Integrated Nutrient Management for Tomato Crop Based on Soil Analysis for Sustaining Soil Fertility and Reducing Environmental Impact

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***Abstract* - Plant growth requires along with water, good amount of nutrients, either already present in the soil or externally added like through the fertilization process. Improper use of fertilizers without having proper knowledge about the release of nutrient from the coated granule leads to loss of the fertility of the soil while increasing the input cost for the farmers. So the concept of integrated nutrient management plays a vital role in deciding optimal uptake of nutrients by the plants. In this paper, by taking the tomato plant as an example, authors discuss the back propagation neural network (BPN) model for nutrient management along with evaluating the performance criteria by Root mean Square Error (RMSE) and Correlation Coefficient (CC) in the first stage. In the second stage, control-release of nutrients from coated fertilizer granules for optimal uptake by plants is mathematically modeled and is used for simulation. The simulated result for saturation and release time from the spherical granule with varying values of radius, point of contact to the ground surface, release rate, evaporation factor, nutrient and water diffusion coefficient, etc are presented. From the computer simulation, results show that in the first stage using BPN model for optimizing the nutrients to be fed for tomato plant on weekly basis performance lies between 82.846-83.545% for selected 72 out of 100 plots dataset. In the second stage, the saturation and nutrient release time of the granule studied by varying the radius, point of contact with a ground surface, evaporation loss, diffusion coefficient, nutrient release time and nutrient diffusion time.**

***Keywords* -** Integrated Nutrient Management (INM); NPK Nutrients; Back Propagation Neural Network (BPN); Saturation time and Release time:

I. INTRODUCTION

Agriculture plays a major role in the development of a country’s economy and helps in the sustenance of farmer’s livelihood in various ways. The agricultural income is fairly volatile, which directly impact the famer’s and also the nation’s requirement of food grains for self sufficiency. Food is the key outcome of agriculture, which feeds all human being and animals of the land [1]. Nowadays, as the population is increasing but agriculture productivity is decreasing due to various reasons such as decreasing fertile agriculture land, inadequate, improper irrigation methods, feeding inadequate and imbalance ratio of nutrients to the crops. In addition all this factors resulting in loosing fertility of the soil [2]. According to International plant nutrition institute nutrient response ratio is declining at the rate of 20-25% for every decade leading to deficiency in some secondary and micro nutrients in the soil [3]. In this research work we have taken the tomato crop for the study.

India stands next to china in the production of tomatoes [4]. Tomato can be grown in wide variety of soil with pH range 6.0 to 7.0 preferred at a diverse set of climatic condition. Typical height of the tomato plant will vary from 3 to 5 feet, where as its roots will penetrate into the ground surface only about 15-55cm [5]. Depending on the soil condition fertilizers may be required to be fed to plant in a time lapse manner based on plant growth stages, while the water content in the soil helps in dissolving of nutrients. So water evaporation factor plays a major role in varying water content in field surface.

Nutrients feed through the soil in turns to plants to increase the productivity to fulfill the hunger of a country. The growth and development of plant need essential nutrients to produce healthy food, which can be supplied through either existing soil minerals or externally applied fertilizers. Fertility of soil plays an important factor in the productivity of agriculture crops, which may consist of primary, secondary and micro nutrients [6]. The primary nutrients like Nitrogen, Phosphorus and Potassium i.e. NPK are fed in large amount compared to other nutrients. Tomato plants require an optimum ratio of nutrients range but it seen that minimum level leads to a deficiency in growth of the produce and excess level leads to toxicity [7]. Soil and nutrients play a major role in the development of an agricultural plant in different growth stages. Therefore, need a precise amount of nutrients to be feed at right time in the right amount to ensure maximum produce.

Fertilizer granules are spherical in shape and are coated with neem in India, which helps in controlling pests. Around 90-95% of the granules are in diameter of 1.70-2.50mm and rest 5-10% is in powder form [8]. The water is a medium for the nutrient release to soil as dry granules need water penetration to get saturated so as to release the nutrients. When the field contains water is in excess amount, nutrients get washed away or get infiltrated down the earth surface below the root system, so right amount of irrigation is essential for optimal nutrient absorption by the plans. In this paper, a new approach is proposed to determine the saturation time and release time of a nutrient granule through mathematical modeling and simulation, based on the certain assumptions. The certainties are granule radius, surface contact area, diffusion coefficient and other parameters on saturation and release times are studied.

II. LITERATURE SURVEY

Food production in India is gradually increasing around 10-12% yearly and is keeping up with the rising population consumption demand while there is a decrease of cultivating land and also the fertility of the soil is sliding downward [9]. In order to achieve food security which is a huge challenge under varying conditions like unpredictable monsoon, unscientific irrigation practice and imbalanced use of fertilizers and pesticides, etc., the farmers have to take appropriate measures to achieve high productivity out of their farm fields. The nutrient plays a major role in the productivity of the crop and over use of certain fertilizer inputs can lead to deteriorating fertility of the soil. The judicious use of primary nutrient elements like nitrogen, phosphorus and potassium has increased nationally by 49%, 33% and 13% respectively in 2011 compared to previous year [10].

Tomato crop cultivation has the highest hectare comparable to other vegetables in India. In horticulture, usage of nitrogen is much higher compared to phosphorus and potassium nutrients, which in turn causes environmental pollution such as eutrophication and GHG emission [11]. Nitrogen along with water supply i.e. fertigation [12] experiment on tomato plant based on Penman-Monteith equation associated with its growth stages has shown that irrigation schedule affects the nitrogen recovery [13]. However, fertigation composition ratio and its frequency affect by a depth of wet soil, soil hydraulic properties, spacing, and placement [14]. High fertigation frequency is suited best comparably due to maintaining constant soil moisture and nutrient concentration at root zone [15], crop performance found to improve in bell peppers [16], melon [17] and tomato [18]. Poor or over usage of phosphorus has increased pressure on phosphate rock and lead eutrophication [19]. Three categories of legacy P soil considered to check the potential of accessibility to crops based on climate, soil ph, soil depth, soil P buffering capacity and farming system [20]. Finally, the potassium usage in crop cultivation is limited, due to the availability of K in the soil. The ANN-based multilayer perceptron, radial basis function, adopted neural network, fuzzy learning approach and general regression neural network models were developed, due to nature of nonlinear mapping, self-adaptation and robustness for the amount of nutrients to feed [21]. Once the nutrients are feed to the soil, takes a step to release nutrient within it through the water as a medium of transport to control saturation time and release time [22].

Agriculture practices that upgrade soil fertility and sustainability to produce have become a challenging task for researchers nowadays. There is a need to be finding a precise amount of NPK ratio to feed the crop based on its development stages. Moreover, it's important to find the nutrients best apply time and control the release time of nutrients from coated nutrients to optimal uptake of a plant using the mathematical model.

III. PROPOSED METHODOLOGY

In the proposed method, the authors propose a two-stage for feeding optimized quantity of NPK for a tomato plant. In the first stage, supervised learning method like Back Propagation Neural Network (BPN) is trained to suggest right amount of NPK to feed based on the Soil elements, pH and plant growth stages. In the second stage, estimated saturation and release time of nutrient is granule based on a mathematical model by understanding the effects to determine the radius, coating width by manufacturers.

a. Soil-Nutrient Analysis

In this work authors created our own database with 100 soil samples from different farm fields around Mysore region in Varuna hobli and tested samples through experts in Department of Agriculture Laboratory for measuring the amount of Soil pH and NPK nutrients. Tomato plant selected for cultivation in a farm field, the three major critically required elements N, P and K helps to increase production based on soil field. The soil field data sets are normalized with threshold values i.e. obtained data from field will normalized by taking maximum and minimum values for that stage and perform the BPN. Here nutrient is recommended to tomato plants in an optimized amount to be feed based on the correlation with reference crop growth properties available nutrient status and external requirement. The BPN based machine learning model designed to find the right amount of nutrients needed depending on the growth stages of the plant.

$$\text{Normalization} = \frac{data - data_{min}}{data_{max} - data_{min}} \quad (1)$$

b. Integrated Nutrient Management

Integrated Nutrient Management is modern methods to optimize all aspects of nutrient, controlling of nutrient release time and minimize the losses through leaching, runoff, immobilization and emission. Here granule of the nutrient radius is taken as '*a*', considered laying on the ground surface with a point of contact '*O*'. The point of contact '*O*' passing upward direction through the center '*Q*' is Cartesian z-axis, the longitudinal direction is x-axis and the transverse direction is y-axis. Here the point of contact '*Q*' considered as origin for sphere, thus '*Q*' has coordinates x = 0, y = 0 and z = -a. The Saturation and release of nutrients from the granule take place due to diffusion process based on evaporation in the soil surface [23]. The three-dimensional Cartesian space describing the mass concentration '*R*' for diffusion coefficient (D_x, D_y & D_z) at a variable time '*t*' in a partial differential equation is given by

$$\frac{\partial R}{\partial t} = \frac{\partial}{\partial x}\left(D_x \frac{\partial R}{\partial x}\right) + \frac{\partial}{\partial y}\left(D_y \frac{\partial R}{\partial y}\right) + \frac{\partial}{\partial z}\left(D_z \frac{\partial R}{\partial z}\right) \quad (2)$$

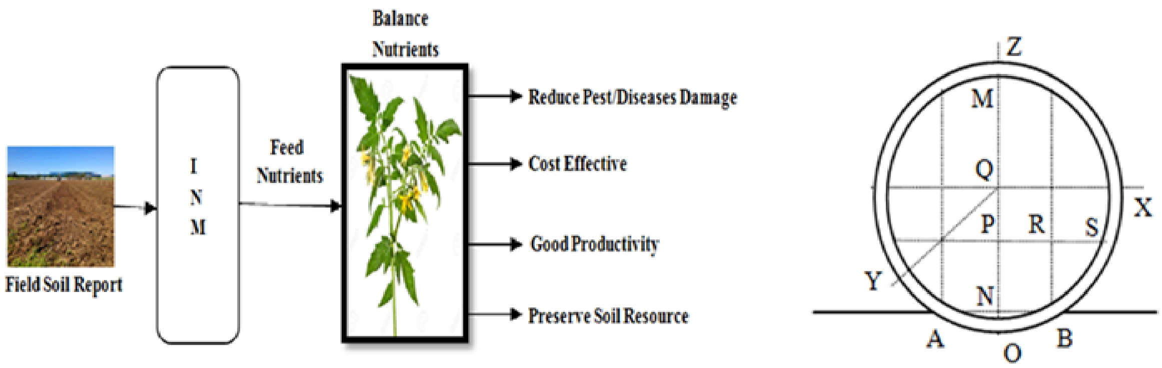

Figure 1: INM method based on input-output and spherical granule with coating and having point of contact with ground surface

i. Saturation of granule

Spherical granule point of contact with ground surface i.e. *arc AOB* leads to percolate the water from the wet field through the contact '*O*' along the z-axis and move along the radial direction in the horizontal circle. Here the portion *ANB* will get saturated faster and start rising water in the vertical direction for granule. Considering the lower half circle in the granule of radius $PS = R_1$ at a vertical distance of z-axis below the center '*Q*' in fig. varying from point of contact ($z = -a$) to top of the granule ($z = a$), then $R_1 = \pm\sqrt{a^2 + z^2}$. At the initial stage, the water content in the sphere is zero i.e. water content at the center of the sphere is taken as 'R_{W0}'. It is considered to evaluate the input concentration of the nutrient mass to be diffused in the sphere with condition that no water comes out of the outer shell of the sphere. At time '*t*', water content at any point (x, y) for the sphere of the horizontal circle is denoted by R_W(x, y, t). Let water diffusion coefficient (D_W), which is depending on the evaporation factor '*f(t)*' and independent of the space variables and direction. The evaporation loss *f(t)* is calculated for every one hour starting from midnight value from zero to maximum value at noon and values decreases in the same rate from noon to midnight, which is expressed in a mathematical function i.e. $f(t) = \alpha(1 - \text{Sin}\ \beta t)$ with choice of weighted values α and β values. Then the water diffusion for nutrient mass in the horizontal circle will get reduces from partial differential Eq. (2) to

$$\frac{\partial R_W}{\partial t} = D_W \left(\frac{\partial^2 R_W}{\partial x^2} + \frac{\partial^2 R_W}{\partial y^2}\right) \quad (3)$$

At Initial condition: $R_W(x, y, t) = 0$; where $-R_1 \le x, y \ge +R_1$ and $t = 0$ (4)

The input boundary condition: $R_W(x = 0, y = 0, t)$; where $t > 0$ (5)

The secondary boundary condition for x and y-axis

$$\left(\frac{\partial R_W}{\partial x}\right) = 0; \quad x = \pm R_1, t > 0 \quad (6)$$

$$\left(\frac{\partial R_W}{\partial y}\right) = 0; \quad y = \pm R_1, t > 0 \quad (7)$$

As the concentration in the horizontal circle is symmetrical about the origin, so ($x^2 + y^2 = r^2$) transformation can be used with a radial direction (r). From initial and boundary conditions the Eq. (3) reduce to

$$\frac{\partial R_W}{\partial t} = D_W \left(\frac{\partial^2 R_W}{\partial r^2} + \frac{1}{r}\frac{\partial R_W}{\partial r}\right) \tag{8}$$

$R_W(r, t = 0) = 0;$ where $-R_1 \le r \le +R_1$ (9)

$\left(\frac{\partial R_W}{\partial r}\right) = 0;$ where $r = \pm R_1$, $t > 0$ (10)

$R_W(r, t) = R_{W0} f(z);$ where $t > 0$, $-R_s \le r \le +R_s$ (11)

Assuming that the input concentration at the portion PR or NB along radial direction at each horizontal circle varying from 1.0 to R_0 at the contact of a circle. Then $f(z)$ is obtained by interpolating the values $f(z) = 1$ at $z = (-a + dz + a/h)$ and $f(z) = R_0$ at $z = (a - dz - a/h)$, where dz is the uniform interval between two successive spherical granule.

$$f(z) = \frac{1}{2(a - dz - a/h)} \left(-z(1 - R_0) + (a - dz - \frac{a}{h})(1 + R_0)\right) \tag{12}$$

The point of contact of spherical granule with a wet ground surface is decided by '$f(z)$' in Fig. (2) From horizontal chord ANB and sector AOB, let 'ON' be taken as (a/h) i.e 'a' as radius and 'h' as a parameter to decide the area of contact. The horizontal chord ANB varying under consideration from N ($z = -a + a/h$) to M ($z = a - a/h$). Then

$$PR^2 = NB^2 = a^2 - QN^2 = a^2 - (-a + a/h)^2 = R_s^2 \tag{13}$$

ii. Nutrients release from granule

A spherical granule as soon saturated with water start to release the nutrients. Here the nutrient release will take place only from the contact point with the wet ground surface, which means it is controlled. The diameter of the granule start decreasing with the release of nutrients but remain a spherical shape till it reaches a small unit and at the end, granule will be collapsed. The nutrient release is a three dimensional, let initial concentration of granule is taken as 'R_{n0}' and at the point of contact nutrient release time (x = 0, y = 0 z = -a) be U. At the concentration point inside the granule R_n (x,y,z,t), the diffusion coefficient of nutrient be 'D_n', where $D_n = D_W + 0.1$. The partial differential Eq. (2) can be written as

$$\frac{\partial R_n}{\partial t} = D_n \left(\frac{\partial^2 R_n}{\partial x^2} + \frac{\partial^2 R_n}{\partial y^2} + \frac{\partial^2 R_n}{\partial z^2}\right) \tag{14}$$

At initial condition: $R_n(x,y,z,t{=}0) = R_{n0}$; where $-a \le x,y,z \le +a$ (15)

Boundary condition: $R_n(x = 0, y = 0, z = -a, t) = U$; where $t > 0$ (16)

From the radial symmetrical transformation ($x^2 + y^2 + z^2 = r^2$), the diffusion equation can be written has

$$\frac{\partial R_n}{\partial t} = D_n \left(\frac{\partial^2 R_n}{\partial r^2} + \frac{2}{r}\frac{\partial R_n}{\partial r}\right) \tag{17}$$

Then, Initial condition: $R_n(r, t = 0) = R_{no}$; where $-R_1 \le r \le +R_1$ and $a \ge R_1 \le d$ (18)

Input boundary condition: $R_n(r = -a, t) = U$; where $t > 0$ (19)

The nutrient release time will be estimated for saturation time (T_1) and release time (T_2) assuming that granule radius reduces result to decrease in time and vice-versa i.e. $T_1 = (\gamma_1 R_1/D_W)$ and $T_2 = (\gamma_2 a/(U D_n))$, where γ is the constant length per unit concentration and U is nutrient release rate represented by $U = 2(R_s/dR_1)$.

IV. EXPERIMENTATION

a. BPN

The BPN is a nonlinear mapping multilayer feed forward network with artificial neurons as layers; each layer is built with multiple artificial neurons [24]. The structure of this network consists of three layers such as input (X_i) (i=1,2,…m), hidden (h_j) (j=1,2,…n) and output (Y_k) (k=1,2,…p) layers, where information flows forward i.e. forward propagation and errors of network are propagated backwards i.e. backward propagation of errors. The normalized dataset of soil pH, nutrients value of N, P and K gave as inputs, which needs to be trained separately along with the integration of corresponding growth stages of tomato plant such as Germination, Seedling, Pollination and Fruit set stages [25]. The training for the BPN is done in three phase's i.e. feed forward phase, back propagation of error and updating of weight and bias. For assumed soil pH = 6.5, the optimum nutrients intake in kilogram for healthy growth and better yield of tomato plant grown in one hectare land is taken as 1ST week (N = 25 ;P = 12 ;K = 6), 2ND week (N = 10 ;P = 12 ;K = 6), 3RD week (N = 10 ;P = 12 ;K = 6), 4TH week (N = 10 ;P = 15 ;K = 7), 5TH week (N = 15 ;P = 15 ;K = 9), 6TH week (N = 22 ;P = 17 ;K = 9), 7TH week (N = 23 ;P = 17 ;K = 9) and similar composition ratio of 7TH week nutrients feed will be carried for further week due to harvesting stage [26]. Here with soil field data of soil pH range from 5.5 to 7.0 selected and outer ranges are rejected, where tomato plant prefers slightly acidic soil.

b. INM

i. Saturation time

The initial and boundary conditions from Eq. (8)-(11) describes the saturation of the granule numerically. For computation purpose, the diffusion coefficient is taken as D_W = 0.35 (mm^2/h) and diameter of granule as 2.00mm. So the spherical radius 'a' as 1.00mm and point of contact varying from z = -1.00 and top of granule z = +1.00 with the center of sphere each horizontal circle lies on the z-axis, such radius at any point on this axis is $R_1 = \sqrt{a^2 - z^2}$. Stability of the circles will be checked by choosing the small distance between the two neighborhood circles taken as dz = 0.01mm, where circles are chosen from z = ($-a + dz$) to ($a - dz$). The sphere is considered saturated in a time period when the water concentration at circumference reaches 90-95% of input concentration. For finite difference computation, taken a radial direction and time interval of dR_1 = 0.1 and dt = 0.005 at uniform interval with ensuring the stability criterion ($dt/(dR_1)^2$) ≤ 0.5 of scheme and convergence.

Saturation time of the whole granule is obtained by integrating the saturation time using trapezoid rule, where the saturation time increases when moving from bottom to center and start decreasing while reaching from center to top. With diffusion coefficient, it varies inversely, so the time period of each sphere is calculated as T_1. Saturation time for every discrete sphere is modified to include the evaporation loss $f(t)$ at an interval of every 1hour (i.e. 24hour for a complete day) with selecting appropriate values for α and β. The evaporation loss is assumed to be zero at midnight, where other values increase at uniform rate and maximum at noon. Here the values decrease in the same rate from noon to midnight for an interval of 12hour.

ii. Nutrient release time

Once the granule saturated start to release nutrients within it. To find the time period of whole nutrient release from granule, the initial and boundary conditions from Eq. 17-19 are solved numerically similar in finding saturation time. For computation purpose, the nutrient diffusion coefficient is taken as $D_n = D_w$+0.1, the radius of a granule, uniform interval along radial direction and time variable are same as saturation time. Within the inner sphere, the initial nutrient concentration at all points is considered as R_{n0} = 1.0. For the time period in which radius reduces by da = 0.1 is that time, at an outer spherical boundary, the nutrient concentration radius reduces from initial value to 'q' i.e. release rate. The radius reduces by 0.1mm each time till it reaches d = 0.2mm. The release rate is estimated by formula T_2, based on assumption release rate decreases as granule radius reduces, it will increase if the contact point of a granule is slower. The estimation is done for three release rate of q i.e. $q = 2(R_s/dR_1)\, q$.

V. PERFORMANCE CRITERIA

To assess the performance of optimized nutrients feed for tomato plant based on growth stage approaches, RMSE (root mean square error) and CC (correlation coefficient) are used in this computation. This is represented in mathematical form as

$$\text{RMSE} = \sqrt{\frac{\sum_{t=1}^{N}((\text{Bo(t)}-\text{Bp(t)})^2)}{N}} \tag{20}$$

$$\text{CC} = \frac{\sum_{t=1}^{N}(\text{Bo(t)}-\text{Bo1})\quad(\text{Bp(t)}-\text{Bp1})}{\sqrt{\sum_{t=1}^{N}((\text{Bo(t)}-\text{Bo1})^2)\quad\sum_{t=1}^{N}((\text{Bp(t)}-\text{Bp1})^2)}} \tag{21}$$

Where B_o and B_p represent the NPK values of soil field dataset and optimum values respectively, B_o^1 and B_p^1 are mean NPK values of soil field dataset and optimum values respectively.

VI. RESULTS

a. Soil-Nutrient Analysis

In this case, normalization values are applied between soil pH and nutrients 'NPK' to determine the regression model for BPN. The proposed BPN model is utilized to give the precise amount of 'NPK' nutrient concentrations to be applied to the soil field. The optimum value of 'NPK' nutrient to one specific soil pH is given as a trained set, and the rest soil pH with varying 'NPK' is given for the testing purpose.

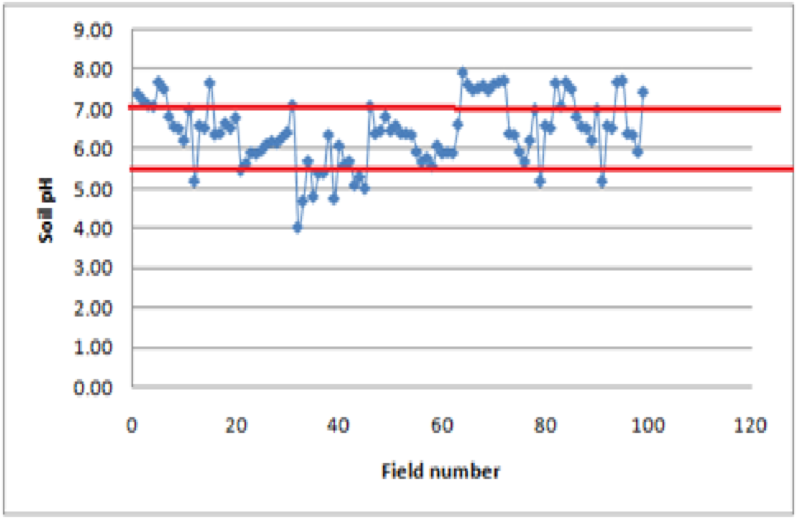

Figure 2: Soil pH lying within the set threshold.

As shown in fig 2, a set of 100 farm field soil pH samples are analyzed for threshold, where 72 field data sets are suited to grow tomato plant by feeding precise ratio of NPK nutrients but others 28 data sets are in extreme condition to give proper nutrients. The performance analysis is calculated on the weekly basis to feed optimize the amount of nutrients to field for the selected 72 field data sets. From the performance analysis that the first-week result shows more close to the observed data of the BPN and the sixth-week result shows the worst performance comparable to the available results.

Table 1: Performance analysis for growth stage.

Weeks	**Features 4**	**72 field data sets**	
		RMSE	**CC**
One	Soil pH, N, P and K	12.455	0.931
Two		13.421	0.954
Three		12.897	0.911
Four		15.543	0.925
Five		16.980	0.946
Six		17.154	0.955
Seven		15.167	0.976

b. Integrated Nutrient Management

The study carried out using the different parameters values for the Eq. represented in methodology and by varying these parameters studied the effects. Radius is chosen in five different values '*a*' (mm) = 0.80, 0.90. 1.00, 1.10, 1.20 and computation did for three values of selecting h = 5, 20, 120, here small value of '*h*' represents the larger surface contact area.

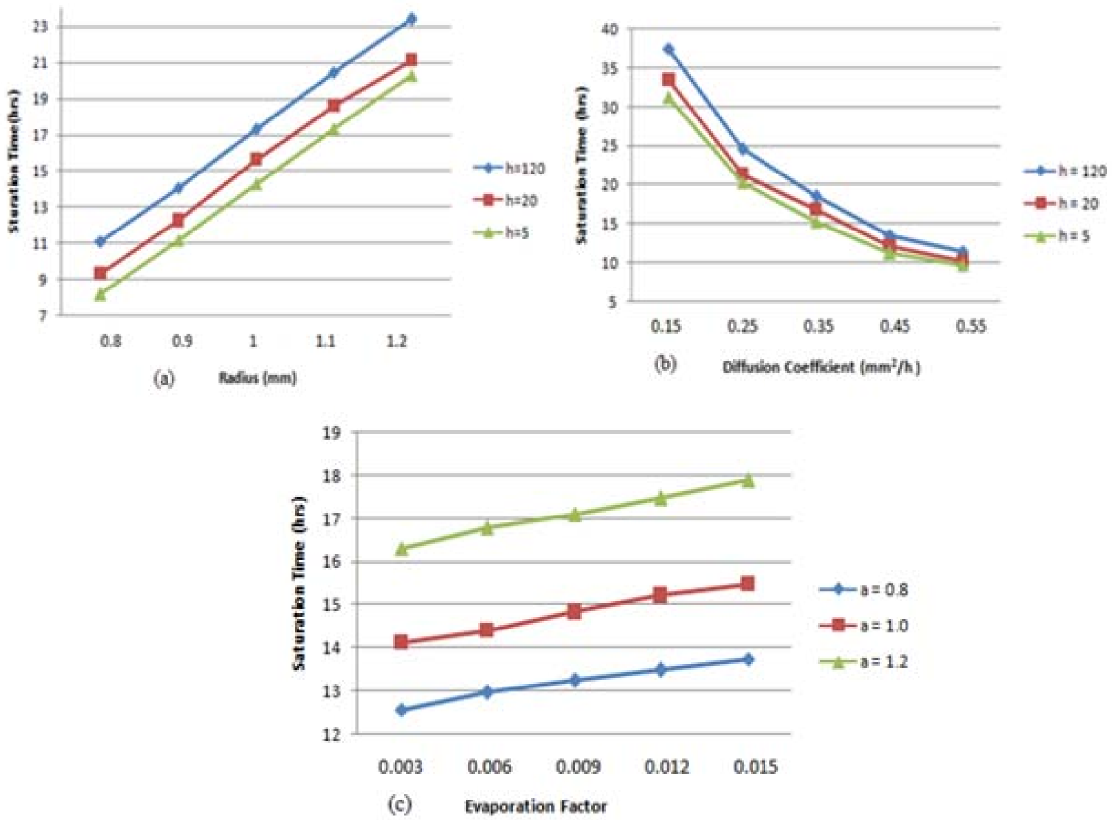

Figure 3: Variation in Saturation time with (a) Granule's radius for point of contact, D_W = 0.35(mm^2/h) and *f(t)* = 0.006. (b) Water diffusion coefficient for point of contact, *a* = 1.0and *f(t)* = 0.006. (c) Evaporation for point of contact, *a* = 0.8, 1.0 & 1.2 and D_W = 0.35 (mm^2/h).

The effect of saturation time with varying granule's radius for three different points of contact (*h*) is shown in fig. 3(a), the saturation time is minimum as the point of contact is minimized and vice-versa with computing for water diffusion coefficient 0.35 and evaporation factor 0.006. That means a radius of granule's increases, the saturation time becomes larger. The effect of saturation time with varying the water diffusion coefficient (D_W) for three different points of contact (*h*) is shown in fig. 3(b), the saturation time decreases for the increase in the diffusion coefficient at a uniform rate. The effect of evaporation loss is shown for different radius selected in fig. 3(c), the evaporation loss will be higher as the evaporation factor increases i.e. at noon evaporation loss is maximum and at midnight evaporation loss is minimum.

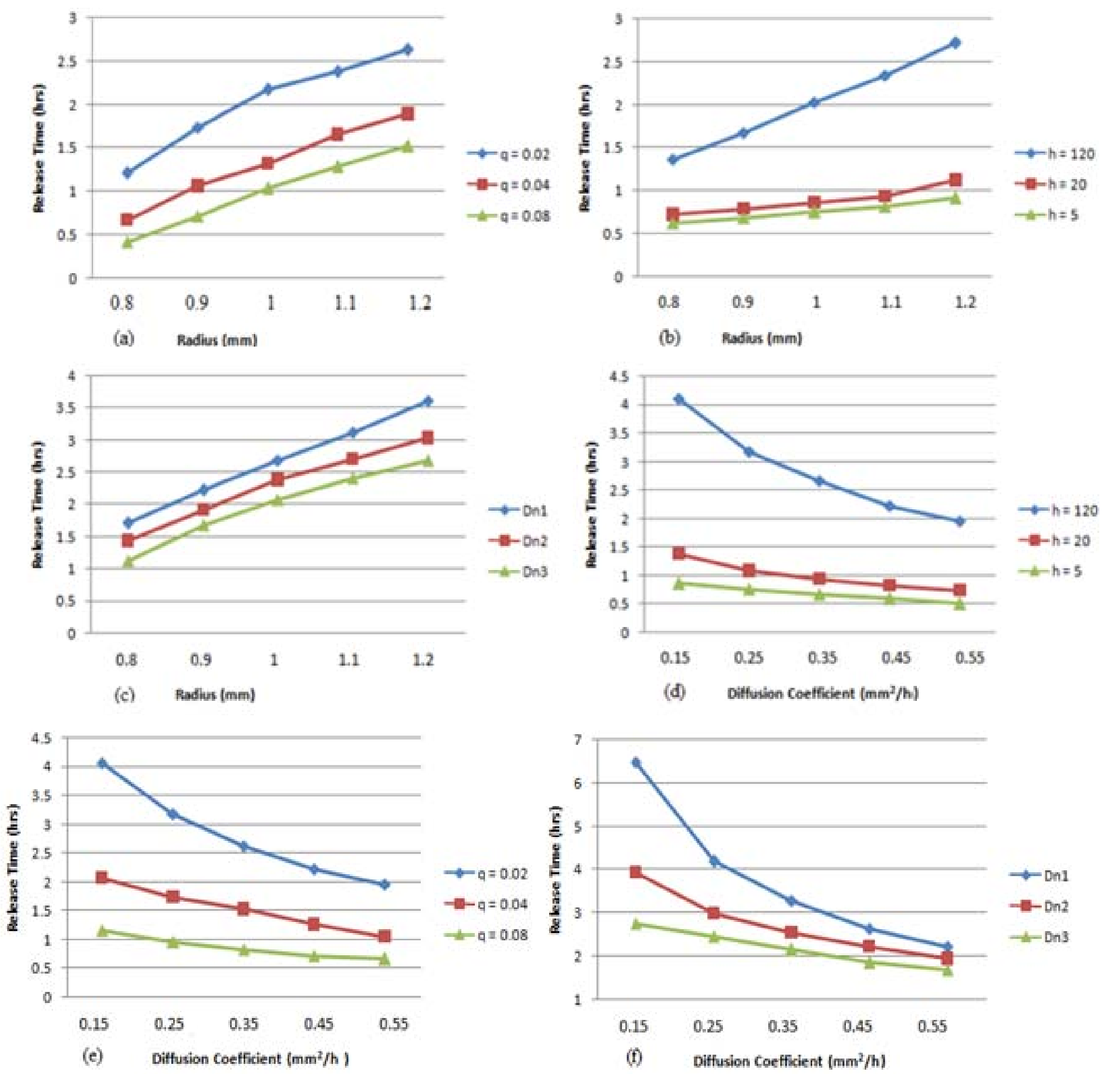

Figure 4: Variation in Release time with (a) Granule's radius for release rate (q) = 0.02, 0.04 & 0.08, $D_n = D_W + 0.1$ and h = 120. (b) Granule's radius for three contact, D_W = 0.35(mm^2/h), $f(t)$ = 0.006 and q = 0.002. (c) Granule's radius for three values of Diffusion coefficient, q = 0.02 and h = 120. (d) Water diffusion coefficient for three contact, a = 1.0, $f(t)$ = 0.006 and q = 0.002. (e) Diffusion coefficient for three release rate, a = 1.0 and h = 120. (f) Three values of diffusion coefficient q = 0.002, a = 1.0 and h = 120.

The effect of release time with varying granule's radius for selected release rate (q) is shown in fig. 4(a), the release time maximize as the radius of granule increases but release time minimized for an increase in release time. With taking the three point of contact (h) with varying the granule's radius shown in fig. 4(b), its shows release time will be minimized for shorter point of contact and granule's radius and vice-versa. Similarly for fig. 4(c) for three diffusion coefficient values, as the diffusion coefficient increases release time decrease and vice-versa. Next, the effect of release time calculated with varying water diffusion coefficient (D_n) is shown in the figure. In fig. 4(d) selected the three different contact point, the shorter contact point shows the maximum release time and vice-versa. Fig. 4(e) shows the dependence of release time on varying water diffusion coefficient for three release rates, the result shows a decrease in release time faster with high release rate. Finally, fig. 4(f) shows the three range nutrient release time behavior for varying water diffusion coefficient.

VII. CONCLUSIONS

In this work, a BPN model is designed for optimizing the 'NPK' nutrients for the tomato plants, considering the features of Soil pH, N, P and K concentration in the farm field. The BPN model is employed to optimize the nutrients based on the trained samples and selecting appropriate weighed factor and performance criteria is analyzed using the RMSE and CC. Computer simulation is done based on the mathematical model to find the saturation time and release time of nutrient from coated fertilizers granule. The simulation was done with varying radius of granules, point of contact of granule with the ground surface, water diffusion coefficient, evaporation factor, nutrient release rate and nutrient diffusion coefficient. It helps to know the slower and fastest saturation and nutrient release time for the spherical granule. For saturation time, the radius of 'a = 0.8mm', point of contact of granule with ground surface of 'h = 5', evaporation loss in minimum i.e. zero and diffusion coefficient of 'D_W = 0.55mm^2/h' granule saturate quickly whereas for the radius of 'a = 1.2 mm', point of contact of granule with ground surface of 'h = 120', evaporation loss in maximum i.e. 0.012 and diffusion coefficient of 'D_W = 0.15mm^2/h' take a large time. Similarly for nutrient release time, in addition to saturation time, it has nutrient release rate and nutrient diffusion coefficient. The release rate with 'q = 0.08 and nutrient diffusion coefficient with 'D_n = 0.65 mm^2/h' shows fastest nutrient release time, whereas release rate with 'q = 0.02 and nutrient diffusion coefficient with 'D_n = 0.45 mm^2/h' shows slowest nutrient release time.

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