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OBSERVATION ON THE INTERRELATION OF MORPHOLOGICAL CHARACTERISTIC OF JUTE LEAF DURING THE GROWTH AND DEVELOPMENT OF JUTE PLANT AT MALDA, WEST BENGAL

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ABSTRACT
Leaf is the prime photosynthetic organ of plant. Structure of the leaf depends on some leaf-characteristics. Typically, a leaf is a thin, dorso-ventrally flattened, for photosynthesis. Photosynthesis mainly occurs in the palisade mesophyll tissue located at the upper side of leaf lamina. Jute leaves are of different shapes, sizes and textures in relation to plant growth and development. Quality of the jute leaf in relation to the days after sowing (DAS) depends on the leaf characteristics like plant height (cm.), basal diameter/plant (cm), number of branches/plant, number of mature pods/ plant, lamina length, lamina thickness, leaf moisture content, leaf area/plant (dm^2), dry matter /plant in gm., leaf weight, petiole length, petiole thickness, number of veins, number of dentition and leaf chlorophyll content. In order to understand the interrelationship of the leaf characteristics in relation to plant growth and development, an observation on the jute leaf features was made during 2017-2018 at Malda, West Bengal, India at three times (40, 60 and 80 DAS). In most of the cases the relation was found significantly positive as the different leaf characters influences mutually each other. However, in some occasional cases the relation, though very sporadic, are negative.

KEY WORDS
Jute leaf, leaf characteristics, correlation value, insect pests

INTRODUCTION:

Natural fibres as 'renewable resource' are completely biodegradable at the end of their life cycle. They are also 'carbon neutral' and produce chiefly organic waste and leaf remainder that can be used for the production of 'bio-energy' and also to make 'eco-friendly' housing material (Das *et al*., 1995). Plants growing in their natural environment are exposed to a variety of stresses encompassing abiotic stress and biotic stress (Agrawal *et al.,* 2008). Biotic stress can cause a severe reduction in the quantity as well as quality of the jute plants. For survival, plants has evolved and developed several defense mechanisms to fight against these organisms. Study on plant-defense mechanisms is very important for crop protection (Agrawal et al*.,* 2008).

Jute is one of the most significant among the fibre producing crops in Indian Subcontinent. Commercially, jute cultivation is mainly restricted between 21^{0}24"N-26^{0}30"N and 80^{0}18"E-92^{0}E in the Indo-Bangladesh sub-continent (Islam, 2013). Herbivorous insect pests consume radically the plant standing biomass and thus subsume primary producers (Wareing, 1970). High quantum insecticide is generally applied without concerning agro-ecological adversity in field to check the herbivore population (Agrawal *et al.,* 2008). Defensive strategies in plant include both chemical and physical 'parameters' to protect themselves from their attack or to deter the herbivore activities. Physical resistance factors comprise 'plant traits' that negatively affect insect preference to host plant selection (Paul *et al*., 2000), oviposition (Panda and Khush, 1995), feeding

(Cyre and Pace, 1993) and other physiological performance like growth rate (Atwal and Dhaliwal, 2003), development (Ghumare and Mukherjee, 2003) and reproductive success (Panda and Khush, 1995). Morphological features related to physical defense includes like thorns, spines, trichomes, epicuticular wax films, wax crystals, tissue toughness, as well as secretory structures. Any plant trait that interferes with host plant selection, oviposition, or feeding of an insect herbivore is a potential resistance factor and may further contribute to plant defense.

Present observation was carried out aiming to unearth the interrelation of different jute leaf morphological characters at Malda, West Bengal.

MATERIAL AND METHODS:

Location of the study area: Two jute-growing fields of the Malda District, West Bengal, India were primarily selected in the study. The places belong to Ratua II (25°'08'05''N 88°02'11''E) and English Bazar (24°55'00''N 88°08'09''E) blocks respectively. Average elevation of these two provinces is between 0.5 and 0.7 m above sea level. Mean annual rainfall ranges from 1150 mm to 1600 mm with the dry season lasting from October/November to April/May. Alluvial soil with natural fertility and mostly neutral (pH 6-6.8) in nature. EC value of soil is 0.28mmhs/cm. N, P_2O_5 and K_2O contents were 280, 26 and 265 kg/ha respectively. During experimentation period temperature was 24.6–38.2°C and RH was 38.2–96.4% respectively.

Sample collection and preservation: The jute plant sample was selected at random fashion from different parts of the study area. Sampling was done for minimum three times for each location. Both the young and adult leaves from the same plant as sample were collected and subjected to standard chemical procedures for preservation.

Assessment on leaf morphological characters:

Plant height (cm.): The plant height was measured in centimetre from ground level from three randomly selected plants from each replication was averaged.

Basal diameter/plant (cm): The basal diameter of plant was measured by venire calliper at the base of the stem.

Number of branches/plant: The number of branches was recorded at 100 days of four randomly selected plants and then means number of branches per plant were calculated.

Lamina length(cm.): The length (in centimetres) of the leaf lamina, fully expanded leaves, measured from leaf base to leaf tip and excluding the petiole and any extensions of the venation, by using special device and measured the centimetre scale. The final value of length recorded by mean value of 3 times measurement in each case.

Lamina and petiole thickness (mm.): The thickness of lamina as well as petiole measured by highly accurate and dependable Mitutoyo absolute digimatic caliper (series 500).

Leaf moisture content (%): Moisture content in damage jute leaf estimated by using Lutron moisture meter (Model no: MS-7003) which gives the precision measurement of moisture.

Leaf area/plant (dm^2): To determine leaf area, three plants were uprooted randomly from each of the selected plots. The leaves were removed from these plants and leaf area was measured by centimetre scale at various sampling dates. Leaf area is expressed as dm^2 per plant.

Dry matter (mean dry matter of leaf in gm.): The collected leaves were kept in to different brown paper bags and were dried in hot air oven at 70^0C till the constant weight attained. Dry matter of leaves, at various stages of growth. The total dry matter was the summation of leaves per plant at various stages.

Leaf weight (gm.): Each individual leaf is measured by a sensitive weight machine in laboratory and the data recorded as mean value of 3-time measurement of each jute leaf.

Petiole length (cm.): Each leaf petiole is measured by scientific divider then its length is measured by centimetre scale.

Number of veins: No of veins observed by minute and sincere observation and data recorded.

No of dentition: No of dentition in each side of the leaf observed by minute and sincere observation and data recorded for each leaf.

RESULTS:

Observation was made for two consecutive years at jute growing areas of Malda, West Bengal. The results are delineated bellow:

Leaf structure:

Jute leaves are simple in nature like other leaves and are arranged in alternate fashion. Leaves are generally 6-10 cm long and 3.5-5 cm broad in average. Its shape is elliptic-lanceolate, and its apical part is acute or acuminates. Jute leaves show characteristics of glabrous and its margin is serrate type. The lower serratures on each side of leaf prolonged into a filliform appendage over 6 mm long and which is rounded at the base. The stipules are subulate, pubescent, glabrous or ciliated. Each leaf contains at least 3-5 nerves for food and water transportation

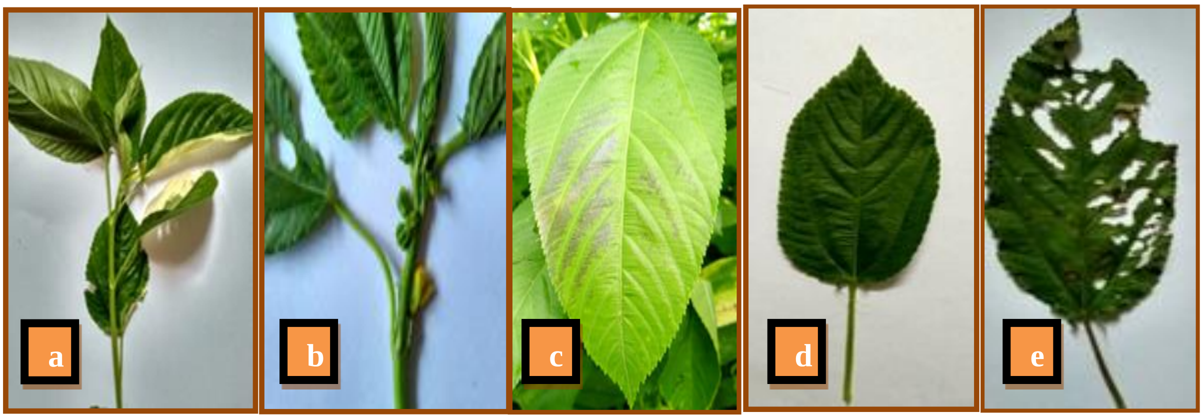

Fig.1: Jute plant and jute leaves (a) at early growth stages (b) at vegetative growth stage (c) at advance growth stage (d) fully grown jute leaf (e) damaged jute leaf

Observation on the interrelation of the leaf characteristics during jute plant growth and development:

During the growth period the leaf characters had shown both positive and negative relation. The extent of relation was further significant and non-significant.

At about 40 DAS in relation to jute plant growth (Table 1):

During 40 DAS, jute plant height has significant relationship with basal diameter of plant (0.87*), number of branches/ plant (0.54*), mature pods/plant (0.65*), days to 50% flowering (no.) (0.78*), leaf area/plant (0.92*), dry matter of leaf (0.72*), leaf weight (-0.92*) and leaf chlorophyll content (0.67*). Further, leaf basal diameter of plant have also significant relationship with leaf moisture content (0.56*), leaf area/plant (0.90*), dry matter of leaf (0.73*), leaf weight (-0.58*), petiole length (0.73*), leaf chlorophyll content (0.74*). On the other hand, number of branches/ plant have significant relationship with mature pods/plant (0.54*), lamina length (-0.51*), leaf moisture content (0.88*), leaf area/plant (0.65*), dry matter of leaf (0.55*), leaf weight (0.51*), petiole length (0.55*) and leaf chlorophyll content (0.52*). In addition to that mature pods/plant have significant relationship with lamina length (-0.57*), Leaf area/plant (0.66*), dry matter of leaf (0.65*), leaf weight (-0.91*), petiole length (0.61*), leaf chlorophyll content (0.65*). Further, days to 50% flowering (no.) have significant relationship with leaf area/plant (0.51*), dry matter of leaf (0.85*), leaf weight (0.71*), petiole length (0.55*), petiole thickness (-0.65*), number of veins (0.61*), number of dentition (-0.67*) and leaf chlorophyll content (0.60*). Further, lamina length and perimeter have significant relationship with lamina thickness (0.74*), leaf moisture content (0.64*), leaf area/plant (0.61*), dry matter of leaf (0.54*), leaf weight (0.58*) and leaf chlorophyll content (0.75*). Lamina and petiole thickness have significant relationship with leaf moisture content (0.57*), dry matter of leaf (0.72*). Leaf moisture content have significant relationship with Leaf area/plant (0.77*), dry matter of leaf (0.58*), leaf weight (-0.71*) and leaf chlorophyll content (0.69*). Leaf area/plant have significant relationship with dry matter of leaf (0.74*), leaf weight (-0.60*), petiole length (0.74*), number of veins (0.74*), number of dentition (-0.61*), leaf chlorophyll content (0.76*). Dry matter of leaf has significant relationship with leaf weight (0.54*), petiole length (0.74*), petiole thickness (-0.50*), number of veins (0.74*) and number of dentition (0.60*). Leaf weight have significant relationship with number of veins (0.74*), number of dentition (0.50*) and leaf chlorophyll content (-0.74*). Petiole length have significant relationship with leaf chlorophyll content (-0.52*). Number of veins have significant relationship with number of dentition (0.57*) and leaf chlorophyll content (0.54*).

At about 60 DAS in relation to jute plant growth (Table 2):

Plant height have significant relationship with basal diameter plant (0.84*), number of branches/ plant (0.51*), mature pods/plant (0.63*), days to 50% flowering (no.) (0.76*), lamina length (0.81*), leaf area/plant (0.90*), dry matter of leaf (0.62*), leaf weight (-0.97*), number of dentition (-0.52*) and leaf chlorophyll content (0.63*). Basal diameter plant has significant relationship with leaf moisture content (0.56*), leaf area/plant (0.90*), dry matter of leaf (0.73*), leaf weight (-0.55*), petiole length (0.72*) and leaf chlorophyll content (0.74*). On the other hand, number of branches/ plant have significant relationship with mature pods/plant (0.50*), lamina length (-0.56*), leaf moisture content (0.85*), leaf area/plant (0.55*), dry matter of leaf (0.53*), leaf weight (0.50*), petiole length (0.53*) and leaf chlorophyll content (0.62*). Mature pods/plant have significant relationship with lamina length (-0.57*), leaf area/plant (0.62*), dry matter of leaf (0.61*), leaf weight (-0.90*), petiole length (0.61*) and leaf chlorophyll content (0.75*). In addition to this, days to 50% flowering (number) have significant relationship with leaf area/plant (0.51*), dry matter of leaf (0.85*), leaf weight (0.71*), petiole length (0.52*), petiole thickness (-0.64*), number of veins (0.62*), number of dentition (-0.64*) and leaf chlorophyll content (0.81*). Lamina length and perimeter have significant relationship with lamina thickness (0.74*), leaf moisture content (0.64*), leaf area/plant (0.61*), dry matter of leaf (0.54*), leaf weight (0.58*) and leaf chlorophyll content (0.74*). On the other hand, lamina and petiole thickness have significant relationship with leaf moisture content (0.57*), dry matter of leaf (0.72*). In addition to this, leaf moisture content has significant relationship with leaf area/plant (0.77*), dry matter of leaf (0.58*), leaf weight (-0.70*) and leaf chlorophyll content (0.61*). Further, leaf area/plant have significant relationship with dry matter of leaf (0.74*), leaf weight (-0.60*), petiole length (0.74*), number of veins (0.61*), number of dentition (-0.65*) and leaf chlorophyll content (0.73*). In addition to this dry matter of leaf have significant relationship with leaf weight (-0.64*), petiole length (0.72*), petiole thickness (-0.50*), number of veins (0.54*) and number of dentition (0.57*). Leaf weight have significant relationship with number of veins (0.74*), number of dentition (0.50*) and leaf chlorophyll content (-0.74*). Petiole length have significant relationship with leaf chlorophyll content (-0.42*). Number of veins have significant relationship with number of dentition (0.52*) and leaf chlorophyll content (0.51*).

At about 80 DAS in relation to jute plant growth* (Table 3)*: Plant height have significant relationship with basal diameter plant (0.81*), number of branches/ plant (0.54*), mature pods/plant (0.65*), leaf area/plant (0.82*), dry matter of leaf (0.71*) a leaf weight (-0.91*) and leaf chlorophyll content (0.67*). Basal diameter plant have significant relationship with leaf moisture content (0.56*), leaf area/plant (0.90*), dry matter of leaf (0.73*), leaf weight (-0.58*), petiole length (0.74*) and leaf chlorophyll content (0.74*). Number of branches/ plant have significant relationship with mature Lamina length pods/plant (0.54*), lamina length (-0.51), Lamina a thickness (-0.56*), leaf moisture content (0.88*), leaf area/plant (0.65*), dry matter of leaf (0.55*), leaf weight (0.61*), petiole length (0.53*) and leaf chlorophyll content (0.52*). In addition to that, mature pods/plant have significant relationship with lamina length (-0.67*), leaf area/plant (0.64*), dry matter of leaf (0.62*), leaf weight (-0.93*), petiole length (0.62*) and leaf chlorophyll content (0.62*). Days to 50% flowering (number) have significant relationship with leaf area/plant (0.51*), dry matter of leaf (0.81*), leaf weight (0.71*), petiole length (0.54*), petiole thickness (-0.62*), number of veins (0.60*), number of dentition (-0.64*) and leaf chlorophyll content (0.61).Lamina length and perimeter have significant relationship with lamina thickness (0.74*), leaf moisture content (0.64*), leaf area/plant (0.63*), dry matter of leaf (0.52*), leaf weight (0.55*), leaf chlorophyll content (0.73*). Lamina and petiole thickness have significant relationship with leaf moisture content (0.54*), dry matter of leaf (0.71*). Leaf moisture content have significant relationship with leaf area/plant (0.73*), dry matter of leaf (0.52*), leaf weight (-0.71*), number of veins (0.55*) and leaf chlorophyll content (0.69*). Further, leaf area/plant have significant relationship with dry matter of leaf (0.71*), leaf weight (-0.62*), petiole length (0.71*), number of veins (0.73*), number of dentition (-0.63*) and Leaf chlorophyll content (0.74*). In addition to this, dry matter of leaf have significant relationship with leaf weight (0.51*), petiole length (0.74*), petiole thickness (-0.53*), number of veins (0.73*) and number of dentition (0.62*). Leaf weight have significant relationship with number of veins (0.71*), No. of dentition (0.61*) and leaf chlorophyll content (-0.70*). Petiole length have significant relationship with leaf chlorophyll content (-0.52*). Further, number of veins have significant relationship with number of dentition (0.52*) and leaf chlorophyll content (0.54*).

Incidence of jute leaf herbivores in relation to plant growth and development (Table 4):

Considerable variation in the incidence jute leaf herbivores was noted during the plant growth and development. Plant height had shown a significant positive relation with insect herbivores up to 75 DAS. After that, the herbivore population had shown insignificant positive relation with plant height. The correlation value between plant height and the insect herbivore population at 15 DAS, 30 DAS, 45 DAS, 60 DAS and 75 DAS was 0.744, 0.852, 0.918, 0.810 and 0.711 respectively and significant. No significant relation was noted between the basal diameter/plant with the insect herbivore population. However, the relation was positive. Number of branches/ plant had shown a significant positive relation with insect herbivore number form 60 DAS till to the maturation of the plant. At 60 DAS, 75 DAS, 90 DAS, 105 DAS and 120 DAS the values are respectively 0.511, 0.691, 0.716, 0.549 and 0.722 respectively. Number of mature pods had shown significant positive relation with herbivores from 90 DAS till to 120 DAS. The values are 0.517, 0.561 and 0.533 respectively. 50% days of flowering had significant and positive relation with leaf herbivores at 105 and 120 DAS only. Lamina length had significant positive relation with herbivore population throughout the growth stages. Lamina thickness was however had shown insignificant negative relation with leaf herbivore population. Leaf moisture content had exhibited significant positive relation at all the growth stages with the insect herbivore population. At all of the growth stages of the jute plant, significant positive relation of jute herbivore was noted with leaf area. Leaf dry matter had shown a significant positive relation with insect population up to90 DAS. However, leaf dry weight had significant positive relation at all the stages of plant growth and development. The petiole length, however, had shown significant relation with plant herbivore population throughout the plant growth stages. Number of leaf vein and leaf chlorophyll content had significant positive relation with leaf herbivore population.

Table 1: Correlation matrix of the important jute plant morphological characters with special reference to leaf properties during 40 days after sowing (DAS).

Characteristics	Acronym	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Plant height (cm.)	A	0.00															
Basal diameter/plant (cm):	B	**0.87***	0.00														
Number of branches/plant:	C	**0.54***	0.47	0.00													
Mature pods/ plant:	D	**0.65***	0.48	**0.54***	0.00												
Days to 50% flowering (No.):	E	**0.78***	0.39	-0.28	0.22	0.00											
Lamina length (cm.)	F	-0.11	0.03	**-0.51***	**-0.57***	0.21	0.00										
Lamina a thickness	G	-0.36	-0.28	-0.26	-0.16	-0.09	**0.74***	0.00									
Leaf moisture content:	H	0.367	**0.56***	**0.88***	0.23	0.35	**0.64***	**0.57***	0.00								
Leaf area/plant (dm^2):	I	**0.92***	**0.90***	**0.65***	**0.66***	**0.51***	**0.61***	-0.26	**0.77***	0.00							
Dry matter of leaf in gm.	J	**0.72***	**0.73***	**0.55***	**0.65***	**0.85***	**0.54***	**0.72***	**0.58***	**0.74***	0.00						
Leaf weight:	K	**-0.92***	**-0.58***	**0.51***	**-0.91***	**0.71***	**0.58***	0.03	**-0.71***	**-0.60***	**0.54***	0.00					
Petiole length	L	0.42	**0.73***	**0.55***	**0.61***	**0.55***	-0.15	-0.21	0.28	**0.74***	**0.74***	0.27	0.00				
Petiole thickness	M	-0.12	-0.28	-0.13	-0.29	**-0.65***	-0.23	0.03	-0.21	-0.12	**-0.50***	-0.20	0.20	0.00			
Number of veins:	N	0.34	0.29	0.35	0.11	**0.61***	-0.15	-0.32	0.28	**0.74***	**0.74***	**0.74***	-0.24	0.20	0.00		
No of dentition:	O	-0.12	-0.28	-0.19	-0.19	**-0.67***	-0.43	0.03	-0.21	**-0.61***	**0.60***	**0.50***	0.41	0.23	**0.57***	0.00	
Leaf chlorophyll content:	P	**0.67***	**0.74***	**0.52***	**0.65***	**0.60***	**0.75***	-0.07	**0.69***	**0.76***	0.473	**-0.74***	**-0.52***	0.25	**0.54***	0.42	0.00

(A)Plant height (cm.), (B) Basal diameter/plant (cm), (C): Number of branches/plant,(D): Number of mature pods/ plant,(E) Days to 50% flowering (No.),(F): Lamina length and perimeter, (G):Lamina and petiole thickness,(H): Leaf moisture content,(I): Leaf area/plant (dm^2), (J): Dry matter (mean dry matter of leaf /plant in gm.),(K):Leaf weight,(L):Petiole length,(M):Petiole thickness,(N):Number of veins,(O):No of dentition,(P): Leaf chlorophyll content

Table 2: Correlation matrix of the important jute plant morphological characters with special reference to leaf properties during 60 days after sowing (DAS).

Characteristics	Acronym	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Plant height (cm.)	A	0.00															
Basal diameter/plant (cm):	B	**0.84***	0.00														
Number of branches/plant:	C	**0.51***	0.44	0.00													
Mature pods/ plant:	D	**0.63***	0.47	**0.50***	0.00												
Days to 50% flowering (No.):	E	**0.76***	0.29	-0.28	0.22	0.00											
Lamina length (cm.)	F	**0.81***	0.15	**-0.56***	**-0.57***	0.21	0.00										
Lamina a thickness	G	-0.26	-0.25	-0.26	-0.16	-0.09	**0.74***	0.00									
Leaf moisture content:	H	0.35	**0.56***	**0.85***	0.23	0.35	**0.64***	**0.57***	0.00								
Leaf area/plant (dm^2):	I	**0.90***	**0.90***	**0.55***	**0.62***	**0.51***	**0.61***	-0.26	**0.77***	0.00							
Dry matter of leaf in gm.	J	**0.62***	**0.73***	**0.53***	**0.61***	**0.85***	**0.54***	**0.72***	**0.58***	**0.74***	0.00						
Leaf weight:	K	**-0.97***	**-0.55***	**0.50***	**-0.90***	**0.71***	**0.55***	0.03	**-0.70***	**-0.60***	**0.64***	0.00					
Petiole length	L	0.43	**0.72***	**0.53***	**0.61***	**0.52***	-0.15	-0.21	0.28	**0.74***	**0.72***	0.27	0.00				
Petiole thickness	M	-0.32	-0.28	-0.13	-0.29	**-0.64***	-0.23	0.03	-0.21	-0.12	**-0.50***	-0.20	0.20	0.00			
Number of veins:	N	0.38	0.29	0.35	0.11	**0.62***	-0.15	-0.32	0.28	**0.61***	**0.54***	**0.74***	-0.24	0.20	0.00		
No of dentition:	O	**-0.52***	-0.28	-0.19	-0.19	**-0.64***	-0.43	0.03	-0.21	**-0.65***	**0.57***	**0.51***	0.41	0.23	**0.52***	0.00	
Leaf chlorophyll content:	P	**0.63***	**0.74***	**0.62***	**0.75***	**0.81***	**0.74***	-0.07	**0.61***	**0.73***	0.473	**-0.74***	**-0.42**	0.25	**0.51***	0.42	0.00

(A)Plant height (cm.), (B) Basal diameter/plant (cm), (C): Number of branches/plant,(D): Number of mature pods/ plant,(E) Days to 50% flowering (No.),(F): Lamina length and perimeter, (G):Lamina and petiole thickness,(H): Leaf moisture content,(I): Leaf area/plant (dm^2), (J): Dry matter (mean dry matter of leaf /plant in gm.),(K):Leaf weight,(L):Petiole length,(M):Petiole thickness,(N):Number of veins,(O):No of dentition, (P): Leaf chlorophyll content

Table 3: Correlation matrix of the important jute plant morphological characters with special reference to leaf properties during 80 days after sowing (DAS).

Characteristics	Acronym	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Plant height (cm.)	A	0.00															
Basal diameter/plant (cm):	B	**0.81***	0.00														
Number of branches/plant:	C	**0.54***	0.47	0.00													
Mature pods/ plant:	D	**0.65***	0.48	**0.54***	0.00												
Days to 50% flowering (No.):	E	0.43	0.39	-0.28	0.22	0.00											
Lamina length (cm.)	F	-0.17	0.03	**-0.51***	**-0.67***	0.21	0.00										
Lamina a thickness	G	-0.35	-0.28	**-0.56***	-0.16	-0.09	**0.74***	0.00									
Leaf moisture content:	H	0.38	**0.56***	**0.88***	0.23	0.35	**0.64***	**0.54***	0.00								
Leaf area/plant (dm^2):	I	**0.82***	**0.90***	**0.65***	**0.64***	**0.51***	**0.63***	-0.26	**0.73***	0.00							
Dry matter of leaf in gm.	J	**0.71***	**0.73***	**0.55***	**0.62***	**0.81***	**0.52***	**0.71***	**0.52***	**0.71***	0.00						
Leaf weight:	K	**-0.91***	**-0.58***	**0.61***	**-0.93***	**0.71***	**0.55***	0.03	**-0.71***	**-0.62***	**0.51***	0.00					
Petiole length	L	0.45	**0.74***	**0.53***	**0.62***	**0.54***	-0.15	-0.21	0.23	**0.71***	**0.74***	0.25	0.00				
Petiole thickness	M	-0.32	-0.28	-0.13	-0.29	**-0.62***	-0.23	0.03	-0.31	-0.12	**-0.53***	-0.21	0.20	0.00			
Number of veins:	N	0.35	0.29	0.35	0.11	**0.60***	-0.15	-0.32	**0.55***	**0.73***	**0.73***	**0.71***	-0.24	0.20	0.00		
No of dentition:	O	-0.12	-0.28	-0.19	-0.19	**-0.64***	-0.43	0.03	-0.25	**-0.63***	**0.62***	**0.61***	0.41	0.23	**0.52***	0.00	
Leaf chlorophyll content:	P	**0.67***	**0.74***	**0.52***	**0.62***	**0.61***	**0.73***	-0.07	**0.69***	**0.74***	0.43	**-0.70***	**-0.52***	0.25	**0.54***	0.43	0.00

(A)Plant height (cm.), (B) Basal diameter/plant (cm), (C): Number of branches/plant,(D): Number of mature pods/ plant,(E) Days to 50% flowering (No.),(F): Lamina length and perimeter, (G):Lamina and petiole thickness,(H): Leaf moisture content,(I): Leaf area/plant (dm^2), (J): Dry matter (mean dry matter of leaf /plant in gm.),(K):Leaf weight,(L):Petiole length,(M):Petiole thickness,(N):Number of veins,(O):No of dentition,(P): Leaf chlorophyll content

Table 4. Correlation of jute leaf herbivores with the plant characteristics during the plant growth and development

Leaf parameters	Growth stages of jute plant (DAS)							
	15	30	45	60	75	90	105	120
Plant height (cm.):	0.744*	0.852*	0.918*	0.810*	0.711*	0.432	0.457	0.311
Basal diameter/plant (cm):	0.398	0.489	0.524	0.565*	0.574*	0.459	0.392	0.334
Number of branches/plant:	0.482	0.413	0.632*	0.511*	0.691*	0.716*	0.549*	0.722*
Lamina length (cm.)	0.874*	0.863*	0.881*	0.766*	0.621*	0.656*	0.555*	0.562*
Lamina thickness (cm.)	-0.312	-0.400	-0.412	-0.412	-0.476	-0.411	-0.422	-0.402
Leaf moisture content:	0.911*	0.910*	0.923*	0.565*	0.947*	0.700*	0.533*	0.519*
Leaf area/plant (dm^2):	0.920*	0.909*	0.957*	0.762*	0.622*	0.821*	0.645*	0.810*
Dry matter(gm.):	0.903*	0.891*	0.913*	0.877*	0.870*	0.702*	0.388	0.403
Leaf weight(gm.):	0.855*	0.813*	0.851*	0.756*	0.666*	0.732*	0.768*	0.711*
Petiole length(cm.):	-0.882*	-0.873*	-0.898*	-0.912*	-0.876*	-0.967*	-0.792*	-0.822*
Number of veins:	0.938*	0.919*	0.974*	0.546*	0.911*	0.743*	0.812*	0.832*
No of dentition:	0.241	0.319	0.454	0.368	0.458	0.422	0.478	0.411
Leaf chlorophyll content:	0.903*	0.891*	0.913*	0.877*	0.870*	0.702*	0.788*	0.903*

(*): significant at 5% level

Principal component analysis had depicted that most of the characters are concentrated and inter correlated. Petiole length and leaf thickness had however had very little impact on the collective characters **(Fig.2).**

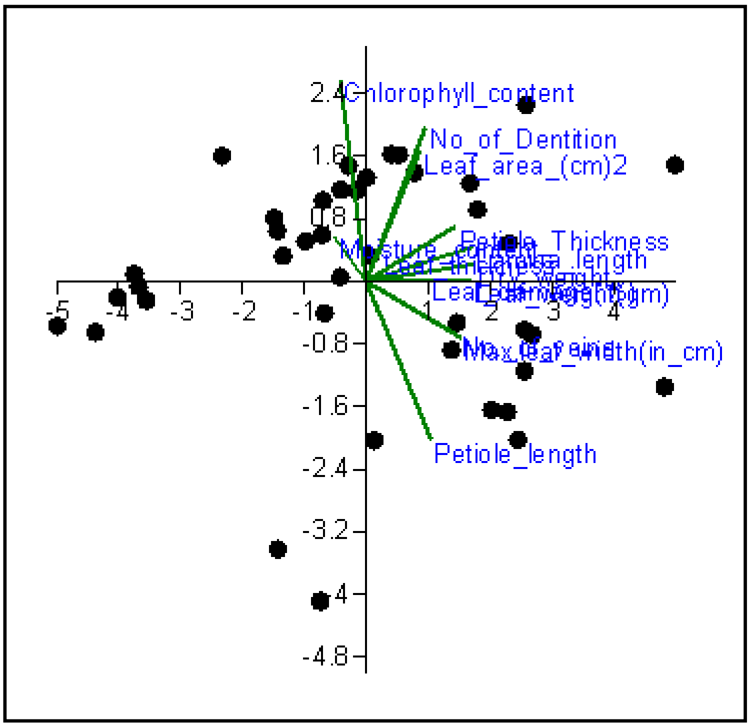

Fig. 2: Principal component (PCA) analysis of the leaf characters indicating their association

Discussion:

Insects consume approx. 14 % of total global agricultural output (Oerke and Dehne, 1997). Herbivore damage is assessed in agricultural fields by surveying the amount of tissue removed from foliage. This approach, however, assumes that the remaining leaf tissue functions normally. Many types of insect damage affect photosynthesis in undamaged tissues, and these 'indirect' effects on photosynthesis may be considerably greater than the direct removal of leaf area (Welter, 1989). Incidence of jute insect pests showed a profound impact on yield attributing characters of the jute crop. Increase in plant vigour after pest attacks is to compensate the damaged caused by pest herbivory (Agrawal and Konno, 2009).

Height of the plant is the prime morpho-physiological characters. The average jute plant height in the present observation was 208.25 cm at maximum growth stage. Similar findings were supported by Kumar *et al*. (2012) and Ali *et al*. (2012). Significantly positive relation was noted between plant height and fibre yield per plant at harvest as observed in this present investigation. This finding was supported by Palit *et al.* (1996). Plant height was found to govern the insect pest distribution perpendicularly by altering the ecological niche along the length of the plant. As the plant grows a distinct variation of micro-climatic conditions were observed. Sarkar *et al.* (2013) had noted that the plant height of jute varied significantly when grown in different strip-cropped system with legumes. Basal diameter of the plant indirectly controls the canopy structure. The basal diameter is one of the parameters affecting the fibre yield per plant (Sarkar *et al.*, 2013). These observations were supported by Joseph *et al*. (1972) and Sobhan and Khatun (1982). Mean number of branches/plant is one of the most significant characters which considerably influenced the leaf biomass of growing plant (Roy, 2013). This finding was supported by Joseph *et al.* (1972) and Pal (1986). In the present observation number of branches/plant is related to the maturation of the pods. Maximum and minimum number of leaves/plant was counted at 1 and 60 DAS, respectively. Leaf canopy helps to accommodate higher number of insect individuals. Higher the foliage development higher would be the insect pest incidence. Such observation is supported by Roy and Ghosh (2004). Number of jute leaf had significant positive relation with the plant height as observed in the present experiment. Leaf area proportionately dictates the available food for insect herbivores. A significant positive relation between the leaves is and the total herbivore insect population was noted at all of the growth stages of the jute plant in the present experiment. However, at the late growth stage due to the senescence of the leaves the number of the insect population falls drastically. Leaf area or the area of leaf surface that intercepts solar radiation is the most important factor. The leaf area/ plant showed significant positive relation with the fibre yield and also with the foliover insect pest abundance in the present studies. Present observation was supported Roy and Ghosh (2004) had noted flowering attracts pollinators most of that are insects (Agrawal, 2004). The ambient climatic conditions at that time are very much congenial for the growth and development for the insect pest population. Increase in leaf thickness makes leaf more harden to eat by pyhtophagous pest which is first line of defence against herbivorous pest (Choong *et al.,* 1992). Present observation corroborates to the study made by Rahman and Khan (2012). Flowering causes a shift or translocation of the plant nutrition to the branches with flowers. For this reason, branches with flower are more prone to insect herbivores. Length of the lamina is positively proportional to the leaf biomass. Higher the laminar length higher would be the available surface area to accommodate more number of insect herbivores. The physical properties of the wax layer as well as its chemical composition are important factors for resistance against insect pest Induced changes in wax production and leaf surface chemistry have been found to offer variable range of resistance to insects. Lamina length corroborates to the lamina weight which is directly proportional to lamina biomass. In the present observation maximum laminar length of 12.6 mm was noted at About 60 DAS. Loh *et al*. (2002) also reported that, leaf thickness affects chlorophyll meter reading and thus increasing variability. Leaf toughness is an important physical factor for plant resistance, as it affects the penetration of plant tissues by mouthparts of piercing-sucking insects, and also increases mandibular wear in biting-chewing herbivores (Schoonhoven *et al.* 2005). Leaf toughness is frequently correlated with insect resistance and is a good predictor of herbivory rates (Bergvinson *et al.* 1995). Cell wall reinforcement for enhanced leaf toughness results from the deposition of 'chemicals', including macromolecules such as lignin, cellulose, suberin, and callose, small organic molecules (*e.g.*, phenolics), and even inorganic silica particles (Schoonhoven *et al.* 2005). Enhanced synthesis and/or deposition of these chemicals after wounding leads to induced physical resistance. Non-glandular trichomes may serve as structural resistance factors preventing small insects from contacting the leaf surface or limiting their movement. Morphological and chemical resistance factors are combined in glandular trichomes. Glands produce substances which may repel insect herbivores or deter them from feeding (antixenosis) or immobilize them on the leaf surface. Maximum leaf moisture content was noted at about 60 DAS. Leaf moisture controls the palatability of the leaves. A critical level of leaf moisture is indispensable for foliage eater. Dry matter production and its partitioning is an important yield contributing character and the knowledge of periodical pattern of dry matter production and its distribution in different parts would give a better understanding of the genotype in relation to its economic productivity. The dry matter accumulation in leaves increased progressively with the advancing age of the crop. The rate was steady up to 80 DAS and thereafter, it became steadily decreased towards the maturity and finally it was totally senescence at harvest. The genotypes differed significantly for mean leaf dry matter (g) per plant. Similar finding were reported by Palit *et al*. (1996). Dry matter of pod per plant was recorded at various growth stages. The genotypes showed the significant differences for mean pod dry matter per plant. The total dry matter accumulation in pods showed a steady rise in all growth stages. While genotype JRO-204 showed the lower accumulation of pod dry matter per plant was closely followed by JRO-524 and JRO- 8432 at all growth stages. Similar results were reported by Bhattacharjee and Mitra (2000). Considerable variation of the petiole length was noted during the period of jute plant growth and development. Petiole is responsible to bear the weight of the leaf. Veins provide rigidity to the leaves. Leaf with higher number of veins offer considerable range of rigidity from mechanical damage. Maximum vein number was noted at about 30 DAS while the minimum was noted at about 65 DAS. Dentition of leaf has not any definite effect on insect pest incidence. Minimum dentition was noted at about 40 DAS while the maximum was noted 70DAS. Leaf chlorophyll accounted for more than 98% of gross primary production variation in field crops (Agrawal, 2004). The chlorophyll content of leaf has been suggested as the community property and has proportional relation to predict productivity.

However, plant can't defend themselves only this morphological defence line and there must be a collaboration between physical and chemical (Agrawal, 2011). Phytochemicals play important role in nutritional ecology and growth of a phytophagous insect (Schoonhoven *et al*., 2005). Host-plant selection by the herbivorous pest influenced by their capability to ingest and assimilate food matter to transform it into body tissues. According to Roy (2014) the development and survival of insects showed significant differences with respect to their food quality. Primary metabolites such as carbohydrate, protein and lipid are key factor for general vitality, growth and reproduction of phytophagous insects (Turunen, 1990). Further, during diapauses lipids provide energy for metabolic processes and also act as precursors of ecdysteroid. Water content in host leaves plays an important role in growth rate of plant-fed larvae (Rahman and Khan, 2012). On the other hand, secondary metabolites including phenols, flavonoids, terpenoids, alkaloids etc. conclude the fitness of the food utilisation of the phytophagous pest and thus govern plant-insect interaction (Agrawal, 2011). Consumption of greater amount of secondary chemicals was found to significantly reduce adult longevity, fecundity, and retardation of larval growth (Mazid and Mohammad 2011). Present study reveals that young and mature leaves (30-90 DAS) of jute plant provide the best quality food for the major defoliator, *A. sabulifera*, because of higher nutritional factors relative to the anti-nutritional secondary metabolites that resulted into high pest incidence. Whereas secondary metabolites dominating over leaf nutrients in late growth phase (120 DAS) that limits pest menace. The better understanding of this defence system will allow us to reach more useful methods for the biological control of insect pests with natural products by the development of new jute varieties with enhanced chemical defences. Since it is also known that tree senescence is an integral age-related biological process intimately linked to Chlorophyll degradation (Iturraspe *et al*., 1995), and that perimeter is a suitable but indirect indicator of tree-age (Orozco, 1982), the corresponding analysis was performed to rule out the possibility that tree size could affect Chl. concentration. Correlation between the perimeter of the group of unharmed trees and their respective Chl. content revealed no significant differences for any of the studied species.

Alteration in phytochemistry of plants due to environmental factors is well recognized (Hunter, 1997; Khadar *et al*., 2014) and some studies have reported the effects of biotic stress on leaf and response in photosynthesis (Aldea *et al*., 2006, Tang *et al.,* 2006). In addition, Aldea et al. (2006) had reported that arthropods damaging leaves in natural ecosystems may reduce photosynthesis rather than directly injured plant tissue, since foliar damage often activates multifaceted interactions between defensive processes and photosynthesis. Damage due to herbivores can modify plant physiology by inducing the production of 'expensive' defensive compounds or disrupting water and nutrient movements. Significant effects of galls infections on photosynthetic efficiency, while chewing damage (caterpillar damage) resulted in minor effects. Plants react against the effect of these harmful agents by developing compensatory mechanisms as activating the growth of leaf tissue or enhancing photosynthetic activity (Mizumachi *et al.,* 2006). Leaf chlorophyll content reacts to pest presence (Baldy *et al*., 1996). On the other hand, most existing assessments of food crop condition are limited to ground-based visual evaluation (Zarco-Tejada *et al*., 2002). However, this is not practical for detecting physiological changes and to characterize stress responses to plant (Sampson *et al.,* 2000). Nevertheless, the physiological evaluation of the plant can indicate plant adaptability to environmental stress (Colombo and Parker, 1999) and may provide early signs of declines in stand vigour and health. Literature containing studies on the eco-physiological responses of plants in Mediterranean ecosystems having the relationships between photosynthesis and the multiple stress-factors characterizes the environmental conditions (Marino, 2000). Chlorophyll fluorescence has been applied to assess environmental stress produced by abiotic factors in urban trees (Percival, 2005).

CONCLUSION:

It was thus concluded from the present study that a definite relation exists between dynamics of herbivorous insect pests with the jute leaf physical parameters. Abundance of insect pest population changes with in relation to the alteration of leaf morphology and side by side adopted cultivation practices during jute growing season. The information may be utilized for planning the appropriate time fitted insect pest management strategies and judicious field management use for sustainable agriculture.

REFERENCES

1. Agrawal, A.A. and Konno, K., 2009. Latex: a model for understanding mechanisms, ecology, and evolution of plant defense against herbivory. *Annual Review of Ecology Evolution and Systematics*. 40: 311–331.
2. Agrawal AA. 2011. Current trends in the evolutionary ecology of plant defense. *Functional Ecology* 25: 420–432.
3. Agrawal A.A., Lajeunesse, M.J. and Fishbein, M., 2008. Evolution of latex and its constituent defensive chemistry in milkweeds (Asclepias): a phylogenetic test of plant defense escalation. *Entomologia Experimentalis Et Applicata* 128: 126–138.
4. Agrawal, A.A., 2004. Resistance and susceptibility of milkweed: competition, root herbivory, and plant genetic variation. *Ecology,* 85:2118–2133
5. Aldea, M., Frank, T.D. and De Lucia, E.H., 2006.A method for quantitative analysis of spatially variable physiological processes across leaf surfaces. *Photosynthesis Research.* 90:161–172.
6. Ali, M. N., Ghosh, A., Sasmal, B. G., Sarkar, H. K., and Das, P. K.,2012. Isozyme diversity in selected leaf mutants of 'tossa'jute (*Corchorus olitorius* L.) *Indian Journal Biotechnology*.11:333-336.
7. Ali, M.I.,1986. Fertilizer use economy in the production of jute (D-154) in the two soils of Bangladesh. *Thailand Journal of AgriculturalScience.* 19(1):207-216.
8. Atwal, A. S., and Dhaliwal, G. S.,2003. Agriculture Pests of South Asia and their Management, In: *Pest Populations and Crop Losses*, Kalyani Publishers, New Delhi, 52-53.
9. *Baldy, R.W., DeBenedictis, J.A., Johnson, L., Weber, E., Baldy, M., Osborn, B. And Burleigh, J., 1996. Leaf colour and vine size are related to yield in a phylloxera-infested vineyard. - *Vitis* 35(4): 201-205.
10. *Bergvinson, D.J., Hamilton, R.I. and Arnason, J.T., 1995. Leaf profile of maize resistance factors to european corn borer, *Ostrinia nubilalis. Journal of Chemical Ecology* 21:343–354.
11. Bhattacharjee, A.K., Mitra, B.N. and Mitra, P.C., 2000. Seed agronomy of jute. II production and quality of *Chorchorus olitorius* seed as influenced by nutrient management. *Seed Science and Technology*. 28 :141-154.
12. Choong, M.F., Lucas, P.W., Ong, J.S.Y., Pereira, B., Tan,H.T.W. and Turner, IM., 1992. Leaf fracture toughness and sclerophylly: their correlations and ecological implications. *New Phytologist*. 121: 597–610.
13. *Colombo, S.J. and Parker, W.C., 1999.Does Canadian forestry need physiology research. - *Forestry Chronicle* 75: 667-673.
14. *Cyre,H., Pace and M.L.,1993.Magnitude and patterns of herbivory in aquatic and terrestrial ecosystems. *Nature*.; 361:148–150.
15. Das,L.K., Sing, B. and Pradhan, S.K., 1995. Efficiency of different synthetic Pyrethyroids insecticides against pest complex of jute, Science and culture.61: 203-204.
16. Ghumare, S.S., and Mukherjee, S.N.,2003. Performance of *Spodopteralitura* Fabricius on different host plants: influence of nitrogen and total phenolics of plants and mid-gut esterase activity of the insect. *Indian Journal of Experimental Biology.* 41: 895-899.
17. *Hunter, M.D. and Mc.Neil, J.N., 1997. Host-plant quality influences diapause and voltinism in a polyphagous insect herbivore. Ecology 78:977-986.

18. Islam, M.M., 2013. Biochemistry, Medicinal and Food values of Jute (*CorchoruscapsularisL. and C. olitorius* L.) leaf: A Review. *International Journal Enhanced Research Science Technology and Engineering* 2(11): 35-44. www.erpublications.com.
19. Iturraspe, J., Moyano, N. and Frydman, B., 1995. A new 5-formylbilinone as the major chlorophyll a catabolite in tree senescent leaves. - *Journal of Organic Chemistry,* 60: 6664-6665.
20. Joseph, J., Saha, A. and Kundu, T.K., 1972. Effect of sowing time on seed yield on tossa jute (*Corchorus olitorius L*.). *Indian Journal of Agricultural Science*. 42: 694-697.
21. *Khadar, B., Prabhuraj, A., Srinivasa, M., Sreenivas, A.G. and Naganagoud, A., 2014.Influence of elevated CO2 associated with chickpea on growth performance of gram caterpillar, *Helicoverpa armigera* (Hüb.). - *Applied Ecology and Environmental Research* 12(2): 345-353.
22. Kumar, S., Saini, M.,Kumar, V., Prakash, O., Arya, R.,Rana, M. and Kumar, D., 2012. Traditional medicinal plants curing diabetes: A promise for today and tomorrow. *Asian Journal Traditional Medicine.* 178–188.
23. *Loh, F.C.W., J.C. Grabosky and N.L. and Bassuk., 2002. Using the SPAD 502 meter to assay chlorophyll and nitrogen content of Benjamin fig and cottonwood leaves. *Horticulture Technology*. 12(4):682-686.
24. *Marino, H., 2002. Respuestas ecofisiológicas de plantas en ecosistemas de zonas con clima mediterráneo y ambientes de alta montaña. - *Revista Chilena de Historia Natural* 75: 625-637.
25. Mazid M., Khan T. and Mohammad F., 2011.Effect of abiotic stress on synthesis of secondary plant products: A Critical Review. *Agricultural Review*. 32, 172-182.
26. Mizumachi, E., Mori, A., Osawa, N., Akiyama, R. and Tokuchi, N., 2006. Shoot development and extension of *Quercus serrata* saplings in response to insect damage and nutrient conditions. - *Annals of Botany* 98: 219-226.
27. Oerke, E-C. and Dehne, H-W., 1997. Global crop production and the efficacy of crop protection – current situation and future trends. *European Journal of Plant Pathology.* 103:203–215.
28. *Orozco, M.F. 1982. Producción forestal. - Trillas, México.
29. Pal, P.K.,1986. Seed yielding potentialities of olitorius jute.Environment and Ecology 4 (4): 738-741.
30. *Palit, P., Sasmal., B.C. and Bhattacharryya, A.C.,1996. Germplasm diversity and estimate of genetic advance of four morpho-physiological traits in a world collection of jute. *Euphytica*. 90:49-58.
31. *Panda, N. and Khush, G.S. 1995. Host plant resistance to insects*. CAB International, Wallingford.*
32. Paul, N.D., Hatcher, P.E., and Taylor J.E., 2000. Coping with multiple enemies: an integration of molecular and ecological perspectives. *Trends Plant Science*. 5:220-225.
33. Percival, G.C., 2005. Use of chlorophyll fluorescence to identify chemical and environmental stress in leaf tissue of three oak (*Quercus*) species. - *Journal of Arboriculture* 31(5): 215-227.
34. Rahman, S. and khan, M.R., 2012. Effect of plant characteristics of jute varieties on incidence of pests in West Bengal, India. *Archives of Phytopathology and Plant Protection.* 45(5): 608- 619. DOI: 10.1080/03235408.2011.588055.
35. Roy, B., 2013. Seed production potential of Jute (*Corchorus olitorius*) under different planting techniques. *Agricultural Science Digest*.33:154 – 157.
36. Roy, N., 2014 Role of *Chorchorus* capsularis phytochemicals on the feeding dynamics of *Diacrisia casignetum* Kollar (Arctiidac : Lepidoptera), *Journal of Entomology and Zoological Studies*, 2(4), 227-236.
37. Roy, N. and Barik, A., 2013. Influence of four host plants on feeding, growth and reproduction of *Diacrisia casignetum* (Lepidoptera: Arctiidae). *Entomological Science*; 16:112-118.
38. Roy, S. and Ghosh, K.K., 2004. Association of leaf characters with fiber yield, plant height and basal diameter in tossa jute. *Indian Jute Genet*. 64(3): 249-250.
39. *Sampson, P.H., Mohamed, G.H., Zarco-Tejada, P.J., Millar, J.R., Noland, T.L., Irving, D., Treitz, P.M., Colombo, S.J. and Freementle, J., 2000. The bioindicators of forest condition Project: A physiological, remote sensing approach. - *Forestry Chronicle* 76(6): 941-952.
40. Sarkar, S., Majumdar, B., and Kundu, D. K., 2013. Strip-cropping of legumes with jute (*Corchorus olitorius*) in jute-paddy-lentil cropping system. *Journal of Crop and Weed, 9*(1), 207-209.
41. Schoonhoven, L.M., Van-Loon, J.J.A. and Dicke, M.,2005. Insect-Plant Biology. Oxford University Press, Oxford.
42. Sobhan, M.A. and Khatun, R., 1982. Variability and correlation in Kenaf. B.J. Fibre. Res. 7(1 and 2) : 103-106.
43. Tang, J.Y., Zielinski, R.E., Zangerl, A.R., Crofts, A.R., Berembaum, M.R. and DeLucia, E.H., 2006.The differential effects of herbivory by first and fourth instars of *Trichoplusia ni* (Lepidoptera: Noctuidae) on photosynthesis in *Arabidopsis thaliana*. - *Journal of Experimental Botany* 57: 527-536.
44. Turunen, S. 1990.Plant leaf lipids as fatty acid sources in two species of Lepidoptera, *Journal of Insect Physiology*: 36, 665-672.
45. *Wareing, P.F., 1970. Growth and its coordination in trees. In: L.C. Luckwill and C.V. Cutting (Editors). *Physiology of Tree Crops*, (Academic Press, New York, USA) 1-21.
46. *Welter, SC., 1989. Arthropod impact on plant gas exchange. In: Bernays EA, editor. Insect–plant interactions. Boca Raton, FL: CRC Press. pp. 135–151.
47. *Zarco-Tejada, P.J., Miller, J.R., Mohammed, G.H., Noland, T.L. and Sampson, P.H. 2002. Vegetation stress

detection through chlorophyll *a+b* estimation and fluorescence effects hyper spectral imagery. - *Journal of Environmental Quality* 31: 1433-1441.

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