ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Correlation Based Association of Nuclear and Plant Cell Morphology Parameters in Cell Cycle, Growth and Development of *Allium* Species.

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ABSTRACT

The *Allium* species (*A. chinense*, *A. tuberosum*, *Allium hookeri*, *A. ascalonicum* and *Allium sativum*) were collected from the different parts of the Nagaland and the data were recorded on the nuclear morphology (nuclear volume, nuclear surface area, nuclear circumference, nuclear diameter, nuclear radius and interphase chromosome volume) and plant cell morphology (plant cell area and plant cell perimeter) for each hour up to 24 hour for the species. The nuclear and plant cell morphology parameters were correlated with each other for their association and contribution towards the growth and development of the plant during the cell division. The parameters were highly correlated and interdependent to each other at $p \leq 0.05$ and $p \leq 0.01$.

Keywords: *Allium* species, cell cycle, correlation, nuclear morphology, plant cell morphology

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ISSN: 0975-8585

INTRODUCTION

The genus *Allium* is a large, perennial and mostly bulbous plant. The important characteristics of the *Allium* include underground storage organs such as bulbs, rhizomes or swollen roots, leaves, inflorescence, ovary, seeds and chemical characteristics [1-5]. The genus *Allium* predominantly posses base chromosome number x=7 and x=8 [6-7].

The cultivated strains of *A. chinense* include diploids, triploids and tetraploids [8-9]. The area of cultivation for *A. chinese* includes the China, Korea, Japan and South East Asia [10-11]. The characteristics of *A. tuberosum* includes that it develops seeds apomictically (facultative apomict), late flowering and small tepals and the cultivated species have triploid and tetraploid which cultivated in China, japan and now worldwide [12-13]. The *A. hookeri* is characterized by the fleshy roots and cultivated in Bhutan, Tibet, North West China, Yunan and North West Thailand [14-15]. The *A. ascalonicum* and *A. sativum* cultivated Mediterranean as well as worldwide [16-18].

The *Allium* species or cultivars (*A. chinense*, *A. tuberosum*, *Allium hookeri*, *A. ascalonicum* and *Allium sativum*) were also found in the different regions of the Nagaland which was collected and studied the 24 hour cell division cycle along with the nuclear (nuclear volume, nuclear surface area, nuclear circumference, nuclear diameter, nuclear radius and interphase chromosome volume) and plant cell (plant cell area and plant cell perimeter) morphology. The nuclear and plant cell morphology parameters were correlated with each other for their association and involvement in the plant growth and development.

MATERIALS AND METHODS

The *Allium* species (*A. chinense*, *A. tuberosum*, *Allium hookeri*, *A. ascalonicum* and *Allium sativum*) were collected from the different parts of the Nagaland and the data were recorded on the nuclear morphology (nuclear volume, nuclear surface area, nuclear circumference, nuclear diameter, nuclear radius and interphase chromosome volume) and plant cell morphology (plant cell area and plant cell perimeter) from the five different slides for each hour up to 24 hour for the species. Mean number of the parameters for nuclear and plant cell morphology was used for correlation analysis.

The following formulae were used for the calculation of nuclear and plant cell morphology parameters.

Nuclear volume (NV)=4/3 π r^3,
Nuclear surface area (NSA)= 4πr^2,
Nuclear circumference (NC)=2πr,
Nuclear diameter (ND)=2r,
Nuclear radius (NR)=d/2,
Interphase chromosome volume (ICV)= Nuclear $Volume_{(Mean)}$ / Somatic Chromosome number,
Plant cell area (PCA)= length×breadth
Plant cell perimeter (PCP)=2(length+breadth)

RESULTS AND DISCUSSION

The nuclear [nuclear volume (NV), nuclear surface area (NSA), nuclear diameter (ND), nuclear radius (NR), interphase chromosome volume (ICV)] and plant cell morphology [plant cell area (PCA) and plant cell perimeter (PCP)] parameters were correlated for association with each other and their contribution towards the morphology of nuclear and plant cell during the cell division (Table 1-5).

Allium chinense

The nuclear and plant cell morphology parameters were correlated for their association that nuclear volume highly correlated with nuclear circumference (0.898**), nuclear surface area (0.997**), nuclear diameter (0.989**), nuclear radius (0.989**), interphase chromosome volume (1.000**) and moderately correlated with plant cell area (0.619**) and plant cell perimeter (0.674**) at p≤0.01. It suggested that any change in nuclear parameters, especially interphase chromosome volume (by synthesizing DNA, RNA and Protein at G1, S and G2 phase of interphase), directly affects the nuclear volume (increased) of the plant cell.

On the similar pattern, nuclear circumference highly correlated with nuclear surface area (0.907**), nuclear diameter (0.911**), nuclear radius (0.910**), interphase chromosome volume (0.898**) at p≤0.01and moderately correlated with plant cell area (0.462*) and plant cell perimeter (0.492*) at p≤0.05. The nuclear surface area highly correlated with nuclear diameter (0.997**), nuclear radius (0.998**), interphase chromosome volume (0.997**) and moderately correlated with plant cell area (0.639**) and plant cell perimeter (0.688**) at p≤0.01. The nuclear diameter highly correlated with nuclear radius (1.000**), interphase chromosome volume (0.989**) and moderately correlated with plant cell area (0.655**) and plant cell perimeter (0.696**) at p≤0.01. The high correlation (100%) of nuclear diameter with nuclear radius suggested that any decrease or increase in nuclear diameter directly affects the change (decrease or increase) in nuclear radius and vice versa. The nuclear radius highly correlated with interphase chromosome volume (0.989**) and moderately correlated with plant cell area (0.654**) and plant cell perimeter (0.695**) at p≤0.01. The interphase chromosome volume moderately correlated with plant cell area (0.619**) and plant cell perimeter (0.674**) at p≤0.01 which suggest that increase or decrease of interphase chromosome volume (by synthesizing or not synthesizing at G1, S and G2 at interphase) may have impact on the plant cell area and perimeter. The plant cell area highly correlated with plant cell perimeter (0.946**) at p≤0.01 which suggest that increase or decrease of plant cell area (by synthesizing or not synthesizing at G1, S and G2 at interphase) may have impact on the plant cell perimeter (smaller or bigger size of the plant cell) (Table 1).

Table 1. Pearson correlation of total mean of nuclear and cell morphology and time in *A. chinense*.

Allium chinense									
	N V	NC	NSA	ND	NR	ICV	PCA	PCP	TIME
NV	1	.898**	.997**	.989**	.989**	1.000**	.619**	.674**	.259
NC		1	.907**	.911**	.910**	.898**	.462*	.492*	.217
NSA			1	.997**	.998**	.997**	.639**	.688**	.228
ND				1	1.000**	.989**	.655**	.696**	.209
NR					1	.989**	.654**	.695**	.209
ICV						1	.619**	.674**	.259
PCA							1	.946**	.082
PCP								1	.100
TIME									1

Allium tuberosum

The nuclear and cell morphology parameters were correlated and observed that all the parameters are highly correlated with each other at p≤0.01. The parameters (nuclear radius, nuclear diameter and interphase chromosome volume) have shown 100 % correlation indicates that the parameters are fully dependent on a particular parameter and any change in one parameter leads to change in another parameter. The nuclear volume highly correlated with nuclear circumference (0.976**), nuclear surface area (0.995**), nuclear diameter (0.975**), nuclear radius (0.976**) and interphase chromosome volume (1.000**). The nuclear volume is fully dependent on interphase chromosome volume any change in nuclear volume directly affects the interphase chromosome volume and vice versa. Nuclear circumference highly correlated with nuclear surface area (0.993**), nuclear diameter (1.000**), nuclear radius (1.000**) and interphase chromosome volume (0.976**). Nuclear circumference has shown direct relationship with nuclear diameter (1.000**) and nuclear radius (1.000**) any change in diameter and nuclear radius directly affects the nuclear circumference and vice versa. Nuclear surface area correlates with nuclear diameter (0.993**), nuclear radius (0.993**) and interphase chromosome volume (0.995). Nuclear diameter correlates with nuclear radius (1.000**) and interphase chromosome volume (0.975**). Nuclear radius directly relates with nuclear diameter. Change in one parameter affects the other. Nuclear radius correlates with interphase chromosome volume (0.976**) and any change in interphase chromosome volume affects the radius of the nucleus. Plant cell area correlates with plant cell perimeter (0.967**), the change in area of a plant cell also affects the perimeter of the plant cell (Table 2).

ISSN: 0975-8585

Table 2. Pearson correlation of total mean of nuclear and cell morphology and time in *A. tuberosum*

Allium tuberosum									
	N V	NC	NSA	ND	NR	ICV	PCA	PCP	TIME
NV	1	0.976**	0.995**	0.975**	0.976**	1.000**	0.207	0.157	0.291
NC		1	0.993**	1.000**	1.000**	0.976**	0.293	0.242	0.170
NSA			1	0.993**	0.993**	0.995**	0.248	0.196	0.239
ND				1	1.000**	0.975**	0.293	0.243	0.165
NR					1	0.976**	0.294	0.243	0.170
ICV						1	0.207	0.158	0.291
PCA							1	0.967**	0.337
PCP								1	0.339
TIME									1

Allium hookeri

The Pearson correlation was analyzed for nuclear and plant cell morphology and all the parameters under the nuclear morphology are highly correlated but the parameters under cell morphology are moderately correlated at p≤0.01. None of the parameter was correlated with time which suggests that none of the parameter can be fixed for a particular time to collect the data on the particular parameter. It, also, suggests that these parameters are variable with time, space, factor, climatic conditions, and species. The nuclear volume are highly correlated with nuclear circumference (0.996**), nuclear surface area (1.000**), nuclear diameter, (0.999**) nuclear radius, (0.999**) interphase chromosome volume (1.000**) and moderately correlated with plant cell area (0.667**) and plant cell perimeter (0.529**) at p≤0.01. The Nuclear circumference was highly correlated with nuclear surface area (0.997**), nuclear diameter (0.997**), nuclear radius (0.997**), interphase chromosome volume (0.996**) and moderately correlated with plant cell area (0.701**) and plant cell perimeter (0.561**) at p≤0.01. Nuclear surface area was highly correlated with nuclear diameter (1.000**), nuclear radius (1.000**), interphase chromosome volume (1.000**) and moderately correlated with plant cell area (0.676**) and plant cell perimeter (0.539**) at p≤0.01. Nuclear diameter was highly correlated with nuclear radius (1.000**), interphase chromosome volume (0.999**) and moderately correlated with plant cell area (0.684**) and plant cell perimeter (0.549**) at p≤0.01. Nuclear radius was highly correlated with interphase chromosome volume (0.999**) and moderately correlated with plant cell area (0.686**) and plant cell perimeter (0.549**) at p≤0.01. Interphase chromosome volume was moderately correlated with plant cell area (0.667**) and plant cell perimeter (0.532**) at p≤0.01 and plant cell area was moderately correlated with plant cell perimeter (0.727**) at p≤0.01 (Table 3).

Table 3. Pearson correlation of total mean of nuclear and cell morphology and time in *A. hookeri*

Allium hookeri									
	N V	NC	NSA	ND	NR	ICV	PCA	PCP	TIME
NV	1	0.996**	1.000**	0.999**	0.999**	1.000**	0.667**	0.529**	0.015
NC		1	0.997**	0.997**	0.997**	0.996**	0.701**	0.561**	0.036
NSA			1	1.000**	1.000**	1.000**	0.676**	0.539**	0.018
ND				1	1.000**	0.999**	0.684**	0.549**	0.020
NR					1	0.999**	0.686**	0.549**	0.019
ICV						1	0.667**	0.532**	0.013
PCA							1	0.727**	0.005
PCP								1	0.193
TIME									1

Allium ascalonicum

The nuclear and plant cell parameters were correlated with each other to observe their influences or associations with each other. It was observed all the parameters nuclear as well as plant cell were highly

correlated with each other at p≤0.01. It also indicates any minor modifications or confirmations in any parameter affects the all parameters nuclear as well as plant cell taken for study (Table 4).

Table 4. Pearson correlation of total mean of nuclear and cell morphology and time in *A. ascalonicum*

Allium ascalonicum									
	N V	NC	NSA	ND	NR	ICV	PCA	PCP	TIME
NV	1	.867**	.927**	.913**	.701**	.934**	.620**	.636**	.246
NC		1	.986**	.990**	.757**	.975**	.548**	.551**	.232
NSA			1	.996**	.765**	.997**	.597**	.605**	.238
ND				1	.764**	.986**	.655**	.696**	.239
NR					1	.762**	.535**	.529**	.193
ICV						1	.566**	.576**	.244
PCA							1	.987**	.022
PCP								1	.019
TIME									1

Allium sativum

All the nuclear morphology and plant cell morphology was correlated with each other and almost all the parameters are highly correlated with each other at p≤0.01 andp≤0.05 respectively. Plant cell area and plant cell perimeter has shown correlation with time (0.572* and 0.597**) at p≤0.05 and p≤0.01, and suggest that the change in plant cell area and plant cell perimeter is time dependent as well as nuclear and cell sap activity. Some other factors may also be involved to obtain a change in plant cell area and plant cell perimeter (Table 5).

Table 5. Pearson correlation of total mean of nuclear and cell morphology and time in *A. sativum*

Allium sativum									
	N V	NC	NSA	ND	NR	ICV	PCA	PCP	TIME
NV	1	0.950**	0.977**	0.950**	0.945**	0.898**	0.527**	0.489*	0.176
NC		1	0.992**	0.991**	0.995**	0.911**	0.497*	0.466*	0.196
NSA			1	0.989**	0.988**	0.917**	0.541**	0.508**	0.225
ND				1	0.997**	0.901**	0.566**	0.537**	0.231
NR					1	0.905**	0.527**	0.498*	0.219
ICV						1	0.428*	0.373	0.157
PCA							1	0.967**	0.572*
PCP								1	0.597**
TIME									1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

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