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Growing Bush bean (*Phaseolus vulgaris* L.) and Kangkong (*Ipomea aquatica*) using natural pesticides and organic fertilizers

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Key words: Organic farming, Bush bean, KANGKONG, Neem, Cow urine, Cattle slurry.

Abstract

Two experiments were conducted to evaluate the use of natural pesticides to control pests in bush bean (*Phaseolus vulgaris* L.) and to study the effect of different organic fertilizers on growth and yield of Kangkong (*Ipomea aquatica*). In the first experiment Neem Seed Kernel Extract (T_1), Tobacco Décoction (T_2), Cow Urine (T_3), and Synthetic Insecticides (T4) were used as treatments to control common insect pests damaging bush bean. All the treatments were able to reduce insect damage when compared to control. No differences were observed among neem seed kernel extraction, tobacco decoction and cow urine in controlling bean fly (*Phaseolus vulgaris*), leaf miner (*Liriomyza trifoli*), leaf eating caterpillars (*Hedylepta indicate*), whitefly (*Bemisia tabaci*) and leaf eating beetles (*Cerotoma trifurcate*) of bean during vegetative stage. Pod borer damage was successfully controlled by Neem seed kernel extract. In the second experiment Cattle Slurry+Compost (T1), Organic Liquid fertilizer (Algifol™)+Compost (T2), Recommended Inorganic Fertilizer (T3), Compost (T4), Control (T5), Organic Liquid fertilizer (Algifol™) (T6) and Cattle Slurry (T7) were evaluated as fertilizers for growing Kangkong. Highest fresh and dry weight of the leaves were obtained with the application of Cattle slurry + Compost (T1) and inorganic fertilizer (T3). This shows that Kangkong grows best with fertilizer having high nutrients and they are easily available. Mean differences of fresh and dry weight of Kangkong yield among Compost (T4), Algifol (T6) and Cattle slurry (T7) applied treatments were non-significant (P=0.05). This study shows that Bush bean and Kangkong can be grown successfully using organic methods.

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Introduction

Organic agricultural methods are receiving worldwide recognition as the answer to problems encountered in the modern day agriculture and to bring stability and sustainability to farming systems (Smith, 2007). These methods are largely based on the traditional knowledge and also on some recent scientific innovations. Identifying and evaluating such methods and approaches are vital to conduct organic agriculture successfully. In this regard methods to control pests and manage soil fertility are two important areas that needs to be developed.

During chemical farming, by applying a specific insecticide can dramatically reduce pest populations in short term, but this will also destroy the natural predators and also promote the development of pesticide resistant strains of insect pests causing an ultimate increase in the pest populations. In addition to this, pesticides cause other problems such as environmental contamination, bioaccumulation and harm to human health. However, there are natural substances with plant and animal origin such as botanicals and cow urine having pesticidal properties due to presence of certain natural chemicals. They are environmentally safer and do not cause ill effects on human health. The anti-insect effects responsible for elimination of insects by these substances are taken place in many different ways, namely repellents, feeding deterrents/antifeedants, toxicants, growth retardants, chemosterilants, and attractants (Hikal *et al,* 2017).

Maintaining soil fertility is another challenge to conduct agriculture sucessfully. However, there are natural substances such as animal manure, green manure and compost that can complement inorganic fertilizer and provide nutrients needed for crop growth.

In this regard two experiments were conducted, the first one to evaluate some natural substances believed to have anti-insect effects to control insect pests in bush bean (*Phaseolus vulgaris* L.) and the second experiment was to evaluate the effect of different organic fertilizers on growth and yield of Kangkong (*Ipomea aquatica*).

Common bean is considered as one of the nature's greatest foods and is a popular vegetable in Sri Lanka. Beans (*Phaseolus vulgaris* L.) belong to the family Fabaceae, which is characterized by the high protein content of the harvestable product as well as the ability to fix atmospheric nitrogen in the root nodules. Further beans are considered as a good protein substitute, which is relatively low in price than an equivalent amount of animal protein. Bush beans attract many insect pests and they cause severe losses in production. Kangkong (*Ipomea aquatica*) is a popular leafy vegetable in Sri Lanka. It is a semiaquatic tropical plant grown for its tender shoots and leaves. Kangkong is a member of Convolvulaceae (Morning glory) family and found throughout the tropical and subtropical regions of the world. The origin of Kangkong is not clear but believed to be in South China or India.

Materials and methods

Two experiments were conducted at the Agricultural Experimental station, Faculty of Agriculture, University of Peradeniya located at Dodangolla, Kundasale, in the IM_3 agro-ecological region of Sri Lanka (Punyawardena, 2008). The soil group of the experimental site is Immature Brown Loam (*Ustropepts*). The physical and chemical properties of the soil are presented in the Annexure 1. This experiment was conducted during the *Maha* (major) season (December, 2004 to February, 2005).

Experiment 1: Natural pesticides to control pests in bush bean (Phaseolus vulgaris)

Randomized complete block design (RCBD) was the experimental design used in the experiment. Four blocks with equal size and having 1m space between them were used to lay the experiment. Each block was sub divided in to 5 five equal size plots (1.5m x 2m) with 1m space between them. Cattle manure based compost was applied as the basal dressing at the rate of 5kg/m^2 (15kg/plot), one week before seed sowing and thoroughly mixed with soil to a 10cm depth. Seeds were planted one seed per hole at 10×40 cm spacing. Dark colour polythene (75cm height) was used to encircle each plot to prevent insect movement across adjacent plots.

The experiment had four treatments in addition to control, namely, Neem Seed Kernel Extract (T_1), Tobacco Décoction (T_2), Cow Urine (T_3), Synthetic Insecticides (Dimethoate) (T4) and Untreated Control (T_5). The preparation of insecticidal solutions is given in the Annexure 2. In 2014 use of Dimethoate in Sri Lanka was banned. The treatments were applied at weekly intervals commencing from one week of seeding. Cattle manure based compost was applied at the rate of 5kg per plot at 3 weeks after planting (WAP) as a side dressing (application of fertilizers in a shallow furrow along the side of vegetable row crops). Watering and manual weeding was done when necessary.

Number of bean fly damaged plants, number of whitefly 'pupa', number of leaf eating caterpillars, number of leaves eaten by leaf eating beetles, number of leaves damaged by leaf miner and number of pods damaged by pod borer were recorded weekly. Also weight of healthy pods and weight of damaged pods were recorded at their maturity. Data were analyzed using ANOVA, CATMOD and DMRT procedures using SAS computer software package.

Experiment 2: Effect of different organic fertilizers on growth and yield of Kangkong.

The treatments of the experiment were Cattle Slurry+Compost (T1), Organic Liquid fertilizer (Algisfol™) + Compost (T2), Recommended Inorganic Fertilizer (T3), Compost (T4), Control (T5), Organic Liquid fertilizers (Algifol™) (T6) and Cattle Slurry (T7). The methods of preparation organic fertilizers and the rates of application are given in the Annexure 3. Cattle manure based compost was applied to the plots used for the treatments one, two and four and seven (T1, T2, T4 and T7) at the rate of 5kg/m² (15kg/plot) and was thoroughly mixed with the soil to a 10cm depth. The physical and chemical properties of the compost were analyzed (Annexure 3).

The treatments were arranged in a Randomized complete Block Design (RCBD), with three replicates. The Land was ploughed using a four wheel tractor and sunken beds were prepared manually.

The size of the beds was 1.5X2m. Healthy, uniform, 20-25cm long Kangkong stem cuttings were planted, 2 cuttings per hill at 30 x 30cm spacing. Lifesaving irrigation was carried out. Weeding was done manually throughout the experimental period. Organic methods were used to control pest and disease.

Plant length, average number of shoots per plant and cumulative plant length was measured at weekly intervals. Leaf area was measured using the automatic leaf area meter to calculate the leaf area index per plant. Destructive sampling was done to measure the yield. An area of 1m² was sampled from each plot by cutting the plants at normal cutting height (10 cm above ground level). There were 9 plants per m². The leaves and the shoots were separated. Average number of leaves/plant, fresh weight of leaves and fresh weight of stems were measured. Harvesting was done at 4 week intervals as Kangkong usually starts flowering after 4 weeks. Two harvests were obtained during the experimental period. The data obtained were statistically analyzed using Statistical Analysis Systems (SAS).

The leaf samples that were harvested at 4 week intervals were grounded after drying to 60°C for 48 hours. The grounded leaf samples were analyzed for total Nitrogen, Phosphorus and Potassium. Samples of compost and soil were analyzed to estimate Total Nitrogen, available Phosphorus, exchangeable Potassium, Calcium, Sodium, Organic Carbon, pH and electrical conductivity using standard methods at the time of planting.

Results and discussion

Experiment 1: Use of natural pesticides to control pests in bush bean

Insect pest incidence

Foliar Damaging Insects

The bean fly (*Melangromiza phaseoli*) is the most serious pest in bush beans (*Phaseolus vulgaris*) who damages the plant at seedling stage. However bean fly was not recorded during this experiment and this may be due to the seasonal or regional effects.

Foliar damaging insects such as leaf miner (*Liriomyza trifoli*), leaf eating caterpillars (*Hedylepta indicata*), white fly (*Bemisia tubaci*) and leaf eating beetle *(Ceratoma trifurcate)* are the other common insect pests in bush bean (AVRDC, 2000; PROTA Foundation, 2004).

Variation of mean number of leaf miner (*Liriomyza trifoli*) damaged leaves per plant, number of leaf eating caterpillars (*Hedylepta indicata*) per plant, number of Whitefly "Pupa" (*Bemisia tubaci*) per plant and number of Leaf eating beetle (*Cerotoma trifurcate*) per plant when treated with different insecticides were measured in the experiment (Table 1). All the treatments were able to reduce the foliar damaging insects in bush bean significantly (P=0.05) when compared to the control (Table 1). Synthetic insecticide (i.e. Dimethoate) was significantly (P=0.05) more effective than natural insecticides in controlling foliar damaging insects. Neem Seed Kernel Extract, tobacco decoction and cow urine were not strong enough to kill foliar damaging insects but they have repellent and antifeedent properties (Hikal *et al,* 2017). According to the observations lowest foliar damages were recorded with Neem Seed Kernel Extract treated plants. Scientists have identified number of biological compounds from neem, including triterpenoids, azadirachtin Butterworth and Morgan (1971) and melantriol (Lavie *et al*, 1967). These compounds reduces the feeding of insect (Pathak and Tiwari, 2012). Of them Azadirachtin-E is the most effective insect growth regulator found in neem (Verkerk and Wrightm, 1993) and it take place due to the disruption of the hormonal control of metamorphosis and moulting (Vardhini *et al*, 1997). It is an example of natural chemical defense by plant, affecting feeding through chemoreception (deterrence) and toxic effect (Mordue and Blackwell, 1993). There are large number of evidences reported in the literature about the effectiveness of neem seed kernel extract in controlling foliar damaging insects in many vegetables as it contain antifeedent, insecticidal and repellent properties (Stoll,1983).

Table 1. Controlling leaf damaging insects using natural insecticides.

Insecticide	Leaf damage caused by insect pests (30 days after planting)			
	Leaf miner (Damaged Leaf/ Plant)	Caterpillar (No. of Caterpillars/ Plant)	Whitefly (No. of Whitefly pupa per plant)	Leaf eating beetle (No. of beetles/ plant)
Neem extraction	2.0^{a}	2.02^{a}	21.4^{a}	8.4^{ab}
Tobacco decoction	2.76^{ab}	3.06^{a}	26.2^{bc}	$10b^{a}$
Cow urine	3.76^{b}	2.28^{a}	30^{c}	10.6^{a}
Dimethoate	0^{c}	0^{b}	19^{a}	06^{b}
Control	5.92^{d}	6.04^{c}	50.4^{d}	17^{c}

Key: Means followed by same letter within the columns are not significantly different from each other at P=0.05.

It is also observed that leaf miner and caterpillar damage reduced with the time. This may be due to their preferences in damaging the plants when they are tender. Further it was observed that whitefly and leaf eating beetle counts have increased with the time in all treated plots. This may be due to increasing number of leaves with the plant growth.

Pod Damaging Insects

Significantly (p=0.05) low pod borer damages per plant were observed with plants applied with neem seed kernel extract and synthetic insecticides treated plants (Table 2).

The same observation was made during a study conducted on efficacy of neem kernel extract and some insecticidal formulations against the gram pod borer (*Heliothis armigera*) by Thakur *et al*, (1979).

Table 2. Pod borer damage (pods per plant).

Treatments	No. of damaged pods per plant
Neem seed kernel extract	3.34^{a}
Tobacco decoction	5.58^{b}
Cow urine	5.94^{b}
Synthetic insecticide (Dimethoate)	1.84^{a}
Untreated control	6.26^{b}

Key: Mean followed by the same letter in one column is not significantly different at 5% probability level, according to DMRT.

Yield

Significantly (p=0.05) less yield damage by pod borer was observed with neem seed kernel extract and synthetic insecticide treated plants when compared to other treatments (Thakur *et al*, 1979). Significantly (p=0.05) higher edible yields were recorded in all natural and synthetic insecticide treated plants than the control (Table 3). Neem seed kernel extract treated plants showed higher edible yield than both tobacco decoction and cow urine treated plants but less than the yield obtain with synthetic insecticide applied treatments (Table 3).

Table 3. Mean edible yield and damage yield under different insecticide treatments.

Treatments	Edible Yield (kg/m^2)	Damage Yield (kg/m^2)
Neem seed kernel extract	2.59^{a}	0.41^{c}
Tobacco decoction	1.84^{bc}	0.64^{ab}
Cow urine	1.98^{b}	0.58^{b}
Synthetic insecticide	2.87^{a}	0.46^{c}
Untreated control	1.42^{c}	0.69^{a}

Key: Mean followed by the same letter in one column is not significantly different at 5% probability level, according to DMRT.

Neem seed kernel extract and cow urine also use as fertilizers in organic farming (Hitinayake *et al,* 2008). Hence their application may have a direct effect on the plant growth in addition to their indirect effect on plant growth by controlling insects.

Tobacco decoction has not proved to be a fertilizer in organic farming. The yield of plots treated with tobacco decoction did not show a significant difference with the control (Table 3).

In the vegetative stage significantly higher foliar damages were observed in neem seed kernel extract plants than the synthetic insecticide treated plants. However the difference was not significant in the edible yield and damage yield at the time of harvesting (Table 3). In beans (*Phaseolus vulgaris*), most important economic part is pods. So neem seed kernel extract can be used as a substitute for highly toxic synthetic insecticides.

Conclusion and suggestions

All the treatments were able to reduce insect damage when compared to control. No differences were observed among neem seed kernel extraction, tobacco decoction and cow urine in controlling bean fly (*Phaseolus vulgaris*), leaf miner (*Liriomyza trifoli*), leaf eating caterpillars (*Hedylepta indicate*), whitefly (*Bemisia tabaci*) and leaf eating beetles (*Cerotoma trifurcate*) during vegetative stage. Neem seed kernel extraction found to be a very effective natural insecticide to control pod borer damage.

It is important to conduct further research to identify most appropriate rates for the application of natural insecticides to control pests.

Experiment 2: Effect of Different types of Organic fertilizers on growth and yield of Kangkong

Results obtained during the first harvest of Kangkong

Effect of different type of fertilizers on yield (g/m^2) of first harvest

Results of the experiment shows (Table 4) that significantly higher (P=0.05) fresh weight and dry weight of leaves were recorded with the compost + cattle slurry treatment (T1).

No significant difference (P=0.05) in fresh and dry weight of leaves detected among treatments, Cattle Slurry (T7), Algifol + compost (T2), Inorganic fertilizer (T3) and Algifol (T6). Compost (T4) treatment obtained the third highest fresh and dry weight of leaves.

Lowest yield of the leaves and stems were recorded in the control (T5). Highest fresh weight and dry weight of the leaves and stems were obtained by Cattle slurry + compost (T7) treatment. Mean differences in both fresh and dry weight of the leaves and stems between treatments Algifol + compost (T2), inorganic fertilizer (T3), Algifol (T6) and Cattle slurry (T7) were nonsignificant (P=0.05).

Table 4. Effect of different types of fertilizers on yield.

Treatments	Fresh weight		Dry weight	
	Leaves	Stems	Leaves	Stems
Cattle slurry + Compost (T1)	360.57^{a}	236.60^{a}	37.83^{a}	13.33^{a}
Algifol+ Compost (T2)	279.43^{b}	197.53^{bc}	27.03^{bc}	12.03^{ab}
Inorganic fertilizer (T3)	302.67^{b}	204.00^{b}	27.56^{b}	12.50^{ab}
Compost (T4)	234.33^{c}	182.00^{dc}	22.80^{cd}	12.33^{ab}
Control (T5)	180.33^{d}	169.00^{d}	18.96^{d}	9.72^{c}
Algifol (T6)	286.33^{b}	188.66^{bcd}	25.2b^{c}	11.76^{b}
Cattle slurry (T7)	292.77^{b}	192.33^{bc}	28.30^{b}	12.40^{ab}

Key: Means followed by same letter within the columns are not significantly different from each other at P=0.05.

Effect of different types of fertilizers on nutrient composition of leaves

Results shows that the mean differences of leaf Nitrogen content between cattle slurry + compost (T7), Algifol + compost (T2), Inorganic fertilizer (T3), and Cattle slurry treatment (T7) were non-significant (P=0.05) (Table 5). Second highest ranks were obtained by compost (T4), and Cattle slurry (T7). Control (T5) showed the lowest nutrient composition. Mean difference in leaf phosphorus content between treatments were not significant (p=0.05). Highest Potassium content was recorded in cattle slurry + compost (T2) treatment. Mean difference between other treatments were non-significant (P=0.05).

Table 5. Nutrient composition of leaves.

Treatments	Nitrogen%	Phosphorus%	Potassiun
Cattle slurry + Compost (T1)	3.796^{a}	0.602^{a}	5.403^{a}
Algifol + Compost (T2)	3.346^{abcd}	0.640^{a}	4.686^{b}
Inorganic fertilizer (T3)	3.706^{ab}	0.623^{a}	4.500^{b}
Compost (T4)	3.230^{bcd}	0.590^{a}	4.530^{b}
Control (T5)	2.992^{d}	0.580^{a}	4.366^{b}
Algifol (T6)	3.093^{cd}	0.616^{a}	4.443^{b}
Cattle slurry (T7)	3.580^{abc}	0.630^{a}	4.640^{b}

Key: Means followed by same letter within the columns are not significantly different from each other at P=0.05.

Effect of different types of fertilizers on plant growth

Mean differences in number of leaves /plant and number of shoots /plant were non-significant among treatments (P=0.05). According to the data in Table 6, the highest LAI/plant was recorded in Cattle slurry + compost (T1) and inorganic fertilizer (T3) treatments. Lowest was recorded in control (T5). Highest total plant length and plant length at third week were recorded in Cattle slurry + compost (T1), Inorganic fertilizer (T3) and Cattle slurry (T7) applied plots.

Results obtained during the second harvest of Kangkong

Effect of different types of fertilizers on yield (g/m²)

Results shows that Cattle slurry + Compost (T1) and Inorganic fertilizer (T3) treatments recorded the highest fresh and dry weight of the leaves (Table 7). Mean differences of fresh and dry weight of stems among Compost (T4), Algifol (T6) and Cattle slurry (T7) applied treatments were non-significant (P=0.05). Lowest fresh and dry weights of stems were recorded in control (T5).

Table 6. Effect of different types of fertilizers on plant growth.

Treatments	LAI/plant (cm²/plant)	Total plant length (cm)	Plant length at third week (cm)
Cattle slurry + Compost (T1)	2495.7^{a}	127.433^{a}	77.667^{a}
Algifol + Compost (T2)	2109.7^{b}	117.500^{ab}	64.667^{c}
Inorganic fertilizer (T3)	2391.0^{ab}	123.367^{a}	74.333^{ab}
Compost (T4)	1773.7^{c}	117.533^{ab}	64.333^{c}
Control (T5)	1237.7^{d}	100.167^{a}	65.667^{c}
Algifol (T6)	2134.0^{b}	121.300^{a}	68.667^{bc}
Cattle slurry (T7)	2138.7^{b}	126.00^{a}	76.333^{ab}

Key: Means followed by same letter within the columns are not significantly different from each other at P=0.05.

Table 7. Effect of different types of fertilizers on yield.

Treatments	Fresh weight		Dry weight	
	Leaves	Stems	Leaves	Stems
Cattle slurry + Compost (T1)	379.55^{a}	237.00^{a}	54.70^{a}	13.80a
Algifol+ Compost (T2)	319.40^{c}	234.33^{a}	52.39^{ab}	13.10^{ab}
Inorganic fertilizer (T3)	384.00^{a}	239.67^{a}	54.09 ^{a}	13.2^{ab}
Compost (T4)	312.33^{c}	250.00^{a}	47.70^{bc}	13.18^{ab}
Control (T5)	227.33^{d}	226.00^{a}	37.40^{d}	12.56^{b}
Algifol (T6)	309.40^{c}	245.67^{a}	45.30^{c}	12.68^{b}
Cattle slurry (T7)	344.00^{bc}	233.00^{a}	44.13^{c}	13.09^{ab}

Key: Means followed by same letter within the columns are not significantly different from each other at P=0.05.

Effect of different types of fertilizers on nutrient composition of leaves

Results shows that highest Nitrogen content of leaves was recorded in Cattle Slurry + compost (T1) and Inorganic fertilizer (T3) applied plants. Compost (T4) treatment showed the highest Phosphorus content in leaves and the lowest was recorded in Cattle slurry + Compost (T1) treated plots (Table 8). In relation to Potassium content of leaves, mean difference between treatments were non-significant (P=0.05).

Table 8. Nutrient contents of leaves.

Treatments	Nitrogen%	Phosphorus%	Potassium%
Cattle slurry + Compost (T1)	3.83^{a}	0.54^{b}	4.57^{a}
Algifol+ Compost (T2)	3.26^{b}	0.58^{ab}	4.52^{a}
Inorganic fertilizer (T3)	3.67^{b}	0.60^{ab}	4.55^{a}
Compost (T4)	3.20^{b}	0.613^{a}	4.54^{a}
Control (T5)	2.97^{b}	0.58^{ab}	4.36^{a}
Algifol (T6)	3.12^{b}	0.59^{ab}	4.51^{a}
Cattle slurry (T7)	3.32 ^{b}	0.56^{ab}	4.59^{a}

Key: Means followed by same letter within the columns are not significantly different from each other at P=0.05.

Effect of different types of fertilizers on plant growth

Highest leaf area index was recorded in the compost + cattle slurry (T1) treatment. Control (T5) recorded the lowest value (Table 9).

Higher final plant length and plant length at third week were obtained by Cattle slurry + compost (T1), Inorganic fertilizer (T3), Algifol (T6) and Cattle slurry (T7) treated plots. Control (T5) obtained the lowest value.

Table 9. Effect of different types of fertilizers on plant growth

Treatments	LAI/plant (cm^2/plant)	Total plant length (cm)	Plant length at third week (cm)
Cattle slurry + Compost (T1)	2456.67^{a}	116.7^{a}	75.00^{b}
Algifol+ Compost (T2)	2246.67^{b}	106.13^{ab}	67.66^{dc}
Inorganic fertilizer (T3)	2336.67^{ab}	111.00^{a}	73.33^{abc}
Compost (T4)	2183.33^{b}	104.60^{ab}	69.33^{bdc}
Control (T5)	1296.67^{c}	94.96^{b}	65.66^{d}
Algifol (T6)	2191.67^{b}	114.66^{a}	72.33^{abc}
Cattle slurry (T7)	2323.33^{ab}	112.33^{a}	76.33^{a}

Key: Means followed by same letter within the columns are not significantly different from each other at P=0.05.

Conclusions

The study clearly shows that application of compost as well as liquid fertilizers is important to obtain high yields from Kangkong. Highest yields were obtained when Kangkong was applied with Cattle slurry + Compost and Inorganic fertilizers. Mean differences of fresh and dry weight of stems among Compost (T4), Algifol (T6) and Cattle slurry (T7) applied treatments were non-significant (P=0.05). Control obtained the lowest yield. Results also shows that application of liquid fertilizers is important for getting high yield in Kangkong than using compost alone.

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Annexure 1.

Physical and chemical properties of the soil.

Soil property	Value
pH	6.28
Total Nitrogen %	0.20
Carbon %	1.45
Organic matter%	2.51
Available Phosphorous (mg P/ g)	0.06
Exchangeable Potassium (meq/ 100g)	0.38
Calcium (meq/ 100g)	2.39
Sodium (meq/ 100g)	0.09
Electrical Conductivity	0.01
C/N ratio	7.28

Annexure 2.

Preparation of Insecticidal Solutions

1. Neem Seed Kernel Extract

Dried neem (*Azadirachta indica*) seed were used at the rate 50g/l to prepare the extract. Seeds were grounded and kept in a water bucket for about 12 hours and was filtered and each liters of extract was mixed with 5 ml of liquid soap (Stoll, 1986; PROTA Foundation, 2004; FWMF, 2017). The final solution was stirred and applied to the plants till they get wet. The application of treatment solution was started after 3 WAP and conducted during evening.

2. Tobacco Decoction

250g of dried tobacco leaves was simmered in 4 liters of water for 30 minutes. Then it was diluted to one part of tobacco decoction with five parts of water (Stoll, 1986; PROTA Foundation, 2004).

3. Cow Urine

The cow's urine was collected and allowed to stand for 2 weeks without being exposed to sunlight. It was diluted at one part of cow urine with six parts of water and filtered using a coarse cloth before spraying (Choudhary *et al,* 2017). Cow Urine is a useful source of nitrogen, also it contains sulphur, phosphate, potassium, sodium, manganese, carbolic acid, iron, silicon, chlorine, salt, enzyme and hormones. This non-toxic effluent is constituted with water (95%), urea (2.5%) and the remaining 2.5% is with minerals, salts, hormones and enzymes (Choudhary *et al,* 2017).

4. Dimethoate

Dimethoate was the insecticide used to control the pest. Dimethoate (O,O-Dimethyl S- (N-methylcarbamoylmethy) phosphorodithioate) is an organophosphate used to kill mites and insects systemically and on contact. It is used against a wide range of insects, including aphids, thrips, planthoppers, and whiteflies. It causes excessive nerve signal transmission in the central nervous system and ultimately death by respiratory failure. Dimethoate was applied four times (2, 4, 6 and 8 weeks after planting) during the cropping period. The dilution and rate of application was 75ml/100L of water or 750ml/ha.

Annexure 3.

Preparation of fertilizer treatments.

1. Application of Algifol™

Algisfol™ is an organic active Biostimulant (Foliar fertilizer) produced using marine algae (Algifol, 2018). 1% Algisfol™ solution was used for the experiment. The cuttings of Kangkong were soaked in Algifol solution for few minutes, before planting. The solution was sprayed to the plants early morning at 10 days interval. Hence, a total of four applications took place during the experimental period.

2. Cattle Slurry

Cattle slurry was made using fully dried cow pats. Cow pats were mixed with water at the ratio 2:1. (Cattle manure: water=2:1). Slurry was kept for two weeks and diluted with the twice the amount of water. The first application was done 2 weeks after planting. In this experiment cattle slurry was applied to the soil at the rate of 1 liter per square meter (2.5 liters per plot) at weekly intervals. The rate of application of cow dung slurry to the soil range from 1-5 liters per square meter.

3. Inorganic fertilizers

Application of inorganic fertilizers (g/plot).

Type	Days after Planting			
	Pre plant	10days	20days	30 days
Urea	32	20	6	6
TSP	43	6	6	-
MOP	24	7.5	4	-

4. Compost

Characteristics of the compost used in the experiment are shown below:

Characteristic	Value
pH	7.67
Total Nitrogen	1.07
Soil organic carbon %*	6.6
Organic matter%*	11.37
Available Phosphorous (µg P/ g soil)	1275.4
Exchangeable Potassium (meq/ 100g soil)	2.14
Calcium (meq/ 100g soil)	10.884
Sodium (meq/ 100g soil)	0.205
Electrical Conductivity	1.8
C/N ratio	6.16

*Soil organic carbon= Soil organic matter x 0.58.