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Effects of Green Manures on Growth, Yield and Quality of Green Okra (*Abelmoschus esculentus* L.) Har Lium Cultivar

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Abstract: This green manure experiment with the use of okra crop as indicator plant was carried out at Mahasarakham University Experimental Farm, Mahasarakham province, Northeast Thailand during May to September 2005 to investigate four types of green manure legume crops on growth, yield and quality of edible fresh pods of okra crop when grown on Roi-Et soil series (Oxic Paleustults). The four types of green manure plants include Jack bean, Cowpea, Green gram, and Giant sensitive plant. The experiment consisted of five treatments, i.e., T1 (Control), T2 (Jack bean), T3 (Cowpea), T4 (Green gram) and T5 (Giant sensitive plant). The experiment was laid in a Completely Randomized Design (CRD) with four replications. The results showed that Roi-Et soil series (Oxic Paleustults) contained some considerable mean values of organic matter (1.64-1.66%) but soil available phosphorus and exchangeable potassium were relatively low, particularly potassium. Green manures of the four legume plants slightly improved soil property of the Roi-Et soil series (tested at the end of the experimental period). The most effective green manure on stem diameter, bushy diameter, leaf numbers plant^{-1} and leaf area of the fifth leaf of the okra plants, in most cases, was found with Jack bean and Cowpea ranked the second. However, in most cases, Cowpea gave a similar effect as that of Green gram and Giant sensitive plant. Pod length and weight pod^{-1}, pod diameter and edible fresh pod yields (5,941.86 kg ha^{-1}) were highest with Jack bean green manure treatment (T2), whilst the rest, in most cases, were similar. Green manure treatments gave highly significant effect on total soluble solids of pods over the control treatment, whilst total acidity, fibre and pectin contents were unaffected by green manure treatments. Green manure of Jack bean was the best legume crop for green manure to be used in improving soil fertility, particularly for Roi-Et soil series (Oxic Paleustults).

Key words: Green manure, growth, okra crop, soil analysis, soil fertility, pod quality, yield

INTRODUCTION

Amongest many important kinds of vegetable crops, Green okra crop (*Abelmoschus esculentus* L.) Har Lium Cultivar has its significant role in supplying nutritive value to human daily diets. This crop could thrive on well in most tropical and subtropical areas where fresh edible pods provide human supplementary vitamins such as Vitamins C, A, B-Complex, iron, and calcium (FAO, 1988; Adebooye and Opunta, 1996; Chutichudet *et al*., 2006). The pod mucilage has its medicinal properties as an emollient, laxative and expectorant (Muresan and Popescu, 1993). Edible fresh pods could be used for fat extraction for use in making brownies (Boelje and Eidman, 1984). Furthermore, other forms of products derive from okra include oven dried pods ready for use in soup preparations, candies and salad dressing (Kalra and Pruthi, 1984; Owolarafe and Shotonde, 2004). With these numerous uses of okra plants, thus many countries in Asia and Africa have increased their land areas for the cultivation of this economic crop. They aim to provide adequate amounts of edible fresh okra pods for domestic and overseas consumption. In the 2004, Thailand exported okra fresh edible pods to Japan, Germany, UK, Netherlands, Iran and other countries with an amount greater than 0.79 million US Dollars (Anonymous, 2004a). Growers of okra plants in Thailand have annually increased a large land area for the cultivation of okra plants, particularly those areas in the Central Plane and northeastern regions. Nevertheless, growers in all regions of the country have come across with many problems such as the use of insecticides and herbicides, which affected export quality standard demanded by customers. Furthermore the problems on diseases and in

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particular poor soil fertility are also having an important role in producing crop yields. The latter has its significant impact in producing both high quality and yield of the okra plants, thus the problem on poor soil fertility should receive priority if both high edible pod yield and quality are to be expected. Recently, there have been a number of workers who pointed out that organic agriculture has its significant role on sustainable agriculture, since most tropical soils contained small amounts of organic matter and soil deterioration could be most rapid due to high leaching rate of soil nutrients caused mostly by rainfalls. Furthermore, decomposition rate of soil organic matter is most rapid due to high environmental temperatures (Rtnapradipa, 1996; Suksri, 1999; Liebman and Davis, 2000; Ngouajio and McGiffen, 2002; Pholsen, 2003; Kasikranan, 2003). The problem on soil deterioration is most severed in most soil series in Northeast Thailand, thus there is an urgent need to improve soil fertility in the region in order to obtain high crop yields (Anonymous, 2004b). One way to improve soil conditions is to add green manure to the soil. Therefore, this investigation focused on the use of four leguminous plant species as green manures added to the soil. They include Sword bean or Jack bean (*C. anavaria ensiformis* L.), Cowpea (*Vigna unguiculata* L.), Green gram (*Vigna radiata* L.) and Giant sensitive plant (*Mimosa invisa* Mart). This work aims to describe the effects due to each green manure on growth, yield and quality of okra crop when grown on Roi-Et soil series (Oxic Paleustults). The obtained data may be useful to growers of the okra plants.

MATERIALS AND METHODS

The experiment was carried out in the rainy season (May to September 2005) at Mahasarakham Experimental Farm, Mahasarakham University, Northeast Thailand to investigate effects of four types of green manure added to Roi-Et soil series (Oxic Paleustults) on growth, yields and quality of okra edible fresh pods (*Abelmoschus esculentus* L.) Har Lium Cultivar. The green manures used include Sword Bean or Jack Bean (*C. anavaria ensiformis* L.), Cowpea (*Vigna unguiculata* L.), Green Gram (*Vigna radiata* L.) and Giant sensitive plant (*Mimosa invisa* Mart). The initial mean values of soil pH, organic matter, nitrogen (%), available phosphorus (P) and exchangeable potassium (K) were 5.5, 1.64%, 0.05, 15.77 and 64.00 ppm, respectively. The layout of the experiment used was a Completely Randomized Design (CRD) with four replications. They consisted of 5 treatments, i.e., control (T1), Jack bean (T2), Cowpea (T3), Green gram (T4), and Giant sensitive plant (T5). The land area was ploughed twice followed by harrowing once. The plot size used was a 1.5×6 m with a path of 1.5 m in between the plots and all of the plots were added with an amount of a complete chemical fertilizer 15-15-15 (NPK) at a rate of 156.25 kg ha^{-1}. Seed weights of Jack bean, Cowpea, Green gram, and Giant sensitive plant used were 62.50, 50, 50 and 12.50 kg ha^{-1}. These amounts of seeds of each plant species were sown directly into their respective plots where appropriate (Anonymous, 2004b). Seeds of Jack bean and Giant sensitive plant were sown 10 days ahead of the rest in order to allow the four legume plant species to flower at the same time, i.e., both Jack bean and Giant sensitive plants were allowed to grow for 60 days, whilst both Cowpea and Green gram were allowed to grow for 50 days before they reached a stage of 50% flowering then they were incorporated into the soil with the use of a tractor unit (Anonymous, 2006). Ten days after the green manures were allowed to ferment in soil then a complete chemical fertiliser 15-15-15 (NPK) at a rate of 187.50 kg ha^{-1} was evenly applied to all plots of all treatments used then 3-5 seeds hole of okra crop were sown by hand directly into their respective plots with distances between rows and within rows of 50×50 cm, respectively, i.e., a hectare has approximately 40,000 plants. Two weeks after emergence, seedlings were thinned out leaving only 2 seedlings $hole^{-1}$. To provide adequate amount of soil moisture content when there was no rainwater, furrow irrigation was given to a level of near field capacity (field capacity of the soil is approximately 13%) four times throughout the growth period. Weeding was carried out twice during the early growth period when okra leaf areas were relatively small then weeding was no longer needed due to a large amount of dense leaves covered the ground area. Benlate (Bennomyl), a fungicide chemical was sprayed where appropriate to the plants for 3 times before the okra plants reached their flowering stage. Lannate (Methomyl), an insecticide was also sprayed to the plants at two-week intervals starting from day 21 after emergence. The rates of both Benlate and Lannate used were as recommended by the chemical company (E. I. Dupont Thailand Co. Ltd.). The harvest for pod yields was carried out from time to time where appropriate starting from day 45 after emergence. The measurement parameters on growth include plant height (measured each stem from above ground level up to the upper most tip of leaves), stem diameter (measured at the point of the first true leaf), bushy diameter, number of leaves, edible fresh pod yields ha^{-1} and leaf area of the fifth leaf (with the use of a portable leaf area meter, model AM-300, ADC Bioscience, England). These measurement parameters were carried out at 15 day intervals starting from day 15 after emergence until day 60, i.e., 4 measurement periods were carried out.

The measurement parameters on yield include pod length, pod diameter, fresh weight pod^{-1}, pod diameter, off standard pods and fresh pod yields ha^{-1}. Chemical analyses on quality of the okra edible pods include total soluble solids% (TSS), total acidity% (TA), fiber content% (FC) and pectin content% (PC). A hand refractometer E type, model N-1E, series 2111-W10, Japan was used for TSS, AOAC. method was used for TA (AOAC, 1984); Gould (1977) method was used for FC and Wattana-wanichakorn (1975) method was used for PC. The obtained data were statistically analysed where appropriate using a computer programme SPSS, Version 6 (SPSS, 1999).

RESULTS

Final soil analysis data: The results on soil analysis data taken from the final soil samples indicated that mean values of organic matter percentages found with soil samples treated with green manures increased slightly in all treated plots but remained the same with the control treatment with values ranged from 1.64 to 1.66% for T1 and T2, respectively (Table 1). A similar trend due to treatments was also found with pH, nitrogen, phosphorus, and potassium, i.e., in most cases, their values slightly increased, particularly soil exchangeable potassium with values ranged from 64 to 66 ppm for T1 and T2, respectively.

Plant height, stem and bushy diameters, leaf numbers and leaf areas: At day 15 after emergence, okra plant heights were similar in all treated plants with values ranged from 9.14 to 9.67 cm for T1 (control) and T5 (Giant sensitive plant), respectively (Table 2). For day 30 after emergence, the results showed that T2 (Jack bean green manure treatment) gave the highest followed by T3 (Cowpea), T4 (Green gram), T1 (control) and T5 (Giant sensitive plant) but all the treated plants, except T2, gave a similar value. The differences between T2 and the rest were statistically significant with values ranged from 18.17 to 21.54 for T5 and T2, respectively. At day 45, the results revealed that the highest plant height was attained with T2 followed by T3, T4, T5 and the lowest was found with T1 with values ranged from 32.15 to 41.80 cm for T1 and T2, respectively. The differences were large and highly significant. With the results at day 60, a similar trend due to treatments as that of day 45 was attained, i.e., T2 ranked the highest followed by T3, T4, T5 and T1 with values ranged from 47.24 to 61.20 cm for T1 and T2, respectively. The differences were large and highly significant.

With stem diameters, the results showed that at days 15 and 30, stem diameters of the okra plants were not affected by green manure treatments but at day 45 okra stem diameters were highly affected by green manure treatments, i.e., T2 ranked the highest followed by T3, T4, T5 and the lowest was found with T1 with values ranged from 2.16 to 2.72 cm for T1 and T2, respectively (Table 3). At day 60, the results showed that stem diameters of all green manure treated plants gave a similar significant value but highly significant over the control treatment (T1) with values ranged from 3.26 to 3.82 for T1 and T2, respectively. With bushy diameter, the results showed that there were no significant effects due to treatments at days 15 and 30 but significantly found at days 45 and 60. In most cases, bushy diameters of the green manure treated plants were similar but significantly greater than the control treatment (T1) with mean values at day 60 after emergence ranged from 53.20 to 67.58 cm for T1 and T2, respectively (Table 4). For leaf numbers, the results showed that leaf numbers at days 15 and 30 were not affected by green manure treatments but highly significant at days 45 and 60 after emergence (Table 5). Leaf number of T2 (Jack bean green manure) was highest, whilst other green manure treatments gave a similar leaf number with mean values at day 60 after emergence ranged from 23.80 to 31.98 leaves for T1 and T2, respectively. A similar trend to leaf numbers was found with leaf areas of the fifth leaf, i.e., there were no significant effects due to green manure treatments found at days 15 and 30 but significantly found at days 45 and 60 where T2 gave the highest but similar to T3 with mean values at day 60 ranged from 533.32 to 643.41 cm^2 for T1 and T2, respectively (Table 6).

Pod length, pod weight and diameter, off standard pods and fresh pod yields: The results showed that fresh pod length was longest with T2 (Jack bean) and the shortest was found with T5 (Giant sensitive plant), which was significantly lower than the control treatment with values ranged from 7.79 to 8.89 for T5 and T2, respectively (Table 7). The differences due to green manure treatments were highly significant. For weight pod^{-1}, the results revealed that all green manure treated plants were highly significant over the control treatment where T2 was the highest whilst other green manure treated plants were similar with values ranged from 9.18 to 12.10 g pod^{-1} for T1 and T2, respectively. With pod diameter, the highest diameter was found with T2 followed by T3

Table 1: Mean values of soil analysis data on organic matter % (OM), pH values, total nitrogen, available phosphorus and exchangeable potassium as influenced by leguminous green manure treatments

Treatments	OM (%)	pH values	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)
T1 (Control)	1.64	5.65	0.05	15.71	64
T2 (Jack bean)	1.66	5.64	0.06	15.74	66
T3 (Cowpea)	1.64	5.56	0.05	16.14	64
T4 (Green gram)	1.65	5.54	0.06	15.82	65
T5 (Giant sensitive plant)	1.65	5.63	0.05	15.74	65

Table 2: Mean values of okra plant heights (cm) taken at days 15, 30, 45 and 60 after emergence as influenced by leguminous green manure treatments

	Days after emergence			
Treatments	15 days	30 days	45 days	60 days
T1 (Control)	9.14	18.33b	32.15d	47.24c
T2 (Jack bean)	9.39	21.54a	41.80a	61.20a
T3 (Cowpea)	9.42	19.65ab	38.16b	56.09ab
T4 (Green gram)	9.21	19.19b	35.61c	51.78bc
T5 (Giant sensitive plant)	9.67	18.17b	34.20c	52.35bc
F-test	NS	*	**	**
LSD	0.42	0.72	0.68	1.89
CV (%)	7.54	8.84	13.43	15.25

Letter(s) within columns indicate least significant differences (LSD) at p** = 0.01, * = 0.05, NS = Non Significant

Table 3: Mean values of okra plant stem diameters (cm) taken at days 15, 30, 45 and 60 after emergence as influenced by leguminous green manure treatments

	Days after emergence			
Treatments	15 days	30 days	45 days	60 days
T1 (Control)	0.76	1.34	2.16c	3.26b
T2 (Jack bean)	0.76	1.38	2.72a	3.82a
T3 (Cowpea)	0.73	1.35	2.44b	3.74a
T4 (Green gram)	0.70	1.28	2.31bc	3.61a
T5 (Giant sensitive plant)	0.66	1.36	2.28bc	3.58a
F-test	NS	NS	**	**
LSD	0.03	0.04	0.08	0.08
CV (%)	9.60	6.27	13.90	15.56

Letter(s) within columns indicate least significant differences (LSD) at *p = 0.01, NS = Non Significant

Table 4: Mean values of okra plant bushy diameter (cm) taken at days 15, 30, 45 and 60 after emergence as influenced by leguminous green manure treatments

	Days after emergence			
Treatments	15 days	30 days	45 days	60 days
T1 (Control)	21.42	28.73	45.99b	53.20b
T2 (Jack bean)	21.00	28.76	54.70a	67.58a
T3 (Cowpea)	21.06	27.29	48.98ab	64.10a
T4 (Green gram)	20.75	27.44	45.13b	61.65a
T5 (Giant sensitive plant)	20.81	28.01	46.91b	64.28a
F-test	NS	NS	*	*
LSD	0.21	0.72	2.00	2.48
CV (%)	6.73	10.60	16.94	9.08

Letter(s) within columns indicate least significant differences (LSD) at *p = 0.05, NS = Non Significant

Table 5: Mean values of leaf numbers/plant of okra plants taken at days 15, 30, 45 and 60 after emergence as influenced by leguminous green manure treatments

	Days after emergence			
Treatments	15 days	30 days	45 days	60 days
T1 (Control)	5.83	14.50	19.63c	23.80c
T2 (Jack bean)	5.55	14.58	25.45a	31.98a
T3 (Cowpea)	5.63	14.63	22.08b	29.70ab
T4 (Green gram)	5.48	14.40	22.03b	28.23b
T5 (Giant sensitive plant)	5.53	14.45	22.48b	27.98b
F-test	NS	NS	**	**
LSD	0.19	0.16	0.44	1.06
CV (%)	7.41	5.80	13.60	8.04

Letter(s) within columns indicate least significant differences (LSD) at **p = 0.01, NS = Non Significant

Table 6: Mean values of leaf area (cm^2) of the fifth leaf of okra plants taken at days 15, 30, 45 and 60 after emergence as influenced by leguminous green manure treatments

	Days after emergence			
Treatments	15 days	30 days	45 days	60 days
T1 (Control)	234.29	254.44	507.55b	533.32c
T2 (Jack bean)	234.09	359.84	578.54a	643.41a
T3 (Cowpea)	228.44	351.37	541.06ab	623.18ab
T4 (Green gram)	226.80	347.80	516.66b	565.08bc
T5 (Giant sensitive plant)	232.74	352.75	535.92ab	582.73abc
F-test	NS	NS	*	*
LSD	4.10	4.19	14.84	23.69
CV (%)	6.12	12.11	13.84	7.74

Letter(s) within columns indicate least significant differences (LSD) at *p = 0.05, NS = Non Significant

Table 7: Mean values of pod length, pod weight, pod diameter, off standard pods and fresh pod yields ha^{-1} of okra plants as influenced by leguminous green manure treatments

Treatments	Pod length (cm)	Weight pod $^{-1}$(gm)	Pod diameter (cm)	Off standard pods (%)	Pod yields (kg ha^{-1})
T1 (Control)	8.27b	9.18c	2.14c	38.37a	3502.95b
T2 (Jack bean)	8.89a	12.10a	2.38a	21.49b	5941.86a
T3 (Cowpea)	8.23b	10.44b	2.21b	23.78b	3614.56b
T4 (Green gram)	8.42b	10.61b	2.09cd	25.21b	4195.24b
T5 (Giant sensitive plant)	7.79c	10.61b	2.05d	29.83ab	4299.03b
F-test	**	**	**	*	**
LSD	0.12	0.28	0.02	3.75	485.83
CV (%)	13.27	9.24	12.06	12.54	14.50

Letter(s) within columns indicate least significant differences at **p = 0.01, *p = 0.05

Table 8: Mean values of total soluble solids, total acidity, fibre content and pectin content of okra edible fresh pods as influenced by leguminous green manure treatments

Treatments	Total soluble solids (%)	Total acidity (%)	Fibre content (%)	Pectin content (%)
T1 (Control)	1.13c	0.19	0.64	0.78
T2 (Jack bean)	1.31a	0.15	0.40	0.88
T3 (Cowpea)	1.21b	0.15	0.52	0.83
T4 (Green gram)	1.24ab	0.16	0.46	0.83
T5 (Giant sensitive plant)	1.27ab	0.14	0.51	0.84
F-test	**	NS	NS	NS
LSD	0.030	0.013	0.106	0.280
C.V. (%)	7.46	11.21	8.93	10.63

Letter(s) within columns indicate least significant differences at **p = 0.01, NS = Non Significant

whilst other green manure treated plants gave a similar pod diameter but T4 was similar to control treatment with values ranged from 2.09 to 2.38 cm for T4 and T2, respectively. For off standard pods, the results showed that percentages of off standard pods were relatively high, i.e., T1 attained the highest followed by T5 where T5 was similar to other green manure treated plants with values ranged from 21.49 to 38.37% for T2 and T1, respectively. With fresh pod yields, the results revealed that T2 was the highest whilst other green manure treated plants gave a similar pod yield to control treatment (T1) with values ranged from 3,502.95 to 5,941.86 kg ha^{-1} for T1 and T2, respectively. The differences were large and highly significant.

Total soluble solids, total acidity, fibre and pectin contents in pods: Chemical analysis showed that percentages of total soluble solids were highest with T2 but more or less similar to other green manure treated plants and the lowest was found with T1 with values ranged from 1.13 to 1.31% for T1 and T2, respectively. The differences were large and highly significant (Table 8). However, total acidity and fibre content due to treatments were not different from one another. Similarly, green manure treatments had no significant effect on pectin content of the okra plants with values ranged from 0.78 to 0.88% for T1 and T2, respectively.

DISCUSSION

The results on soil analysis data at the final sampling period indicated that soil OM, pH, total nitrogen, available phosphorus, exchangeable potassium of the plots treated with green manures, in most cases, have increased slightly. The results suggested that green manures

added to the soil had its significant impact in improving soil conditions although some certain amounts of nutrients, particularly nitrogen could have been taken up by the okra plants during the growth period even though there had been an application of a complete chemical fertilizer 15-15-15 (NPK) added to the soil before sowing but the added amount failed to increase these macronutrients in soil. The results suggested that an amount of 156.25 kg ha^{-1} of the complete chemical fertilizer added to the soil was not adequate enough to sustain a higher level of these macronutrients. Thus the recommended rate being applied may not be suitable for Roi-Et soil series (Oxic Paleustults) hence further work should be carried out in order to justify the most suitable rate for this particular soil type. Furthermore, It seems more likely that some further amounts of organic materials are needed with this Roi-Et soil series apart from a complete chemical fertilizer 15-15-15 (NPK), since soil analysis data showed that only some small amounts of soil nutrients have increased when green manures were added to the soil after the crop was harvested. The decomposition of green manures added to the soil improves soil conditions by increasing organic matter%, soil organic carbon concentration, humus and polysaccharides have been reported (Biswas and Khosla, 1971; MacRae and Mehuys, 1985; Boparai *et al*., 1992; Suksri, 1999). Furthermore, the improvement of soil conditions includes soil aggregation, pore spaces, bulk density and ability to absorb a considerable amount of water (Mandal *et al*., 2003). Nevertheless, it has been reported that in most areas in the tropics soil deterioration could be most rapid due to a rapid decomposition rate as a result of high soil temperatures (Miller and Donahue, 1992; Ratnapradipa, 1996; Suksri, 1999; Kasikranan, 2003; Pholsen, 2003). Thus growers of the crop plants, particularly vegetable crops need to add more plant materials to their soils annually. Rochester *et al.* (2001) reported that when leguminous crops are grown and used for green manures they provide up to 40% of nitrogen available in soils by the decomposition of nodules and other biomass of the leguminous green manure crops.

With the present work, the effect due to green manure treatments on growth was relatively clear when the okra plants reached an age of 45 days after emergence, i.e., green manures of Jack bean, Cowpea, Green gram and Giant sensitive plant gave significantly higher plant height, stem diameter, bushy diameter, leaf numbers and leaf area of the fifth leaf than the control treatment. With respect to growth parameters, green manure of Jack bean, in most cases, attained the best results than the rest followed by Cowpea, whilst both Green gram and Giant sensitive plant gave similar growth parameters but significantly greater than the control treatment. The results indicated that green manure of Jack bean could be the best legume crop for use in improving soil fertility than the rest and Cowpea may be used as a second choice, whilst Green gram and Giant sensitive plant could be the last choice to be used in improving soil property. The differences found among the four legume crops may be attributable to the differences in the amounts of growth within a period till flowering. It could have been possible that Jack bean attained a greater biomass than the rest or it may be possible that this legume crop had produced a large amount of nodules than the rest. Gitari *et al.* (2003) showed that Jack bean was the most appropriate legume crop for use as a green manure material when okra crop is grown for high fresh edible pods. Kamidi *et al.* (2000) and Mukalama (2000) reported that Jack bean possesses a higher amount of growth of tops more than other legume crops hence its biomass could cover the ground area greater than other legume crops. MacRae and Mehuys (1985) stated that Jack bean could perform a deep anchorage roots than other legume crops being used thus it provided more soil pore spaces where more O_2 could be adequately available for plant roots. Chaiyadok (1992) reported that living bacteria around roots and nodules of legume crops normally possess a selective property to its legume hosts. Thus an assay on the identification of different types of bacteria in roots of Jack bean may be useful in explaining the effectiveness of some specific microorganisms that enable to promote a rapid growth of the Jack bean plants.

The results on pod length and diameter, weight pod^{-1} and pod yields ha^{-1} revealed that green manure of Jack bean (T2) gave the highest and the differences were large and highly significant. Furthermore, percentages of off standard pods were significantly lower than the control treatment but similar to all green manure treated plants. The highest edible fresh pod yield of T2 (5,941.86 kg ha^{-1}) signifies the utmost result of Jack bean as a green manure legume crop. Thus growers of most cash crops should prepare to multiply seeds of this legume crop annually. An analysis on total soluble solids showed that Jack bean treatment (T2) gave the highest but similar to both Giant sensitive plant and Green gram and these green manure treatments were highly significant over the control treatment. The results indicated that with this soil type green manure application is needed whenever okra crop is to be grown for a better quality of edible fresh pods. With further work, it may be of tangible value to analyze protein contents of the pods so that a full detail of nutritive values could be described and grading standard may be specified. However, with this work analyses on protein contents were not carried out. The

percentages on total acidity, fibre content and pectin of edible fresh pods were not significantly different from one another. The results suggested that green manure treatments had no significant effect on total acidity, fibre and pectin contents. However, it was found that values on total acidity and fibre content of the control treatment were higher than the manure treatments. This may be attributable to the differences in the amounts of nitrogen in soil where the green manure treatments could have contained more nitrogen than control treatment, particularly during the growing period hence total acidity and fibre content of the green manure treatments were slightly lower than the control treatment. It was also found that mean values of available phosphorus and exchangeable potassium were relatively low with mean values of 15.71 and 64 ppm, respectively. These mean values of both soil available phosphorus and soil exchangeable potassium may be considered to be inadequate for growth of most crops as stated by Miller and Donahue (1990) and Suksri (1999) where the mean values should reach at least 20 ppm for available phosphorus and 80 ppm for exchangeable potassium. Although an amount of a complete cheical fertilizer 15-15-15 (NPK) of 187.50 kg ha^{-1} was added to the plots but their residual effects due to the complete chemical fertilizer P and K added were not found. This may be partly attributable to the utilization of the okra plants where a large amount of both P and K must have been partly used apart from the loss of soil nutrients by leaching due to both rainfalls and furrow irrigation. Thus the final values of both P and K in soil were not relatively increased. Therefore, some further amounts of chemical fertilizers P and K must be added to the soil if a further cultivation of okra crop is to be carried out.

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REFERENCES

Adebooye, O.C. and C.O. Opunta, 1996. Effects of galex on growth and fruit nutrient composition of okra (*Abelmoschus esculentus*). Ife J. Agric., 18: 1-9.

Anonymous, 2004a. Vegetables Enthusiastic Group, Department of Agric., Extension, Ministry of Agriculture and Fisheries, Thailand. http://suphanburi.doae.go.th

Anonymous, 2004b. Department of Agricultural Extension, Ministry of Agriculture and Fisheries, Thailand. http://www.doae.go.th/library/html/detail/paddy/d2.html

Anonymous, 2006. An improvement of saline soils fertility with the use of African sesbania plants as green manure. http://www.sisaket.go.th/WEB-idd/Soil/Page07.htm.

AOAC., 1984. Official Methods of Analysis. 14th Edn., Washington, DC: Association of Official Analytical Chemists.

Biswas, T.D. and B.K. Khosla, 1971. Building up of organic matter status of the soil and its relation to soil physical properties. Intl. Symp. Soil Fert. Evaluation Proc., 1: 831-843.

Boelje, M.D. and V.R. Eidman, 1984. Farm Management. John Wiley and Sons, New York, USA.

Boparai, B.S., Y. Singh and B.D. Sharma, 1992. Effect of green manure (*Sesbania aculeate*) on physical properties of soil and growth of rice-wheat and maize-wheat cropping system. Intl. Agrophys., 6: 95-101.

Chaiyadok, K., 1992. The contribution of leguminous crops to maize plants when grown under intercropping systems. M.Sc. Thesis, Kasetsart University, Bangkok, Thailand.

Chutichudet, B., P. Chutichudet and T. Chanaboon, 2006. Effect of chemical paclobutrazol on growth, yield and quality of okra (*Abelmoschus esculentus* L.) Har lium cultivar in Northeast Thailand. Pak. J. Biol. Sci. (In Press).

FAO, 1988. Food and Nutrition Paper 42. Traditional Food Plants. Rome, pp: 320.

Gitari, J.N., S.K. Karumba, D.N. Mugendi and J. Kung'u, 2003. Effect of intercropping different densities of green manure legumes on maize performance in the central highlands of Kenya. Legume Res. Network Project Newslett., 10: 7-11.

Gould, W.A., 1977. Food Quality Assurance. The AVI Publishing Company, Inc., Westport, Connecticut, pp: 314 .

Kalra, C.L. and J.S. Pruthi, 1984. Chemistry and technology of okra (*Hibiscus esculentus* L.). Central Food Tech. Res. Inst. India, Food Packer, pp: 37-57.

Kamidi, M., F. Gitahi, P. Osore, D. Cheruiyot, M. Okumu and G. Barasa, 2000. Effect of green manure legume on the yield of maize and beans in Matunda farm, Trans Nzoia District, Kenya. Legume Res. Net. Proj. Newslet., 4: 2-4.

Kasikranan, S., 2003. The effects of nutrient supply on the production of commercial baby corn (*Zea mays* L.) in Thailand. Ph.D. Thesis. University of Hertfordshire, College Lane, Hatfield, Herts, UK.

Leksuntarakorn, Nipa, 1997. Residual effects of peanut and green manure legume crops when grown together with maize as main crop on soil properties. Ph.D. Thesis. Kasetsart University, Bangkok, Thailand.

Liebman, M. and A.S. Davis, 2000. Integration of soil, crop and weed management in low-external-input farming systems. Weed Res., 40: 27-47.

MacRae, R.J. and G.R. Mehuys, 1985. The effect of green manuring on the physical properties of temperate area soils. Adv. Soil Sci., 3: 71-100.

Mandal, U.K., G. Singh, U.S. Victor and K.L. Sharma, 2003. Green manuring its effect on soil properties and crop growth under rice-wheat cropping system. Euro. J. Agron., 19: 225-237.

Miller, R.C. And R.L. Donahue, 1990. Soils. An Introduction to Soils and Plant Growth. 6th Edn., Prentice Hall, Englewood Cliffs, NJ07632, USA.

Mukalama, J., 2000. Introduction of legume cover crops to communities in Western Kenya. Legume Res. Net. Proj. Newslett., 4: 17-19.

Muresan, R. and H. Popescu, 1993. *Abelmoschus esculentus* L. Monench. Cultivatla Cluj ca sursa de poliholozide. Clujul Medical, 66: 267-274.

Ngouajio, M. and M.E. McGiffen, 2002. Going organic changes weed population dynamics. HortTechnology (In Press).

Owolarafe, O.K. and H.O. Shotonde, 2004. Some physical properties of fresh okra fruit. J. Food Engin., 63: 299-302.

Pholsen, S., 2003. Effects of nitrogen, potassium and organic matter on growth, chemical components and seed yields of IS 23585 forage sorghum cultivar. Ph.D Thesis. University of Hertfordshire, Collage Lane, Hatfield, Herts, UK.

Ratnapradipa, P., 1996. Effects of organic amendments in combination with commercial fertilizer on soil properties, growth and kernel yield of maize (*Zea mays* L.) grown on Stuk loamy sand. Ph.D Thesis. Central Luzon State University, the Philippines.

Rochester, I.J., M.B. Peoples, N.R. Hulugalle, R.R. Gault and G.A. Constable, 2001. Using legumes to enhance nitrogen fertility and improve soil condition in cotton cropping systems. Field Crops Res. 70: 27-41.

SPSS, 1999. Base 9.0 for Windows Users Guide. SPSS Inc., USA.

Suksri, A., 1999. Some Agronomic and Physiological Aspects in Growing Crops in Northeast Thailand. 1st Edn., Khon Kaen University Press, Khon Kaen, Thailand., pp: 212.

Wattana-wanichakorn, S., 1975. Relationship between temperature and time in extracting pectin contents from *Cissampelos* Linn. Hirsutus variety. An undergraduate case study, Department of Food Sci., Kasetsart University, Bangkok, Thailand.