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INFLUENCE OF SPLIT APPLICATION OF NPK ON MULBERRY LEAF YIELD AND NUTRIENT UPTAKE UNDER TEMPERATE CLIMATIC CONDITIONS OF KASHMIR

S. Nooruldin*, Afifa, S. Kamili, M. R. Mir and Sharma, R. K.
Temperate Sericulture Research Institute, Mirgund, Sher-e- Kashmir University of Agricultural Sciences and Technology of Kashmir Srinagar, Kashmir- 191121, India.
*Corresponding author email: skeikhn@gmail.com; nooruldin@rediffmail.com

ABSTRACT
A study was taken to assess Influence of split application of NPK on leaf yield and nutrient uptake under temperate climatic conditions of Kashmir. The experiment was laid down in RBD with 11 different combinations of N P K and two controls, one where no fertiliser was used and the other as per package of practices for temperate region. Fertilisers were applied in two splits, first in the first week of April and the second split in the last week of June after harvesting first crop. Nitrogen was applied in three levels *viz*., N1, N2 and N3 (150 +150; 180 + 120 and 120 + 180), phosphorus in two levels *viz*., P1 and P2 (120 + 00 and 60 + 60) and potassium was also applied in two levels K1 and K2 (120 +00 and 60+60) respectively. Significantly higher leaf yield (14379.1 kg/ha) was recorded in autumn as against spring (12553.4 kg/ha). Higher levels of nitrogen in NPK combination did influence leaf yield (15196.5 kg/ha) in spring as well as in autumn (16850.7 kg/ha). Nitrogen and potassium recorded higher uptake (131.94 and 63.54 kg/ha) during autumn season whereas phosphorus recorded higher uptake (7.35 kg/ha) during spring season. Split application of P and K along with N exhibited improvement in quality and quantity of mulberry leaf especially during autumn suggesting the need for rescheduling the existing fertiliser schedule under Kashmir climatic conditions for maximization of leaf harvest, both qualitatively and quantitatively to enable farmers to undertake second silkworm rearing commercially.

KEY WORDS: Mulberry, NPK, split application, season, yield, uptake.

INTRODUCTION
The silkworm (*Bombyx mori* L.) being a monophagous insect derives complete nutrient supply required for its growth from the mulberry leaves, which play a predominant role on healthy growth of silkworm. Mulberry is a deep rooted perennial plant mainly cultivated to harvest leaves for rearing of silkworms and requires timely application of balanced dose of fertiliser. The mulberry's regular annual pattern of growth and the requirement of leaf for silkworm rearing determine the time of fertiliser application. With respect to utilization of applied fertilisers in temperate region, Yokoyama (1962) recognized three phases in the growth of mulberry *viz*. unfolding stage, assimilation stage and preservation stage. The assimilation stage represents the active growth period of mulberry through late spring and summer when new leaf/shoot lets and shoots are actively and abundantly formed. Application of fertiliser at this stage is most efficacious not only because of its influence on the leaf yield of that season but also on the quality of leaves harvested in next spring. Hence balanced fertilisers are required to be applied at this stage also. For established plantations under irrigated Kashmir conditions NPK is applied @300:120:120 kg/ha/yr in two splits, first dose comprising of half of N and entire P& K applied in March/April and second dose comprising of remaining N applied in June (Anonymous, 2003). Chen and Lu (2006) have confirmed significance of split application of nutrients in mulberry for improvement in quality and quantity and recommended their split application to match seasonal requirements.

Production of mulberry per unit area is of high importance so for as the silk industry is concerned as the quantum of leaf determines the quantity of silkworm seed to be reared. It is an accomplished fact that application of NPK influences the leaf yield and is major contributing factors but at the same time there is need for ascertaining their requirement on the basis of different crops during the year thus necessitating the present investigation.

MATERIAL AND METHODS
The present investigation was carried out at the experimental farm of Temperate Sericulture Research Institute (located at 34°.17′ N latitude, 74°.17′ E longitude and at an altitude of 1585 meters above mean sea level) during the year 2009 and 2010. Chemo-assay of the mulberry genotype was carried out at the Division of Soil Science SKUAST-K Shalimar.

Established mulberry plantation of Goshoerami (the most popular variety of mulberry used for commercial rearing in the region) with uniform growth and vigour was used for the study. The plantation was maintained as dwarf at 6′x 6′ spacing. Cultural operations were followed as per the package of practices recommended by the Temperate Sericulture Research Institute Mirgund(Anonymous, 2003) except for the application of chemical fertiliser which was done in a more split manner.

Experiment was laid down in RBD, three replications were maintained per treatment and number of plants per treatment/per replication was five. Fertiliser was applied in two splits, first in the first week of April and the second split in the last week of June after harvesting first crop. Nitrogen was applied in three levels *viz*., N1, N2 and N3 (150 +150; 180 + 120 and 120 +180 kg/ha/yr), phosphorus in two levels *viz*., P1 and P2 (120+00 and 60+60 kg/ha/yr) and potassium was also applied in two levels K1 and K2 (120 + 00 and 60 + 60 kg/ha/yr) respectively.

Fertiliser combinations

T_1	$N_0P_0K_0$	T_2	$N_1P_1K_1$	T_3	$N_1P_1K_2$	T_4	$N_1P_2K_1$	T_5	$N_1P_2K_2$
T_6	$N_2P_1K_1$	T_7	$N_2P_1K_2$	T_8	$N_2P_2K_1$	T_9	$N_2P_2K_2$	T_{10}	$N_3P_1K_1$
T_{11}	$N_3P_1K_2$	T_{12}	$N_3P_2K_1$	T_{13}	$N_3P_2K_2$				

T1 - No Fertiliser (control 1); T2 – NPK @150:120:120 kg/ha, 150:000:000 kg/ha 1st & 2nd dose (control 2)

Pruning of the mulberry plants was done in the first week of June, corresponding with the end of spring rearing by resorting to basal pruning. Composite leaf samples as described by Nakashima (1931) were collected on June 1, and October 1during both the years of study and processed as per the procedure advocated by Chapman (1964).

For estimation of nitrogen, samples were digested in conc. H_2SO_4 in presence of digestion mixture comprising of potassium sulphate, iron sulphate, copper sulphate and salicylic acid in the ratio of 10:1:05:1. The digestion was carried out in the digestion unit by initially keeping the temperature of unit at 100^{o}c for 30 minutes and then raising the temperature to 410^{0}C for 2 hours till the samples became clear. For determination of phosphorus, potassium the samples were digested in di acid (nine parts of HNO_3 and four parts of $HClO_4$). The digestion was carried out in 100ml conical flasks on hot plate till the solution became clear.

Distillation of the digested samples for determining Nitrogen was carried out on kjelteck apparatus by collecting ammonia on boric acid forming ammonium borate which was later titrated with N/50 H_2SO_4 following the procedure given by Jackson (1973). Phosphorus was determined by Vanadomolybdo phosphoric acid yellow colour method as outlined by Jackson (1973) and Potassium was estimated on flame photometer as described by Jackson (1973).

Data on leaf yield was taken on June 1 and October 1 corresponding to the 5th stage of spring and autumn silkworm rearing in the field respectively and per plant values were converted to kg/ha.

Statistical analysis

Data was compiled and analysed as per standard statistical procedure (Gomez and Gomez, 1984).

RESULTS

Leaf yield

Data pertaining to leaf yield of mulberry (Goshoerami) as influenced by seasons and fertiliser levels is presented in Table 1 and illustrated in Fig. 1.

TABLE 1: Seasonal trends in mulberry leaf yield as influenced by fertiliser levels/splits

Fertiliser level	Leaf yield (kg/ha)			
	Spring	Autumn	Mean	Total
$N_0P_0K_0$	9185.9	10371.9	9778.9	19557.8
$N_1P_1K_1$	14343.9	14925.7	14634.8	29269.6
$N_1P_1K_2$	12151.3	11738.4	11944.8	23889.7
$N_1P_2K_1$	11753.0	14247.6	13000.3	26000.6
$N_1P_2K_2$	13206.7	15161.3	14184.0	28368.0
$N_2P_1K_1$	12475.4	14639.8	13557.6	27115.2
$N_2P_1K_2$	12928.1	14812.2	13870.2	27740.3
$N_2P_2K_1$	15196.5	16373.3	15784.9	31569.8
$N_2P_2K_2$	13019.1	15253.7	14136.4	28272.8
$N_3P_1K_1$	12504.3	14487.8	13496.1	26992.1
$N_3P_1K_2$	14436.3	16850.7	15643.5	31287.0
$N_3P_2K_1$	11271.9	14357.4	12814.6	25629.3
$N_3P_2K_2$	10721.2	13708.6	12214.9	24429.8
Mean sampling dates	12553.4	14379.1		26932.5
$CD_{(0.05)}$	2269.90	2051.48		2830.67
$CD_{(0.05)}$ for seasons			575.96	
$CD_{(0.05)}$ for fertiliser means			1468.42	

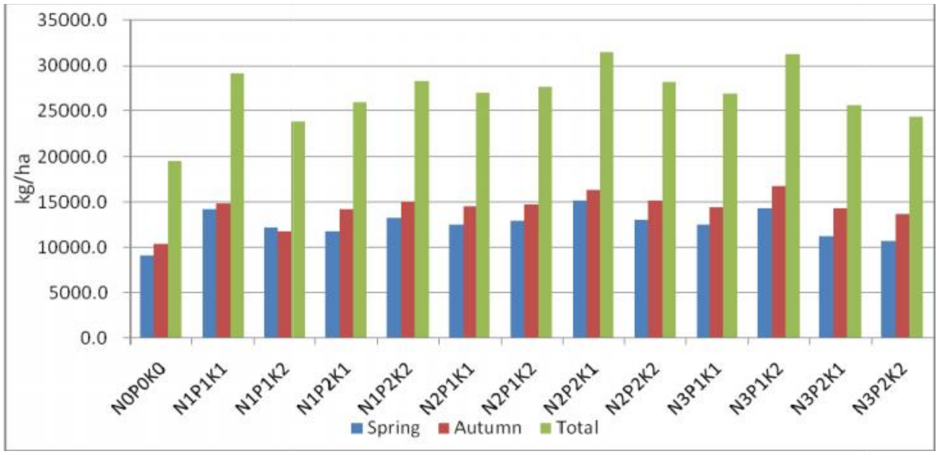

FIGURE 1: Influence of fertiliser levels on Leaf yield

Seasonal influence

So for as seasonal influence on leaf yield is concerned highest leaf yield of 14379.1 kg/ha was recorded in autumn season which was significantly higher than spring yield of 12553.4 kg/ha.

Influence of fertiliser levels and splits

During spring season highest leaf yield of 15196.5 kg/ha was recorded in T8 which was statistically at par with T11 (14436.3 kg/ha), T2 (14343.9 kg/ha), T5 (13206.7 kg/ha) and T7 (12928.1 kg/ha). Lowest leaf yield of 9185.9 kg/ha was recorded in T1. Whereas during autumn highest leaf yield of 16850.7 kg/ha was recorded in T11 which was statistically at par with T8 (16373.3 kg/ha), T9 (15253.7 kg/ha), T5 (15161.3 kg/ha), T2 (14925.7 kg/ha) and T7 (14812.2 kg/ha). Lowest leaf yield of 10371.9 kg/ha was recorded in T1 which was statistically at par with T3 (11738.4 kg/ha).

Annual yield from both seasons revealed that highest leaf yield of 31569.8 kg/ha was recorded in T8 which was statistically at par with T11 (31287.0 kg/ha) and T2 (29269.6 kg/ha). Lowest leaf yield of 19557.8 kg/ha was recorded in T1.

Increment over recommended dose of fertiliser

Perusal of data (Table-1; Fig. 1) revealed that in spring, T8 with leaf yield of 15196.5 kg/ha and T11 with leaf yield of 14436.3 kg/ha recorded an increase of 5.94% and 0.64% respectively over the recommended treatment (T2) with leaf yield of 14343.9 kg/ha, like wise during autumn T11 with leaf yield of 16850.7, T8 with 16373.3, T9 with 15253.7 and T5 with 15165.3 kg/ha recorded an increase of 12.90, 9.70, 2.20 and 1.58 per cent respectively over the recommended treatment (T2) with leaf yield of 14925.7 kg/ha.

Annual yield data revealed that T8 with leaf yield of 31569.8 kg/ha and T11 with leaf yield of 31287.0/kg/ha recorded an increase of 7.86 per cent and 6.89% respectively over the recommended treatment (T2) with leaf yield of 29269.6 kg/ha.

TABLE 2: Seasonal variation in uptake of primary nutrients as influenced by fertiliser levels/splits

Fertiliser level	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
	Spring	Autumn	Total	Spring	Autumn	Total	Spring	Autumn	Total
$N_0P_0K_0$	63.75	82.90	146.65	4.67	3.96	8.63	40.74	43.82	84.56
$N_1P_1K_1$	133.64	134.83	268.47	8.98	7.19	16.17	64.66	67.46	132.12
$N_1P_1K_2$	114.43	103.64	218.07	6.58	5.16	11.74	54.00	40.94	94.94
$N_1P_2K_1$	119.26	133.65	252.91	6.22	6.19	12.41	57.94	68.41	126.35
$N_1P_2K_2$	132.32	136.88	269.20	8.17	8.89	17.06	60.18	67.83	128.01
$N_2P_1K_1$	130.82	136.68	267.50	7.01	7.46	14.47	57.74	57.09	114.83
$N_2P_1K_2$	128.80	138.52	267.32	7.94	6.07	14.01	59.64	67.00	126.64
$N_2P_2K_1$	151.94	150.18	302.12	9.30	8.60	17.90	75.03	71.87	146.89
$N_2P_2K_2$	136.30	136.48	272.78	7.20	6.78	13.98	58.68	71.64	130.32
$N_3P_1K_1$	107.46	141.73	249.19	8.39	6.02	14.41	56.57	66.57	123.14
$N_3P_1K_2$	119.14	163.42	282.56	7.94	7.14	15.08	66.78	73.95	140.73
$N_3P_2K_1$	101.45	139.49	240.94	6.85	6.99	13.84	53.94	62.80	116.75
$N_3P_2K_2$	85.79	116.84	202.63	6.32	7.62	13.94	49.85	66.63	116.48
Mean	117.32	131.94	249.26	7.35	6.77	14.12	58.13	63.54	121.67
$CD_{(0.05)}$	19.62	21.28	27.98	1.41	1.15	1.76	10.49	10.59	13.73

Nutrient uptake through leaf

Data pertaining to nitrogen, phosphorus and potassium uptake by mulberry (Goshoerami) leaf as influenced by seasons and fertiliser levels is presented in Table 2 and illustrated in Fig. 2to 4.

Seasonal influence

So for as seasonal influence on nitrogen uptake is concerned higher nitrogen uptake of 131.94 kg/ha was recorded in autumn season as against 117.32 kg/ha during spring season. Higher phosphorus uptake of 7.35 kg/ha was recorded in spring season as against 6.77 kg/ha during autumn. Highest potassium uptake of 63.54 kg/ha was recorded in autumn season as against 58.13 kg/ha during spring.

Influence of fertiliser levels/splits on nutrient uptake

Nitrogen uptake

Highest nitrogen uptake of 151.94 kg/ha was recorded during spring season in T8 which was statistically at par with T9 (136.30 kg/ha), T2 (133.64 Kg/ha) and T5 (132.32 kg/ha) and significantly different from other treatments. Lowest uptake of 63.75 kg/ha was recorded in T1. During autumn season on the other hand, highest nitrogen uptake of 163.42 kg/ha was recorded in T11 which was statistically at par with T8 recording uptake of 150.18 kg/ha and significantly different from rest of treatments. Lowest N uptake of 82.90 Kg/ha was recorded in T1.

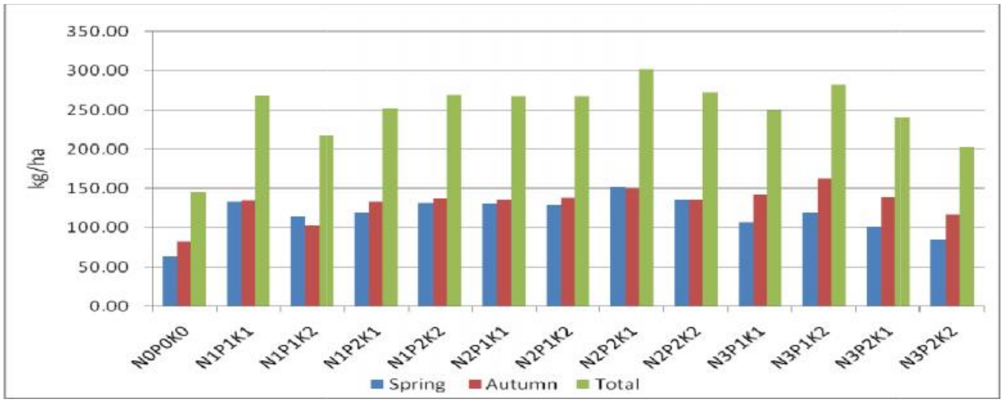

FIGURE 2 :Influence of fertiliser levels on N uptake (kg/ha)

So for as annual nitrogen uptake during both seasons is concerned higher N uptake of 302.12 kg/ha was recorded in T8 which was statistically at par with T11 registering an uptake of 282.56 kg/ha. Lowest N uptake of 146.65 kg/ha was recorded in T1.

Phosphorus uptake

During spring season highest phosphorus uptake of 9.30 kg/ha was recorded in T8 which was statistically at par with T2 (8.98 kg/ha), T10 (8.39 kg/ha), T5 (8.17 kg/ha), T7 (7.94 kg/ha) and T11 (7.94 kg/ha) respectively and significantly different from other treatments. Lowest uptake of 4.67 kg/ha was recorded in T1.Whereas during autumn season highest uptake of 8.89 kg/ha was recorded in T5 which was statistically at par with T8 recording uptake of 8.60 kg/ha and significantly different from rest of treatments. Lowest P uptake of 3.96 kg/ha was recorded in T1.

So for as annual phosphorus uptake during both seasons is concerned higher phosphorus uptake of 17.90 kg/ha was recorded in T8 which was statistically at par with T5 (17.06 kg/ha) and T2 (16.17 kg/ha) respectively and significantly different from other treatments. Lowest phosphorus uptake of 8.63 kg/ha was recorded in T1.

Potassium uptake

During spring season highest potassium uptake of 75.03 kg/ha was recorded in T8 which was statistically at par with T11 (66.78 kg/ha) and T2 (64.66 kg/ha) respectively and significantly different from other treatments. Lowest uptake of 40.74 kg/ha was recorded in T1. Whereas during autumn season highest uptake of 73.95 kg/ha was recorded in T11which was statistically at par with T8 (71.87), T9 (71.64), T4 (68.41), T5 (67.83), T2 (67.46), T7 (67.00), T13 (66.63) and T10 (66.57) and significantly different from rest of the treatments. Lowest K uptake of 40.94 kg/ha was recorded in T3 which was at par with T1 with K uptake of 43.82 kg/ha.

Annual potassium uptake during both seasons revealed that higher K uptake of 146.89 kg/ha was recorded in T8 which was statistically at par with T11 registering an up take of 140.73 kg/ha and significantly different from other treatments. Lowest K uptake of 84.56 kg/ha was recorded in T1.

DISCUSSION

Leaf yield as influenced by seasons and fertiliser levels/splits

Significantly higher leaf yield (14379.1kg/ha) was recorded in autumn as compared to spring season (12553.4 kg/ha) which is in harmony with the findings of Mir *et al*. (2003) and Singh and Saraswat (2003). Similar seasonal variations have been reported by Das and Vijayaraghavan (1990), Shivaprakash *et al.* (2000); Majumder *et al*. (2003) and Fotadar *et al*. (2006). During spring as well as autumn seasons highest leaf yield (15196.5 kg/ha, 16850.7 kg/ha)) was recorded in treatments receiving higher levels of N. These results are concomitant with those of Kashi viswanathan *et al.* (1977); Fotedar *et al*. (1988); Das *et al*. (1993); Bongale *et al.* (2000); Sannapa *et al*. (2003); Kuwada *et al.* (2006) and Shivaprakash *et al.* (2006). The results of this nature could be attributed to better response of mulberry to higher doses of nitrogen at optimum soil moisture conditions, especially from June to September. Split application of fertilisers (having higher levels of N) during both the seasons have resulted in improvement in leaf yield (5.94 % in spring and 12.90 % in autumn) over the control. Improvement in yield due to split application of fertilisers are supported by the earlier findings of Mishra *et al.* (1993); Subbarayappa *et al*. (1994); Sundareswaren *et al*. (1997); Patil *et al.* (2003); Subbaswamy *et al.* (2003); Setua *et al.* (2005) and Shivaprakash *et al.* (2006). The improvement in leaf yield and quality due to split application of K along with N could be due to response of mulberry to nitrogen which is a constituent of plant proteins, nucleic acids and vitamins. Potassium also plays an important role in plant biochemical functions, development and yield of foliage and leaf quality improvement (Shankar and Rangaswamy, 1999). Increase in leaf yield over control might also be due to greater availability of nutrients due to balanced NPK fertiliser application as has also been reported by Singh *et al*. (1983).

Nutrient uptake through leaf

Perusal of data reveal higher N uptake (131.94 kg/ha) in autumn as compared to spring (117.32 kg/ha). Similar variations in seasonal uptake have been reported by Shivaprakash *et al.* (2000); Setua *et al.* (2005, 2007). Higher uptake during autumn season can be attributed to longer growth period and also to better utilisation of soil nutrients under suitable environmental conditions available during its growth period. Higher uptake of nitrogen (151.94 kg/ha, 163.42kg/ha during both seasons) was also observed in treatments with higher level of N application registering an increase of 13.69 and 21.20 % over recommended treatment. These findings are in accordance with the earlier reports of Bongale *et al*. (2000); Sannapa *et al*. (2003); Shivaprakash *et al.* (2006) in mulberry. Promotion of nitrogen uptake with progressive increase in its supply could be explained in terms of higher osmotic suction of the soil solution at higher level of nitrogen supply as has also been observed by Greenwood *et al*. (1974).

Higher Phosphorus uptake (7.35 kg/ha) was recorded in spring as against autumn (6.77 kg/ha). Variations in seasonal uptake of phosphorus have been reported by Shivaprakash *et al.* (2001) and Setua *et al.* (2005). During both the seasons higher uptake of P (9.30 kg/ha, 8.89 kg/ha during spring and autumn) was recorded in treatment combinations where P has been applied in split doses which could be attributed to its influence on increasing cation exchange capacity of roots, thereby causing better absorption of plant nutrients. These findings are in accordance with that of Majumdar *et al*. (2003) and give credence to the earlier reports of Ghosh *et al*. (1997) and Shivaprakash *et al*. (2001).

Higher uptake of K (63.54 kg/ha) was recorded in autumn as against spring (58.13 kg/ha). Similar variations in seasonal uptake of potassium have been recorded by Setua *et al.* (2005). During spring higher uptake of K (75.03 kg/ha) was observed in treatment with higher dose of K application as basal dose, however it did not differ significantly from most of treatments with split application of K. While as during autumn higher uptake of K (73.95 kg/ha) was recorded in treatment with split application of K which can be attributed to the fact that application of K with N play a vital role in enhancing nutrient use efficiency. Similar observations have been made by Nagendra Rao (2007).

Further, split application of NPK did exhibit improvement in nutrient uptake over the control *viz*. (150:120:120 and 150:0:0). These recordings are in accordance with the findings of Mishra *et al.* (1993); Sundareswaren *et al*. (1997); Patil *et al*. (2003); Subbaswamy *et al.* (2003); Setua *et al.* (2005) and Shivaprakash *et al.* (2006). This may be attributed to the fact that Split application of N and K play vital role in enhancing their use efficiency and results in their higher uptake (Gobi *et al*., 2008). Increase in uptake of N, P and K over the control through split application could be attributed to the synergetic effect of NPK on uptake of respective element and on each other. These observations are in conformity with the findings of Li *et al*. (1985); Subbaswamy *et al.* (2001); Mendhe *et al*. (2002) and Subbaswamy *et al.* (2003). Present findings envisage the application of NPK in proper ratio for improving their uptake. This type of recommendation has also been given by Takagishi *et al*. (1985) and Subbaswamy *et al*. (1998).

CONCLUSION

It is concluded that for improving mulberry both qualitatively and quantitatively NPK application be done in two splits, with first dose of NPK @ 180:60:60 Kg/ha during April and second dose of NPK @ 180:60:60 Kg/ha, about 25 days in advance of scheduled date for 2^{nd} rearing which will not only enhance the quality and yield of leaf but also growth of silkworms vis-à-vis cocoon yield during both the seasons.

REFERENCES

Anonymous (2003) Package of practices for silkworm rearing and mulberry cultivation in Kashmir. *Technical document.* Directorate of Extension Education, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, pp. 5-6.

Bongale, U.D., Narayana Gowda, S.N. and Veeresh, M. (2000) Effect of different plant densities and nitrogen levels on Viswa (DD), S-36 and M-5 Mulbery (*Morus indica* L.) varieties under irrigated condition. *Indian Journal of Sericulture* **39**(2): 103-107.

Chapman, H.D. (1964) Suggested foliar sampling and handling techniques for determining the nutritional status of some field, horticultural and plantation crops. *Indian Journal of Horticulture* **21** : 97-119.

Chen, F. and Lu, J.W. (2006) Identifying gaps in mulberry fertilization in Hubei Province. *Better Crops with Plant Food* **90**(4) : 29-31.

Das, P.K. and Vijayaraghavan, K. (1990) Studies on the effect of different mulberry varieties and seasons on the larval development and cocoon characters of silkworm *Bombyx mori* (L). *Indian Journal of Sericulture* **29**(1): 44-53.

Das, P.K., Choudhary, P.C., Gupta, Y.K., Gosh, A. and Datta, R.K. (1993) Effect of different levels of nitrogen, phosphorus and spacings on the growth, yield and nutritional quality of mulberry under rainfed condition. *Indian Journal of Sericulture* **32**(2): 201-207.

Fotadar, R.K., Dhar, A., Sengupta, D. and Khan, M.A. (2006) Yield variability in mulberry. *Perspectives in Cytology and Genetics*, **12** : 205-210.

Fotedar, R.K., Chakraborty, S., Darzi, G.M., Dhar, K.L. and Ahsan, M.M. (1988) Effect of nitrogen levels on growth and yield of mulberry. *Indian Journal of Sericulture,* 27(1): 7-15.

Ghosh, A., Ambica, P.K. and Mishra, R.K. (1997) Effect of varieties, spacing & fertiliser doses on growth, yield and quality of mulberry. *Indian Journal of Sericulture* **36**(2) : 138-141.

Gobi, R., Ramesh, S., Pandian, B.J. and Chandrasekaran, B. (2008) Evaluation of establishment methods and split application of N and K on growth analysis, NPK uptake, nitrogen use efficiency and soil fertility status of CoRH2 rice hybrid. *Internat. J. Agric. Sci*. **4**(1): 173-180.

Gomez, K.A. and Gomez, A.A. (1984) *Statistical procedures for agricultural research* 2nd Ed. A Wiley Interscience Publication. John Wiley and Sons.

Greenwood, D.J., Wood, J.T. and Cleaner, T.J. (1974) A dynamic model for the effects of soil and weather conditions on nitrogen response. *J. Agric. Sci*. **82** : 455-467.

Jackson, M.L. (1973) *Soil Chemical Analysis*. Prentice Hall of India Private Ltd., New Delhi.

Kasiviswanathan, K., Iyengar, M.N.S. and Venkataramu, C.V. (1977) Studies on dry farming of mulberry in Mysore. Parts i- iv. *Indian J. Seric*. **16**(1) : 34-42.

Kuwada, M., Shiraiwa, T. and Horie, T. (2006) Changes in total nitrogen and total carbon contents in soil and leaf yield of a long term unfertilized mulberry under field condition. *Japanese Journal of Crop Science,* 75(1) : 28-37.

Li, G.Y., Yu, S.W., Qiu, W.C. and Chen, X.B. (1985) Effects of applying Nitrogen combined with P and K on the uptake of nutrients by mulberry and their utilization rates. *Guangdong Agricultural Science Guangdong, Nongye Kexue,* **2** : 30-33.

Majumder, S.K., Bose, P.C., Kar, R., Banerjee, N.D. and Ghosh, J.K. 2003. Studies on the seasonal variation of NPK uptake by mulberry (*Morus alba* L.). *Indian Journal of Sericulture,* **42**(1): 1-3.

Mendhe, S.N., Singh, R.P. and Mendhe, S.S. (2002) Effect of sowing time, phosphorus and potash on NPK uptake of *Stylosanthes hamata* (L.) and residual soil fertility. *Journal of Soils and Crops,* **12**(1): 85-90.

Mir, M.R., Baksh, S., Darzi, G.M., Isa, Md. and Khan, M.A. (2003) Evaluation of different mulberry genotypes under rainfed conditions in Kashmir province of J & K State. **In:** *Proc. Workshop: prebreeding strategies, Seric. Germplasm, CSGRC., Hosur,* pp. 12-15.

Mishra, R.K., Choudhury, P.C., Ghosh, A., Singh, G.B. and Datta, R.K. (1993) Cultivation technology for chawki mulberry garden. *Indian Silk,* 31(12): 11-13 & 20.

Nagendra Rao, T. (2007) Improving nutrient use efficiency- The role of beneficial management practices. *Better crops India,* pp. 6-7.

Nakashima (1931) **In** : *Moriculture: Science of mulberry cultivation*. (Ed. K. Minamizawa, 1997). Oxford and IBH Publishing Company Pvt. Ltd., New Delhi, pp. 431.

Patil, V.C., Angadi, S.A., Roodagi, L.I., Angadi, S.S. and Patil, R.R. (2003) Effect of fertigation and vermicompost on yield and quality of mulberry. **In**: *Nutritional management and quality improvement in Sericulture. Proc. Natl. Sem. Mulb. Seri. Res.* India, 2001, [Eds. U.D. Bongale], KSSRDI, Bangalore, pp. 277-281.

Sannappa, B., Devaiah M.C. and Govindan, R. (2003) Effect of nitrogen levels supplied through calcium ammonium nitrate on yield, organic and elemental composition of rainfed mulberry. **In**: Nutritional management and quality improvement in Sericulture, *Proc. Natl. Sem. Mulb. Seri. Res*. India, 2001. [U.D. Bongale], KSSRDI, Bangalore, pp. 192-197.

Setua, G.C., Das, N.K., Banerjee, N.D., Sengupta, T., Sudhakar, P., Sen, S. and Saratchandra, B. (2005) Effect of integrated nutrient management on quality leaf production in mulberry (*Morus alba*) under rainfed, alluvial soil conditions. *Indian Journal of Agricultural Sciences* **75**(8): 474-478.

Setua, G.C., Setua, M., Ghosh, A., Debnath, S., Dutta, A.K., Banerjee, N.D. and Sarkar, A. (2007) Effect of integrated nutrient management on sustainable quality leaf production in mulberry (*Morus alba*) under irrigated, alluvial soil conditions. *Indian Journal of Agricultural Sciences*, **77**(5): 286-290.

Shankar, M.A. and Rangaswamy, B.T. (1999) Effect of applied nitrogen and potassium on mulberry leaf yield and quality in relation to silkworm cocoon characters. *Better Crops International* **13**(2) : 20-21.

Shivaprakash, R.M., Bongale, U.D. and Narayana Gowda, S.N. (2006) Nutrient uptake in three improved varieties of mulberry under irrigated condition. *Sericologia,* **46**(3) : 327-334.

Shivaprakash, R.M., Bongale, U.D., Dandin, S.B., Basavaiah, Narayana Gowda, S.N. and Siddalingaswamy, N. (2001) Phosphorus uptake in three improved varieties of mulberry (*Morus indica* L.) under irrigated field cultivation. *Sericologia* **41**(2): 279-286.

Shivaprakash, R.M., Bongale, U.D., Dandin, S.B., Basavaiah, Siddalingaswamy, N. and Narayana Gowda, S.N. (2000) Nitrogen uptake and shoot yield in three improved varieties of mulberry (*Morus indica* L.) under irrigated field cultivation. *Indian Journal of Sericulture* **39**(2.): 145-148.

Singh, B., Sharma, K.N., Rana, D.S., Sodhi, G.S. and Kapur, M.L. (1983) Available P and K and soil organic matter content as influenced by long term application of fertilizers and FYM to wheat, maize rotation. *J. Indian Soc. Soil Sci*. **3:** 491-494.

Singh, B.D. and Saraswat, S.B. (2003) Fertiliser response on the growth and biomass of mulberry (*Morus alba* L.) in sub tropical conditions. **In**: Nutritional management and quality improvement in Sericulture, *Proc. Natl. Sem. Mulb. Seri. Res*. India, 2001. [U.D. Bongale], KSSRDI, Bangalore, pp. 198-201.

Subbarayappa, C.T., Sundareswaran, P., Sinha, A.K. and Reddy, M.M. (1994) Nitrogen nutrition in mulberry garden. *Indian Silk* **33**(1): 7-10.

Subbaswamy, M.R., Munirathnam Reddy, M. Sinha, A.K. and Srinivasan, E.B. (1998) Soil fertility status of mulberry gardens of ten districts in south India. *Indian Silk* **37**(2): 11-13.

Subbaswamy, M.R., Singhvi, N.R., Srinivasan, E.B., Vedavyasa, K. and Sarkar, A. (2003) Effect of supply of graded levels of phosphorus on mulberry leaf yield, quality, Silkworm rearing assay and soil phosphorus status. **In**: *Nutritional Management and Quality Improvement in Sericulture. Proc. Natl. Sem. Mulb. Seri. Res.* India, 2001. [Eds. U.D. Bongale *et al*.], KSSRDI, Bangalore, pp. 252-257.

Subbaswamy, M.R., Singhvi, N.R., Naidu, B.V., Reddy, M.M., Jayaram, H. and Suryanarayana, N. (2001) Effect of source of nitrogen on phosphorus uptake and arginine content in mulberry. *Indian Journal of Sericulture* **40**(2) : 182-184.

Sundareswaran, P., Subbarayappa, C.T., Munirathnum Reddy, M., Srinivasan, E.B. and Himantharaj, M.T. (1997) Nutritional studies on mulberry in relation to cocoon production. *Indian Journal of Sericulture,* **36**(2): 147-149.

Takagishi, H., Shirata, K., Kawanchi, I., Watanabe, K. and Horie, Y. (1985) Effects of fertilization on leaf quality of mulberry. *Bull. Seric. Expt. Stn*. **30**(1) : 65-81.

Yokoyama, T. (1962) *Synthesised Science of Sericulture*. Central Silk Board Bombay India, pp. 23-27.