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A study on efficacy of SAR chemicals on biochemical constituents of mulberry leaves

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Abstract
The present investigation revealed that biochemical changes in respect to crude proteins, total carbohydrates, total phenols, total chlorophyll, chlorophyll-a, chlorophyll-b, moisture and ash content also shows significant variation among all the treatments. Further, it is quite clear that crude proteins, total carbohydrates, chlorophyll (a and b), moisture *etc.*, also showed significant increase in healthy leaves when tested with SAR chemicals, whereas total phenols increase with respect to disease intensity among various treatments.

Keywords: disease, healthy leaves, biochemical, chemicals

Introduction
Mulberry trees have been grown worldwide as a crop to rear silkworm for a long time. Mulberry (*Morus* spp.) the sole food plant of silkworm, *Bombyx mori* L. is a perennial crop with diverse genetic base. The intensive cultivation of high yielding varieties under a wide range of agro climatic conditions has made mulberry vulnerable to various plant pathogens (Philip *et al.*, 1994; Teotia and Sen, 1994 and Sukumar and Padma 1989) [1, 2]. It is essential that mulberry leaf should be disease free to increase the productivity and quality of cocoons. Weather situations favour diseases outbreaks leading to 15 to 20% mulberry crop losses and also affect the silk cocoon production too. Among mulberry diseases, leaf spot and powdery mildew are the major foliar diseases of mulberry in Kashmir valley which are the impediments in the production of quality leaf/feed (Khan *et al*., 2004) [4]. The present study was carried out to examine the effect of SAR chemicals on healthy and disease leaves.

Materials and Methods
Biochemical analysis of leaves was done at division of Soil Science and Post Harvest Technology, Shalimar; during 2011 on samples collected randomly from the field 45 and 70 days after pruning.
Leaf chemical analysis was carried out for chlorophyll (mg/g), moisture (%), carbohydrates (%), crude protein (%), ash content (%), phenol (mg/g) and minerals (N, P& K).
Leaf samples collected for analysis were first oven dried at 70°c up to constant weight. These oven dried leaves were then powdered by using mortar and pestle. Only for the estimation of chlorophyll fresh leaf samples were used. Leaf samples were biochemically analysed as per the below mentioned procedures.

Crude proteins
Crude proteins were estimated by Micro Kjeldhal mehod suggested by Jackson (1973) [5].

Total carbohydrates
Total carbohydrates were estimated by using phenol-sulphuric acid method as suggested by Dubios *et al*. (1956) [6].

Total phenols
Estimation of total phenols was carried out with folin-ciocalteu reagent method suggested by Bray and Thorpe (1954) [7].

Chlorophyll
Chlorophyll content was estimated as per method suggested by Arnon (1949) [8].

Moisture (%)

Moisture was determined gravimetrically by taking a sample of 100 g of leaf and oven dried at 70 ºC to a constant weight. Moisture content was determined as per the given formula:

$$\text{Moisture (\%)} = \frac{\text{Fresh weight of leaves - Dry weight of leaves}}{\text{Fresh weight of leaves}} \times 100$$

Ash content (%)

One gram of leaf sample was ignited at 60 ºC to burn off all the organic material. The inorganic material which does not volatize at that temperature is called as ash. It was calculated by using the following formula:

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Estimation of macronutrients (N, P and K)

Estimation of nitrogen

Nitrogen content was estimated by Micro Kjeldhal mehod suggested by Jackson (1973) [5].

Total phosphorus and potassium

Estimated as per the method suggested by Skoog *et al*. (1988) [9].

Results and Discussion

Crude protein (%)

Crude protein content in all treatments differs significantly as depicted in Table 1. The overall protein content was found highest at 45 days after pruning as compared to 70 days after pruning.

At 45 days after pruning protein percentage was highest in healthy leaves (16.12%) which was followed by BABA (15.64%) being statistically at par. They were significantly different from carbendazim 13.36 per cent, INA 13.23 per cent, salicylic acid 13.17 per cent, sodium salicylate 12.82 per cent, calcium chloride 12.65 per cent and ascorbic acid 11.68 per cent which were at par with others. Minimum protein content was assessed in EDTA 10.97 per cent and was at par with diseased leaves (9.96%).

Highest increase in protein content was observed in healthy leaves (61.10%) followed by BABA (56.98%), INA (32.75%), salicylic acid (32.15%), sodium salicylate (2.63%), calcium chloride (29.92%), ascorbic acid (17.23%) whereas minimum increase in protein content was observed in EDTA (10.07%).

Table 1: Effect of SAR chemicals on per cent disease intensity and per cent disease control (70 days after pruning) under field conditions

Treatment		Conc. (mg/ml)	70 days after pruning			
Treatment code	Chemical		2011	2012	Pooled	Per cent disease control
T_1	Salicylic acid	1.5	15.42 (4.05)	16.75 (4.21)	16.0 (4.13)^b	56.50
T_2	Isonicotinic acid	2.0	14.39 (3.92)	16.68 (4.20)	15.53 (4.06)^b	58.01
T_3	Calcium chloride	10	19.70 (4.55)	21.43 (4.73)	20.57 (4.64)^d	44.39
T_4	Ascorbic acid	3.0	19.32 (4.50)	22.60 (4.85)	20.96 (4.68)^d	43.33
T_5	Ethylene diamine tetra acetic acid	1.0	20.46 (4.63)	22.81 (4.87)	21.63 (4.75)^d	41.52
T_6	Sodium salicylate	2.0	16.47 (4.17)	18.00 (4.35)	17.23 (4.26)^c	53.41
T_7	β-amino butyric acid	2.0	7.84 (2.97)	10.59 (3.40)	9.21 (3.18)^a	75.10
T_8	Check (Carbendazim 50% WP)	0.5	8.77 (3.12)	9.81 (3.28)	9.29 (3.20)^a	74.88
T_9	Control (Distilled water sprayed leaves)	-	35.64 (6.05)	38.34 (6.27)	36.99 (6.16)^e	-
	CD ($p \leq 0.05$)	-	0.208	0.214	0.143	-

Figures in parentheses are square root transformed values

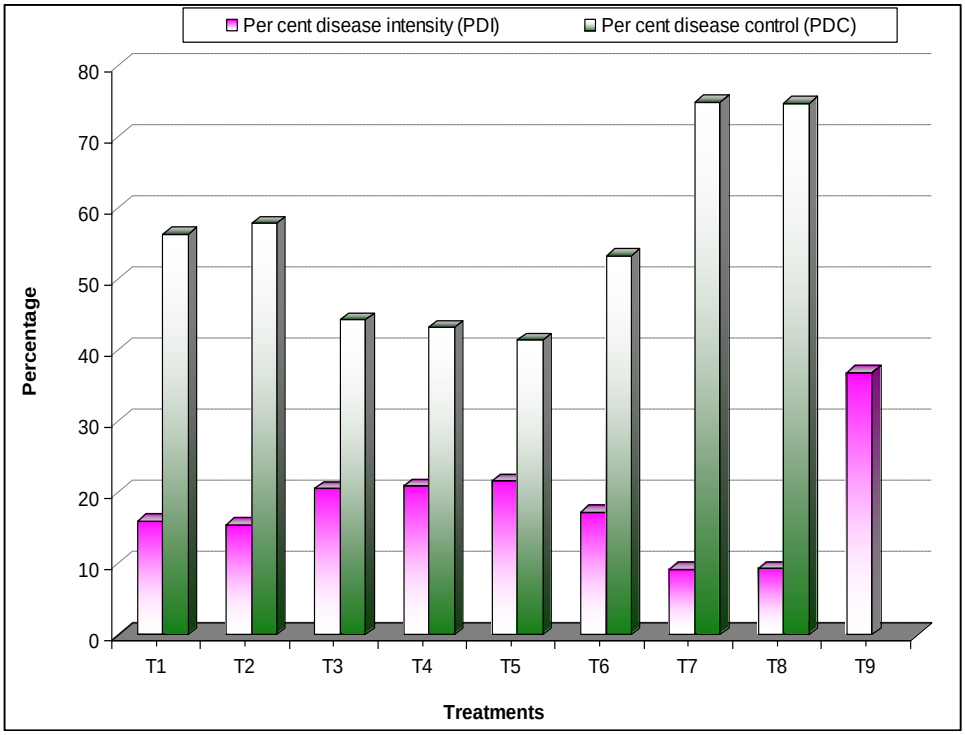
Figures superscripted with identical letter(s) do not differ significantly

Table 2: Effect of SAR chemicals on protein content in the leaves of mulberry (*Morus* spp.)

Treatments	Protein (%)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	13.17 (3.76)^b	32.15	10.94 (3.45)^b	38.03
Isonicotinic acid	13.23 (3.77)^b	32.75	11.27 (3.50)^b	42.28
Calcium chloride	12.65 (3.70)^b	26.93	10.08 (3.33)^b	27.22
Ascorbic acid	11.68 (3.56)^b	17.23	9.64 (3.26)^c	21.67
Ethylene diamine tetra acetic acid	10.97 (3.46)^c	10.07	8.70 (3.11)^c	9.81
Sodium salicylate	12.82 (3.72)^b	28.63	10.49 (3.39)^b	32.44
β-amino butyric acid	15.64 (4.08)^a	56.98	14.82 (3.98)^a	87.13
Check (Carbendazim 50% WP)	13.36 (3.79)^b	34.10	11.92 (3.59)^b	50.45
C-1 (Healthy leaves)	16.12 (4.14)^a	61.70	15.30 (4.04)^a	93.18
C-2 (Diseased leaves)	9.96 (3.31)^c	-	7.92 (2.98)^d	-
CD ($p \leq 0.05$)	0.238	-	0.266	-

*Figures in parentheses are square root transformed values

** Figures Superscripted with identical letter(s) do not differ significantly



T_1 = Salicylic acid; T_2 = Isonicotinic acid; T_3 = Calcium chloride; T_4 = Ascorbic acid; T_5 = Ethylene diamine tetra acetic acid; T_6 = Sodium salicylate; T_7 = β-amino butyric acid; T_8 = Check (Carbendazim 50% WP); T_9 = Control (Distilled water sprayed leaves)

Fig 1: Effect of SAR chemicals on per cent disease intensity and per cent disease control (70 days after pruning) under field conditions

At 70 days after pruning highest protein content was recorded in healthy leaves (15.30%) followed by BABA (14.82%) and were statistically at par with each other. They were followed by carbendazium (11.92%), INA (11.27%), salicylic acid (10.94%), sodium salicylate (10.49%), calcium chloride (10.08%) and were all statistically at par. They were followed by ascorbic acid (9.64%), EDTA (8.70%) and were statistically at par whereas minimum protein content was recorded in diseased leaves (7.92%).

Highest increase in protein content at 70 days after pruning was observed in healthy leaves (93.18%) followed by BABA (87.13%), carbendazim (50.45%), INA (42.28%), salicylic acid (38.03%), sodium salicylate (32.44%), calcium chloride (27.22%), ascorbic acid (21.67%) whereas minimum increase in protein content was observed in EDTA (9.81%).

Total carbohydrate (%)

Total carbohydrate content in all treatments differs significantly as presented in Table 2. The overall total carbohydrate content was found highest at 45 days after pruning compared to 70 days after pruning.

At 45 days after pruning the total carbohydrate percentage ranged from 10.50 to 16.14 per cent (Table 12). Highest carbohydrate content was observed in healthy leaves (16.14%) which was followed by BABA (14.83%) being statistically at par. They were statistically significant from carbendazim (14.82%),

Table 2: Effect of SAR chemicals on carbohydrate content in the leaves of mulberry (*Morus* spp.)

Treatments	Carbohydrate (%)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	14.59 (3.95)^{b}	38.91	14.23 (3.90)^{c}	45.34
Isonicotinic acid	14.78 (3.97)^{b}	40.79	14.33 (3.91)^{b}	46.36
Calcium chloride	14.10 (3.88)^{b}	34.28	13.63 (3.82)^{d}	39.21
Ascorbic acid	12.83 (3.72)^{c}	22.22	12.70 (3.70)^{e}	29.68
Ethylene diamine tetra acetic acid	12.48 (3.67)^{c}	18.86	12.30 (3.65)^{e}	25.60
Sodium salicylate	14.35 (3.91)^{b}	36.63	14.00 (3.87)^{c}	42.96
β-amino butyric acid	14.83 (3.98)^{a}	41.27	14.73 (3.97)^{b}	50.44
Check (Carbendazim 50% WP)	14.82 (3.98)^{b}	41.11	14.53 (3.94)^{b}	48.40
C-1 (Healthy leaves)	16.14 (4.14)^{a}	53.71	15.60 (4.07)^{a}	59.30
C-2 (Diseased leaves)	10.50 (3.39)^{d}	-	9.79 (3.28)^{f}	-
CD ($p \leq 0.05$)	0.162	-	0.056	-

*Figures in parentheses are square root transformed values

** Figures Superscripted with identical letter(s) do not differ significantly

INA (14.78%), salicylic acid (14.59%), sodium salicylate (14.35%) and calcium chloride (14.10%) which was at par with each other. They were followed by ascorbic acid (12.83%) and EDTA (12.48%) being statistically at par. Minimum carbohydrate content was observed in diseased leaves (10.50%).

Highest increase in carbohydrate was observed in healthy leaves (53.71%) followed by BABA (41.27%), carbendazim (41.11%), INA (40.79%), salicylic acid (38.91%), sodium salicylate (36.63%), calcium chloride (34.28%), ascorbic acid

(22.21%) whereas minimum increase in carbohydrate content was observed in EDTA (18.86%).

At 70 days after pruning highest carbohydrate content was recorded in healthy leaves (15.60%). It was followed by BABA (14.73%), carbendazim (14.53%), INA (14.33%) and were statistically at par. They were followed by salicylic acid (14.23%) and sodium salicylate (14.00%) being statistically at par. They were followed by calcium chloride (13.03%), ascorbic acid (12.70%) and EDTA (12.30%) and minimum carbohydrate content was observed in diseased leaves (9.79%).

Maximum increase in carbohydrate content was observed in healthy leaves (59.30%) followed by BABA (50.44%), carbendazim (48.40%), INA (46.36%), salicylic acid (45.34%), sodium salicylate (42.96%), calcium chloride (39.21%), ascorbic acid (29.68%) and minimum increase was observed in EDTA (25.59%).

Total phenol content (mg/g)

Total phenol content in all treatments differed and varied significantly as depicted in Table 3. The overall total phenol content was observed highest at 70 days after pruning as compared to 45 days pruning.

At 45 days after pruning the phenol content was minimum in healthy leaves (73.33 mg/g) followed BABA (79.00 mg/g) being statistically at par. They were statistically significant from carbendazim (84.33 mg/g), INA (92.00 mg/g) and salicylic acid (92.66 mg/g) and were statistically at par with each other.

Table 3: Effect of SAR chemicals on phenol content in the leaves of mulberry (*Morus* spp.)

Treatments	Phenol (mg/g)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	92.66[b]	21.47	146.33[b]	15.25
Isonicotinic acid	92.00[b]	22.03	143.66[b]	16.80
Calcium chloride	95.33[c]	19.21	152.00[c]	11.96
Ascorbic acid	97.00[c]	17.80	156.66[c]	9.27
Ethylene diamine tetra acetic acid	108.33[d]	8.47	166.00[d]	3.87
Sodium salicylate	94.00[c]	20.34	150.00[c]	13.12
β-amino butyric acid	79.00[a]	33.05	136.83[b]	20.75
Check (Carbendazim 50% WP)	84.33[b]	28.53	137.66[b]	20.27
C-1 (Healthy leaves)	73.33[a]	37.85	82.66[a]	52.12
C-2 (Diseased leaves)	118.00[e]	-	172.66[d]	-
CD ($p \leq 0.05$)	8.978	-	11.988	-

*Figures superscripted with identical letter(s) do not differ significantly

They were followed by sodium salicylate (94.00 mg/g), calcium chloride (95.33 mg/g), ascorbic acid (97.00 mg/g) and EDTA (108.33 mg/g) whereas maximum phenol content was observed in diseased leaves (118.00 mg/g).

Maximum decrease in phenol content was observed in healthy leaves (37.85 mg/g) followed by BABA (33.05 mg/g), carbendazim (28.53%), INA (22.03%), salicylic acid (21.47%), sodium salicylate (20.34%), calcium chloride (19.21%), ascorbic acid (17.80%) and minimum decrease was observed in EDTA (8.47%).

At 45 days after pruning minimum phenol content was observed in healthy leaves (172.66 mg/g). It was found statistically significant from BABA (136.88 mg/g), carbendazim (137.66 mg/g), INA (143.66 mg/g), salicylic acid (146.33 mg/g) and were found statistically at par with others. They were statistically significant from sodium salicylate (150.00 mg/g), calcium chloride (152.00 mg/g), ascorbic acid (156.66 mg/g) whereas maximum phenol content was observed in EDTA (166.0 mg/g) and decreased leaves (172.66 mg/g) and were at par with other.

Minimum decrease in phenol content at 70 days after pruning was observed in EDTA (3.87%) followed by ascorbic acid (9.21%), calcium chloride (11.96%), sodium salicylate (13.12%), salicylic acid (15.25%), INA (16.80%), carbendazim (20.27%) and BABA (20.75%), whereas maximum decrease was observed in healthy leaves (52.12%).

Chlorophyll-a (mg/g)

Chlorophyll-a content in all treatments differs significantly as represented in Table 4. The overall chlorophyll-a was observed highest at 70 days after pruning in all treatments except diseased leaves as compared to 45 days after pruning.

Chlorophyll-a was observed highest in healthy leaves as compared to SAR treated and diseased leaves.

Table 4: Effect of SAR chemicals on chlorophyll-a (mg/g) in the leaves of mulberry (*Morus* spp.)

Treatments	Chlorophyll-a (mg/g)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	0.87[d]	51.84	1.08[c]	126.41
Isonicotinic acid	0.89[c]	55.17	1.11[c]	132.70
Calcium chloride	0.80[f]	38.88	0.95[d]	99.37
Ascorbic acid	0.73[g]	28.72	0.78[e]	63.52
Ethylene diamine tetra acetic acid	0.61[h]	6.13	0.67[f]	40.67
Sodium salicylate	0.84[e]	44.31	1.00[d]	109.64
β-amino butyric acid	0.95[a]	66.90	1.25[b]	162.05
Check (Carbendazim 50% WP)	0.93[b]	62.52	1.15[c]	141.09
C-1 (Healthy leaves)	0.97[a]	69.35	1.27[a]	166.25
C-2 (Diseased leaves)	0.57[i]	-	0.48[g]	-
CD ($p \leq 0.05$)	0.018	-	0.093	-

*Figures superscripted with identical letter(s) do not differ significantly

At 45 days after pruning chlorophyll-a was found highest in healthy leaves (0.971 mg/g) which was followed by BABA (0.951 mg/g), being statistically at par. They were followed by carbendazim (0.930 mg/g), INA (0.89 mg/g), salicylic acid (0.87 mg/g), sodium salicylate (0.841 mg/g), calcium chloride (0.791 mg/g), ascorbic acid (0.73 mg/g) and EDTA (0.61 mg/g), which statistically differ from each other whereas minimum chlorophyll-a content was observed in diseased leaves (0.571 mg/g).

Maximum increase in chlorophyll-a was observed in healthy leaves (69.35%) followed by BABA (66.90%), carbendazim (62.52%), INA (55.16%), salicylic acid (51.83%), sodium salicylate (44.30%), calcium chloride (38.87%), ascorbic acid (28.72%), whereas minimum increase was observed in EDTA (6.12%).

At 70 days after pruning chlorophyll-a content increased with leaf age. Highest chlorophyll-a content was recorded in healthy leaves (1.27 mg/g), INA (1.11 mg/g), salicylic acid (1.08 mg/g), sodium salicylate (1.00 mg/g), calcium chloride (0.951 mg/g), ascorbic acid (0.781 mg/g), EDTA (0.671 mg/g) whereas lowest chlorophyll content was observed in diseased leaves (0.47 mg/g).

Maximum increase in chlorophyll-a content was observed in healthy leaves (166.24%) followed by BABA (162.05%), carbendazim (141.09%), INA (132.70%), salicylic acid (126.41%), sodium salicylate (109.64%), calcium chloride (99.37%), ascorbic acid (63.52%) and minimum increase in chlorophyll-a content was observed in EDTA (63.52%).

Chlorophyll-b (mg/g)

Chlorophyll-b in all treatments differs significantly as represented in Table 5. Chlorophyll-b was observed highest in healthy leaves as compared to SAR treated and diseased leaves.

At 45 days after pruning the chlorophyll-b content ranged from 0.25 to 0.38 mg/g. Highest chlorophyll-b was observed in healthy leaves (0.38 mg/g) which was followed by BABA (0.38 mg/g), carbendazim (0.37 mg/g) and INA (0.36 mg/g) being statistically at par. They were followed by salicylic acid (0.35 mg/g). Salicylic acid statistically differ from calcium chloride (0.33 mg/g) and sodium salicylate (0.33 mg/g) at being at par with one other. They were followed by ascorbic acid (0.32 mg/g), EDTA (0.29 mg/g) whereas minimum chlorophyll-b was observed in diseased leaves (0.26 mg/g).

Table 5: Effect of SAR chemicals on chlorophyll-b content in the leaves of mulberry (*Morus* spp.)

Treatments	Chlorophyll-b (mg/g)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	0.35[b]	38.28	0.39[b]	69.26
Isonicotinic acid	0.37[a]	42.97	0.42[b]	83.12
Calcium chloride	0.33[c]	27.34	0.36[c]	54.11
Ascorbic acid	0.30[d]	19.14	0.32[c]	37.23
Ethylene diamine tetra acetic acid	0.29[d]	15.23	0.28[d]	21.21
Sodium salicylate	0.33[c]	29.30	0.37[b]	60.61
β-amino butyric acid	0.38[a]	48.83	0.49[a]	112.12
Check (Carbendazim 50% WP)	0.37[a]	44.92	0.44[b]	90.91
C-1 (Healthy leaves)	0.38[a]	49.61	0.51[a]	122.07
C-2 (Diseased leaves)	0.26[e]	-	0.23[d]	-
CD ($p \leq 0.05$)	0.021	-	0.071	-

*Figures superscripted with identical letter(s) do not differ significantly

Maximum increase in chlorophyll-b content at 45 days after pruning was observed in healthy leaves (49.60%), carbendazim (44.92%), INA (42.96%), salicylic acid (38.28%), sodium salicylate (29.29%), calcium chloride (27.34%), ascorbic acid (27.34%) whereas minimum increase was observed in EDTA (15.23%).

At 70 days after pruning maximum chlorophyll-b content was observed in healthy leaves (0.51 mg/g), BABA (0.49 mg/g) and are being statistically at par. They were followed by carbendazim (0.44 mg/g), INA (0.42 mg/g), salicylic acid (0.39 mg/g) and sodium salicylate (0.37 mg/g) whereas minimum amount of chlorophyll-b was observed in EDTA (0.28 mg/g) and diseased leaves (0.23 mg/g).

Maximum increase in chlorophyll-b at 70 days after pruning was observed in healthy leaves (122.07%) followed by BABA (112.12%), carbendazim (9.90%), INA (83.11%), salicylic acid (69.26%), sodium salicylate (60.60%), calcium chloride (54.11%), ascorbic acid (37.22%) and minimum increase was recorded in EDTA (21.21%).

Total chlorophyll (mg/g)

Perusal of data (Table 6) revealed that total chlorophyll content in all the treatments differs significantly.

Table 6: Effect of SAR chemicals on total chlorophyll content in the leaves of mulberry (*Morus* spp.)

Treatments	Total chlorophyll (mg/g)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	1.21[c]	46.31	1.47[c]	107.62
Isonicotinic acid	1.25[b]	51.15	1.53[b]	116.10
Calcium chloride	1.11[d]	34.22	1.30[d]	83.61
Ascorbic acid	1.03[e]	24.55	1.09[e]	53.95
Ethylene diamine tetra acetic acid	0.90[f]	8.95	0.95[f]	34.32
Sodium salicylate	1.17[c]	41.48	1.37[c]	93.50
β-amino butyric acid	1.33[a]	60.82	1.74[a]	145.76
Check (Carbendazim 50% WP)	1.29[b]	55.99	1.59[b]	124.57
C-1 (Healthy leaves)	1.36[a]	64.44	1.79[a]	152.82
C-2 (Diseased leaves)	0.83[g]	-	0.71[g]	-
CD ($p \leq 0.05$)	0.037	-	0.105	-

*Figures superscripted with identical letter(s) do not differ significantly

Overall total chlorophyll content was observed highest at 70 days after pruning in all treatments except in diseased leaves as compared to 45 days after pruning. Total chlorophyll content was observed highest in healthy leaves as compared to SAR treated and diseased leaves. At 45 days after pruning maximum total chlorophyll content was observed in healthy leaves (1.36 mg/g) being statistically at par with BABA (1.133 mg/g) followed by carbendazim (1.29 mg/g) and INA (1.25 mg/g) in turn is being at par. They were followed by salicylic acid (1.21 mg/g) and sodium salicylate (1.17 mg/g) being again at par, followed by calcium chloride (1.11 mg/g), ascorbic acid (1.03 mg/g) and EDTA (0.90 mg/g) whereas minimum total chlorophyll content was observed in diseased leaves (0.83 mg/g).

Maximum increase in total chlorophyll was observed in healthy leaves (64.44%) followed by BABA (60.82%), carbendazim (55.99%), INA (51.15), salicylic acid (46.31%), sodium salicylate (41.48%), calcium chloride (34.22%), ascorbic acid (24.55%) and minimum increase was observed in EDTA (8.95%).

At 70 days after pruning total chlorophyll content was observed maximum as compared to 45 days after pruning. Maximum total chlorophyll was observed in healthy leaves (1.79 mg/g) being at par with BABA (1.74 mg/g), followed by carbendazim (1.59 mg/g) and INA (1.53 mg/g) and they were again at par. They were followed by salicylic acid (1.47 mg/g) and sodium salicylate (1.37 mg/g) were at par, which are followed by calcium chloride (1.30 mg/g), ascorbic acid (1.09 mg/g) and EDTA (0.95 mg/g).

Maximum increase in total chlorophyll was observed in healthy leaves (152.82%) followed by BABA (145.76%), carbendazim (124.57%), INA (116.10%), salicylic acid (107.62%), sodium salicylate (93.50%), calcium chloride (83.61%), ascorbic acid (53.95%) and EDTA (34.32%) respectively.

Moisture content (%)

Perusal of data (Table 7) revealed that moisture content was observed maximum at 45 days after pruning as compared to 70 days after pruning. Moisture content ranged from 62.78 to 73.53 per cent at 45 days after pruning. Maximum moisture content was observed in healthy leaves (73.53%) followed by BABA (72.36%). They are followed by carbendazim (71.38%) and INA (69.51%) and were statistically at par with others. Salicylic acid, sodium salicylate and calcium chloride were also at par with moisture content (68.29, 67.93 and 67.19%, respectively) followed by ascorbic acid and EDTA with 66.27 and 65.53 per cent moisture content. Minimum moisture content was observed in diseased leaves (62.78%).

Table 7: Effect of SAR chemicals on moisture content in the leaves of mulberry (*Morus* spp.)

Treatments	Moisture (%)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	68.29 (55.71)^{c}	8.76	63.69 (52.93)^{b}	16.24
Isonicotinic acid	69.51 (56.46)^{b}	10.72	64.66 (53.50)^{b}	18.00
Calcium chloride	67.19 (55.04)^{c}	7.02	62.08 (51.97)^{b}	13.30
Ascorbic acid	66.27 (54.47)^{d}	5.55	61.31 (51.52)^{c}	11.89
Ethylene diamine tetra acetic acid	65.58 (54.06)^{d}	4.45	58.67 (49.97)^{c}	7.07
Sodium salicylate	67.93 (55.49)^{c}	8.20	62.25 (52.07)^{b}	13.61
β-amino butyric acid	72.36 (58.26)^{a}	15.25	66.40 (54.56)^{a}	21.19
Check (Carbendazim 50% WP)	71.38 (57.37)^{b}	13.70	64.89 (53.65)^{a}	18.43
C-1 (Healthy leaves)	73.53 (59.01)^{a}	17.11	68.02 (55.54)^{a}	24.13
C-2 (Diseased leaves)	62.78 (52.39)^{e}	-	54.79 (47.74)^{d}	-
CD ($p \leq 0.05$)	1.227	-	1.903	-

*Figures in parentheses are angular transformed values

** Figures superscripted with identical letter(s) do not differ significantly

Maximum increase in moisture content was observed in healthy leaves (17.11%) followed by BABA, carbendazim, INA, salicylic acid, sodium salicylate, calcium chloride, ascorbic acid and EDTA with 15.25, 13.70, 16.72, 8.76, 8.20, 7.02, 5.55 and 4.45 per cent increase respectively.

Moisture content decreased with leaf age. At 70 days after pruning maximum moisture percentage was observed in healthy leaves (68.02%) with BABA (66.40%) and carbendazim (64.89%) statistically at par. INA, salicylic acid, sodium salicylate and calcium chloride were also at par with moisture content of 64.66, 63.69, 62.25 and 62.28 per cent respectively. Least moisture content was observed in diseased leaves (54.79%).

Maximum increase in moisture content at 70 days after pruning was observed in healthy leaves (24.13%) followed by BABA (21.19%), carbendazim (18.43%), INA (18.00%), salicylic acid (16.27%), sodium salicylate (13.61%), calcium chloride (13.30%) and minimum increase was observed in EDTA (7.07%) respectively.

Ash content (%)

It is evident from data (Table 8) that the ash increased with leaf age. Ash content is more at 70 days after pruning as compared to 45 days after pruning. Ash increased in healthy leaves as compared to diseased leaves. Maximum ash was observed in healthy leaves (14.10%), BABA, carbendazim, INA, salicylic acid, sodium salicylate and calcium chloride were at par with 12.43, 12.17, 12.06, 11.76 and 11.21 per cent ash content respectively at 45 days after pruning. They are followed by ascorbic acid (10.45%) and EDTA (10.02%) respectively which again at par.

Minimum ash was observed in diseased leaves (9.15%) respectively.

Maximum increase at 45 days after pruning was observed in healthy leaves (54.04%), INA (31.72%), sodium salicylate (28.51%), calcium chloride (22.51%), ascorbic acid (14.20%) and EDTA (9.43%), respectively.

Table 8: Effect of SAR chemicals on ash content in the leaves of mulberry (*Morus* spp.)

Treatments	Ash (%)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	11.82 (3.58)[b]	29.17	12.41 (3.66)[b]	27.86
Isonicotinic acid	12.06 (3.61)[b]	31.72	12.77 (3.71)[b]	31.61
Calcium chloride	11.21 (3.49)[b]	22.51	12.05 (3.61)[b]	24.15
Ascorbic acid	10.45 (3.38)[c]	14.20	11.10 (3.47)[c]	14.36
Ethylene diamine tetra acetic acid	10.02 (3.32)[c]	9.43	10.69 (3.42)[c]	10.13
Sodium salicylate	11.76 (3.57)[b]	28.51	12.30 (3.64)[c]	26.80
β-amino butyric acid	12.43 (3.66)[b]	35.83	13.03 (3.74)[b]	34.25
Check (Carbendazim 50% WP)	12.17 (3.63)[b]	32.92	12.93 (3.730)[b]	33.22
C-1 (Healthy leaves)	14.10 (3.88)[a]	54.04	15.20 (4.02)[a]	56.68
C-2 (Diseased leaves)	9.15 (3.18)[d]	-	9.70 (3.27)[d]	-
CD ($p \leq 0.05$)	0.179	-	0.190	-

*Figures in parentheses are angular transformed values

** Figures superscripted with identical letter(s) do not differ significantly

Similar trend was also observed at 70 days after pruning. Maximum ash was observed in healthy leaves (15.20%) followed by BABA, carbendazim, INA and salicylic acid with 13.03, 12.93, 12.77 and 12.41 per cent ash respectively. They were followed by sodium salicylate, calcium chloride, ascorbic acid and EDTA with 12.30, 12.05, 10.10 and 10.69 per cent ash and were also at par. Minimum ash was observed in diseased leaves (9.70%).

Maximum ash content at 70 days after pruning was observed in healthy leaves (56.68%) followed by BABA, carbendazim, INA, salicylic acid, sodium salicylate, calcium chloride, ascorbic acid and EDTA with 34.25, 33.22, 31.61, 27.86, 26.80, 24.14 and 14.36 per cent increase respectively.

Nitrogen (%)

Nitrogen content differs significantly among all the treatments. Nitrogen content was observed highest at 45 days after pruning as compared to 70 days after pruning (Table 9). Nitrogen decreased in diseased leaves as compared to healthy leaves and SAR treated leaves. Nitrogen ranged (Table 20) from 1.59 per cent in diseased leaves to 2.57 per cent in healthy leaves. It is observed maximum in healthy leaves (2.57%) at par with BABA (2.50%). Carbendazim, INA, salicylic acid, sodium solicylate, calcium chloride and ascorbic acid were at in turn at par with 2.13, 2.11, 2.10, 2.05, 2.02 and 1.86 per cent nitrogen. Minimum nitrogen content was observed in EDTA and diseased leaves (1.75 and 1.59%) and were at par.

Maximum increase in nitrogen content at 45 days after pruning was observed in healthy leaves (61.63%) followed by BABA (57.23%), carbendazim (33.96%), INA (32.70%), sodium salicylate (28.93%), calcium chloride (27.04%) and ascorbic acid (16.98%). EDTA shows minimum increase (10.06%).

Table 9: Effect of SAR chemicals on nitrogen content in the leaves of mulberry (*Morus* spp.)

Treatments	Nitrogen (%)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	2.10 (1.76)[b]	32.07	1.74 (1.65)[b]	38.09
Isonicotinic acid	2.11 (1.76)[b]	32.70	1.80 (1.67)[b]	42.86
Calcium chloride	2.02 (1.73)[b]	27.04	1.61 (1.61)[c]	27.78
Ascorbic acid	1.86 (1.69)[b]	16.98	1.54 (1.59)[c]	22.22
Ethylene diamine tetra acetic acid	1.75 (1.65)[c]	10.06	1.39 (1.54)[c]	10.32
Sodium salicylate	2.05 (1.74)[b]	28.93	1.67 (1.63)[b]	32.54
β-amino butyric acid	2.50 (1.87)[a]	57.23	2.37 (1.83)[a]	88.09
Check (Carbendazim 50% WP)	2.13 (1.77)[b]	33.96	1.90 (1.70)[b]	50.79
C-1 (Healthy leaves)	2.57 (1.89)[a]	61.63	2.44 (1.85)[a]	93.65
C-2 (Diseased leaves)	1.59 (1.77)[c]	-	1.26 (1.50)[d]	-
CD ($p \leq 0.05$)	0.081	-	0.088	-

*Figures in parentheses are angular transformed values

** Figures superscripted with identical letter(s) do not differ significantly

Nitrogen content at 70 days after pruning ranged from 1.26 to 2.44 per cent. Highest nitrogen content was observed in healthy leaves (2.44%) and was at par with BABA (2.37%), followed by carbendazim, INA, salicylic acid and sodium salicylate which were again at par with 1.90, 1.80, 1.74 and 1.67 per cent respectively. Calcium chloride, ascorbic acid and EDITA were having 1.61, 1.54 and 1.39 per cent nitrogen. EDTA shows minimum amount of nitrogen content.

Maximum increase in nitrogen content was observed in healthy leaves (93.65%) followed by BABA (88.09%), INA (42.86%),m salicylic acid (38.09%), sodium salicylate (32.54%), calcium chloride (27.78%), ascorbic acid (22.22%) and EDTA shows minimum increase (10.32%).

Phosphorus (%)

Perusal of data (Table 10) indicates that the phosphorus content decreased with leaf age. At 45 days after pruning phosphorus content was maximum in healthy leaves (0.38%) followed by BABA (0.37%), carbendazim (0.36%) and INA (0.32%). Sodium salicylate and salicylic acid were at par with 0.31 and 0.30 per cent phosphorus respectively. They were followed by calcium chloride, ascorbic acid and EDTA with 0.27, 0.24 and 0.23 per cent phosphorus.

Maximum increase at 45 days after pruning was observed in healthy leaves (72.73%) followed by BABA (68.18%), carbendazim (62.27%), INA (43.64%), salicylic acid (39.09%), sodium salicylate (35.91%), calcium chloride

(22.73%) and EDTA having minimum increase (7.27%).
At 70 days after pruning phosphorus content was maximum in healthy leaves (0.28%) followed by BABA and ascorbic acid having phosphorus content (0.21 and 0.20%). INA and salicylic acid were at par with 0.19 and 18 per cent, followed by sodium salicylate, calcium chloride and ascorbic acid with 0.16, 0.15 and 0.15 per cent phosphorus respectively.

Table 10: Effect of SAR chemicals on phosphorus content in the leaves of mulberry (*Morus* spp.)

Treatments	Phosphorus (%)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	0.31 (1.14)^{e}	39.09	0.18 (1.09)^{c}	70.37
Isonicotinic acid	0.32 (1.147)^{d}	43.64	0.19 (1.09)^{c}	74.07
Calcium chloride	0.27 (1.13)^{f}	22.73	0.15 (1.07)^{d}	41.67
Ascorbic acid	0.24 (1.11)^{g}	7.27	0.15 (1.07)^{d}	37.04
Ethylene diamine tetra acetic acid	0.23 (1.11)^{g}	5.45	0.14 (1.07)^{e}	29.63
Sodium salicylate	0.30 (1.14)^{e}	35.91	0.16 (1.08)^{d}	46.30
β-amino butyric acid	0.37 (1.17)^{b}	68.18	0.21 (1.10)^{b}	98.15
Check (Carbendazim 50% WP)	0.36 (1.16)^{c}	62.27	0.20 (1.10)^{b}	88.89
C-1 (Healthy leaves)	0.38 (1.17)^{a}	72.73	0.28 (1.13)^{a}	156.48
C-2 (Diseased leaves)	0.22 (1.10)^{h}	-	0.11 (1.052)^{f}	-
CD ($p \leq 0.05$)	0.0032	-	0.0054	-

*Figures in parentheses are angular transformed values
** Figures superscripted with identical letter(s) do not differ significantly

Per cent increase in phosphorus content at 70 days after pruning was maximum as compared to 45 days after pruning (Table 20). Maximum increase was observed in healthy leaves (156.48%) followed by BABA (98.15%), carbendazim (88.89%), INA (74.7%), salicylic acid (70.37%), sodium salicylate (46.30%), calcium chloride (41.67%), ascorbic acid (37.04% and EDTA (29.63%).

Potassium (%)

Perusal of data (Table 11) indicates that potassium differs significantly. At 45 days after pruning maximum potassium content was observed in healthy leaves (1.95%), and was at par with BABA (1.86%), carbendazim (1.85%), INA (1.82%), salicylic acid (1.78%) and sodium salicylate (1.77%). Calcium chloride, ascorbic acid, EDTA and diseased leaves with phosphorus content of 1.72, 1.70, 1.70 and 1.56 per cent respectively were in turn at par.

Maximum increase at 45 days after pruning was observed in healthy leaves (24.47%) followed by INA (16.67%), salicylic acid (14.10%), sodium salicylate (13.65%), calcium chloride (10.45%), ascorbic acid (9.17%) and EDTA (8.72%).
At 70 days after pruning phosphorus content was observed maximum in healthy leaves (1.85%). BABA, carbendazim, INA and sodium salicylate were at par with 1.85, 1.83, 1.80 and 1.77 per cent phosphorus respectively. Sodium salicylate (1.68%), calcium chloride (1.66%), ascorbic acid (1.64%) and EDTA (1.57%) were again at par. Minimum phosphorus was observed in diseased leaves (1.28%).
Per cent increase in potassium content was maximum at 70 days after pruning as compared to 45 days after pruning. Maximum increase was observed in healthy leaves (44.76%) followed by BABA (44.22%), carbendazim (43.20%), INA (40.86%), salicylic acid (38.51%), sodium salicylate (31.48%), calcium chloride (29.69%), ascorbic acid (28.36%) and EDTA (22.89%), respectively.

Table 11: Effect of SAR chemicals on potassium content in the leaves of mulberry (*Morus* spp.)

Treatments	Potassium (%)			
	45 days after pruning	Per cent increase	70 days after pruning	Per cent increase
Salicylic acid	1.78 (1.67)^{a}	14.10	1.77 (1.66)^{a}	38.51
Isonicotinic acid	1.82 (1.68)^{a}	16.67	1.80 (1.67)^{a}	40.86
Calcium chloride	1.72 (1.65)^{b}	10.45	1.66 (1.60)^{c}	29.69
Ascorbic acid	1.70 (1.64)^{b}	9.17	1.64 (1.62)^{c}	28.36
Ethylene diamine tetra acetic acid	1.70 (1.64)^{b}	8.72	1.57 (1.60)^{c}	22.89
Sodium salicylate	1.77 (1.66)^{a}	13.65	1.68 (1.64)^{b}	31.48
β-amino butyric acid	1.86 (1.69)^{a}	19.42	1.85 (1.69)^{a}	44.22
Check (Carbendazim 50% WP)	1.85 (1.69)^{a}	18.33	1.83 (1.68)^{a}	43.20
C-1 (Healthy leaves)	1.95 (1.72)^{a}	24.74	1.85 (1.69)^{a}	44.76
C-2 (Diseased leaves)	1.56 (1.60)^{b}	-	1.28 (1.51)^{d}	-
CD ($p \leq 0.05$)	0.058	-	0.030	-

*Figures in parentheses are angular transformed values
** Figures superscripted with identical letter(s) do not differ significantly

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