Research Article

Mathematical modelling of nitrogen, potassium and phosphate supply and uptake by ginger plant in one life cycle using graphical analysis

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Abstract

Introduction: We discuss here the graphical analysis of nitrogen, potassium and phosphate requirement for ginger crop in one life cycle which is about ten month, per day per acre. We use data of amount requirement of nitrogen, potassium and phosphate supply per acre suggested by agricultural department. We provide mathematical analysis of nutrient supply graphically and fit the curves with solutions of simple differential equations.
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Subject classification (AMS): 03C, 05C, 14H, 65A, 65S and 92B.

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INTRODUCTION

Application of fertilizer is an important issue in agricultural industry. Ginger is word wide crop. Due to the fluctuation of rate of ginger in market and its productivity is closely related with modern techniques, it is important to discuss nutrient supply for plant in its life cycle with constant PH of water, because in suitable PH of water plant root uptake the nutrient. For the high production of ginger, farmer require heavy budget and unbalance supply of nutrient can results into destroy of bulb, therefore farmer are interested into to maintain the sharp supply of nutrient through drip irrigation. We collect data of nitrogen and phosphate supply per acre per day suggested by agricultural department and plot graph. It is found that it fit with graph of nature symmetrical normal distribution.

DATA COLLECTION OF NITROGEN SUPPLY

We write collected data in tabular form[1]

Table 1

Days	Nitrogen supply per acre in kg
1 to 45	10
46 to 90	25
91 to 130	10
131 to 250	5

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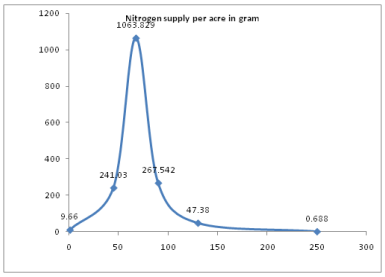
We calculated the amount of nutrient supplied at prominent days. In first 45 day, we require 10 kilogram of nitrogen fertilizer, which is supplied as increasing with per day. After calculation we found that, the first day require 9.66 gram of nitrogen and for 45th day require 486.78 gram of nitrogen. Such small quantity of nitrogen is supplied through drip irrigation daily. For 46th day require 494.07gm nitrogen per acre. But in the period 46th to 90th day requirement of supply of nitrogen is highest. It indicates plant in this period is growing speedily. It is found that 67th day is the height nitrogen requirement day for ginger plant, i.e., it is pick point. The requirement of nitrogen on the 67th day is 1069.56 gram per acre. As per tabular information for 90th day the supply of nitrogen is 494gram and 91th day require487.80 gram per acre. Calculation indicates 130th day require 12.19 gram per day, for 131th day require 81.88 and 250th day require 0.67gram per day per acre. After 300 day the requirement of nitrogen is completely stops. But 130 and 131th has contradicting observation, so take mean for the same, due to which graph will be plane in nature. So we have tabular data in form

Table 2

Days	Nitrogen supply per acre in gm
1	9.66
46	494
67	1069.56
91	487.80
130	92.07
250	0.67
300	0

We now plot graph for above table



Graph 1

DATA COLLECTION OF PHOSPHATE SUPPLY PER ACRE

Table 3

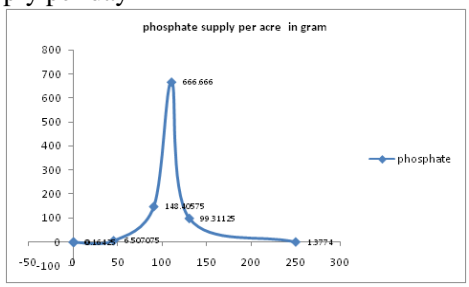
Days	phosphate supply per acre in kg
1 to 45	07
46 to 90	10
91 to 130	14
131 to 250	10

Day wise amount of phosphate requirement for ginger crop per acre calculated as calculated for nitrogen. It is found that 111th day will be day of highest requirement of phosphate.

Table 4

Days	Phosphate
0	0
1	0.16
45.5	6.51
90.5	148
111	667
131	99.3
251	1.38

Graphical presentation of phosphate supply per day



Graph 2

The graph of nitrogen and phosphate supply per acre fit to symmetric normal distribution and function for normal distribution of nitrogen supply for ginger plant is given by[2]

$$f_x(x;\mu,\sigma) = \frac{1}{x\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}, x \geq 0.$$

Where, μ is the mean, σ is the standard deviation and x is the days.
The differential equation of above function is given by

$$\frac{dy}{dx} = \frac{y(\mu-x)}{\sigma^2} \tag{3.1}$$

Since

$$\frac{dy}{y} = \frac{\mu-x}{\sigma^2} dx \tag{3.2}$$

$$\ln\left(\frac{y}{y_0}\right) = -\frac{1}{2\sigma^2}(\mu-x)^2 \tag{3.3}$$

$$y = y_0 e^{-\frac{(x-\mu)^2}{2\sigma^2}} \tag{3.4}$$

$$f_x(x;\mu,\sigma) = \frac{1}{x\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}, x \geq 0 \tag{3.5}$$

Comparing we get

$$y_0 = \frac{1}{x\sigma\sqrt{2\pi}}$$

DATA COLLECTION OF POTASSIUM SUPPLY PER ACRE

Table 5

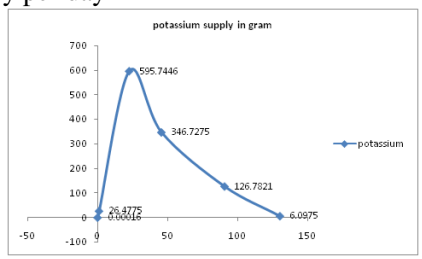
Days	Potassium supply per acre in kg
1 to 45	15
46 to 90	10
91 to 130	5
131 to 250	

Day wise requirement of amount of potassium requirement for ginger crop per acre is given by as follows. It is found that 22th is day of highest day of requirement of potassium.

Table 6

Days	Potassium
0	0
1	26.5
22.5	596
45.5	347
90.5	127
131	6.1

Graphical presentation of phosphate supply per day



Graph 3

If you mean a scalar multiple of a curve with the same form as a gamma probability density function, here's an example using nlinfit from the Statistics Toolbox: function main
y = [0, 26.5, 596, 347, 127, 6.1];
x = 1:1000;
p = nlinfit (x, y, @f, [0 150 700])
plot (x, y, 'bo', x, f (p, x),'r-')
end
function y = f(abc, x)
a = abc (1); b = abc(2); c = abc(3);
y = c * x. ^ (a-1) * exp(-x/b) / (b^a * gamma(a)); end
Graph 3 curve fit with the gamma probability density function

$$f(x;k,\theta) = \frac{x^{k-1}e^{-\frac{x}{\theta}}}{\theta^k \Gamma(k)} \text{ for } x > 0 \text{ and } k, \theta > 0 \qquad (4.1)$$

Here Γ (k) is the gamma function evaluated at k. Particular for k=2 and $\theta = 2$ Probability density function of gamma distribution is also known as Erlang distribution.[3]
The Erlang distribution is solution of the following Differential equation.

$$xf'(x) + (\lambda x + 1 - k)f(x) = 0 \qquad (4.2)$$

With initial condition $f(1) = \frac{e^{-\lambda}\lambda^k}{\Gamma(k)}$ (the Poisson distribution).

Where $\theta = \frac{1}{\lambda}$

CONCLUSIONS

We were interesting to mathematical modeling of nitrogen supply for ginger crop plant per day in form of differential equation and its graphical analysis. From the graph 1, 2 and 3 we found graph 1and 2 are solution of simple first order ordinary differential equation. Graph 3 has positively skewed symmetric distribution whose curve fit with curve of probability density function of gamma distribution; it is solution of simple ordinary differential equation. It is also found that the order of highest requirement of fertilizer as per pick point is potassium, nitrogen and phosphate. Therefore the farmer in India generally uses the fertilizer of brand 18:46:00 in early period of growth of ginger crop, also the brand is famous for the basal dose and known as DAP.

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