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Integrated Effect of FYM and Potassium Humate on Mulberry Leaves and Bioassay of Silkworm in Acid Soils of Kalimpong Hills

R. L. Ram[1*], S. Chatterjee[1], C. Maji[1], P. K. Sharma[2] and Y. V. Singh[2]

[1]Regional Sericultural Research Station, Central Silk Board, Kalimpong, West Bengal (734 301), India
[2]Dept. of Soil Science and Agricultural Chemistry, IAS, Banaras Hindu University, Varanasi, U.P. (221 005), India

Corresponding Author

R. L. Ram
e-mail: ramlakhanram08@gmail.com

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Abstract

A field experiment was conducted during 2014–16 at Regional Sericultural Research Station farm in Kalimpong hills, West Bengal with six treatments and four replications to study the integrated effect of FYM and potassium humate (KH) on growth attribute characters, leaf yield and quality of existing BC_259 (*Morus alba* L.) mulberry variety. This experiment was also extended to check its adverse effect on bioassay of SK6×SK7 (*Bombyx mori* L.) silkworm. Based on data analyzed, it was found that, the highest annual leaf yield 14.97 mt ha^{-1} was recorded after the application of FYM @ 10 mt+KH @ 25 kg+NPK @ 150:50:50 kg ha^{-1}, however, only 12.00 mt ha^{-1} leaf yield was recorded in control after the application of FYM @ 10 mt ha^{-1}+NPK @ 150:50:50 kg ha^{-1}. The total leaf yield gain in above treatment was 24.74% higher than control. The nutritional quality like moisture content 76.78%, total chlorophyll 1.77 mg g^{-1}, total soluble protein 24.78 mg g^{-1}, total soluble sugar 36.23 mg g^{-1}, total carbon 43.77%, total ash 12.46%, total N 3.58%, total P 0.35% and crude protein 22.40% were also recorded as higher side over control. Bioassay of silkworm reveals that, the mulberry leaves of above treatment have significant result on single cocoon weight, cocoon yield 100 $dfls^{-1}$ and shell% respectively. The higher cost benefit ratio was also recorded as 1:1.92% with net profit ₹ 1.69 Lakhs ha^{-1} $year^{-1}$ after the application of above treatment than control.

Keywords: FYM, potassium humate, mulberry, bioassay, silkworm

1. Introduction

Kalimpong hills, an extension of sub-Himalayan region are sericulture hub and well known for production of bivoltine silkworm cocoons. Soils of this region have potential with high organic carbon content and available nitrogen, but, shallow to moderately deep soil depth, light textured soil, steep sloping, severe erosion, terrace farming, low temperature, heavy rainfall, leaching of bases, low nutrients uptake, rainfed cultivation and soil acidity are major constraints to achieve the targeted yield of mulberry leaves in a sustainable manner (Ram et al., 2016; 2015).

Mulberry (*Morus* spp.) a silkworm host plant is economically and traditionally very important plant for the development of sericulture industry. The mulberry leaves are basic food material for silkworm *Bombyx mori* L. and nutritious leaves are the most important growth regulating factors for above silkworm. Being a monophagous insect, it derives almost all the nutrients essential for its growth from the mulberry leaf itself. Bulk of the silk produced in the world by the mulberry silkworm is directly derived from protein of mulberry leaves; hence, silkworm should be feed with good quality of mulberry leaves in abundant quantity for the successful cocoon production.

For production and productivity of quality mulberry leaves by sustaining the fertility status of soils, integrated nutrient management is an effective array in the arsenal of planners and stake holders. Farmyard Manure (FYM) made with cow dung plays a major key role in this regard, but, the availability of good quality of FYM in this region is a challenging task, hence, it is essential to boost or to improve the quality of FYM. Potassium humate (KH) was used to improve the quality of FYM.

Potassium humate is a highly concentrated form of humus in the naturally from lignite brown coal, alkaline, rich in carboxylic and phenolic groups, aromatic in nature and provides favourable conditions for physical improvement, chemical reactions and biological activity of soil. The higher solubility of the KH facilitates a complete fusion with other soluble fertilizers (e.g. Fe, Al, Mn and Zn) in acid soils which is vital to reduce the lockup rate of soluble phosphate sources. KH is easily available in the market in humate powder and crystal form and more popular as foliar and soil application.

The significant effect of KH to enhance the growth attributing characters, yield and quality of various crops have also been reported by various workers across the globe (Kumar et al., (2014); Prakash et al. (2013, 2011a, 2011b, 2010); Ahmed et al. (2013); Arancon et al., 2002); Chen and Aviad (1990).

2. Materials and Methods

2.1. Experimental site and climate

The experiment was conducted during 2014–16 at Regional Seri cultural Research Station (RSRS) farm in Kalimpong hills, Darjeeling district, West Bengal. The experimental area lies between 26°31′ to 27°13′ N latitude and 87°59′ to 88°53′ E longitude and situated at 3550 feet (1076 m) above mean sea level. Sandstone, quartzite and mica are the major geologic formation in this area which acts as parent materials for the formation of the soil. River Teesta and its tributaries are main water bodies.

The climate is subtropical type (Sub-Himalayan region) with hot dry summers and cold winters. The mean maximum temperature during the hottest months (March to June) in the year 2011–15 was about 27.7 °C, while the mean minimum temperature in the coldest months (December to February) in same years was as low as 9.9 °C. The mean annual temperature was 21.2 °C. The onset period of monsoon was in the second week of June. The mean annual rainfall was 1870.2 mm, four-fifth of which was received during June to September and remaining one-fifth in October to May. The temperature curve and obmrothermic diagram is given in Figure 1 and Figure 2.

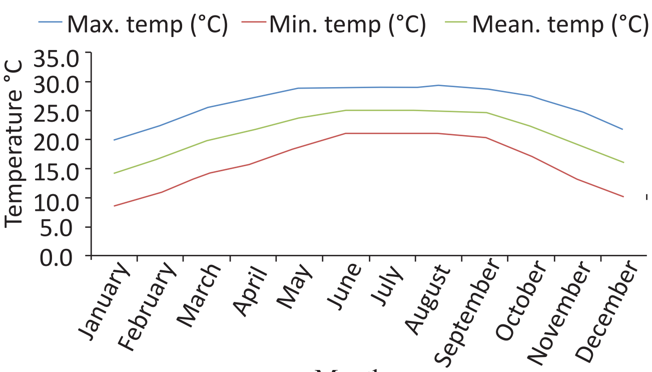

Figure 1: Temperature curves (2011–2015)

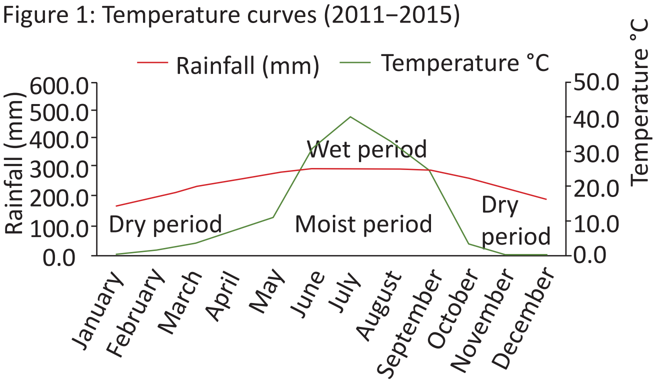

Figure 2: Ombrothermic diagram (2011–2015)

2.2. Treatment combination

The experiment was conducted for two years during 2014–16 with six management practices, viz., T_1: FYM @ 10 mt ha^{-1}+NPK @ 150:50:50 kg ha^{-1}; T_2: FYM @ 10 mt ha^{-1}+KH @ 25 kg ha^{-1} +NPK @ 150:50:50 kg ha^{-1}; T_3: FYM @ 7.5 mt ha^{-1}+ KH @2 5 kg ha^{-1}+ NPK @ 150:50:50 kg ha^{-1}; T_4: FYM @ 5 mt ha^{-1}+KH @ 25 kg ha^{-1}+ NPK @ 150:50:50 kg ha^{-1}; T_5: FYM @ 20 mt ha^{-1}+KH @ 25 kg ha^{-1}; T_6: FYM @ 10 mt ha^{-1}+KH @ 25 kg ha^{-1} respectively.

2.3. Mulberry *variety and silkworm races*

The experiment was conducted in the existing $BC_2$59 (*Morus Alba* L.) mulberry variety. The plantation was about 25 years old. The variety was developed by back cross technique by earlier researchers and it is most suitable under the climatic conditions of the Kalimpong hills. The branches of this variety are semi-erect, medium in number, with moderate growth, whereas, the leaves are smooth, unlobed, glossy and thick (Dandin and Giridhar, 2010). Silkworm rearing was conducted only at RSRS farm and bivoltine mulberry silkworm races SK6×SK7 (*Bombyx mori* L.) was chosen for this purpose.

2.4. Nature of manures, KH and fertilizers applied

Integrated application FYM, KH and mineral fertilizers were applied as the treatment plan. Cow dung was the only source of FYM, whereas, KH, a byproduct of lignite coal with 85%–90% water solubility containing around 80% humic acid and 12%–15% potassium was applied. Likewise, nitrogen was applied through urea (46% N), phosphorus through single superphosphate (18% P_2O_5), and potash through muriate of potash (60% K_2O). The treatments were distributed in a randomized complete block design (RCBD) with four replications in different terrace of fixed plot size.

2.5. Soil *and plant analysis*

Soil samples were collected, dried, sieved and analyzed by adopting the standard procedure (Black, 1985; Jackson, 1979). The processed soil samples were analyzed by following the standard procedures e.g. soil pH (1:2.5 soil: water suspension); easily oxidizable $K_2Cr_2O^7$+H_2SO^4 organic C (Walkley and Black, 1934); alkaline $KMNO_4$ oxidizable N (Subbiah and Asija, 1956); 0.025 N HCl+0.03 N NH4F extractable P (Bray and Kurtz, 1945) and available K (1N NH4OAc exchangeable K) respectively. Likewise, processed mulberry leaves were analyzed by following the standard procedure e.g. leaf moisture (Hot oven drying method), total chlorophyll (Arnon, 1949); total soluble protein (Lowry et al., 1951); and total soluble sugar (Morris, 1948) respectively. The statistical analysis was done by using SPSS 16.0 and Microsoft Excel, 2007 software.

3. Results and Discussion

3.1. Morpho-physico-chemical properties of soils

Soils of experimental site are shallow to very deep in depth; dark yellowish brown (10 YR 4/4) to brown (10 YR 5/4 and 6/4) in colour; sandy loam to sandy clay loam texture; single grain to fine, medium, subangular blocky structure; dry semi hard, moist very friable to friable, wet slightly sticky to sticky and wet slightly plastic consistency; very fine to fine, few too many pores and clear to gradual smooth to wavy horizon boundary. Chemical properties of the soils under this study are given in Table 1.

Table 1: Chemical properties of the soils

Sl. No.	Soil parameters	Nutrient status
1.	pH (1:2.5)	5.48
2.	EC (dSm^{-1})	0.12
3.	Organic C (%)	1.22
4.	Available N (kg ha^{-1})	490.6
5.	Available P (kg ha^{-1})	22.7
6.	Available K (kg ha^{-1})	160.5
7.	Available S (kg ha^{-1})	13.1

The morpho-physical properties were analyzed following the procedure of Soil Survey Manual (1970) and Soil Survey Staff (2006; 1998). The variation of colour was due to prevalence of well drained conditions, admixture of organic matter (Ram et al., 2015; Swarnam et al., 2004; Rao et al., 2008) whereas, the variation in soil texture was caused by slope, terrace and translocation of clay in lower horizons (Nayak et al., 2002). The variation in soil structure and consistency was due to variation in clay content of pedons (Rao et al., 2008; Singh and Agrawal 2003). Findings of various workers in the soils of Darjeeling hills under various land use also correlates with our findins (Ray and Mukhopadhyay, 2012; Singh et al., 2011).

3.2. Effect of FYM and KH on growth and yield characteristics of mulberry leaves

Based on the data analyzed, it has been observed that, the effect of KH on growth attributes characters and leaf yield of mulberry was significant in both autumn and spring season. Maximum height of shoot, number of leaves $shoot^{-1}$, and leaf yield was observed in T_2 followed by T_3 and T_5 over the control. While observing the effect of season (S)×Treatment (T), it was observed that, the higher leaf yield was recorded in spring than autumn. In autumn season, maximum leaf yield 6.88 mt ha^{-1} was recorded in T_2 treatment combination followed by 6.75 mt ha^{-1} in T_3 and 6.42 mt ha^{-1} in T_5 respectively. Likewise, in spring season, maximum leaf yield 8.09 mt ha^{-1} was in T_2 treatment combination followed by 7.90 mt ha^{-1} in T_3 and 7.75 mt ha^{-1} in T_5 respectively. The effect of FYM and KH on season wise growth attributes characters and leaf yield of mulberry at RSRS farm is given in Table 2.

Table 2: Effect of FYM and KH on season wise growth attributes characters and leaf yield of mulberry at RSRS farm

	Autumn, 2014					Spring, 2015				
Treat-ment	No. of shoots $plant^{-1}$	Height of single shoot (cm)	No.of leaves $shoot^{-1}$	Total leaves $plant^{-1}$	Leaf yield (mt ha^{-1})	No.of shoots $plant^{-1}$	Height of single shoot (cm)	No.of leaves $shoot^{-1}$	Total leaves $plant^{-1}$	Leaf yield (mt ha^{-1})
T_1	10.35	95.44	17.25	178.62	5.76	10.65	101.01	18.35	195.37	6.25
T_2	10.25	108.49	20.60	211.27	6.88	10.80	113.74	22.15	239.23	8.09
T_3	10.30	105.07	19.90	204.97	6.75	10.90	111.53	21.75	237.05	7.90
T_4	10.35	91.99	15.85	164.25	5.42	10.75	96.94	17.05	183.19	5.61
T_5	10.50	103.10	19.05	200.00	6.42	11.00	110.67	21.50	236.49	7.75
T_6	10.15	92.25	16.65	168.99	5.32	10.55	97.15	17.15	180.92	5.55
SEm±	0.12	0.364	0.134	2.805	0.075	0.042	0.157	0.052	0.552	0.040
CD (p=0.05)	NS	2.404	0.671	14.308	0.452	NS	2.186	0.547	9.954	0.292

While analyzing the total leaf yield $annum^{-1}$, highest leaf yield 14.97 mt ha^{-1} was recorded in T_2 followed by 14.66 mt ha^{-1} in T_3 and 14.17 mt ha^{-1} in T_5 treatment combination, whereas lowest leaf yield was 5.32 mt ha^{-1} in T_6 treatment combination. The total leaf yield 12.00 mt ha^{-1} $annum^{-1}$ was recorded in control. The total leaf yield gain over control was 24.74% in T_2, 22.13% in T_3 and 18.09% in T_5 treatment respectively. Effect of FYM and KH on annual growth attributes characters and total leaf yield of mulberry at RSRS, farm are given in Table 3.

It is well known fact that, the growth attributing characters and yield of mulberry is highly influenced by the nutrients available in the soil. KH facilitates the solubility rate of both primary and secondary nutrients in acid soils, which directly affects the yield and quality of any crops. The significant effect of KH to enhance the growth attributing characters, yield and quality of various crops have also been reported by various workers across the globe (Dileep Kumar et al. (2014); Ahmed et al. (2013); Arancon et al., 2002); Chen and Aviad (1990). Findings of the Shujrah et al. (2010) also correlate with this report. He has reported a significant effect of KH on physico-chemical characteristics in rice growing field of acid soils in Alor Kedah. Albert et al. (2005) also demonstrated that the application of KH is potentially effective as a soil conditioner in improving aggregate stability of acidic soils.

Table 3: Effect of FYM and KH on annual growth attributes characters and total leaf yield of mulberry at RSRS farm

Treatment	TSPY	TLSPY	TLTSY	TLPY	TLYY	TLYG
T_1	21.00	196.45	35.60	373.99	12.00	0.00
T_2	21.05	222.23	42.75	450.50	14.97	24.74
T_3	21.20	216.60	41.65	442.02	14.66	22.13
T_4	21.10	188.93	32.90	347.44	11.03	-8.09
T_5	21.50	213.76	40.55	436.49	14.17	18.09
T_6	20.70	189.40	33.80	349.91	10.87	-9.40
SEm±	0.125	0.345	0.149	2.724	0.094	2.540
CD (*p*=0.05)	NS	3.564	0.888	16.749	0.557	5.15

TSPY: Total shoots plant^{-1} year^{-1}; TLSPY: Total length of shoots plant^{-1} year^{-1} (cm); TLTSY: Total leaves two shoots^{-1} year^{-1}; TLPY: Total leaves plant^{-1} year^{-1}; TLYY: Total leaf yield year^{-1} (mt ha^{-1}); TLYG: Total leaf yield gain (%)

After the application of KH with RD of FYM, highest leaf yield gain in mulberry were also correlates with the findings of Prakash et al. (2013, 2011, 2010) in mulberry. Patil et al. (2011) obtained significant result in growth attributing characters and yield of wheat, soybean and black gram after the application of KH with other nutrients.

3.3. *Effect of FYM and KH on nutritious quality of mulberry leaves*

Analysis of nutritional quality of the mulberry leaves also revealed that the T_2 treatment combination was found high significant result on leaf moisture content, total chlorophyll, total soluble protein, total soluble sugar, total dry matter, total ash, total nitrogen, crude protein and total phosphorus in inorganic mulberry farming, whereas, it was highly significant in T_5 treatment in organic mulberry farming. Effect of FYM and KH on moisture content and other nutritious quality of mulberry leaves are given in Table 4.

Leaf moisture, total chlorophyll content and other biochemical parameters indicated above play key role in the silkworm rearing. KH in combination with FYM or other organic manures and inorganic fertilizers enhanced the overall metabolism of various crops (Kui Zeng, 2002), humic acid improved the plant growth and productivity of beans (El-Bassiony et al., 2010); okra (Mustafa et al., 2010) and seedling, fresh and dry leaf weight of root, shoot and stem of pepper (Fusun et al., 2010). The integrated effect of organic manures and vermicompost have increased the nutritional quality of mulberry variety S-1635 have also reported by Chowdhury et al. (2013).

Table 4: Effect of FYM and KH on nutritious quality of mulberry leaves

Treat-ment	Moisture (%)	Fresh weight (mg g^{-1})			Dry weight (%)				
		Total chlorophyll	Total soluble protein	Total soluble sugar	Total carbon (%)	Total ash (%)	Total nitrogen	Crude protein	Total phosphorus
T_1	74.79	1.29	19.88	30.09	43.29	13.43	3.11	19.43	0.26
T_2	76.78	1.77	24.78	36.23	43.77	12.46	3.58	22.40	0.35
T_3	75.53	1.69	23.40	35.56	43.33	13.34	3.42	21.39	0.33
T_4	72.83	1.34	20.20	34.27	42.73	14.55	3.09	19.32	0.26
T_5	75.67	1.61	23.30	34.34	43.68	12.65	3.33	20.78	0.33
T_6	72.63	1.33	20.60	29.40	43.07	13.85	2.85	17.83	0.26
SEm±	0.17	0.02	0.16	0.19	0.38	0.76	0.06	0.37	0.01
CD (*p*=0.05)	0.855	0.060	1.10	0.620	0.354	0.708	0.313	1.954	0.018

Shankar (1990) reported that the unbalanced nutrient management or deficiency of essential nutrients in the soil has been found to cause nutritional, anatomical and histological disorders in mulberry, however, Krishna and Bongale, (2001) opined that, unbalanced nutrient management have adverse effect on crop productivity and nutrients availability. Modern concept of soil health management is to apply the plant nutrients in an integrated manner to achieve the targeted yield with maintaining soil health at benchmark level. Hence, several workers have conducted the research in this regard. Umesha and Sannappa (2014) reported that, INM of FYM with other treatment combination enhanced the bio-chemical and mineral nutrients of mulberry leaves. Similar findings have also been reported by various workers (Ting-Xing et al., 1980; Ray et al. (1973).

3.4. *Correlation between total leaf yield, growth attributing characters and nutritive values of mulberry leaves*

A correlation matrix also showed significant correlations (*p*=0.05) between leaf yield, growth attributing characters and nutritive values of mulberry leaves except total shoots plant^{-1}, total soluble sugar and total carbon. This matrix indicates that the total shoots plants^{-1} and total carbon in the dry mulberry leaves have negligible role in the yield and quality of mulberry leaves. Correlation between total leaf yields, growth attributing characters and nutritive values of mulberry leaves are given in Table 5.

3.5. *Effect of FYM and KH on season wise bioassay of silkworm*

Effect of FYM and KH on season wise bioassay of silkworm at RSRS farm revealed that the, weight of ten matured larvae and ERR number of ten thousand matured larvae were non-significant, however, single cocoon, single shell and shell percent and yield 100 dfls^{-1} were found significant. While analyzing the data of silkworm rearing, it was found that the total cocoon yield in spring season was slightly higher than autumn. Highest cocoon yield 61.75 kg 100 dfls^{-1} were recorded in T_2 treatment and lowest cocoon yield 58.22 kg 100 dfls^{-1} in T_6 in autumn season. Likewise, in spring season, highest cocoon yield was 63.18 kg 100 dfls^{-1} in T_2 treatment and lowest cocoon yield 59.80 kg 100 dfls^{-1} in T_6 treatment. Effect of KH on season wise bioassay of silkworm is given in Table 6.

Table 5: Correlation between total leaf yield, growth attributing characters and nutritive values of mulberry leaves

	TLY	TS	TSL	TL	TLP	TM	TCH	TSP	TSS	TC	TA	TN	TCP	TP
TLY	1.000	0.609	0.997**	0.995**	0.998**	0.945**	0.954**	0.939**	0.760	0.847*	-0.846*	0.947**	0.946**	0.973**
TS		1.000	0.565	0.547	0.618	0.547	0.506	0.482	0.633	0.446	-0.439	0.596	0.587	0.582
TSL			1.000	0.998**	0.996**	0.948**	0.964**	0.957**	0.751	0.869*	-0.869*	0.945**	0.945**	0.982**
TL				1.000	0.996**	0.941**	0.957**	0.951**	0.715	0.874*	-0.874*	0.923**	0.923**	0.975**
TLP					1.000	0.939**	0.952**	0.944**	0.736	0.868*	-0.868*	0.927**	0.926**	0.977**
TM						1.000	0.839*	0.839*	0.628	0.911*	-0.909*	0.925**	0.923**	0.883*
TCH							1.000	0.990**	0.836*	0.759	-0.760	0.920**	0.921**	0.989**
TSP								1.000	0.786	0.811	-0.813*	0.890*	0.891*	0.990**
TSS									1.000	0.400	-0.398	0.870*	0.871*	0.803
TC										1.000	-1.000**	0.742	0.738	0.831**
TA											1.000	-0.739	-0.736	-0.832*
TN												1.000	1.000**	0.923**
TCP													1.000	0.922*
TP														1.000

**: Correlation is significant at the p=0.01 level (2-tailed); *: Correlation is significant at the p=0.05 level (2-tailed); TLY: Total leaf yield; TS: Total shoots; TSL: Total length of shoots; TL: Total leaves; TLP: Total leaves plant^{-1}; TM: Total moisture; TCH: Total chlorophyll; TSP: Total soluble protein; TSS: Total soluble sugar; TC: Total carbon; TA: Total ash; TN: Total nitrogen; TCP: Total crude protein; TP: Total phosphorus

While analyzing the combined mean of total cocoon yield 100 dfls^{-1} in autumn and spring season, the highest cocoon yield was 62.47 kg 100 dfls^{-1} and lowest cocoon yield was 59.01 kg 100 dfls^{-1}. Annual bioassay mean of silkworm rearing is given in Table 7. Silkworm growth and quality cocoon production dependent on nutritious mulberry leaves, however, yield and quality of mulberry leaves dependent on nutrient management and agronomic practices. According to Sannappa et al., (2005); Raje (1996) application of organic fertilizers to mulberry had a significant influence on cocoon yield, shell ratio, silk productivity and single cocoon filament length. Singhal et al. (1999) opined that quality of mulberry leaf fed to silkworms is the most important factor that influences successful cocoon production by mulberry silkworm.

3.6. *Cost benefit ratio (₹)*

The economic gain or cost benefit ratio is the difference of total input and output cost of a produce. In the case of mulberry, sale of seed cocoon is the cost of output and this output is directly related with the leaf: cocoon ratio, total mulberry leaf yield and total cocoon production. In this case, the economic gain or cost benefit ratio was analyzed based on the total mulberry leaf (mt ha^{-1} year^{-1}) and silkworm cocoon yield (kg ha^{-1} year^{-1}) at RSRS farm (Table 3 and Table 7). Though, this zone has been declared as bivoltine seed zone by Department of Textiles (Sericulture), Government of West Bengal. The concerned authority directly purchased the good seed cocoons from the sericulture farmers at the rate of ₹ 500 kg^{-1} onwards, hence, this is also one of the reasons for handsome return. Due to higher leaf yield (14.97 mt ha^{-1} year^{-1}) with 24.74% leaf yield gain and economic consumption of mulberry leaves (Leaf: Cocoon ratio=21.15:1) for production of one kg cocoon favours the high economic gain (1:1.92%) with T_2 treatment. Based on critical analysis of net benefit ratio, it was found that, the net benefit ₹ 1.69 lakhs ha^{-1} year^{-1} was recorded with T_2 against the total input cost ₹ 1.85 lakhs and output cost ₹ 3.54 lakhs ha^{-1} year^{-1}. The cost benefit ratio is given in Table 8.

Table 6: Effect of FYM and KH on season wise bioassay of silkworm

Treatment	Autumn, 2014							Spring, 2015						
	WTML	ERR 10000 larvae^{-1}		Y	WSC	WSS	Shell (%)	WTML	ERR 10000 larvae^{-1}		Y	WSC	WSS	Shell (%)
		No.	Wt.						No.	Wt.				
T_1	39.48	8617	14.67	58.67	1.702	0.290	17.32	39.55	8758	15.30	61.22	1.747	0.304	17.40
T_2	40.00	8850	15.44	61.75	1.744	0.315	18.18	40.06	8933	15.79	63.18	1.768	0.322	18.19
T_3	39.60	8692	14.96	59.83	1.721	0.301	17.70	39.56	8775	15.43	61.73	1.759	0.315	17.90
T_4	38.87	8600	14.54	58.17	1.691	0.291	17.37	39.14	8908	15.30	61.21	1.718	0.299	17.38
T_5	39.71	8675	14.95	59.81	1.724	0.301	17.65	39.80	8700	15.23	60.91	1.750	0.313	17.86
T_6	38.89	8567	14.56	58.22	1.699	0.289	17.15	38.89	8633	14.95	59.80	1.732	0.297	17.12
SEm±	0.046	14.873	0.096	0.385	0.009	0.001	0.081	0.067	34.124	0.069	0.278	0.003	0.002	0.055
CD*	0.525	105.470	0.278	1.111	0.017	0.005	0.332	0.384	130.917	0.310	1.241	0.014	0.004	0.285

WTML: Weight of ten matured larvae (g); ERR: ERR: Effective rate of rearing; Y: Yield 100 dfls^{-1} (kg); WSC: Weight of single cocoon (g); WSS: Weight of single shell (g); CD*: CD (p=0.05)

Table 7: Annual bioassay mean of silkworm rearing

Treatment	Weight (g)	Yield 10000 larvae^{-1}		Yield (kg)	Weight (g)		Shell (%)
	Ten matured larvae	ERR (No.)	ERR (Wt.)	100 dfls	Single cocoon	Single shell	
T_1	39.52	8688	14.99	59.95	1.725	0.297	17.36
T_2	40.03	8892	15.62	62.47	1.756	0.319	18.19
T_3	39.58	8734	15.20	60.78	1.740	0.308	17.80
T_4	39.01	8754	14.92	59.69	1.705	0.295	17.38
T_5	39.76	8688	15.09	60.36	1.737	0.307	17.76
T_6	38.89	8600	14.76	59.01	1.716	0.293	17.14
SEm±	0.057	24.499	0.083	0.332	0.006	0.002	0.068
CD (p=0.05)	0.455	118.194	0.294	1.176	0.016	0.005	0.309

Table 8: Cost benefit ratio* (Lakh ₹)

Treatment	Mulberry		Silkworm rearing		Total cost (₹)	Total leaf yield (mt ha^{-1} year^{-1})	Total cocoon yield 100 dfls^{-1}	Total cocoon yield (kg ha^{-1} year^{-1})	Leaf co-coon ratio	Cost of sale of cocoon (₹ 500 kg^{-1})	Net profit (₹)	Cost: benefit ratio (%)
	Input cost year^{-1} (₹)	Labour cost year^{-1} (₹)	Input and deprecia-tion cost year^{-1} (₹)	Labour cost year^{-1} (₹)								
T_1	0.25	0.30	0.20	0.89	1.64	12.00	59.95	564.4	21.27	2.82	1.18	1:1.71
T_2	0.27	0.30	0.20	1.07	1.85	14.97	62.47	707.8	21.15	3.54	1.69	1:1.92
T_3	0.24	0.30	0.20	1.08	1.81	14.66	60.78	691.6	21.19	3.46	1.65	1:1.91
T_4	0.20	0.29	0.20	0.81	1.50	11.03	59.69	511.1	21.58	2.56	1.05	1:1.70
T_5	0.34	0.32	0.20	1.04	1.91	14.17	60.36	665.7	21.29	3.33	1.42	1:1.74
T_6	0.21	0.29	0.20	0.81	1.51	10.87	59.01	507.2	21.44	2.54	1.03	1:1.68

*Labour cost: ₹ 169.00 manday-1; FYM: ₹ 1350.00 mt^{-1}; pressmud: ₹ 5500.00 mt^{-1}; Dolomite: ₹ 3000.00 mt^{-1}; Urea: ₹ 700.00 q^{-1}; SSP: ₹ 1000.00 q^{-1}; MOP: 19.00 q^{-1}; Cost of seed cocoon: ₹ 500.00 kg^{-1}

4. Conclusion

The application of FYM @ 10 mt ha^{-1} +KH@25 kg ha^{-1}+ NPK @ 150:50:50 kg ha^{-1} for inorganic and FYM @ 20 mt ha^{-1} +KH @ 25 kg ha^{-1} for organic mulberry farming have significant effect on season and year wise growth attributes characters, leaf yield and nutritional quality of mulberry variety $BC_2$59. The bioassay of treated mulberry leaves was also found significant result in same treatment combination. While analyzing the cost benefit ratio, it was found that the net profit upto ₹ 1.69 lakhs ha^{-1} $year^{-1}$ may also be obtained with same treatment against the total input cost as reported above.

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