Growth of Some Seasonal Plants – A Study with Statistical Tools

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Abstract:
Statistics play a vital role in studying plant growth. It has been proved that plant growth follows the exponential trend statistics. The data of some seasonal plants has been taken and analyzed. Primrose (leaves and flowers), Geranium (leaves), Hibiscus (leaves), Yellow Lilium (leaves and flowers) and Dahlia (leaves) exhibited good fitting of growth data in exponential trend line $R^2 > 0.9$ where as Geranium (flowers), Kalanchoe (leaves) and Kalanchoe (flowers) showed poor fitting with exponential trend $R^2 < 0.8$.

Keywords: Plant Growth, Exponential Trend line, Statistical Analysis, Exponential Growth, Pelargonium, Hibiscus rosa-sinensis, Primula vulgaris, Dahlia, Kalanchoe blossfeldiana, Zephyranthes citrina

Introduction:

Quantitative methodologies have continuously been central within the life sciences, and a few of those belong to the overall area of statistics. Different ways of data analysis have their part to play, and it is of ongoing importance for the sector of statistics to adapt to those developments. Besides the role of statistical methods in generating new knowledge, there are also regulatory uses of statistics, particularly in plant growth and in an environmental standard setting. Statistical data from official sources and elsewhere play important roles in the life sciences [1]. A proper application of experimental statistics is a very important issue in plant and crop research. There are widely used statistical methods which are useful in plant and crop research. This includes research design and statistical analyses, basic assumptions and transformations, ANOVA application, regression and correlation analyses [2]. Various Statistical methods have also been used in plant pathology where the regression line is fitted to the data of comparison of different chemical treatments for control of plant disease in the laboratory, the greenhouse, and in the field [3]. Plant growth is determined by a mathematical Fibonacci sequence which studies the arrangement of leaves, branches, flowers or seeds in plants, with the main aim of highlighting the existence of regular patterns [4]. Presently the growth data of some seasonal plants Geraniums, Hibiscus, Primrose, Dahlias, Yellow Lilium and Kalanchoe has been taken and analyzed statistically.

1. Geraniums

Geranium is a genus of four hundred and twenty -two species of annual, biennial and perennial that are referred to as geraniums or cranesbills [5].The Botanical name of the plant Geranium is Pelargonium. It is also called Storksbills [6]. Geraniums are appreciated for their long blooming season that starts in spring and can last into fall. These plants may be grown as houseplants or annual flowers. Throughout the summer, they can be kept outdoors in a sunny location; however, in overwinter they must be kept indoors. They can bloom indoors all the year if they are provided enough light. These plants should be planted in pots with drainage holes to avoid plant disease, and they should be planted in sandy soil. These plants mostly bloom in summer and spring Season. The leaves of these plants are broadly circular in form. Its flowers have 5 petals and are colored white, pink, purple or blue, typically with distinctive veining. Geranium species have symmetrical flowers with petals all the same size and shape. For maximum bloom of these plants, they need to be placed in space where they will get 4-6 hours of sunlight. While watering these plants, permit the soil to dry to some extent, then again watering can be done. Common issues can be low light or over- or beneath watering. The leaves will turn yellow if watering is too little or too much. In this case, attempt to even the watering out and move the geraniums to a brighter place.

2. Hibiscus

Hibiscus is a genus of flowering plants in the mallow family, Malvaceae [7]. The Botanical name of the plant Hibiscus is *Hibiscus rosa-sinensis* [8]. The growth period of the flower is from March to October .These has massive, disc-shaped, hollyhock-like flowers that can measure up to twelve inches across. These species found in gardens are the results of crossbreeding native hibiscus species, including Hibiscus moscheutos (Rose Mallow) and Hibiscus coccineus (Swamp Hibiscus). In areas that receive a tough frost, these species will die back to the bottom in winter, regrowing with in the spring. Dwarf varieties reach only a few feet in height, whereas normal varieties may grow up to eight feet tall. The larger, more shrub-like hardy hibiscus species, Hibiscus Syriacus (Rose of Sharon), produces an abundance of smaller flowers; however, grows into a far larger bush that doesn't die back to the bottom in winter. They must be planted with in the spring. Rose of Sharon is generally purchased as tiny shrubs. They can be planted in spring or fall .These can be kept in the full or partial sun; however, should not be exposed to strong winds to avoid breakage of long stems. The flowers are large, conspicuous, and trumpet-shaped, with 5 petals and their colors

are often white to pink, red, orange, peach, and yellow or purple that are 4–18 cm broad. The flowers from numerous cultivars and hybrids are either one single flower or a double flower. Hibiscus plants are known for their large, colorful flowers. These blossoms can make an ornamental addition to a home or garden; however, they also have medicative uses. The flowers and leaves can be made into teas and liquid extracts that can help treat a variety of conditions.

3. Primrose

Primula vulgaris, the common primrose, is a species of flowering plant in the family Primulaceae, native to western and southern Europe, northwest Africa, and parts of southwest Asia. The common name is the primrose or occasionally common primrose or English primrose to distinguish it from other Primula species also called primroses [9]. Its Botanical name is *Primula vulgaris* [10]. It blooms throughout the summer and in some areas, they will continue to delight the fall season with their outstanding colors. This plant needs the proper combination of sunlight (bright but indirect) and water whereas growing indoors and once planting them outside, place in a shady or dappled corner. These plants need a loose, well-drained, very rich potting mix with a high level of humus. Primrose needs adequate, even, and regular moisture to bloom. Its leaves are 5–25 cm long and 2–6 cm broad .Flowers of this plant are pale to deep yellow with darker yellow-orange centers. The single flowers have 5 notched petals which form on the ends of upright woolly stalks. Primrose flowers bloom in early spring, providing a variety of form, size, and color. There are also purple and blue primrose flowers. These perennial plants prefer damp, woodland-like conditions.

4. Dahlia

Dahlia is a genus of tuberous plants that are members of the Asteraceae family; related species include the sunflower, daisy, chrysanthemum, and zinnia. They grow from little tubers planted within the spring. Its Botanical name is *Dahlia* [11]. The growth period of the flower is mid-summer (late June) to winter (early December). In order to flower well, dahlias need full sun, ideally a minimum of six to eight hours every day. In hotter climates, they will do better with a touch of shade during the peak afternoon hours, when the sun is particularly hot. These are grown from tubers, which can be started indoors in early spring and moved outdoors once the danger of frost has passed. They love the morning daylight best. There are nearly ten varieties of modern Dahlia flowers [12]. They range in color from pink and red to orange and yellow. These flowers

are often a good single flower that resembles an orchid or a double flowering bloom with pompons that are bright and colorful.

5. Kalanchoe

Kalanchoe is a popular houseplant usually available for sale during late winter and spring months. It is a durable flowering potted plant requiring little maintenance within the home or workplace. Its Botanical name is *Kalanchoe blossfeldiana* [13]. Kalanchoe plant flowering time is from late fall to early spring, making it the perfect houseplant for brightening gloomy winter days. It has dark green, thick waxy leaves with scalloped-edges and little, four-petaled flowers in clusters held above the foliage. It is also available in a double flowering variety with as many as twenty- six petals per bloom. Kalanchoe brightens the indoors with flowers in various shades of red, magenta, pink, orange, yellow and white [14]. Kalanchoe is a comparatively hands-off varietal, preferring lots of sunlight and well-draining soil. It is also suited to a range of temperatures; however, will not bloom throughout the winter months. However, starting in spring, you will be treated to bursts of colorful flowers which will last many weeks and may reoccur throughout the year, as long because the plant receives the right light exposure and is cropped properly between blooms by removing the flowering heads and providing minimal watering for some weeks. Kalanchoe plants need a great deal of sunlight to bloom, in order that they should be kept in a room with an abundance of bright, natural light. Avoid putting them on windowsills or in direct daylight, however, because it can scorch the leaves and cause the plant to not bloom.

6. Yellow Lilium

Yellow Lilium is a genus of herbaceous flowering plants growing from bulbs, all with large distinguished flowers. Most species are native to the temperate northern hemisphere, although their range extends into the northern climatic zone. Its Botanical name is *Zephyranthes citrina* [15]. Lilies tend to bloom from early summer to fall. Lilies have six plain or strikingly marked petals and are usually trumpet-shaped, sitting atop a tall, erect stem with slim, long, lance-shaped leaves. They are available in several lovely colors, including pink, gold, red, orange, yellow and white. There are eight types of lilies: Asiatic lilies, Oriental lilies, Trumpet lilies, Orienpet lilies, LA Hybrid lilies, Longiflorium lilies, Canada lilies and Turk's Cap lilies. Yellow Lilium comes under the type Orienpet lilies. It is one amongst the best kinds of lilies for summer gardens, Orienpet lilies

are a cross between Oriental hybrids and trumpet lilies. Their blooms have a shallow trumpet form before they totally open into a broad bloom. It should be planted in mid spring and early summer. This will encourage sturdy growth and a lot of attractive flowers. Depending on the variety, Orienpets sometimes start blooming in mid-to late-summer, with flowers lasting 6-8 weeks. They need at least six hours of direct sunlight each day with well-drained soil. The flowers are 6 to 10 inches across, and they come in shades of pink, yellow, red, orange, and white. The outward facing flowers are heavily scented and therefore the plants reach two to three feet in height. There are some really beautiful selections of these lilies. Orienpets create glorious cut flowers.

Models:

Various mathematical models are developed to describe the plant growth. Plant growth is a botanical process and mathematical modeling provides a fundamental structure to explore its elementary unrevealed mechanisms. Number of models has been designed to study the plant growth. Smithers[16] introduced mathematical principles and models of plant growth mechanics that demonstrated the breadth of mathematically rich problems available among plant sciences. Mackerron[17] formulated simulation models which treated the potato crop, its growth and development and its interactions with its environment and with other organisms. Hall[18] developed mathematical models for plant water loss and plant water relations to quantify the descriptions of the functioning of individual organisms. Roose et al.[19] introduced model of plant soil interaction to illustrate and discussed the mathematical modeling for understanding the plant–soil interactions. Presently the data of leaves and flowers of some seasonal plants are observed statistically. The data is best fit under exponential trend line. An exponential model is associated with any species can potentially increase in numbers according to a geometric series. If a species has non-overlapping populations (e.g., annual plants), and each organism produces R offspring, then, population numbers N in generations t= 0, 1, 2, ... is equal to:

$$N_t = N_0 \times R^t$$

When t is large, then this equation can be approximated by an exponential function:

$$N_t = N_0 \times e^{rt}$$

There are many real life examples which grow exponentially as like a pathology test in the hospital, a medical specialist follows the concept of exponential growth to grow the organism extracted from the sample [20]. When cooked or uncooked food is kept at the room or warm temperature, it begins to urge spoiled after some time, there is green discoloration that ruins the food and spreads quite fast. Microorganisms need a heat to grow and divide at an exponential rate [20]. Cancer is one of the most dreadful diseases within the world. Millions of people have already died of cancer, and many more are suffering from it, and therefore the worst note is that cancer cells divide exponentially [21]. During the influenza pandemic of 1918, the rate of patients suffering from flu increased and, therefore, it was considered an exponential growth of the disease [21].

Methodology:

Six different seasonal plants Primrose, Geranium, Hibiscus, Kalanchoe, Yellow Lilium and Dahlia were taken in pots. The height of each pot was about 28 cm, diameter was about 27 cm and depth of soil in the pot was about 25 cm. Watering was done when the plants need the required moisturizing. No overwatering was done. The growth of leaves and flowers of all the plants were being noted on alternate days starting from the date 10th January, 2021 and the data is as following (Table 1):

The starting date of observation of all six plants was 10th January, 2021. This date was considered as 0 day

Days	Primrose		Geranium		Hibiscus		Kalanchoe		Yellow Lilium		Dahlia	
	Leaves	flower	Leaves	flower	Leaves	flower	Leaves	flower	Leaves	flower	leaves	flower
1	25	0	7	0	42		8		40		30	
3	27	0	8	0	48		13		46		32	
5	30	0	9	0	53		14		56		35	
7	31	5	9	0	58		15		65		39	
9	35	6	11	0	65		16		70		45	
11	38	9	11	0	70		17		73		48	
13	42	11	12	0	76		18		78		51	
15	46	14	12		82		20		84		54	
17	49	17	12		87		20		90		58	

19	53	19	13		93		21		101		64	
21	59	25	13		95		21	1	103		67	
23	64	30	14		101		21	2	108		71	
25	69	35	14		105		21	6	111		76	
27	75	38	15		107	1	21	30	118		81	
29	80	50	16		109	3	21	43	122		86	
31	84	60	16		111	4	21	63	126		91	
33	89	72	18		113	5	21	73	131		96	1
35	91	85	18		117	6	21	85	133		98	1
37	97	110	20		121	7	21	95	138		102	2
39	104	119	21		125	7	22	110	142		104	2
41	109	122	21		129	7	23	120	145	1	106	2
43	144	127	22		132	7	26	130	148	1	108	2
45	119	131	23	1	138	7	26	135	151	2	110	2
47	124	135	23	1	142	7	27	145	156	3	112	2
49	126	140	25	2	143	7	28	155	160	4	116	2

Table 1

Results:

Six different seasonal plants: Primrose, Geranium, Hibiscus, Kalanchoe, Yellow Lilium and Dahlia were taken and the growth rate data of its leaves and plants are given in above table 1. The growth rate of leaves and flowers of all six plants is plotted in graphs from fig. 1 to fig.12.

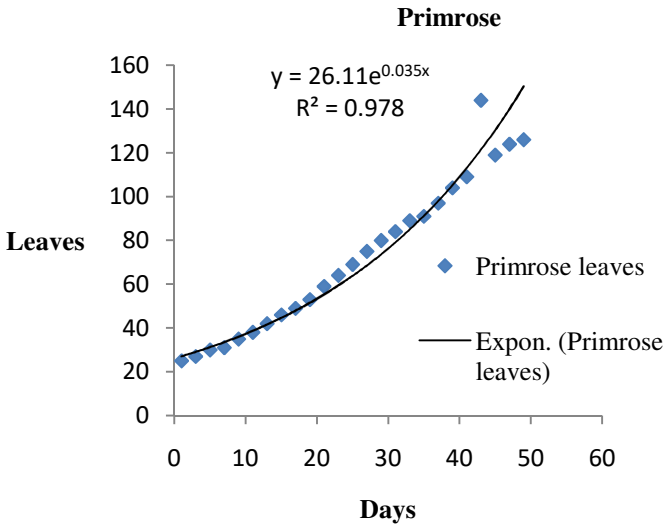
Primrose
y = 26.11e0.035x
R² = 0.978
Leaves
Days
Primrose leaves
Expon. (Primrose leaves)
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60

Fig. 1

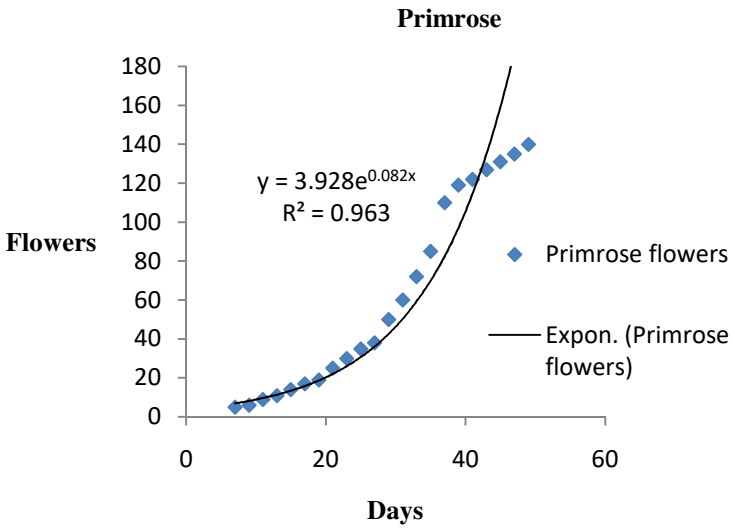
Primrose
y = 3.928e0.082x
R² = 0.963
Flowers
Days
Primrose flowers
Expon. (Primrose flowers)
0
20
40
60
80
100
120
140
160
180
0
20
40
60

Fig. 2

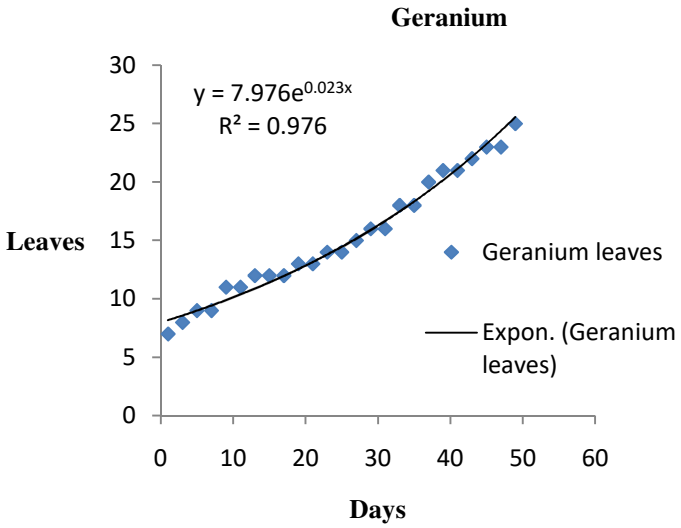

Fig .3

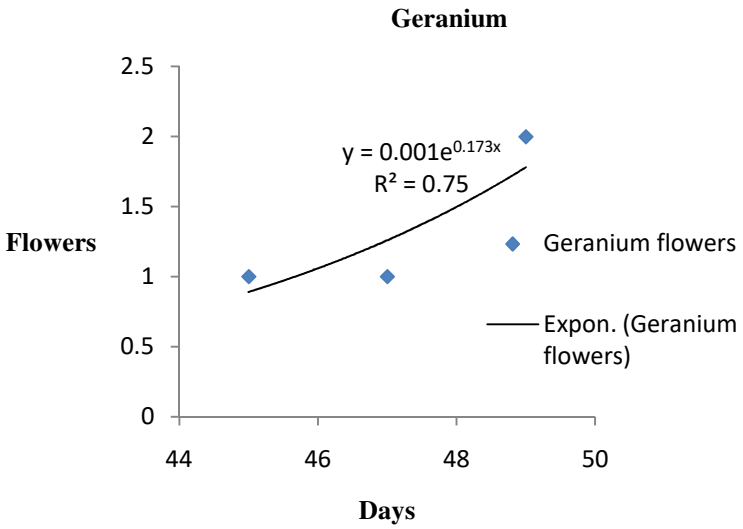

Fig. 4

Date 10th January, 2021 is considered as 0 day

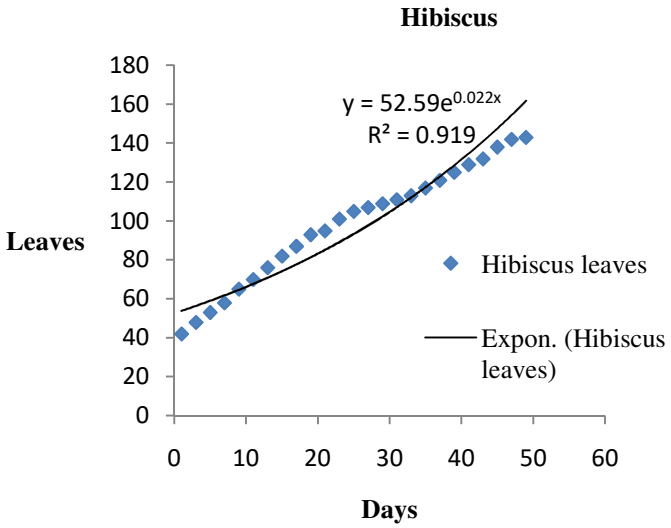
Hibiscus
y = 52.59e0.022x
R² = 0.919
Leaves
Days
Hibiscus leaves
Expon. (Hibiscus leaves)
0
20
40
60
80
100
120
140
160
180
0
10
20
30
40
50
60

Fig. 5

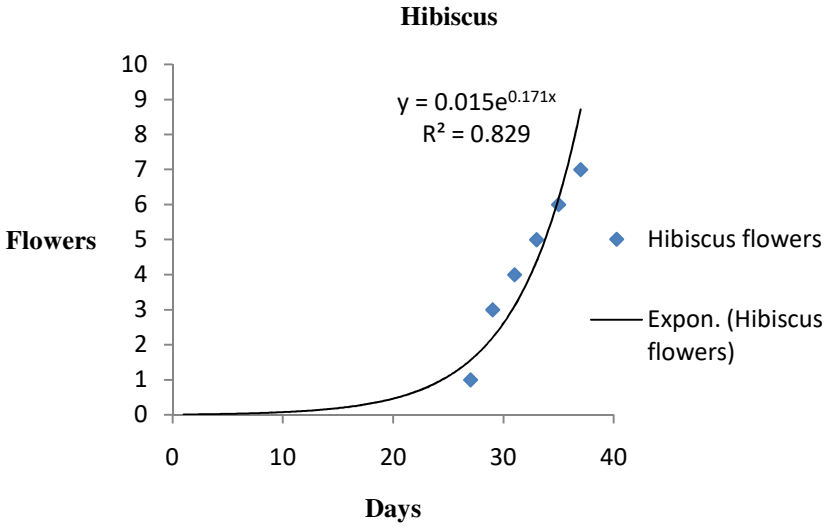
Hibiscus
y = 0.015e0.171x
R² = 0.829
Flowers
Days
Hibiscus flowers
Expon. (Hibiscus flowers)
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40

Fig.6

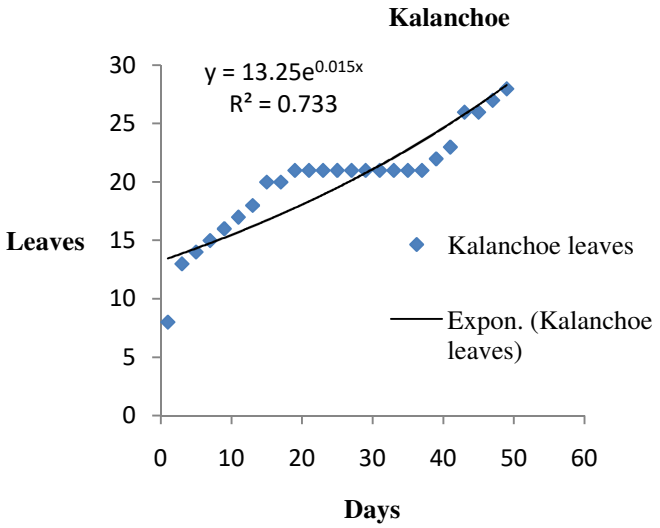
Kalanchoe
y = 13.25e0.015x
R² = 0.733
Leaves
Days
Kalanchoe leaves
Expon. (Kalanchoe leaves)
0
5
10
15
20
25
30
0
10
20
30
40
50
60

Fig. 7

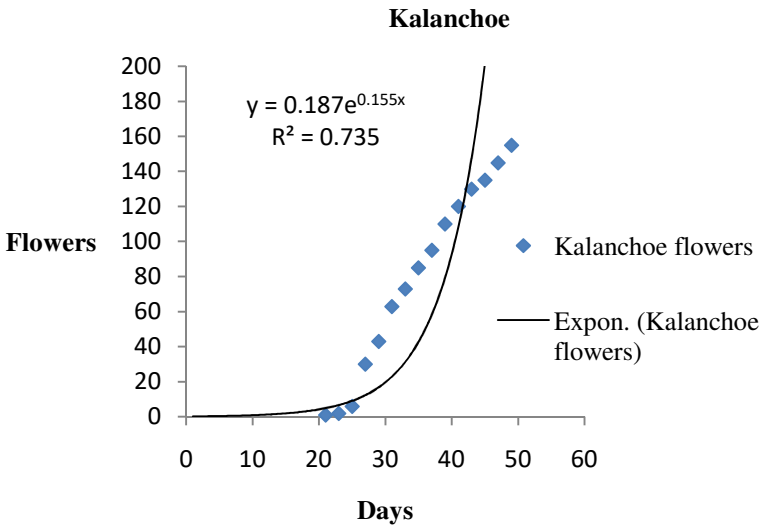
Kalanchoe
y = 0.187e0.155x
R² = 0.735
Flowers
Days
Kalanchoe flowers
Expon. (Kalanchoe flowers)
0
20
40
60
80
100
120
140
160
180
200
0
10
20
30
40
50
60

Fig. 8

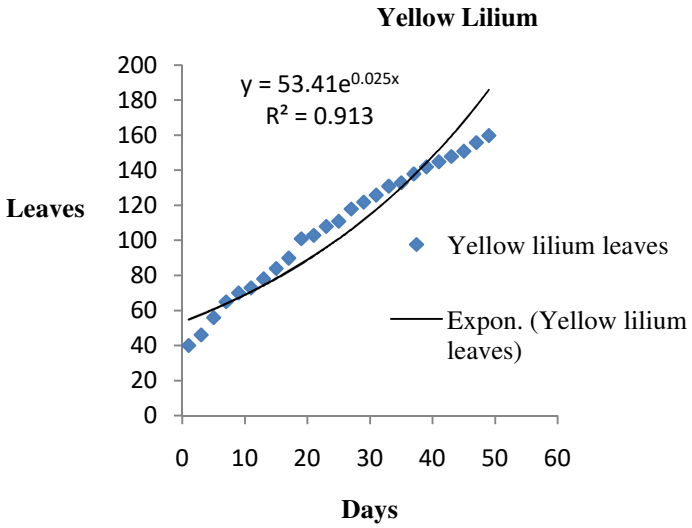
Yellow Lilium
y = 53.41e^0.025x
R² = 0.913
Leaves
Days
Yellow lilium leaves
Expon. (Yellow lilium leaves)
0
20
40
60
80
100
120
140
160
180
200
0
10
20
30
40
50
60

Fig. 9

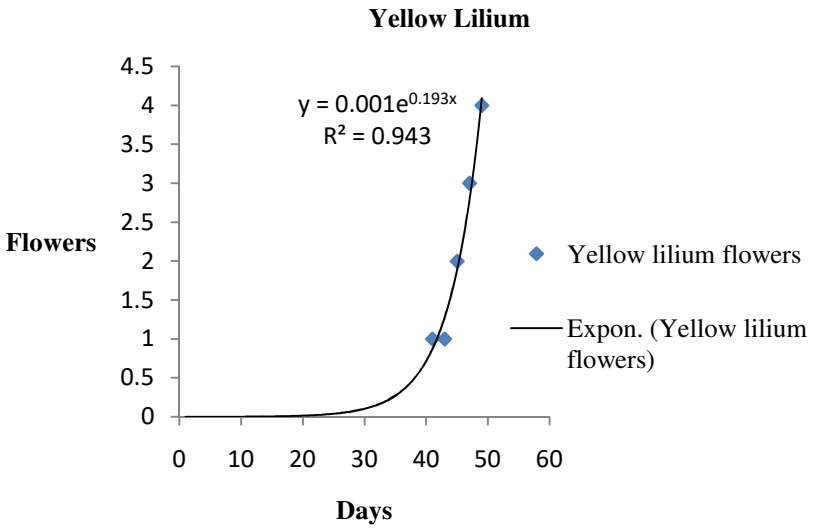
Yellow Lilium
y = 0.001e^0.193x
R² = 0.943
Flowers
Days
Yellow lilium flowers
Expon. (Yellow lilium flowers)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
10
20
30
40
50
60

Fig. 10

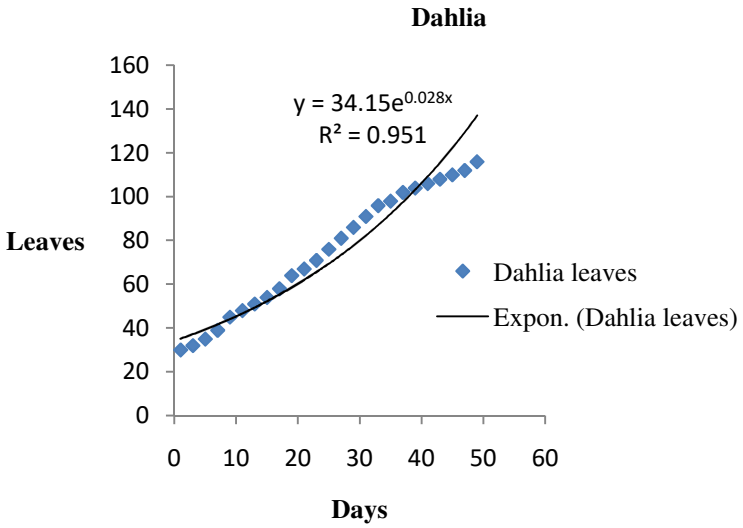

Fig.11

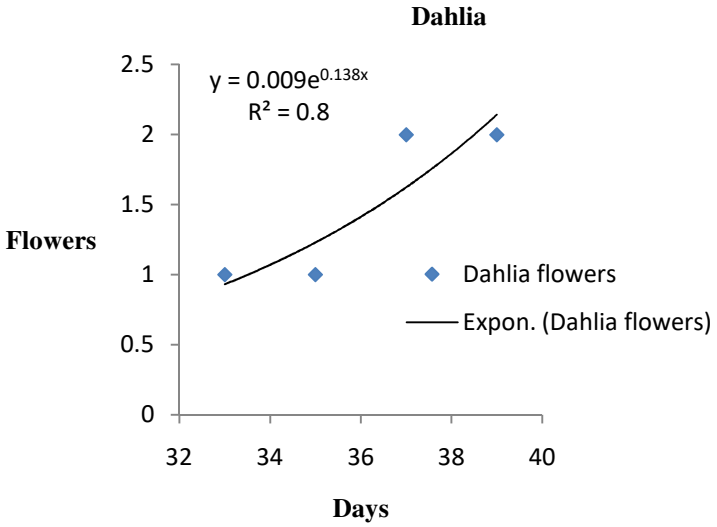

Fig.12

Discussion:

As Roose[18] gave such a quantitative mechanistic model will lead to a more intense understanding of the fundamental science of plants which help in managing real-world problems such as food shortages and global warming. Paine et al.[22] fit a non-linear plant growth model that shows a

way to calculate function-derived growth rates and how to propagate uncertainty in the estimated parameters to precise uncertainty in growth rates of plants. Erickson[23] used differential equations to model plant growth as there are many resources of mathematics are available for solving them. Presently Exponential growth function $y = ae^{bx}$ fits the data of all plants where *a* represents an initial value and *b* represents the continuous growth rate of leaves and flowers of plants. The exponential trend line best fit Primrose flowers data with equation $y = 26.11e^{0.035x}$, R^2 =0.978, growth rate =3.5% and Primrose leaves with $y = 3.928e^{0.082x}$, R^2 = 0.963, growth rate =8.2%. The exponential tend line also obey Geranium leaves data with $y = 7.976e^{0.023x}$, R^2 =0.976, growth rate =2.3% but does not obey Geranium flowers with $y = 0.001e^{0.173x}$, R^2 = 0.75, growth rate =17.3%. Hibiscus leaves data also fit best in exponential trend line with $y = 52.59e^{0.022x}$, R^2 =0.919, growth rate =2.2% but the data of Hibiscus flowers fit average in exponential trend line with $y = 0.015e^{0.171x}$, R^2 = 0.829, growth rate =17.1%. The data of Kalanchoe leaves and flowers poorly fit the exponential trend line with $y = 13.25e^{0.015x}$, R^2 =0.733, growth rate =1.5% and $y = 0.187e^{0.155x}$, R^2 =0.735, growth rate =15.5% respectively. The exponential trend line also best fit Yellow Lilium flowers and leaves data with $y = 53.41e^{0.025x}$, R^2 =0.913, growth rate =2.5% and $y = 0.001e^{0.193x}$, R^2 = 0.943, growth rate =19.3% respectively. It also fits best Dahlia leaves data with $y = 34.15e^{0.028x}$, R^2 = 0.951, growth rate =2.8% but does not obey the data of Dahlia flowers with $y = 0.009e^{0.138x}$, R^2 = 0.8, growth rate =13.8%.

Conclusion:

It has been found that plants growth (leaves and flowers) is exponential in behavior. The exponential trend line gave best fits of the growth of Primrose (leaves and flowers) ,Geranium (leaves) ,Hibiscus (leaves), Yellow Lilium (leaves and flowers) and Dahlia (leaves) with $R^2 > 0.9$ and Geranium (flowers), Kalanchoe (leaves), Kalanchoe (flowers) showed poor fitting with exponential trend $R^2 < 0.8$. It is observed that there is a potential in this subject of further research in order to get insight of the statistics of many more plants with more parameters.

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Learn vocabulary, terms and more with flashcards, games and other study tools.Ä 5. In what way does the petiole of a eudicot leaf represent an adaptation of the plant to increase photosynthesis? a. It orients the leaf to receive maximum sunlight. b. It prevents the leaf from losing water. The statistical analysis was perf ormed by using parametric and non parametric tests, and Poisson distribution has an essential role when dealing with germination experiments. Finally, we describe some interesting results related to the changes in varia bility, which seems to be a primary target of homeopathic treatment effect. Discover the world's research. 20+ million members. In this study, evaluated some morphological traits and genotypes by multivariate statistical methods in some oak species (Q. castaneifolia C. A. Mey, Q. pedunculiflora C. Koch., Q. iberica Stev., Q. macranthera Fisch. & C. A. Mey ex Hohen, Q. ilex L.). 910 leaves were sampled from 91 trees, 8 population across Azerbaijan, and 6 morphological traits were assessed.Â Plant taxonomists believe that the leaves of some oak species under environmentalÂ To avoid seasonal and positional variations, samples were collected from different branches at approximately the same height and location, where leaf growth had stopped.Â Table 4. Values of indicator elements in accordance with studied genotypes. Genotypes PC 1 PC 2 PC 3 Genotypes PC 1 PC 2 PC 3. Continued growth of plants in natural ecosystems depends on the cycling of nutrients between biomass and organic and inorganic stores (Miller and Larson, 1990). Table 6-1 estimates the major, manageable, national nitrogen inputs and outputs for harvested croplands in 1987.Â Some of that fixed nitrogen is removed when the crop is harvested, but some remains in the soil and is available for subsequent crops. Estimates of the amount of nitrogen actually fixed by particular legumes are problematic because there are no unequivocal methods for measurement (see Appendix).Â New tools are needed to measure the actual nitrogen available from mineralization and other residuals to account for and take advantage of annual variability. Nitrogen Outputs.