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Effect of Sowing Distances on Edible Pod Yields and Yield Components of Three Vegetable Cowpea Cultivars (*Vigna unguiculata* L. Walp.) *Sesquipedalis* Subspecies, Grown in Northeast Thailand

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Abstract: This experiment was conducted at the Experimental Farm, Mahasarakham University, Mahasarakham 44000, Northeast Thailand in the 2006 (August to October) to investigate effect of sowing distances on edible pod yields and yield components of three vegetable cowpea cultivars (*Vigna unguiculata* L. Walp.) *Sesquipedalis* subspecies. The experiment was laid in a split plot arranged in a Randomize Complete Block Design with four replications. Five sowing distances were used as main plots (50×10, 50×20, 50×30, 50×40 and 50×50 cm between rows and within rows, respectively) and three cowpea cultivars were used as subplots (MSU 1, KKU 40 and SNU 1). The results showed that there were no statistical differences due to cultivars on total dry weight ha^{-1}, number of branches $plant^{-1}$, marketable pods ha^{-1}, 100-seed weight and total fresh weight of pods ha^{-1} where in most cases genetic potential of the three cultivars were similar. Number of off standard pods was significantly highest with KKU 40 (6.13 pods $plant^{-1}$), whilst MSU 1 and SNU 1 cultivars gave smaller values but both were similar (4.80 and 4.53 pods $plant^{-1}$, respectively). The closest sowing distances (T_1) gave significantly higher total dry weight ha^{-1} and number of off standard pods $plant^{-1}$ than other treatments (T_2-T_5). An increase in sowing distances significantly increased number of branches $plant^{-1}$ up to T_2 but T_2 was similar to other higher sowing distances (T_3-T_5). Total marketable pods (12,196.50 kg ha^{-1}) and total fresh weight of edible pods (12,588.88 kg ha^{-1}) were significantly highest with T_3 where T_3 was the most suitable sowing distances for either of the three cowpea cultivars (50×30 cm between rows and within rows, respectively).

Key words: Cowpea, edible pod yields, marketable pod yield, sowing distances and yield components

INTRODUCTION

Amongst tropical countries, pods of both vegetable cowpea and Yard long bean of different cultivars have been utilized as a kind of vegetables for daily diets for a number of years, i.e., both *Vigna unguiculata* (Cowpea) and *Vigna sesquipedalis* (Yard long bean) have been cultivated in most tropical countries, e.g., India, Malaysia, Pakistan, Philippines, Indonesia and particularly in Thailand where plant breeders had established some amounts of new varieties with outstanding features such as high palatability, short life cycle and high pod yields with high resistant to diseases where the combination of genes of new varieties derived from both types of the crop was possible, i.e., cowpea×yard long bean. That is why within this decade a number of outstanding varieties have been established such as KVC 7, KKU 40, Mahasarakham 1, Suranaree 1 and many others. For this study, the latter three cultivars were chosen for the experiment since they proved to be the most promising cultivars for growers to cultivate for both fresh pods and grains apart from other benefits derive from them such as green leaves and stems can be used to feed beef cattle, cows and many other kinds of animals. Stover materials when added to the soils in a large quantity could enormously improve soil conditions and some of the varieties could fix nitrogen and form nodules in soils (Suksri and Seripong, 1991). The latter three varieties mentioned earlier have been bred and selected by plant breeders of Khon Kaen University, Mahasarakham University and Suranaree Technology University, respectively. The plant breeders of the three institutions aim to establish outstanding varieties for growers in connection with the high demand for fresh edible pod production for use in most of domestic markets throughout the country apart from their definite aims, i.e., with the established new cultivars, they hope to produce a number of lengthy pods of yard long bean type

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(approximately 60-85 cm long) where the crop plants require no stakes for the climbing up of stems and branches for radiant energy from the sun due to its short branching characteristics (lesser than 70 cm long). Yard long bean type of pods of its kind has its tremendous economic impact since the local people use them for making their daily diets into different kinds of dishes. Thus the objective in carrying out this experiment was to identify suitable sowing distances between rows and within rows of these cowpea plants in relation to soil fertility level, pod yields and yield components of the crop plants. Gesch *et al.* (2003) carried out experiments for two years with cowpea on sowing distances reported that sowing distances of 12.5×2.9 cm between rows and within rows gave the highest plant density (3.01×10^6 plants ha^{-1}) and the sowing distances of 25×1.9 cm between rows and within rows gave the highest dry matter yield of 1.72 tons ha^{-1} whilst the sowing distances of 75×1.3 cm between rows and within rows gave both seed yield and 1000 seed weight of 1,083 kg ha^{-1} and 3.09 g, respectively. Aiwe *et al.* (2005) with cowpea reported that a sowing distance of 1.20 m for IT86d-715 cultivar gave the highest yield and a wider distance wider than 1.20 m prevented best the disturbance of insect pests. Ismail and Anthony (2005) with three cultivars of cowpea and three cultivars of yard long bean reported that the sowing distances of 51×35 and 76×35 cm between rows and within rows gave the highest yields for both types of the crop, respectively and the wider sowing distances of 102×35 gave the least. Therefore, it may be of tangible value to investigate how the cowpea cultivars responded to different sowing distances under field conditions at Mahasarakham Province, Northeast Thailand. The obtained results may be useful to growers of the cowpea plants, particularly the growers in northeastern region of Thailand.

MATERIALS AND METHODS

This rain-fed experiment was conducted at the Experimental farm, Faculty of Technology, Mahasarakham University, northeastern region of Thailand during a period from August to October 2006 to investigate the effect of sowing distances on growth and pod yields of three cowpea cultivars, i.e., KKU 40, Mahasarakham 1 and Suranaree 1 and it was carried out during the rainy season. The experiment was laid in a split plot arranged in a Randomized Complete Block Design (RCBD) with four replications where main plots were sowing distances, i.e., 50×10 (T_1), 50×20 (T_2), 50×30 (T_3), 50×40 (T_4) and 50×50 cm (T_5) and subplots were cowpea cultivars, i.e., KKU 40, Mahasarakham 1 (MSU 1) and Suranaree 1 (SNU 1). The Roi-Et soil series (Oxic Paleustults) was used for this experiment and the land area was ploughed twice followed by harrowing once. The plot size used was a 4×5 m with a walking path between the plots of 1 m. There were all together 60 plots where four sets of plots were arranged in each set of replications, i.e., sets of replication 1 up to 4 were used and each of them had 15 plots. Before sowing of seeds, each set of replications was randomly chosen for their respective treatments and all of the plots were evenly applied with Furadan, an insecticide at a rate of 12.50 kg ha^{-1} to prevent seed damages cause by insect pests. Seeds of KKU 40, MSU 1 and SNU 1 cultivars were sown by hand directly into their respective treatments where appropriate. To insure germination of these legume seeds then each hole or drill received 3 seeds. One week after emergence (germination was taken place 3 days after sowing), seedlings were thinned out leaving only one seedling $hole^{-1}$. Lannate (Methomyl), an insecticide was weekly sprayed to the plants at a recommended rate of the chemical company (E.I. Dupont Thailand Co. Ltd.) to prevent damages to the plants cause by insect pests and the spraying was carried out at one week after emergence. Weeding was carried out by mechanical means twice, i.e., at days 20 and 40 after emergence. A complete chemical fertilizer 15-15-15 (NPK) at a rate of 312.50 kg ha^{-1} was applied to the plots twice, i.e., one half at the beginning of the experiment and the other half at 30 days after sowing. The following measurement parameters were used, i.e., total dry weights ha^{-1} (all plant samples collected from each replication were weighed out and recorded then the plant samples were evenly mixed together for a random chosen of ten different fresh weights and all of the ten samples were placed in a hot air oven at 80°C for 4 days for dry weight determinations). In carrying out this way, all of the recorded fresh weights of the plants of each treatment were converted into dry weights, i.e., growth analysis technique was partly used where the technique has been reported by Sestak *et al.* (1971), Bullock *et al.* (1993) and Suksri (1999). Number of branches $plant^{-1}$, off standard pods $plant^{-1}$, marketable pods ha^{-1} and 100-seed weights (Seeds were allowed to dry under the sun for 4 days) were used for the determination of yield components. The actual fresh weights of pod yields ha^{-1} were also recorded. In each sampling period of each replication, 12 Stake-less Yard long bean plants within the inside rows were chosen. The obtained data were statistically calculated using an MSTAT-C computer programme (Nissen, 1989).

RESULTS

Total dry weights ha^{-1} and number of branches $plant^{-1}$: With total dry weights, the results showed that average values of total dry weights of the cowpea cultivars ranged

Table 1: A two-way analysis of means of total dry weights ha^{-1} of cowpea cultivars as affected by sowing distances

	Cultivars			
Treatments	MSU1	KKU40	SNU1	Total dry weight (kg ha^{-1})
	kg ha^{-1}			
T_1	1429.07	1350.33	1518.00	1432.47a
T_2	754.47	761.63	955.17	823.76b
T_3	675.11	593.54	484.00	584.22bc
T_4	513.50	479.29	506.48	499.76c
T_5	534.49	392.58	444.40	457.16c
Average	781.325	715.48	781.61	

Letter(s) in column indicate least significant differences of Duncan's Multiple Range Test (DMRT) at probability (p) of 0.01

Table 2: A two-way analysis on mean values of number of branches plant^{-1} of cowpea cultivars as affected by sowing distances

	Cultivars			
Treatments	MSU 1	KKU 40	SNU 1	No. of branches plant^{-1}
	kg ha^{-1}			
T_1	7.00	4.33	5.33	5.56b
T_2	9.67	10.33	11.33	10.44a
T_3	10.33	10.00	11.67	10.67a
T_4	10.33	10.33	10.33	10.33a
T_5	11.67	11.33	12.33	11.78a
Average	9.80	9.27	10.20	

Letter(s) in column indicate least significant differences of Duncan's Multiple Range Test (DMRT) at probability (p) of 0.01

from 715.48 to 781.61 kg ha^{-1} for KKU 40 and SNU 1, respectively. There were no statistical differences due to cultivars found among the three cultivars used (Table 1). However, with the effect due to sowing distances, the results showed that total dry weight was highest with T_1 (50×10 cm) followed by T_2, T_3, T_4 and $T_5$with average values ranged from 457.16 to 1432.47 kg ha^{-1} for T_5 and T_1, respectively, i.e., total dry weights decreased with an increase in sowing distances although T_5 was similar to T_4 and T_3. The differences were large and statistically significant. For numbers of branches plant^{-1}, the results revealed that the effect due to cultivars was not found where numbers of branches plant^{-1} were similar with average values ranged from 9.27 to 10.20 for KKU 40 and SNU 1, respectively (Table 2). However, with the effect due to sowing distances, the results showed that numbers of branches plant^{-1}, in most cases, increased with an increase in sowing distances although T_2 was similar to T_3, T_4 and T_5 with average values ranged from 5.56 to 11.78 for T_1 and T_5, respectively. The differences were large and statistically significant.

Numbers of off standard pod plant^{-1} and marketable pods ha^{-1}: The results showed that among the three Stake-less Yard long bean cultivars, numbers of off standard fresh pods were highest with KKU 40 followed by MSU 1 and SNU 1 with average values of 6.13, 4.80 and 4.53, respectively (Table 3). The differences were large and statistically significant. However, numbers of off standard pods of MSU 1 was similar to SNU 1. The effect due to sowing distances showed that the highest

Table 3: A two-way analysis on mean values of off standard pods of cowpea cultivars as affected by sowing distances

	Cultivars			
Treatments	MSU 1	KKU 40	SNU 1	No. of off standard pods plant^{-1}
	kg ha^{-1}			
T_1	10.33b	13.67a	10.00b	11.33a
T_2	5.67d	8.00c	5.33d	6.33b
T_3	4.67d	5.67d	4.33d	4.89c
T_4	2.00e	2.33e	2.00e	2.11d
T_5	1.33e	1.00e	1.33e	1.11d
Average	4.80b	6.13a	4.53b	

Letter(s) in each row and column indicate least significant differences of Duncan's Multiple Range Test (DMRT) at probability (p) of 0.01

Table 4: A two-way analysis on mean values of fresh marketable pods of cowpea cultivars as affected by sowing distances

	Cultivars			
Treatments	MSU 1	KKU 40	SNU 1	Marketable pods (kg ha^{-1})
	kg ha^{-1}			
T_1	8208.31e	7522.94f	7966.69ef	7899.31c
T_2	10200.00bc	9670.81cd	10414.56b	10095.13b
T_3	12529.19a	12050.00a	12010.38a	12196.50a
T_4	10070.81bc	10266.69bc	10054.19bc	10130.56b
T_5	9164.56d	10025.00bc	9689.56bcd	9626.38b
Average	10034.56	9907.06	10027.06	

Letter(s) within rows and columns indicate least significant differences of Duncan's Multiple Range Test (DMRT) at probability of (p) 0.01

numbers of off standard pods plant^{-1} were found with T_1 followed by T_2, T_3, T_4 and T_5, i.e., in general, an increase in sowing distances significantly increased numbers of off standard pods although T_4 was not statistically different from T_5.

With marketable pods ha^{-1}, the results showed that there were no statistical significance found among the three cultivars but the effects due to sowing distances were relatively found (Table 4). That is an increase in sowing distances highly increased marketable fresh pod yields and the increase was only up to T_3 (50×30 cm) and then a decline to T_4 and T_4 was similar to T_5 with values ranged from 7,899.31 to 12,196.50 kg ha^{-1} for T_1 and T_3, respectively.

100 seed weights and total fresh weights of edible fresh pods: With 100 seed weights, the results showed that the differences due to treatments on 100 seed weights among the three cultivars were not significantly found where the average weights ranged from 10,705.00 to 10,808.75 kg ha^{-1} for SNU 1 and MSU 1, respectively (Table 5). Similarly, the effect due to sowing distances was not found where the three cultivars gave a similar 100-weight with values ranged from 13.00 to 13.77 g for T_1 and T_3, respectively.

For total fresh weights of edible pods, the results showed that the effect due to cultivars was not significantly found with values ranged from 10,705.00 to 10,808.75 kg ha^{-1} for SNU 1 and MSU 1, respectively (Table 6). However, the results due to sowing distances

Table 5: A two-way analysis on mean values of 100 seed weight (seed sizes) of cowpea cultivars as affected by sowing distances

	Cultivars			
Treatments	MSU 1	KKU 40	SNU 1	100 seed weight (g)
	---------- g ----------			
T_1	13.38	12.45	13.17	13.00
T_2	12.88	14.17	14.12	13.72
T_3	13.40	14.15	13.75	13.77
T_4	14.08	13.26	13.66	13.66
T_5	13.66	14.65	12.80	13.70
Average	13.48	13.74	13.50	NS

NS = Non Significant

Table 6: A two-way analysis on mean values of total pod yields (off standard pods plus marketable pods) of cowpea cultivars as affected by sowing distances

	Cultivars			
Treatments	MSU 1	KKU 40	SNU 1	Total fresh weight of pods (kg ha^{-1})
	---------- kg ha^{-1} ----------			
T_1	10489.56bc	10002.06cd	9970.81cd	10154.19bc
T_2	11054.19b	11093.75bc	11093.75b	10898.63b
T_3	12937.50a	12462.50a	12364.56a	12588.88a
T_4	10252.06c	10487.50bc	10216.69c	10318.75bc
T_5	9310.44d	10145.13c	9879.19cd	9778.50c
Average	10808.75	10729.56	10705.00	

Letter(s) within rows and columns indicate least significant differences of Duncan's Multiple Range Test (DMRT) at probability (p) of 0.01

were relatively found, i.e., an increase in sowing distances highly increased total fresh edible pods ha^{-1}. The increase was up to T_3 (50×30 cm) and then a decline with values ranged from 9,778.50 to 12,588.88 kg ha^{-1} for T_5 and T_3, respectively.

DISCUSSION

With the results found with this work, it is necessary for the Thai growers or perhaps growers of many countries around the world, particularly the countries located in the tropics to realize how a large amount of Yard long bean vegetable pods or even cowpea seeds could be annually produced to supply domestic markets or even exported overseas. What would be the suitable sowing distances to be used for each cultivar in relation to soil fertility in order to obtain maximum outputs of edible pod yields from land areas and the chemical fertiliser inputs. Therefore, growers need to know perhaps type of soils and what fertility level available for the plants, i.e., soil analysis should be carried out. For this study, it is well advocated that Roi-Et soil series (Oxic Paleustults) being used for crop cultivation has its mean value of soil pH of 5.5 (1:2.5 soil:water by volume) with initial mean values of soil Organic Matter (OM), soil nitrogen (N), available phosphorus (P) and exchangeable potassium (K) of 1.64 and 0.05%, 15.77 and 64 ppm, respectively. Chutichudet *et al.* (2007) had published these results recently. With the present research, soil analysis was not carried out although the location used is located nearby and it belongs to the same type of soil series. Therefore, fertility level should not be varied largely. Suksri (1999) stated that most of the soil series in Thailand possess high level of soil acidity and poor in mineral contents, thus fertility programme should be planned and applied before the sowing of seeds of any cereal crops. He further added that soil pH should be within a range of 6 to 6.5 (1:2.5 soil:water by volume) and microelements must be sprayed to the plants at least once or twice during the growth period since most soil types possess an inadequate amount of micro nutrients. This suitable range of soil pH confirms by a number of workers such as Mengel and Kirkby (1987), Miller and Donahue (1990) and Suksri (1999). Therefore, some improvements to be carried out for this Roi-Et soil series (Oxic Paleustults) are presumably needed when further experiments are to be carried out.

The growth of the cowpea plants found with this work showed that an increase in sowing distances significantly increased numbers of branches plant^{-1} up to T_2 although an increase in sowing distances did not significantly increase total dry weight ha^{-1} of the cowpea plants. This could have been attributed to the poor level of soil fertility and soil property of the Roi-Et soil series used, e.g., soil pH level was at a point below suitable range. Furthermore, soil P and K levels were relatively low. Another reason for this could have been possibly related to perhaps the branching characteristics of the cowpea plants may have been influenced by genetic traits where the three cultivars possessed similar growth characteristics. The results indicated high output of dry matter yield per unit area of land of T_1, which was higher than the other treatments of a wider sowing distances used. Thus the distances being used for T_1 may not be the most appropriate distances if total dry matter ha^{-1} is alone to be taken into account. Another reason for this could be due to the ratio between N and K in soil where N had its effect on top growth, whilst K promotes the growth of pods. It could have been possible that N level of the soil series used was relatively higher than K hence top growth was relatively promoted. Suksri and Wongwiwatchai (1988) stated that tuber roots of cassava (*Manihot esculenta* Crantz) were promoted most by higher K than N, whilst higher N than K promoted top growth. It has been emphasized that K has its significant role in increasing the rate of photosynthesis by a rapid unloaded assimilates, i.e., K assists in the process of translocation of assimilates by its influences on electron (e^-) transport in the transport chain of the plants (Overnell, 1975; Mengel and Kirkby, 1987; Suksri, 1998). It was found that in most cases an increase in sowing

distances significantly decreased total dry weight ha^{-1} of the cowpea plants where T_1 was the highest. The results suggested that some closer sowing distances, i.e., closer than T_1 may provide a greater dry weight yield than T_1 but for this research the experiment aimed to find the most suitable distances between rows and within rows for the utmost edible pod yield ha^{-1} rather than aiming to attain high amount of green manure materials. Thus the most suitable sowing distance was found with T_3 (50×30 cm between rows and within rows, respectively) where fresh marketable pod yield ha^{-1} was the highest (12,196.50 kg). Thus the results indicated the efficacy of soil fertility level and chemical fertiliser inputs only up to T_3 of the sowing distances. However, it may be possible that a higher marketable fresh pod yield could possibly be achieved if fertility programme has been carried out before the sowing of seeds and a suitable N:K ratio derives from chemical fertiliser has been improved. That is high workable values of soil pH, OM, N, P and K have been increased when free radiant energy from the sun could be adequately available for the crop plants.

The results on number of branches indicated that an increase in sowing distances significantly increased number of branches only up to T_2. This could perhaps be attributable to genetic traits of the crop plants as mentioned earlier where maximum number of branches could be achieved only up to the distances used of T_2 even though with other wider spaces available to the crop plants but still the crop plants were not able to produce more of the branches. The effect due to the three cultivars on total dry weight ha^{-1} was not found suggesting that all of the cultivars being used possess a similar amount of growth due to a similar genetic potentiality. However, when it comes to total fresh weight of pods and marketable pods, the results showed that an increase in sowing distances significantly increased total fresh weight and marketable pods up to T_3 (50×30 cm, between rows and within rows, respectively) and then a decline was attained with higher sowing distances. The results suggested that with a wider sowing distances wider than T_3 then a competition for light (radiant energy from the sun) among leaf canopies could have been relatively small, i.e., the crop plants could possibly have attained Leaf Area Indices (LAI) within a range of 2-3 where no shading effect of leaves could have been occurred, i.e., 100% of light interception among leaf canopies could have been possible. If this circumstance was attained then it may indicate poor level of soil fertility. Another reason for this may be due to the ratio between N and K where K assisted the growth of pods when there was no competition for radiant energy among leaf canopies. Suksri (1997) stated that horizontal structure of leaves of soybean required LAI values between 4-6 where 90% light interception among leaf canopies could be, more or less, optimum for growth. Thus the most suitable sowing distances for cowpea cultivars with the use of Roi-Et soil series should be at a distance between rows and within rows of 50×30 cm, respectively. The results indicated that these three cowpea cultivars provide a similar efficacy on growth and yield under this Oxic Paleustults soil group. It is unfortunate that there has been no data on growth and edible pod yields published since the three cultivars have been released not long ago. These three cultivars possess bushy growth characteristics similar to other ordinary cowpeas but they provide long pods just like Yard long bean.

With the results on sowing distances on number of off standard pods plant^{-1}, the results revealed that the closer the distances the higher the number of off standard pods. This could possibly be attributable to the competition for light where shading effect of leaves could have been occurred for T_1 and T_2 hence the supply of assimilates was inadequately taken place, i.e., there should have been a competition for assimilates among the newly established pods with time when assimilates were not adequately available so many pods were not fully developed unlike the wider sowing distances of T_4 and T_5 where a small amount of off standard pods was relatively smaller since more spaces were available for leaves to expand and intercept more light. Thus the crop plants were able to synthesize its food more rapidly and perhaps some adequate amounts of assimilates could have been used for the filling up of the pods reflecting the lower numbers of off standard pods. Further experiments with the use of different rates of organic manure and chemical fertilisers nitrogen and potassium may be of tangible value in order to produce higher fresh edible pod yields of Yard long bean type higher than T_3 where the pod yields could meet the demand of the domestic markets or perhaps exported overseas.

To sum up, it was found that the narrowest sowing distances (T_1) gave the highest total dry weight ha^{-1} of the cowpea plants. The wider the sowing distances the lower the total dry weight ha^{-1}. An increase in sowing distances, i.e., wider than T_1 gave a similar numbers of branches plant^{-1} and numbers of off standard edible pods significantly decreased with an increase in the sowing distances but only up to T_4. Seed sizes (100-seed weight) were similar in all cowpea cultivars used. The highest marketable pod yields (12,196.50 kg ha^{-1}) and total fresh weight of pods ha^{-1} (12,588.88 kg ha^{-1}) were found with the sowing distances of 50×30 cm (T_3) between rows and within rows, respectively.

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