http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 13 (6): 263-270, 2010
ISSN 1028-8880

Some Physiological Measurements on Growth, Pod Yields and Polyamines in Leaves of Chili Plants (*Capsicum annuum* cv. Hua Reua) in Relation to Applied Organic Manures and Chemical Fertilisers

[1]J. Rapatsa and [2]S. Terapongtanakorn
[1]Department of Plant Sciences, Maha Sarakham Rajabhat University, Mahasarakham 48000, Thailand
[2]Department of Plant Sciences, Ubon Ratchathani University, Warin Chamrarb District, Ubon Ratchathani 34190, Thailand

Abstract: The experiment was carried out at the Faculty of Agriculture, Ubon Ratchathani University during November 2006 to July 2007. A Completely Randomized Design (CRD) with four replications was used. Six treatments were allocated into two experimental fields, i.e., field A, animal manures added soil. Field B, chemical fertilizers added soil and both fields have been used for chili cultivation for more than 5 years and they belong to Warin soil series (Oxic Paleustults). The results showed that mean values of soil pH and organic matter% of field A were much higher than field B but mean values of nitrogen% and phosphorus were much higher for field B than field A. Exchangeable potassium were inadequately available in all treatments. All treatments of field B gave excessive amounts of available phosphorus at a toxic level. T_3 of field A gave higher plant height, total dry weight plant^{-1}, pod fresh and dry weights plant^{-1} than T_5 of field B. Of overall results in terms of growth and yields of chili plants, field A gave much better advantages over field B. The CO_2 uptake and CO_2 in leaves were higher for field A than field B. Polyamines of putrescine (Put), spermidine (Spd) and spermine (Spm) of T_2 were affected by stress conditions due to previous applied chemical fertilisers. Available phosphorus mean values in most treatments were excessively available. Amounts of polyamines in chili leaves due to the added organic manure and chemical fertilizers (T_3 up to T_6) were not cleared.

Key words: Chili plants, fermented crop residues, animal manures, chemical fertilizers, polyamines

INTRODUCTION

Chili crop (*Capsicum annuum* cv. Hua Reua) is one of many important vegetable crops being cultivated in most Asian countries such as the Philippines, Myanmar, India, Laos, Cambodia, Malaysia, Thailand and many others. Chili is not a native of tropical countries but being introduced to this tropical region from Americas by the Portuguese and Spanish (Suksri, 1999). The common varieties being cultivated in Asia are the finger-length chilies (*Capsicum annuum* cv. Group *longum*) and the fiery little bird's eye chilies (*Capsicum frutescens*) and some of them have possessed mild, fat long, yellow or creamy white; small rounded, arrow shaped, pale orange chilies and many others. The hottest portion of chili is found with seeds in each pod, whilst the flesh gives pungent flavour (Hutton and Mealin, 1997). The hot taste of chili seeds in each pod depended most on the ratio between nitrogen and potassium in soil being applied for crop cultivation, i.e. the higher the amount of nitrogen (N) in soil than potassium (K) the hotter the taste in matured pods, yet a reverse taste could be found if K in soil is much higher than N (Suksri, 1999).

For the Thai people, pods of chili plants both fresh and dry are commonly used in many cooking recipes as to achieve a tasty daily food with high in both palatability and nutritious values. Apart from these, chili pods could be used in many industrial products, e.g., animal rations, insecticides, irritated gas to be used against riot movement of crowd, mixed in insulated materials to protect electrical wires from damages made by rats and others (Siriborirak, 1996). Thus chili crop could be recognized as an import economic crop for many countries in the tropics. In a period from the 1998 to 2007, Thailand used an area of approximately 95,545 ha for chili cultivation with an average annual fresh weight of chili pods for both domestic and overseas markets up to 311,231 metric tons (Leelawanitchai, 2007). In the 2001, Thailand exported fresh chilies mainly to Malaysia followed by The Netherlands, Sweden, Singapore and Taiwan up to 12,283 metric tons (Senadee, 2006). However, at the same time Thailand also imported dry

Corresponding Author: Dr. Janthasri Rapatsa, Department of Plant Sciences, Faculty of Agricultural Technology, Maha Sarakham Rajabhat, Maung District, Mahasarakham 48000, Thailand

chilies from overseas with an amount of up to two folds greater than the exported amount (Anonymous, 2002). The imported amount indicated that chili production in Thailand could not be able to cope up domestic consumption, particularly dry chilies. Therefore, it is of an urgent need for the Thai growers to produce some large amounts of chili pods annually in order to meet the high demand of the consumers both domestic and overseas. Nevertheless, there have been some problems in exporting both fresh and dry pods of chili overseas due to health regulations, e.g., the presence of some minute amounts of toxic chemical contained in pods (insecticides, herbicides and etc.) is not allowed in some countries such as Japan and many others (Ammaramon, 2006). Thus organic chili products should be of important value, i.e., chili plants must be grown without harmful chemicals where organic compost, animal manure may be used in place of chemical substances and organic insecticides must be used. At present situation, growers of vegetable crops in Thailand have paid more attention to organic agriculture than inorganic agriculture when their produced products gained more interest from consumers and at the same time growers pay less for their investments and their produced products are widely accepted by consumers although its annual production could be relatively low (Anonymous, 2002). In Thailand nowadays, organic vegetables are normally produced with the use of organic composts where some useful microorganisms are applied along with the use of some herbal insecticide solutions being extracted from some specific plants (Panyakul, 2004). Therefore, it is of a tangible value to carry out an experiment with the use of chili plants in order to determine some physiological activities on CO_2 uptake, transpiration, aperture of stomata, dry weights, pod yields and polyamines (Putrescine, Spermidine and Spermine) contents in leaves of chili plants in relation to environmental conditions and previous application of organic manures and chemical fertilizers. Polyamines chemical compounds obviously use as an indicator on the changes in growth environment, particularly the stresses in growth cause by the changes in environmental conditions, e.g., drought conditions and etc. (Terapongtanakorn, 2000). Thus this field experiment and laboratory works were carried out. The main objective of this work was to prove current practices in growing chili crop plants of the villagers in Northeast Thailand if what they have been practiced are of any significant value to be recommended for further uses and to compare the important effect of organic manures against chemical fertilizers upon growth and pod yields of the chili plants.

MATERIALS AND METHODS

This experiment was carried out at the Faculty of Agriculture, Ubon Ratchathani University, Ubon Ratchathani 34190, Northeast Thailand during November 2006 to July 2007 to investigate effect of organic manures and chemical fertilizers on plant height, total dry weight, pod fresh and dry weights, polyamines contents in leaves, CO_2 uptake and CO_2 in leaves of chili plants when two different historical backgrounds of land areas were used but of the same soil series (Warin soil series, Oxic Paleustults). The first one is a land area where organic manures alone (cattle manure) have been continuously applied to the soil for chili cultivation for more than 5 years (field A) and the second one is a piece of land where chemical fertilizers have been continuously applied for more than five years for chili cultivation (field B). The two pieces of land areas were ploughed twice followed by harrowing once. Soil samples in each treatment were taken twice to the depth of approximately 30 cm, i.e., soil samples were taken before transplanting and at the end of the experimental period. They were used for the determination of soil pH, organic matter, nitrogen (N,%), phosphorous (available P) and exchangeable potassium (K, ppm). The dimension of each plot being used for each replication was a 2×10 m in width and length, respectively with a path of 1.5 m in width between the plots. The transplanting distances used for chili seedlings were 80×80 cm between rows and within rows, respectively, i.e., a rate of 15,625 chili plants ha^{-1} was used. To encourage a rapid growth of seedlings, before the transplanting of seedlings was carried out, a seedbed for germination of chili seeds was prepared, i.e., the seedbed with a dimension of a 2×15 m in width and length, respectively was thoroughly added with (1) raw rice husk at a rate of 125 kg ha^{-1}, (2) burned rice husk at a rate of 625 kg ha^{-1} and (3) fermented cattle manure (approximately 30% moisture content) at a rate of 625 kg ha^{-1}, respectively. All these materials were thoroughly mixed into the soil before sowing of seeds. Chili seeds of approximately 400 g were wrapped with a piece of cotton clothing material and then placed into a jar of warm water at approximately 50°C for 30 min and then evenly sown all seeds into seedbed. The seedbed was covered with a thin layer of rice straws and then a daily watering was carried out for 30 days. At 30 days after sowing, seedlings were pulled out and transplanted into the experimental plots. Each experimental plot had a dimension of a 2×10 m in width and length, respectively. All of the experimental plots were ridged up approximately 10 cm above ground level to provide adequate drainage of some excess amount of water when watering. The transplanting distances within rows and between rows of 80×120 cm were used, i.e., approximately 208 plants in each plot. Each plot was divided into five subplots for different sampling periods. A Completely Randomised Design (CRD) with four replications was used. Transplanting of seedlings in each plot was carried out at an age of 30 days after sowing. Ten plant samples from each replication in each treatment were randomly chosen from subplot of each replication in each sampling period. The plant samples were used for the determination of plant height, dry weights plant^{-1}, fresh and dry pod yields ha^{-1} and also photosynthetic activities (photosynthetic rate, leaf water transpiration, available CO_2 in leaf and leaf temperature). The experiment consisted of six treatments, i.e., field A: Control treatment (T_1), field B: Control treatment (T_2). Treatment 3 (T_3) was carried out in field A where, the plot was evenly added with fermented crop residues at a rate of 3,125 kg ha^{-1} plus fermented poultry manure at a rate of 3,125 kg ha^{-1}. The chili plants were sprayed with Neem seeds extracted solution (*Scirtothrips dorsalis*) once a month (50 g of ground Neem seeds plus 1 L of tap water and allowed to ferment for one week then added with 20 L of tap water filtered with the use of clothing material then evenly sprayed to the chili plants. This amount of solution was used for each spraying period). The spraying of Neem seeds extracted solution was used by spraying to plants to prevent insect damages to chili plants. During the growth period, chili plants were sprayed once a week with fermented juices derived from green leaves of vegetable crops (mostly cabbages, 20 kg fresh weight : 20 L tap water and allowed to ferment for five weeks) as to provide foliage nutrient supplement. Fermented crop residues of the mixture of fruits of pine apple, papaya and other wastes of orchard fruits were mixed up with tap water and then sprayed to chili plants once a month (1:2 by volume). This treatment was a repeat of the practices carried out by villagers in Northeast Thailand.

With treatment 4 (T_4) in Field B, each replication was added with fermented cattle manure at a rate of 1,562.5 kg ha^{-1} plus chemical fertilizer 15-15-15 (NPK) at a rate of 93.75 kg ha^{-1}. At 30 days after transplanting, urea (46-0-0: NPK) was added at a rate of 62.50 kg ha^{-1} and later at 60 days after transplanting, chemical fertilizer 16-16-16 (NPK) was applied at a rate of 125 kg ha^{-1} and two weeks later, chemical fertilizer 12-24-12 (NPK) was added again at a rate of 93.50 kg ha^{-1}. The spraying of Carbofuran insecticide was carried out at 10-day intervals to control the spread out of *Scirtothrips dorsalis*, whilst Mancozeb and Carbendazin fungicides were applied once a month to control the spread out of *Colletotrichum zbethinum* Sacc.

For treatment 5 (T_5), field B, each replication was added with fermented crop residues at a rate of 3,125 kg ha^{-1} plus 3,125 kg ha^{-1} of fermented poultry manure. The chili plants were sprayed with Neem seeds extracted solution as that of Treatment 3. The chili plants were also applied once a month with bacteria BT i.e., *Bacillus thuringiensis* where, 1 g of BT was mixed with 100 mL coconut juices and allowed to ferment for 2 days then added up with 20 L of tap water then sprayed to chili plants to control the spread out of sooty mold (*Capnodium* sp.). The spraying was carried out once a month.

With treatment 6 (T_6), field A, at 30 days after transplanted, each plot was added with cattle manure at a rate of 1,562.50 kg ha^{-1} plus 93.75 kg ha^{-1} of chemical fertilizer 16-16-16 (NPK). When the chili plants reached an age of 62 days after transplanting, chemical fertiliser 16-16-16 (NPK) was applied again at a rate of 125.00 kg ha^{-1} plus 125 kg ha^{-1} of chemical fertiliser 12-24-12 (NPK). The control of insect pests was carried out as that of treatment 4.

The following growth parameters were measured, i.e., plant height, total dry weight plant^{-1} (Sestak *et al*., 1971; Suksri, 1999), pod fresh weight, pod dry weight, leaf photosynthetic rate of CO_2 uptake with the use of a portable photosynthetic meter Model LCA4 ADC. The measurements were carried out before noon (10 -12 a.m.), CO_2 content in leaves, leaf temperature, polyamines of putrescine, spermidine and spermine contents in leaves with the methods described by Flores and Galston (1982), Smith and Davies (1985) and Terapongtanakorn (2000). Polyamines were determined with the use of a pair of third leaves (counted from top) with an amount of 30 g fresh weight from each replication. These measurements were carried out four times at days 62, 90, 121 and 151 after transplanting but measurement on total dry weight plant^{-1} was carried out only once at day 151 after transplanting. Due to a similar trend in all attained parameters, hence only the data taken at days 62 and 151 after transplanting are included in this publication. The obtained data were statistically analyzed with the use of a computer programme (SAS, 1989).

RESULTS

Soil analysis data: With initial soil analysis data, the results showed that mean soil pH values ranged from 3.97 to 6.39 for T_5 and T_3, respectively (Table 1). Organic matter values ranged from 0.73 to 1.48% for T_5 and T_3, respectively. Nitrogen values ranged from 0.029 to 0.058% for T_1 and T_4, respectively. Available phosphorus values ranged from 30.90 to 61.29 ppm for T_3 and T_2, respectively. Exchangeable potassium values ranged from 46.38 to 65.44 ppm for T_6 and T_1, respectively. The results on soil analysis at the end of the experimental period showed that soil pH values ranged from 4.32 to 7.92% for T_5 and T_3, respectively (Table 1). Organic matter values ranged from 0.734 to 1.438% for T_5 and T_3, respectively. Soil nitrogen values ranged from 0.032 to 0.063% for T_1

Table 1: Mean values of initial and final soil analysis data of the Warin soil series (Oxic Paleustults) of the Experimental plots (fields A and B) being used for growth and pod yields of chili plants cv. Hua Reua, grown in Northeast Thailand

Treatments	pH	Organic matter	Nitrogen	Phosphorus	Potassium
		---------- (%) ----------		---------- (ppm) ----------	
Initial soil analysis					
T_1 (control)	6.29	0.635	0.029	38.17	65.44
T_2 (control)	4.61	0.411	0.042	61.29	53.10
T_3	6.39	0.998	0.031	30.90	50.69
T_4	4.35	0.462	0.058	44.50	72.34
T_5	3.97	0.581	0.046	60.13	65.12
T_6	6.30	0.973	0.049	38.25	46.38
Final soil analysis					
T_1 (control)	6.08	0.582	0.032	40.10	60.91
T_2 (control)	4.42	0.395	0.046	62.44	42.38
T_3	7.92	1.438	0.049	45.89	56.09
T_4	4.85	0.827	0.063	55.39	79.25
T_5	4.32	0.734	0.054	78.45	68.74
T_6	6.98	1.378	0.058	48.15	52.67

Table 2: Mean values of plant height, total dry weight, pod fresh weight and pod dry weight at 62 and 151 days after transplanting of seedlings of chili plants cv. Hua Reua, grown on Warin soil series (Oxic Paleustults) in Northeast Thailand

	Plant height (cm plant^{-1})		Total dry weight (g plant^{-1})	Pod fresh weight (g plant^{-1})		Pod dry weight (g plant^{-1})	
Treatments	62 days	151 days	for 151 days	62 days	151 days	62 days	151 days
T_1 (control)	21.80c	50.20c	74c	70.44b	580.22c	22.65ab	145.05b
T_2 (control)	12.21d	38.11d	68bc	59.07c	436.31c	10.63c	112.60c
T_3	38.66a	86.75a	179a	92.73a	812.22a	31.12a	215.02ab
T_4	28.18c	57.12c	112ab	79.12b	860.34a	25.74a	280.29a
T_5	25.21c	50.85c	115ab	65.72bc	659.31b	15.34b	142.24b
T_6	30.36b	61.14b	94b	88.15a	775.18b	19.31b	221.12ab
t-test	**	**	**	**	**	**	**
CV (%)	4.32	5.46	9.25	3.14	5.11	8.16	4.35

Letter(s) in each column indicated least significant differences of Duncan's multiple range test at probability (**p) = 0.01

and T_4, respectively. Available phosphorus values ranged from 45.89 to 78.45 ppm for T_3 and T_5, respectively. Soil exchangeable potassium values ranged from 52.67 to 79.25 ppm for T_6 and T_4, respectively.

Plant height, total dry weight, pod fresh weight and pod dry weight plant^{-1}: Plant height values at 62 days after transplanting were highest with T_3 followed by T_6, T_4, T_5, T_1 and least for T_2 with values of 38.66, 30.36, 28.18, 25.21, 21.80 and 12.21 cm plant^{-1}, respectively (Table 2). The differences were large and highly significant. At 151 days after transplanting, plant height was highest with T_3 followed by T_6, T_4, T_5, T_1 and T_2 with values of 86.75, 61.14, 57.12, 50.85, 50.20 and 38.11 cm plant^{-1}, respectively. The differences were large and highly significant. For total dry weight (g plant^{-1}) at 151 days after transplanting, total dry weights ranged from 74 to 179 g plant^{-1} for T_1 and T_3, respectively. The differences were large and highly significant. With pod fresh weights at 62 days after transplanting, the results revealed that pod fresh weight was highest with T_3 followed by T_6, T_4, T_1, T_5 and T_2 with values of 92.73, 88.15, 79.12, 70.44, 65.72 and 59.07 g plant^{-1}, respectively. The differences were large and highly significant. At 151 days after transplanting, pod fresh weight was highest with T_4 followed by T_3, T_6, T_5, T_1 and T_2 with values of 860.34, 812.22, 775.18, 659.31, 580.22 and 436.31 g plant^{-1}, respectively. The differences were large and highly significant. The results on pod dry weights at 62 days after transplanting, it showed that pod dry weight was highest with T_3 followed by T_4, T_1, T_6, T_5 and T_2 with values of 31.12, 25.74, 22.65, 19.31, 15.34 and 10.63 g plant^{-1}, respectively. The differences were large and highly significant. At 151 days after transplanting, pod dry weights ranged from 112.60 to 280.29 g plant^{-1}, respectively. The differences were large and highly significant.

CO_2 uptake, CO_2 in leaves and leaf temperature: At 62 days after transplanting, the amount of CO_2 uptake by leaves of chili plants was highest with T_4 followed by T_6, T_3, T_5, T_2 and T_1 with values of 6.72, 6.53, 5.59, 3.91, 2.44 and 2.34 μmol/m/^{2}sec, respectively. The differences were large and highly significant (Table 3). At 151 days after transplanting, CO_2 uptake values ranged from 4.95 to 8.44 μmol/m/^{2}/sec for T_2 and T_4, respectively. The differences were large and highly significant. With CO_2 in leaves of chili plants at 62 days after transplanting, their values ranged from 190.94 to 372.74 million^{-1} for T_1 and T_6, respectively. The differences were large and highly significant. At 151 days after transplanting, values of CO_2 in leaves ranged from 359.10 to 521.33 million^{-1} for T_2 and

Table 3: Mean values of CO_2 uptake (µmol m^{-2} s^{-1}) by leaves, CO_2 available in leaves (volume/million) and leaf temperature (°C) of chili plants at 31 and 91 days after transplanting, grown on Warin soil series (Oxic Paleustults) in Northeast Thailand

	CO_2 uptake		CO_2 in leaves		Leaf temperature	
Treatments	62 days	151 days	62 days	151 days	62 days	151 days
T_1 control	2.34c	6.35b	190.94c	521.33a	30.70c	49.92a
T_2, control	2.44c	4.95c	221.18c	359.10b	32.60b	49.51a
T_3	5.59ab	7.18ab	309.12b	412.48ab	31.28c	42.38c
T_4	6.72a	8.44a	364.08a	408.04ab	34.10a	47.34b
T_5	3.91b	4.78c	323.65b	362.63b	34.29a	46.82b
T_6	6.53a	6.90b	372.74a	399.78b	33.45b	44.38c
T-test	**	**	**	**	**	**
CV (%)	4.41	3.55	5.31	3.72	4.12	3.26

Letter(s) in each column indicated least significant differences of Duncan's multiple range test at probability (**p) = 0.01

Table 4: Mean values of chemical contents of putrescine (Put), spermidine (Spd), spermine (Spm) of chili plants cv. Hua Reua, grown on Warin soil series (Oxic Paleustults) in Northeast Thailand

	Put		Spd		Spm	
Treatments	62 days	151 days	62 days	151 days	62 days	151 days
T_1 control	580b	478b	375c	394b	229d	298c
T_2 control	684a	512ab	612a	496a	662a	509a
T_3	675ab	489b	639a	445ab	432b	346b
T_4	668b	587a	562b	483a	615a	498a
T_5	545c	389c	387c	346b	455b	374b
T_6	433d	359c	194d	297c	345c	313c
T-test	**	**	**	**	**	**
CV (%)	4.41	3.26	5.52	5.20	5.90	5.90

Put: Putrescine, Spd: Spermidine, Spm: Spermine. Letter(s) in each column indicated least significant differences of Duncan's Multiple Range test at probability (**p) = 0.01

T_1, respectively. The differences were large and highly significant. With leaf temperature at 62 days after transplanting, leaf temperature values ranged from 30.70 to 34.29°C for T_1 and T_5, respectively. The differences were large and highly significant.

Polyamines of putrescine, spermidine and spermine contents in leaves of chili: For chemical contents of Putrescine (Put) at 62 days after transplanting, the results showed that Put content mean values ranged from 433 to 684 nanomolar g-1FW for T_6 and T_2, respectively (Table 4). The differences were large and highly significant. At 151 days after transplanting, Put mean values ranged from 359 to 587 nanomolar g-1FW for T_6 and T_4, respectively. The differences were large and highly significant. With Spermidine (Spd) chemical contents at 62 days after transplanting, the results showed that Spd mean values ranged from 194 to 639 nanomolar g-1FW for T_6 and T_3, respectively. The differences were large and highly significant. At 151 days after transplanting, Spd mean values ranged from 297 to 496 nanomolar g-1FW for T_6 and T_2, respectively. The differences were large and highly significant. The results on chemical contents of Spermidine (Spm) at 62 days after transplanting revealed that Spm mean values ranged from 345 to 662 nmol g-1FW for T_6 and T_2, respectively. The differences were large and highly significant. At 151 days after transplanting, the Spm values ranged from 298 to 509 nanomolar g-1FW for T_6 and T_2, respectively. The differences were large and highly significant.

DISCUSSION

With the results on mean values of initial soil analysis of field A (organic manure added soil) of T_1, T_3 and T_6 treatments, it indicated that mean values of soil pH and organic matter (%) were much higher than field B of T_2, T_4 and T_5 treatments (chemical fertilizers added soil). The results indicated that after some years of organic manures have been continuously added to the soil for chili cultivation, values of soil pH and organic matter percentages have increased. Whilst mean values of soil nitrogen% (N), available phosphorus (P, ppm) and exchangeable potassium (K, ppm) of field B (chemical fertilizers added soil), in most cases, possessed higher mean values of NPK than Field A. The results suggested that NPK elements contained in organic manure resources could have been much smaller in quantity than that of the chemical fertilizers yet some larger amount of calcium ions could have been found in manure resources, whilst in most complete chemical fertilizers formulae, calcium sources were slightly added or even left out. Thus organic manures possess greater advantages in improving soil conditions for plant growth and development than chemical fertilizers since organic manures released Ca^{2+} thus soil pH value is relatively high so it promotes the flocculation of soil colloids and thus improves soil structure and the stability of soil particles. This has been confirmed by a number of workers, e.g., Mengel and Kirkby (1987), Miller and Donahue (1990), Suksri *et al.* (1991), Suksri (1992, 1999), Kasikranan (2003) and Pholsen (2003). Therefore, organic manures possess important value in growing crop plants in all soil series, particularly with the soils in the tropics where a high leaching rate of soil nutrients occurred due to heavy rains or high rate of soil erosion. Soil analysis results at the final harvest revealed that T_1 and T_2 attained lower values of soil pH and soil organic matter% than that of the initial soil. This could have been attributed to the depletion of soil nutrients and some certain amount could have been taken up by plants, particularly Ca^{2+} and perhaps the low values could have been due to a high leaching rate of soil nutrients. Other treatments (T_3 up to T_6) gave higher values than that of the initial values such as pH, organic matter and NPK. This must be attributable to the added amounts of organic manures either cattle or poultry. Furthermore, all treatments except both control treatments (T_1 and T_2) received additional amounts of fermented crop residues and even those of chemical fertilizers treatments (T_4 and T_6) were also added with fermented crop residues, hence soil conditions of the plots have improved.

When compare the results on plant height, total dry weight plant^{-1}, pod fresh weight and pod dry weight plant^{-1} in relation to previous history of chili crop cultivation of both fields (both fields A and B) of the control treatments (T_1 and T_2), it revealed that the land area that had been continuously added with organic manures for chili cultivation (field A) gave significantly higher values of all determined items. This must be attributable to the improvement of soil property by organic manures where soil structure and nutrient contents have been improved. Therefore, it may be inferred that the use of animal manures and fermented crop residues could provide sustainable agriculture. Furthermore, there is a high demand for chili pod production being produced by organic agriculture. However, Suksri (1992) stated that cattle manure and green manure gave significantly better growth and yield of maize (*Zea mays* L.) when combined with chemical fertilizers, particularly in combination with complete chemical fertilizers of high potassium (K) formulae such as 13-13-21 (NPK).

In comparing the effects due to treatments among the organic manure treated chili plants, i.e., T_3 of field A is compared with T_5 of field B. These two treatments received the same rates of both fermented crop residues and fermented poultry manure. The results showed that in most cases, T_3 gave significantly higher values of plant height, total dry weight plant^{-1}, pod fresh weight and pod dry weight plant^{-1} than T_5. The results indicated that field A suited most for the growth of chili plants due to its previous history of the plot where organic manures had been used for chili cultivation for a number of years whereas field B had been added with chemical fertilizers for chili pod production for a number of years. Thus, organic manure added plots of each replication provided more suitable soil conditions for growth of chili plants than chemical added plots. When comparing the results of T_4 to T_6, these two treatments received a similar amount of fermented crop residues but different chemical fertilizers formulae and amounts of NPK elements. The two treatments were carried out as a repeat of villagers' practices. It was found that plant height was greater for T_6 (manures added soil) than T_4 (chemical fertilizers added soil), total dry weight plant^{-1} was slightly higher for T_4 than T_6 but statistically similar yet both fresh and dry weights of pods were significantly greater for T_4 than T_6. This must be attributable to the differences in the amounts of available phosphorus and exchangeable potassium where both nutrients were much higher for T_4 than T_6 hence greater amount of leaf assimilates were produced by chili plants of T_4 greater than T_6. Phosphorus has its significant role in many respects, e.g., the production of energy of Adenosine Tri-phosphate (ATP) and encouraging the production of flowers, while potassium helps in transporting assimilates from sources (leaves) to sinks (pods) thus higher pod yields could be attained in each sampling period (Mengel and Kirkby, 1987; Suksri, 1999). Nevertheless, it was found that mean values of available phosphorus (P) in all treatments were relatively high, particularly the plots of Field B (T_2, T_4 and T_5). This must be attributable to the previous history of the plots where some high amount of chemical phosphorus in any complete chemical fertilizers formulae had been added to the soil. Whilst the mean values of exchangeable potassium (K) were, in all cases, lesser than the required minimum amount of 80 ppm of exchangeable K for optimum yields of many agronomic crops, e.g., maize, soybeans and others.

At the final sampling period, it was found that values of CO_2 uptake and CO_2 in leaves were significantly greater for T_1 than T_2. This could have been attributed to the differences in the rapid unloading of assimilates in leaves of chili plants of T_1 greater than T_2 hence pod yield was significantly higher. A similar trend was attained between T_3 and T_5 and between T_4 and T_6 where amounts of both CO_2 in leaves and the uptake of chili plants are corresponded with pod yields, i.e., the higher the amounts of CO_2 taken up and available in leaves the greater the pod yields of the chili plants.

With polyamines content in leaves of the chili plants, i.e., the chemical compounds of putrescine (Put), spermidine (Spd) and spermine (Spm), these chemical compounds possess its important role in the establishment of protein structure, enzyme activities and others (Bagni and Pistocchi, 1992). When any plants undergone stress conditions such as lack of water, high salts concentration, hot and cold environments then the plants could produce more of Putrescine chemical compound (Evan and Malmberg,1989). With this work, when T_1 compared with T_2, it was found that T_2, in most cases, attained significantly greater amounts of the three chemical compounds than $T_1$and the highest value was found with putrescine (Put). The results suggested that the chili plants of T_2 could have been subjected to soil environmental stresses, i.e., low values of soil pH and organic matter% but with high amounts of nitrogen (N) and phosphorus (P), particularly phosphorus where the amount reached a mean value of 61.29 ppm. This available amount of P could be considered as an excessive amount in soil thus the chili plants were subjected to a stress condition apart from the low soil pH value and an inadequate amount of exchangeable K. The optimum mean value of available P in soil should be in a range from 20 to 30 ppm (Suksri, 1999). The higher level of P could cause toxic effect to plants. Teraphongtanakorn (2000) stated that polyamines chemical compounds could be synthesized in plant cells and the amount could be increased if grown under stress conditions. However, when compared T_3 (field A) to T_5 (Field B), these two treatments are comparable since each of them attained a similar amount of fermented crop residues, organic manures and chemical fertilizers. The results turned out that initial values of soil pH and organic matter% were much higher for T_3 than T_5 yet initial values of soil nitrogen, phosphorus and potassium were much higher for T_5 than T_3, particularly phosphorus. The results indicated that the chili plants of T_5 should have subjected to a severe stress due to high phosphorus, apart from the low mean value of soil pH (3.97). The poor soil pH could have been affected the release of soil nutrients since some amount of nutrients could have been fixed in clay minerals (Mengel and Kirkby, 1987; Miller and Donahue, 1990). Thus, the chili plants could have been subjected to a severe stress of poor available nutrient. Another important factor is a relatively high environmental temperature in the summer months, thus some of them could have been severely wilted and unable to produce some large amount of polyamines chemicals. Of overall effects due to treatments, it is evidently found that field B of chemical fertilizer treated soil has an excessive amount of available phosphorus, thus it may be inferred that this piece of land if many types of crops are to be grown even chili crop then they may not be able to produce a high tolerant sign of survival due to P toxicity. Therefore, to overcome the problem, some large amount of fermented crop residues should be added to the soil and at the same time some certain amount of potassium chemical fertilizer should be added since all treatments attained mean values of exchangeable potassium lesser than 80 ppm. Therefore, initial soil analysis data are needed before organic manure or chemical fertilizer experiments are to be carried out. This could avoid unnecessary amounts of chemical fertilizers to be added to the soil. The results of this study indicated that many soil series in the tropics require some large amount of organic manures in order to improve soil properties for optimum output of crop yields.

CONCLUSIONS

Chili plant has its important role in the Thai economy both fresh and dry pods are enormously used for cooking and industrial purposes. Previous additional amounts of organic manures in field A for chili production gave much higher pH and organic matter% than field B of the chemical fertilizers yet field B gave much higher nitrogen% and available phosphorus (ppm) than field A and the high mean value of P is considered as an excessive amount of toxicity level. Both fields A and B contained an inadequate amount of potassium (K). This was found even at the end of the experimental period. Field A of fermented crop residues plus poultry manure (T_3) gave highly significant differences on plant height, total dry weight plant^{-1}, pod fresh and dry weights plant^{-1} than field B (T_5). When Fields A of organic manures and B of chemical fertilizers were compared in terms of growth and yields of chili plants, it revealed that field A, in most cases, gave highly significant differences over field B, thus organic manures added plots of field A possess more advantages than Field B. CO_2 uptake and in leaves were, in most cases, higher for field A than field B. Amounts of polyamines, i.e., putrescine (Put), spermidine (Spd) and spermine (Spm) of T_2 were affected by stresses caused by previous chemical fertilizers added to the soil hence higher values of Put, Spd and Spm than T_1 were attained. The high mean value of available phosphorus (P) in most treatments could have caused toxic effect to chili plants thus a trend on polyamines contents in leaves of the chili plants of all manures and chemical fertilizers treated plants was not cleared.

ACKNOWLEDGMENTS

The authors wish to express their sincere thanks to the Thailand Research Fund for financial assistance and the Faculty of Agricultural Technology, Maha Sarakham Rajabhat University, Mahasarakham 48000, Thailand for laboratory facility provided.

REFERENCES

Anonymous, 2002. Division of horticultural extension. Department of Agricultural Extension, Ministry of Agricultural and Cooperatives, Bangkok, Thailand.

Ammaramon, T. , 2006. Outstanding *Edible chili* pods of the year, Thailand. Agric. Home Econ. J., 30: 70-90.

Bagni, N. and R. Pistocchi, 1992. Polyamine Metabolism and Compartmentation in Plant Cells. In: Nitrogen Metabolism of Plants, Mengel, K. and D.J. Pilbeam (Eds.). Clarendon Press, Oxford, pp: 229-248.

Evan, P.T. and R.L. Malmberg, 1989. Do polyaminess have roles in plant development. Ann. Rev. Plant Physiol. Plant Mol. Biol., 40: 235-269.

Flores, H.E. and A.W. Galston, 1982. Analysis of polyamines in higher plants by high performance liquid chlomatography. Plant Physiol., 69: 701-706.

Hutton, W. and P. Mealin, 1997. Tropical Vegetables of Thailand: A Periplus Nature Guides. Asia Books Media, Thailand.

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.

Leelawanitchai, K., 2007. Hot flavour of pods of chili plants (*Capsicum annuum* L.). Res. Commun. Publicat., 13: 6-9.

Mengel, K. and E.A. Kirkby, 1987. Principles of Plant Nutrition. 4th Edn., International Potash Institute, Bern, Switherland.

Miller, R.W. and R.L. Donahue, 1990. Soils, an Introduction to Soils and Plant Growth. 6th Edn., Prentice Hall, Englewood Cliffs, NJ.

Panyakul, W., 2004. Sustainable Agriculture: Agricultural Pathways for Future. Saiyai Pandin Foundation, Bangkok, Thailand, pp: 335.

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.

SAS, 1989. SAS/STAT User's Guide. Version 6, Statistical Analysis System Institute Inc., Cary, NC.

Senadee, W., 2006. Undefeatable industry in chili production. Home Agric. J., 30: 101-108.

Sestak, Z., J. Catsky and P.G. Jarvis, 1971. Plant Photosynthetic Production Manual of Methods. Dr. W. Junk N.V. Publishers, The Hague.

Siriborirak, S., 1996. Pharmaceutical Foods, Bangkok. Bangkok Publishing House, Thailand.

Smith, M.A. and P.J. Davies, 1985. Separation and quantification of polyaminess in plant tissue by high performance liquid Chromatography of their dansyl derivatives. Plant Physiol., 78: 89-91.

Suksri, A., 1992. Effects of cattle manure, green manure and chemical fertilizer 13-13-21 (NPK) on growth and kernel yield of maize (*Zea mays* L.) grown on yasothon soil. J. Agric., 8: 204-210.

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.

Suksri, A., S. Seripong and S. Teerapongtanaporn, 1991. Effects of green manure, cattle manure and chemical fertilizer on growth and yield of maize (*Zea mays* L.) grown on yasothon soil. J. Agric., 7: 1-8.

Terapongtanakorn, S., 2000. Effect of Sodium chloride on photosynthesis and polyamines production in rice leaves (*Oryza sativa* L.). Ph.D Thesis. Department of Biology, Chulalongkorn University, Bangkok, Thailand.