75±0.59e-g	14.08±4.03d-k	12.88±3.59g-n	47.75±2.54b-f	37.25±4.82b-d	969.30±93.56d-o	661.30±30.87el
Violet 696	40.91 ±5.99l-n	39.36±8.58m-p	17.75±0.28gh	16.00±0.47g	14.38±4.03d-j	11.95±1.70l-p	47.75±5.68b-f	44.50±5.26a-c	847.40±94.37f-q	712.10±95.99d-i
Winggao OP	43.48 ±10.21h-n	45.22±7.41i-o	24.64±1.13de	23.06±0.35b-d	13.65±6.66g-m	11.40±5.35n-p	48.50±3.70b-f	44.25±1.47a-c	1195.00±91.09a-d	1020.30±21.36ab
Yokkhaw	42.02 ±10.13i-n	46.28±14.39h-m	19.5±0.26fh	19.63±0.93e	14.60±4.16d-i	12.93±1.93g-n	53.75±3.90b-f	45.02±2.94a-c	1048.10±75.41b-j	838.50±57.41a-h
CV. %	9.06	11.22	4.68	5.39	6	6.93	10.72	11.76	10.94	5.95

Means in the same column with the same letter(s) are not significantly different by Duncan’s New Multiple Range Test (DMRT) at 0.05 probability level.

*Cowpea genotypes.

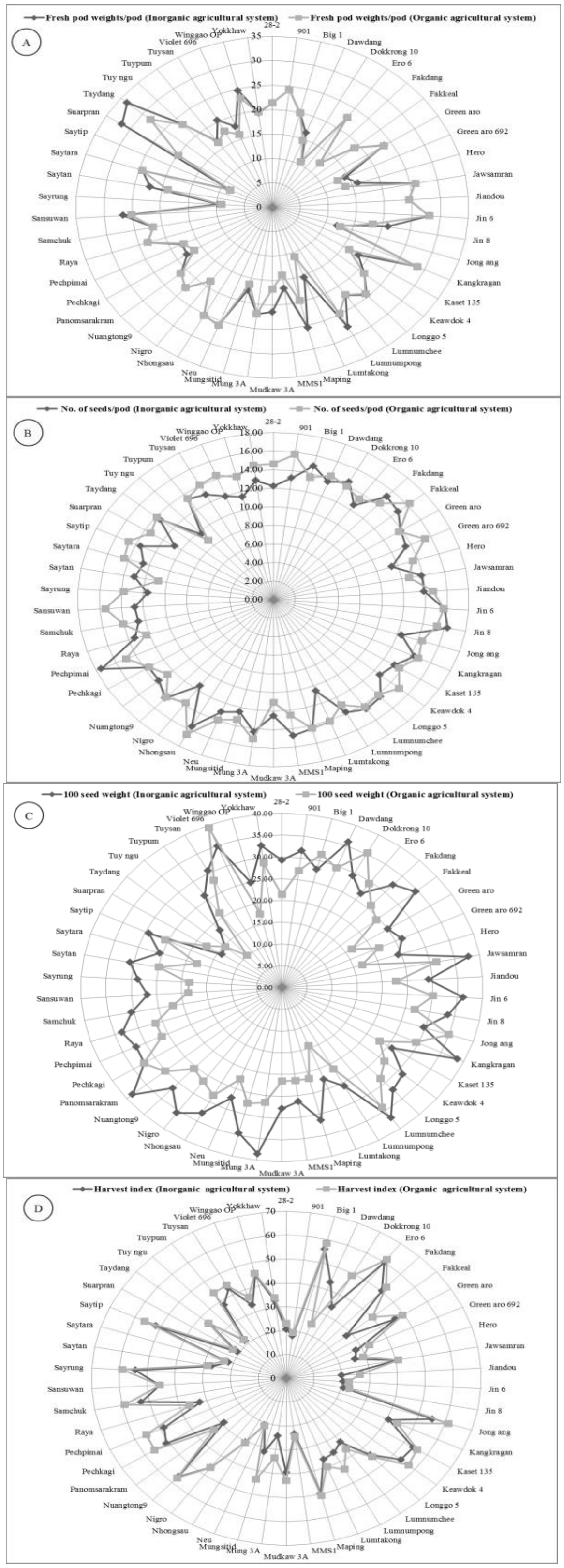

Fig 2. pod weight(A), seed numbers(B), 100 seed weight(C) and harvest index(D) of *Vigna* spp.

Table 3. Means for total anthocyanin content, total phenolic content, and antioxidant capacity determined by DPPH and TEAC methods (Mean±SE)

	TAC (mg C3GE/100 g Sample)		TPC(mg GAE/100g of Sample)		TEAC(%Inhibition)		DPPH(%Inhibition)	
Genotypes	Inorganic agricultural system	Organic agricultural system	Inorganic agricultural system	Organic agricultural system	Inorganic agricultural system	Organic agricultural system	Inorganic agricultural system	Organic agricultural system
28-2	37.40±10.09d	89.51±17.02e-g	4.57±1.28a-f	4.67±0.23a-f	84.32±0.91f-j	85.15±1.26b-k	5.90±0.88g-i	8.97±1.16h-l
901	85.70±6.52cd	65.64±17.24e-g	4.78±0.82a-f	4.50±0.86b-g	71.69±3.01no	67.93±5.58q-v	13.91±0.49c-e	16.92±3.89b-l
Big 1	33.70±11.40d	36.07±10.21fg	3.29±0.07c-f	3.25±0.04e-h	81.48±2.07h-k	83.44±1.03c-r	7.80±0.42e-i	9.03±1.85h-l
Dawdang	388.50±12.40ab	603.83±12.76a	4.20±0.58 a-f	6.18±0.40ab	74.38±5.56l-n	66.16±4.47r-v	18.01±1.54c	23.40±5.24bc
Dokkrong 10	57.04±0.79cd	59.43±8.34fg	5.23±0.18a-d	5.08±0.07a-d	55.29±1.80pq	61.92±6.92 uv	8.45±0.01e-i	18.02±4.86b-h
Ero 6	61.80±16.70cd	68.09±17.47fg	4.56±0.60a-f	4.57±0.61b-g	87.21±2.47b-h	84.23±3.79c-l	10.04±0.88d-i	10.35±3.39e-l
Fakdang	293.90±16.80a-c	262.56±18.25b-f	5.11±0.87a-e	6.42±0.24a	79.17±6.27j-m	75.31±2.82l-q	34.20±1.33a	35.61±1.46a
Fakkeal	92.21±4.25cd	235.12±14.41c-g	4.01±0.70a-f	5.66±0.14a-c	87.97±1.61b-g	88.38±3.14a-f	30.08±1.77ab	30.14±1.13ab
Green aro	59.30±16.09cd	64.09±10.54e-g	3.34±0.53c-f	2.68±0.65f-h	89.56±2.31a-f	89.44±0.97a-e	7.28±0.08f-i	8.72±1.93h-l
Green aro 692	55.40±3.06cd	152.29±17.35c-g	3.17±0.08c-f	3.12±0.14e-h	84.27±1.03f-j	83.02±1.03c-m	9.75±1.06d-i	11.84±2.95e-l
Hero	104.61±16.67cd	130.90±6.67d-g	5.64±0.45ab	5.64±0.45a-c	74.22±1.08l-n	79.18±4.72g-o	11.40±0.74d-i	11.35±2.39e-l
Jawsamran	121.60±24.49bc	134.90±16.67d-g	3.39±0.25c-f	3.65±0.10d-h	84.50±1.13f-j	89.44±2.03a-e	11.24±0.80d-i	10.76±0.43f-l
Jiandou	74.81±9.52cd	94.85±15.29e-g	3.16±0.01c-f	3.13±0.04e-h	82.59±3.06g-k	78.01±4.76 i-p	10.17±1.16d-i	13.53±1.33d-j
Jin 6	144.72±14.18bc	168.32±15.62c-g	4.98±0.92a-f	4.90±0.02a-e	76.65±1.89k-n	70.42±2.85o-u	12.69±0.49c-f	14.44±1.31d-j
Jin 8	38.80±16.28d	366.04±11.76b-d	4.40±0.31a-f	3.81±0.54c-h	75.18±2.68l-n	75.88±5.72k-q	15.61±0.97cd	15.34±1.18b-j
Jong ang	51.80±14.20cd	61.45±14.79e-g	3.22±0.36c-f	3.11±0.31e-h	73.08±5.50mn	73.60±4.69m-s	9.31±0.99d-i	12.67±1.54d-k
Kangkragan	207.53±12.12bc	480.59±9.71ab	4.15±0.93a-f	2.99±0.54e-h	85.49±7.70e-l	92.38±2.85a-d	7.30±1.21f-i	8.77±1.31h-l
Kaset 135	116.54±12.76bc	109.54±10.09e-g	3.46±0.78c-f	3.52±0.88d-h	77.20±0.85k-n	78.54±1.74h-p	8.60±0.60e-i	10.10±2.27h-l
Keawdok 4	92.20±10.33cd	92.49±7.57e-g	3.71±0.22a-f	4.09±0.51c-h	88.84±2.22b-g	89.79±1.07a-e	11.91±0.06c-g	7.32±1.70j-l
Longgo 5	90.90±10.08cd	91.15±4.01e-g	3.59±0.91b-f	3.85±0.98c-h	90.48±2.31a-f	94.31±1.13ab	9.49±1.34d-i	11.56±2.18e-l
Lumnumchee	50.80±16.20cd	61.45±2.31e-g	3.55±0.93 b-f	3.55±0.93d-h	90.07±3.35a-f	91.62±1.38a-d	9.96±1.57d-i	8.70±1.62h-l
Lumnumpong	30.80±6.14d	64.12±9.31e-g	2.71±0.05f	2.47±0.30h	77.69±2.18k-n	78.14±1.26h-p	7.20±0.01f-i	8.45±0.98i-l
Lumtakong	129.01±17.03bc	166.10±10.83c-g	4.82±0.39a-f	4.77±0.78a-e	589.25±7.04p	64.38±5.03t-v	15.10±0.64cd	19.86±2.49b-f
Maping	45.92±8.96d	47.71±9.67fg	2.72±0.58f	2.59±0.39gh	77.86±1.48k-n	82.31±0.89d-m	6.89±0.67f-i	9.18±0.20h-l
MMS1	212.42±14.36bc	273.56±18.45b-f	2.98±0.40ef	2.92±0.35e-h	93.23±3.02ab	95.10±0.29a	6.88±0.55f-i	5.96±0.40j-l
mudkaw 3A	62.81±14.49cd	125.58±9.41e-g	3.37±0.42c-f	3.76±0.76c-h	89.38±0.68a-f	91.95±0.79a-d	5.08±0.45 hi	2.98±0.10l
Mung 3A	71.63±15.37cd	297.91±10.43b-e	4.36±0.41a-f	4.88±0.05a-e	76.50±6.97k-n	84.52 ±1.74c-l	11.44±0.90d-h	19.46±2.63b-g
Mungsitid	193.71±13.45bc	233.78±4.63c-g	5.26±0.55a-c	4.35±0.15b-h	78.07±3.20k-n	81.44±2.89e-n	15.25±0.52cd	15.16±2.15c-j
Neu	231.11±11.60bc	232.12±10.41c-g	3.97±0.69a-f	3.91±0.76c-h	88.18±1.43b-g	87.61±1.27a-h	9.35±0.89d-i	13.16±1.88d-k
Nhongsau	79.02±11.68cd	113.55±18.99e-g	3.75±0.64a-f	3.75±0.64c-h	85.35±0.87e-j	85.46±2.06 b-j	6.90±0.25f-i	8.32±1.19 i-l
Nigro	101.10±23.93cd	110.55±18.99e-g	3.49±0.27c-f	3.38±0.06d-h	82.53±0.75g-k	85.92±2.11a-j	13.87±2.24c-f	10.53±1.26g-l
Nuangtong9	60.11±10.54cd	62.59±11.79e-g	4.55±0.67a-f	2.74±0.39f-h	87.94±2.70b-h	87.39±3.20a-j	9.49±0.60d-i	7.28±1.85j-l
Panomsarakram	177.72±14.79bc	63.49±5.50e-g	3.18±0.29c-f	4.13±0.03c-h	94.94±0.38a	95.36±0.29a	4.86±0.65i	3.88±1.30kl
Pechkagi	171.09±15.82bc	440.59±19.71ab	4.24±0.80a-f	4.08±0.65c-h	66.97±2.65o	69.30±2.13p-u	7.94±0.23e-i	10.80±1.59f-l
Pechpimai	103.08±20.10bc	211.07±13.10c-g	5.03±0.77a-e	4.44±0.22b-h	88.20±2.23b-g	78.55±2.64h-p	25.15±2.76b	33.86±1.13a
Raya	44.01±14.45d	109.54±14.71e-g	3.09±0.55d-f	3.10±0.18e-h	92.69±1.18a-c	91.11±0.85a-d	6.77±0.72f-i	6.99±1.69j-l
Samchuk	87.83±24.06cd	88.83±16.68e-g	3.95±0.65a-f	3.83±0.69c-h	74.52±1.50l-n	75.11±0.12l-r	7.22±0.29f-i	8.58±2.05h-l
Sansuwan	70.12±14.82cd	80.23±14.69e-g	3.44±0.36c-f	3.55±0.49d-h	91.18±1.70a-e	89.74±3.91a-e	9.34±0.61d-i	9.42±3.36h-l
Sayrung	159.40±6.96bc	191.04±25.58c-g	4.48±0.65a-f	4.49±0.65b-g	66.97±1.71o	64.77±2.74s-v	13.07±1.68c-f	20.54±2.29b-e
Saytan	145.93±11.46bc	180.88±11.48c-g	4.51±0.30a-f	4.53±0.34b-g	80.17±0.71i-k	80.98±0.82e-n	12.94±1.45c-f	10.07±3.60h-l
Saytara	278.41±17.20abc	252.49±19.58c-g	5.69±0.71a	4.08±0.24c-h	86.48±1.35c-h	88.99±1.14a-f	12.07±4.20c-g	12.71±4.39d-k
Saytip	77.81±11.87cd	82.14±8.02e-g	4.34±0.01a-f	4.35±1.01b-h	73.75±1.41mn	77.42±1.04j-p	9.43±0.20d-i	11.28±3.42f-l
Suarpran	82.22±7.31cd	83.83±14.69e-g	2.79±0.59f	3.15±0.54e-h	74.97±3.56l-n	72.27±1.14n-t	9.46±0.96d-i	11.60±1.67e-l
Taydang	99.62±12.30cd	103.74±18.31e-g	3.51±.07b-f	3.83±0.62c-h	36.16±1.51r	41.96±3.75w	12.80±0.30c-f	16.77±1.84b-i
Tuy ngu	63.14±11.54cd	71.71±8.66e-g	3.01±0.47ef	3.04±0.51e-h	75.07±1.16l-n	79.56±1.23f-o	5.27±0.44hi	6.60±1.23j-l
Tuypum	205.51±17.12bc	480.43±11.65ab	4.55±0.28a-f	6.50±2.34a	87.35±1.22b-h	69.63±3.45p-u	11.38±1.66d-i	24.19±2.70b
Tuysan	498.32±27.22a	470.15±21.15ab	5.10±0.50a-e	3.48±0.34d-h	92.19±3.29a-d	88.77±0.83a-f	10.60±1.31d-i	12.91±2.39d-k

Violet 696	334.43±20.20a-c	391.42±20.57bc	3.56±0.18b-f	3.72±0.15c-h	53.43±0.14q	60.45±6.37v	15.59±1.31cd	21.07±4.84b-d
Winggao OP	86.84±24.71cd	362.03±13.15b-d	3.98±0.48a-f	3.34±0.94d-h	89.66±4.60a-f	85.27±4.99b-k	6.59±0.58f-i	9.39±2.30h-l
Yokkhaw	40.07±11.40d	59.97±13.76e-g	3.03±0.14ef	4.39±0.43b-h	86.05±2.57d-i	89.83±3.97a-e	8.23±0.05e-i	10.53±2.81g-l
CV.%	7.34	8.16	6.31	11.63	4.07	5.98	8.58	8.22

Means in the same column with the same letter(s) are not significantly different by Duncan’s New Multiple Range Test (DMRT) at 0.05 probability level.

Table 4. Mean squares from combined analysis of variance for system, genotypes, and interaction for two production systems.

Sources of variance	DF	Pod length (cm)	No. of seeds.pod^{-1} (seed)	No. of pods.plant^{-1} (pod)	Fresh pod yield.plant^{-1} (g)	100 seed weight(g)	Harvest index
Systems(S)	1	4,313.86**	16.85**	2,079.12*	2,084,964.17*	724.04*	63.28*
Blocks. Within S	6	1,227.78ns	14.44ns	1,002.28ns	71,722.12ns	316.24ns	38.19ns
Genotypes (G)	49	4,749.10**	56.22**	2,629.00**	4,749,423.99**	3,999.61**	111.86**
S x G	49	4,486.57**	49.25**	2,146.96**	4,465,499.02**	2,230.15**	78.69**
Pooled error	294	604.65	7.68	489.20	430332.68	180.11	15.98

*,** Significant at 5% and 1% levels of probability, respectively. ns, not significant.

Table 5. Means for pod lenght, pod weight, seeds/plant, pods/plant 100 seed weight and harvest index of *Vigna* spp. at two growing systems.

Systems	Pod length (cm)	Fresh pod weight.pod^{-1}(g)	No. of seeds.pod^{-1} (seed)	No. of pods.plant^{-1} (pod)	Fresh pod yield.plant^{-1}(g)	100 seed weight (g)	Harvest index
Inorganic	45.25a	21.60a	13.96a	41.34a	849.19a	29.86a	37.44b
Organic	46.57a	20.82b	13.38a	34.78b	718.99b	24.89b	40.53a
Means	45.91	21.21	13.67	38.06	784.09	27.38	38.99

Means in the same column with the same letter(s) are not significantly different by Duncan’s New Multiple Range Test (DMRT) at 0.05 probability level.

Chavas et al., 2009). *Vigna* spp. genotypes have high variations in pod color, starch properties and nutritionally important components (Peyrano et al, 2016). The pod colors of *Vigna* spp. include white, green yellow, green, purple, brown, red and black. Previous study indicated that pod colors of *Vigna* spp. were closely related to phytochemical constituents and concentrations. In this study, *Vigna* spp. genotypes with white, green, purple, brown, red and black colors were selected because they are rich in anthocyanins and phenolic compounds, and the results indicated that Dawdang (organic agricultural system) had the highest total anthocyanin content at edible stage (603.83±12.76 mg CGE.100g^{-1} of fresh weight (FW). In previous investigations with many crops, total anthocyanin contents were 0.59±0.01 mg CGE.100g^{-1} in brown colored common bean (Dzomba et al. 2013). Total anthocyanin contents (ranging from 30.80±6.14 to 603.83±12.76 mg CGE.100g^{-1} of FW in fresh pod) in *Vigna* spp. in this study were higher than those in previous study. The differences in the results among different studies were due largely to plant species and plant genotypes and plant parts. The results in this study and previous studies indicate that there is variation in anthocyanin content in *Vigna* spp. and breeding for high anthocyanins in *Vigna* spp. is possible. Moreover, the results showed that many genotypes of bean planted under organic agricultural system had height antioxidants and their capacities than inorganic agricultural system. The significant interaction between system and genotype effects indicated that genotype responded differently to changes in system production. High proportion of variation on yield and yield components were found for the genotype effect, therefore more testing sites are needed or the environments in locations need to be controlled (Gurung et al., 2012; El-Shaieny et al., 2015). Many study researchers and many plants reported that yield and yield components content are affected by genetic and environment conditions. Moreover, Singh et al. (2006) and Adeyanju et al. (2012) reported environment has stronger effect on yield. In contrast, Gurung et al. (2012) found that genotype plays a major role in yield contents as more than 70% of the variation was due to cultivar effect although SxG were significant. However, most genotypes were local varieties in countries. Hence, this experiment is to study in real conditions and Kangkragan genotype should be used for further breeding or plant in commercial genotypes. Because this genotype can adapt and give height yields under two production systems.

Materials and Methods

Plant materials

Fifty genotypes of yardlong bean and cowpea including 28-2, 901, Big 1, Jin 6, Jin 8, Dawdang, Dokkrong 10, Ero 6, Fakdang, Fakkeal, Green aro, Green aro 692, Hero, Jawsamran, Jiandou, Jong ang, Kangkragan, Kaset 135, keawdok 4, Longgo 5, Lumnumchee, Lumnumpong, Lumtakong, Maping, MMS1, mudkaw 3A, Mung 3A, Mungsitid, Neu, Nhongsau, Nigro, Nuangtong 9, Panomsarakram, Pechkagi, pechpimai, Raya, Samchuk, Sansuwan, Sayrung, Saytan, Saytara, Saytip, Suarpran, Taydang, Tuy ngu, Tuypum, Tuysan, Violet 696, Winggao OP, and Yokkhaw were selected from anyplace in Thailand and other countries.

Treatments and experimental design

Fifty genotypes of *Vigna* spp. (treatments) were selected from someplace in many areas. Plot experiments were planted at the Department of Plant Science, Faculty of Technology and Community Development Thaksin University Phatthalung Campus, Phatthalung Thailand (7° 37' 0" N, 100° 5' 0" E). The soil type was Phatthalung series (Yt: Fine, kaolinitic, isohyperthermic, plinthic, paleaquults). All genotypes of yardlong bean and cowpea were sown under field trial conditions. 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 5 m (5 m^2). Seeds were dropped in each hole. Plant to plant and row to row spacing was maintained at 0.50 m and 0.75 m, respectively. The rows were planted in pairs. Seven days after planting, they were separated and only one plant was left in the hole. This experiment was conducted between January and June 2015. The study was performed as a Randomized Complete Block Design (RCBD) with four replications and twenty plants.replication^{-1}. Soil preparation and crop management for organic trail followed the International Federation of Organic Agriculture Movements (IFOAM, 2005). Inorganic fertilizer (formula 15-15-15 of NPK) was applied to the inorganic trial at the rate of 650 kg.ha^{-1} and compost manure was applied to organic trial at the same rate of 650 kg.ha^{-1}. Two types of fertilizers (inorganic and organic) were applied in two splits. At first split, the fertilizers (325 kg.ha^{-1}) were applied at the bottoms of the hills shortly before transplanting. At second split, the fertilizers (325 kg.ha^{-1}) were applied around the stems of the plants and hilled up by hoes (pilling soil up around the base of the plant). Manual weeding was practiced for both inorganic and organic systems, and inorganic control of insects and diseases was practiced under inorganic system only (Benchasri, 2015), whereas biological control was practiced under organic farming systems (Oyesola and Obabire, 2011). Yardlong bean and cowpea harvesting was carried out when the pods were still fresh. Fresh pods were collected 5 – 7 days after flowering.

Data collection

Soil and meteorological condition.

Soil contents and chemical properties were measured. Weather condition about rainfall, humidity and air temperature such as maximum, minimum and average air for this experiment were also measured monthly from plantation to harvest by a weather station located 100 m away from the experimental field.

Yield and yield component traits

Important morphological characteristics of *Vigna* spp. such as pod length, fresh pod weight, number of seeds.pod^{-1}, number of pods.plant^{-1} and fresh pod yield.plant^{-1} were measured for 60 pods.treatment^{-1}. In addition, 100 seed weight and harvest index were also recorded all genotypes. The pods of this crop were harvested for yield assessment at 5 – 7 days after flowering.

Sample Extraction and Determination of Total Anthocyanin Content (TAC)

Anthocyanins in distinct pod parts were extracted according to the method previously described by Yang et al. (2009) and Simla et al. (2016) with slight modification. Portion of 0.5g samples were put into a conical flask containing 25mL of acidified methanol (methanol-1% citric acid, 80:20 v.v^{-1}) mixed well and stored for 24 h at 4ºC. The solution was then transferred to a tube and centrifuged at 11,538 xg for 10 min at 4°C. Further, the supernatants were collected and kept at -20ºC in the dark until analysis.

Total anthocyanin content was measured using the pH differential method as described by Dzomba et al. (2013). A UV-vis spectrophotometer (UV-1700 Pharmaspec, Shimadzu, Japan) was used to measure the absorbance at 510 and 700 nm. Anthocyanin levels were expressed as mg of cyanidin-3-glucoside equivalents.g^{-1} of fresh weight (mg CGE.$100g^{-1}$ of FW), using the reported molar extinction coefficient of 26900 $M^{-1}.cm^{-1}$ and a molecular weight of 449.2 $g.mol^{-1}$.

Determination of Total Phenolic Content (TPC)

Total phenolic contents were determined using FolinCiocalteu (F-C) method described by Hu and Xu (2011). Briefly, the appropriate dilutions of extracts were oxidized with F-C reagent, and the reaction was neutralized with sodium carbonate. The absorbance of the resulting blue color was measured at 765 nm after 90 min, and the phenolic content was expressed as mg of gallic acid equivalents (GAE).$100g^{-1}$ of fresh weight (mg GAE. $100g^{-1}$ of FW).

Determination of antioxidant activity

The capacity for scavenging DPPH radicals was assessed by measuring the bleaching of a black-coloured methanol solution containing DPPH radicals as described by Yang and Zhai (2010). Briefly, 0.1 mM solution of methanolic DPPH solution was prepared. The initial absorbance of the DPPH in methanolic was determined at 517 nm and did not change throughout the period of assay. An aliquot (0.1mL) of each sample (with appropriate dilution if necessary) was added with 3 mL of methanolic DPPH solution. Discolorations were measured at 517 nm after incubation for 30 min at 30 ºC in the dark. Measurements were performed at least in triplicate. The percentage of DPPH was calculated as:

%DPPH reduction = $(Abs_{control} - Abs_{sample}) \times 100 / Abs_{control}$,where $Abs_{control}$ is the absorbance of the control, and Abs_{sample} is the absorbance of the sample.

Trolox equivalent antioxidant capacity (TEAC) assay, which measures the reduction of radical cations of ABTS by antioxidants was conducted as described by Yang and Zhai (2010). The ABTS scavenging rate was calculated as:

%ABTS reduction = $(Absinitial - Abs_{final}) \times 100 / Abs_{initial}$, where $Abs_{initial}$ is the absorbance of the control, and Abs_{final} is the absorbance of the sample.

Statistical analysis

Data for separate locations were analyzed statistically according to a Randomized Complete Block Design. All analyses were done using the statistical programme of SPSS (Statistical Package for the Social Science for Windows) version 16.0. Significant treatment differences were separated using the Duncan's New Multiple Range Test (DMRT) at 0.05 probability level. Yield, yield components, anthocyanin content, total phenolic content and antioxidant capacity traits were statistically analyzed for each system. Error variances were tested for homogeneity with Bartlett's test as described by Gomez and Gomez (1984). Combined analysis of variance was done for two environments (production systems) according to a statistical model explained by Freeman (1973).

Conclusion

Vigna spp. plants grown in soil treated with chemical fertilizer were shown a vigorous vegetative growth (pod length, number of pods.$plant^{-1}$ and fresh pod yield) compare to application of an organic agricultural system. However, organic *Vigna* spp. products are expected to be healthy for humans and may be more profitable than those from produced by a conventional production system. The outcome of the study may be used as guidance for *Vigna* spp. production in Thailand.

Acknowledgments

The authors would like to thank the Graduate School, Thaksin University and the authors also would like to thank the Research and Development Institute, Thaksin University and National Research Council of Thailand (NRCT) for funding this research.

References

Abbas G, Abbas Z, Aslam M, Malik AU, Ishaque M, Hussain F (2011) Effects of organic and inorganic fertilizers on mungbean (*Vigna radiata* (l.)) yield under arid climate. Int Res J Plant Sci. 2(4): 94 – 98.

Adeoye PA, Adebayo SE, Musa JJ (2011) Growth and yield response of cowpea (*Vigna unguiculata*) to poultry and cattle manure as amendments on sandy loam soil plot. Agri Sci. 6(5): 218 – 221.

Adeyanju AO, Ishiyaku MF, Echekwu CA, Olarewaju JD (2012) Generation mean analysis of dual purpose traits in cowpea (*Vigna unguiculata* [L.] walp). Afr J Biptechnol. 11(46): 10473 – 10483.

Agyeman K, Berchie JN, Osei-Bonsu I, Tetteh Nartey E, Fordjour JK (2014) growth and yield performance of improved cowpea (*Vigna unguiculata* L.) varieties in Ghana Agri Sci. 2(4): 44 – 52.

Aikins SHM, Afuakwa JJ (2008) Growth and dry matter yield responses of cowpea to different sowing depths. ARPN J Agric Biol Sci. 3(5 – 6): 50 – 54.

Attigah AS, Asiedu EK, Agyarko K, Dapaah HK (2013) Growth and yield of okra (*Abelmoschus esculentus* L.) as affected by organic and inorganic fertilizers. ARPN J Agric Biol Sci. 8(12): 766 – 770.

Badiane FA, Gowda BS, Cisse N, Diouf D, Sadio O, Timko MP (2012) Genetic relationship on SSR markers. Genet Mol Res. 11(1): 292 – 304.

Bastos EA, Folegatti MV, Faria RT, Júnior ASA, Cardoso MJ (2002) Simulation of growth and development of irrigated cowpea in Piauí State by CROPGRO model. Pesq Agropec Bras Brasília. 37(10): 1381 – 1387.

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, Bairaman C (2010) Evaluation of yield, yield components and consumers' satisfaction towards yardlong bean and cowpea in agricultural organic system. Bulg J Agric Sci. 16(6): 705 – 712.

Benchasri S, Bairaman B, Nualsri C (2012) Evaluation of yardlong bean and cowpea for resistance to *Aphis craccivora* Koch in southern part of Thailand. J Anim Plant Sci. 22(4): 1024 – 1029.

Chavas JP, Posner JL, Hedtcke JL (2009) Organic and conventional production systems in the Wisconsin integrated cropping systems trial: II. economic and risk analysis 1993–2006. Agron J. 101(2): 288 – 295.

Chinma CE, Emelife, IG, Alemede IC (2008) Physicochemical and functional properties of some Nigerian cowpea varieties. Pak J Nutr. 7(1): 186 – 190.

Connell SO, Shi W, Grossman JM, Hoyt GD, Fager KL, Creamer NG (2015) Short-term nitrogen mineralization from warm-season cover crops in organic farming systems. Plant Soil. 396(1): 353–367.

Drinkwater LE (2002) Cropping systems research: reconsidering agricultural experimental approaches. Horttechnology. 12(3): 355 – 361.

Dzomba P, Togarepi E, Mupa M (2013) Anthocyanin content and antioxident activities of common bean species (*Phaseolus vulgaris* L.) Growth in Mashonaland Central, Zimbabwe. Afr J Agric Res. 8(25): 3330 – 3333.

El-Shaieny AAH, Abdel-Ati YY, El-Damarany AM, Rashwan AM (2015) Stability analysis of components characters in cowpea (*Vigna unguiculata* (L.) Walp). J Hortic For. 7(2): 24 – 35.

Fang J, Roberts PA, Ehlers JD, Chih-Cheng T (2007) Genetic diversity of cowpea (*Vigna unguiculata* (L.) Walp) in four West African and USA breeding programs as determined by AFLP analysis. Genet Resource Crop Evol. 54(6): 1197 – 1209.

Farahvash F, Mirshekari B (2011) Yield and yield components of cowpea as affected by different sources and application rates of nitrogen fertilizers. J Food Agric Environ. 9(3 – 4): 295 – 298.

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

Gomez KA and Gomez AA (1984) Statistical Procedure for Agricultural Research. John Wiley and Sons. New York.

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

Hamid S, Muzaffar S, Wani IA, Masoodi FA, Bhat MM (2016) Physical and cooking characteristics of two cowpea cultivars grown in temperate Indian climate. J Saud Soc Agric Sci. 15(2): 127–134.

Henry AE, Chinedu PP (2014) Cowpea (*Vigna unguiculata* L. Walp) response to phosphorus fertilizer under two tillage and mulch treatments. Soil Till Res. 136: 70–75

Hu QP, Xu JG (2011) Profiles of carotenoids, anthocyanins, phenolics, and antioxidant activity of selected color waxy corn grains during maturation. J Agri Food Chem. 59: 2026 – 2033.

Huaqiang T, Manman T, Qian L, Yongpeng Z, Jia L, Huanxiu L (2012) A review of molecular makers applied in cowpea (*Vigna unguiculata* L. Walp.) J Life Sci. 6: 1190 – 1199.

International Federation Organic Movement (2009) Die Deutsche Bibliothek. Bonn.

Karikari B, Arkorful E, Addy S (2015) Growth, nodulation and yield response of cowpea to phosphorus fertilizer application in Ghana. J Agron. 14(4): 234 – 240.

Kongjaimun A, Kaga A, Tomooka N, Somta P, Vaughan DA, Srinives P (2012) The genetics of domestication of yardlong bean, *Vigna unguiculata* (L.) Walp. ssp. *unguiculata* cv.-gr. *Sesquipedalis*. Ann Bot. 109: 1185–1200.

Lotter DW (2003) Organic agriculture. J Sustain Agric. 21(4): 59 – 128.

Madukwe DK, Christo IEC, Onuh MO (2008) Effects of organic manure and cowpea (*Vigna unguiculata* (L.) WALP) varieties on the chemical properties of the soil and root nodulation. Sci World J. 3(1): 43 – 46.

Magani IE, Kuchinda C (2009) Effect of phosphorus fertilizer on growth, yield and crude protein content of cowpea (*Vigna unguiculata* [L.] Walp) in Nigeria. J Applied Bio. Sci. 23: 1387 – 1393.

Mahoney PR, Olson KD, Porter PM, Huggins DR, Perillo CA, Crookston RK (2004) Profitability of organic cropping systems in Southwestern Minnesota. Renew Agr Food Syst. 19(1): 35 – 46.

Masvodza DR, Mazhude N, Mugabe J, Musango R (2014) Preliminary genetic diversity analysis of introduced and local Zimbabwe cowpea landraces. Afr J Agric Res. 9(49): 3571 – 3580.

Mukhtar FB, Singh BB (2006) Influence of photoperiod and gibberellic Acid (GA3) on the growth and flowering of cowpea [*Vigna unguiculata* (L.) Walp]. Food Agric Environ. 4(2): 201 – 203.

Naeem M, Iqbal J, Bakhs MAAHA (2006) Comparative study of inorganic fertilizers and organic manures on yield and yield components of mungbean (*Vigna radiat* L.). J Agric Soc Sci. 2(4): 227–229.

Nirmal DE, Kumar RAJ, Kalloo G (2001) Diet versatility in cowpea (*Vigna unguiculata*) genotypes. Indian J Agric Sci. 71(9): 598 – 601.

Nkaa FA, Nwokeocha OW, Ihuoma O (2014) Effect of phosphorus fertilizer on growth and yield of cowpea (*Vigna unguiculata*). IOSR J Pharm Biol Sci. 9(5): 74 – 82.

Ntare BR (1991) Variation in reproductive efficiency and yield of cowpea under high temperature conditions in a Sahelian environment. Euphytica. 59(1): 27 – 32.

Odedeji JO, Oyeleke WA (2011) Comparative Studies on Functional Properties of Whole and Dehulled Cowpea Seed Flour (*Vigna unguiculata*). Pak J Nutr. 10(9): 899–902.

Olusegun OO (2014) Influence of NPK 15-15-15 Fertilizer and pig manure on nutrient dynamics and production of cowpea, *Vigna unguiculata* L. Walp. Am J Agr Forestry. 2(6): 267 – 273.

Oyesola OB, Obabire I (2011) Farmers' perceptions of organic farming in selected local government areas of Ekiti State, Nigeria. J Org Syst. 6(1): 20 – 26.

Petlamul W, Ngampongsai A, Petcharat J (2009) Oviposition preference of papaya fruit fly, *Bactrocera papayae* Drew &Hancock (Diptera: Tephritidae) on some chili varieties. Thaksin J. 12(2): 43 – 49.

Peyrano F, Speroni F, Avanza MV (2016) Physicochemical and functional properties of cowpea protein isolates treated with temperature or high hydrostatic pressure. Innov Food Sci Emerg Tech. 33: 38–46.

Phansak P, Taylor PWJ, Mongkolporn O (2005) Genetic diversity in yardlong bean (*Vigna unguiculata* ssp. *sesquipedalis*) and related *Vigna* species using sequence tagged microsatellite site analysis. Sci Hortic. 106(2): 137 – 146.

Reganold JP, Wachter JM (2016) Organic agriculture in the twenty-first century. Nature Plants 2(2):15221.

Sarutayophat T, Nualsri C, Santipracha Q, Saereeprasert V (2007) Characterization and genetic relatedness among 37 yardlong bean and cowpea accessions based on morphological characters and RAPD analysis. Songklanakarin J Sci Technol. 29(3): 591 – 600.

Shevkani K, Kaur A, Kumar S, Singh N (2015) Cowpea protein isolates: functional properties and application in gluten-free rice muffins. LWT - Food Sci Technol. 63(2): 927 – 933

Simla S, Boontang S, Harakotr B (2016) Anthocyanin content, total phenolic content, and antiradical capacity in different ear components of purple waxy corn at two maturation stages. Aust J Crop Sci. 10(5): 675 – 682.

Singh BB, Ajeigbe HA, Tarawali SA, Fernandez-Rivera S, Abubakar M (2003) Improving the production and utilization of cowpea as food and fodder. Field Crops Res. 84(1 – 2): 169–177.

Singh I, Badaya SN, Tikka SBS (2006) combining ability for yield over environments in cowpea (*Vigna unguiculata* L. Walp). Indian J Crop Sci. 1(1 – 2): 205 – 206.

Win KT, Oo AZ (2015) Genotypic difference in salinity tolerance during early vegetative growth of cowpea (*Vigna unguiculata* L. Walp.) from Myanmar**.** Biocatalysis Agric Biotechnol. 4(4): 449 – 455.

Win KT, Oo AZ, Aung HP, Terasaki A, Yokoyama T, Bellingrath-Kimura SD (2015) Varietal differences in growth and Cs allocation of blackgram (*Vigna mungo*) under water stress. Environ Exp Bot. 109: 244–253.

Yang Z, Chen Z, Yuan S, Zhai W, Piao X, Piao X (2009) Extraction and identification anthocyanin from purple Corn (*Zea mays* L.). Int Food Sci Tech. 44(12):2485 – 2492.

Yang Z, Zhai W (2010) Identification and antioxidant activity of anthocyanins extracted from the seed and cob of purple corn (*Zea mays* L.). Innov. Food Sci Emerg Tech. 11(1):169 – 176.