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Recommender System for Nutrient Management Based on Precision Agriculture

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Abstract*: *Agriculture is the heart of our nation and society. It is influenced by several factors and parameters such as uneven monsoon, changing climate as well as weather circumstances, rainfall and nutrient facts during the harvest. Agriculture is primarily crucial and also the main source of our livelihood. But, owed to the scarceness of nutrients in plants, the human is strained to handle many dare in everyday life. The restoration of the nutrient is essential, in this view there is need to adopt precision agriculture system which change crop related plans and regulations, whereas nutrient management is a major domain that is needed to be spotlight in the field of farming techniques. The main aim of this research is to create an idea of developing a precision based recommender system for nutrient management and the main scope of this paper to describe the initial phase of the research. The experimental study of this research work is conducted using a terrace garden. The nutrient management with respect to the horticulture crop tomato is considered as the objective. The samples are grouped as two sets namely A and B representing samples without using natural fertilizers/manures and with natural fertilizers/manures. The growth parameters are analyzed and the results are presented. The data collection phase using sensors and Arduino kit is described here. The impact of pests and the remedy taken during the period of growth is recorded. The advices from the experts given in the soil tests are considered for preparing this nutrient management system.

Keywords*: *Agriculture; Recommender systems; Precision Agriculture; Nutrient Management.

I. INTRODUCTION

Agriculture demands for proper management of agriculture resources that satisfy augmented demand for food. To accomplish a healthy life, there is a need for precision agriculture which provides advanced technologies like the sensors, wireless networks, mobile applications and IOT [1] etc., As an inventiveness of [2] Modern India, digital expertise will be act as a key to increase agriculture yield by delivering tuned recommendations to farm user, based on crop protection, analysis of weather, nutrient management, marketing techniques, whereas the huge challenge for India is its ever increasing in population and to equivalent it with the main aspect, which is nothing but the food production. As well as Recommendation and precision based nutrient management are a major and also a thirst area needs to be concentrated in the field of Agriculture, with the help of Recommender system based on Internet of Things (IoT).The Recommender system is a true way to reach users. The main endeavor is to provide easy access and timely accessibility of Nutrient management to the practitioners, nutrient identification and suggest them with the best management strategies to improve their yield with the help of Recommender system. Recommender systems are used in precision-based farming which provides end user an accessible and also a gainful background with precision nutrient crop control, sensor-based data collection and also to relieve the trouble of the users and make comfortable with automated farming techniques. Phase 1 consists of the following works, II about the literature review, part III describes the proposed frame work, IV describes the diseases, pest, fungal infections and nutrient deficiency of tomato crop, V describes the overall observations of the experimental setup, VI shows the conclusions and future research works, remaining consists of references part.

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II. LITERATURE REVIEW

This research work is motivated by the following existing works. The main aim of this [1] research is to gather the indicators of nutrients in crop growth and analyze the data. a horticulture crop is chosen for research process. The data collection is done by both traditional and precision methods. This is an attempt towards creating an expert system based on precision data collection.. The paper [2] describes about the parameters like color, texture and morphological are important to classify the diseases in plants with the help of image processing techniques. In the research work [3] the author describes the detection system used for terrace gardening system or greenhouse disease detection system and it mainly used for tomato gardening system with the help of android platform.

The article [4] describes about the two main pests occur while planting tomatoes in terrace garden and gives the remedy based on android platform. The research work [5] has the brief concept of various pest and diseases occurred in tomato gardening system and identify those diseases based on IOT detection sensors services and explains the whole works. The research article [6] describes the modern tools, new farming techniques and various traditional techniques used in farming. The main scope of [7] is to describe site specific field environments, nutrient efficiency, crop sensor services, and fertilizer and irrigation systems.

It also describes the importance of agriculture and facts.The author of [8] describes the nutritional facts, macro nutrient facts, modeling water irrigation, Nutrient and water use of tomato crop. The Nitrogen use efficient of plants are described in [9] as well as two main factors such as utilizing efficiency and uptake efficiency of nitrogen are explained in this paper.

Water stress level and temperature facts are described in [10] as well as genomics facts are described. The main focus of this paper is to elucidate fertilizer management for plants. The author of [11] describes the functions of WSN and precision agriculture techniques. It has the complete details of sensor related data collection and shows the future scope of precision agriculture domain. Precision cultivation [12] is the forthcoming domain and it has current agricultural techniques. It describes the concept of wireless sensor networks.IOT based smart result of crop fitness and mechanism to denote unfit crops. [13]briefly explains about low cost sensor usage, sustainable agricultural practices, holistic agricultural monitoring system, novel agricultural practices and emerging IOT use in the field of agriculture. In precision agriculture [14], with the help of Wireless Sensor Networks, It can help increase optimize resources and reduce cost. It describes the SPARC solution for agricultural practices. The paper [15] shows the link between agricultural population dynamics and production dynamics. It also shows the agricultural crop trends. This knowable effort relies on self-reliant internet of things (IoT) enable wireless sensors support soil high temperature measuring device, environmental temperature sensor and moisture of the soil [16].Lastly, index-based solution deficiency is considered.IOT gives away various applications such as growth monitoring and specifically for the farming domain [17]. It describes about Sensors Network is widely used to assemble decision support systems. The major lead is implementation of WSN in satellite based Agriculture will have the usage of fewer fertilizers while maximize the yield of the crop and also will help in predicting the weather condition of the farm. Authors highlight the problems in precision agriculture and provide the solutions of those problems, while identifying the factors for upgrading and potential guidelines of work using the new age technologies [18].This paper impacts the new techniques in the field of agriculture [19], which is satellite based precision farming techniques, which makes a new generation of agricultural practices than traditional or manual farming techniques. The limitations and borders of WSNs in the agricultural field are briefly explained and management techniques for long-term monitoring are tinted [20]. The main aim of [21] is to sense the data and parameter control based on Things Cloud. The functions of IOT are briefly explained in terms of precision agriculture. These approaches may also boost the number of opportunities for processing Internet of Things (IoT) data specifically for tomato green house. Previous Nutrient management Recommender Systems like, Kissan, Nutrisonic, NUMASS and many Agri tech portals are focusing on providing various Nutrition values and facts concerned with or involving the theory of area of study rather than its practical application to the user's .But, the main research challenge is to be user friendly for the harvester or end user. The Existing system is based on manual data and recordings which can be recorded daily with open eye readings. The user just collects the information and applies fertilizers without optimum calculation, Expert advice is not obtained directly or No direct interaction between user of the farm and agricultural expert. Due to improper managements of the nutrients, improper soil testing and sampling, Physiological disorders may occur. It is nothing but the abnormal growth pattern or abnormal external or internal conditions of plant due to adverse environmental conditions such as deviation from normal state of temperature, light, moisture, nutrient, harmful gases and in adequate supply of growth regulators. Existing agricultural practices consists of lack of proper soil testing, lack of watering and water testing, lack of fertilizer calculation, lack of proper pesticide, manual data collection of micro- organisms and need more man power, The three set parameters of a crop are Moisture of soil, light intensity and pH value, these are tedious and difficult process for a user to take open eye reading for all the crop in the field.

III. PROPOSED FRAMEWORK

The proposed model aims to develop a recommendation system based on the observations. The system obtain better precision and provide a complete [3] and integrated decision support for the users that focus on crop protection and provide the users with balanced nutrient management strategies, for that purpose several observations are recorded and measured . Figure.1. shows the architecture of Nutrient, Disease and pest management recommender System.

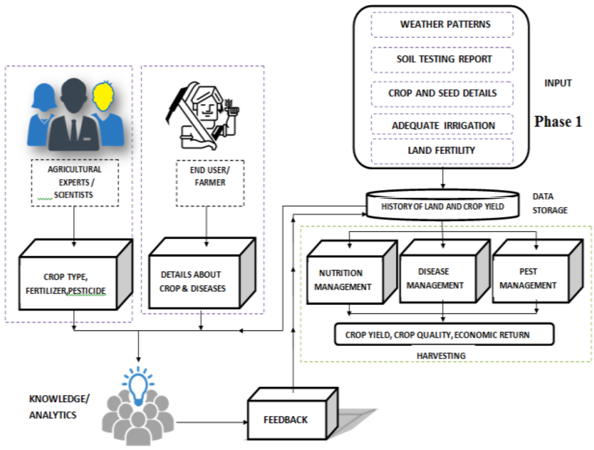

Fig. 1.Architecture of Recommender System

The horticultural crop tomato is chosen, Tomato plant has the scientific name as "Solanum lycopersicum". Figure 2 show the experimental setup of the terrace garden.

Fig.2. Experimental setup of the terrace garden

Figure 3 shows the preparation stage of the experiment consisting of seeds of tomato and tray.

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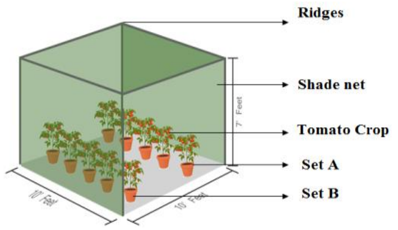

Fig. 3. Seeds and Seeding Tray

India is one among the top producer of tomatoes in the world. Initially, the selection of tomato variety should be based on region soil; proper soil test should be taken place, and Ph range above 6 to 7.5. This paper consists of the initial phase 1 work of the research which consists of Manual Testing of soil Fertility (Ph) using Universal Indicator paper, Manual testing of soil moisture and light intensity using a three way soil testing meter. The data collection also completed from pre-seedling stage to harvesting stage. Figure 4 shows the Overall ten samplings where placed in the terrace garden for observation (s1t,s2,s3,s4 and so on up to s10) and Diseases, pest, fungal, nutrient deficiencies causing infections, weed collection status, Duration of plants growth, size of leaves and stems are observed and recorded up to 200 images for manual data collection.

Fig. 4.Terrace Garden

The decision is to be made by considering many factors such as weather, soil testing, sampling at regular intervals, PH level of the soil, soil fertility of the land, supply of water requirements, Bio and organic manures, Level of NPK (Nitrogen, Phosphorus and Potassium) values such as Macro and Micro nutrients, nutrient functions and deficiency symptoms in order to reach a better decision. several stages of tomato are as follows, Figure 5-10 shows the several stages of tomato crop.

Fig. 5.Seedling Stage

Fig. 6.Germination Stage

Fig. 7.Vegitattive Stage

Fig. 8.Flowering Stage

Fig. 9.Fruiting Stage

Fig. 10. Side, Top and Cross Section Views

IV. DISEASES, PEST, FUNGAL INFECTIONS AND NUTRIENT DEFICIENCY OF TOMATO CROP

This section will record the pest, disease, nutrient deficiency or fungal infection observed [4] and the treatment followed during different stages of the experimental setup.

A. Mealy bug *(5 weeks, 33 Days)*

It is a White cotton-like gathering or mass appears on leaves, stems, flowers and fruits. Appearance may be like yellowing and curling of leaves, short growth of plants and fall of fruits before ripening. The honeydew cause bacterial and fungal infections. Insects such as ants maybe attracted by the honeydew and spread the pest to other plants.

Treatments:

Neem and Liquid soap spray. It needs 2 to 3 weeks and results in reduction in mealy bug growth.

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B. Leaf miner flies *(6 weeks)*

They are nothing but, the pest lives nearby or inside the plants and eats the tissues [5] and leaves of the tomato plant [6]. Symptoms may be look like crooked circuitous ash color lines and patches on the leaves.

Treatments:

It needs neem spray or pyrethrin spray.

C. Nitrogen Deficiency *(6 weeks)*

Nitrogen deficiency causes leaves and stem turn whitish green with light red discolorations of petioles and veins. Initially, it will become chlorotic and then [7] yellowish-white. Leaves grow smaller than normal size, early death and shedding or dropping of leaves may occur.

Treatments:

The 2 % Urea solution is recommended based on the soil test.

D. Water Deficiency *(6 weeks)*

Water is most essential for plants and it should be given to tomato plants at regular intervals of time but, if Water deficiency (6weeks) occurs, its consequences may lead to reduced leaf size, shorter stems than usual and diminished root systems. If not cured in early stage, it leads to the yellowing of leaves, wilting and premature leaf drop and at last it may leads to unavoidable plant death.

Treatments:

Avoid too much of direct sunlight, place the crops under green net, water the plant periodically.

E. HelicoverpaCaterpillar *(7 weeks)*

It will damage the flowers and fruits and to a lesser extent on leaves. Holes bored into reproductive structures and new fruits and leaves are affected and destroyed completely. Growth of secondary microorganisms such as bacteria and fungi lead to the decaying of tissues, fruits and leaves.

Treatments:

Insecticidal soaps, it will break down easily and speedily in environment. It will kill the larvae or caterpillar at the early stage.

F. Verticilium wilt *(7weeks)*

Usually it will appear on mature leaves. It causes damage of the plant mostly on warm and sunny days. The Symptoms are look like Brown discoloration of the vascular tissue and the shoots may also wilt in these conditions.

Treatments:

Verticilium wilt will be getting rid of when watering regularly and provides afternoon shade.

G. Spider mites *(7 weeks)*

This make the plants to appear like pale and stunted. In addition, yellow spots appear on the upper side of leaves while the underside of the plant is covered by dust or powder-like sediment

Treatments:

It can be recovered by garlic mixture and insecticidal soap.

H. Early Blight *(11 weeks)*

It causes stems, leaves and foliage. Occasionally, even the fruits in the later stages may have its effect and it is nothing but a fungal [8] infection. Where the fungus lives in the soil itself .It may infect the plant early in the season.

Treatments:

It can be avoided by making the tomato in free spacing in the garden or farm and with let air to move along the leaves as possible.

V. OBSERVATIONS OF THE EXPERIMENTAL SETUP

Totally ten samples are used to record the parameters of the tomato plant (sample1-s1 to sample10-s10). Sample set A (s1 to s5) are grown without natural manure [9] and Sample set B (s6 to s10) are grown with natural manure [10].

A. Observation 1

The parameters of tomato crop consider for readings are plant height (cm), [11] Number of branches per plant, Number of sub branches per plant, Size of stem (cm), Maximum size of leaves (cm), Number of flowers per plant, Number of clusters per plant, Number of fruits per cluster, Average fruit length (cm) and Average fruit weight (g).

a. Plant height (p1)

In set A, The maximum plant height is about 44.0 cm and minimum plant height is about 30.0 cm .The average height of all tomato plant is 35.66 cm. In set B, The maximum plant height is about 70.0 cm and minimum plant height is about 26.1 cm .The average height of all tomato plant samples are about 53.42 cm.

b. Number of branches per plant (p2)

In set A, The number of main branch per tomato plant is varied, maximum of main branch is about 7 and minimum is about 4.The average of main branches per plant is 6. In set B, The number of main branch per tomato plant is also varied, maximum number of main branch is about 11 and minimum is about 5.The average of main branches per plant is 7.8.

c. Number of sub branches per plant (p3)

In set A, The number of sub branch per tomato plant is varied, maximum of sub branch is about 9 and minimum is about 3.The average of sub branches per plant is 5.6. In set B, The number of sub branch per tomato plant is varied, [12] maximum of sub branch is about 10 and minimum is about 2.The average of sub branches per plant is 6.

d. Size of stem (p4)

In set A, The size of stem for tomato plant is varied, maximum size of stem is about 2.7 cm and minimum is about 1.8 cm. The average of stem size is 2.22cm. In set B, The size of stem for tomato plant is varied, maximum size of stem is about 3.5 cm and minimum is about 2.3 cm. The average of stem size is 3.00cm.

e. Maximum size of leaves (p5)

In set A, The size of leaf for tomato plant is varied, maximum size of stem is about 7.0cm and minimum is about 4.8 cm. The average of leaf size is 5.34 cm. In set B, The size of leaf for tomato plant is varied, maximum size of stem is about 6.4 cm and minimum is about 4.5 cm. The average of leaf size is 5.68 cm.

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f. Number of flowers per plant (p6)

In set A, The maximum number of flowers in tomato plant is about 11 and minimum number of flowers in tomato plant is about 3 .The average numbers of flower in all tomato plant samples are about 7.2. In set B, The maximum number [13] of flowers in tomato plant is about 37 and minimum number of flowers in tomato plant is about 8 .The average numbers of flowers in all tomato plant samples are about 20.2.

g. Number of clusters per plant (p7)

In set A, The maximum number of cluster per tomato plant is about 4 and minimum number of cluster per tomato plant is about 1 .The average of cluster per tomato plant is about 2.0 of all the samples. Let c be the cluster, clusters in set A are about (c1 = 2,c2 = 4,c3 = 2,c4 = 1,c5 = 1) and the sum of c1 to c5 is 10.In set B, The maximum number of cluster per tomato plant is about 6 and minimum number of cluster per tomato plant is about 2.The average of cluster per tomato plant is about 3.8 of all the samples and clusters in set B are about (c6 = 4,c7 = 2,c8 = 6,c9 = 4,c10 =3) and the sum of c6 to c10 is about 19.

h. Number of fruits per cluster (p8)

In set A, The maximum number fruits per cluster of tomato plant are about 7 and minimum number of cluster per tomato plant is about 1. The average of cluster per tomato plant is about 4.6 of all the samples. In set B, The maximum number fruits per cluster of tomato plant is about 13 and minimum number of cluster per tomato plant is about 8 . The average of cluster per tomato plant is about 14.2 of all the samples.

i. Average fruit length (p9)

In set A, The average fruit length of all tomato plant samples are about 3.34cm, 3.97cm, 3.80cm, 3.20cm, and 3.00cm respectively. In set B, The average height of all tomato plant [14] samples are about 3.20 cm, 3.42 cm, 4.16 cm, 3.97 cm, and 3.33cm respectively.

j. Average fruit weight (p10)

In set A, The average fruit weight of all tomato plant samples are about 27.50g, 30.89g, 28.89g, 20.01g, and 23.56g respectively. In set B, The average weight of all tomato plant samples are about 40.82g, 34.83g, 60.43 g, 43.93g and 36.26g respectively. These are the parameters (p1-p10) of the tomato plant, By comparing the values of Set A (s1-s5) and Set B (s6-s10) parameter values, Set B has the maximum plant growth than Set A based on the average values.

The following Table I shows the observation and recorded values of Set A (s1– s5), where the plant grown without natural manure, it consist of all the parameters from p1 to p10 and its readings.

Table- I: Parameter wise observations for Set A samples

Set A	**p1 (cm)**	**p2**	**p3**	**p4 (cm)**	**p5 (cm)**
s1	38.3	7	3	2.1	5.1
s2	44.0	7	9	2.7	7.0
s3	35.0	7	9	1.8	4.8
s4	31	5	4	2.5	5.0
s5	30	4	3	2.0	4.8

Set A	**p6**	**p7**	**p8**	**p9 (cm)**	**p10 (g)**
s1	10	2	5	3.34	27.50
s2	11	4	8	3.97	30.89
s3	8	2	7	3.80	28.89
s4	3	1	2	3.20	20.01
s5	4	1	1	3.00	23.56

The sum and average of set A [15] are calculated manually and Table II shows the observation and recorded values of Set B (s6 – s10), where the plant grown with natural manure.

Table- II: Parameter wise observations for Set B samples

Set B	**p1 (cm)**	**p2**	**p3**	**p4 (cm)**	**p5 (cm)**
s6	38.7	7	3	3.5	5.3
s7	26.1	5	2	2.3	4.5
s8	62.3	9	9	3.0	6.4
s9	70	11	10	3.0	6.2
s10	70	7	6	3.2	6.0

Set B	**p6**	**p7**	**p8**	**p9 (cm)**	**p10 (g)**
s6	20	4	12	3.20	40.82
s7	8	2	8	3.42	34.83
s8	37	6	30	4.16	60.43
s9	23	4	12	3.97	43.93
s10	13	3	9	3.33	36.26

The following table III shows the comparison values of parameter 9 between set A and set B samples.

Table- III: Parameter 9 Comparison of Set A and Set B

Plant growth without using Natural Fertilizer and Manure	Plant growth with Natural Fertilizer and Manure
s1 – s5	s6 – s10
3.34	3.20
3.97	3.42
3.80	4.16
3.20	3.97
3.00	3.33

Table IV shows the comparison value of parameter 10 between set A and set B values.

Table- IV: Parameter 10 Comparison of Set A and Set B

Plant growth without using Natural Fertilizer and Manure	Plant growth with Natural Fertilizer and Manure
s1 – s5	s6 – s10
27.50	40.82
30.89	34.83
28.89	60.43
20.01	43.93
23.56	36.26

B. Observation: 2

The Three essential parameters needed [16] for nutrition rich plant growth such as Light intensity, soil moisture and pH values are recorded using Soil Testing meter. All the measured parameters are having different ranges and different values. They are as follows:

a. Light Intensity

Light is the important factor for photosynthesis for nutrition elevated plant growth, it should not too high or too low for plant. The range of light intensity is a deciding factor of textures of tomato. The soil testing meter having ranges from (Dark-0 to Light-2000).

b. Soil Moisture

Moisture is the crucial factor for absorption of soil nutrition for plant growth, if it is too high plant will decay, if it is too low dryness may occur to plant.

The soil testing meter having ranges from (Dry-0 up to wet-10) readings.

c. pH values

pH is nothing but the potential of Hydrogen, soil Ph is a measure of acidity and alkalinity in soils, pH level ranges from 0 to 14,with 7 being neutral, below 7 acidic, above 7 alkaline. Tomato plant's [17] optimal pH value should lies between 6.0 to 7.5. They can be tested by using the following ways

- By using Universal indicator paper
- By using soil testing meter
- By using chemical test

C. Observation: 3

NPK is the real nutrient uplifting factor in plants and these macro nutrients are very vital for plant growth, where chemical tests were undergone to obtain the NPK values of Set A and Set B soil samples. NPK values are not constant in soil. The depleted amount of nutrients should be restored according to the ratio of NPK; table V shows the results of NPK values using [18] soil test reports.

Table- V: NPK Values

Nutrient Name	Set A	Set B
Nitrogen(N)	Moderate	Moderately low
Phosphorous(P)	Moderate low	Moderate low
Potassium(K)	Moderately Low	Normal

Nitrogen encourages leaf growth. But it should not exceed the normal range in tomato. If so, it will affect the flowering and fruiting process. Phosphorous is used to improve the flowering and fruiting process, whereas Potassium [19] is used in the stage of flowering.

D. Observation: 4

Stepping into [20] precision agriculture, Initially Soil Moister sensor is used to measure the moisture content for obtaining the values with accuracy. It overcomes the overburden work of manual recordings and soil testing meters, the steps for soil moisture are:

Algorithm:

Step 1: Input as Soil Moisture Real Time Data.
Step 2: Read the sensed data from Soil moisture sensor andsent it to the gateway node.
Step 3: Execute the sleep thread with the time quantum of tenminutes.
Step 4: Repeat the loop from step 3 again.
Step 5: Output data can be sent to gateway node.

The above algorithm shows the steps of soil moister sensor, the reading of soil moister sensor is taken as the input. The time quantum is set according to requirement of the plant requirement and agriculture domain expert. After reading the data, node goes to the sleep for next 10 minutes. These readings help to obtain précised data.

The following Figure 11 shows Arduino Uno, Figure 12 shows the coding window of Arduino Uno with soil moisture sensor readings, Figure 13 shows the value before reading, where as Figure 14 shows the reading of soil moister sensor initial values.

Fig. 11. Arduino genuine Uno

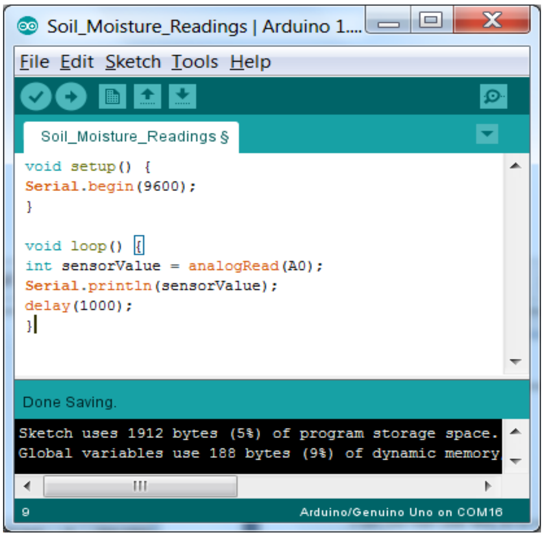

Fig .12. Arduino genuine Uno with soil moisture sensor

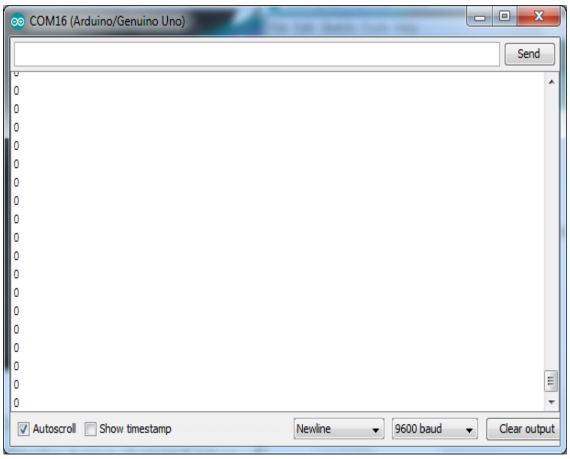

Fig. 13. Coding window before sensing moisture

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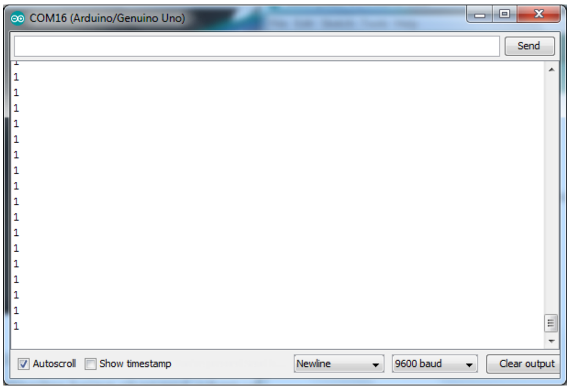

Fig.14. Initial sensing soil moisture

The linear association between two variables can be identify by correlation equation. The correlation value between soil moisture and weather conditions are calculated using the equation (1) is as follows

$$r = \frac{\sum_i (xi - \overline{x})(yi - \overline{y})}{\sqrt{\sum_i (xi - \overline{x})2}\sqrt{\sum_i (yi - \overline{y})2}} \quad (1)$$

Where X: X Values

- Y: Y Values
- Mx: Mean of X Values
- My: Mean of Y Values
- X - Mx & Y - My: Deviation scores
- $(X - Mx)^2$ & $(Y - My)^2$: Deviation Squared
- (X - Mx)(Y - My): Product of Deviation Scores

X Values:
$\sum = 70$
Mean = 7
$\sum(X - Mx)^2 = SSx = 10$
Y Values:
$\sum = 70$
Mean = 7
$\sum(Y - My)^2 = SSy = 10$
X and Y Combined:
N = 10
$\sum(X - Mx)(Y - My) = 10$
R Calculation:
$r = \sum((X - My)(Y - Mx)) / \sqrt{((SSx)(SSy))}$
$r = 10 / \sqrt{((10)(10))} = 1$
Meta Numeric : r = 1

The X and Y values taken for the calculation are (6,6) (6,6) (6,6) (6,6) (7,7) (7,7) (7,7) (8,8) (8,8) (9,9) .X values AND Y values are correlated and X having Mean = 7, $\sum = 70$, $\sum$(X - Mx)2 = SSx = 10 and Y having Mean = 7, $\sum = 70$, $\sum$(Y - My)2 = SSy = 10, X and Y Combined where N = 10 , $\sum$(X - Mx)(Y - My) = 10, By applying the correlation equation 1 to X values and Y values, R Calculation can be calculated as $r = \sum((X - My)(Y - Mx)) / \sqrt{((SSx)(SSy))}$, $r = 10 / \sqrt{((10)(10))} = 1$, therefore r = 1 that provides a positive correlation.

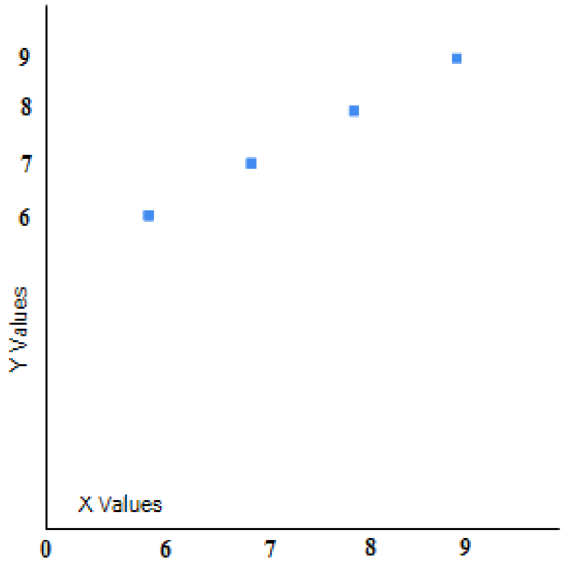

Fig.15. Correlation values

In the above Figure 15, the graph represents the results of positive correlation of X and Y values. Thus, the result is strong positive correlation, which means that high X variable scores go with high Y variable scores (and vice versa).The value of R, the coefficient of determination is 1.

E. Observation: 5

The following table VI shows the sample [21] recommendation report from experts for tomato crop based on the soil test.

Table- VI: Recommendation from Agricultural Experts

S.no	Content	Recommendation
1	pH ,O.C% And NPK are less	***Set A:*** Needed per Acre/Kg : N : 235 P_20_5 :11.7 K_20 : 145 Micro nutrients :12.5 Kg Fertilizer : Rizobium 400g Available pH: 7.3 Needed pH :6 - 7
2	N , P , K is optimum	***Set B:*** Needed per Acre/Kg : N : 228 P_20_5 :10.3 K_20 : 123 Farm yard manure: 12.5 kg Available pH: 7.1 Needed pH :6 - 7

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VI. CONCLUSION

In this paper various observations are carried out for the horticultural crops, Totally ten samplings were taken, they are taken account into set A and B, for set A which is grown without natural manure, where as in set B tomato samplings are grown based on natural manure and compost. Initially ten parameters were observed and values are recorded manually .then, three ways soil testing meter is used to calculate the essential parameters like light, moisture and pH values, NPK values of soil are also recorded. Finally, the sensors are used to calculate the soil moisture, algorithms are formulated and correlation is calculated for two variables which produce positive correlation, In future, manual work will be altered based on IOT that provides a user friendly cost effective background with high-precision nutrient crop control, pest and disease free crop to the user, Figure 16 shows the future work.

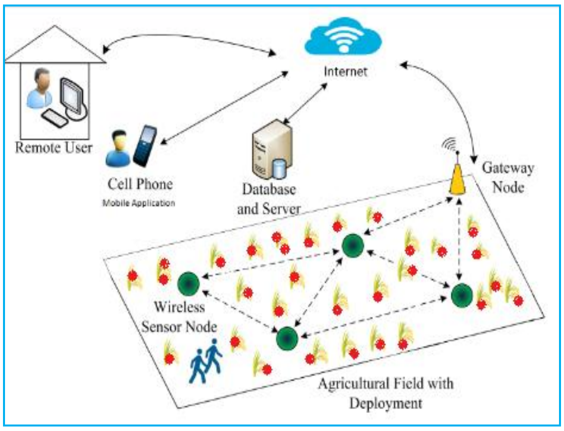

Fig.16. Precision based agriculture

By using precision agriculture, tedious manual data collection will be overcome by automated data collection and also to relieve the burden of the users and make comfortable with automated farming techniques. It is a true way to reach the farmer. Thus, it provides easy access and timely accessibility of Nutrient management to the practitioners.

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