PLASTOCHRON INDEX, LEAF PLASTOCHRON INDEX AND HAUN INDEX IN AGROECOLOGICAL STUDIES OF *ALLIUM HOOKERI* THW. ENUM DURING ZAID SEASON

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Abstract - In Allium hookeri Thw. Enum (Manipuri – Maroi Napakpi), a perennial green leafy herbal spice, the potential of Haun Index, Plastochron index and Leaf plastochron index, in exploration to the state of crop with relation to the physiology, growth and development of agriculturally important and current model on advanceproduction practices viz. fertilization, irrigation, harvesting time and number etc. for selective cropping season of zaid for two cropping years was investigated. The occurrences of critical developmental events in growing plant population have determined. The sink, source and transition status of leave, duration of sink to source, transition process and the number of leaves under transition at a given time were vividly analysed.

Index terms – Allium hookeri, perennial, Haun index, Plastochron index, Leaf plastochron index, sink, source, transition, zaid season

I.INTRODUCTION

Plastochron index (PI), a continuous developmental scale based on leaf number, is a key feature in understanding the physiology, growth and development of agriculturally important and current model plant species [1,2]. The developmental processes such as leaf elongation, epidermal and palisade growth, expansion of lamina surface, relative elemental rates of lamina growth and other aspects in a plant, have been investigated as a function of the leaf plastochron index (LPI) [3]. Further, all above ground organs in a plant usually originate from the shoot apical meristem (SAM) [4]. Shoot apical meristem (SAM) produces lateral organs in a regular spacing (phyllotaxy) and regular timing i.e. the plastochron; thus convergent the idea of many biologist [5,6].

Allium hookeri Thw Enum of Liliaceae family, locally known as “Maroi napakpi” is an important green leafy spice widely used as herbal spice and medicinal purpose. Normally growing in a wide range of soils and climatic condition. *Allium hookeri* has hardly any bulb instead much reduced underground rhizome produces fibrous roots [7]. The leaves are thick evergreen, linear with prominent midribs, basal leaves membranous and shorter than the tall sub trigonous scape. Edible parts are the thick, flat, green leaves with prominent midrib and white fibrous roots [8].

Plants grown under uniform condition normally attained the morphological and physiological development state in leaves of same plastochron age. Consequently use of plastochron index permits the adjustment of plant development and metabolism for age effects. Further, the plastochron index inevitably used to demonstrate that the rate of net photosynthesis, dark respiration, enzyme production, C^{14} distribution [9,10]. Furthermore plastochron index extended the use of morphological indices to semi deterrent nature species [11]. However, plastochron index and associative indices in *Allium hookeri* is very meager [12,13,14]. Henceforth, the present work have undertaken with the objectives: to determine the effectiveness of the plastochron index (PI), leaf plastochron index (LPI), Hauns index (HI) etc. on the dynamics of leaf appear and length in *Allium hookeri* cv. local type and its impact on yield and yield parameters during zaid season.

II.MATERIALS AND METHODS

The present investigation work on plastochron, Leaf plastochron index, Plastochron ratio, Hauns index etc. of *Allium hookeri* was conducted on farmer’s experimental field at Moirangkampu Sajeb Loukol in Imphal East district, Manipur. (Latitude $23^{0}56'$N to $25^{0}44'$N and $93^{0}02'$E to $94^{0}47'$E, altitude 790 m asl). Detailed observation on leaf emergence, leaf length and sequences of leaves of *Allium hookeri* were investigated when crop growth had been achieved but main leaves had not fallen during zaid season of cropping year 2014 and 2015 respectively.

Meteorological data for the experimentation were collected from Imphal International Airport, Imphal and ICAR, Lamphelpat, Imphal, the nearest meteorological stations from the experimental field one week prior during and one week after the sampling period.

Experiment

For the present experimentation *Allium hookeri*, local variety was planted at 1st week of June each year at a spacing of 25 × 25 cm plant to plant and row to row. Plots of the experimental field were 1.25×1.25 m. The crops were precision planted by taking utmost care in a randomized block design with three replications. Irrigation was supplied when needed to avoid water stress to the planting test crop. Manual weed control was practiced althroughout the season of the investigation cropping years i.e. 2014 and 2015.

Field records

Twenty **(**20) plants were randomly marked within each sub plot to record the main leaf number and length. Measurement was taken daily althroughout the investigation period. Leaf length was the length of the visible leaf lamina measured to the nearest 5mm from its tips to its insertion into the previous leaf.

The 20 choosen leaves represented the full ranges of development from extremely young to fully mature lamina. The lengths of leaves were recorded directly and the plastochron index and other requirement were computed.

Haun's index (HI), an observational developmental index based on relative proportion of leaf lamina and average maximum length, was determined following Haun [15].

$$HI = (n-1) + Ln/(Ln-1) \quad (1)$$

Where, n was the number of leaves that have appeared on the shoot.

Ln-1 was the blade length of the penultimate (subtending) leave.

Ln was the blade length of the youngest expanding leaf that is emerging from the sheath of the penultimate leaf.

The PI was calculated by using the formula of Erickson and Michelini [1]

$$PI= n+(\ln L_n-\ln R)/\ln L_n – \ln L_{n+1} \quad (2)$$

Where, L_{n+1} was the length (mm) of a leaf or organ just shorter than R mm

L_n was the length of the next leaf that was slightly longer than R

n was the serial number of leaf/organ for which PI is being calculated

R was the reference length of organ or leaf.

A reference length of 30 mm was found to be appropriate for the present test species.

The PI was therefore equivalent to the distance in time between two successive leaves reaching 30 mm.

The Leaf Plastochron Index (LPI) was determined by using the approved formula -

$$LPI = PI – a \quad (3)$$

Where, "a" was the serial number of the chosen leaf, PI was the plastochron index

The number of days per increment in LPI (LPI_d) was computed by using the equation

$$LPI_d =(Lni-Lno)/d \quad (4)$$

Where, Lno was the first measured LPI of Ln,

Lni was the second measured LPI of Ln,

d was the number of days between measurements

Plastochron ratio, "a" the increases of a single organ during plastochron was determined by using formula following Richards [16]

$$a=Ln/(Ln+1) = LOn/LOn+1 \quad (5)$$

Erickson [17] further pointed out that the ratio of Ln/Ln+1 was introduced the variable "a" termed plastochron ratio by Richards [16] and Reiterated this relative plastochron rate of elongation in their original article the natural log of "a" symbolized by "ρ" represents the relative plastochron rate of leaf elongation.

Thus ρ = Natural log of "a" where "a" was the plastochron ratio

Data analysis

All information observed during the investigation was recorded and data were analyzed using statistically approved tests.

III.RESULTS AND DISCUSSIONS

Haun index determination on *Allium hookeri*, accord 1.03, 2.10, 3.06, so on to 18.14 for HI2, HI3, HI4, so on to HI19 respectively for zaid season of 2014; 1.14, 2.03, 3.12, so on to 18.07 for HI2, HI3, HI4, so on to HI19 respectively for zaid season of cropping year 2015. Consequent to the validity of the Haun's index i.e. the value of Ln/Ln-1 bounded only within the range of 0 and 1 i.e. mathematically $0 \leq Ln/Ln-1 \leq 1$, the observed value were accessed, examined and proved the validity [Table 1(a) & Table 1(b)].

The pattern of leaf appearance for *Allium hookeri* (local type) was consistent across the planting date during zaid season of the cropping years i.e. 2014 and 2015. In general, a leaf tip (n) became visible only after the matured leaf n-2 attends its maximum height. This indicated that leaf n-2 [Figure 1(a) and Figure 1(b)] had reached its maximum length only when leaf tip of leave n emerge. This is manifested in Figure 1(a) for the zaid season of cropping year 2014 and Figure 1(b) for the zaid season of the cropping year 2015. It is evident by plotting the leaf length against calendar days, thermal time and leaf plastochron index [Figure 2(a) and Figure 2(b)]. The observed regression accord Y=-6.75+10.95x with r^2=0.98 during 2014, and Y=5.74+9.61x with r^2=0.98 for 2015 and computed regression equation Y=-8.5+0.77x with r^2 = 0.99 during 2014, and Y=2.68+0.7x with r^2=0.99 for 2015 was accorded for correlation regression with leaf length and GDD [Figure 3(a) and Figure 3(b) and Figure 4(a) and Figure 4(b)].However, in case of leaf emergence, the pattern appeared to be independent of both the leaf that was emerging and attend its maximum length [Figure 1 (a) and Figure 1 (b)]. In the present case, during the cropping season, 2014, the 15th leaf for that period of observation from the day of transplanting achieved its maximum height only when the 13^{th} leaf emerged. In other words, the 13^{th} leaf emerged only when the 15^{th} leaf attend its maximum height in the zaid season. Thus it is evident that plastochron index exhibit better clarification than that of calendar date in chronological studies of plant growth and development. For the cropping year 2015, 12th leaf emerge as 10th leaf reached its maximum length and when 12th leaf reached its maximum length the tip of 14th leaf had emerged in zaid season; The result clarified the existence of consequential scale of plastochron index for investigation on growth and development of a plant. The existence pattern was in corroborative with the results reported in different seasons of *Allium hookeri* [12,13,14].

Thus, for this genotype of *Allium hookeri* there were always two visible leaves expanding at the same time until the attainment of maximum length of leaf of the next to penultimate leaf. Hence leaf expansion takes 2 plastochron. However, this plastochron differs from wheat, where only one leaf is usually expanding [18].

The plastochron index (PI) and leaf plastochron index (LPI) of all the selected plants was worked out [19,1] thus substantiate the growth of the plants and authenticate the different status of growth and development of leaves. The PI ranges from 2.20 to 19.53 and 2.32 to 19.39 during Zaid season of crop years 2014 and 2015 respectively (Table 2).

All measured leaves accord leaf plastochron index (LPI) of -0.47 in minimum and 18.53 in maximum for the test zaid season of cropping year 2014; similarly, the minimum measured leaf plastochron index (LPI) accord -0.48 and maximum was 18.39 for zaid season of cropping year 2015 {Table 3(a) &3(b)}. The finding was in agreement with that of Ferris et.al. [20]. Further, the finding indicates that a new allium leaf forms from the encased SAM (Shoot Apical Meristem) and eventually emerges from the leaf sheath of the preceding leaf. The finding was in corroborative with the results of Itoh et.al.[21].

Regarding sink, transition and source, the LPI values vividly evince the status of leaves involvement to activities incorporation with administering and dispensation of chemicals viz. 0 – 0.4 implies sink, 0.41 – 2 denotes transition and above 2 connotes source following function of sink, source and transition categorization. Consequently evidence the existence of sink, transition and source independently to all observed leaves of test plants in zaid season of both cropping years 2014 and 2015 [Table 3(a) and Table 3(b)]. In average, in a tiller of the present test crop having 19 leaves, 1-2 leaves categorized to sink, 1-2 leaves in transition and 15 classified under source {Table 3(a.1) and Table 3(b.1)}. The findings highlight the appropriateness of LPI in assigning the growth of the plant with relation to status of the embodied chemicals within the leaves of the test crop. Further the investigation on “source sink depending leaf duration” blaze the establishment of senescence in the leaves of test crop when leaves procured LPI value of over 9. The finding evidence the senescence levels of leaves normally codified after acquiring LPI 9 and onwards, correspondingly the leaf appearance changes from green to brown exhibiting the function of source-sink relationship within the tillers of the test crop. The finding was in accordance with the manifestation of allocations and transformation of chemicals in plant leaves [22, 23, 24, 25, 26]. Regarding agriculturally importance, the LPI values, over 6 indicates the sign for harvesting of matured productive leaves by removing individual leaf from each tiller of a hill and from all hills of the field. Keeping leaves over LPI value of 9 being approach to senescence the situation thus warned to the producers or farmers, not to under estimate the economic threshold of the test crop by maintaining the prime task of serialization of harvesting viz.1st, 2^{nd} 3^{rd} till 20^{th} harvesting in the zaid season. In this connection many disciplines have long been interested in monitoring leaf age for individual plants [27] and leaf life span for many species [28, 29].

Table 4 revealed the plastochron ratio, the increases of a single organ i.e. leaf length during plastochron ranges from 6.8 to 56 for 2014 crop season and 5.54 to 78 for 2015 crop season confirming the central tendency of yearly mean from 6.17 to 67 with mean of 36.6.

Further Table 4 displayed the Plastochron rate of elongation (ρ) of the test crop ranges from 1.92 to 4.03 for 2014 and 1.71 to 4.36 for 2015 cropping years of this zaid season. It is evident from the present investigation that the plastochron rate of elongation ranges from 1.82 to 4.2 with a mean of 3.

Table 5 demonstrate the number of days per increment in LPI of test crop, *Allium hookeri* accord 0.13 to 0.18 for zaid season in both 2014 and 2015 cropping years. The finding highlight the numbers of days per increment never reach 1 and fluctuate in lesser range. The temperature and other parameters for both 2014 and 2015 cropping years are shown in Figure 5(a) & Figure 5(b).

The present finding evidence that the plastochron works including PI, LPI, PR, PR etc. of *Allium hookeri* have its uniqueness in adding new information to the vast ocean of knowledge of plant sciences and provides a new room for further investigation to different area of their applicability to applied sciences like post harvest, yield, yield parameters, agronomical techniques, environmental resources, the shoot, plant and other plastochron based research works.

Table 1 (a). Determination of Haun's Index of *Allium hookeri* for zaid season of cropping year 2014.

Years and season	n	L_n	L_{n-1}	n-1	L_n/L_{n-1}	HI_n	Remarks
2014 Zaid	2	2	61	1	0.03	1.03	$0 \le L_n/L_{n-1} \le 1$ are True
	3	9	88	2	0.10	2.10	
	4	5	80	3	0.06	3.06	
	5	10	78	4	0.13	4.13	
	6	7	80	5	0.09	5.09	
	7	1	56	6	0.02	6.02	
	8	5	72	7	0.07	7.07	
	9	4	86	8	0.05	8.05	
	10	8	61	9	0.13	9.13	
	11	3	74	10	0.04	10.04	
	12	2	78	11	0.03	11.03	
	13	9	74	12	0.12	12.12	
	14	6	83	13	0.07	13.07	
	15	4	84	14	0.05	14.05	
	16	10	68	15	0.15	15.15	
	17	3	92	16	0.03	16.03	
	18	8	68	17	0.12	17.12	
	19	12	84	18	0.14	18.14	

Haun's Index, $HI = (n-1) + L_n/L_{n-1}$ where, $0 \le L_n/L_{n-1} \le 1$

Table 1(b). Determination of Haun's Index of *Allium hookeri* for zaid season of cropping year 2015

Years and season	n	L_n	L_{n-1}	n-1	L_n/L_{n-1}	HI_n	Remarks
2015 Zaid	2	8	56	1	0.14	1.14	$0 \le L_n/L_{n-1} \le 1$ are True
	3	2	67	2	0.03	2.03	
	4	10	86	3	0.12	3.12	
	5	4	88	4	0.05	4.05	
	6	10	72	5	0.14	5.14	
	7	9	64	6	0.14	6.14	
	8	11	65	7	0.17	7.17	
	9	12	82	8	0.15	8.15	
	10	1	78	9	0.01	9.01	
	11	3	71	10	0.04	10.04	
	12	5	65	11	0.08	11.08	
	13	13	72	12	0.18	12.18	
	14	5	65	13	0.08	13.08	
	15	5	57	14	0.09	14.09	
	16	8	59	15	0.14	15.14	
	17	6	62	16	0.097	16.097	
	18	10	80	17	0.125	17.125	
	19	6	84	18	0.07	18.07	

Haun's Index, $HI = (n-1) + L_n/L_{n-1}$ where, $0 \le L_n/L_{n-1} \le 1$

Figure 1(a). Graphical presentation of *Allium hookeri* growth in Leaf length (mm) against time for Zaid season of cropping year 2014

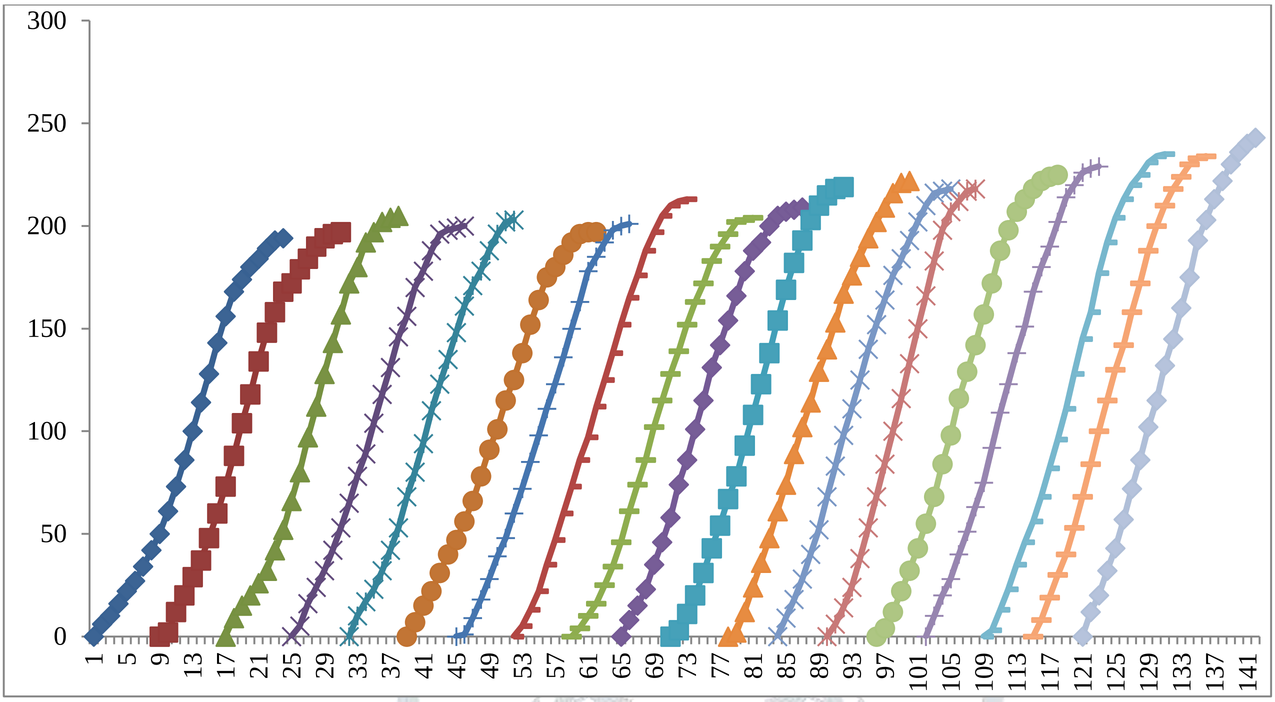


Figure 1(b). Graphical presentation of *Allium hookeri* growth in Leaf length (mm) against time for Zaid season of Cropping year 2015

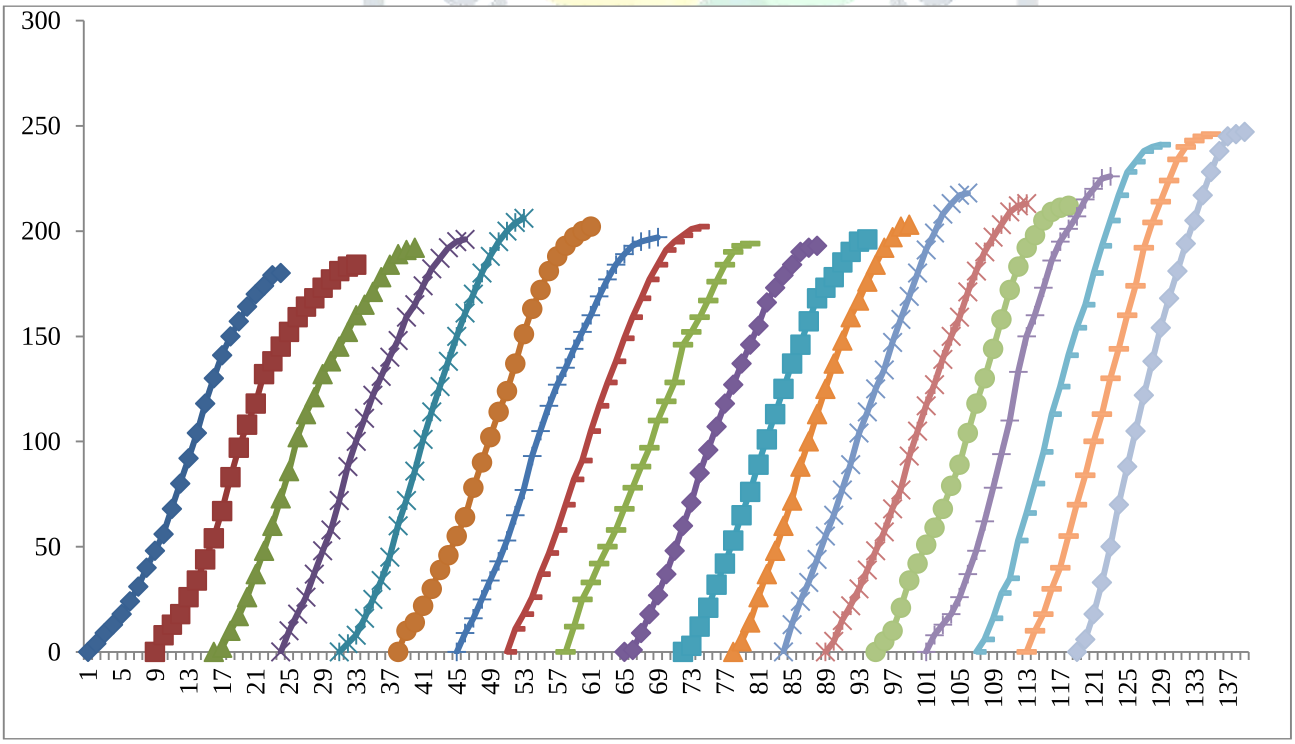


Fig.2 (a). Graphical representation of (i) leaf length against calendar days (ii) leaf length against thermal time (GDD) (iii) leaf length against LPI for *Allium hookeri* for zaid season of cropping year 2014.

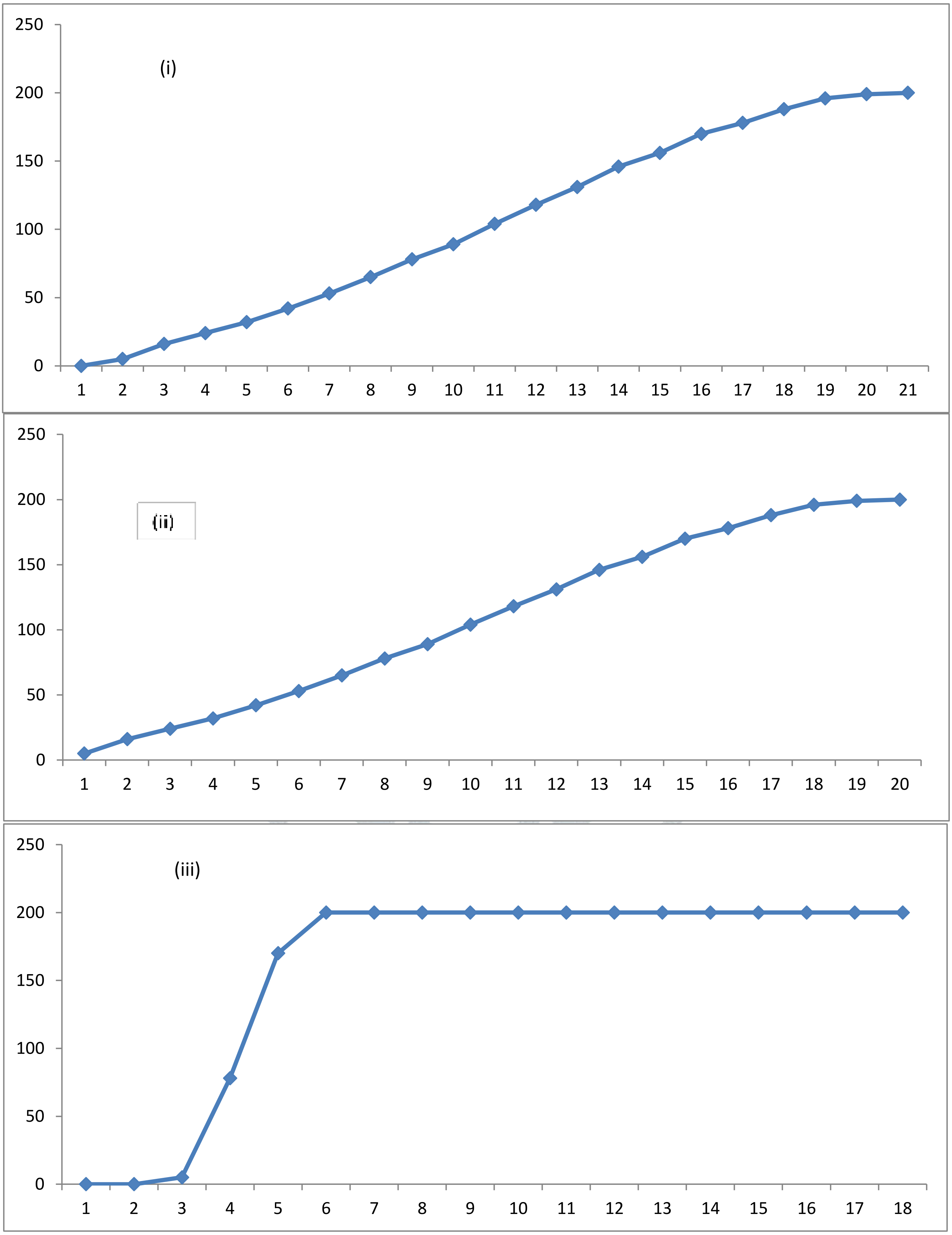


Fig.2 (b). Graphical representation of (i) leaf length against calendar days (ii) leaf length against thermal time (GDD) (iii) leaf length against LPI for *Allium hookeri* for zaid season of cropping year 2015.

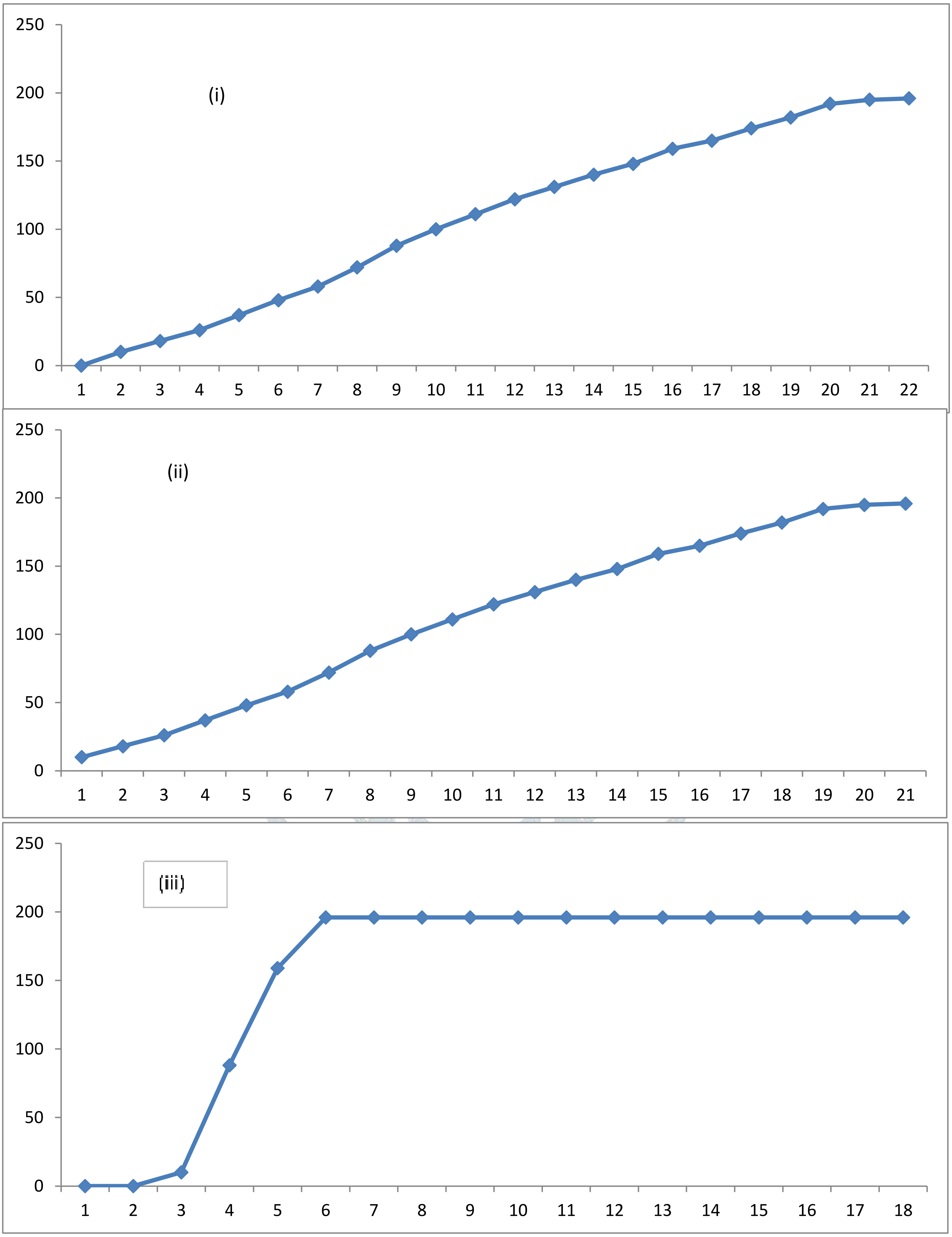
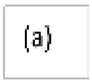


Figure 3. Regression between (a) Days and leaf length (mm) during Zaid 2014 (n=21, A=-6.75,B=10.95,r=0.99, r^2=0.98) (b) Days and leaf length (mm) during Zaid 2015 (n=22,A=5.74, B=9.61, r=0.99, r^2 = 0.98)



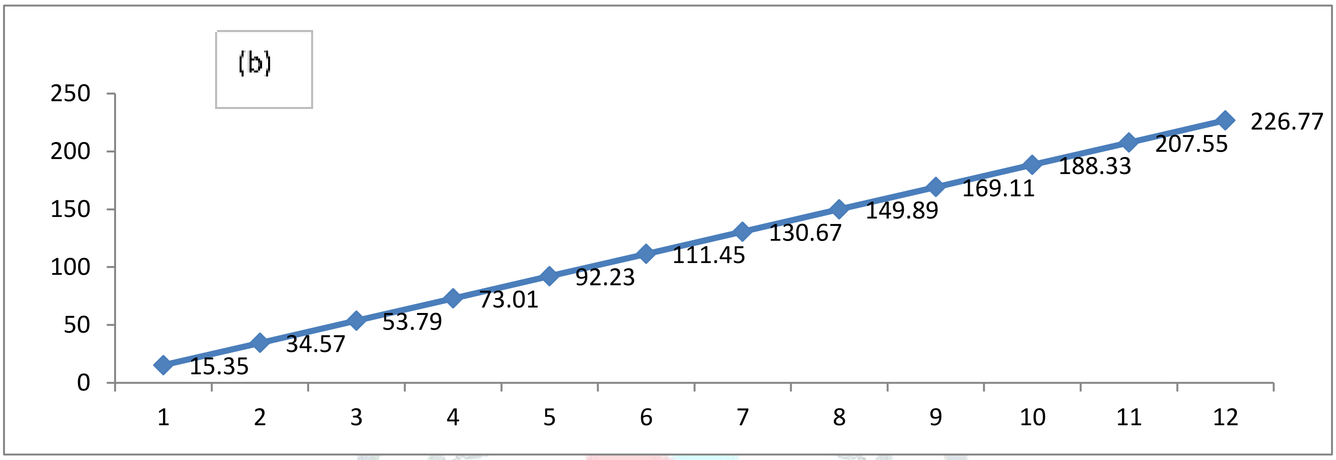


Figure 4. Regression between (a) Thermal temperature (GDD) and leaf length (mm) during Zaid 2014 (n=20, A=-8.5,B=0.77,r=0.99, r^2=0.99) (b) Thermal temperature (GDD) and leaf length (mm) during Zaid 2015 (n=21,A=2.68, B=0.7, r=0.99, r^2 = 0.99)

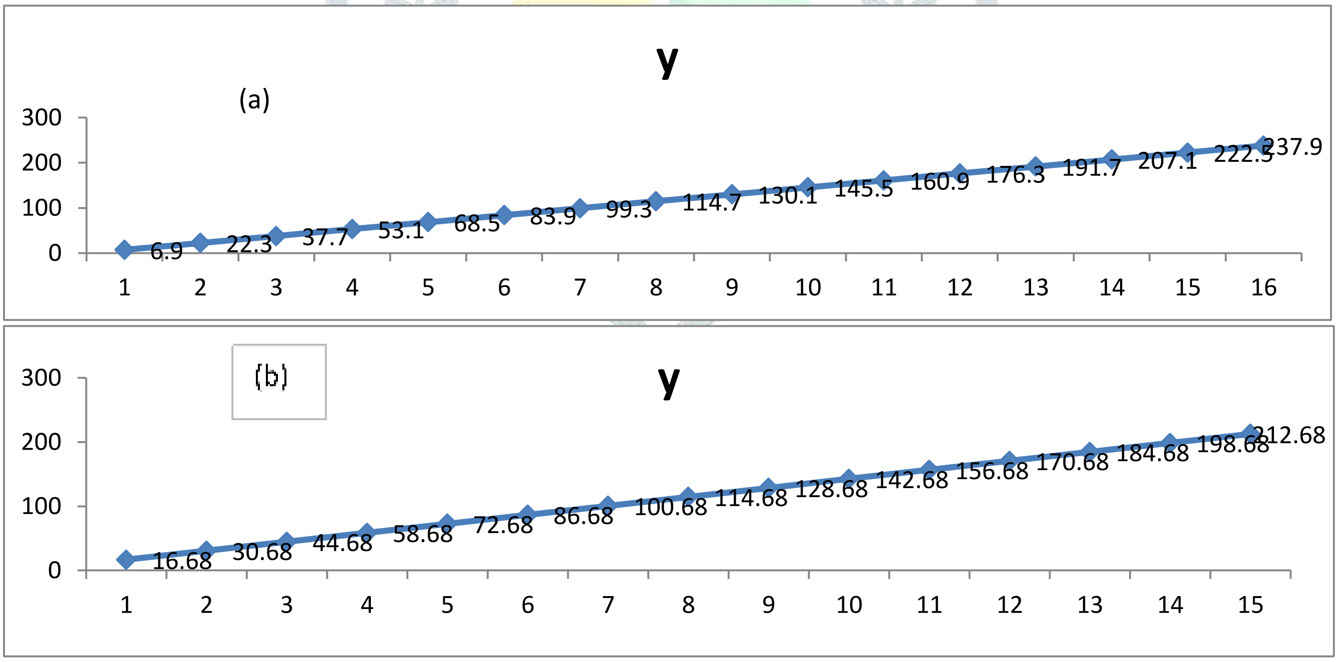


Table 2. Plastochron index (PI) of *Allium hookeri* for the crop season, zaid during cropping year 2014 and 2015.

Years				Remarks
2014		2015		
Leaves	PI	Leaves	PI	PI compute on separate season
L2	2.20	L2	2.32	
L3	3.47	L3	3.23	
L4	4.35	L4	4.49	
L5	5.47	L5	5.35	
L6	6.40	L6	6.44	
L7	7.16	L7	7.39	
L8	8.33	L8	8.44	
L9	9.34	L9	9.52	
L10	10.35	L10	10.22	
L11	11.28	L11	11.27	
L12	12.26	L12	12.30	
L13	13.43	L13	13.51	
L14	14.39	L14	14.30	
L15	15.34	L15	15.26	
L16	16.43	L16	16.34	
L17	17.33	L17	17.31	
L18	18.38	L18	18.47	
L19	19.53	L19	19.39	

[Plastochron Index, $PI = n+(\ln L_n - \ln R)/(\ln L_n - \ln L_{n+1})$]

Table 3 (a). Leaf Plastochron Index (LPI) of *Allium hookeri* for Zaid season of cropping year 2014

Days /Leaf	Leaves																		Remarks
8	1.20	0.20	-0.8																
16	2.47	1.47	0.47	-0.53															
24	3.35	2.35	1.35	0.35	-0.65														
31	4.47	3.47	2.47	1.47	0.47	-0.53													
38	5.40	4.40	3.40	2.40	1.40	0.40	-0.6												
44	6.16	5.16	4.16	3.16	2.16	1.16	0.16	-0.84											
51	7.33	6.33	5.33	4.33	3.33	2.33	1.33	0.33	-0.67										
58	8.34	7.34	6.34	5.34	4.34	3.34	2.34	1.34	0.34	-0.66									-ve indicates leaf primordia
64	9.35	8.35	7.35	6.35	5.35	4.35	3.35	2.35	1.35	0.35	-0.65								
70	10.28	9.28	8.28	7.28	6.28	5.28	4.28	3.28	2.38	1.38	0.38	-0.72							
77	11.26	10.26	9.26	8.26	7.26	6.26	5.26	4.26	3.26	2.26	1.26	0.26	-0.74						
83	12.43	11.43	10.43	9.43	8.43	7.43	6.43	5.43	4.43	3.43	2.43	1.43	0.43	-0.57					
89	13.39	12.39	11.39	10.39	9.39	8.39	7.39	6.39	5.39	4.39	3.39	2.39	1.39	0.39	-0.61				
95	14.34	13.34	12.34	11.34	10.34	9.34	8.34	7.34	6.34	5.34	4.34	3.34	2.34	1.34	0.34	-0.66			
101	15.43	14.43	13.43	12.43	11.43	10.43	9.43	8.43	7.43	6.43	5.43	4.43	3.43	2.43	1.43	.43	-0.57		
108	16.33	15.33	14.33	13.33	12.33	11.33	10.33	9.33	8.33	7.33	6.33	5.33	4.33	3.33	2.33	.33	0.33	-0.67		
114	17.38	16.38	15.38	14.38	13.38	12.38	11.38	10.38	9.38	8.38	7.38	6.38	5.38	4.38	3.38	.38	1.38	0.38	-0.62	
120	18.53	17.53	16.53	15.53	14.53	13.53	12.53	11.53	10.53	9.53	8.53	7.53	6.53	5.53	4.53	.53	2.53	1.53	0.53	-0.47

Table 3 (b). Leaf Plastochron Index (LPI) of *Allium hookeri* for Zaid season of cropping year 2015

Days/Leaf	Leaves																			Remarks
8	1.32	0.32	-0.68																	
15	2.23	1.23	0.23	-0.77																
23	3.49	2.49	1.49	0.49	-0.51															
30	4.35	3.35	2.35	1.35	0.35	-0.65														
37	5.44	4.44	3.44	2.44	1.44	0.44	-0.56													
44	6.39	5.39	4.39	3.39	2.39	1.39	0.39	-0.61												
50	7.44	6.44	5.44	4.44	3.44	2.44	1.44	0.44	-0.56											
57	8.52	7.52	6.52	5.52	4.52	3.52	2.52	1.52	0.52	-0.48										-ve indicates leaf primordia
64	9.22	8.22	7.22	6.22	5.22	4.22	3.22	2.22	1.22	0.22	-0.78									
71	10.27	9.27	8.27	7.27	6.27	5.27	4.27	3.27	2.27	1.27	0.27	-0.73								
77	11.30	10.30	9.30	8.30	7.30	6.30	5.30	4.30	3.30	2.30	1.30	0.30	-0.70							
83	12.51	11.51	10.51	9.51	8.51	7.51	6.51	5.51	4.51	3.51	2.51	1.51	0.51	-0.49						
88	13.30	12.30	11.30	10.30	9.30	8.30	7.30	6.30	5.30	4.30	3.30	2.30	1.30	0.30	-0.70					
94	14.26	13.26	12.26	11.26	10.26	9.26	8.26	7.26	6.26	5.26	4.26	3.26	2.26	1.26	0.26	-0.74				
100	15. 34	14. 34	13. 34	12. 34	11. 34	10. 34	9. 34	8. 34	7. 34	6. 34	5. 34	4. 34	3. 34	2. 34	1. 34	. 34	-0.66			
106	16.31	15.31	14.31	13.31	12.31	11.31	10.31	9.31	8.31	7.31	6.31	5.31	4.31	3.31	2.31	.31	0.31	-0.69		
112	17.47	16.47	15.47	14.47	13.47	12.47	11.47	10.47	9.47	8.47	7.47	6.47	5.47	4.47	3.47	.47	1.47	0.47	-0.53	
118	18.39	17.39	16.39	15.39	14.39	13.39	12.39	11.39	10.39	9.39	8.39	7.39	6.39	5.39	4.39	.39	2.39	1.39	0.39	-0.61

Table 3 (a.1). LPI of *Allium hookeri* for Zaid season of cropping year 2014 showing sink (red box), transition (green box) and source (white box).

Days/Leaf	Leaves																			Remarks
8	1.20	0.20	-0.8																	
16	2.47	1.47	0.47	-0.53																
24	3.35	2.35	1.35	0.35	-0.65															
31	4.47	3.47	2.47	1.47	0.47	-0.53														
38	5.40	4.40	3.40	2.40	1.40	0.40	-0.6													
44	6.16	5.16	4.16	3.16	2.16	1.16	0.16	-0.84												-ve is in leaf primordia
51	7.33	6.33	5.33	4.33	3.33	2.33	1.33	0.33	-0.67											
58	8.34	7.34	6.34	5.34	4.34	3.34	2.34	1.34	0.34	-0.66										
64	9.35	8.35	7.35	6.35	5.35	4.35	3.35	2.35	1.35	0.35	-0.65									
70	10.28	9.28	8.28	7.28	6.28	5.28	4.28	3.28	2.38	1.38	0.38	-0.72								
77	11.26	10.26	9.26	8.26	7.26	6.26	5.26	4.26	3.26	2.26	1.26	0.26	-0.74							
83	12.43	11.43	10.43	9.43	8.43	7.43	6.43	5.43	4.43	3.43	2.43	1.43	0.43	-0.57						
89	13.39	12.39	11.39	10.39	9.39	8.39	7.39	6.39	5.39	4.39	3.39	2.39	1.39	0.39	-0.61					
95	14.34	13.34	12.34	11.34	10.34	9.34	8.34	7.34	6.34	5.34	4.34	3.34	2.34	1.34	0.34	--0.66				
101	15.43	14.43	13.43	12.43	11.43	10.43	9.43	8.43	7.43	6.43	5.43	4.43	3.43	2.43	1.43	0.43	-0.57			
108	16.33	15.33	14.33	13.33	12.33	11.33	10.33	9.33	8.33	7.33	6.33	5.33	4.33	3.33	2.33	1.33	0.33	-0.67		
114	17.38	16.38	15.38	14.38	13.38	12.38	11.38	10.38	9.38	8.38	7.38	6.38	5.38	4.38	3.38	2.38	1.38	0.38	-0.62	
120	18.53	17.53	16.53	15.53	14.53	13.53	12.53	11.53	10.53	9.53	8.53	7.53	6.53	5.53	4.53	3.53	2.53	1.53	0.53	-0.47

Table 3 (b.1). LPI of *Allium hookeri* for Zaid season of cropping year 2014 showing sink (red box), transition (green box) and source (white box).

Days/Leaf	Leaves																			Remarks
8	1.32	0.32	-0.68																	
15	2.23	1.23	0.23	-0.77																
23	3.49	2.49	1.49	0.49	-0.51															
30	4.35	3.35	2.35	1.35	0.35	-0.65														
37	5.44	4.44	3.44	2.44	1.44	0.44	-0.56													
44	6.39	5.39	4.39	3.39	2.39	1.39	0.39	-0.61												
50	7.44	6.44	5.44	4.44	3.44	2.44	1.44	0.44	-0.56											
57	8.52	7.52	6.52	5.52	4.52	3.52	2.52	1.52	0.52	-0.48										-ve indicates leaf primordia
64	9.22	8.22	7.22	6.22	5.22	4.22	3.22	2.22	1.22	0.22	-0.78									
71	10.27	9.27	8.27	7.27	6.27	5.27	4.27	3.27	2.27	1.27	0.27	-0.73								
77	11.30	10.30	9.30	8.30	7.30	6.30	5.30	4.30	3.30	2.30	1.30	0.30	-0.70							
83	12.51	11.51	10.51	9.51	8.51	7.51	6.51	5.51	4.51	3.51	2.51	1.51	0.51	-0.49						
88	13.30	12.30	11.30	10.30	9.30	8.30	7.30	6.30	5.30	4.30	3.30	2.30	1.30	0.30	-0.70					
94	14.26	13.26	12.26	11.26	10.26	9.26	8.26	7.26	6.26	5.26	4.26	3.26	2.26	1.26	0.26	-0.74				
100	15. 34	14. 34	13. 34	12. 34	11. 34	10. 34	9. 34	8. 34	7. 34	6. 34	5. 34	4. 34	3. 34	2. 34	1. 34	. 34	-0.66			
106	16.31	15.31	14.31	13.31	12.31	11.31	10.31	9.31	8.31	7.31	6.31	5.31	4.31	3.31	2.31	.31	0. 31	-0.69		
112	17.47	16.47	15.47	14.47	13.47	12.47	11.47	10.47	9.47	8.47	7.47	6.47	5.47	4.47	3.47	.47	1.47	0.47	-0.53	
118	18.39	17.39	16.39	15.39	14.39	13.39	12.39	11.39	10.39	9.39	8.39	7.39	6.39	5.39	4.39	.39	2.39	1.39	0.39	-0.61

Table 4. Plastchron Ratio "a" [a=Ln/Ln+1= Lon/Lon+1 result will be >1] and "Relative Plastochron Rate of leaf elongation =lna = ρ" of *Allium hookeri* for the crop season zaid of cropping years 2014 and 2015.

Year						Remarks
2014			2015			
Leaf nos.	a	ρ	Leaf nos.	a	ρ	
L2	30.5	3.42	L2	7	1.95	True since ratio is greater than 1
L3	9.78	2.28	L3	33.5	3.51	
L4	16	2.72	L4	8.6	2.15	
L5	7.8	2.05	L5	22	3.09	
L6	11.43	2.44	L6	7.2	1.97	
L7	56	4.03	L7	7.11	1.96	
L8	14.4	2.67	L8	5.91	1.78	
L9	21.5	3.07	L9	6.83	1.92	
L10	7.63	2.03	L10	78	4.36	
L11	24.67	3.21	L11	23.67	3.16	
L12	39	3.66	L12	13	2.56	
L13	8.22	2.11	L13	5.54	1.71	
L14	13.83	2.63	L14	13	2.56	
L15	21	3.04	L15	11.4	2.43	
L16	6.8	1.92	L16	7.38	2	
L17	30.67	3.42	L17	10.33	2.34	
L18	8.5	2.14	L18	8	2.08	
L19	7	1.95	L19	14	2.64	

Table 5. Number of days per increment in LPI of *Allium hookeri* for the crop season, zaid of two consecutive cropping years 2014 and 2015.

Years						Remarks
2014			2015			
Sl.No.	Leaf No.	$LPI_d = (Ln_i - Ln_o)/d$	Sl.No.	Leaf No.	$LPI_d = (Ln_i - Ln_o)/d$	
3&5	4	0.15	2&3	3	0.18	$0.1 < LPI_d > 0.2$
11&13	7	0.18	5&8	7	0.15	
15&16	12	0.132	12&14	11	0.16	

Figure5(a). Meteorological data (average) for zaid season of the cropping year 2014 (Tmax, Tmin, Tmean, RH max, RHmin, RHmean, Sunshine, Rainfall, windspeed (km/hr)

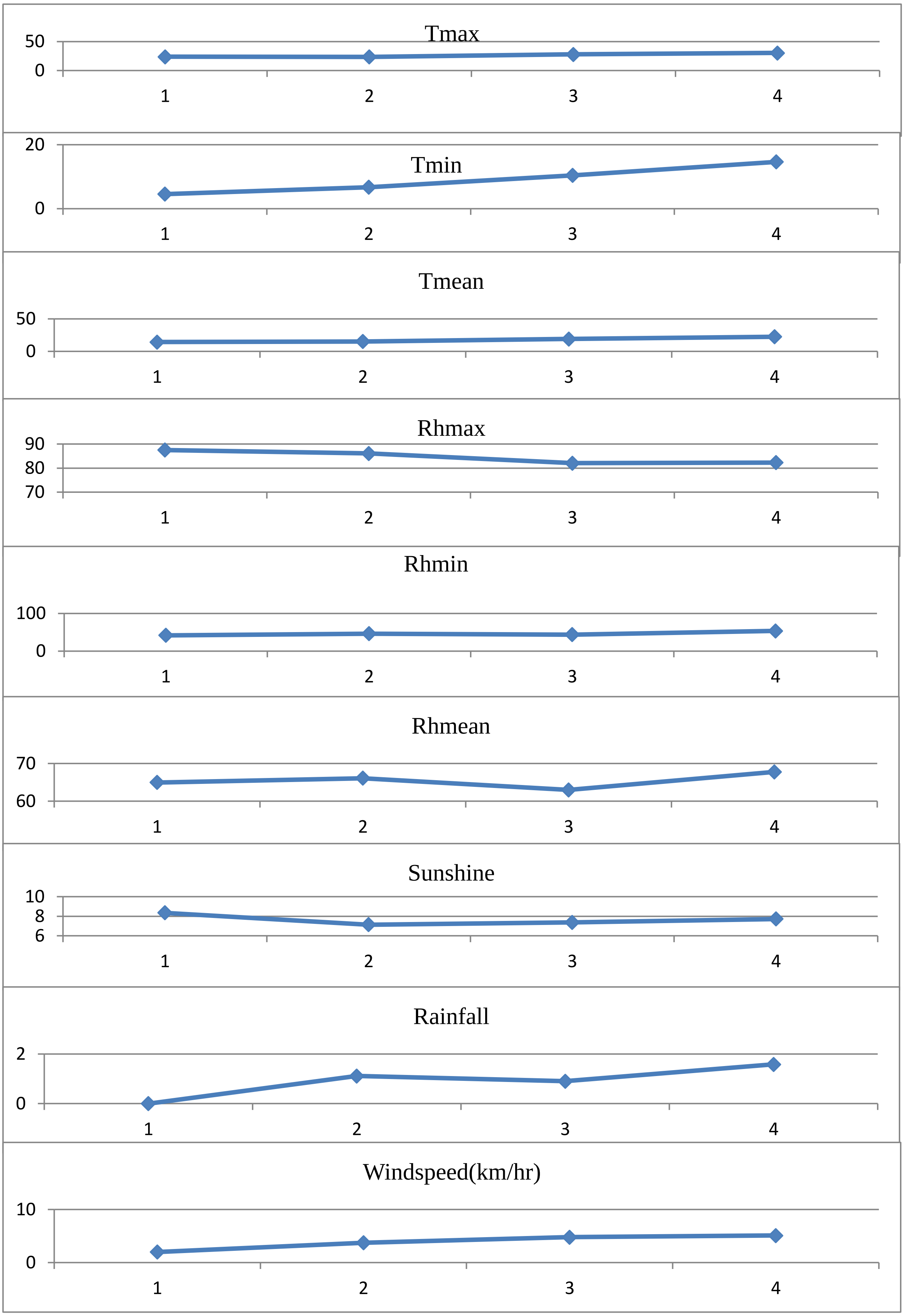
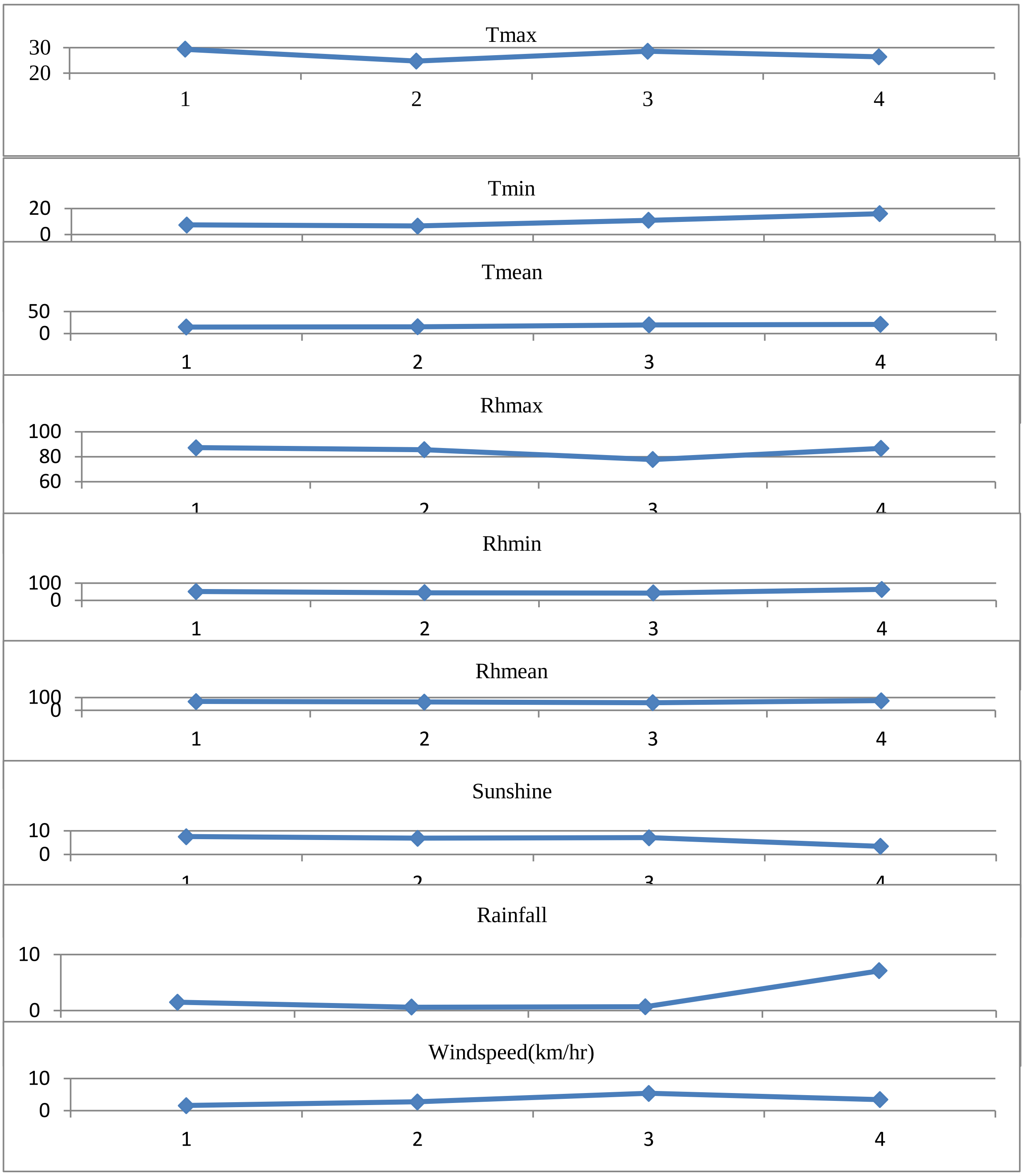


Figure5(b). Meteorological data (average) for zaid season of the cropping year 2015 (Tmax, Tmin, Tmean, RH max, RHmin, RHmean, Sunshine, Rainfall, windspeed (km/hr)



IV.CONCLUSION

The present investigation show the importance of plastochron and plastochron allieds to test crop *Allium hookeri*. Variation in LPI values signifies the morphological status of leaves. PI manifest the allocation and transformation of chemicals.

All the observed and computed PI, LPI values effectively clarified the expected leaf age (leaf lifespan) and the evolutionary trait of leaf economic spectrum, the scientific variation in leaf appearance rate and other factors other than crop season may be involve.

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