The Optimization Machine Learning Approach Of Sensitive Analysis Of Fuzzy Inventory Germination Of Plants Generates One-Year-Old-Seeds And Two-Year- Old-Seeds With Fuzzy Inventory

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Abstract
In this article, a mathematical fuzzy inventory model is formulated to describe the propagation of annual plants. We use fuzzy inventory numerical methods with the parameters $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, $\boldsymbol{\gamma}$ and $\boldsymbol{\delta}$ to represent the number of seeds produced by a plant, the percentage of one-year-old seeds that germinate, the percentage of two-year-old seeds that germinate, and the percentage of seeds that survive a given winter. In this fuzzy inventory model, the germination method of one year and two year old seedlings will be compared inside the dormant form of seeds for having survived a winter to a new generation. Germination methods such as micro-propagation will be employed. The result of plant increment will be monitored and determined by calculating using a machine learning approach.

Keywords: Seed bank, Germination, Annual plants, Difference Equations, Fuzzy inventory, Machine learning.

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Introduction

Mathematical models have been used in the field of studies related to pandemic periods in human Population, spread of pests and diseases in agriculture etc. Seeds have been generated at the conclusion of the flowering season of the plants, which then die. “Differential evolution algorithm for solving multi- Objective crop planning model” by Josiah Adeyemo [4]. Some of the produced seeds cross over the winter successfully, and some shoot up during the start of the season, and thus a new generation of plants is produced. The portion of seeds that revives hangs on the age group of the seeds. Lecture Notes on "Difference Equation and Its Application" by Subhendu Kumar Rath [1]

A seed is a fertilized ovule that contains an embryo and an outer covering that acts as a protection. Seed is formed in the process of reproduction in flowering plants, which are classified as gymnosperms and angiosperms.

The process in which the seed grows into a seedling is termed as Seed germination. In this process, the metabolism, which supports the development and shooting up of the seed root and shoot, is triggered. Three primary conditions are necessary for germination. (1) The embryo must have life, and this is viability (2) Any factor that supports inactiveness and prevents development should be removed (3) Appropriate ambience and climatic setting should be present. An Introduction to Mathematical models in Ecology and Evolution" Time and space by Michael Gillman[8]

Germination takes place in two phases: (1) epigeal germination and (2) hypogeal germination.

(1) Epigeal germination: The seed germinates above the ground in this type of germination. The cotyledon is pushed upward as the hypocotyl lengthens.

(2) Hypogeal germination: In this type of germination, the seed undergoes germination below the ground. The hypocotyl doesn’t elongate and the shoot gets pushed above the ground by the epicotyl. Mathematical models in Biology" by Leah Edelstein-Keshet [9]

At the time of seed germination, five processes occur: (1) imbibition (2) respiration (3) impact of sunshine on germinating seeds (4) selection of nutrient content and influence of growth regulators (5) The seedling emerges from the embryo axis. Effects of on-farm seed priming on consecutive daily sowing occasions on the emergence and growth of maize in semi-arid Zimbabwe proposed by F. S. Murungu, C. Chiduza, P. Nyamugafata, L. J. Clark, W. R. Whalley, and W. E. Finch-Savage [10]

As seeds are the primary genetic link between two generation of a plant species, they should have a good storage capacity.

Seeds should be stored so that their ability to germinate and vigour do not deteriorate. While seeds can be kept at room temperature for extended periods of time in temperate climates, they must be adjusted for moisture and temperature in tropical and subtropical areas in order to maintain the vigour of the seeds. Due to insects, rodents, and bacteria, over 30% of the seeds are lost during storage. Influence of osmopriming on the germination and early seedling growth of coarse and fine rice introduced by A. S. Basra, M. Farooq, I. Afzal, and M. Hussain [11].The storage phase starts as soon as the seeds reach their physiological maturity in the field and lasts until they are sown the following season.

To preserve the seeds' potential to germinate, viability, and vigour, care must be taken. This guidebook describes several seed storage theories and procedures. P. Gupta and D. Mukherjee [15] proposed “Influence of GA3 pre-soaking of seeds on biochemical changes in seedling parts of Pennisetum typhoides Rich”

An important step in the life cycle of a seed plant and the foundation of food production is seed germination, which decides when the plant enters natural or agricultural habitats. Primary dormancy prevents newly produced seeds from germinating, which helps the seeds prepare for unfavourable circumstances. Y. Zhang, Z. Ni, Y. Yao, X. Nie, and Q. Sun[14] introduced by “Gibberellins and heterosis of plant height in wheat When the dormancy is lost through moist freezing (stratification) or after-ripening, the seeds will transition from a dormant condition to a germination state at the proper time. In order to avoid unsuitable weather and undesirable environments during plants growth and reproductive growth, seed germination is a precisely scheduled checkpoint. B. Guan, D. Cao, and J. B. Yu [16] introduced "Eco-physiological responses of seed germination of sweet sorghum to seed priming," The rate of seedling survival and vegetative growth, which are consequently linked to final production and quality, will depend on seed germination in crops. Crop cultivars must be prepared for quick and uniform germination at sowing in order to increase crop output and quality, however this choice during crop breeding frequently leads to poor dormancy, which is one of the causes of PHS during the rainy season, which frequently coincides with harvest time. Hence, to enhance crop agronomic performance, crop cultivars must be designed for uniform and quick germination at sowing while avoiding PHS during breeding.

A branch of artificial intelligence (AI) and computer science called machine learning focuses on using data and algorithms to simulate how humans learn, gradually increasing the accuracy of the system. Given sample data or prior knowledge, machine learning is the process of programming computers to maximise a performance criterion. The Economic order quantity in a Fuzzy Environment for a periodic inventory model with variable demand by Kalaiarasi[17,18].

We have a model that has been developed up to a certain point, and learning is the application of a computer programme to optimise the model's parameters using training data or prior knowledge. The model may be descriptive to learn from the data or predictive to make future predictions. Well how build computer programmes that automatically get better with experience is a topic of research in the field of machine learning.

Machine learning is a branch of ai technologies that involves developing computational methods and mathematical models that allow computers to acquire expertise and improve their performance on tasks. These models and algorithms are designed to learn from data and predict or make decisions without being explicitly instructed. Machine learning can be classified into three types: deep reinforcement, unsupervised, and supervised learning. In contrast to unsupervised classification, which involves training a model with unsupervised learning, supervised learning means training a model with labelled data. A model is developed through trial and error using reinforcement learning. Machine learning is used in many fields, including natural language processing, recommendation systems, image and audio recognition, and others.

Seed Germination

Machine learning is a branch of ai technologies that involves developing computational methods and mathematical models that allow computers to acquire expertise and improve their performance on tasks. These models and algorithms are designed to learn from data and predict or make decisions without being explicitly instructed. Machine learning can be classified into three types: deep reinforcement, unsupervised, and supervised learning. In contrast to unsupervised classification, which involves training a model with unsupervised learning, supervised learning means training a model with labelled data. A model is developed through trial and error using reinforcement learning. Machine learning is used in many fields, including natural language processing, recommendation systems, image and audio recognition, and others.

Seeds begin to develop into embryos after cultivation and the formation of the zygote. During the zygote's preliminary division, two cells are produced. The bottom cell develops into a multicellular structure that links the fertilized egg and aids in the absorption of nutrients from the endosperm. The top cell gives rise to the embryo. A proembryo is a series of cells by the first cell divisions of the top cell. As cell divisions continue, the embryo takes on a globular shape. At this stage of development, cells begin to differentiate.

Cotyledons then begin to form. A cotyledon is a seed leaf that stores nutrition in the form of amino acids and starch for such embryo.

Monocotyledon plants (monocots) have an only one cotyledon, whereas dicotyledon plants (dicots) have two. Monocot plants contain the major part of their energy in the endosperm. Dicots' food storage organs are the two cotyledons. Cotyledons spread and grow. The force of the developing embryo crushes the suspensor as it matures.

The radicle , an embryonic shoot , one or two cotyledons, and an embryonic root make up the mature embryo. The epicotyl and the hypocotyl are the two primary components of the embryonic shoot, or plumule. The section of the embryonic stem above the junction where the stem and cotyledon are joined is known as the epicotyl (s). The portion below the point of attachment is known as the hypocotyl. The radicle and hypocotyl are joined.

A protective seed coat surrounds the seed. The endosperm and embryo are shielded from physical harm and drying. At the tip or down the side of the seed coat, there is a scar, known as the hilum. The seed's point of attachment to the ovary wall is designated by the hilum. The micropyle, a microscopic opening in the seed coat that can occasionally be seen close to the hilum, is present.

The process of germination involves the way the seed embryo starts to grow. When an embryonic root protrudes from the seed coat, the seed is said to have germinated. From seeds, several significant crops are grown. Vegetables, cotton, corn, soybeans, and other crops are started from seeds. When the conditions are right for growth, the intricate process of seed germination starts.

During the initial stages of germination, rapid water absorption by the seeds causes inflammation and optimal temperature-induced weakening of the seed coat. This stage is referred to as imbibition. To begin the growth, enzymes are activated. After stimulating its internal physiology, the seed begins to produce proteins, respire, and absorb nutrients this same food that has been stored. This is the lag phase of seed germination. When the seed coat bursts, the radicle emerges and develops into a primary root. The seed starts to absorb water from the soil. The stem begins to ascend after the root and peduncle have emerged. In the final stage of seed germination, the seed cell elongates, divides, and then becomes metabolically active to produce the seedling.

Germination percentage

A high percentage of germination is necessary to obtain a good crop count with less number of seeds. The percentage of germination required for certification is high in a crop like maize (90%), but moderate in many others. Germination percentage is the calculation of the viability of a certain number of seeds. It is calculated by using the following equation.

$$Gp = \frac{seeds\ germinated}{total\ seeds} \times 100$$

The germination rate helps to measure the time taken for seed germination.

Difference equations play a vital role in the mathematical modelling of physical systems.

Several stages of plant generation are explained by formulating various difference equations. Combinations of the basic parameters are used and the system of equations is compacted to a single equation.

Mathematical Model

Mathematical computations are based on equations which help us to determine the value of a function recursively from a given set of values. Such equations are termed as difference equations or recurrence equations. These equations are used in various Mathematical scenarios, and its applications in the field of statistics, dynamical systems, biology etc.

First we shall write all the parameters and constants, next, we shall define the variables.

$\boldsymbol{\alpha}$ = the number of seeds per plant in August

$\boldsymbol{\beta}$= a proportion of one-year-old seedlings that grow in May

$\boldsymbol{\gamma}$ = a proportion of two-year-old seedlings that sprout in May

$\boldsymbol{\delta}$ = the percentage of seeds that sustain a given winter

It should be noted that seed bank changes frequently throughout the year due to the following factors: (1) germination of a specific number of seeds, (2) development of new seeds, and (3) ageing and death of some seedlings. To be more specific, we assume that seeds older than 2 years are no longer viable and are thus ignored.

To define the quantities

p_n = quantity of plants in a generation n

s_n^1 = number of seeds that are one year old (prior to germination)

s_n^2 = number of seeds that are two years old (prior to germination)

$\overline{s_n^1}$ = number of one-year-old seeds remaining (post germination of some seeds)

$\overline{s_n^2}$ = number of two-year-old seeds remaining (post germination of some seeds)

s_n^0 = the number of new seedlings generated

The superscripts indicate the age of the seeds and the subscripts denote the year number.
A fraction $\boldsymbol{\beta}$ of one-year-old and $\boldsymbol{\gamma}$ of two-year-old seeds give rise to new plants.
So,

$$p_n = (Plants\ from\ one\ year\ old\ seeds) + (plants\ from\ two\ yearold\ seeds)$$

$$p_n = \beta s_n^1 + \gamma s_n^2 \rightarrow ①$$

The level of seed bank gets decreased after germination of certain seeds. So, for every age class, the number of seeds left is calculated as below.

$$Seeds\ left = (Fraction\ not\ germinated) \times (original\ number\ of\ seeds)$$

$$\overline{s_n^1} = (1-\beta)s_n^1 \rightarrow ②$$

$$\overline{s_n^2} = (1-\gamma)s_n^2 \rightarrow ③$$

The production of new seeds takes place at the rate of $\boldsymbol{\alpha}$ per plant

$$s_n^0 = \alpha p_n \rightarrow ④$$

After crossing the winter, the level of seed bank gets altered due to death rate and aging of seeds. Seeds which had been fresh in generation n would be one year aged in the following generation n+1
So,

$$s_{n+1}^1 = \delta s_n^0 \rightarrow ⑤$$

$$s_{n+2}^2 = \delta \overline{s_n^1} \rightarrow ⑥$$

The annual integrated total germination seeds production,

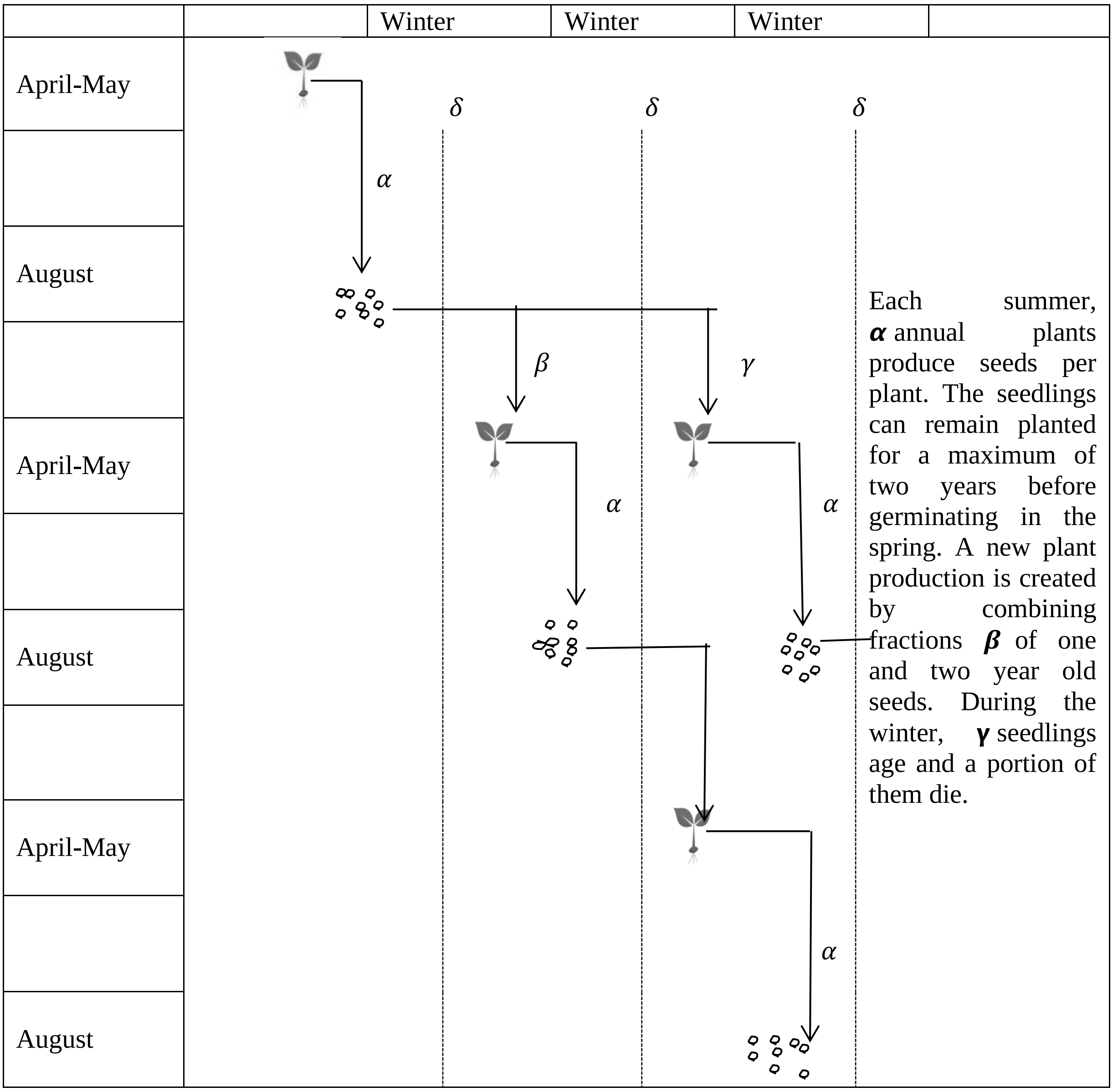
$$G_{SS} = \frac{2P_C P_{SC}}{\alpha} + \alpha\,(F_C\,L_C) + (L_C M_{CL})\alpha + \frac{T_C}{\alpha}\beta + F_C L_C M C_L\,\gamma$$

Diff with respect to α, we get

$$\frac{\partial G_{SS}}{\partial \alpha} = 2P_C P_{SC}\left(\frac{-1}{\alpha^2}\right) + F_C\,L_C + L_C M_{CL} - \frac{T_C}{\alpha}\beta = 0$$

$$\alpha = \sqrt{\frac{2(T_{C\beta} + P_C P_{SC})}{F_C L_C + L_{CM} C_L}}$$

Each summer, $\boldsymbol{\alpha}$ annual plants produce seeds per plant. The seedlings can remain planted for a maximum of two years before germinating in the spring. A new plant production is created by combining fractions $\boldsymbol{\beta}$ of one and two year old seeds. During the winter, $\boldsymbol{\gamma}$ seedlings age and a portion of them die.



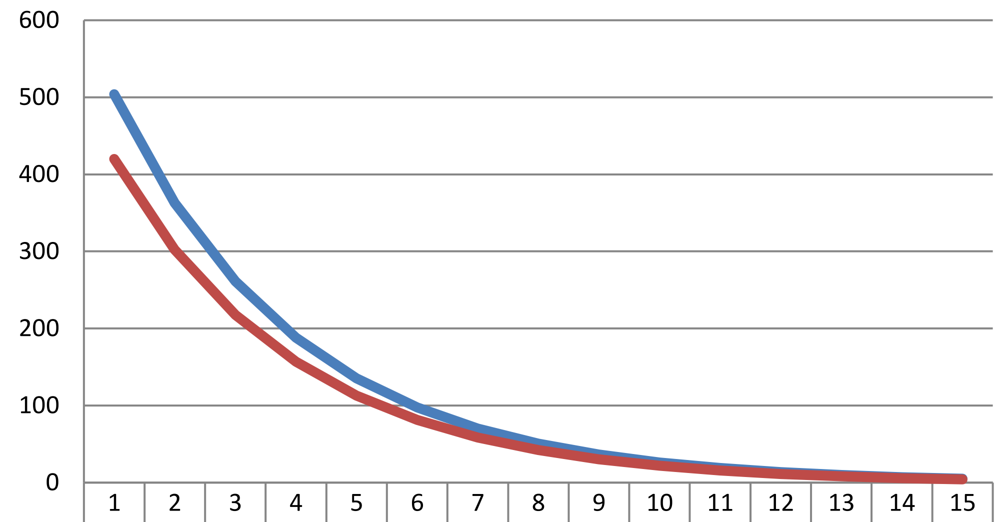
Result analysis

Variations in a plant population over 15 generations

a) $\alpha = 2.0, \beta = 0.6, \delta = 0.6$:

Generation	Plants	New seeds	One year old seeds
0.	350	700	-
1.	252	504	420
2.	181.44	362.88	302.4
3.	130.64	261.28	217.73
4.	94.06	188.12	156.77
5.	67.72	135.45	112.87
6.	48.76	97.52	81.27
7.	35.11	70.22	58.51
8.	25.28	50.56	42.13
9.	18.2	36.39	30.33
10.	13.1	26.21	21.84
11.	9.43	18.87	15.72
12.	6.79	13.59	11.32
13.	4.89	9.78	8.15
14.	3.52	7.05	5.87
15.	2.54	5.07	4.23

Table 1: Variations in a plant population over 15 generations for $\alpha = 2.0, \beta = 0.6, \delta = 0.6$



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
New seeds 700	504	362.9	261.3	188.1	135.5	97.52	70.22	50.56	36.39	26.21	18.87	13.59	9.78	7.05	5.07
One year old seeds -	420	302.4	217.7	156.8	112.9	81.27	58.51	42.13	30.33	21.84	15.72	11.32	8.15	5.87	4.23

Figure 1: Variations in New seeds and One year old seeds over 15 generations for $\alpha = 2.0, \beta = 0.6, \delta = 0.6$

Figure 1 displays the variations for α =2.0, β =0.6, and δ =0.6 across 15 generations for new seeds and seeds older than one year.

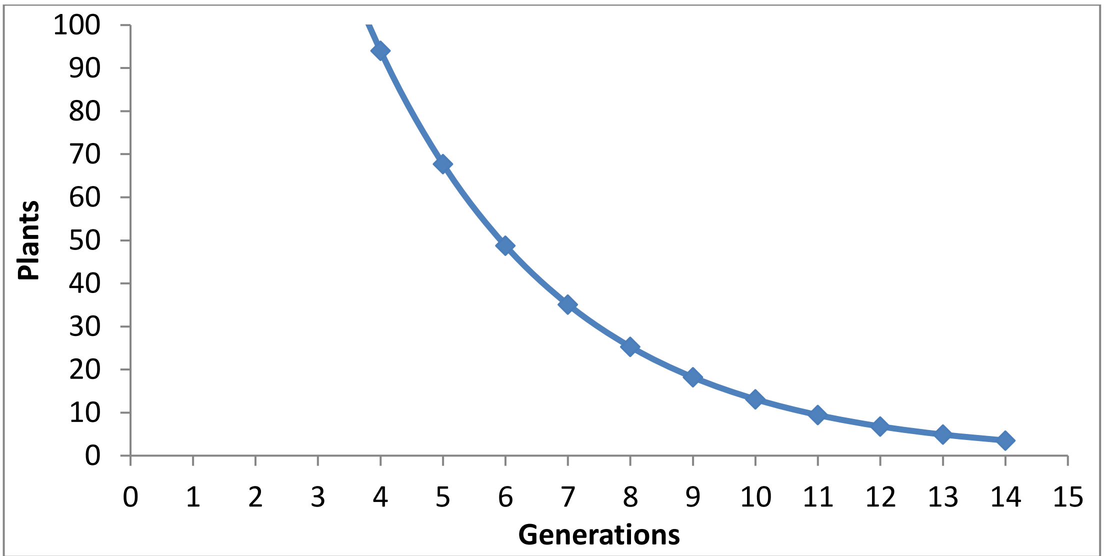


Figure 2: Variations in a plant population over 15 generations for $\alpha = 2.0, \beta = 0.6, \delta = 0.6$

The number of plants decreases with respect to α, β and γ . If this continues, after a few generations that particular plant species may become completely extinct. This may be the reason for the total destruction of some plant species.

Machine learning (ML), a type of ai technology, allows software programmes to predict the outcome more accurately without being explicitly guided to do so. Algorithms for machine learning use historical data as input to predicted new output values.

Each variable in the data set is symbolized by a dot in a scatter plot. One method for producing scatter plots using the Matplotlib module is to use identical arrays, one for the values of the x-axis and one for the values of the y-axis:

```
import matplotlib.pyplot as plt

x = [0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15]
y = [350,252,181.44,130.64,94.06,67.72,48.76,35.11,25.28,18.2,13.1,9.43,6.79,4.89,3.52,2.54]
plt.scatter(x, y)
plt.show()
```

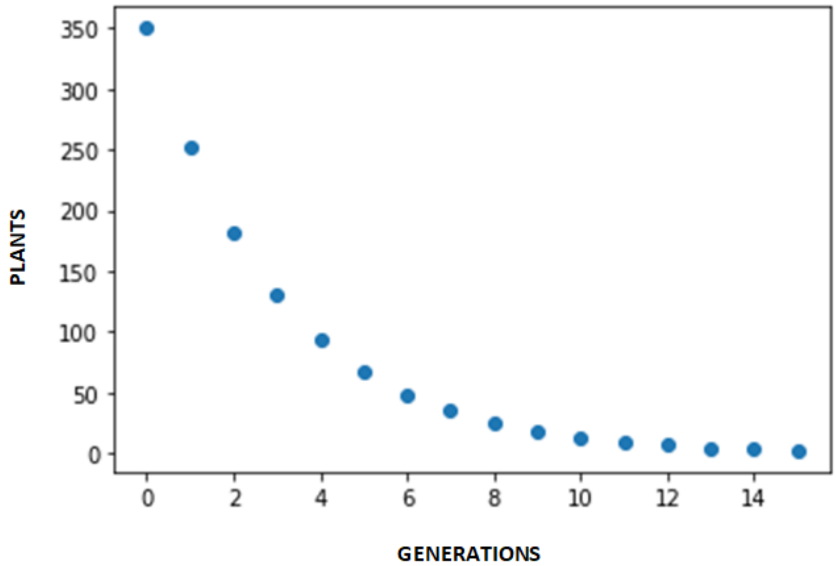


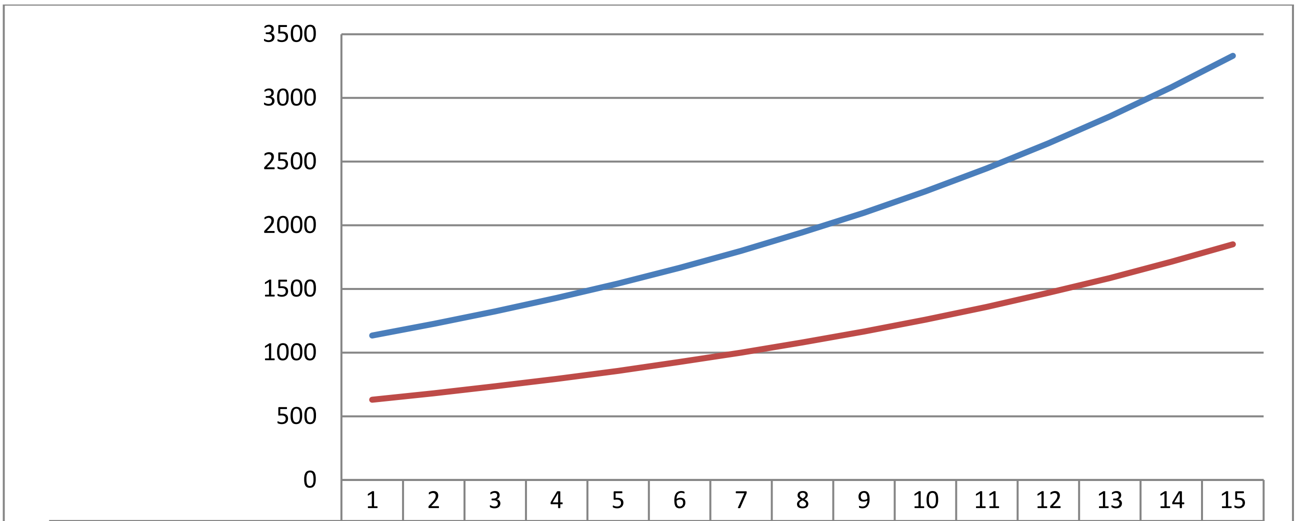
Figure 3: Scatter plot representation for the Variations in a plant population over 15 generations for $\alpha = 2.0, \beta = 0.6, \delta = 0.6$

In the above graph the x array represents the generations. The y array represents the plant. The number of plants decreases with respect to α, β *and* γ . If this continues, after a few generations that particular plant species may become completely extinct. This may be the reason for the total destruction of some plant species.

b) $\alpha = 2.0, \beta = 0.6, \delta = 0.6$:

Generation	Plants	New seeds	One year old seeds
0.	350	1050	-
1.	378	1134	630
2.	408.24	1224.72	680.4
3.	440.89	1322.69	734.83
4.	476.17	1428.51	793.61
5.	514.26	1542.79	857.11
6.	555.41	1666.22	925.68
7.	599.84	1799.52	999.73
8.	647.83	1943.48	1079.71
9.	699.65	2098.95	1166
10.	755.62	2266.87	1259.37
11.	816.06	2448.22	1360
12.	881.36	2644.08	1468.93
13.	951.87	2855.6	1586.45
14.	1028.02	3084.05	1713.36
15.	1110.26	3330.78	1850.43

Table 2: Variations in a plant population over 15 generations for $\alpha = 2.0, \beta = 0.6, \delta = 0.6$



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
New seeds 1050	1134	1225	1323	1429	1543	1666	1800	1943	2099	2267	2448	2644	2856	3084	3331
One year old seeds -	630	680.4	734.8	793.6	857.1	925.7	999.7	1080	1166	1259	1360	1469	1586	1713	1850

Figure 4: Variations in a New seeds and One year Old seeds over 15 generations for $\alpha = 2.0, \beta = 0.6, \delta = 0.6$

Figure 4 displays the variations for α =2.0, β =0.6, and δ =0.6 across 15 generations for new seeds and seeds older than one year.

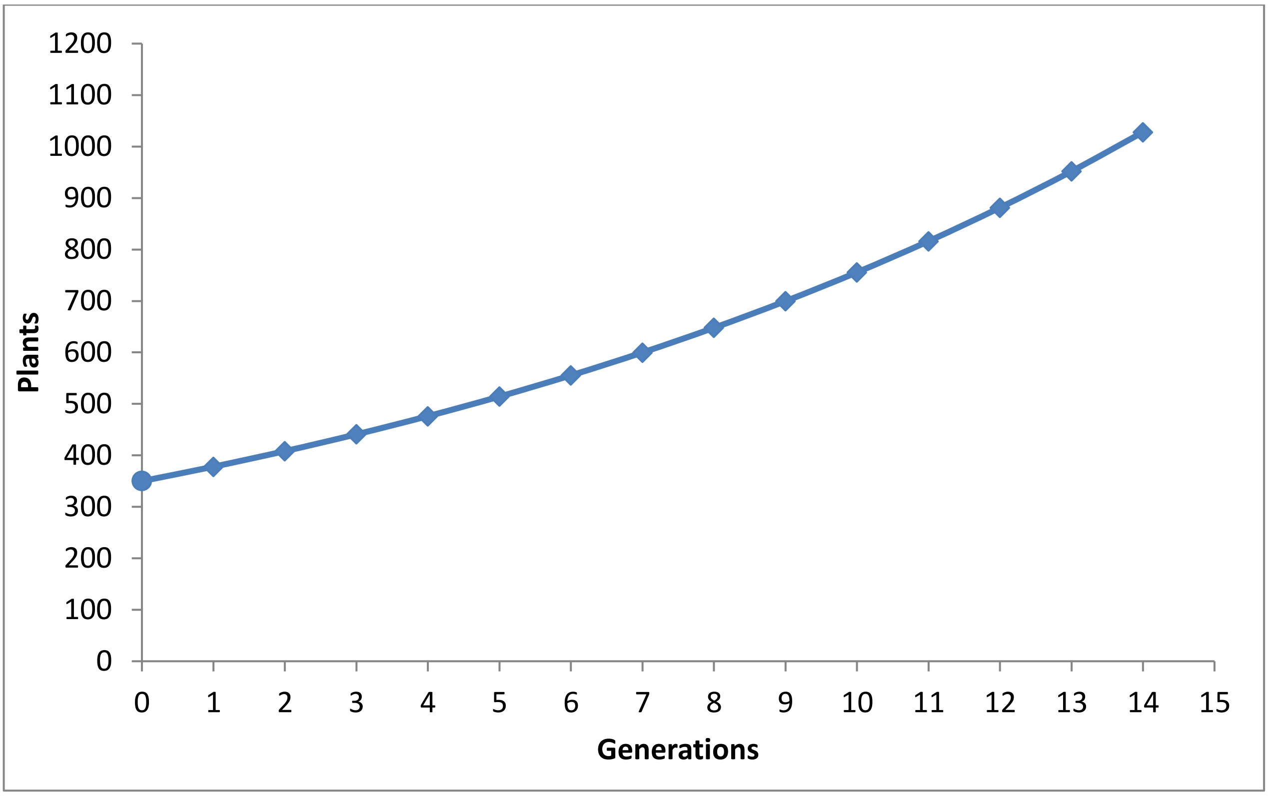


Figure 5: Variations in a plant population over 15 generations for $\alpha = 2.0, \beta = 0.6, \delta = 0.6$

In the above graph, the number of plants increases with respect to α, β *and* γ. Here we increase the value of $\boldsymbol{\alpha}$ so that the number of plants gets increased, generation by generation.

```
import matplotlib.pyplot as plt

x = [0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15]
y = [350,378,408.24,440.89,476.17,514.26,555.41,599.84,647.83,699.65,755.62,816.06,881.36,951.87,1028.02,1110.26]
plt.scatter(x, y)
plt.show()
```

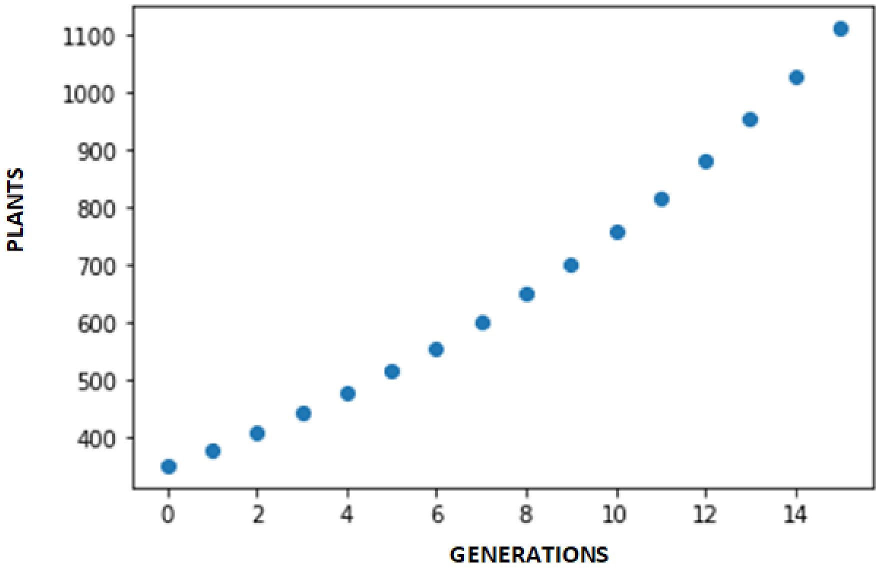


Figure 6: Scatter plot representation for Variations in a plant population over 15 generations for $\alpha = 2.0, \beta = 0.6, \delta = 0.6$

In the above graph, the x array represents the generations. The y array represents the plant. the number of plants increases with respect to α, β *and* γ. Here we increase the value of $\boldsymbol{\alpha}$ so that the number of plants gets increased, generation by generation.

c) $\alpha = 2.0, \beta = 0.6, \delta = 0.6, \gamma = 0.25$

Generation	Plants	New seeds	One year old seeds	Two year old seeds
0.	350	700	-	-
1.	-	-	420	-
2.	25.2	50.4	-	100.8
3.	-	-	30.24	-
4.	4.35	8.71	-	7.26
5.	-	-	5.23	-
6.	0.75	1.5	-	1.25

Table 3: Variations in a plant population over 6 generations for $\alpha = 2.0, \beta = 0.6, \delta = 0.6, \gamma = 0.25$
From the above result analysis table, the two year old seeds may be neglected.

Conclusion

Some of the plant species have become completely extinct due to the actions of humans, animals, nature etc. Moreover, there are chances of plants getting extinct due to less production of seeds. Such plants which are getting extinct can be identified and genetic modification can be processed in such plants to increase the production of seeds. By using methods like micro propagation, the number of plants can be increased and this increase can be monitored and calculated using a Mathematical model and sensitive analysis is done by Python. Thus, the plants can be saved from getting perished.

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