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Sink, Source, Transition, Their Relationship In Partitioning The Photoassimilates In *Allium Hookeri Thw. Enum* During Zaid Season

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Abstract - *Allium hookeri* Thw. Enum (Manipuri – Maroi napakpi), a perennial green leafy herbal spice, pack with the potentials of Leaf plastochron index in exploration to the strength and status of the crop with respect to the dissemination of photoassimilates to different organs that taking part in the physiology, growth and development of agriculturally important and harvestable vegetative parts and current paradigm on advance production practices was investigated. The occurrences of critical developmental events in growing plant population with relevance to the sink, a net importer; source, a net exporter, and transition, a net transporter organs of a plant designated to the status of leave in production, dispension and storation of Photosynthetats and bio-chemicals within the crop plant has determined. The duration of sink to source, timing of transition process and the number of leaves under transition at a given time were vividly analysed.

Key words – *Allium hookeri*, perennial, Leaf plastochron index, sink, source, transition, zaid season

I.INTRODUCTION

Allium hookeri Thw. Enum of Liliaceae family, locally known as "Maroi napakpi" is an important green leafy spice widely used as herbal spice, green and cookie vegetable and medicinal purposes. Broadly growing in a wide range of soil types and climatic condition. *Allium hookeri* has hardly any bulb instead much reduced underground rhizome produces fibrous roots (Hooker, 1978). The leaves are thick evergreen, linear with distinct 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 (Singh, 1996).

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 (Dickmann 1971; Dickson 1986).

Furthermore plastochron index extended the use of morphological indices to semi deterrent nature species (Hanson et.al. 1986). However, the experimental work on leaf plastochron index, plastochron index and other associative indices in *Allium hookeri* is very meager (Naorem et.al. 2018a; 2018b; 2018c) and completely nil in growth phases codes. Henceforth, the present work have undertaken with the objectives: to determine the effectiveness of sink, source, transition and their relationship in dissemination of photoassimilates and photosynthetats etc. in *Allium hookei* cv. local type and thereof credible practicability of agroecological farming practices and its impact on yield and yield parameters during zaid season.

II. MATERIALS AND METHODS

With intensive care and determined targeted goal the present investigation work on leaf plastochron index, sink, source and transition state 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 with close examination on leaf emergence, leaf length and sequences of leaves of *Allium hookeri* were investigated when crop growth had been attained but main leaves had not fallen during zaid season of cropping year 2017 and 2018 respectively.

The meteorological data of the course of investigation 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 to and one week after the sampling period.

Experiment

The test crop, *Allium hookeri*, local variety was planted at 1st week of June each year at a optimum range of spacing of 25 × 25 cm plant to plant and row to row. For better interpretation of the observed data, plots of the experimental field were maintained at 1.25×1.25 m. With utmost care the crops were precisely planted in a randomized block design with three replications. Other agronomic practices including irrigation were applied when needed to avoid adverse effect to plant and water stress and other disadvantageous to the planting test crop. For the present experimentation absolute manual weed control was practiced for least harm to crop althroughout the season of the cropping years i.e. 2017 and 2018.

Field records

Keeping intensive care on adoption of sampling rules, twenty **(**20) plants were randomly marked within each sub plot rejecting the border lines to record the main leaf number, length and emergence day. Daily measurements were taken althroughout the investigation period for observing data, record and for further analysis. Consciously during the experiment the leaf length was reckon with the length of the visible leaf lamina measured to the nearest 5mm from its tips to its insertion into the previous leaf. First and foremost the 20 chosen leaves represent the full ranges of development from extremely young to fully mature lamina. Directly in the field the precision lengths of leaves were recorded and the leaf plastochron index and other associative indices were estimated.

The Leaf Plastochron Index (LPI) for understanding developmental scale was determined by using the validated formula

$$LPI = PI - a \qquad (1)$$

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

Then the PLastochron index (PI) was established by using the formula of Erickson and Michelini (1957).

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

Where, PI was the plastochron Index
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.

For statistical significance of measurement a reference length of 30 mm was accounted as appropriate for the present test species. Based on the basis of PI formula the PI was eventually equivalent to the distance in time between two successive leaves reaching 30 mm.

III. RESULTS AND DISCUSSIONS

Leaf plastochron index ranges from -0.58 at 4th leaf on 16th day to 16.21 at 18th leaf on 107th day during cropping year 2017 and LPI value ranges from -0.46 at 5th leaf on 24th day to 16.31 at 18th leaf from 107 days for cropping year 2018. The observed status was tabulated in Table 3A and 3b for cropping year 2017-18. The –ve values in LPI indicate the primordial status of the growth. Probing to the observed data and in depth analysis nucleated for a concrete convergent conclusion that the leaf plastochron index (LPI) of all the selected plants was worked out with well known methodology (Dickson and Larson, 1981; Erickson and Michelini, 1957) substantiate to the growth and development of the plants and authenticate the different status of continuous developmental scale of leaves during Zaid season of 2 crop years 2017 and 2018 respectively [Table 1 (a) and 1(b)].

It is obvious that there is at least one new leaf forms from the encased SAM (Shoot Apical Meristem) in a growing plant. Eventually all measured leaves accorded leaf plastochron index (LPI) ranging from -0.58 in minimum and 16.21 in maximum for the test zaid season of cropping year 2017; similarly, the minimum measured leaf plastochron index (LPI) accord -0.46 and maximum was 16.37 for zaid season of cropping year 2018 [Table 1(a) & 1(b)]. Perusal on the data and indepth analysis conclude the finding was in agreement with that of Ferris et.al. (2001). Moreover, the finding implies that a new allium leaf forms from the encased SAM (Shoot Apical Meristem) and ultimately emerges from the leaf sheath of the preceding leaf to become a bonafide matured leaf. The finding of leaf emergence establishing from primordial initiation was in corroborative with the repercussion conclusion of Itoh et.al. (2005).

The positive aspect of source sink relationship in dissemination of photosynthats in the crop plant, a balance has to be maintained between vegetative reproductive growth for improvement in yield and yield quality of crops. Taking into account the sink, transition and source, the LPI values vividly evince the status of leaves involvement to activities incorporation with administering and dispensation of photosynthats and metabolite bio-chemicals viz. 0 – 0.4 implies sink, 0.41 – 2 denotes transition and above 2 connotes source following functions of sink, source and transition categorization. Substantial analysis of LPI values evidence the existence of sink, transition and source independently to all observed leaves of test plants in zaid season of both cropping years 2017 and 2018 [Table 1(a1) and Table 1(b1)]. The present investigation work provide a vivid picture that in a tiller of the present test crop having 19 leaves, 1-2 leaves categorized to sink, 1-2 leaves in transition and others classified under source [Table 1(a.1) and Table 1(b.1)]**.** Sink, a net importer, source, a net exporter and transition, a net transporter organ of a plant, designate the activities undergoing in distribution, allocation and disbursement of the photoassimilates and organic materials in a well manage system. Further photosynthetically active source organs are mainly the net exporters of photoassimilates represented mainly by mature leaves and sink organs that are photosynthetically inactive are normally referred as net importers of fixed carbon like root, seed, fruit, root tubers, expanding shoot tips, expanding leaves, buds, flowers and stems. Further the carbohydrates once produce by the plant may be initially partitioned between use by source leaf and transport as to other plant organs. Carbohydrates available for transport must then be allocated between the many competing sinks on the plant. Competing sink being includes roots expanding shoot tips, expanding leaves, buds, stems, fruits, flowers exploration on the detection of sink, source, transition organs in a crop plant become a prerequisite for maintaining the productivity of the crop. Hence the comparative proportion of the sink, source, transition of the present test crop determined with 1-2, 0-15, 1-2. The finding authenticate the prevailing disseminating system of photoassimilates, biochemicals and metabolites in a growing crop plant, their storage, need base management, stocking for needy time etc. The current exploration in analysis of observed data highlights the appropriateness of LPI in assigning the growth of the plant with relation to status of the embodied metabolite bio-chemicals within the different leaves of the test crop. The state of primordial on the emerging leaf highlights the needs of proper agronomical practices for better and desired yield.

Sink may be of primary or secondary, primary sink includes economically useful parts seeds – rice timber-food crops, fruits – mango, leaves – green, stem – sugarcane. They are prime importance to man. Secondary sink - rhizomes, tubers, corns. In a plant, tubers are produced as storage organ. This plant might also produce seeds. These storage organs are produced much earlier to the reproductive organs / seeds (ultimately) development. Secondary sinks are also useful for vegetative reproduction. Increasing photosynthesis can increase crop yield potential (Yu et.al 2015, Calderini et.al. 2006) when photosynthat part timing and factors influencing sink growth remain unchanged (Chand and Zhu 2017).

Moreover the investigation on "source sink depending leaf duration" blazes the establishment of senescence in the leaves of test crop when leaves procured LPI value of over 9. Thus 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 (Turgeon 1989; Gagnon and Beebe 1996; Wilson et.al. 2001; Kitajima et.al.2002; Pantin et.al. 2012). Considering the 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, 2nd 3rd till 20th harvesting in the zaid season. In this connection many disciplines have long been interested in monitoring leaf age for individual plants (Field, 1983) and leaf life span for many species (Funk and Cornwell 2013; Osnas et.al. 2013).

Sink, source, transition and their relationship of *Allium hookeri* evidence that the basic properties of partitioning of photoassimilates of the crop showed its uniqueness for framing the basis of productive harvestable vegetable parts, a sustainable vegetative farming approach (practices) and social (economy and agronomic system, social adaptability) movement based on scientific discipline, it adds new information to the vast ocean of knowledge of applied plant sciences along with social changes and provides a new room for further investigation to different area of their applicability to other applied sciences like post harvest, yield, yield parameters, agronomical techniques, environmental resources, the shoot, whole plant and other plastochron based research works. The temperature and other parameters with leave pattern for both 2017 and 2018 cropping years are shown in Figure 1(a) & 1(b). The ratio of sink, transition and source of the test crop for cropping years 2017 and 2018 are shown in Figure 2 (a) and (b).

Table 1 (a). Leaf Plastochron Index (LPI) of *Allium hookeri* for Zaid season of cropping year 2017

Days /Leaf	Leaves																			Remarks
8	1.16	0.16	-0.84																	
16	2.42	1.42	0.42	-0.58																
24	3.29	2.39	1.29	0.29	-0.71															
31	4.41	3.41	2.41	1.41	0.41	-0.59														
38	5.35	4.35	3.35	2.35	1.35	0.35	-0.65													
45	6.18	5.18	4.18	3.18	2.18	1.18	0.18	-0.82												
52	7.27	6.27	5.27	4.27	3.27	2.27	1.27	0.27	-0.73											-ve indicates leaf primordia
59	8.23	7.23	6.23	5.23	4.23	3.23	2.23	1.23	0.23	-0.77										
65	9.29	8.29	7.29	6.29	5.29	4.29	3.29	2.29	1.29	0.29	-0.71									
71	10.21	9.21	8.21	7.21	6.21	5.21	4.21	3.21	2.21	1.21	0.21	-0.79								
77	11.22	10.22	9.22	8.22	7.22	6.22	5.22	4.22	3.22	2.22	1.22	0.22	-0.78							
83	12.38	11.38	10.38	9.38	8.38	7.38	6.38	5.38	4.38	3.38	2.38	1.28	0.28	-0.62						
89	13.27	12.27	11.27	10.27	9.27	8.27	7.27	6.27	5.27	4.27	3.27	2.27	1.27	0.27	-0.73					
95	14.27	13.27	12.27	11.27	10.27	9.27	8.27	7.27	6.27	5.27	4.27	3.27	2.27	1.27	0.27	0.73				
101	15.37	14.37	13.37	12.37	11.37	10.37	9.37	8.37	7.37	6.37	5.37	4.37	3.37	2.37	1.37	.37	-0.63			
107	16.21	15.21	14.21	13.21	12.021	11.21	10.21	9.21	8.21	7.21	6.21	5.21	4.21	3.21	2.21	.21	0.21	-0.79		

Table 1 (b). Leaf Plastochron Index (LPI) of *Allium hookeri* for Zaid season of cropping year 2018

Days/Leaf	Leaves																		Remarks
8	1.38	0.38	-0.62																
1	2.34	1.34	0.34	-0.66															
24	3.54	2.54	1.54	0.54	-0.46														
31	4.41	3.41	2.41	1.41	0.41	-0.59													
38	5.41	4.41	3.41	2.41	1.41	0.41	-0.59												
45	6.44	5.44	4.44	3.44	2.44	1.44	0.44	-0.56											
52	7.49	6.49	5.49	4.49	3.49	2.49	1.49	0.49	-0.51										
59	8.48	7.48	6.48	5.48	4.48	3.48	2.48	1.48	0.48	-0.52									
65	9.27	8.27	7.27	6.27	5.27	4.27	3.27	2.27	1.27	0.27	-0.73								
71	10.29	9.29	8.29	7.29	6.29	5.29	4.29	3.29	2.29	1.29	0.29	-0.71							
77	11.36	10.36	9.36	8.36	7.36	6.36	5.36	4.36	3.36	2.36	1.36	0.36	-0.64						-ve indicates leaf primordia
83	12.54	11.54	10.54	9.54	8.54	7.54	6.54	5.54	4.54	3.54	2.54	1.54	0.54	-0.46					
89	13.4	12.4	11.4	10.4	9.4	8.4	7.4	6.4	5.4	4.4	3.4	2.4	1.4	0.4	-0.6				
95	14.32	13.32	12.32	11.32	10.32	9.32	8.32	7.32	6.32	5.32	4.32	3.32	2.32	1.32	0.32	-0.68			
101	15. 39	14. 39	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	. 39	-0.61		
107	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	

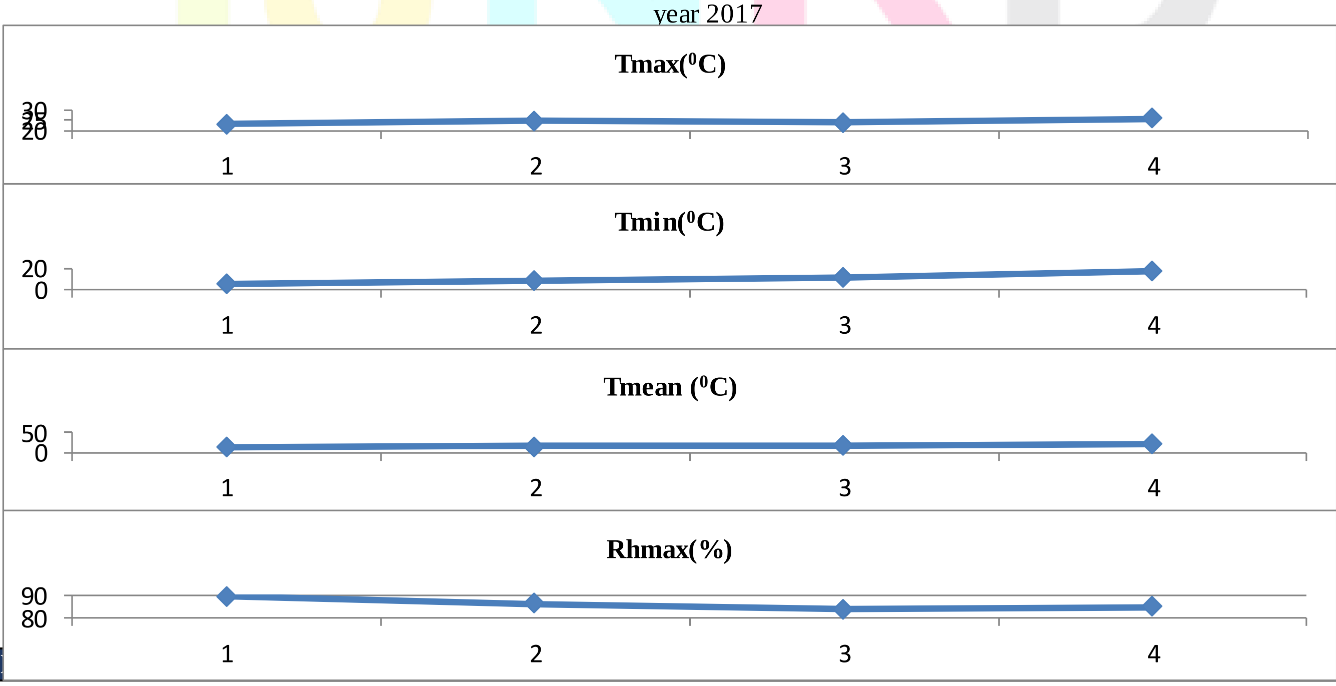
Table 1 (a.1). LPI of *Allium hookeri* for Zaid season of cropping year 2017 showing sink (red box), transition (green box) and source (white box).

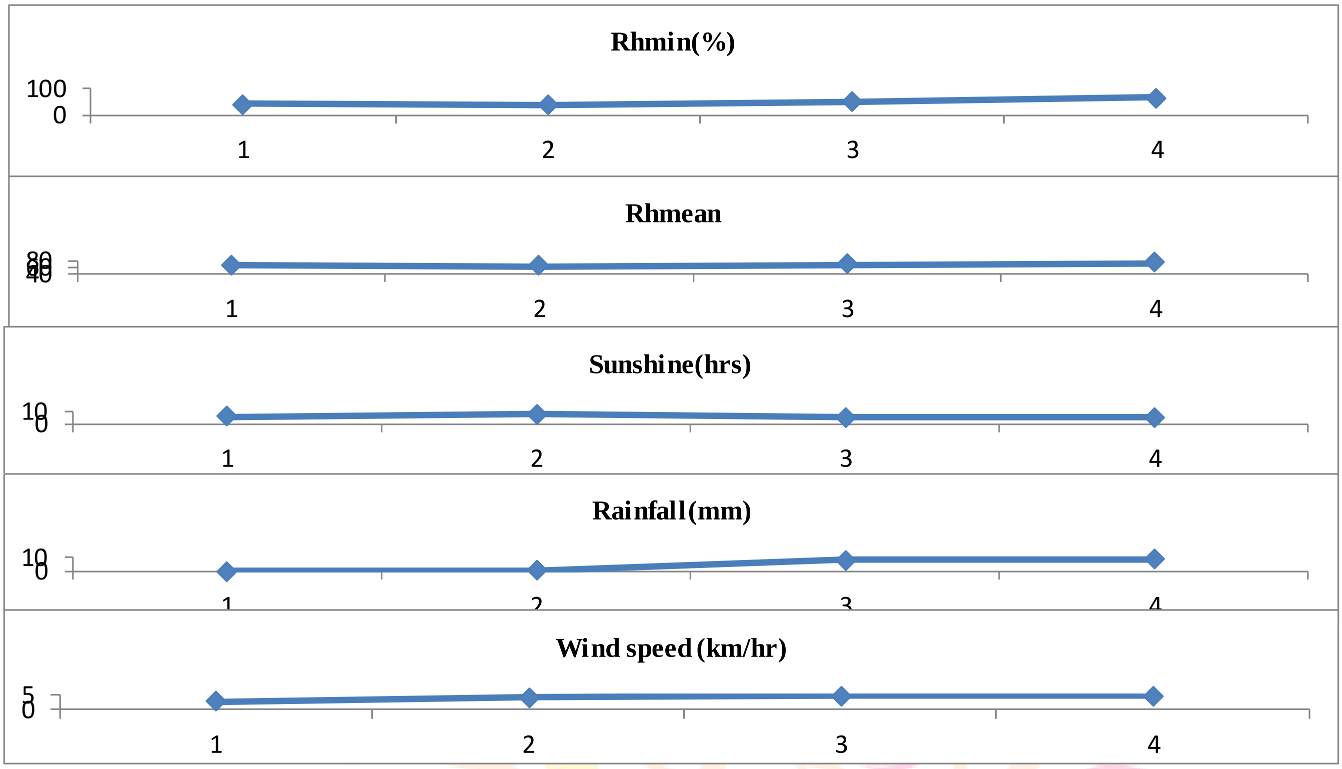
Days /Leaf	Leaves																			Remarks
8	1.16	0.16	-0.84																	
16	2.42	1.42	0.42	-0.58																
24	3.29	2.39	1.29	0.29	-0.71															
31	4.41	3.41	2.41	1.41	0.41	-0.59														
38	5.35	4.35	3.35	2.35	1.35	0.35	-0.65													
45	6.18	5.18	4.18	3.18	2.18	1.18	0.18	-0.82												
52	7.27	6.27	5.27	4.27	3.27	2.27	1.27	0.27	-0.73											-ve indicates leaf primordia
59	8.23	7.23	6.23	5.23	4.23	3.23	2.23	1.23	0.23	-0.77										
65	9.29	8.29	7.29	6.29	5.29	4.29	3.29	2.29	1.29	0.29	-0.71									
71	10.21	9.21	8.21	7.21	6.21	5.21	4.21	3.21	2.21	1.21	0.21	-0.79								
77	11.22	10.22	9.22	8.22	7.22	6.22	5.22	4.22	3.22	2.22	1.22	0.22	-0.78							
83	12.38	11.38	10.38	9.38	8.38	7.38	6.38	5.38	4.38	3.38	2.38	1.28	0.28	-0.62						
89	13.27	12.27	11.27	10.27	9.27	8.27	7.27	6.27	5.27	4.27	3.27	2.27	1.27	0.27	-0.73					
95	14.27	13.27	12.27	11.27	10.27	9.27	8.27	7.27	6.27	5.27	4.27	3.27	2.27	1.27	0.27	.73				
101	15.37	14.37	13.37	12.37	11.37	10.37	9.37	8.37	7.37	6.37	5.37	4.37	3.37	2.37	1.37	.37	-0.63			
107	16.21	15.21	14.21	13.21	12.02 1	11.21	10.21	9.21	8.21	7.21	6.21	5.21	4.21	3.21	2.21	.21	0.21	-0.79		

Table 1 (b.1). LPI of *Allium hookeri* for Zaid season of cropping year 2018 showing sink (red box), transition (green box) and source (white box).

Days/Leaf	Leaves																		Remarks
8	1.38	0.38	-0.62																
16	2.34	1.34	0.34	-0.66															
24	3.54	2.54	1.54	0.54	-0.46														
31	4.41	3.41	2.41	1.41	0.41	-0.59													
38	5.41	4.41	3.41	2.41	1.41	0.41	-0.59												
45	6.44	5.44	4.44	3.44	2.44	1.44	0.44	-0.56											
52	7.49	6.49	5.49	4.49	3.49	2.49	1.49	0.49	-0.51										-ve indicates leaf primordia
59	8.48	7.48	6.48	5.48	4.48	3.48	2.48	1.48	0.48	-0.52									
65	9.27	8.27	7.27	6.27	5.27	4.27	3.27	2.27	1.27	0.27	-0.73								
71	10.29	9.29	8.29	7.29	6.29	5.29	4.29	3.29	2.29	1.29	0.29	-0.71							
77	11.36	10.36	9.36	8.36	7.36	6.36	5.36	4.36	3.36	2.36	1.36	0.36	-0.64						
83	12.54	11.54	10.54	9.54	8.54	7.54	6.54	5.54	4.54	3.54	2.54	1.54	0.54	-0.46					
89	13.4	12.4	11.4	10.4	9.4	8.4	7.4	6.4	5.4	4.4	3.4	2.4	1.4	0.4	-0.6				
95	14.32	13.32	12.32	11.32	10.32	9.32	8.32	7.32	6.32	5.32	4.32	3.32	2.32	1.32	0.32	-0.68			
101	15. 39	14. 39	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	. 39	-0.61		
107	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	

Fig.1(a). Meteorological data (average) and *Allium hookeri* growth in Leaf length (mm) against time for zaid season of cropping year 2017





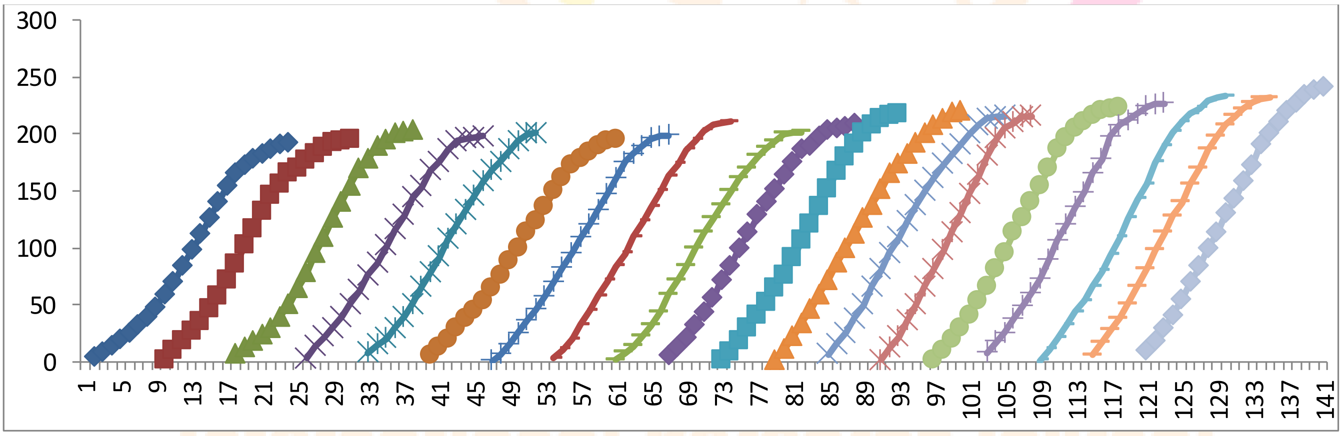
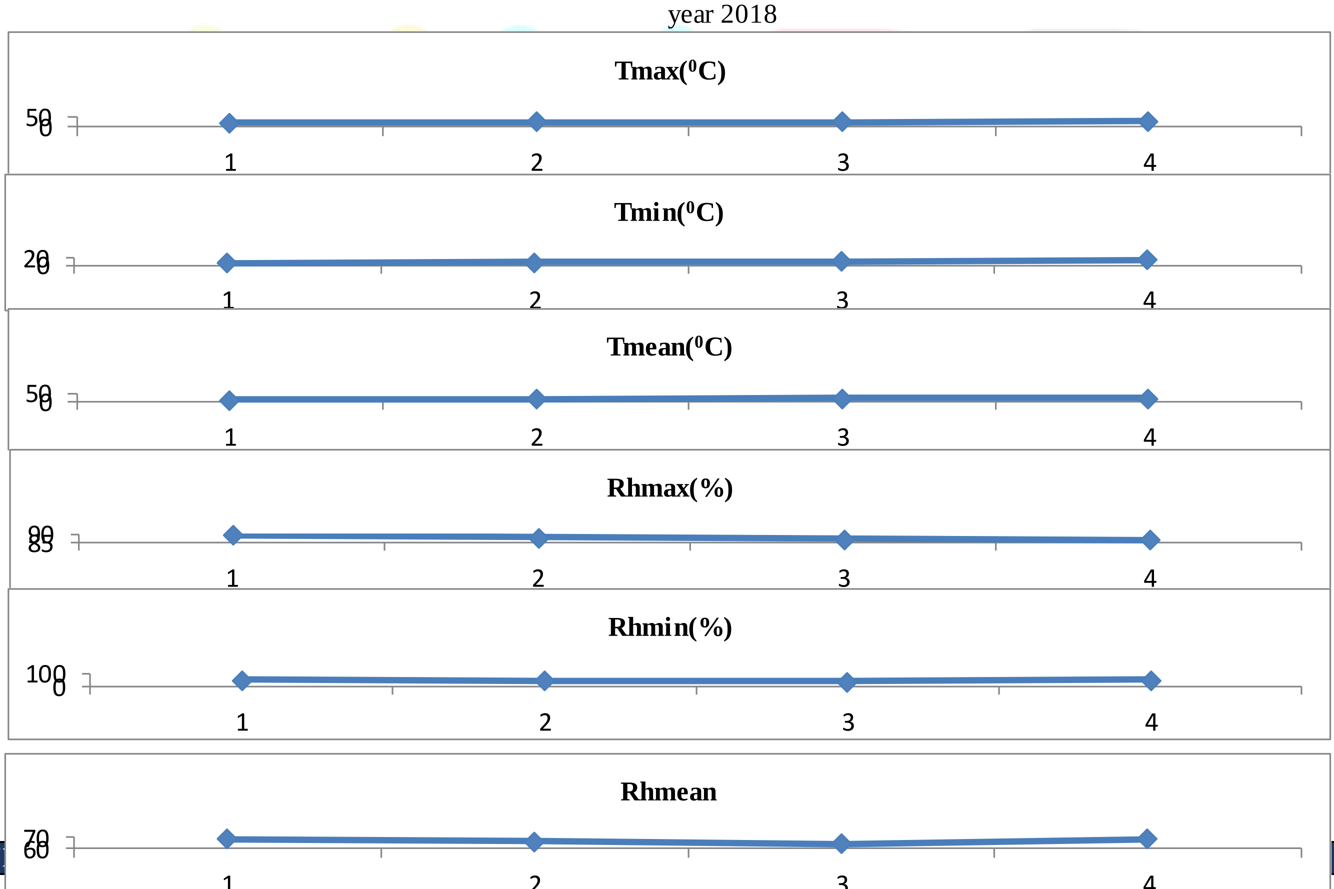


Fig.1(b). Meteorological data (average) *Allium hookeri* growth in Leaf length (mm) against time for zaid season of the cropping year 2018



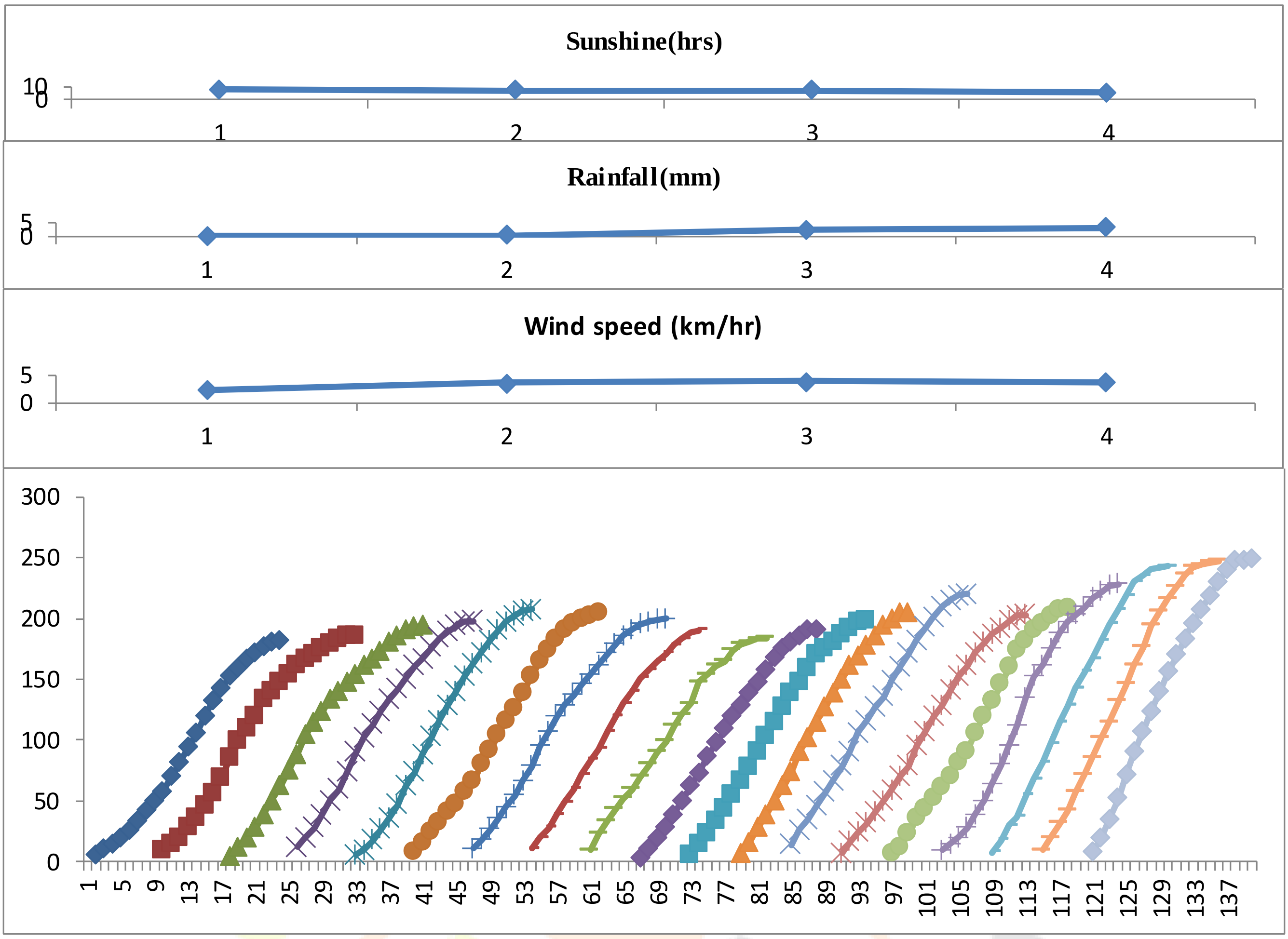
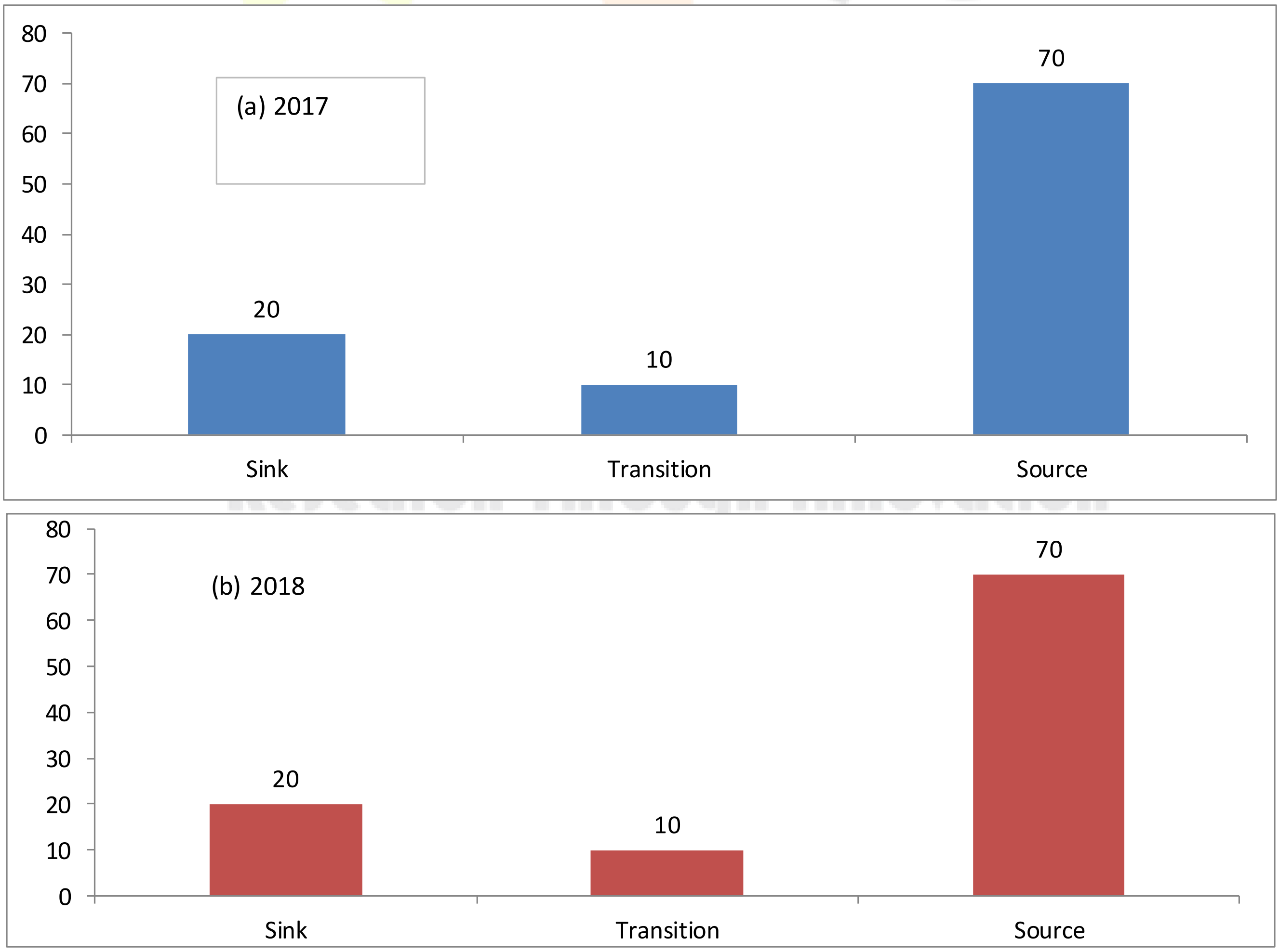


Fig.2.Graphical representation of Sink, transition and source ratio for *Allium hookri* for zaid season of cropping year (a) 2017 (b) 2018



IV. CONCLUSION

The importance of sink, source, transition functions in organs and their relationship reflect to the growth development and senescence of test crop *Allium hookeri*. Variation in LPI values signifies the continuous developmental approach to morphological status of leaves. LPI further demonstrate the allocation and transformation of photosynthetats, metabolites and bio-chemicals eventually make vulnerable to harvestable vegetative parts and seeds. Scientific exploration exposed PI, LPI values effectively elucidated the expected leaf age (leaf lifespan) and the evolutionary trait of leaf economic spectrum, the scientific variation in leaf appearance rate and other factors which may be involve in action and activity of the sink, source, transition functions.

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