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Improving mulberry (*Morus alba* L.) leaf yield, silkworm (*Bombyx mori* L.) cocoon yield and income using sustainable fertilizer management practices

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Abstract

To meet local and international demand for silk products, six (6) fertilizer management strategies involving green leaf manuring and silk waste composting were evaluated to improve mulberry leaf and silkworm cocoon yields and income at DMMMSU-Sericulture Research and Development Institute, Bacnotan, La Union, Philippines. The treatments were laid out in RCBD with three replications. Mulberry leaf and cocoon yields were gathered, analyzed using ANOVA and means were compared using HSD. Cost return analysis was estimated. Average single leaf weight was significantly higher in fertilized treatments than the control. Growing mulberries in May-July 2014 produced heavier mulberry leaf and biomass yield. Mulberry plants applied with ½ RRN + PK/ha + 5 tons silk waste + 10 tons *Katurai* leaves during May –July 2014 produced heavier leaf and biomass yields. The different fertilizer treatments did not significantly influence cocoon yields of silkworms. All fertilizer treatments significantly produced higher effective rearing rates and cocoon yield in November-December rearing seasons. The use of ¼ N + PK + 10 tons *Katurai* leaves + 5 tons silk wastes, and 10 tons *Katurai* leaves + 5 tons silk wastes alone are promising fertilizer management options to increase farm yields and income.

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Introduction

Based on the nutrient access concept, an increasing number of institutions involved in shifting agriculture begun to use some or all of the five principles for maintaining soil fertility such as (1) maximizing organic matter production; (2) keeping the soil covered; (3) using zero tillage; (4) maximizing biodiversity; and (5) feeding the crops through the litter layer. Using these principles, farmers prefer getting harvests about as good, if not better each year they crop rather than harvest that decreases dramatically from one year to the next (International Fund for Agricultural Development, International Development Research Centre, Cornell International Institute for Food, Agriculture and Development, International Centre for Research in Agroforestry and International Institute for Rural Reconstruction, 2001).

Due to the unsustainability of using inorganic fertilizer in intensive agriculture, the use of organic fertilizers; integrated nutrient management or combined use of organic and in-organic fertilizers and diversified farming are options for improving soil quality (Rola, 2003). Organic fertilizers consist of organic manures from living organisms such as green and green leaf manures and decayed organisms including animal and composts. Integrated use of organic and inorganic fertilizers involves developing location-specific recommendations where both micro and macro nutrients are taken into account.

Silk wastes are source of fertilizers when composted and applied into the soil. A box of silkworm (20,000 larvae) could generate about 410kg of fresh litters (Padilla *et al.*, 1999). For animal wastes, no biological systems can assimilate more than 40% of the nutrients in food. Therefore, a minimum of 60% of the nutrients of the original intake is present in the excreta. Organic manure is not deficient in any nutrients (about 3-40 elements) and is capable of supplying every nutrient gradually so that all the nutrients applied can be assimilated by the plants. It releases the nutrients gradually so that all the nutrients are supplied over a long time in right proportions.

Contact between plant root hairs and organic manure particles ensures conservation, thus there is a built-in economy (Ghosh, 1999). Organic matter can regulate the concentration of ions and can provide a steady level of nutrients to the roots of the plants (Hikari, 2000). Soils loaded with organic matter can hold many times its weight of water, heavy rain is absorbed not run off, until the top soil holds all it can and then the excess goes to the sub-soils (Rateaver *et al.*, 1994). Some nitrogen fixing trees are capable of returning large biomass of herbage for the plants. An example of which is the *Sesbania grandiflora* (*Katurai)*, although with a moderate growth rate has good tolerance to stress conditions such as drought, water logging and low fertility, yet could provide as much as 15-22 tons of herbage yields (International Institute for Rural Reconstruction, 1983). This makes it as good as animal feeds and green manure crop. This plant, commonly grown in the Ilocos Region, Philippines produces flowers that are consumed as food.

Integrated use of organic and mineral fertilizers has been found to be promising. Balanced fertilization is the optimum use of organic and in-organic fertilizers with proper grades and amounts that supply the correct ration of plant nutrients and ensures soils to sustain high crop yields over long cropping seasons. In balanced fertilization, recommendation is location specific and dynamic. That is, the recommended mix of fertilizers for the current year is different from that of the next year and year thereafter.

Thus, the need to know the right combinations of organic and in-organic fertilizers combined with generated silk waste in sericulture. Specifically, the study determined the growth and yield characteristics of mulberry using different fertilizer management practices and growth, cocoon yield and quality of silkworms fed with leaves in different rearing seasons. Moreover, the effects of fertilizer management strategies and seasons of growing on the growth and yield of mulberry, and on silkworm's growth and cocoon yield and quality, were compared. The study also determined the cost-returns of producing cocoons in different fertilizer management practices.

Materials and methods

Study A. Growth and yield of mulberry as affected by different fertilizer management practices grown in different seasons

To improve the existing sericulture farming systems and practices of the farmers in Region 1, Philippines, fertilizer management strategies were developed into experimental packages of technologies. To integrate the wastes to be used in each system, silk waste generated from the treatments were composted and applied as follows:

Treatments

A 200-50-50kg NPK ha^{-1} (RR N+PK ha^{-1})
B 200-50-50kg NPK ha^{-1} + 5 tons silk waste (SW) (RR N+PK ha^{-1} + 5 tons SW ha^{-1})
C 100-50-50kg NPK ha^{-1} + 5 tons SW + 10 tons *Katurai* leaves (KL)/ha^{-1}
(1/2 RR N + PK ha^{-1} + 10 tons KL + 5 tons SW)
D 50-50-50kg NPK ha^{-1} + 5 tons SW + 10 tons KL ha^{-1}
(¼ N + PK ha^{-1} + 5 tons SW + 10 tons KL ha^{-1})
E 5 tons SW + 10 tons Katurai leaves ha^{-1}
F No Fertilizer – control

Commercial Urea fertilizer (45-0-0) and complete fertilizer (14-14-14) were used as inorganic fertilizer. Decomposed silk wastes generated from each treatment were used as organic animal manure. *Katurai* plants were planted along edges of mulberry plantation as source of *Katurai* green leaf manure. The leaves were harvested, and applied fresh around the mulberry plants as green leaf manures.

The fertilizer treatments were applied just after pruning at the height of 50cm. In-organic fertilizers were drilled in between plants at 15cm away from the mulberry trunks. The silk waste manures were also applied at about 15-20cm away from the trunks at the rate of 5 tons ha^{-1} or 0.35kg per plant. These were incorporated into the soil through inter-cultivation. Regular care and management of the plants such as weeding, inter-cultivation and watering were employed until leaf harvesting (45 days after pruning). For each year, the study was conducted in two mulberry growing seasons and two silkworm rearing trials.

Data gathered

Ten sample plants were randomly selected for data gathering on number of branches, number and weight of harvestable leaves per plant, and average single leaf weight.

For the number of branches, all branches that emerged from the main stem were counted, while the number and weight of harvestable leaves per plant were obtained by counting and weighing the leaves appropriate for feeding starting at 55 days after pruning. The average single leaf weight was computed based on the total weight of leaves divided by the total number of leaves. The plant biomass yield was taken by weighing all the above plant parts (50cm above or pruning height were cut).

Study B. Response of silkworm fed with leaves in different fertilizer management practices with silk waste fertilization

The study made use of the leaves harvested from the mulberry plantation in Study A. Silkworm hybrid DMMMSU 346 was used in this study where silkworm rearing trial started 45 days after pruning, employing the recommended rearing practices in the La Union Techno-guide in Silkworm Rearing.

Statistical Design and Analysis

The treatments were laid out in Randomized Complete Block Design (RCBD) with three replications using 100 worms per treatment. Analysis of Variance in RCBD combined analysis was used to determine the effects of fertilizer treatments on the growth and yield of silkworms. Treatment means were compared using HSD.

Data gathered

Cocoon assessment was done just after harvesting. The data used in evaluating the performance of silkworm were Effective rearing rate (ERR), weight of ten matured larvae, average single cocoon weight, average single shell weight, cocoon shell percentage (CSP), and cocoon yield per box (CYPB).

The ERR was calculated by taking the number of worms that produced cocoons divided by the number of worms reared then multiplied by 100%.

For the weight of ten matured larvae, these were randomly picked and weighed. For the average single cocoon weight, twenty cocoons were randomly selected and weighed then divided by the number of cocoon samples.

On the other hand, the average single shell weight was computed by randomly selecting ten cocoons which were cut and weighed, then divided by the number of cocoon shell samples. CSP was based on the weight of shell divided by the weight of cocoons multiplied by 100%. Lastly, CYPB was computed as the number of silkworms reared per box multiplied by the ERR multiplied by the single cocoon weight (from total harvest per treatment).

Results and discussion

Growth and Yield Characteristics of Mulberry Grown in Different Fertilizer Management Practices

The number of branches, number and weight of leaves, and biomass yields of mulberry were not significantly influenced by the different fertilizer strategies (Table 1).

Number of branches ranged from 7 to 10, while number of leaves ranged from 115 to 143. Weight of leaves was from 152 to 279g /plant and biomass yields from 398 to 639g/plant.

Average single leaf weight was comparable in all fertilizer treatments and implies that the application of fertilizers, whether organic or inorganic increased the average single leaf weight of plants.

Growth and Yield Characteristics of Mulberry Grown in Different Seasons

More branches were observed during early rehabilitation stage particularly during the months of May to July and September to November 2014 growing season than in later years (2015 to 2017 growing season) (Table 2).

Table 1. Growth and yield characteristics of mulberry grown in different fertilizer management practices in Bacnotan, La Union, Philippines.

Treatment	No. of branches	No. of leaves	Weight of Leaves/ Plant (gm)	Ave. single Leaf weight (gm)	Total Biomass Yield (fresh)
RR N +PK/ha	8.83	126.3	246.7	1.92a	584.0
RR N +PK/ha + 5t SW	8.40	115.5	200.7	1.67ab	470.7
½ RRN +PK/ha+ 5t SW+10t KL	9.66	137.6	279.3	1.81ab	627.3
¼ RRN + PK/ha+ 5t SW+ 10t KL	10.00	133.5	261.5	1.81ab	540.0
5t SW + 10t KL	10.16	143.4	273.5	1.82ab	638.6
Control-No fertilizer	7.29	109.3	151.6	1.31b	398.7
Significance	ns	ns	ns	**	ns
cv	15.62	17.67	24.86	12.2	21.93

In a column, means followed by the same letter are not significantly different at 5% level, HSD.

Table 2. Growth and yield characteristics of mulberry grown in different seasons in Bacnotan, La Union, Philippines.

Growing Season	No. of branches	No. of leaves	Weight of Leaves/ Plant (gm)	Average single Leaf weight (gm)	Total Biomass Yield (fresh)
May 20- July 20, 2014	13.02a	209.4a	479.5a	2.28a	1062.9a
Sept. 22- Nov. 22, 2014	12.31a	146.6b	239.1c	1.61b	515.4bc
July 6- Sept. 6, 2015	6.44b	94.3cd	146.6cd	1.53b	314.8d
June 29- Aug. 29, 2016	8.07b	106.1bc	270.1b	2.08a	660.0b
April 27- June 27, 2017	6.9b	111.9c	172.5bd	1.55b	391.5cd
Sept. 14- Nov. 14, 2017	7.68b	77.2d	105.2d	1.36b	304.8d
Significance	**	*	*	**	**
cv	15.62	17.67	24.86	12.2	21.93

In a column, means followed by the same letter are not significantly different at 5% level HSD.

Table 3. Growth and yield characteristics of mulberry as affected by different fertilizer management approaches and different growing seasons.

Growing Season	No of branches	No of Leaves/ plant	Weight of Leaves/Plant g/plant	Ave. single Leaf Weight/ g/leaf	Total Biomass Yield g/plant
May 20-July 20, 2014					
RR N + PK/ha	12.07 ab	204.1 bc	401.3 cd	1.97 bc	1007.2 bc
RR N + PK/ha + 5t SW	9.67 b	155.2 e	372.7 cd	2.43 ab	828.8 c
½ RRN +PK/ha+ 5t SW+10t KL	15.38 a	273.2 a	764.7 a	2.80 a	1588.1 a
¼ RRN + PK/ha+ 5t SW+ 10t KL	12.89 ab	201.1 bc	479.2 bc	2.39 ab	988.4 bc
5t silk waste + 10t KL	13.82 a	216.3 b	550.1 b	2.56 a	1133.4 b
Control-No fertilizer	14.28 a	206.6 bc	30.1 d	1.51 c	837.4 c
Sept. 22- Nov. 22, 2014					
RR N +PK/ha	11.50 bc	130.5 b	209.1 ab	1.60 ab	457.4 ab
RR N +PK/ha + 5t SW	11.67 bc	155.2 ab	264.0 ab	1.85 a	541.6 ab
½ RRN +PK/ha+ 5t SW+10t KL	12.83 ab	141.3 b	228.0 ab	1.62 ab	510.8 ab
¼ RRN + PK/ha+ 5t SW+ 10t KL	13.50 ab	157.0 ab	256.7 ab	1.63 b	521.1 ab
5t silk waste + 10t KL	15.68 a	196.0 a	333.9 a	1.69 b	697.8 a
Control-No fertilizer	8.68 c	112.0 b	142.9 b	1.29 b	363.8 bc
July 6- Sept 6, 2015					
RR N +PK/ha	6.60 a	108.1 a	223.7 a	2.05 a	487.8 a
RR N +PK/ha + 5t SW	6.21 a	77.61 a	108.5 a	1.40 b	235.6 a
½ RRN +PK/ha+ 5t SW+10t KL	6.30 a	92.5 a	152.1 a	1.64 ab	324.2 a
¼ RRN + PK/ha+ 5t SW+ 10t KL	7.10 a	93.3 a	133.5 a	1.4 2 b	291.6 a
5t silk waste + 10t KL	7.50 a	192.7 a	150.7 a	1.417 b	325.6 a
Control-No fertilizer	4.85 a	91.8 a	111.2 a	1.22 b	223.7 a
June 29- Aug 29, 2016					
RR N +PK/ha	7.00 ab	117.2 ab	314.2 ab	2.62 a	752.8 ab
RR N +PK/ha + 5t SW	8.99 ab	152.6 a	210.5 bc	1.34 b	631.9 ab
½ RRN +PK/ha+ 5t SW+10t KL	9.05 a	119.7 ab	263.5 bc	2.18 a	628.7 ab
¼ RRN + PK/ha+ 5t SW+ 10t KL	7.10 a	160.7 a	430.4 a	2.59 a	806.8 a
5t silk waste + 10t KL	7.49 ab	118.0 ab	273.1 b	2.76 a	639.7 ab
Control-No fertilizer	5.62 b	88.4 b	129.1 c	1.47 b	504.4 b
April 27- June 27, 2017					
RR N +PK/ha	7.10 ab	118.9 ab	215.0 a	1.80 a	505.4 a
RR N +PK/ha + 5t SW	5.10 b	89.9 b	142.6 a	1.74 a	302.5 a
½ RRN +PK/ha+ 5t SW+10t KL	9.00 a	147.8 a	205.9a	1.39 a	503.8 a
¼ RRN + PK/ha+ 5t SW+ 10t KL	6.90 ab	100.6 ab	153.1a	1.50 a	346.5 a
5t silk waste + 10t KL	6.20 ab	130.1 ab	200.0a	1.54 a	455.29 a
Control-No fertilizer	5.10 b	91.0 b	118.6a	1.31 a	2.25 a
Sept. 14- Nov. 14, 2017					
RR N +PK/ha	8.70 ab	79.0 a	116.7a	1.49 a	298.5 ab
RR N +PK/ha + 5t SW	9.00 a	82.0 a	105.3a	1.28 a	237.5 b
½ RRN +PK/ha+ 5t SW+10t KL	5.40 bc	51.0 a	61.4a	1.20 a	208.5 b
¼ RRN + PK/ha+ 5t SW+ 10t KL	9.60 a	88.5 a	116.0a	1.31 a	285.5 b
5t SW + 10t KL	8.30a-c	97.0 a	133.2a	1.38 a	579.0 a
Control-No fertilizer	5.10 c	66.0 a	98.5a	1.49 a	183.0 b
Significance	**	**	**	**	**
Cv	15.62	17.67	24.86	12.2	21.93

Likewise, more and heavier leaves were produced average single leaf weight, total biomass yields were significantly higher in plants grown during May to July 2014 growing season compared to the rest of the treatments.

Comparison of fertilizer management approaches at each level of seasons

During the May-July growing season, plants applied with ½, ¼ RRN + PK + 5 tons SW +10 tons KL and 5 tons SW + 10 tons KL alone; also the control; and RRN + PK/ha had comparable number of branches. Plants applied with ½ RRN +PK/ha + 5 tons SW+10 tons KL had significantly more and heavier leaves and consequently more biomass yields than the rest of the treatments. Heavier leaves and biomass per plant were recorded in fertilized treatments than in control plants during the September – November 2014 growing season. During the July - September 2015 growing season, average single leaf weight was comparable in plants fertilized with RRN + PK and ½ RRN + PK + 5 tons SW + 10 tons KL and were higher than the rest of the treatments.

In the June - August 2016 growing season, plants in fertilized treatments had higher biomass yield due to more branches and leaves compared to those in the control treatments.

Plants applied with RRN + PK/ha + 5 tons SW, ¼ to ½ RRN +PK + 5 tons SW + 10 tons KL and 5 tons SW + 10 tons KL alone had comparable number of branches and leaves during the April - June 2017 growing season. Whereas, in the September - November 2017 growing season, plants applied with ¼ RRN + PK/ha + 5 tons SW + 10 tons KL, 5 tons SW + 10 tons KL alone had comparable number of branches with those applied with RRN + PK/ha and RRN + PK/ha + 5 tons SW. Plants applied with 5 tons SW + 10 tons KL and RRN + PK/ha had comparable biomass yield and were higher than the rest of the treatments.

Performance of Silkworm Fed With Leaves Applied With Different Fertilizer Strategies and Reared in Different Rearing Seasons

Growth, Cocoon Yield and Quality of Silkworms Fed with Leaves Applied with Different Fertilizer Management Approaches

Regardless of seasons, the growth and cocoon yield of silkworms were not significantly affected by the different fertilizer treatments. The weight of 10 mature larvae ranged from 29 to 30 g; effective rearing rate was from 51.39 to 62.55%; single cocoon weight was from 1.45 to 1.54 g; single shell weight was from 0.289 to 0.306 g; single shell weight was from 0.290 to 0.306 g; and cocoon yield ranged from 19.21 to 22.87kg/box (Table 4).

Table 4. Growth, cocoon yield and quality of silkworm fed with leaves applied with different fertilizer management approaches.

Fertilizer Management Approaches	Growth and yield parameters					
	Weight of ten Mature larvae (g)	Effective Rearing Rate (%)	Single Cocoon Weight (g)	Single Shell Weight (g)	Cocoon Shell Percentage (%)	Cocoon Yield Per Box (kg)
RR N + PK/ha	29.81	57.60	1.49	0.289	19.47	21.64
RR N +PK/ha + 5t SW	30.23	58.21	1.52	0.295	19.41	22.45
½ RRN +PK/ha+ 5t SW+10 tons KL	30.11	61.03	1.47	0.296	19.63	22.67
¼ RRN + PK/ha+ 5t SW+ 10 t KL	30.82	61.68	1.54	0.306	19.89	23.82
5t silk waste + 10t KL	30.25	62.55	1.54	0.306	19.78	24.28
Control-No fertilizer	29.16	51.39	1.45	0.290	20.15	19.21
Significance	ns	ns	ns	ns	ns	ns
CV (%)	4.82	12.9	5.04	3.83	4.7	10.67

In a column, means followed by the same letter are not significantly different

5% level, HSD

The result implies that the different organic farming practices could be a good alternative to the conventional chemical fertilizer treatments. These options are more economical aside from being environment-friendly, thus making it sustainable to mulberry establishment and rehabilitation.

Growth, Cocoon Yield and Quality of Silkworm Fed with Leaves Applied with Different Fertilizer Management Approaches in Different Seasons

Silkworms reared in August to September significantly produced the heaviest mature larvae. This was followed by silkworms fed during the November-December 2014 rearing season. The lightest larva was produced in the months of July to August 2014, September to October 2015 and July to August 2017 (Table 5)**.**Higher effective rearing rate was recorded in silkworms fed during the months of July-August and November-December 2014 rearing seasons compared to other seasons of the year. The lowest was recorded during the November-December 2017 rearing season due to the prevalence of Grasserie and Flacherie disease infections. Single cocoon weight was significantly highest in silkworms fed during the months of August-September 2016 and November-December 2017 rearing seasons while the lightest cocoon was recorded in July-August 2014 and September-October 2015 rearing seasons.

Table 5. Growth, cocoon yield and quality of silkworm fed with leaves applied with different fertilizer management approaches in different seasons.

Rearing Seasons	Growth and yield parameters					
	Weight of ten Mature larvae	Effective Rearing Rate	Single Cocoon Weight	Single Shell Weight	Cocoon Shell Percentage	Cocoon Yield Per Box
July 27- August 23, 2014	28.69c	83.06a	1.46c	0.258d	18.92cd	22.71b
Nov. 24- Dec. 21, 2014	30.60b	86.56a	1.54b	0.303c	19.75bc	27.35a
Sept. 29-Oct. 28, 2015	28.11c	44.56c	1.42c	0.264d	19.70bc	12.46c
Aug 30- Sept. 28, 2016	35.08a	63.11b	1.60a	0.333a	18.70cd	20.42b
July 26- Aug 22, 2017	28.66c	72.33b	1.57b	0.308bbc	20.44ab	21.53b
Nov. 15- Dec 23, 2017	29.*24bc*	90.33a	1.62a	0.319ab	19.66bc	29.25a
Significance	**	**	**	*	**	**
CV (%)	4.62	12.92	5.06	3.83	4.53	10.67

In a column, means followed by the same letter are not significantly different at 5% level HSD.

Single shell weight was significantly highest in silkworms reared in August-September 2016 rearing season, while the lightest was registered in silkworms raised in July-August 2014 rearing season.

Cocoon yield was significantly highest in silkworm fed during the November-December 2017 rearing season followed by November-December 2014 rearing season. The lowest was recorded in August-September 2016 and July-August 2016 rearing seasons**.** The good rearing performance could be due to favorable climatic conditions prevailing during those seasons. These months (November and December) were colder and conditions were favorable for the growth of worms as the optimum temperature range for the normal growth of silkworms is between 20°C to 28°C (AICAF, 1995).

Further, the relative humidity during that rearing period was from 80% which is within the optimum relative humidity requirement for the normal growth of silkworms at 70 to 85% (Association for International Cooperation of Agriculture and Forestry, 1995). For good growth and development of silkworms, the optimum relative humidity is about 80-90% for young worms and 65-75% for grown silkworms (Datta, 1992). Relative humidity directly affects the physiological functions of the silkworms and indirectly influences the withering of leaves in the silkworm beds. It was reported that optimum humidity of 75+/-22% ensured normal growth of silkworms (Krishnaswami *et al.*, 1973).

Comparison of treatment at each level of seasons

The weight of ten matured larvae, effective rearing rate, single shell weight and cocoon yield per box were not significantly influenced by the interaction between fertilizer management approaches and rearing seasons during the 2014 rearing season (Table 6).

During the September-October 2015 rearing season, effective rearing rate was comparable in silkworms fed with leaves applied with ¼ RRN + PK + 5 tons SW + 10 tons KL, 5 tons SW + 10 tons KL and RRN + PK, while cocoon yield per box was comparable in silkworms fed with leaves from unfertilized plants except with plants fertilized with ½ RRN + PK + 5 tons SW. The same trend was observed during the September-October 2016 rearing season.

During the August-September 2017 rearing season, heavier mature larvae was recorded in silkworms fed with leaves applied with RR N + PK, RRN + PK + 5 tons SW, ¼ to ½ N + PK + 5 tons SW+ 10 tons KL and were significantly different with the rest of treatment combinations.

Cocoon yield was significantly heavier in silkworms fed with leaves applied with fertilizers during the

November-December 2017 rearing season. This could be due to the colder weather during these months where growth of silkworms are enhanced leading to higher effective rearing rates, thus producing heavier single cocoon shell weights.

Table 6. Growth, cocoon yield and quality of silkworm as affected by interaction between different fertilizer management approaches and rearing seasons.

Seasons	Growth and yield parameters					
	Weight of 10 mature larvae (g)	Effective Rearing Rate (%)	Single Cocoon Weight (g)	Single Shell Weight (g)	Cocoon Shell % tage (%)	Cocoon yield per box (kg)
July 27- August 23, 2014						
RR N +PK/ha	21.71a	76.00a	1.34a	0.250a	18.61a	20.40a
RR N +PK/ha + 5t SW	28.02a	85.67a	1.32a	0.253a	19.18a	22.70a
½ RRN +PK/ha+ 5t SW+10t KL	28.22a	83.00a	1.34a	0.257la	19.15a	22.24a
¼ RRN + PK/ha+ 5t SW+ 10t KL	29.02a	89.67a	1.42a	0.270ja	19.10a	25.46a
5t SW + 10t KL	30.17a	90.00a	1.38a	0.260la	18.88a	24.76a
Control-No fertilizer	29.00a	74.00a	1.4a	0.210a	18.60a	20.72a
Nov. 24- Dec. 21, 2014						
RR N +PK/ha	28.93a	86.00a	1.37a	0.290a	18.77a	25.35a
RR N +PK/ha + 5t SW	30.39a	88.00a	1.38a	0.290a	17.47a	26.27a
½ RRN +PK/ha+ 5t SW+10t KL	30.14a	96.00a	1.44a	0.287a	18.63a	29.46a
¼ RRN + PK/ha+ 5t SW+ 10t KL	32.17a	94.00a	1.5a	0.323a	18.30a	29.85a
5t SW+ 10t KL	31.39a	84.67a	1.45a	0.323a	19.66a	27.86a
Control-No fertilizer	30.55a	86.67a	1.43a	0.310a	19.36a	25.28a
Sept. 29-Oct. 28, 2015						
RR N +PK/ha	29.26a	48.00ab	1.43a	0.267a	18.77a	13,61ab
RR N +PK/ha + 5t SW	27.87a	40.00b	1.42a	0.260a	17.47a	12.06ab
½ RRN +PK/ha+ 5t SW+10t KL	29.90a	33.00b	1.5a	0.257a	18.63a	9.10b
¼ RRN + PK/ha+ 5t SW+ 10t KL	27.57a	60.56a	1.53a	0.266a	18.30a	12.77ab
5t SW + 10t KL	27.92a	46.00ab	1.53a	0.277al	19.66a	16.23a
Control-No fertilizer	26.32a	39.53b	1.44a	0.267a	19.36a	10.66b
August Sept. 28, 2016						
RR N +PK/ha	35.11ab	60.00ab	1.46a	0.333ab	20.45a	19.55ab
RR N +PK/ha + 5t silk waste	35.61a	70.67ab	1.49a	0.340ab	21.44a	22.39ab
½ RRN +PK/ha+ 5t SW+10t KL	35.85ba	62.67ab	1.54a	0.337ab	20.46a	20.58ab
¼ RRN + PK/ha+ 5t SW+ 10t KL	37.53a	58.67ab	1.59a	0.343a	21.07a	19.56ab
5t SW + 10t KL	34.62ab	73.00a	1.65a	0.330ab	20.15a	24.01a
Control-No fertilizer	31.78b	53.67b	1.53a	0.313a	21.80a	16.90b
August 30- Sept. 28, 2017						
RR N +PK/ha	27.17b	74.67a-c	1.46a	0.287b	19.74a	21.38abc
RR N +PK/ha + 5t silk waste	29.54ab	64.00 bc	1.52a	0.307fab	19.62a	19.81bc
½ RRN +PK/ha+ 5t SW+10t KL	27.26ab	90.67a	1.47a	0.300ab	20.57a	26.41a
¼ RRN + PK/ha+ 5t SW+ 10t KL	30.74a	66.33bc	1.45a	0.323a	20.93a	20.36bc
5t SW+ 10t KL	28.64ab	60.67ab	1.57a	0.320a	20.69a	25.00ab
Control-No fertilizer	28.60ab	57.67c	1.44a	0.317a	20.79a	16.23c
Nov. 15- Dec 23, 2017						
RR N +PK/ha	30.70a	91.33a	1.44a	0.310a	20.04a	29.54ab
RR N +PK/ha + 5t SW	29.97a	94.67a	1.50a	0.320a	19.24a	31.49a
½ RRN +PK/ha+ 5t SW+10t KL	29.47a	85.00a	1.41a	0.337a	20.29a	28.25ab
¼ RRN + PK/ha+ 5t SW+ 10t KL	27.87a	91.00a	1.43a	0.317a	19.56a	29.50ab
5t silk waste + 10t KL	28.77a	96.00a	1.54a	0.320a	19.66a	31.28a
Control-No fertilizer	28.70a	94.00a	1.44a	0.313a	20.00a	25.47b
Significance	**	**	ns	*	ns	**
CV (%)	4.62	12.92	5.06	3.83	4.53	10.67

In a column, means followed by the same letter are not significantly different at 5% level, HSD.

Cost-Return of Producing Cocoons in Different Fertilizer Management Approaches

Total cocoon production was highest in plants applied with 5 tons SW and 10 tons KL, followed by plants applied with 100-50-50kg NPK + 5 tons SW and 10 tons KL due to higher cocoon yield per box.

Gross Income, Expenses, Net Income of Producing Cocoons in Different Fertilizer Management Approaches

Gross income was highest in plants applied with 5 tons SW and 10 tons KL followed by plants applied with½ RRN + PK/ha+ 5 tons SW + 10 tons KL, and ¼ RRN + PK/ha+ 5 tons SW + 10 tons KL due to higher mulberry and cocoon yields. The lowest was recorded in plants with no fertilizer application (Table 7).

Plants applied with 5 tons SW + 10 tons KL, ¼ RRN + PK/ha + 5 tons and ½ RR N + PK/ha + 5 tons SW + 10 tons KL had net incomes of 16,903.53, 16,403.82, 12,856.53 pesos respectively. Net incomes were higher by 10,757.18, 10,257.47 and 6,710.18 pesos over the control in the same treatments respectively.

Table 7. Gross income, expenses, and net income of producing cocoons in different fertilizer management approaches.

Fertilizer Management Approaches	Gross Income in Pesos	Expenses in Pesos	Net Income in Pesos	ROI (%)
RR N +PK/ha	47,434.00	45,895.12	1557.81	3.39
RR N +PK/ha + 5t silk waste	40,050.00	46,617.42	-6567.62	-14.09
½ RRN +PK/ha+ 5t SW+10t KL	56,266.00	43,423.92	12856.53	29.61
¼ RRN + PK/ha+ 5t SW+ 10t KL	55,358.00	39,963.06	16403.82	41.06
5t SW + 10t KL	59,048.00	42122.37	16903.53	40.13
Control-No fertilizer	25,934.00	19739.55	6146.35	31.12

Return on Investment was recorded high in plants applied with 5 tons SW + 10 tons KL, and ¼ RRN + PK/ha+ 5 tons SW +10 tons KL with 40.13 and 41.06, respectively.

Conclusions

The number of branches, number and weight of leaves, and biomass yields of mulberry were not significantly influenced by the different fertilizer strategies. Average single leaf weight was comparable in all fertilizer treatments and implies that the application of fertilizers whether organic and inorganic increased the average single leaf weight of plants.

More branches were observed during early rehabilitation stage particularly during the months of May-July and September-November 2014 growing season than in later years (2015 to 2017 growing season). More and heavier leaves, average single leaf, total biomass yields were significantly higher in plants grown during May - July 2014 growing season compared to the rest of the treatments.

During the May-July 2014 growing season, plants applied with ½ RRN +PK/ha+5 tons SW + 10 tons KL had significantly more and heavier leaves and biomass. Heavier leaves and biomass were recorded in fertilized treatments in Sept –November 2014 growing season

During the July-September 2015 growing season, average single leaf weight was comparable in plants fertilized with RRN +PK and ½ RRN +PK + 5t SW +10tKL while in June –August 2016 growing season, plants in fertilized treatments had higher biomass yield due to more branches and leaves.

Plants applied with RRN + PK/ha + 5 tons SW, ¼ to ½ RRN +PK + 5 tons SW + 10 tons KL and 5 tons SW + 10 tons KL alone had comparable number of branches and leaves during the April-June 2017 growing season. During the September- November 2017 growing season, plants applied with ¼ RRN + PK/ha+5 tons SW + 10 tons KL, 5t SW + 10 tons KL had comparable number of branches with RRN + PK/ha and RRN + PK ha + 5 tons SW. Plants applied with 5 tons SW + 10 tons KL and RRN+ PK/ha had comparable biomass yield.

Regardless of seasons, the growth and cocoon yield of silkworms were not significantly affected by the different fertilizer treatments. Silkworm raised during the August-September 2014 rearing season significantly produced the heaviest mature larvae. Higher effective rearing rates were recorded in silkworms fed during the months of July-August and November-December 2014 rearing seasons. Single cocoon weight was significantly heaviest in silkworms fed during the months of August-September 2016 and November-December 2017 rearing season.

Single shell weight was significantly heaviest in silkworm reared during the August-September 2016 rearing season. Cocoon yield was significantly highest in silkworm fed during the November-December 2017 rearing season followed by November-December 2014 rearing season. The lightest was recorded in August-September 2016 and July-August 2016 rearing season.

The weight of ten matured larvae, effective rearing rate, single shell weight and cocoon yield per box were not significantly influenced by fertilizer management approaches during the 2014 rearing season. During the September-October 2015 rearing season, effective rearing rate was comparable in silkworms fed with leaves applied with ¼ RRN + PK + 5 tons SW + 10 tons KL, 5 tons SW + 10 tons KL and RRN + PK, while cocoon yield per box was comparable in silkworms fed with leaves in fertilized plants, except with plants fertilized with ½ RRN + PK + 5 tons SW. The same trend was observed during the September-October 2016 rearing season. Cocoon yield was significantly heavier in silkworms fed with leaves applied with fertilizers during the November-December 2017 rearing season.

Net incomes were higher by 10,757.18, 10,257.47 and 6,710.18 pesos over the control treatment while Return on Investment (ROI) was recorded high in plants applied with 5 tons SW + 10 tons KL, ¼ RRN + PK/ha + 5 tons SW + 10 tons KL with 40.13 and 41.06 percent, respectively.

Conflict of interest statement

The authors declare that there is no conflict of interest in the conduct of the study.

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