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Effect of planting geometry and intercropping on growth attributes, leaf yield, quality of mulberry (*Morus alba*) and its economics under irrigated, Gangetic alluvial soil conditions

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ABSTRACT

A field experiment was conducted under irrigated condition to study the effect of planting geometry and intercropping on growth characters, leaf yield and quality in newly evolved, triploid, high yielding, recommended and popular S 1635 mulberry (*Morus alba* L.) along with intercrop yield and additional net profit. The plants were established through saplings in seven different spacing with variable number of plants / ha and were maintained through recommended package of practices for irrigated garden. Four different suitable intercrops, one in each season and one green manure crop in July September were taken up annually in mulberry for judicious utilization of space, time, nutrients and also for soil enrichment.

Significant differences were observed among the treatments in all the parameters studied. Growth attributes and leaf quality were improved along with soil nutrient status in paired row system, particularly in (90cm + 120cm) × 60cm spacing. Besides, it registered almost similar leaf yield (29 488.98kg/ha/year) compared to 60cm × 60cm spacing (control) in spite of 42.9% less plant population (15 873/ha) over control (27 777/ha), higher leaf yield / plant (0.37kg) and optimum intercrop yield as well as additional net profit of ₹35 368/ha/year (₹5974.00 more over control).

Hence, this paired row spacing [(90cm + 120cm) × 60cm] may be useful and recommended to the farmers for mass practice in the cultivation of S 1635 mulberry with four intercrops and one green manure crop / year at least up to three years which did not adversely affect mulberry under irrigated condition. In addition, there is also a scope for partial mechanization which enables to reduce manpower requirement as well as economy in cultivation.

Key words: Economics, Intercropping, Irrigated mulberry, Leguminous green manure, *Morus alba,* Planting geometry

Out of 178 000 ha mulberry plantation in India, West Bengal, being the third silk producing state, has about 11 948 ha mulberry plantation and contributes only 9.6% (1 758.68 million tonnes raw silk production out of 18 370 million tonnes in India) raw silk production in the country during 2008–09 (Anonymous 2009). Sericulture plays a vital role for the development of rural economy, self-employment and reduces migration to urban areas. The major production of raw silk takes place in 35–40% irrigated area of Gangetic alluvial soil conditions of Malda, Murshidabad, Birbhum and Nadia districts of West Bengal. The leaf of mulberry (*Morus alba* L.) is the sole food of silkworm (*Bombyx mori* L.). It is a perennial deep rooted plant, generally cultivated in 60cm × 60cm spacing for under irrigated condition. But the appropriate spacing for newly evolved triploid mulberry S 1635 is not known for its better exploitation when the leaf productivity is at the tune of 35–40 million tonnes/ha/year.

Moreover, due to severe climatic fluctuation in West Bengal, out of five, 2–3 cocoon crops (July, September and at times April) either fail or become unprofitable and show variation in leaf yield in different seasons (Anonymous 2003). In contrast, the leaf production is reduced and becomes scarce during November and February due to low temperature and humidity in winter when it is congenial for silkworm rearing (Anonymous 1990).

Plenty of works done on planting geometry in agricultural crops revealed that wider spacing (60cm × 20cm) increased sweet corn yield, nitrogen uptake, net returns and benefit:cost ratio than conventional system (Kar *et al*. 2006 and Thavaprakaash *et al*. 2005). Ahmad *et al*. (2007) reported that intercropping (cowpea and *Sesbania*) of forage sorghum with legumes at wider spacing (45cm spaced double-row strips with 15cm space between the rows in a strip) contributed

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more production and profit than monocropped sorghum and 30cm × 30cm spacing. Padhi *et al*. (2010) observed that early duration pigeonpea intercropping with finger millet at 2:4 row ratio was found superior in productivity, economics and energy output over other spacing.

In mulberry, few works on planting geometry were reported. Ramakant *et al*. (2001) observed highest leaf yield along with better protein, sugar, N, P and K uptake in S 36 mulberry under paired row system [(90cm+180cm) × 60cm] of plantation in comparison with 60cm × 60cm, 90cm × 90cm, 180cm × 60cm and others, while much wider spacing was found detrimental because of quick drying and cracking of soil. Krishnaswamy *et al*. (1970), Rahaman *et al*. (1999) and Doss *et al*. (2000) opined that wider spacing improved leaf quality, i e protein, sugar, moisture, rearing performances as well as ERR% and digestibility.

But there was no report available on planting geometry required for S 1635 mulberry with suitable intercropping for judicious utilization of space, time and nutrients available towards additional income and to overcome the crop loss. Therefore, the objective of the present study was to ascertain the appropriate planting geometry of newly evolved, triploid, high-yielding, recommended and popular S 1635 mulberry (*Morus alba* L.) with suitable intercropping on growth characters, leaf yield, leaf quality and intercrop yield as well as additional net profit until it adversely affects mulberry.

MATERIALS AND METHODS

The experiment was undertaken during 2007–10 at Berhampore, Murshidabad (West Bengal), under irrigated, Gangetic alluvial soil conditions. The physico-chemical characteristics and nutrient status of soil before and after completion of each year were studied and the references for analytical methods have been cited. The initial soil was sandy loam, *p*H 7.97 (Jackson 1973), EC 0.15 dS/m, and contained available 224 kg/ha nitrogen (Subbiah and Asija 1956), 31kg/ha phosphorus and 378kg/ha potassium (Jackson 1973). Mulberry S1635 (a triploid, high yielding) was established in the following seven different spacing (treatment) in the experimental field in RBD with three replications under irrigated condition (Ullal and Narasimhanna 1987). The seven different treatments (spacings) and plant population/ha in parentheses are:

T_1 (control) : 60 cm × 60 cm (27 777), T_2: 90 cm × 90 cm (12 345), T_3: (90 cm + 150 cm) × 60 cm (13 888), T_4: (60 cm + 120 cm) × 60 cm (18 518), T_5: (60 cm + 150 cm) × 60 cm (15 873), T_6: (90 cm + 120 cm) × 60 cm (15 873) and T_7: (90 cm + 150 cm) × 30 cm (27 778).

The recommended dose of FYM @ 20 million tonnes and NPK @336:180:112kg/ha/year, in five equal splits for mulberry and NPK/ha for respective intercrop [greengram (*Vigna radiata*) var. B1 (seed rate: 12kg/ha and NPK @20:40:20kg)] in May-July, cowpea (*Vigna sinensis*) var. BC1 (seed rate:12kg/ha and NPK @ 25:70:50kg) in September–November. Toria (*Brassica campestris* L. var. *toria* Duth) var. B54 (seed rate: 5kg/ha and NPK @ 50:25:25kg) in November-February and Amaranth leafy vegetable (*Amaranthus blitum* var. *oleracea*) preferably champa notey (seed rate : 2.5kg/ha and NPK@50:50:50kg) in March–April and one green manure crop sunnhemp, (*Crotalaria juncea*) in July–September (seed rate: 25kg/ha and 25kg super phosphate/ha) were applied followed by irrigation. The green biomass of green gram (5 million tonnes/ha) and cowpea (6 million tonnes/ha) after crop harvest and green biomass of sunnhemp (4 million tonnes/ha) were also incorporated in soil.

The data on plant height, no. of branches/plant, no. of leaves/plant, leaf area (Satpathy *et al*. 1992), LAI, leaf-shoot (%), total and per plant leaf yield in mulberry, intercrop yield and weight of green bio-mass of green manure, greengram and cowpea were recorded in all the five seasons (July, September, November, February and April) consecutively for three years. Leaf moisture (oven drying method), photosynthesis (Licor 6200 photosynthetic meter), total chlorophyll (Arnon 1949), total soluble protein (Lowry *et al*. 1951) and total soluble sugar (Morris 1948) were also studied accordingly.

Season-wise as well as three years pooled data were statistically analyzed (Panse and Sukhatme 1967). Analysis of variance was done for five seasons of three consecutive years. The overall mean of each of the seven treatments and critical difference value (P=0.05) for treatments, season × treatment and year × treatment and CV(%) as well as economic gain were calculated.

RESULTS AND DISCUSSION

Effect of planting geometry on soil nutrient status

The overall soil nutrient status was found to be improved after first year of experimentation. Maximum available N was found in T_5 and T_6, followed by T_3 and T_7, P was obtained in T_5 and T_6, followed by T_3 and T_4 and K was found in T_3, followed by T_5. After second year, the available nitrogen and phosphorus content in soil were marginally reduced and potassium content in soil remained almost similar or increased (T_2, T_3 and T_4) over initial status. After third year, the available nitrogen and phosphorus content in soil were marginally reduced over initial status except T_5 which was at par or marginally more in case of phosphorus. Potassium content remained almost similar or increased in T_2, T_3 and T_4 over initial status (Table 1). Year-wise comparison indicated that overall available nitrogen, phosphorus and potassium contents in soil were found to be slightly reduced or remained almost similar in most of the treatments during second and third year over first year which did not reflect in leaf yield. However, year-wise leaf yield was increased in all the treatments (Fig 2).

Table 1 Effect of planting geometry on soil nutrient status

Treatment	Available N (kg/ha)				Available P (kg/ha)				Available K (kg/ha)			
	Initial	I yr	II yr	III yr	Initial	I yr	II yr	III yr	Initial	I yr	II yr	III yr
T_1(c)	224	233	196	190	31	32	21	19	378	390	382	380
T_2		233	205	207		35	19	24		440	448	454
T_3		243	196	199		36	18	22		476	430	435
T_4		233	205	200		36	24	25		394	410	408
T_5		308	196	193		38	30	32		474	376	380
T_6		308	187	182		38	20	23		470	366	369
T_7		243	196	188		35	24	21		444	374	369

Effect of planting geometry on growth attributes, yield of mulberry leaf and intercrops

Three years pooled data revealed that the effect of the treatments was found to be significant on plant height, number of branches/plant, number of leaves/plant and leaf area index (LAI) except leaf area which was at par. Maximum plant height was observed in paired row system of plantation, particularly in T_6, followed by T_5 compared to T_1 and T_7, having almost similar no. of plants. Highest branches/plant was found in T_2, followed by T_6 (paired row) over T_1 and T_7. Maximum number of leaves/plant was obtained in T_2, followed by T_3 over T_1 and T_7. The maximum leaf area was obtained in T_5, followed by T_3 over T_1 and T_7. Maximum LAI was registered in T_1, followed by T_7 over other paired row spacing (Table 2).

The effect of the treatments was found significant on leaf yield, while S × T and Y × T interactions were at par. Maximum leaf yield was registered in T_1, followed by marginally lower leaf yield in T_6, while T_4 registered significantly lower leaf yield over T_2, ie control (Table 2). The result also indicated that the congenial environment influenced maximum leaf production in particular season (July), followed by April, September, November and February which also supported the earlier findings (Anonymous 2003) irrespective of treatments and age of the plants (Fig 1). Maximum leaf yield was registered in July (27%), followed by April (22.07%), September (20.3%), November (19.28%) and February (11.35%).Year-wise leaf yield indicated a significant increasing trend among the treatments which registered 6.09% increase in second year over first year and 22.69% in third year over second year (Fig 2).

It is interesting to note that the effects of the treatments and S × T interaction were found significant on leaf yield/plant (Table 2, Fig 3). Seasonal and year-wise variation in leaf yield/plant were observed, of which it was maximum in July (0.43kg), followed by April (0.35kg), September (0.32kg), November (0.31kg) and February (0.18kg) which correlates the trend of production and increase in leaf yield as a whole in July (42.57%), April (34.86%), September (32.0%), November (30.71%) and February (18.14%) in various seasons as well as in year-wise annual leaf yield of mulberry. In respect of treatments, overall maximum leaf yield/plant was observed in T_2, followed by T_3. However, minimum leaf yield/plant was observed in T_7, followed by T_1

Table 2 Effect of plating geometry on growth attributes, mulberry leaf yield, intercrop yield and net profit (average of three years)

Treatment (no. of plants /ha)	Plant height (cm)	No. of branches/plant	No. of leaves/plant	Leaf area (cm²)	LAI	Leaf yield (million tonnes/ha/year)	Leaf yield (kg/plant)	Intercrop yield (million tonnes/ha/year)	Net profit (₹/ha/ year)
T_1 (control) (27 777)	131.76	7.23	134.72	166.85	6.15	30.76	0.22	9.04	29394
T_2 (12 245)	136.92	9.43	200.18	168.59	4.12	25.42	0.41	11.75	30466
T_3 (13 888)	137.38	8.95	182.75	174.10	4.35	26.42	0.38	10.92	37211
T_4 (18 518)	132.19	8.08	147.24	168.79	4.56	27.68	0.30	10.93	42040
T_5 (15 873)	139.48	8.43	160.19	177.94	4.45	26.77	0.34	10.73	37089
T_6 (15 873)	140.30	9.04	176.03	172.44	4.78	29.49	0.37	9.71	35368
T_7 (27 778)	133.20	6.67	123.89	172.06	5.83	27.10	0.20	11.55	39031
CD (P= 0.05)	5.44	0.60	12.82	10.73	0.55	0.42	0.03	0.39	
(S×Y)	NS	NS	15.17	NS	0.65	NS	0.03	NS	
(Y×T)									

T_1, 60cm × 60cm; T_2, 90cm × 90cm; T_3, (90cm +150cm) × 60cm; T_4, (60cm +120cm) × 60cm; T_5, (60cm +150cm) × 60cm; T_6, (90cm +120cm) × 60cm, T_7, (90cm +150cm) × 30cm

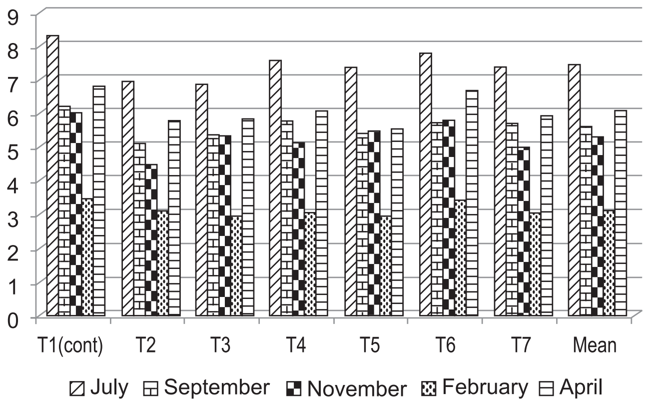

Fig 1 Effect of planting geometry on leaf yield (million tonnes/ha/crop) (season-wise average of three years)

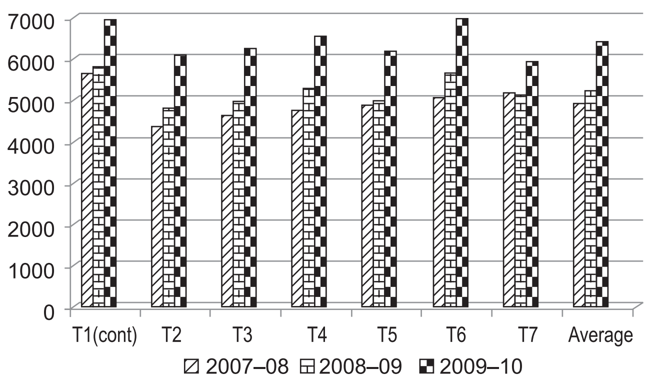

Fig 2 Effect of planting geometry on mulberry leaf yield (million tonnes/ha/crop) (year- and treatment-wise average)

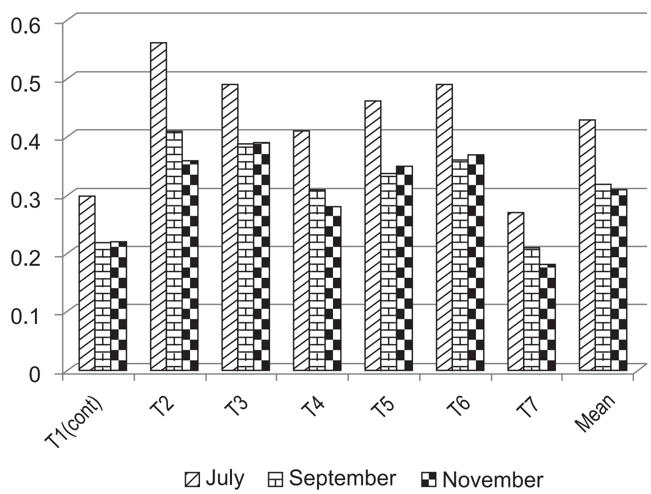

Fig 3 Effect of planting geometry on leaf yield (kg/plant) (season-wise average of three years)

where almost similar number of plant population was there. It was further observed that all the treatments of wider spacing, ie 90cm × 90cm (T_2) and paired-row system (T_3–T_6) registered maximum leaf yield/plant over recommended spacing (60cm×60cm) confirmed that more spacing contributed more leaf yield/plant.

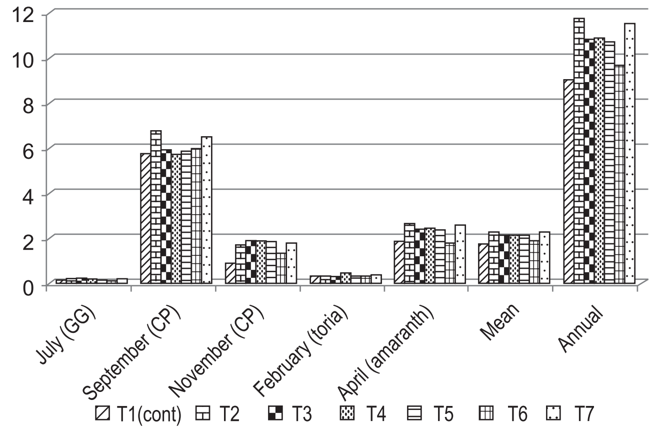

Fig 4 Effect of planting geometry on intercrop yield (million tonnes/ha) (season-wise average of three years)

The effect of the treatments was found significant on intercrop yield, whereas S × T and Y × T interactions were at par (Table 2). Maximum greengram yield was obtained in T_3, followed by T_4 and T_7 in July, maximum bio-mass yield of green manure (*Crotalaria juncea*) in T_2, followed by T_7 in September, maximum cowpea yield in T_3, followed by T_4 in November, maximum toria in T_4, followed by T_7 in February and maximum amaranth leafy vegetable was obtained in T_2, followed by T_7 in April (Fig 4). Overall highest annual average yield of intercrop was registered in T_2, followed by T_7. However, lowest intercrop yield was obtained in T_1. It was also observed that though intercrop yield was marginally increased (+8.3%) in second year over first year, but it was drastically reduced by 15.98% in third year compared to second year production due to reduction of space slowly caused by the growth and age of mulberry stumps and canopy development of mulberry (Fig 5).

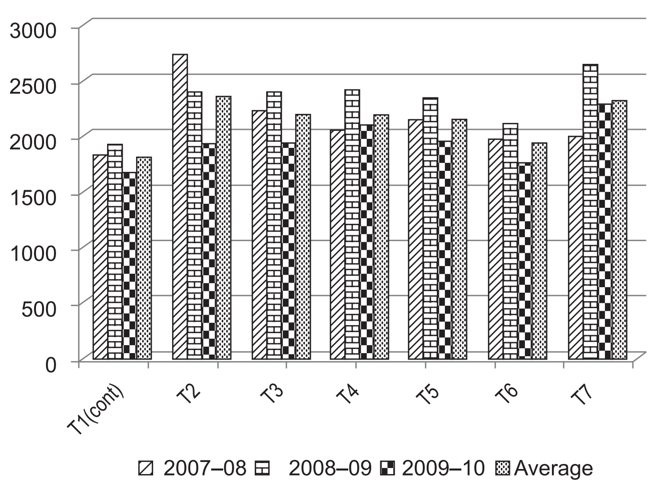

Fig 5 Effect of planting geometry on intercrop yield (year- and treatment-wise average)

Effect of planting geometry on leaf quality

Effect of the treatments was found to be at par with leaf moisture (%) and highest was obtained in T_5, followed by T_3. The effect of the treatments was significant on photosynthesis. Maximum photosynthesis was obtained in T_3, followed by T_6 and least in T_1. Highest photosynthesis was observed in February, followed by November and least in September. There was an increasing trend (14.54%) in photosynthesis observed in third year over second year. The rate of photosynthesis was higher in paired row system in comparison with 60cm × 60cm spacing. The effect of the treatments was significant on total chlorophyll content in leaf. Maximum chlorophyll content was registered in T_6, followed by T_3 and least in T_1 (Table 3). Highest chlorophyll content was observed in September, followed by July and least in February. Year-wise improvement in chlorophyll content by 12.39% was observed in third year over second year and paired row spacing registered maximum chlorophyll than 60cm × 60cm spacing.

Treatment effect was found significant on total soluble protein (TSP) content in leaf. Maximum TSP content in leaf was observed in T_4, followed by T_3 and least in T_1 which confirmed that the leaf produced from 60cm × 60cm spacing contained low TSP than paired row system. Highest TSP content in leaf was observed in September, followed by April and least in November and 7.4% more TSP was observed in third year over second year. However, TSP was found minimum in 60cm × 60cm and maximum in paired row spacing. The effect of the treatments was found significant on total soluble sugar (TSS) content in leaf. Maximum TSS was observed in T_3, followed by T_6 and least in T_5. There was no such specific trend found in TSS content among the paired row system and 60cm × 60cm spacing, though of course, all paired rows, especially T_3 and T_6 as well as 60cm × 60cm spacing registered maximum TSS (Table 3). Highest TSS content in leaf was found in September, followed by February and least in July as well as in April. An increasing trend of 14.18% TSS content in leaf was observed in third year in comparison with second year.

Table 3 Effect of planting geometry on leaf quality (average of three years* and two years data)

Treatment	*Leaf moisture (%)	Photosyn thesis (μm/m²/s)	Total chlorophyll (mg/g f. wt)	Total soluble protein (mg/g f. wt)	Total soluble sugar (mg/g f. wt)
T_1	78.42	6.12	2.17	28.07	35.55
T_2	78.35	8.18	2.34	29.83	35.11
T_3	78.66	9.22	2.50	30.44	36.54
T_4	78.28	8.95	2.40	30.49	35.07
T_5	78.88	9.11	2.39	29.28	34.86
T_6	78.82	9.17	2.68	30.35	35.73
T_7	78.38	9.13	2.34	30.40	35.69
CD (P= 0.05) (T)	NS	1.23	0.15	0.81	0.99
CV(%)	1.81	6.15	12.18	5.34	5.39

It is apparent from the above study that paired-row system of plantation, especially T_4 and T_6 possessed overall more photosynthetic ability and contained higher total chlorophyll, total soluble protein and total soluble sugar content in leaf which are essential for successful silkworm rearing.

Effect of planting geometry on economic gain

Overall maximum net profit of ₹42 040/ha/year was obtained in T_4, followed by T_7 (₹39 031/ha/year) and T_3 (₹37 211/ha/year) considerin S 1635 mulberry and intercrop production in four seasons, value of sale proceeds, effect of green manuring in one season and net profit including all expenditure (Tables 1, 4).

It was further observed that paired row system of plantation [(90cm+120cm) × 60cm], ie T^6 registered almost similar leaf yield, ie 29 488.98kg/ha/year with control, ie 60cm × 60cm spacing (with 15 873 plant population/ha, ie 42.9% less than 60cm × 60cm spacing), 0.37kg leaf yield/plant (0.15 kg/plant more than 60cm × 60cm spacing) and net profit of ₹ 35 368/ha/year (₹ 5 974more over 60cm × 60cm spacing) in comparison with leaf yield of 30 764.19 kg/ha/year in 27 777 plant population /ha, 0.22kg leaf yield/plant and net profit of ₹ 29 394/ha/year in 60cm × 60cm spacing under irrigated condition. T_4 [(60cm + 120cm) × 60cm] though registered highest net profit of ₹ 42 040/ha/year but produced significantly lower leaf yield, ie 27 679.79 kg/ha/year, 0.30kg leaf yield/plant in spite of higher number of plant population (18 518 plants/ha) over T_6, hence it will not be beneficial to the sericulturist.

The reason for better performance in paired row system of plantation particularly T_6 [(90cm+120cm) × 60cm] might be due to availability of more space in between the rows, helps the plants to grow in a better manner by rational utilization of organic and chemical fertilizer as well as by growing and incorporating the leguminous biomass of intercrops and green manure plants which helps in proper assimilation and availability/consumption of nutrients through better uptake as well as due to less competition because of lower number of plants (42.9% less plant population in T_6 than control i.e. 60cm × 60cm spacing).

The result corroborated the findings on better sweet corn yield in wider spacing (60cm × 20cm) by Kar *et al*. (2006), better baby corn yield with radish or coriander in wider planting geometry (60cm × 19cm) applying INM practices by Thavaprakaash *et al*. (2005), better production of forage sorghum with forage legumes, i e, cowpea or *Sesbania* in wider spacing (15cm × 45cm) by Ahmad *et al*. (2007), better production of early duration pigeonpea with finger millet intercropping at 2:4 row ratio and for medium

Table 4 Effect of planting geometry on overall net profit (₹ha/year) through intercropping in mulberry (season-wise average of three years)

Treatment (no. of plants/ha)	July Greengram (@ ₹ 40 000/ million tonnes) (₹)	September Green manure (*C. juncea*) (₹)	November Cowpea (@ ₹12 000/ million tonnes) (₹)	February Toria (@ ₹ 25 000/ million tonnes) (₹)	April Amaranth leafy vegetable (@ ₹ 5000/ million tonnes) (₹)	Mean of five crops of three years (₹)	Addl. Annual net profit with mulberry (@ ₹ 2000/ million tonnes) and intercrops (₹ ha/year)
T_1 (27 777)	22 345	15 828	16 717	9 179	24 114	5 879	29 394
T_2 (12 345)	12 615	9 436	26 700	8 274	34 373	6 093	30 466
T_3 (13 888)	25 590	11 251	36 044	6 708	32 041	7 442	37 211
T_4 (18 518)	25 494	13 522	34 593	18 435	34 076	8 408	42 040
T_5 (15 873)	26 123	11 260	36 720	7 365	29 800	7 418	37 089
T_6 (15 873)	25 462	13 177	26 164	11 599	29 702	7 074	35 368
T_7 (27 778)	24 534	13 055	31 751	13 669	34 084	7 806	39 031

Cost of cultivation (₹ha): Mulberry, 38 990/year; greengram, 5 200/crop; sunnhemp, 7 078/crop; cowpea, 5 687/crop; toria, 4 140/crop; Amaranth leafy vegetable, 4 500/crop

duration 2:8 row ratio by Padhi *et al*. (2010). Besides, similar result was also obtained by Ramakant *et al*. (2001), who recorded highest leaf yield, better sugar and protein content in leaf in S36 mulberry under paired-row system (90cm+120cm) × 60cm and better leaf quality in wider spacing was obtained by Krishnaswamy *et al*. (1970) in popular mulberry and by Rahaman *et al*. (1999) as well as Doss *et al*. (2000) in S 1635 mulberry.

Thus, it is inferred from the above study that the paired row system of S 1635 mulberry with (90cm + 120cm) × 60cm spacing along with four suitable intercrops (greengram in May–July, cowpea in September–November., Toria in November–February and Amaranth Leafy Vegetable in March–April) until it adversely affects mulberry and one green manure crop sunnhemp *(Crotalaria juncea)* in July–September) per year may be recommended to the farmers for mass practice to achieve sustainable quality leaf yield, better net profit and improvement in soil nutrient status with a scope for partial mechanization under irrigated condition.

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REFERENCES

Ahmad A U H, Ahmad R, Mahmood N and Tanwar A.2007. Performance of forage sorghum intercropped with forage legumes under different planting patterns. *Pakistan Journal of Botany* **39** (2): 431–9.

Anonymous 1990. Maximization of leaf and improvement of leaf quality of mulberry. (*in*) *Annual Research and Administrative Report*, pp 35–48. Central Sericultural Research and Training Institute, Berhampore, West Bengal,.

Anonymous 2003. Growth performance and seasonal leaf yield of some superior hybrids under irrigated condition (Table 8), (*in*) *Annual Research and Administrative Report*, 24 pp. Central Sericultural Research and Training Institute, Berhampore, West Bengal.

Anonymous 2009. Silk production scenario, (*in*) *Annual Report*, Central Silk Board, CSB Complex,

Arnon D I. 1949. Copper enzymes in isolated chloroplasts polyphenol oxidase in *Beta vulgaris*. *Plant Physiology* **24**: 1–15.

Ministry of Textiles, Government of India, Madivala, Bangalore, p. 5.

Doss S G, Vijayan K, Rahman M S, Das K K, Chakraborty S P and Roy B N. 2000. Effect of plant density on growth, yield and leaf quality in triploid mulberry. *Sericologia* **40** (1): 175–80.

Jackson M L. 1973. *Soil Chemical Analysis*, pp 326–8, Prentice-Hall Pvt. Ltd, New Delhi.

Kar P P, Barik K C, Mahapatra P K, Garnayak L M, Rath B S, Bastia D K and Khanda C M. 2006. Effect of planting geometry and nitrogen on yield, economics and nitrogen uptake of sweet corn (*Zea mays*). *Indian Journal of Agronomy* **51** (1): 43–5.

Krishnaswamy S, Roy D and Mukherjee S K. 1970. Yield and nutritive value of mulberry leaves as influenced by planting season, spacing and frequency of pruning. *Indian Journal of Sericulture* **9** (1): 38–42.

Lowry O H, Rosebrough N J, Farr A L and Randall R J. 1951. Protein measurements with Folin phenol reagent. *Journal of Biological Chemistry* **193** : 265–75.

Morris D L 1948. Quantitative determination of carbohydrates with Drey wood Anthrone reagent. *Science* **107**: 254–5.

Padhi A K, Panigrahi R K and Jena B K. 2010. Effect of planting geometry and duration of intercrops on performance of pigeon pea-finger millet intercropping systems. *Indian Journal of Agricultural Research* **44** (1): 43–7.

Panse V G and Sukhatme P V. 1967. *Statistical Methods for Agricultural Workers*, pp 110–9. ICAR, New Delhi.

Rahman M S, Doss S G, Vijayan K, and Roy B N. 1999. Performance of the mulberry variety S 1635 under three systems of planting in West Bengal. *Indian Journal of Sericulture* **38** (2): 165–7.

Ramakant, Singh B D, Sarkar A, and Sastawa A K. 2001.The effect of different planting geometry and levels of fertilizer on yield of semi-mechanized mulberry garden under irrigated condition/ corporate sectors. *Proceedings of the National Seminar on Mulberry Sericulture Research in India*, pp 288–94, held at Bangalore during 25–28 November,.

Satpathy B, Shivnath, Rao K M, Ghosh P L and Nair B P. 1992. An easy and rapid method of leaf area estimation in white mulberry (*Morus alba* L). *Indian Journal of Agricultural Sciences* **62**: 489–91.

Subbiah B V and Asija G L. 1956. A rapid procedure for the estimation of available nitrogen in soil. *Current Science* **25**: 259–61.

Thavaprakaash N, Velayudham K and Muthukumar V B. 2005. Effect of crop geometry, intercropping systems and integrated nutrient management practices on productivity of baby corn (*Zea mays* L.) based intercropping systems. *Research Journal of Agricultural and Biological Sciences* **1** (4) : 295–302.

Ullal S R and Narasimhanna M N.1987. Mulberry cultivation. (*in*) *Handbook of Practical Sericulture*, pp 7–32. Sampath J (Ed.). Central Silk Board, Bangalore. *Indian Journal of Sericulture* **29**(2): 263–72.