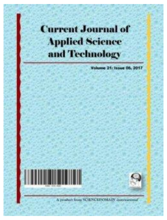

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Integrated Effect of Mixed Cake and Farm Yard Manure on Mulberry Sericulture in Acid Soils of Kalimpong Hills

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Authors' contributions

This work was carried out in collaboration between all the authors. Author RLR designed the study, performed the statistical analysis, wrote the protocol and drafted the manuscript. Author CM was project coordinator and author KT was executive authority. Author RPS managed the statistical analysis and review literature of the study. All authors read and approved the final manuscript.

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ABSTRACT

A pilot study was conducted during 2013-16 at Regional Sericultural Research Station, Kalimpong, West Bengal research farm with five treatments and four replications to study the integrated effect of mixed cake and FYM on existing mulberry variety BC_259 (*Morus alba* L.). This study was also extended to check its adverse effect on silkworm rearing of SK6×SK7 silkworm (*Bombyx mori* L.). The mixed cake was applied through 'Spic Surabhi'. The main ingredient in Spic Surabhi was oilseed cake of Neem, Groundnut, Castor and Sesame with Turmeric powder and Pungamia extracts. These oil cakes were fortified well together in a well balanced mixed with NPK. Based on data analyzed, it was found that the integrated application of mixed cake @1.0 mt + FYM@ 7.5 mt

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ha^{-1} (T_4) and mixed cake@1.5 mt + FYM@ 5.0 mt ha^{-1} (T_5) performed economically and significantly better than rest of the treatments. The annual leaf yield of treatment T_4 and T_5 ranged from 16.44 to 16.49 mt ha^{-1} with 32.0 to 32.42% leaf yield gain against control T_1 (12.45 mt ha^{-1}). The nutritional quality like moisture content, total chlorophyll, total soluble protein, total soluble sugar, total N, total P and crude protein were also recorded higher with T_4 and T_5 than rest of the treatment. Silkworm rearing performance reveals that the mulberry leaves with above nutrient combinations do not have an adverse effect on single cocoon weight, cocoon yield and shell% respectively. The higher cost-benefit ratio T_4 and T_5 was 1:2.03% with net profit ₹. 2.13 Lakhs ha^{-1} $year^{-1}$ after the application of T_4 and T_5 treatment than control.

Keywords: Mixed cake; farm yard manure; mulberry; silkworm; silkworm rearing.

1. INTRODUCTION

Sericulture is one of the oldest agro-based industry in India and probably dates back to the beginning of the Christian era [1]. Mulberry is the strongest pillar of this industry which plays a key role in the empowerment of women and rural livelihood. Besides, this industry is also an array in the arsenal of weavers' community, which is giving the huge employment to them. The success and failure of this industry are fully dependent on the production of quality mulberry leaves, because, the mulberry leaves are basic food material for silkworm *Bombyx mori* L. [2] and nutritional quality of mulberry leaves supplied as food have great influence on silkworm growth and cocoon yield [3]. Besides, feeding of good quality mulberry leaves to silkworm larvae results in lower mortality of silkworm [4].

Kalimpong hills, an extension of the sub-Himalayan region have great influence on Indian sericulture industry, because, it is a sericulture hub and well known for the production of bivoltine silkworm seed cocoons. Besides, Kalimpong hills also have its own identity as 'silk route of India'. 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 injudicious use of fertilizers leads 'active acidity' resulting these soils are known as problem soils [5].

Like agricultural crops, the yield and quality of mulberry leaves are also dependent on soil health, nature of mulberry variety, integrated nutrient management, agronomic practices, environmental condition and protection measures from diseases and pests, among them, soil health, environmental condition and nutrient management have greater influence. It is a universal fact that, soil is soul of infinite life, which nourishes the whole living things; however, integrated nutrient management (INM) is the wonderful array in the arsenal of farmers and planners to sustain the soil health for desired production and productivity of crops.

It is now being realized that the use of organic manures with other nutrient combinations may help to maintain the soil health for sustaining the mulberry sericulture. Farmyard manure (FYM) made with cow dung plays a key role in this regard, but, the availability and timely application of good quality of FYM is a challenging task, hence, integrated application of FYM with other alternative organic manures is highly desired for sustaining the soil health and quality mulberry leaf production. There are several alternatives of FYM available to fulfil the requirements, but, either, these alternatives are less available and unaffordable or not much effective to achieve the targeted yield, hence, mixed cake was chosen for its integrated application with FYM.

The mixed cake was applied through 'Spic Surabhi'. The main ingredient in Spic Surabhi was oilseed cake of Neem, Castor, Groundnut and Sesame with Turmeric powder and Pungamia extracts. These oil cakes were fortified well together in a well-balanced mixed with NPK. Neem, (*Azadirachta indica),* a native of arid zone of Indian sub-continent are well known for its nutritional and medicinal values worldwide. Due to its bio-degradable and eco-friendly nature, it provides all the macro and micro-nutrients to the soil and plants. It has also been used as the denitrifying agent, urea coating agent, fumigant and pesticide etc. both in soil and plants. Castor (*Ricinus communis* L.) is and industrial oilseed crop belongs to the family *Euphorbiaceae*, extensively cultivated in India, China and Brazil [6,7]. Castor is used as organic fertilizer worldwide [8-10], because, it is a major source of both macro and micronutrients which improves the physical, chemical and microbial properties of the soil [9]. Like neem and castor cake, groundnut and sesame cake are also very rich in both macro and micronutrients which are responsible for the enhancement of nutrient uptake in plans and improvement of physical, chemical and microbial properties of the soil [11].

2. MATERIALS AND METHODS

2.1 Experimental Site and Climate

The experiment was conducted during 2013-16 at Regional Sericultural Research Station (RSRS) farm, Kalimpong 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.

2.2 Treatment Combination

The experiment was conducted for three years during 2013-16 with five nutrient management practices, *viz*, T_1: Control: FYM @ 10 mt ha^{-1}; T_2: mixed cake@0.5 mt ha^{-1} + FYM@10 mt ha^{-1}; T_3: mixed cake@0.75 mt ha^{-1} + FYM@10 mt ha^{-1}; T_4: mixed cake@1.00 mt ha^{-1} + FYM@7.5 mt ha^{-1} and T_5: mixed cake@1.5 mt ha^{-1} + FYM@5 mt ha^{-1} respectively. The recommended doses of NPK @150:50:50 kg ha^{-1} and soil test based doses (STBD) of dolomite @ 1.5 mt ha^{-1} was applied uniformly in all the treatment plots [12].

2.3 Mulberry Variety and Silkworm Breed

The experiment was conducted in the existing BC_259 (*Morus alba* L.) mulberry variety. This variety was developed by backcross technique by earlier researchers and 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 [13]. Silkworm rearing was conducted in autumn and spring season at RSRS farm and bivoltine mulberry silkworm breed SK6×SK7 (*Bombyx mori.* L.) was chosen for this purpose.

2.4 Nature of Manures, Fertilizers and Dolomite Applied

Integrated application mixed cake, FYM, dolomite and mineral fertilizers were applied as per the treatment plan. Cow dung was the only source of FYM, whereas, the 'Spic Surabhi' was the source of mixed cake. The main ingredient in Spic Surabhi was oil seed cake of Neem, Groundnut, Castor and Sesame with Turmeric powder and Pungamia extracts. These oil cakes were fortified well together in a well-balanced mixed with NPK. The chemical composition of the mixed cake was as under: moisture content 9.2%; pH – 5.5; Electrical Conductivity (dSm^{-1}) – 0.34; organic carbon – 26.5%; Nitrogen –2.45%; Phosphorus – 0.96% ; Potash – 1.0% and C:N ratio – 10:81.1 respectively. The dolomite (Calcium Carbonate Equivalent @109%) was applied as liming materials, however, 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 five treatment and 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 [14,15]. 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 [16]; alkaline $KMNO_4$ oxidizable N [17]; 0.025 N HCl+0.03 N NH4F extractable P [18] and available K (1N NH_4OAc exchangeable K) respectively. Likewise, processed mulberry leaves were analyzed by following the standard procedure e.g. leaf moisture (Hot oven drying method), total chlorophyll [19]; total soluble protein [20] and total soluble sugar [21] respectively. The statistical analysis was done by using SPSS 16.0 and Microsoft Excel, 2007 software.

3. RESULTS AND DISCUSSION

3.1 Morph-physicochemical 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, sub-angular 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 pilot 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})	0.15
3.	Organic C (%)	1.29
4.	Available N (kg ha^{-1})	499.6
5.	Available P (kg ha^{-1})	23.7
6.	Available K (kg ha^{-1})	166.5
7.	Available S (kg ha^{-1})	13.9

The morpho-physical properties were analyzed following the procedure of Soil Survey Manual of All India Soil and Land Use Survey [22] and Soil Survey Staff [23,24]. The variation of colour was due to prevalence of well drained conditions and admixture of organic matter [12,25,26] whereas; the variation in soil texture was caused by slope, terrace and translocation of clay in lower horizons [27]. The variation in soil structure and consistency was due to variation in clay content of pedons [26]. Findings of various workers in the soils of Darjeeling hills under various land use also correlates with this research [28; 29].

3.2 Effect of Mixed Cake and FYM on Growth and Yield Characteristics of Mulberry Leaves

Based on the data analyzed, it has been observed that the effect of mixed cake on growth attributing characters and leaf yield of mulberry was significant in both autumn and spring season. The maximum height of shoot, number of leaves $shoot^{-1}$, and leaf yield was observed in T_4 and T_5 treatment over control. While observing the effect of season (S)×Treatment (T), it was found that the higher leaf yield was recorded in spring than autumn. In autumn season, maximum leaf yield 7.84 mt ha^{-1} was recorded in T_4 treatment followed by 7.87 mt ha^{-1} in T_5 and 5.91 mt ha^{-1} in T_1 (control). Likewise, in spring season, maximum leaf yield 8.60 mt ha^{-1} was in T_4 treatment combination followed by 8.62 mt ha^{-1} in T_5 and 6.54 mt ha^{-1} in T_1 (control) respectively. The **e**ffect of mixed cake and FYM on season wise growth attributing characters and leaf yield of mulberry are given in Table 2.

While analyzing the total leaf yield $annum^{-1}$, highest leaf yield 16.44 mt ha^{-1} was recorded in T_4 followed by 16.49 mt ha^{-1} in T_5 whereas lowest leaf yield was 12.45 mt ha^{-1} in T_1 (control). The highest leaf yield gain over control was 32.0% in T_4 followed by 32.42% in T_5 respectively. Effect of mixed cake and FYM on annual growth attributes characters and total leaf yield of mulberry are given in Table 3.

It is well-known fact that, the growth attributing characters and yield of mulberry are highly influenced by the nutrients available in the soil. Besides, nutrient management also plays the major role in this regard, While working on mulberry, Chowdhury et al. [30] reported the significant result on yield and quality of mulberry leaves after integrated application of organic manures. Thakur et al. [31] reported that the integrated application of neem cake in the combination of other organic manures and chemical fertilizers had significant impact on cane yield in both plant and ratoon crop. Virdia and Patel [32] also reported the similar findings. Mahajan et al. [33] reported that the application of neem cake @2.5 mt ha^{-1} is an ideal organic nutrition module to meet the nutritional requirement of basmati crop and is the best alternative to inorganic fertilizer without significant loss in grain yield. Significant results of neem cake in combination with other organic nutrients on various crops were also reported by the majority of the scientific community. Prabhakar et al. [34] found the highly significant result of neem cake on growth, yield and quality of rose onion (*Allium cepa*) whereas; Singh et al. [35] reported the similar findings on rice crop and Kumpawat [36] on productivity and nutrient uptake of black gram. Similar findings were also reported by the various workers across the country [37-40].

Table 2. Effect of mixed cake and FYM on season wise growth attributing characters and leaf yield of mulberry

Treatment	Autumn 2014					Spring 2015				
	Number of shoots plant^{-1}	Height of single shoot (cm)	Number of leaves shoot^{-1}	Total leaves plant^{-1}	Leaf yield (mt ha^{-1})	Number of shoots plant^{-1}	Height of single shoot (cm)	Number of leaves shoot^{-1}	Total leaves plant^{-1}	Leaf yield (mt ha^{-1})
T_1	9.85	96.62	16.11	158.58	5.91	10.54	100.28	17.65	186.07	6.54
T_2	10.10	102.12	18.36	185.66	6.91	11.18	105.45	20.05	223.94	7.53
T_3	10.85	110.73	21.34	232.07	7.53	11.55	112.90	21.65	249.83	7.82
T_4	11.86	115.99	22.61	268.07	7.84	11.93	119.95	23.15	276.27	8.60
T_5	11.90	116.46	22.68	269.72	7.87	11.97	120.15	23.18	277.29	8.62
SEm(±)	0.15	0.50	0.21	4.80	0.09	0.10	0.60	0.31	1.63	0.03
CV(%)	0.07	0.25	0.10	2.40	0.05	0.05	0.30	0.15	0.82	0.01
CD ($p \geq 0.05$)	0.73	3.45	1.01	19.40	0.63	0.05	3.04	1.07	19.94	0.44

Table 3. Effect of Mixed cake and FYM on annual growth attributing characters and total leaf yield of mulberry

Treatment	Total shoots plant^{-1} year^{-1}	Mean length of single shoot (cm)	No. of leaves/ shoot	Total leaves plant^{-1} year^{-1}	Total Leaf yield year^{-1} (mt ha^{-1})	Total Leaf Yield gain (%)
T_1	20.39	98.45	16.88	344.28	12.45	0.00
T_2	21.28	103.78	19.20	408.78	14.44	15.99
T_3	22.40	111.82	21.49	481.55	15.35	23.25
T_4	23.79	117.97	22.88	544.33	16.44	32.00
T_5	23.87	118.30	22.93	547.07	16.49	32.42
SEm(±)	0.09	0.90	0.22	5.82	0.09	2.23
CV(%)	0.05	0.23	0.11	2.91	0.04	1.114
CD ($p \geq 0.05$)	1.06	2.27	0.72	29.22	0.93	7.80

Table 4. Effect of mixed cake and FYM on moisture content and other nutritious quality of mulberry leaves

Treatment	Moisture (%)	Fresh weight (mg g^{-1})			Dry weight (%)		
		Total chlorophyll	Total soluble protein	Total soluble sugar	Total nitrogen	Crude protein	Total phosphorus
T_1	73.65	1.29	20.05	29.83	2.99	18.70	0.28
T_2	73.78	1.30	24.48	30.15	3.05	19.05	0.30
T_3	74.30	1.42	25.78	32.80	3.22	20.15	0.32
T_4	75.63	1.63	25.63	34.35	3.41	21.31	0.31
T_5	75.66	1.63	25.64	34.37	3.41	21.30	0.32
SEm (±)	0.09	0.01	0.17	0.35	0.01	0.07	0.01
CV (%)	1.327	0.035	0.824	1.476	0.168	1.053	0.017
CD (p≥0.05)	1.327	0.035	0.824	1.476	0.168	1.053	0.017

Table 5. Effect of mixed cake and FYM on the seasonal performance of silkworm rearing

Treatment	Autumn, 2013-14							Spring 2014-15						
	Weight of ten matured larvae (g)	ERR/10000 larvae		Cocoon yield (kg)/ 100 dfls	Weight of single cocoon (g)	Weight of single shell (g)	Shell (%)	Weight of ten matured larvae (g)	ERR/10000 larvae		Cocoon yield (kg)/ 100 dfls	Weight of single cocoon (g)	Weight of single shell (g)	Shell (%)
		No.	Weight (kg)						No.	Weight (kg)				
T_1	37.95	8775	14.5	57.9	1.65	0.28	17.0	39.73	8817	14.9	59.8	1.70	0.301	17.8
T_2	38.17	8767	14.4	57.5	1.64	0.28	17.1	39.75	8908	15.1	60.6	1.70	0.302	17.8
T_3	39.71	8833	14.6	58.6	1.66	0.29	17.6	40.20	8992	15.3	61.1	1.70	0.305	17.9
T_4	39.35	8842	15.0	60.0	1.70	0.30	17.7	40.10	9033	15.7	62.7	1.74	0.316	18.2
T_5	40.12	8825	15.0	60.0	1.70	0.30	17.7	40.12	9008	15.7	62.6	1.74	0.317	18.2
SEm (±)	0.32	26.44	0.08	0.33	0.0	0.0	0.04	0.18	42.02	0.06	0.23	0.0	0.0	0.06
CV (%)	0.16	13.22	0.04	.16	0.0	0.0	0.02	0.09	21.01	0.03	0.11	0.0	0.0	0.03
CD (p≥0.05)	NS	NS	0.36	1.43	0.03	NS	NS	NS	NS	0.28	1.12	0.02	0.01	0.28

Table 6. Annual mean performance of silkworm rearing

Treatment	Weight of ten matured larvae (g)	ERR/10000 larvae		Cocoon yield (kg)/ 100 dfls	Weight of single cocoon (g)	Weight of single shell (g)	Shell (%)
		No.	Weight (kg)				
T_1	38.8	8796.0	14.7	58.9	1.68	0.29	17.4
T_2	39.0	8837.5	14.8	59.1	1.67	0.29	17.5
T_3	40.0	8912.5	15.0	59.9	1.68	0.30	17.8
T_4	39.7	8937.5	15.4	61.4	1.72	0.31	18.0
T_5	40.1	8916.5	15.4	61.3	1.72	0.31	18.0
SEm (±)	0.3	34.2	0.1	0.28	0.00	0.00	0.05
CV (%)	0.13	17.12	0.04	0.14	0.00	0.00	0.03
CD (p≥0.05)	NS	NS	0.32	1.28	0.03	0.01	0.14

Table 7. Cost benefit ratio[*] (Lakh ₹.)

Treat-ment	Mulberry		Silkworm rearing		Total Cost (₹.)	Total leaf yield (mt ha^{-1} $year^{-1}$)	Total cocoon yield (kg) 100 $dfls^{-1}$	Total cocoon yield (kg ha^{-1} $year^{-1}$)	Leaf cocoon ratio	Cost of sale of cocoon (₹. 550 kg^{-1})	Net Profit (₹.)	Cost benefit ratio (%)
	Input cost $year^{-1}$ (₹.)	Labour cost $year^{-1}$ (₹.)	Input and depreciation cost $year^{-1}$ (₹.)	Labour cost $year^{-1}$ (₹.)								
T_1	0.26	0.30	0.20	0.91	1.68	12.45	57.90	556.7	22.36	3.06	1.38	1:1.82
T_2	0.34	0.30	0.20	1.05	1.89	14.44	57.52	638.4	22.62	3.51	1.62	1:1.85
T_3	0.38	0.30	0.20	1.13	2.00	15.35	58.56	696.3	22.04	3.83	1.83	1:192
T_4	0.38	0.29	0.20	1.21	2.07	16.44	59.95	763.4	21.53	4.20	2.13	1:2.03
T_5	0.35	0.32	0.20	1.21	2.07	16.49	60.01	764.2	21.58	4.20	2.13	1:2.03

[*]Labour cost: ₹. 169.00 $manday^{-1}$; FYM: ₹. 1500.00 mt^{-1};mixed cake: ₹. 15000.00 mt^{-1}; Dolomite: ₹. 3000.00 mt^{-1}; Urea: ₹. 700.00 $quintal^{-1}$; SSP: ₹. 1000.00 $quintal^{-1}$; MOP: 19.00 $quintal^{-1}$.

3.3 Effect of Mixed Cake and FYM on Nutritious Quality of Mulberry Leaves

Leaf moisture, total chlorophyll content and other biochemical parameters play a key role in the silkworm rearing. Mixed cake in combination with FYM or other organic manures and inorganic fertilizers enhanced the overall metabolism of various crops. Analysis of nutritional quality of the mulberry leaves revealed that the T_4 and T_5 treatment combination was found highly significant on leaf moisture content, total chlorophyll, total soluble protein, total soluble sugar, total nitrogen, crude protein and total phosphorus over control (T_1). Ram et al. [41] reported that the organic manure pressmud in combination with FYM has significant result on biochemical parameters of mulberry leaves. Findings of Chowdhury et al. [30] have also reported the similar findings on mulberry variety S-1635. The unbalanced nutrient management or deficiency of essential nutrients in the soil has been found to cause nutritional, anatomical and histological disorders in mulberry [42], however, unbalanced nutrient management has adverse effect on crop productivity and nutrients availability [43]. Effect of INM of FYM with other treatment combination enhanced the biochemical and mineral nutrients of mulberry leaves were also reported by various workers [44-46]. Effect of mixed cake and FYM on moisture content and other nutritious quality of mulberry leaves are given in Table 4.

3.4 Effect of Mixed Cake and FYM on Season Wise Performance of Silkworm Rearing

Effect of mixed cake and FYM on season wise performance of silkworm rearing was non-significant in respect of weight and ERR of matured larvae, however, single cocoon, single shell and shell percent and cocoon yield 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 60.00 kg 100 dfls^{-1} were recorded in T_4 and T_5 treatment in and lowest cocoon yield 57.9 kg 100 dfls^{-1} in T_1 in autumn season. Likewise, in spring season, highest cocoon yield was 62.7 kg 100 dfls^{-1} in T_4 treatment and lowest cocoon yield 59.80 kg 100 dfls^{-1} in T_1 treatment. Effect of mixed cake and FYM on season wise performance of silkworm rearing for important economic traits is given in Table 5.

While analyzing the combined mean of total cocoon yield 100 dfls^{-1} in both seasons, the highest cocoon yield 61.4 kg 100 dfls^{-1} was recorded in T_4 treatment followed by lowest 58.9 kg 100 dfls^{-1} in T_1 (control). Silkworm growth and quality cocoon production dependent on nutritious mulberry leaves, however, yield and quality of mulberry leaves are dependent on nutrient management and agronomic practices. According to Sannappa et al. [47] and Raje [48] 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. [49] opined that quality of mulberry leaf fed to silkworms is the most important factor that influences successful cocoon production by mulberry silkworm. Annual mean performance of silkworm rearing is given in Table 6.

3.5 Cost Benefit Ratio (≠.)

The economic gain or cost benefit ratio is the difference between 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 to 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 6). 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 ≠. 550 kg^{-1} and even more, depending upon the quality of cocoon, hence, this is also one of the reasons for handsome return. Due to higher leaf yield (16.44 mt ha^{-1} year^{-1} in T_4 and 16.49 mt ha^{-1} year^{-1} in T_5) and economic consumption of mulberry leaves [Leaf: Cocoon ratio=21.53:1 (T_4) and 21.58:1 (T_5)] for production of one kg cocoon favours the high economic gain (1:2.03%) with T_4 and T_5 treatment. Based on critical analysis of net benefit ratio, it was found that, the net benefit ≠. 2.13 lakhs ha^{-1} year^{-1} was recorded with T_4 against the total input cost ₹. 2.07 lakhs and output cost ≠. 4.20 lakhs ha^{-1} year^{-1}. The cost benefit ratio is given in Table 7.

4. CONCLUSION

Based on the findings, it has been concluded that, the application of mixed cake@1.00 mt ha^{-1} + FYM@7.5 mt ha^{-1} (T_4) or mixed cake@1.5 mt ha^{-1} + FYM@5 mt ha^{-1} (T_5) with RD of NPK @150:50:50 kg ha^{-1} have significant effect on season and year wise growth attributes characters, leaf yield and nutritional quality of mulberry variety $BC_2$59. The performance of silkworm rearing with treated mulberry leaves was also found the significant result in same treatment combination. The highest profit of worth ₹. 2.07 lakhs ha^{-1} $year^{-1}$ was recorded with same treatment against the total input cost as reported above.

COMPETING INTERESTS

Authors have declared that no competing interests exist

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