ISSN Print: 2664-844X
ISSN Online: 2664-8458
Impact Factor: RJIF 5.6
IJAFS 2022; 4(1): 38-52
www.agriculturaljournals.com
Received: 11-02-2022
Accepted: 21-03-2022

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Utilization of farm yard manure as a source of nutrients for sustainable mulberry production

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DOI: https://doi.org/10.33545/2664844X.2022.v4.i1a.64

Abstract
Quality and quantity mulberry leaf production is a great challenge in Bangladesh for sericulture farmers because of in balanced fertilizer management. Recently, farmyard manure (FYM) is an alternative, inexpensive and existing source of organic nutrient due to requiring of cow dung. The present study was conducted to determinant the impact of FYM on mulberry productivity, leaf quality, foliar diseases and soil, besides contributes of more production for sericulture farmers. Randomized completely block design with three replications and four levels of fertilizer treatments were used to evaluate the effect of FYM on soil properties, productivity and harshness of foliar diseases in mulberry plant. Genstat 12.1thedn for Windows (Lawes Agricultural Trust, UK), sigma Plot 12.5 versions and statistic-10 software were used for analyzed and representing the results. From the results, improved soil properties, maximum leaf yield with greater leaf quality and maximum reduction of foliar diseases infestation were identified for amendments of farm yard manure (FYM) in soil for mulberry cultivation. Between, two cropping years in 2nd year the leaf yield was 38.39% and 101.93% respectively greater with higher moisture, soluble carbohydrate, total chlorophyll, crude protein, mineral and total sugar as well as lower % of powdery mildew, leaf spot and tukra diseases for the mutual dose of FYM + BSRTI recommended basal dose of N300P150K100 kg/ha/year respectively. This experiment generally assessed the impact of FYM on soil quality, productivity and foliar diseases infestation in mulberry. The findings encouraging sericulture farmers utilize FYM for sustainable and productive mulberry cultivation.

Keywords: Pruning, leaf spot, powdery mildew, tukra, decomposition, days after pruning (DAPr)

Introduction
Mulberry (*Morus* spp) is the backbone of sericulture industry, because, both economically and traditionally it is a very important plant for the development of sericulture industry. Mulberry leaves are basic food material for silkworm Bombyx mori L. (Ravikumar, 1988) [40] and nutritional quality of mulberry leaves supplied as food have great influence on silkworm growth and cocoon yield (ESCAP, 1993) [13]. Besides, feeding of good quality mulberry leaves to silkworm larvae results lower mortality of silkworm (FAO, 1990) [14]. It was reported that feeding of nutrient deficient mulberry leaves to developing silkworms led to 17.11% cocoon production loss (Singhvi *et al*., 2007) [47]. So, silkworms should be fed with good quality mulberry leaves in abundant quantity for the successful silk cocoon production (Vijaya *et al*., 2009) [54]. Mulberry is a perennial, heterozygous and high biomass producing hardy deciduous plant continues to grow throughout the year for leaves production as a sole food of monophagous insect silkworm, Bombyx mori L. (Aggarwal *et al*.,2004) [3]. However, the nutritive value of mulberry leaf is influenced by the soil nutrient status (Bongale, 2006) [7]. The continuous production of mulberry for a long time results in gradual reduction in leaf yield and quality (Rashmi *et al*., 2009) [39]. It requires the macro and micro nutrients *viz*: N, P, K, Ca, Mg, S, Fe, B, Ma, Zn, Cu, Mo and some other microelements from the soil for its growth and development Anonymous (1975) [4].The leaf quality and quantity as well as the nutritional status of mulberry leaf are directly influenced by the application of manures and fertilizers to soil (Murarkar *et al*., 1998) [27].
Farmyard manure (FYM) refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 percent N, 0.2 percent P2O5and.0.5 percent K2O (Tnau, 2016) [51].

FYM supplies all major nutrients (N, P, K, Ca, Mg, S,) necessary for plant growth, as well as micronutrients (Fe, Mn, Cu and Zn) hence, it acts as a mixed fertilizer. FYM improves soil physical, chemical and biological properties. Improvement in the soil structure due to FYM application leads to a better environment for root development. FYM also improves soil water holding capacity. The fact that the use of organic fertilizers improves soil structure, nutrient exchange, and maintains soil health has raised interests in organic farming (Kunj *et al*., 2018) [20]. Farm yard manure rich in organic matter contents most of the nutrients *viz*: nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, zinc and copper (Venu gopal *et al*., 2010) [53]. Combined application of farm yard manure with inorganic fertilizer NPK has a great impact on leaf yield and quality of mulberry plant (Waktole *et al*., 2013) [57]. Application of farm yard manure in mulberry plant exhibited better results in maintaining the diseases than the others organic amendments due to contain more amounts of organic nutrients and makes resistance against the fungal diseases of mulberry (Ranadive *et al*., 2011) [38].

Therefore, the impact of farm yard manure on mulberry plant production and suppression of mulberry diseases are scarcely available. That's why, the present study was undertaken to estimate the impact of FYM on soil improvement, mulberry plant productivity, leaf quality and suppression of mulberry diseases. It may be hypothesized that FYM will be the best suited eco-friendly nutrient management practice for sustainable leaf yield, quality and suppression of foliar diseases in mulberry plant.

Materials and Methods Study Area

This research was laid out of Bangladesh Sericulture Research and Training Institute (BSRTI), Rajshahi, Bangladesh. This location is located at the 24°22′29″ N and 88°37′84″ E.

Plant Material

The mulberry (*Morus spp*) variety BM-11 (BM = Bangladesh Mulberry) and high-bush plantation system was used for this study as a trail plant. This plant is perennial, deep rooted, and small to medium sized shrubs or trees with a thick tan-gray ridged trunk that is hardy in nature. Mulberry is cultivated in wide-ranging of soil and agro-climatic surroundings for its perennial, profound rooted and robust habit.

Situation of Study

Commonly, each year four commercially seasons are followed for silkworm rearing in Bangladesh. On the requirements of mulberry leaf for silkworm rearing season four times each after 90 days interval mulberry garden is pruned. Each after 20 DAPr (Days after Pruning) the treatments were used. The others cultural practices *viz*: irrigation, digging cum weeding, insect-pest management etc. were done as per obligation.

Design and Treatments

The experiment was conducted in RCBD design with 4 fertilizer treatments having three replications. The applied treatments are as follows: T_0: Control (No input)

T_1: N300P150K100 kg/ha/year

T_2: Only 7 Mt farm yard manure (FYM) per hectare per year

T_3: 7 Mt FYM/ha/yr + T_1

Yield and Yield Contributing Parameters

Node per meter, length of the longest shoot/plant, total branch number/plant, total branch height /plant (cm), total shoot weight/plant (g), 10 leaves area per plant (cm2), 10 leaves weight/plant (g) and total leaf yield per hectare per year (Mt) were noted for this study. Data were collected at for each cropping seasons. Four times data was recorded each after 90 DAPr and the annual yield was computed by pooling the two years data.

Soil Condition

The soils of the experimental plots of BSRTI were mainly clay loam in nature, having normally alkaline characteristics with pH ranging from 7.2 to 7.6. As a consequence of this alkalinity, the soil is poor in potassium and available phosphorus. Both carbon and nitrogen levels are low in uncultivated as well as in the cultivated plots. Nitrogen level is not in balanced with carbon. This is more prominent in the farm areas where mulberry is cultivated for years. Toxic metals are present in traces but they are well below the harmful levels (BSR, 1991) [5]. The basic physical and chemical properties of initial soil are presented in (Table 1).

Table 1: Initial soil properties of the experimental soil

Soil pH	Organic Carbon (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Ca (%)	Mg (%)	Na (%)	Mn (ppm)	Cu (ppm)	Zn (ppm)
8.2	0.29	129.00	11.10	204.00	1.69	0.53	0.05	11.00	3.71	8.80

Analysis of soil

Soil texture analysis was conducted by using an abbreviated version of the international pipette method. Clay content was determined by a pipette method after pretreatment with H2O2 to remove organic matter (Gee and Bauder, 1986) [15]. The soil pH was determined in deionizer water using a soil: water ratio of 1:5 by using the glass electrode method (Haber *et al*., 1909) [16]. Organic carbon of the soil samples was determined by wet oxidation method (Walkley and Black, 1934) [56]. Soil organic matter content was determined by multiplying the percent value of organic carbon with the conventional Van-Bemmelen's factor of 1.724 (Piper, 1950) [32]. The nitrogen content of the soil sample was determined by distilling soil with alkaline potassium permanganate solution (Subhaiah and Asija, 1956) [49]. The distillate was collected in 20 ml of 2% boric acid solution with methylred and bromocresol green indicator and titrated with 0.02 N sulphuric acid (H2SO4) (Podder *et al.*, 2012) [33]. Soil available S (ppm) was determined by calcium phosphate extraction method with a spectrophotometer at 535 nm (Petersen, 1996) [31]. The soil available K was extracted with 1N NH4OAC and determined by an atomic absorption spectrometer (Biswas *et al.*, 2012) [6]. The available P of the soil was determined by spectrophotometer at a wavelength of 890 nm. The soil sample was extracted by Olsen method with 0.5 M NaHCO3 as outlined by Huq and Alam (2005) [18]. Sodium, calcium and magnesium content were determined following the method of Tandon (1993) [50] and copper were estimated by atomic absorption spectrophotometer (AAS) Tandon, 1993)

[50]. Manganese was estimated by Spectrometrically (Jackson, 1973; Chopra *et al.*, 1991) [19, 9]. The atomic absorption spectrophotometer (AAS) was used form ensured Zn in the soil sample (Soltanpour and Workman, 1979) [48].

Leaf Quality Evaluation

The mulberry leaf samples at different heights of the plant (top, middle and bottom) were collected in paper bags at 70 DAPr and composite leaf samples were made. Then, the prepared leaf samples were shade dried for three

days and again dried in hot air oven at 70 °C for one hour and were ground into powder for chemo-assay. The moisture (%) was determined following Vijayan *et al*., (1996) [55], soluble carbohydrate (%) following Dubois *et al*., (1956) [11] method, total chlorophyll content was estimated by the procedure of Hiscox and Israelstam, (1979) [17] using spectrophotometer and computed using the standard formulae of Arnon (1949) [2], crude protein (%) following Kjeldahl's method (Wong, 1923) [56], total mineral (%) following AOAC, (1980) [1], Total sugar (%) following Miller (1972) [[26] and Loomis *et al*., (1937) [22] procedure.

Measurement of Disease Incidence (%)

The disease incidence percentage %) was measured by random selected 10 disease infected mulberry plants for each replication for two successive years. The data was recorded 60 days of pruning for the foliar diseases of powdery mildew (*Phyllactinia corylea*), leaf spot (*Pseudocercospora mori*) and tukra (*Maconellicoccus hirsutus*) respectively. The percentage of disease incidence ***(**PDI**)*** was calculated by using the formula of Rai and Mamatha (2005) [36].

$$\text{Disease Incidence Percent (\%)} = \frac{\text{Numberoftotalleavesoneach plant}}{\text{Numberofdiseasedleavesoneach plant}} \times 100$$

Statistical Analysis

The Genstat 12.1thedn for Windows (Lawes Agricultural Trust, UK) and one-way ANOVA was used for analyzed the growth and yield contributing parameters. The results were represented as a figure form through using the Sigma Plot 12.5 versions. The Statistic-10 software was used for leaf quality and diseases data was statistical analyzed and mean values were evaluated by DMRT test. The mean values of post-harvest soil properties were recorded for this study.

Results

Impact of FYM on Post-Harvest Soil Properties

Results showed that soil organic carbon, nitrogen (N), phosphorus (P), potassium (K), Ca, Mg, Na, Mn, Cu and Zn were significantly increased for7 Mt FYM + BSRTI recommended basal dose of NPK (T_3) treated soil, followed by only the 7 Mt FYM (T_2) treated soil when compared to control (T_0). On the contrary, the soil organic carbon content was decreased for only the BSRTI recommended basal dose of NPK (T_2) treated soil. At the same time the soil pH was increased compare to T_2 and T_3. Among the four types of treatments and between the two cropping years the maximum average OC, N, P, K, Ca, Mg, Na, Mn, Cu and Zn were found 3.25%, 224.33 kg/ha, 15.43 kg/ha, 269 kg/ha, 2.70%, 0.67%, 0.13%, 27 ppm, 13.95 ppm and 33.80 ppm respectively in 2nd year soil for the treatment of T_3. However, the minimum average OC, N, P, K, Ca, Mg, Na, Mn, Cu and Zn were 0.29%, 129 kg/ha, 11.10 kg/ha, 204 kg/ha, 1.69%, 0.53%, 0.05%, 10.8 ppm, 3.17 ppm and 8.80 respectively in 1st year soil by the T_0 treated plot. The soil pH was markedly reduced for FYM treated soil whereas the minimum soil pH was 7.71 in 2nd year soil for the application of 7 Mt FYM/ha/year (T_2) followed by T_3, T_1 and T_0treatments respectively (Table 2).

Table 2: Effect of FYM on Post-Harvest Soil Properties

Treatments	pH		Organic Carbon (%)		N (kg/ha)		P (kg/ha)		K (kg/ha)		Ca (%)	Mg (%)		Na (%)		Mn (ppm)	Cu (ppm)			Zn (ppm)		
	1styr	2nd yr	1styr	2ndyr	1styr	2ndyr	1styr	2ndyr	1styr	2ndyr	1styr	2ndyr	1styr	2nd yr	1styr	2ndyr	1styr	2nd yr	1styr	2ndyr	1styr	2ndyr
T_0	8.2a	8.1 0b	0.29 cf	0.30 c	129. 00b	130. 33b	11.1 0d	11.2 0d	204. 00d	205. 67d	1.69 e	1.70 de	0.53 e	0.5 5d	0.05 d	0.07 cd	11.0 0d	10. 8d	3.71 d	3.74 d	8.80 c	8.93 c
T_1	7.91 c	7.8 4c	0.20 d	0.22 2d	189. 00a	201. 67a	13.0 0c	13.1 0c	238. 67c	240. 33c	1.72 cd	1.73 c	0.53 e	0.5 4d e	0.06 cd	0.07 bc	11.2 0d	11. 3d	4.5c	4.54 c	10.4 0b	10.5 b
T_2	7.72	7.7	2.66	2.68	189.	190.	13.4	13.5	256.	257.	2.31	2.33	0.55	0.5	0.07	0.0.0	17.c	18.	5.00	5.06	10.5	10.6
	dc	1d	b	b	00a	67a	0b	0b	00b	67b	b	b	d	6c	cd	8b		9d	bc	b	0b	7b
T_3	7.86 c	7.8 4c	3.23 ab	3.25 a	199. 67a	224. 33a	15.3 a	15.4 3a	267. 00a	269. 00a	2.69 a	2.70 a	0.65 b	0.6 7a	0.11 a	0.13 a	23.0 db	27. 0a	13.9 0a	13.9 5a	33.7 0a	33.8 0a

Here, FYM = Farm Yard Manure, T_0 = Control, T_1 = BSRTI recommended basal dose of NPK (BRBD), T_2 = 7 Mt FYM/ha/year, T_3 = 7 Mt FYM/ha/year + BRBD

Effect of Treatments and Cropping Years on Yield and Yield Contributing Parameters Node per Meter per Plant

The mean nodes per meter were markedly significant both for the fertilizer treatment ($p \leq 0.001$) and cropping

year ($p \leq 0.01$). Between the two cropping years the highest number of node per meter was 22.25 for T_3 (7 Mt FYM/ha/yr + BRBD) treated plant in 2nd year crop followed by the T_2 and T_1 compared to the control treatment. However, the lowest node per meter was 16.56 in 1styear crop for T_0 (control) treated mulberry plant (Table 3, Figure 01).

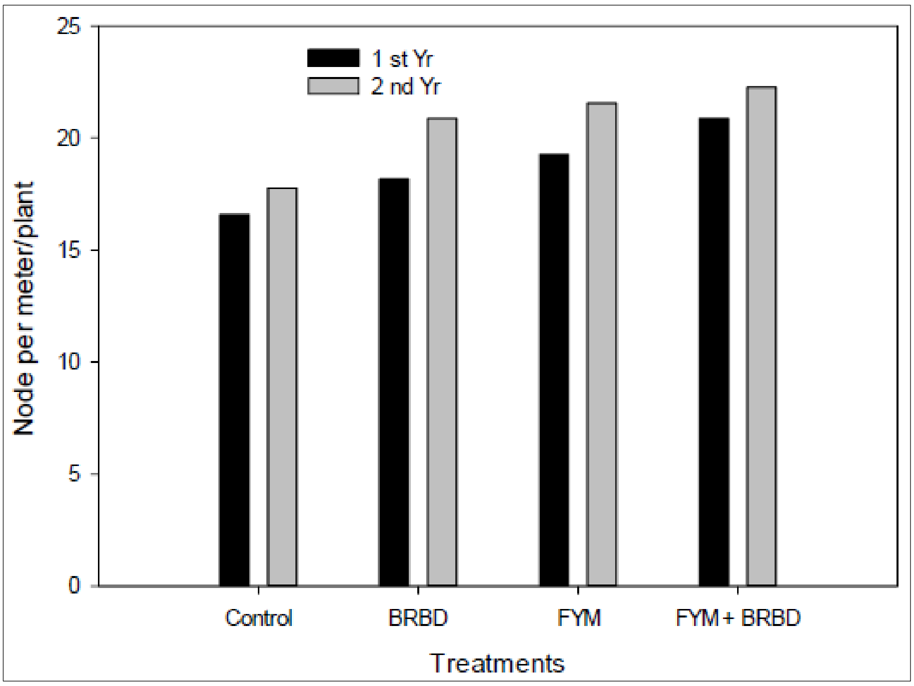

Fig 1: Node per meter in mulberry plants as influenced by the fertilizer treatments. Where, T_0 = Control, T_1 = BRBD of NPK, T_2 = Only 7 Mt FYM/ha/year and T_3 = 7 Mt FYM/ha/year + BRBD. Vertical bar represent LSD (P= 0.05) different fertilizer treatments and mulberry cropping years interactions

Number of Branches per Plant

Number of branches per plant was considerably differed only for the fertilizer treatment but there was no significant different between the cropping years and their interactive effect (Table 3, Figure 2). The maximum average numbers of branches were 13.9 in 2nd year for T_3 treatment followed by the T_2, $T_1$and T_0 respectively. The lowest number of total branch was 9.96 in 1st year for T (control) treated plant.

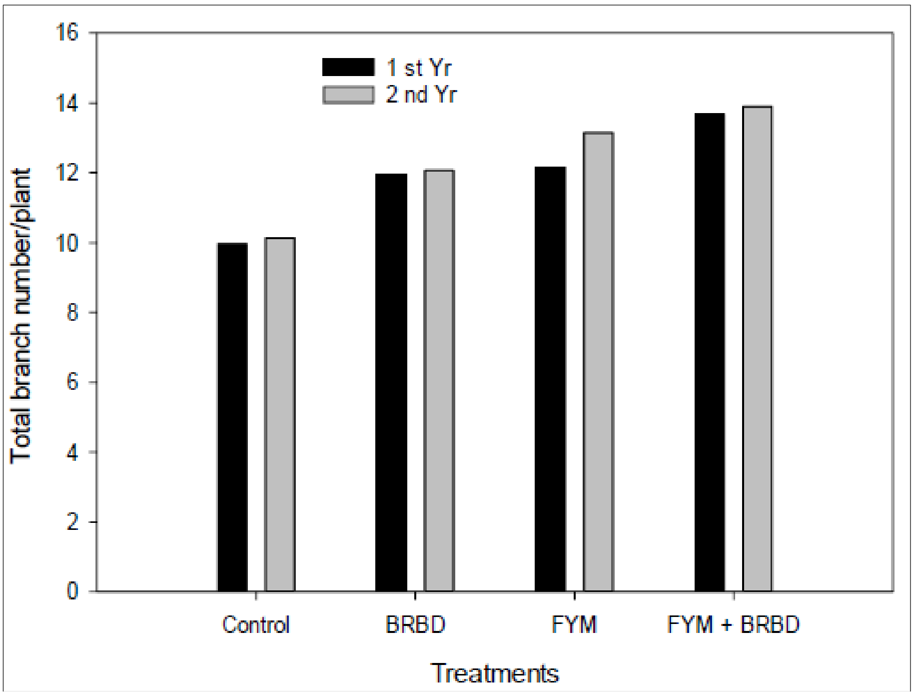

Fig 2: Total branch number per plant in mulberry plants as influenced by the fertilizer treatments. Where, T_0 = Control, T_1 = BRBD of NPK, T_2 = Only 7 Mt FYM/ha/year and T_3 = 7 Mt FYM/ha/year + BRBD. Vertical bar represent LSD (P= 0.05) different fertilizer treatments and mulberry cropping years interactions

Total Height of Branches (cm)

The7 Mt FYM/ha/yr + BRBD treated plot showed the maximum average total branch height per plant which was also significantly (p≤0.05) differed within the fertilizer treatments but did not significantly varied between the cropping years. However, the maximum total branch height was 1384.58cm in 2nd year for T_3treated plant and the lowest height of branches were 944.55cm in 1st year for control treatment (Table 3, Figure 3).

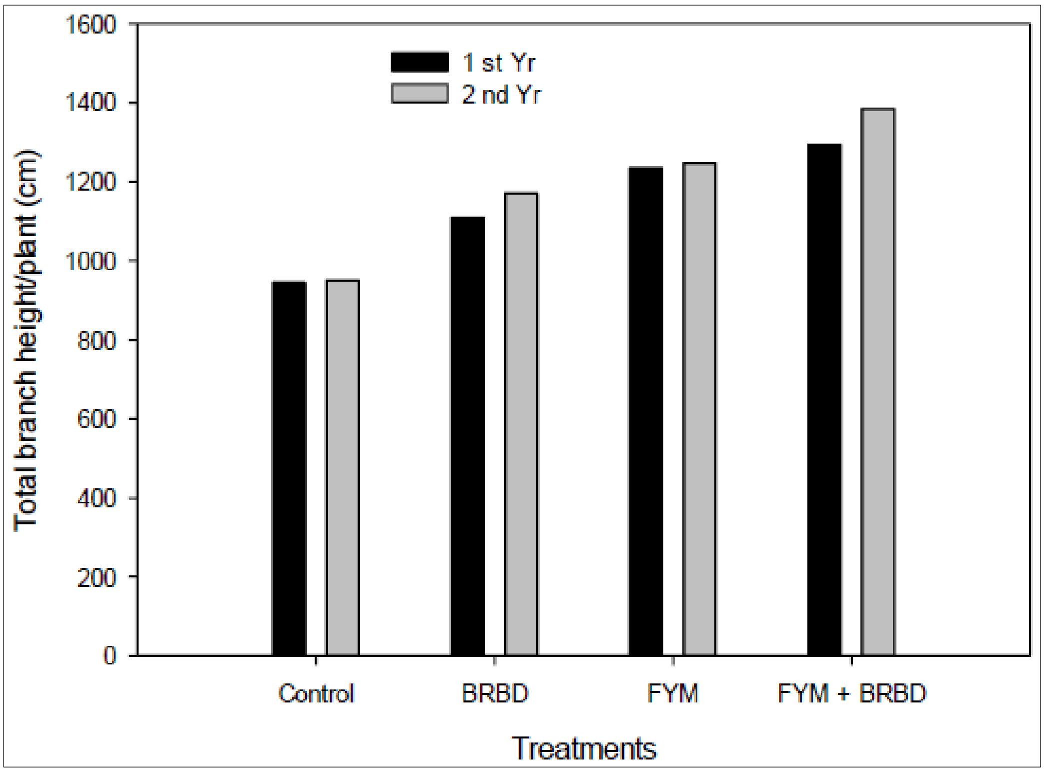

Fig 3: Total branch height per plant in mulberry plants as influenced by the fertilizer treatments. Where, T_0 = Control, T_1 = BRBD of NPK, T_2 = Only 7 Mt FYM/ha/year and T_3 = 7 Mt FYM/ha/year + BRBD. Vertical bar represent LSD (*P*= 0.05) different fertilizer treatments and mulberry cropping years interactions.

Weight of Shoots per Plant (g)

The average total weight of shoots were highly significant ($p \leq 0.001$) by the fertilizer treatments. Between the two cropping years, the maximum total shoot weight was 371.10g in 2nd year for T_3 (7 Mt FYM/ha/yr + BRBD) treatment followed by the T_2 and T_1 compared to the T_0 treatment. However, the lowest weight of total shoots were214.12 g for T_0 (control) treated 1st year plant (Table 3, Figure 4).

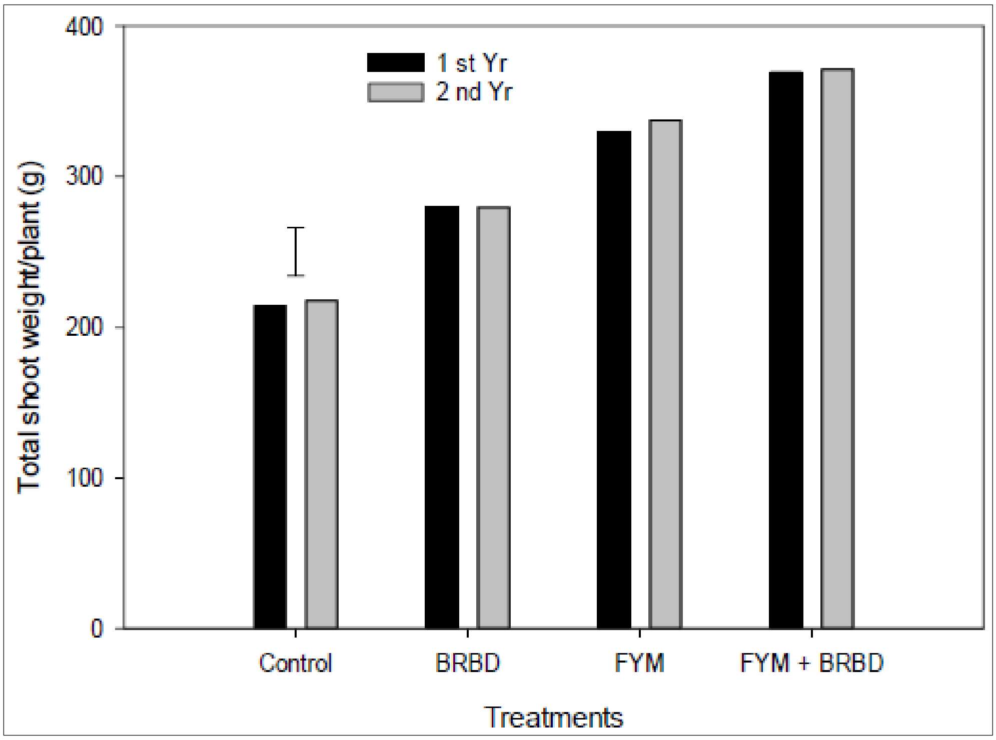

Fig 4: Total shoot weight per plant in mulberry plants as influenced by the fertilizer treatments. Where, T_0 = Control, T_1 = BRBD of NPK, T_2 = Only 7 Mt FYM/ha/year and T_3 = 7 Mt FYM/ha/year + BRBD. Vertical bar represent LSD (*P*= 0.05) different fertilizer treatments and mulberry cropping years interactions

Table 3: Level of significance for the main and interaction effect on fertilizer treatments and cropping years

Source of variation	Node per meter per plant	Total branch number per plant	Total branch height per plant (cm)	Total shoot weight per plant (g)	Length of longest shoot (cm)	Total leaf number per plant	10Leaf area (cm) per plant	10 Leaf weight (g) per plant	Total leaf weight per plant (g)	Total leaf yield/ ha/yr (Mt
Treatments	***	**	*	***	***	***	***	***	***	***
Cropping years	**	n.s.	n.s	n.s	n.s	n.s	n.s.	n.s	n.s	n.s
Treatments × Cropping years	n.s	n. s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s	n.s

Note. Where n.s.,*, ** and *** represent probability of > 0.05, ≤ 0.05, ≤ 0.01 and ≤ 0.001. Values were mean of three replicate

Longest Shoot Height (cm)

Between the two cropping years longest shoot height was markedly ($p \leq 0.001$) differed by the treatment. Among the four fertilizer treatments the average maximum longest shoot height was 119.77 cm for T_3 treated 2nd year plant. The l st 3, Figure 5)

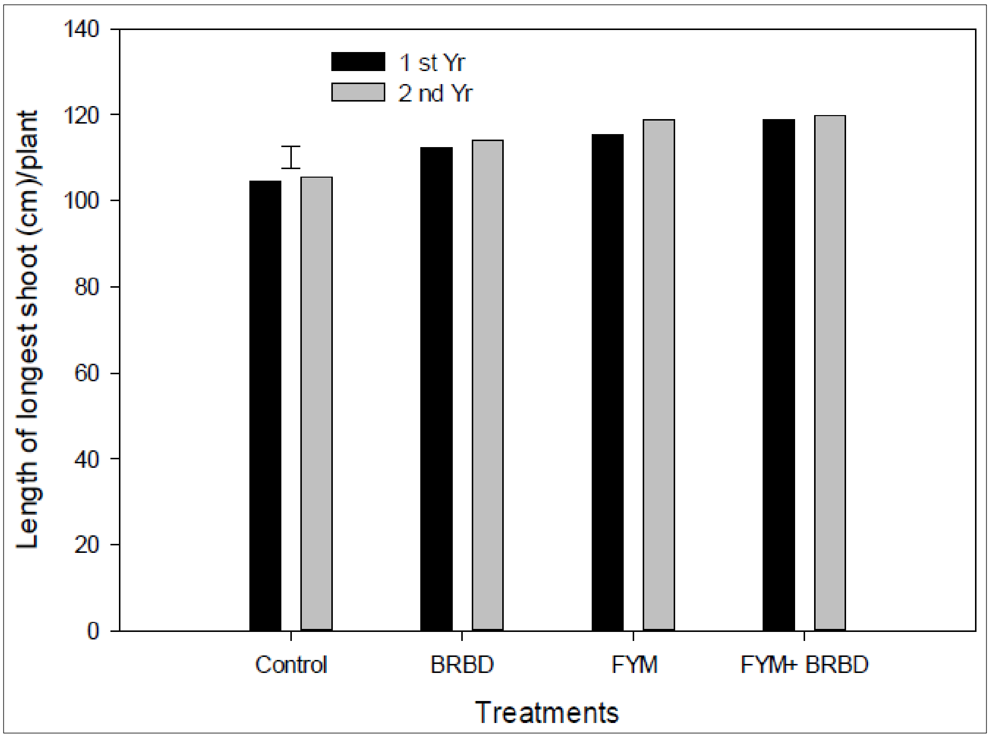

Fig 5: Length of the longest shoot per plant in mulberry plants as influenced by the fertilizer treatments. Where, T_0 = Control, T_1 = BRBD of NPK, T_2 = Only 7 Mt FYM/ha/year and T_3 = 7 Mt FYM/ha/year + BRBD. Vertical bar represent LSD (P= 0.05) different fertilizer treatments and mulberry cropping years interactions

Number of Total Leaf per Plant

The average number of total leaf per plant was highly significant ($p \leq 0.001$) for the treatments (Table 3; Figure 6. Between the cropping years the maximum average number of total leaf per plant was 321.61 in 2nd year forT_3 followed by the T_2 and T_1 respectively compared to T_0 treatment. However, the minimum total leaf number was 220.18 1st year.

10 Leaves Areas (cm2) per Plant

The 10 leaves area of mulberry plant was significantly varied for the treatments (Table 3, Figure 7).The maximum 10 leaves area was 600.47 cm2forT_3treated 2nd year plant followed by the treatments of T_2, T_1 and T_0. However, the minimum 10 leaf area was 368.05 cm2 in 1st year for control treatment International.

10 Leave Weights per Plant (g)

The 10 leaves weight was significantly ($p \leq 0.001$) differed for the fertilizer treatments (Table 3, Figure 8). The maximum average 10 leaves weight was 30.88 g in 2nd year for T (7 Mt FYM/ha/yr + BRBD) treatment. The minimum 1

Total leaf weight per plant (g)

The leaf weight of mulberry plant was highly significant ($p \leq 0.001$) by the fertilizer treatment (Table 3, Figure 9).Between two cropping years, highest total leaf weight was 894.42g in 2nd year for T_3treatment over the T_2 and T_1 compared to T_0treatment. Similarly, lowest total leaf weight was 442.88 g for control treated1st year plant.

Yield of mulberry leaf/ha/yr (Mt)

Leaf yield of mulberry plant was markedly significant ($p \leq 0.001$) by the fertilizer treatments (Table 3, Figure 10).Between the two cropping years the highest total leaf yield was 42.93 Mt in 2nd year plant for T_3 treatment followed by the T_2, T_1 and T_0treatments respectively. The lowest leaf yield was recorded 21.26 Mt in 1st year plant for the co.

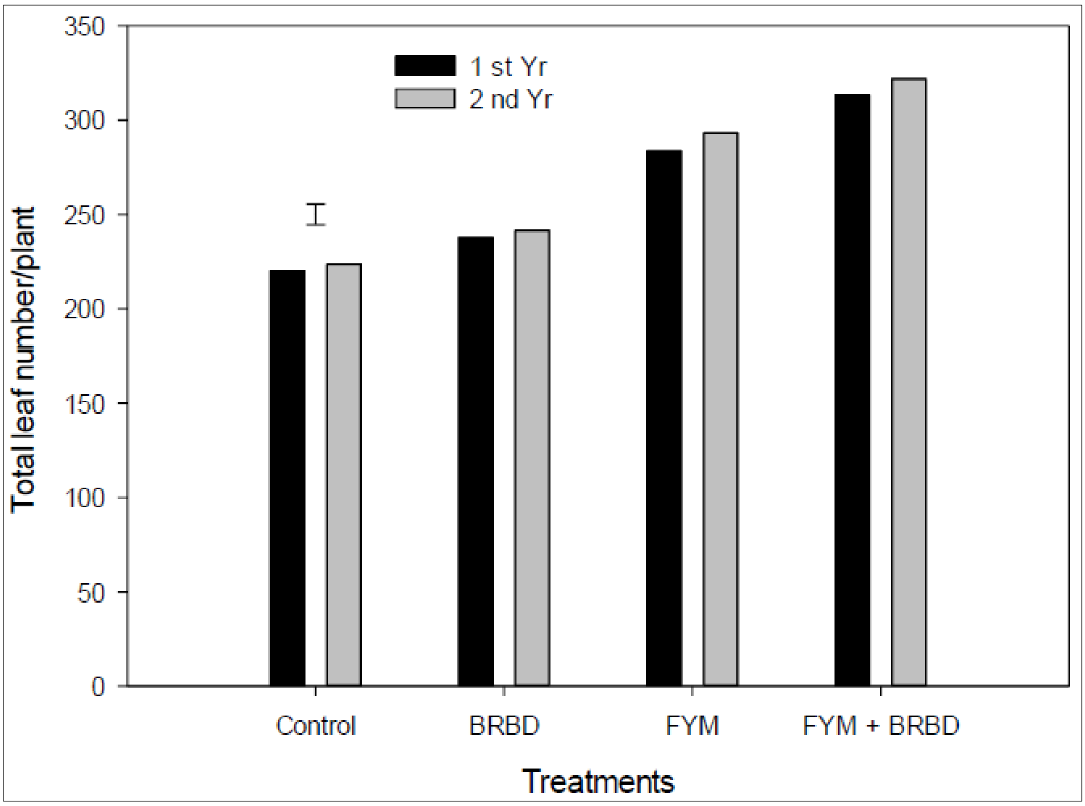

Fig 6: Total leaf number per plant in mulberry plants as influenced by the fertilizer treatments. Where, T_0 = Control, T_1 = BRBD of NPK, T_2 = Only 7 Mt FYM/ha/year and T_3 = 7 Mt FYM/ha/year + BRBD. Vertical bar represent LSD (P= 0.05) different fertilizer treatments and mulberry cropping years interactions

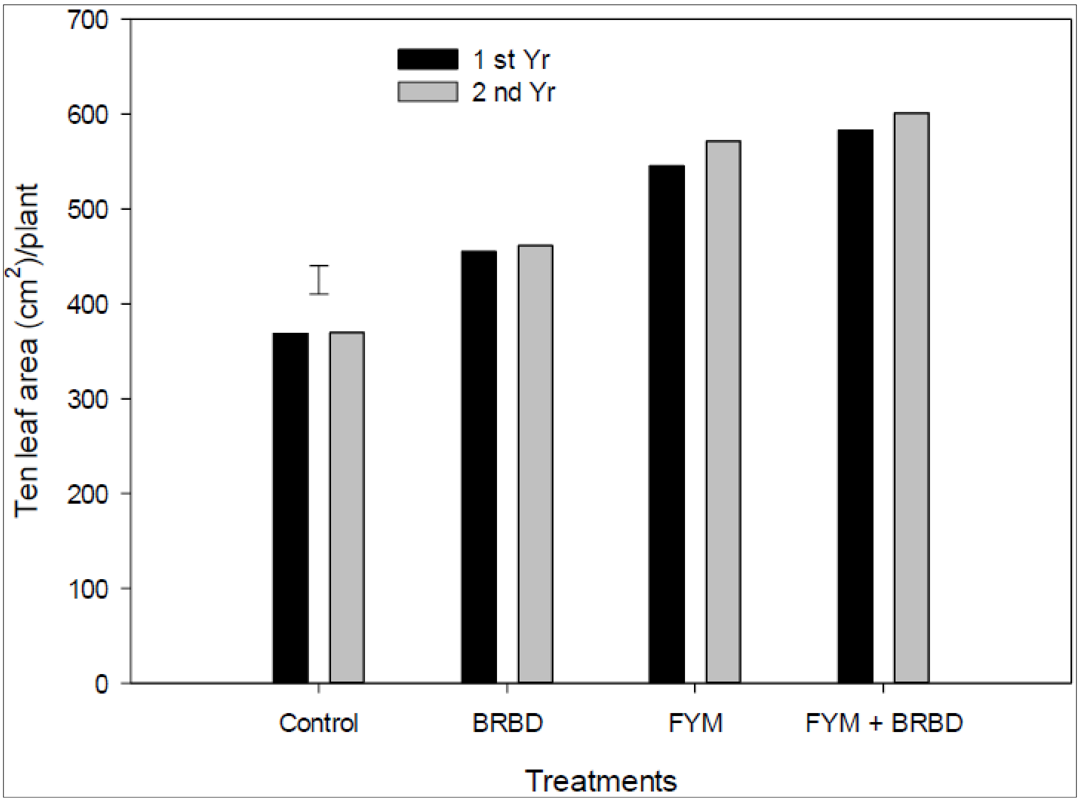

Fig 7: 10 leaf areas per plant in mulberry plants as influenced by the fertilizer treatments. Where, T_0 = Control, T_1 = BRBD of NPK, T_2 = Only 7 Mt FYM/ha/year and T_3 = 7 Mt FYM/ha/year + BRBD. Vertical bar represent LSD (P= 0.05) different fertilizer treatments and mulberry cropping years interactions

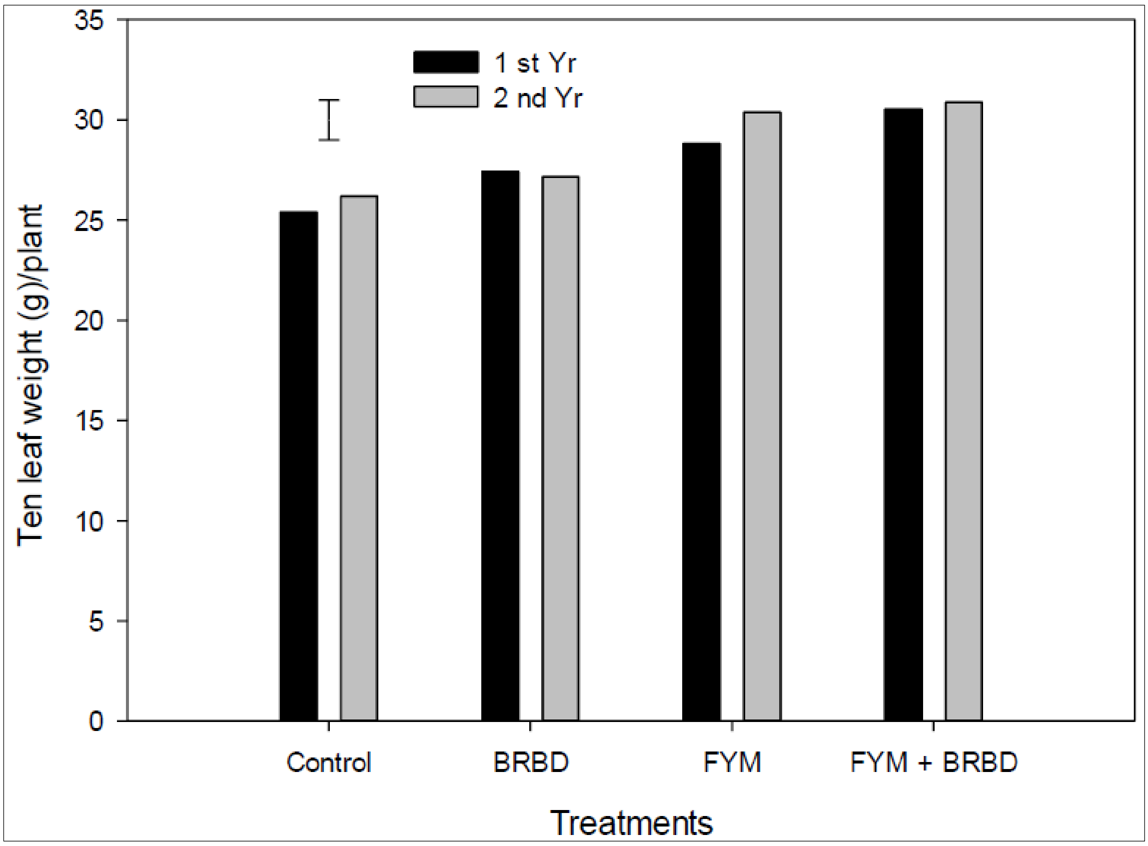

Fig 8: 10 leaves weight per plant in mulberry plants as influenced by the fertilizer treatments. Where, T_0 = Control, T_1 = BRBD of NPK, T_2 = Only 7 Mt FYM/ha/year and T_3 = 7 Mt FYM/ha/year + BRBD. Vertical bar represent LSD (*P*= 0.05) different fertilizer treatments and mulberry cropping years interactions

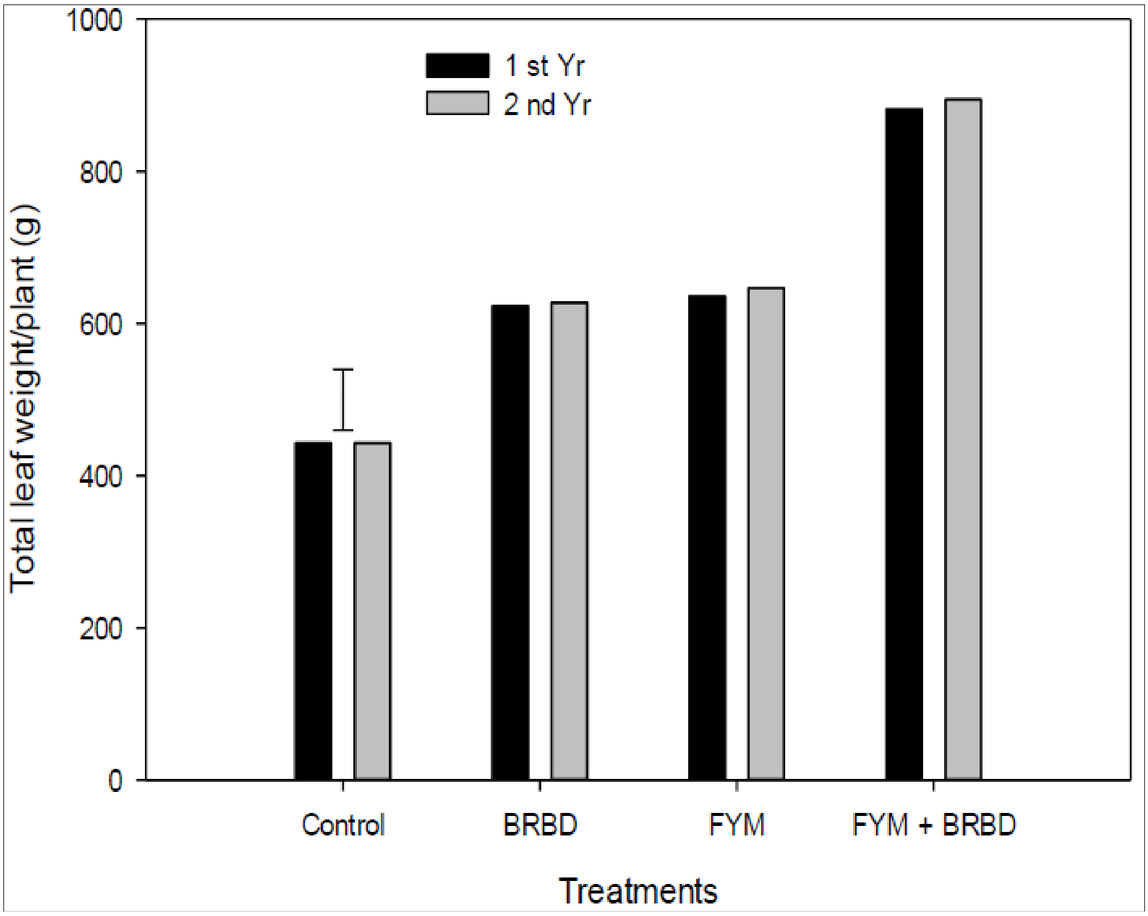

Fig 9: Total leaf weight per plant in mulberry plants as influenced by the fertilizer treatments. Where, T_0 = Control, T_1 = BRBD of NPK, T_2 = Only 7 Mt FYM/ha/year and T_3 = 7 Mt FYM/ha/year + BRBD. Vertical bar represent LSD (*P*= 0.05) different fertilizer treatments and mulberry cropping years interactions

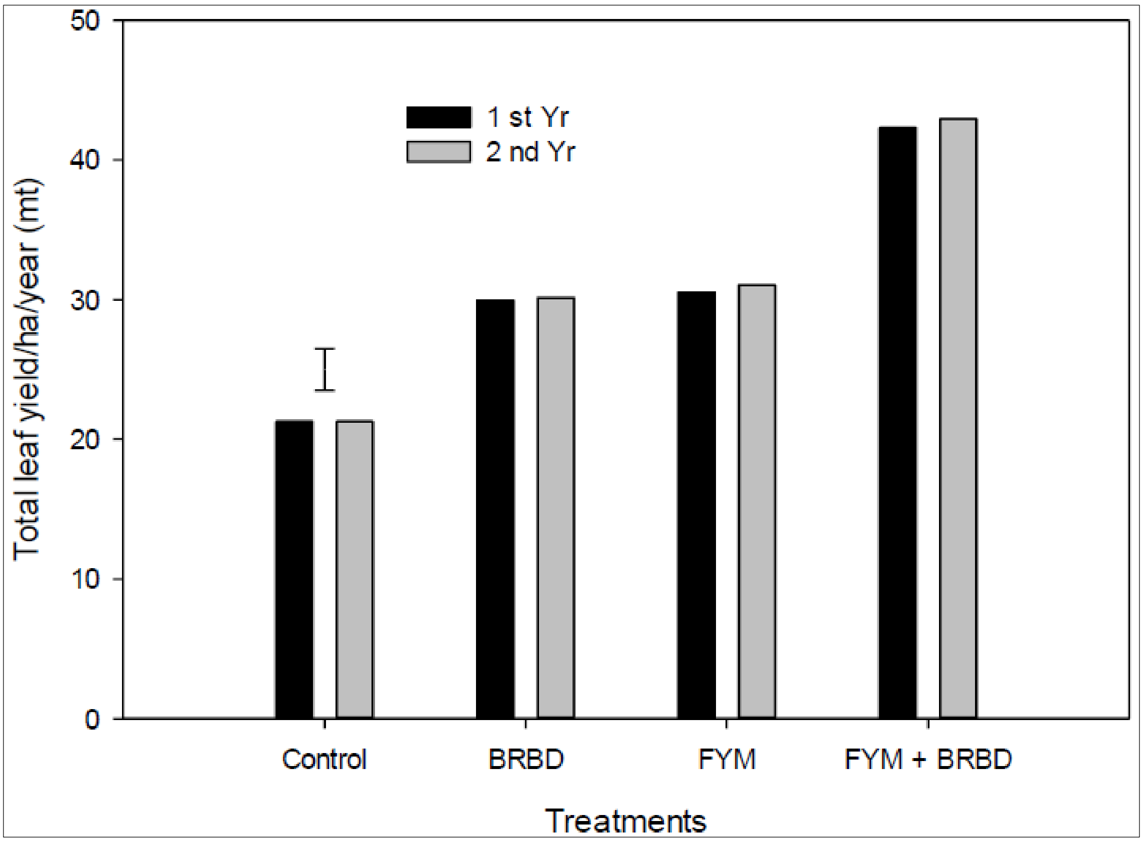

Fig 10: Total leaf yield per hectare per year in mulberry plants as influenced by the fertilizer treatments. Where, T_0 = Control, T_1 = BRBD of NPK, T_2 = Only 7 Mt FYM/ha/year and T_3 = 7 Mt FYM/ha/year + BRBD. Vertical bar represent LSD (*P*= 0.05) different fertilizer treatments and mulberry cropping years interactions

Effect on Leaf Quality of Mulberry

Bio-chemical constituents of mulberry leaf *viz*: moisture, soluble carbohydrate, total chlorophyll, crude protein, mineral and total sugar percentage were significantly improved for the soil applied FYM. But there was no significant changed were found for bio-chemical constituents of mulberry leaf between the cropping years. However, among the four types of fertilizer treatments and between the two cropping years the maximum moisture, soluble carbohydrate, total chlorophyll, crude protein, mineral and total sugar were 73.76%, 8.36%, 3.09 mg/g, 17.44%, 13.86% and 5.38% respectively in 2nd year crop for the treatment of 7 Mt FYM/ha/year + BRBD (T_3) followed by the treatments of T_2 and T_1 compared to control treatment. On the contrary, the minimum moisture, soluble carbohydrate, total chlorophyll, crude protein, mineral and total sugar were 69.30%, 7.36%, 2.46 mg/g, 15.35%, 9.06% and 4.36% respectively in 1st year for the control treatment (Table 4).

Table 4: Effect of FYM on the bio-chemical properties of mulberry leaf

Treatments	Moisture (%)		Soluble Carbohydrate (%)		Total Chlorophyll mg/g		Crude protein (%)		Mineral (%)		Total Sugar (%)	
	1st yr	2nd yr	1st yr	2nd yr	1s tyr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
Control	69.30f	70.11e	7.36 e	7.44e	2.46e	2.52de	15.35d	15.39d	9.06d	9.33d	4.36e	4.44e
BRBD	70.89d	70.93d	7.95d	8.07cd	2.62de	2.68cd	16.38c	16.47c	10.36cd	10.78cd	4.99d	5.05cd
FYM (7 Mt/ha/year)	72.36c	73.00bc	8.17bc	8.22abc	2.83bc	2.85bc	16.84b	16.88b	11.64bc	12.03abc	5.12cd	5.18bc
FYM (7Mt/ha/yr +BRBD)	73.28ab	73.76a	8.31ab	8.36a	2.99ab	3.09a	17.23a	17.44a	13.70ab	13.86a	5.32ab	5.38a

Here, FYM = Farm Yard Manure, T_0 = Control, T_1 = BSRTI recommended basal dose of NPK (BRBD), T_2 = 7 Mt FYM/ha/year, T_3 = 7 Mt FYM/ha/year + BRBD

Effect on Mulberry Foliar Diseases

The soil applied FYM significantly ($P \geq 0.05$) declined the infestation rate of powdery mildew, leaf spot and tukra diseases in mulberry plant. Results showed that among the four types of fertilizer treatments and between two cropping years, the average minimum leaf spot, powdery mildew and tukra diseases infestation rate were 1, 2 and 1.26% respectively in 2nd year plant for T_3 treatment followed by the single application of 7 Mt FYM/ha/yr, BRBD and control treatments respectively. Between the two cropping years the infestation almost of all the three diseases were found at the same level both the 1st year and 2nd year there were no significant different. However, recorded average maximum leaf spot, powdery mildew and tukra incidences (%) were 5.18, 6.18 and 4.66 respectively for control treated mulberry plant (Table 05).

Table 5: Effect of FYM on foliar diseases of mulberry plant

Treatments	Leaf Spot		Powdery mildew		Tukra	
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
Control	4.86a	5.18a	5.86a	6.18a	4.47a	4.66a
BRBD	3.04b	3.58ab	4.04b	4.58ab	3.18b	3.08b
FYM (10 MT/ha/year	2.34bc	2.38bc	3.34bc	3.38bc	1.87c	1.86c
FYM (10 MT/ha/year) + BRBD	1.13c	1.00c	2.13c	2.00c	1.38c	1.26c

Here, FYM = Farm Yard Manure, T_0 = Control, T_1 = BSRTI recommended basal dose of NPK (BRBD), T_2 = 7 Mt FYM/ha/year, T_3 = 7 Mt FYM/ha/year + BRBD

Discussions

FYM Influenced the Physio-Chemical Properties of Soil

Farm yard manure (FYM) has a significant impact on improving the soil properties. Findings showed that among the four types of fertilizer management soli applied FYM significantly increased the organic carbon, N, P, K, Ca, Mg, Na, Mn, Cu and Zn content in soil. The unlike soil pH was considerably reduced for the single applied 7 Mt FYM/ha/yr (T_2) but these values were increased due to the application of only chemical fertilizers (T_1) followed by the combined application of 7 Mt FYM/ha/yr + BRBD (T_3). Similar Devi *et al.*, (2018) [12] found that soil applied 8-10Mt FYM and also the combined dose of 25% inorganic fertilizer plus 8-10Mt FYM/ha/yr significantly reduced the soil pH. Their speculation was the soil applied FYM might be accumulated organic acids from microbial metabolism or produced the fulvic and humic acids through decomposition of organic matter which reduced soil pH. Similarly, Kunj *et al.*, (2018) [20] also found that the soil pH value was 7.40 for combined application of FYM + NPK fertilizer whereas as the pH values were 7.75 and 7.81 respectively due to the compared application of NPK and control treatments respectively. They reported that the applied FYM might be released organic acids and carbon dioxide (CO2) into the soil through decomposition of FYM that would be reduced the soil pH. Our speculation was the soil applied FYM might be produced organic acids through decomposition and mineralization of organic matter that may be helped to condensed the soil pH which was closely relevant with the previous findings (Sing *et al.*, 1980) [45]. They found that for decomposition and mineralization of organic matter from the FYM the soil pH was reduced in FYM treated soil.

Our results showed that the combined dose of 7Mt FYM/ha/yr with BRBD of NPK (T_3) and single dose of 7Mt FYM/ha/yr treated significantly increased the organic carbon content, 3.25% and 2.68% respectively over control (0.30%). These findings were similar with the earlier findings (Kunj *et al.*, 2018) [20]. They reported that the soil applied FYM either alone or in combination with NPK increased the soil organic carbon content in soil 43.1 and

27.5% respectively greater over the NPK and control treated soil respectively. Our experimental results also found that the quantities values of major soil nutrients *viz*: N, P and K were comparatively greater (224.33, 15.43 and 269) respectively in T_3 treated soil followed by the other treatments. These findings were related with the previous result (Devi *et al.*, 2018) [12]. They found that the combined dose of 75% reduced dose of recommended N & P + 8-10 Mt/ha/yr FYM soil content the maximum N (217.36), P (35.06) and K (337.30) kg/ha respectively over the single recommended chemical fertilizers dose of BSRTI. They speculated that the amount of organic carbon in soil was increased could be accredited to better involvement of biomass to the soil in stubble and residues form of FYM as well as organic matter corrosion through microbes. In addition the soil applied FYM could be enhancement physical and chemical properties of soil and also created a better nitrogen-fixing capacity in soil resulting the available N, P and K content in soil was increased. However, our speculation was the mutual application of FYM + NPK provides adequate biomass through increasing the decomposition rate of microbes that may helps enhanced microbial population in the soil in terms numbers of microbes was sustainable increased. Resulting, the soil organic carbon, nitrogen, phosphorus and potassium content were comparatively greater in T_3 treatments among the all treatments. In addition, farm yard manure might be encouraged the biological N2 fixation in soil, which could be responsible for increasing the N and available K content in soil. Besides, alone or combined application of FYM with NPK could be attributed the direct addition of K in soil. Similarly, Kunj *et al.*, (2018) [20] reported that soil applied FYM either alone or in combination with NPK increased P content in soil 33.22% and 52.26% respectively over the control due to biologically release of P during rotting of organic matter or produced organic acids for the organic matter period. The concept was agreed by Devi *et al.*, (2018) [12] and Prabhuraj *et al.*, (2005) [34]. They reported that organic manures might be provided plenty of biomass as a feed source for the soil microbes resulting increasing microbial population rate in soil through application of FYM. Furthermore, the mutual application of FYM with NPK significantly higher population of inoculated phosphate solubilizing microorganism and N-fixing bacteria. Soil micro nutrients *viz*: calcium, magnesium, sodium, manganese, cupper and zinc content were also increased for 7 Mt FYM/ha/yr with BRBD of NPK treated soil over the other treatments (Table 1). Similarly, Pratab *et al.*, (2016) [3]0] found that due to the full doses of RDF (NPK+ZnSO4) + 10 t/ha FYM increased the Zn (0.65 ppm) content in soil compared to control (0.33 ppm). In another study, Zhang *et al.*, (2015) [58] found that the soil micro nutrients *viz*: Iron (Fe), Mn, Cu and Zn were significantly greater for the management of organic matter (straw) + NPK over to the control treatment. The mutual dose of FYM + NPK might be content maximum amount of organic matter and high levels of total and available nutrients as a results its improved the soil microbial population as well as enhanced organic matter decomposition rate, changed the soil structure, the availability of nutrients and decrease the soil pH in terms the soil micro nutrient properties *viz*: calcium, magnesium, sodium, manganese, copper and zinc were increased for T_3 treatment followed by the others treatments. Similarly, Brady *et al.*, (2002) [8] found that if the soil pH is decrease than the availability of soluble plant nutrients calcium, magnesium, sodium, manganese, copper and zinc are increased. Likewise, Mahmood *et al.*, (2017) [23] reported that soil micronutrients availability is increased due to application of organic manures in soil.

Effect of FYM on yield and yield contributing parameters of mulberry: Farm yard manure (FYM) had a great impact on yield and yield contributing characters of mulberry plant (Table 2). The maximum number of nodes per meter, number total branches, total branch heights, weight of total shoots, longest shoot heights, number total leaf, 10 leaves area, weight of 10 leaves, weight of total leaves per plant and leaf yield per hectare per year were obtained for the treatment of T_3 followed by the T_2, T_1 and T_0treatments respectively. However, the recorded higher leaf yield was 42.93 Mt/ha/year for T_3 treatment which was 38.39%, 42.25% and 101.93% respectively greater than the single application of 7 Mt FYM/ha/year (T_2), BRBD of NPK (T_1) and control (T_0) treatments treated plots respectively. This result was similar with the earlier finding (Ram *et al*., 2017) [37]. They reported that the combined application of 5mt/ha FYM + 2 Mt/ha press mud treated mulberry plot showed the maximum number of shoots per plant, length of the total shoots, number of total leaves per plant and total leaf yield per year. In the same way, Chowdhury *et al*., (2009) [10] found that the mulberry plot treated by the 20 Mt FYM/ha/year plus N336:P2O180:K2O112 kg per hectare per year produced higher branches per plant, plant height, leaf area and yield of leaf/kg/ha/crop compared to the control treatment. Ranadive *et al*., (2011) [38] also found the maximum leaves weight and leaf area for farmyard treated mulberry plants and he also showed that the leaves weight was positively correlated with the dose (1.98 g to 2.98 g) of farmyard manure.

The applied FYM + inorganic fertilizers might be supplied sufficient amount of essential plant nutrients in available form through proper or balanced rottenness, mineralization and solubilizing of organic matter. Resulting, improved the soil physical properties as well as enhanced the nutrients uptake capacity by the plants subsequently growth and establishment of mulberry plant was comparatively better for T_3 treated mulberry plant. So the mulberry plant productivity was optimum for T_3 treated plot followed by the T_2 and T_1treated plant compared to control (T_0). Our speculation was aggregated with the previous findings (Shankar, 1990; Krishna *et al*., 2001; Setua *et al*., 2002; Kunj *et al*., 2018) [43, 21, 44, 20]. They reported that organic manure (FYM) has a potential effect on growth and yield contributing characters of mulberry plant through balanced nutrient management as well as enhancing the appropriate nutrient decomposition, mineralization, solubilizing and increasing the nutrients availability rate in soil.

FYM influenced the leaf quality of mulberry plant

The analyzed nutritional data of mulberry leaf reveals that, the higher moisture content (773.76%), soluble carbohydrate (8.36%), total chlorophyll (3.09 mg/g), crude protein (17.44%), mineral (13.86%) and total sugar (5.38%) was for T_3 treated mulberry plant. Besides, application of only the 7Mt FYM/ha/year (T_2) also performed better as compared to BRBD of NPK (T_1) and control (T_0). Interestingly, the soluble carbohydrate and mineral percentage were slightly higher in treatment (T_3) compared to T_2 treatment but there was no significant different. But the moisture content, total chlorophyll, crude protein and total sugar percentage were significantly increased in T_3 treatment than the others. This finding was similarly with the earlier results (Ram *et al*., 2017) [37]. They reported that the mutual application of 5mt FYM/ha with 1 Mt press mud/ha gave the higher 76.84% moisture, 1.67 mg/g total chlorophyll, 25.78 mg/g total soluble protein and 34.85 mg/g total soluble sugar among the all treatments. Likewise, Umesha *et al*., (2014) [52] found that the application of (50% of Rec. FYM) plus FYM (50% of Rec. FYM) plus N-biofertilizer plus P-biofertilizer plus 200N plus 110P plus 140 K kg/ha/yr showed better leaf moisture followed by sheep manure (Equivalent to 50% of Rec. FYM) plus FYM (50% of Rec. FYM) plus N-biofertilizer plus P-biofertilizer plus 200N plus 110P plus 140 K kg/ha/yr and over the control treatment. In our study the moisture% was greater may be due to the more moisture absorption and increased the soil fertility status for 7 Mt FYM/ha/year + BRBD (T_3) treated soil that was similar with previous result (Rao *et al*., 2011) [35]. They reported that organic manures (FYM) might been enhancement the organic matter and water holding capacity of soil thereby, absorption of water by the plant as well as the leaf was increased. Rao *et al*., (2011) [35], also found that the combined application of FYM with chemical fertilizer increased the amount of total chlorophyll content in mulberry leaf.

In our study the amount of total chlorophyll content in mulberry was increased might be due to additional application of N as a basal dose along with 7 Mt FYM/ha/yr improved the photosynthesis rate among the all treatments. In terms, the total chlorophyll content was greater for T_3 treated mulberry plant. This finding was conformity by the Singhal *et al*., (2000) [46] who reported that nitrogen as an essential component of photosynthesis that plays a greater role in improving the chlorophyll combination. Umesha *et al*., (2014) [52] also found that the application of (50% of Rec. FYM) plus FYM (50% of Rec. FYM) plus N-biofertilizer plus P- biofertilizer plus 200 N plus 110 P plus 140 K kg/ha/yr treated mulberry garden statistically more total sugar content followed by sheep manure (Equivalent to 50% of Rec. FYM) plus FYM (50% of Rec. FYM) plus N-biofertilizer plus P-biofertilizer plus 200 N plus 110 P plus 140 K kg/ha/yr and over to control treated plot. They speculated that the applied (50% of Rec. FYM) plus FYM (50% of Rec. FYM) plus N-biofertilizer plus P- biofertilizer plus 200 N plus 110 P plus 140 K kg/ha/yr might be improved mineralization process resulting enhanced the production of growth elements and enzymatic activities which could been enriched total sugar content in mulberry leaf. Similarly, Rashmi *et al*., (2009) [39] also found that the total sugar percentage in mulberry leaf was increased due to the mutual doses of chemical fertilizers + FYM. In another study Devi *et al*., (2018) [12] found that the protein and Carbohydrate content percentage were highly significant for the doses of 8-10 Mt FYM/ha/year. However, in our study, the protein and carbohydrate content were higher in T_3 treated mulberry plot could be the combined doses of 7Mt FYM/ha/year + BSRTI recommended basal dose of NPK (T_3) content maximum amount of organic matter, essential plant nutrients in accessible forms that may enhanced the proper organic matter decomposition rate and sufficient uptake of nutrients in balanced proportion by the T_3 treated mulberry plant.

FYM Reduced the Foliar Diseases of Mulberry Plant

Farmyard manure significantly reduced the infestation of foliar diseases *viz*: leaf spot, powdery mildew and tukra of mulberry plant. The experimental results represent that among the four types of fertilizer treatments the lowest incidence of leaf spot, powdery mildew and tukra was for T_3 treated mulberry plant over the control (T_0). Analysis of variance revealed that the leaf spot, powdery mildew and tukra diseases severity were 71.33, 67.64 and 72.96 percentages respectively low in 7 Mt FYM/ha/yr + BRBD of NPK (T_3) treated mulberry plant followed by the control treated plant. However, the incidence of all the three foliar diseases in T_3 treated plant was more or less similar with only the 7 Mt FYM/ha/yr (T_2) treated plants. This finding was comparable with the previous results (Maji *et al.*, 2013) [24]. They recorded the powdery mildew and leaf spot infestation percentage were 4.47 and 4.40 respectively due to combined application of 20 Mt/ha/yr FYM + (336 N: 180 P: 112 K kg/ha/yr) in mulberry garden. However, in case of control treatment the powdery mildew and leaf spot incidence % was 10.06 and 15.22 respectively. They speculated that their applied combined dose of FYM + NPK might be enriched soil valuable myco flora and provide of nutrient for vigorous growth of plant that could be convey forth resistance against the powdery mildew and leaf spot. Similarly, Ranadive *et al*., (2011) [38] found that the infestation of fungus population was reduced due to the soil applied farmyard manure. Tukra incidence cause by mealy bug (*Maconellicoccus hirsutus*) was also significantly reduction due to the same fertilizer management. The maximum incidence percentage was 4.47 in control treatment which was 71.81% greater than the 7 Mt FYM/ha/yr + BRBD of NPK treated mulberry plant. Samuthiravelu *et al.*, (2012) [41] found that the average infestation of mealy bug, pest of tukra disease was lowest for the treatment of organic fertilizer (Panchakavya 10%) that was closely related with our experimental results. However, the occurrence of foliar diseases *viz*: leaf spot, powdery mildew and tukra were significantly reduction in FYM treated mulberry plant may be due to farmyard manure contain more amount of organic nutrients essential for microbes and plant growth, phenolic compound which enriched beneficial bacterial population which improved the successive growth and establishment of mulberry plant as well as stimulation of systemic conflict aligned with the fungal pathogen.

Thus the collective applied 7 Mt FYM/ha/yr + BRBD of NPK in mulberry garden suppresses the foliar diseases incidence in mulberry garden.

Effect of Cropping Year on Soil, Leaf Productivity, Leaf Quality and Foliar Diseases of Mulberry Plant

In respect of application duration of farm yard manure (FYM) the soil physio-chemical properties were some extent to vary in soil. Our experimental results showed that most of the soil physiochemical properties *viz*: N, P, K, Ca, Mg, Na, Mn, Cu and Zn except soil pH were to some extent increased in 2nd year due to amendment of FYM +NPK. The recorded maximum soil pH was 8.2 in 1st year for control treatment but the minimum pH was 7.71 in 2nd year for T_2 treatment that was statistically parallel with the treatment value 7.84 of T_3 treatment in 2nd year. However, in 2nd year the soil pH was 5.97% reduced in soil treated by the only 7 Mt/ha/yr FYM over to the control treatment. The maximum nitrogen content was recorded in 2nd year soil for T_3 treated soil which was statistically similar with the T_2 and T_1 respectively treated soil of 1st year (Table 1). The maximum OC, N, P, K, Ca, Mg, Na, Mn, Cu and Zn was recorded in 2nd year soil for T_3 treated plot which was 0.62%, 12.35%, 0.85%, 0.75%, 0.37%, 3.08%, 18.18%, 17.39%, 0.36% and 0.30% respectively greater than the 1st year soil for the same treatment. The similar trend was observed (Malle *et al*., 2017) [25] who found that in 2008 the P, K and Mg content in soil were 195, 140 and 64 mg/kg respectively but in 2014 the P, K and Mg content in soil were 210, 152 and 99 mg/kg respectively for soil applied FYM and also the organic carbon content was enlarged also for the use of FYM with respect to application duration. Likewise, Musaida *et al*., (2013) [28] also showed that increasing the organic matter use duration, the P content was increased by more than 80 ppm; K content was increased by more than 14 ppm and Cu content in were increased 8.0 ppm in soil. Because, P does not exist in elementary form and most of the P was insoluble in the organic compost (FYM) and unavailable to the soils and plants but increase of K due to the good nutrient absorbing properties of clay-loam soil and the micro-organisms in the FYM reloaded the soil with more K ions which hence the K increased in soil. Similarly, increased the soil Cu content due to increase the organic matter which resulted in improved soil aeration and soil microbial activity. As the FYM was applied both in1st year and 2nd year soil the total applied quantity of organic material was increased as well as the activities of soil micro-organisms was abundant in 2nd year soil than the 1st year soil in terms of the Zn and Mn content increased because FYM is a rich organic material which is similar with earlier result (Mortvedt, 2000) [29]. He found that the presence of organic material in the soil increased the micro- organisms activities as well as improved the soil aeration due to the movement thereby increasing Zn and Mn content avail ability in soil. However, with the respect of application duration FYM may be promoted the steady and slow release of nutrients in the soil and the combined application of inorganic NPK with FYM as a basal dose for each year the overall soil nutrients quality *viz*: OC, N, P, K, Ca, Mg, Na, Mn, Cu and Zn was comparatively increased in 2nd year than the 1st year soil.

The mulberry plant productivity parameters were showed the diverse responses between the cropping years due to soil applied farmyard manure. Between the two cropping years the markedly indicated growth and yield contributing parameters were recorded in 2nd year for the T_3 treatment followed by the T_2, T_1 and T_0 treatment respectively. Similarly, the leaf quality parameters *viz*: moisture, soluble carbohydrate, total chlorophyll, crude protein, mineral and total sugar were also 0.65%, 0.60%, 3.34%, 1.22%, 1.17% and 1.13% respectively greater in 2nd year mulberry leaf than the 1st year mulberry leaf also for the same fertilizer management. It may be due to the reasons that with respect of farm yard manure application duration with inorganic NPK the decomposition of organic matter, microbial diversity and populations of micro-organisms, soil physio-chemical properties, soil water holding capacity, soil fertility status, release of plant nutrients (Macro and micro) in soil as well as the availability of soluble macro and micronutrients might be improved in 2nd year soil than the 1st year soil. Thus the essential plant nutrients and growth regulators uptake by the 2nd year mulberry plant was sufficient quantity and balanced proportion resulting the growth, development and establishment of mulberry plant was healthier in 2nd year than the 1st year in terms the growth and leaf yield as well as the leaf quality parameters *viz*: moisture (%), soluble Carbohydrate (%), total Chlorophyll (mg/g), crude protein (%), mineral (%) and total sugar % were slightly increased in 2nd year crop than the 1st year crop.

The incidence of foliar diseases in mulberry plant was comparatively reduced with respect to application duration of farm yard manure. The occurrence of leaf spot, powdery mildew and tukra were observed in two different cropping years. The results showed that increasing the FYM application duration the intensity of mulberry foliar diseases *viz*: leaf spot, powdery mildew and tukra were reduced from 1st year to 2nd year. Between the two cropping years the infestation of leaf spot, leaf rust and tukra diseases were slightly reduced in 2nd year for both the T_3 and T_2treatment respectively. However, the maximum frequency percentage of leaf spot, powdery mildew and tukra diseases were 5.18, 6.18 and 4.66 respectively in 2ndyear for control treatment, whereas the minimum incidence percentage were 1.00, 2.00 and 1.26 in 2nd year crop which was 11.50%, 6.10% and 8.69% respectively reduced in 2nd year than the 1st year crop for the treatment of T_3. But the infestation of leaf spot, powdery mildew and tukra were 80.69, 67.64 and 72.96 percentage reduced in 2nd year for T_3 treatment when it compared with the incidence percentage of 2ndyear for the control treatment. The reduction of foliar diseases in mulberry plant with the respect of FYM application duration could be due to the slow breakdown and slow discharge of organic matter essential for microbes, phenolic compounds and plant growth regulators as well as production of maximum various growth substances or hormones by the applied FYM + inorganic NPK in 2nd year soil than 1st year. Thus the applied FYM + BRBD of NPK make resistance against the fungal pathogens as well as the mealy bug pest of tukra and reduced the incidence percentage of the mentioned diseases that is similar with previous results of Sharma *et al*., (1994) [42]. Their findings were organic amendments (azotobacter and Azospirillum) with partial application of nitrogen produce various growth substances or hormones which develop the resistance power against the pathogen.

Conclusions

This study revealed that organic amendments (FYM) with inorganic fertilizers (NPK) have sound effect on the production of mulberry and suppression of foliar diseases under field condition. Farm yard manure have contributed the higher mulberry plant productivity with better leaf quality as compared to the single application of recommended NPK dose and thereby trend to improve the fertilizer use efficiency, soil nutrient status as well as reducing the incidence of foliar diseases which subsequently ensure sustainable mulberry production.

Acknowledgements

We gratefully acknowledge the Director of Bangladesh Sericulture Research and Training Institute (BSRTI),
Rajshahi, for providing the experimental field and laboratory services for methodical and physio-chemical analysis. The authors would like to acknowledge both the scientific staff of Bangladesh Sericulture Research & Training Institute and Soil Resources Development Institute (SRDI), Rajshahi, Bangladesh for their assistance concerning the experiment and their precious implication about soil samples collection and analysis.

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