National Journal of Life Science, **Vol. 10(2) 2013 : 105-112** ISSN : 0972-995X (Print), 2321-7960 (Online)

SEASONALITY OF NUTRIENT CONTENTS OF DIFFERENT LEAF TYPES OF FOUR HOST PLANTS OF *SAMIA RICINI* DENOVAN IN NAGALAND

MERENJUNGLA and L. N. KAKATI*

Department of Zoology, Nagaland University, Lumami (Nagaland)

ABSTRACT : In Nagaland, along with *R.communis* (Castor), *H.fragnans* (Kesseru), *E.fraxinifolia* (Payam) and *M.esculanta* (Tapioca) are used for rearing of *S.ricini* Donovan (eri silkworm). Seasonal variation of nutrient contents in tender, semi tender and mature leaves of these four host plants were analysed in Mokokchung district of Nagaland. Highly significant variation was observed between the leaf types for moisture, nitrogen, protein crude fibre phosphorous and calcium. Nitrogen, protein, organic carbon, phosphorus and calcium were recorded to be maximum in Castor; however, Kesseru exhibited the highest content for moisture, cellulose, crude fibre. Carbohydrate and Potassium was slightly higher in Payam. While seasonal variation was not found to be significant except for nitrogen, protein, carbohydrate, crude fibre and phosphorous, highly significant difference among host plants was noticed for moisture, nitrogen, protein, phosphorous and calcium. The results suggested both individual and combined effect of leaf types, seasons and host plants on the nutritive value of leaves and highlighted the importance of Payam and Tapioca at par with Castor and Kesseru host plant on rearing of eri silk worm species in different seasons.

Key words : *Samia ricini, Foliar Constituents, Payam, Tapioca, Leaf types.*

INTRODUCTION

The growth, development and economic characters of silkworms are influenced to a great extent by a variety of food plants and nutritive contents of foliage (Singh and Das,2006). Production parameters and palatability among silkworm species depend on the seasonal variation of foliar nutrients, the quantitative estimate of which have already been made in different silkworm host plants like Mulberry (Sujathamma & Dandin,2000 and Bose & Bindroo,2001), Tropical tasar (Sinha & Jolly,1971; Sinha *et al.*,1992 and Sinha *et al.*,2005), Muga (Yadava & Goswami,1992; Dutta *et al.*,1997; Choudhury *et al.*,1998 and Kakati & Kakati,2011), Oak tasar (Sinha *et al.*,1986 and Banerjee *et al.*,1993) and Eri host plants (Dutta,2000 and Hazarika *et al.*,2003). Among different types of food plants in eri culture, *R.communis* (Castor) and *H.fragnans* (Kesseru) are primarily used for rearing of *S.ricini* Donovan (eri silkworm) in Nagaland, while *E.fraxinifolia* (Payam) and *M.esculanta* (Tapioca) are considered as the important secondary food plants in this hilly state. Most of the earlier works on nutrient analysis of eri silk worm food plants are of general in nature based on one or two rearing seasons (Pathak,1988 and Deuri,2004), however there is dearth of data on seasonal variation of nutrient contents of different leaf types which differently influence the eri silk worm feeding from initial to maturation stages. Hence, the present study is conducted in Mokokchung district of Nagaland to evaluate the seasonal effect (spring, summer and winter) on foliar constituents with special reference to the three different leaf types *i.e.* tender, semi-tender and mature leaves of four host plants of eri silk worm.

MATERIAL AND METHODS

Fresh leaves of all the three types *i.e.* tender, medium (Semi tender) and mature having different sizes of each group from the four food plants *i.e.* Castor, Kesseru, Payam and Tapioca from sericulture farm, Ungma, Mokokchung (rearing site) were collected separately in spring, summer and autumn seasons corresponding to the rearing schedule of eri silkworm. The leaves were properly cleaned and used for different estimations. The moisture content and crude fibre was estimated by using the method of AOAC (1970). Total Nitrogen was determined by micro-kjeldahl method and the nitrogen percentage was multiplied by 6.25 to calculate crude protein. Total soluble sugar and total carbohydrate was estimated by Anthrone method (Yem and Willis,1954). Organic carbon was determined by Walkley and Black's titration method. Phosphorus and potassium were analyzed using the method by Adrian (1973). Calcium was estimated by using method of Ferguson *et al.* (1993) and AOAC (Padmore,1990). The estimation for all leaf types were done seasonally in triplicate and mean value was recorded for interpretation of results. The data were statistically analyzed following the analysis of variance for leaf types, seasons as well as host plants in a randomized complete block design and co-efficient of variation (CV%) was calculated following the method described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Foliar constituents of different leaf types of the four food plants *i.e.* Castor, Payam, Kesseru and Tapioca estimated for three rearing seasons are given in Table.1 and Figs.1&2.

Moisture content : Moisture retention in three leaf types in different seasons was found to be irregular, however mean value was recorded to be maximum in tender leaves followed by medium and mature leaves in different host plants and showed highly significant difference. In Castor, summer season retained highest quantity of moisture followed by autumn

*Corresponding author (email : kakati_ln@yahoo.com) Received 18.02.2013 Accepted 10.03.2013

Table. 1 Seasonality of nutrient contents (Mean±SE) of four food plants of *Samia ricini* in Mokokchung, Nagaland.

		Moisture (%)	Nitrogen (%)	Protein (%)	Carbohydrate (%)	Cellulose (mg)	Cr. Fibre (%)	Organic carbon (%)	Phosphorus (%)	Potassium (%)	Calcium (%)
Castor	I	77.06±0.96	6.21±0.58	38.88±3.63	15.12±1.47	271.49±75.09	13.74±8.04	0.194±0.171	2.37±0.66	7.46±0.17	0.10±0.03
	II	80.36±1.52	5.68±1.27	35.53±7.92	7.54±0.96	581.06±58.57	17.89±3.57	0.107±0.003	2.10±0.86	7.53±0.19	0.13±0.03
	III	78.00±2.19	5.70±0.39	35.64±2.44	8.22±1.02	286.29±88.60	24.46±7.14	0.100±0.004	2.19±0.41	7.50±0.23	0.11±0.02
Leaf	Te	80.26±1.56	7.51±0.96	40.82±2.46	7.51±0.9	320.32±35.37	11.70±4.03	0.145±0.060	2.81±0.33	7.48±0.15	0.10±0.01
type	St	80.26±0.84	7.34±1.76	38.62±1.37	7.34±1.76	365.59±96.68	18.91±6.87	0.168±0.165	2.26±0.47	7.50±0.17	0.11±0.03
mean	Ma	74.94±1.08	6.03±2.14	30.60±4.13	6.03±2.14	449.93±82.46	25.46±4.92	0.088±0.024	1.60±0.48	7.52±0.26	0.12±0.04
Total Mean		**78.48±1.72**	**5.87±0.84**	**36.68±5.26**	**6.96±1.76**	**379.61±84.42**	**18.69±7.73**	**0.134±0.104**	**2.22±0.65**	**7.50±0.19**	**0.11±0.03**
Payam	I	74.56±1.28	3.50±0.90	21.89±5.61	5.93±0.78	318.59±53.14	15.60±5.07	0.069±0.029	1.54±0.85	7.52±0.16	0.09±0.02
	II	70.98±1.91	3.26±0.81	20.39±5.05	8.27±2.52	318.58±53.14	18.92±5.92	0.107±0.003	0.74±0.36	7.51±0.35	0.11±0.02
	III	74.66±2.29	4.91±0.71	30.66±4.46	8.08±1.39	419.00±58.48	27.83±7.22	0.102±0.004	0.67±0.35	7.49±0.27	0.10±0.02
Leaf	Te	76.82±0.58	5.61±0.74	30.34±3.43	5.61±0.74	472.72±73.27	14.54±6.51	0.093±0.01	1.27±0.95	7.51±0.30	0.09±0.01
type	St	73.26±2.39	7.79±0.77	22.86±7.25	7.79±0.77	285.95±74.45	20.40±2.87	0.081±0.036	1.11±0.48	7.52±0.29	0.10±0.02
mean	Ma	70.14±0.84	8.88±2.30	19.75±3.88	8.88±2.30	297.50±49.43	27.41±7.66	0.104±0.005	0.56±0.26	7.49±0.21	0.11±0.03
Total Mean		**73.40±2.00**	**3.89±1.07**	**24.31±6.70**	**7.43±1.98**	**352.06±33.46**	**20.78±7.90**	**0.093±0.024**	**0.98±0.68**	**7.51±0.26**	**0.10±0.02**
Kesseru	I	80.82±0.53	4.97±1.86	31.04±11.63	3.25±1.85	432.92±48.45	21.97±6.88	0.092±0.022	2.04±1.33	7.48±0.26	0.09±0.01
	II	78.36±1.70	3.72±0.47	23.27±2.92	3.88±1.40	353.15±88.54	26.49±6.55	0.102±0.004	1.69±1.08	7.50±0.69	0.09±0.05
	III	81.98±1.75	5.34±1.19	33.37±7.45	5.19±0.93	418.03±10.47	26.48±11.15	0.105±0.004	0.90±0.46	7.50±0.52	0.09±0.01
Leaf	Te	82.48±0.92	3.51±0.77	38.02±8.24	3.51±0.77	203.89±52.32	15.72±3.79	0.088±0.019	2.61±0.90	7.48±0.28	0.09±0.01
type	St	81.38±0.97	5.55±0.13	28.34±5.17	5.55±0.13	513.66±81.85	24.95±2.32	0.105±0.004	1.57±0.68	7.50±0.75	0.09±0.02
mean	Ma	77.28±1.47	3.27±2.07	21.31±3.03	3.27±2.07	486.55±72.86	34.27±4.05	0.106±0.003	0.45±0.16	7.50±0.15	0.10±0.05
Total Mean		**80.38±1.58**	**4.68±1.44**	**29.22±8.98**	**4.11±1.61**	**401.37±76.66**	**24.98±8.41**	**0.100±0.014**	**1.54±1.10**	**7.49±0.50**	**0.09±0.03**
Tapioca	I	77.48±0.68	4.90±1.08	30.60±6.74	4.77±1.02	341.00±72.34	17.10±6.49	0.118±0.052	1.95 ±0.93	7.49±0.10	0.09±0.02
	II	76.60±1.07	5.78±0.81	36.10±5.06	5.19±2.80	296.26±49.16	25.92±7.56	0.107±0.007	1.87±0.96	7.50±0.29	0.08±0.02
	III	74.24±3.30	5.80±1.48	36.23±9.23	7.99±2.66	352.13±51.89	31.22±5.79	0.103±0.003	1.25±0.40	7.50±1.25	0.09±0.05
Leaf	Te	79.82 ± 0.75	6.12±2.14	42.88±3.60	6.12±2.14	224.30±35.18	17.09±6.03	0.110±0.009	2.54±0.57	7.48±0.19	0.09±0.02
Type	St	76.30±0.71	6.23±3.56	33.12±2.73	6.23±3.56	333.02±10.97	25.10±7.35	0.120±0.050	1.69±0.54	7.51±0.40	0.09±0.02
Mean	Ma	72.24±2.22	5.60±2.33	26.93±3.66	5.60±2.33	432.07±83.84	32.06±5.51	0.099±0.009	0.84±0.14	7.49±1.16	0.09±0.05
Total Mean		**76.12±2.08**	**5.49±1.19**	**34.31±7.43**	**5.98±2.65**	**329.80±55.29**	**24.75±8.72**	**0.110±0.030**	**1.69±0.84**	**7.49±0.69**	**0.09±0.03**
F value	Leaf type	15.60***	35.73***	35.75***	NS	NS	50.43***	NS	20.92***	NS	7.54**
	Season	NS	5.46*	5.47*	5.09*	NS	24.08***	NS	4.72*	NS	NS
	Host plant	10.71***	18.16***	18.16***	4.85*	NS	6.35**	NS	7.58**	NS	7.42**
	LxS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	LxH	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	SxH	NS	3.01*	3.01*	NS	NS	NS	NS	NS	NS	NS
CV%		**12.5**	**12.46**	**16.5**	**32.72**	**36.8**	**16.5**	**36.9**	**34.8**	**0.66**	**11.2**

and spring, however the trend in other host plants was in order of autumn>spring>summer in Payam; autumn>spring >summer in Kesseru and spring>summer>autumn in Tapioca. Highly significant difference was noticed among the host plants with the maximum record of annual mean in Kesseru (80.38±1.58%) followed by Castor (78.38±1.72%), Tapioca (76.12±2.08%) and Payam (73.40±2.00%). Interaction effect between leaf type x season, leaf type x host plant, and season x host plant was not found to be significant. Pathak (1988) recorded highest moisture content in gulancha followed by Tapioca, Kesseru and Castor. However, Deuri (2004) reported that regardless of the leaf type, moisture content was recorded significantly high in castor (73.99%) which was similar to that of Barpat (73.55%), while the lowest percentage was recorded in Barkesseru (67.73%). Yadava and Goswami (1992) observed a gradual declining trend in moisture with the maturity of leaves in different host plants of muga silkworm species. In a study on the status of biochemical constituents in four morphotypes of *Persea bombycina*, Baruah and Baruah (2007) estimated higher moisture content in the tender leaves than that of semi mature and mature leaves. Paul et al. (1992) observed that availability of moisture content in the leaves enhanced the feeding efficiency of the larvae which in turn increased the growth rate.

Total nitrogen : With the maximum content in tender leaf total nitrogen content was decreasing with maturation of leaves irrespective of seasons in all four food plants and exhibited highly significant difference among leaf types, seasons and host plants. The variations in nitrogen content may partly be attributed to re-translocation of leaf nitrogen into branches before leaf fall and partly due to a dilution factor with expansion and maturity of the leaves (Khosla *et al.*,1992). Similar findings have also been reported in the leaves of mulberry (Jawale *et al.*,1981) and muga silk worm food plants (Yadava & Goswami,1992 and Kakati & Kakati,2011). The nitrogen content within the food plants exhibited seasonal variability at 5% probability level in the order of spring >autumn >summer in Castor; autumn >spring >summer in Payam and Kesseru and autumn>summer>spring in Tapioca. Nitrogen content was recorded to be maximum in Castor followed by Kesseru, Tapioca and Payam during spring season. However during summer and autumn season maximum was recorded in Tapioca followed by Castor, Kesseru and Payam. Annual nitrogen content as a whole was recorded higher in Castor (5.87 ±0.84) in comparison to Tapioca (5.49±1.19), Kesseru (4.68± 1.44) and Payam (3.89±1.07).

Protein content : Highly significant difference at 0.01% probability was evident in protein content among the leaf types with the maximum in tender leaf showing a decreasing trend with the maturity of leaf in all seasons and host plants. A similar pattern of decreasing trend of crude protein with the maturity of leaves was reported in mulberry (Tazima,1978 and Rangaswami *et al.*,1976) and muga food plant (Bharali and Saikia,1979). Ruba *et al.* (1993) observed that the concentration of crude protein was significantly higher in tender than medium and matured leaves. Seasonal variability within the food plants was significant (P>0.05) and was found to be in the order of spring>autumn>summer in Castor; autumn> spring>summer in Payam and Kesseru and autumn>summer >spring. Mean protein content in different seasons among the food plants varies greatly; however did not maintain a specific trend. The annual mean was also recorded to be maximum in Castor (36.68±5.26%) followed by Tapioca (34.31±7.43%), Kesseru (29.22±8.98%) and Payam (24.31±6.70%) exhibiting highly significant difference among the food plants. Interaction effect was significant between season and host plant only. Pathak (1988) and Deuri (2004) also recorded higher crude protein content in Castor in comparison to other host plants *i.e.* Tapioca, Kesseru, Barpat and Barkesseru. Crude protein content is highly variable in different sericigenous plants and is greatly influenced by environment and heredity (Agarwal *et al.*,1980).

Carbohydrate : With the maximum in semi-tender leaf of Castor (9.42±0.03%) during autumn season, the maximum percentage of total carbohydrate in tender and mature leaf was recorded during summer in Tapioca (8.97±0.03%) and Payam (10.98+0.03%) respectively. While variability among different leaf types with in the host plants was not significant, carbohydrate content in the leaves as a whole was found to be maximum in Payam during spring (5.93±0.78%) and summer (8.27±2.52%) and in Castor during autumn season (8.22 ±1.02%). Seasonal variability of carbohydrate content within the food plants was significant at 5% probability level and found to be in the order of spring <summer <autumn in Castor; spring <summer>autumn in Payam; spring<summer >Autumn in Kesseru and spring<summer>autumn in Tapioca. The mean total carbohydrate content was also found to be maximum in Payam (7.43±1.98%) followed by Castor (6.96±1.76%), Tapioca (5.985%) and Kesseru (4.11±1.61%). Interaction effect between season and food plant was found to be significant at 5% probability level. Deuri (2004) observed decreasing trend of carbohydrate content with the age of the leaves and recorded maximum percentage of carbohydrate in castor followed by Barpat and Barkesseru. Yadava and Goswami (1992) however recorded higher carbohydrate content in medium-aged leaves than tender and mature leaves of Som and Soalu host plants. Probably, the moisture quantity of the leaves maintain a degree of relationship in carbohydrate content in different seasons, because reduction of moisture content of leaves from summer to winter may be due to utilization of moisture to build the carbohydrates and other constituents of leaves, thereby increasing dry matters (Sharma and Devi,1997).

Cellulose : Variability among the leaf types with in three seasons was also reflected in mean cellulose content which did not exhibit any definite trend in different food plants. While cellulose has been found to be increasing with maturity of leaf in Castor and Tapioca, maximum content in Payam and Kesseru was recorded in tender and semi tender leaf respectively. Further no definite trend on seasonal variability was observed in different host plant and was found to be in the order of summer >autumn>spring in Castor; autumn>spring >summer in Payam; spring>autumn>summer in Kesseru and autumn>spring>summer in Tapioca. The mean total cellulose

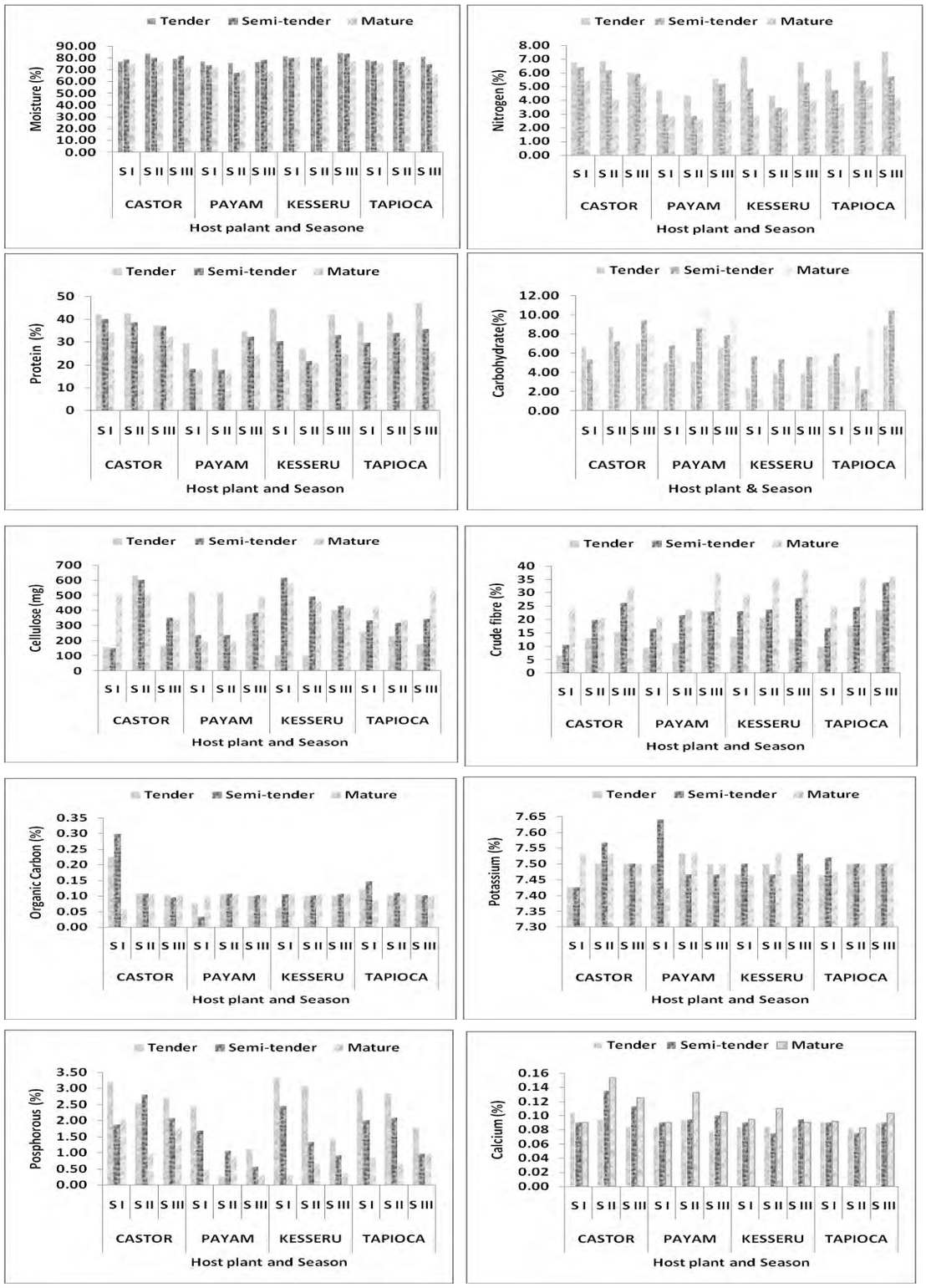

Fig. 1 Seasonal variation of foliar constituents in three leaf types of four host plants in Mokokchung.

content was found to be maximum in Kesseru (401.37± 176.66 mg) followed by Castor (379.61±184.42 mg), Kesseru (352.06±133.46 mg) and Tapioca (329.80±100.29 mg).

Crude fibre : Crude fibre content was found to be maximum in mature leaf and minimum in tender leaf in three seasons for all food plants showing highly significant difference among leaf types. Among the four host plants, crude fibre was recorded to be maximum in Tapioca during autumn season (31.22±5.79%) minimum in Castor during spring season (13.74±8.04%). Seasonal variability within food plants was found to be significant (0.01% probability level) and recorded the maximum content during autumn followed by summer and spring in all host plants except for Kesseru which recorded slightly higher content during summer than autumn season. The mean crude fibre content was also found to be maximum in Kesseru (24.98±8.41%) followed by Tapioca (24.75±8.72%), Payam (20.78±7.90%) and Castor (18.69± 7.73%). However, the interaction effect due to leaf type x season, leaf type x host plant and season x host plant was not significant. Small amount of crude fibre is essential in the diet composed of cellulose and lignin, but cannot be digested by the silkworm larvae; therefore reduction in the fibre content has been considered as an advantage for better silkworm crop yield (Vasuki and Basavanna,1969). While analysing the chemical composition of three *Ailanthus* species *viz.*, *A.excels, A.grandis* and *A.altissima* in relation to growth, nutrient and cocoon characters of eri silkworm, Shaw (1988) observed that with the higher amount of moisture, total nitrogen, crude protein, crude fat and lower amount of crude fibre, *A.grandis* emerged out as the most efficient host plant for rearing of eri silkworm than *A.excels* and *A.altissima*.

Organic carbon : While there was no significance difference within the leaf types, season and host plant, organic carbon content was recorded to be maximum in semi tender leaf (0.17±0.02%) followed by tender leaf (0.15±0.06%) in castor and mature leaf (0.11±0.01%) in Kesseru. Seasonal variability within the food plants was found to be in the order of spring >summer >autumn in Castor and Tapioca; spring<summer> autumn in Payam and spring<summer<autumn in Kesseru. The mean organic carbon content was also found to be maximum in Castor (0.13±0.04%) followed by Tapioca (0.11± 0.03%), Kesseru (0.10±0.01%) and Payam (0.09±0.02%). Yadava and Goswami (1992) also recorded variability in organic carbon content in different leaf types of host plants of muga silk worm species.

Potassium : There was not much variation of Potassium content in three leaf types within and between the four host plants of which Payam recorded maximum in tender (7.51±0.30%) and semi tender (7.52±0.29%) and Castor in mature leaf (7.52±0.19%). Seasonal variability within host plant was also not very apparent exhibiting maximum content during summer followed by autumn and spring in Castor, while in Payam it recorded maximum during spring followed by summer and autumn. However, in Kesseru and Tapioca no variation at all recorded during summer and autumn having slightly less amount in spring season. The annual mean Potassium content was slightly higher in Payam (7.51±0.26%) than Castor (7.50 ±0.19%) and recorded minimum content both in Kesseru and Tapioca (7.49±0.50%), however no significant interaction effect was observed between leaf type and season, leaf type and host plants and season and host plant.

Phosphorous : Mean phosphorous content was recorded to be maximum in tender leaf which decreased with maturity of leaves in all host plants in different seasons and exhibited highly significant difference among leaf types and host plants at 0.1% and 0.01% probability level. There was seasonal variability at 5% probability level having a record of maximum during spring followed by summer and autumn season in all host plants. The content of phosphorus was maximum in Castor (2.22±0.65) followed by Tapioca (1.69±0.84), Kesseru (1.54±1.10) and Payam (0.98±0.68). However interaction effect due to leaf type, season and host plants was not found to be significant. Similar findings were also reported earlier with the maximum record of phosphorus in castor followed by other host plants like Kesseru, Gulancha and Tapioca etc. from Jorhat area of Assam (Bharali,1984 and Pathak,1988).

Calcium : With the variation in leaf types in different seasons, mean calcium content was recorded to be maximum in mature leaf followed by semi tender and tender leaf in all host plants. However minimum and maximum calcium content ranged from 0.06±0.001% in semi tender leaf of Tapioca to 0.15± 0.02% in mature leaf of Castor during summer season highlighting highly significant difference at 0.1% probability level. Seasonal variability within food plants was not found to be significant and recorded the maximum content during summer followed by autumn and spring in Castor and Payam; in the order of autumn>spring >summer in Tapioca, while in Kesseru, the content remained same in all seasons. The mean total calcium content was found to be maximum in Castor (0.11±0.03%) followed by Payam (0.10±0.02%), Tapioca (0.09±0.03%) and Kesseru (0.09±0.03%) and exhibited highly significant difference at 0.1% probability level. However interaction effect between leaf types, season and food plant was not found to be significant. Bharali (1984) and Pathak (1988) also recorded maximum amount of calcium content in Castor and minimum in Gulancha host plant.

Comparative analysis of ten foliar constituent different leaf types of the four food plants, namely, *Ricinus communis, Evodia fraxinifolia, Heteropanax fragnans* and *Manihot esculanta* showed seasonal variation among them and acts as a guideline to evaluate the nutritional status of different food plants for their selection for feeding of the silkworm. It has been observed that leaves of different maturity of all four host plants collected during three rearing seasons revealed highly significant difference in moisture, nitrogen, protein, crude fibre, phosphorus and calcium and significant difference in carbohydrate while difference was not significant for cellulose, organic carbon and potassium. The results suggested both individual and combined effect of leaf types, seasons and host plants on the nutritive value of leaves which greatly influenced the silk worm feeding on different larval

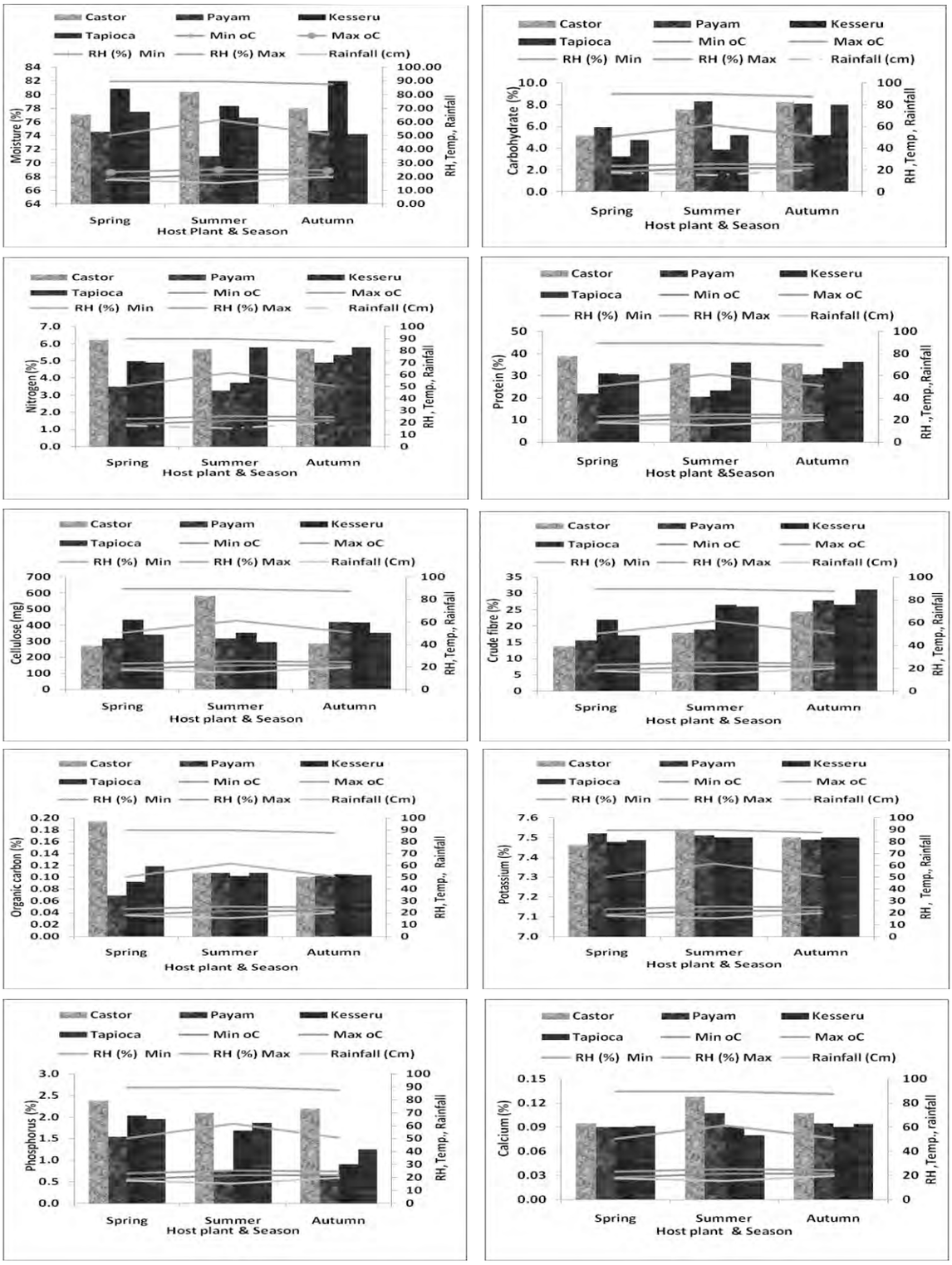

Fig. 2 Mean nutrient content of four host plants in relation to seasonal climatic variation in Mokokchung.

stages and highlighted the importance of Payam and Tapioca at par with Castor and Kesseru host plant on rearing performance and cocoon production in different season.

REFERENCES

A.O.A.C. (1970). *Official methods of analysis* (XI edn.), Washington D.C., pp. 34-58.

Adrian, W. J. (1973). Method of analyzing P and K content. *Analyst*, **98** : 212-213

Agarwal, S. C.; M. S. Jolly and A. K. Sinha (1980). Foliar constituents of secondary food plants of tasar silkworm, *Antheraea mylitta* D. *Indian Forester,* **106** : 846-581.

Banerjee, N. D.; A. K. Choudhury, U. S. P. Sinha and B. N. Brahmachari (1993). Studies on the foliar constituents of the food plants of temperate tasar silkworm, *Antheraea proylei* Jolly. *Indian J. Seric.*, **32(2)** : 228-230.

Baruah, A. B. and P. K. Baruah (2007). Studies on the status of biochemical constituents in four morphotypes of muga food plant som (*Persea bombycina*) In : *Proceeding International Conference "Sericulture Challenges in the 21st Century*" Vratza, Bulgaria, pp. 72-74.

Bharali, N. (1984). Investigation on the growth & development of muga worm (*Antheraea assama* Westwood) on different morpho-physico types of 'Som' plants (*Machilus bombycina*) and chemical analysis of the leaves and hormone treatment of seeds to select the best variety plants. *Ph.D. Thesis*, Dibrugarh University, Assam.

Bharali, N. and B. C. Saikia (1979). Chemical analysis of 'Som' leave of certain varieties. Coordinated study of RRL, Jorhat and SRS Dhakuakhana.

Bose, P. C. and B. B. Bindroo (2001). Response of mulberry (*Morus alba* L.) to varying combinations of nitrogen, phosphorus and potassium under rain fed condition of subtropical region-growth, productivity and economics. *Indian Journal of Sericulture*, **40** : 116-118.

Choudhury, S. N.; R. Z. Ahmed, A. Barthel, P. A. Leclerq (1998). Essential oil composition of *Cinnamomum bejolghota* (Buch-Ham.) Sweet-A Secondary Muga (*Antheraea assamensis* W/w) Food Plant from Assam. *Sericologia*, **38(3)** : 473-478.

Deuri, G. (2004). *Biochemical analysis of Ailanthus leaves and its impact on proximate composition of eri silkworm pupae. M.Sc. Thesis*, Assam Agriculture University, Jorhat, Assam.

Dutta, L. C. (2000). Effect of Castor varieties of growth, nutrition and Cocoon characters of Eri Silkworm, *Samia cynthia ricini Boisduval*. *Ph.D. Thesis*, Department of Sericulture, Faculty of Agriculture, Assam Agricultural University, Jorhat, Assam.

Dutta, L. C.; M. N. Kalita and C. R. Sarkar (1997). Foliar Constituents of the food plants of Muga Silkworm *Antheraea assama* Westwood. *Indian J. Seric.*, **36(1)** : 85-86.

Ferguson, E. L.; R. S. Ibson, C. Opare-Obisaw, F. Osei-Opare, A. M. Stephen, J. Lehrfeld and L. U. Thompson (1993). The zinc, calcium, copper, manganese, non-starch polysaccharide and phytate content of seventy-eight locally grown and prepared African foods. *J. Food Comp. Anal.*, **6** : 87-99.

Gomez, K. A. and A. A. Gomez (1984). Statistical procedures for agricultural research : 2nd edition, Wiley Inter science Publication, John Wiley and Sons, pp. 187-238.

Hazarika.U.; A. Baruah, J. D. Phukan and K. V. Benchamin (2003). Studies on the effect of different food plants and seasons on larval development and cocoon characters of eri silkworm *Samia Cynthia ricini* Bois. *Bulletin India Academy of Seric.*, **7(1)** : 77-85.

Jawale, A. N.; V. K. Patil and G. U. Malewar (1981) Variation in the nutritional elements in mulberry leaves. *Indian J. Seric.*, **20** : 35-38.

Kakati, L. N. and B. T. Kakati (2011). Seasonality of nutrient contents of different leaf types of two primary host plants of *Antheraea assamensis* Helfer. *The Ecoscan*, **1** : 261-265.

Khosla, P. K.; O. P. Toky, R. P. Bisht and S. Himidullah (1992). Leaf dynamics and protein content of six important fodder trees of the western Himalaya. *Agroforestry Systems*, **19** : 109-118.

Padmore, J. (1990). Animal feed. *J. Assoc. O+. Anal. Chem.*, **33** : 69-75.

Pathak, A. K. (1988). Studies on nutrition, growth and cocoon characters of eri silkworm (*Philosamia ricini* Hutt) fed on different varieties of leaves. *M.Sc. Thesis*, Assam Agriculture University, Jorhat.

Paul, D. C.; G. Subha Rao and D. C. Dev (1992). Impact of dietary moisture on nutritional indices and growth of *Bombyx mori* and concomitant larval duration. *Journal of Insect Physiology*, **38(3)** : 229-235.

Rangaswami, G.; M. N. Narasimhanna, K. Kasiviwanathan, C. R. Sastry and M. S. Jolly (1976). Mulberry cultivation. Sericulture Manual-1. *FAO Bull., Rome,* p. 66.

Ruba, T. R.; M. Seshagiri Rao and K. Srinivasa Reddy (1993). Positional nutrient status of mulberry (*Morus alba* L.) leaves. *Indian J. Seric.*, **32(1)** : 125-127.

Sharma, D. K. and D. Devi (1997). Seasonal variation of the foliar constituents of the primary food plants of the Muga silkworm (*Antheraea assama* Ww). *Sericologia*, **37(2)** : 251-258.

Shaw, C. (1998). Evaluation of Ailanthus species in relation to nutrition, growth and cocoon characters of eri silkworm, *Philosamia ricini* Hutt. *M.Sc. Thesis*, Assam Agriculture University, Jorhat, Assam.

Singh, B. K. and P. K. Das (2006). Prospects and problems for development of eri culture in non-traditional states. In : *Proceeding of Regional seminar on Prospects and problems of sericulture an economic enterprise in North West India*, pp. 312-315.

Sinha, A. K. and M. S. Jolly (1971). Foliar constituents of the food plants of tasar silkworm, *Antheraea mylitta* D. *Indian Forester*, **97(5)** : 262-263

Sinha, A. K.; S. K. Choudhury, B. N. Brahmachari and K. Sengupta (1986). Foliar constituents of the food plants of temperate tasar silkworm, *Antheraea proylei*. *Indian J. Seric.*, **25(1)** : 42-43.

Sinha, U. S. P.; A. K. Sinha, P. P. Srivastava and B. N. Brahmachari (1992). Studies on the variations in chemical constituents in relation to maturity of leaves in three primary food plants of tropical tasar silkworm, *Antheraea mylitta* D. *Indian J. Seric.*, **31(1)** : 83-86.

Sinha, U. S. P.; A. K. Sinha, S. K. Chaudhary, J. Prasad and N. Suryanarayana (2005). Comparative study on the nutritive value of the food plants of Tasar silkworm *Antheraea mylitta* Drury. The 20th Congress of the International Sericultural Commission, Bangalore, **2** : 281-284.

Sujathamma, P. and S. B. Dandin (2000). Leaf quality evolution of

mulberry (*Morus* spp.) genotypes through chemical analysis. *Indian J. Seric.*, **39(2)** : 117-121.

Tazima, Y. (1978). *The silkworm : an Important Laboratory Tool*. Kodansha Ltd. Tokyo, pp. 121-152.

Vasuki, K. and H. M. Basavanna (1969). Variety difference in the content of total and soluble minerals of mulberry leaves. *Silkworm Information Bull.*, **1** : 31-35.

Yadava, G. S. and B. C. Goswami (1992). Studies on the Foliar constituents of Som (*Machilus bombycina* King) and Soalu (*Litsea polyantha* Juss.), *Sericologia*, **32(3)** : 447-451.

Yem, E. W. and A. J. Willis (1954). The estimation of carbohydrates in plant extract by anthrone. *Biochem. J.*, **57** : 508-514.