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Short Communication **Open Access**

Solar Operated Automatic Seed Sowing Machine

Swetha S.[1] and Shreeharsha G.H.[2]

[1]Department of Aeronautical Engineering, Acharya Institute of Technology, Bangalore, Karnataka, India
[2]Industrial Automation & Robotics, Department of Mechanical Engineering, Karavali Institution of Technology, Mangalore, Karnataka, India

Correspondence should be addressed to Swetha S., swetha4shree@gmail.com

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Abstract The real power required for machine equipment depends on the resistance to the movement of it. Even now, in our country 98% of the contemporary machines use the power by burning of fossil fuels to run IC engines or external combustion engines. This evident has led to widespread air, water and noise pollution and most importantly has led to a realistic energy crisis in the near future. Now the approach of this project is to develop the machine to minimize the working cost and also to reduce the time for digging and seed sowing operation by utilizing solar energy to run the robotic machine. In this machine solar panel is used to capture solar energy and then it is converted into electrical energy which in turn is used to charge 12V battery, which then gives the necessary power to a shunt wound DC motor. This power is then transmitted to the DC motor to drive the wheels. And to further reduction of labor dependency, IR sensors are used to maneuver robot in the field. Here 4 post sensors are used to define the territory and robot senses the track length and pitch for movement from line to line. Seed sowing and digging robot will move on different ground contours and performs digging, sow the seed and water the ground after closing.

Keywords *Direct Current Motor; Infrared Sensors; Internal Combustion Engines; Special Purpose Vehicle*

1. Introduction

Today the environmental impact of agricultural production is very much in focus and the demands to the industry is increasing. In the present scenario most of the countries do not have sufficient skilled man power in agricultural sector and that affects the growth of developing countries. Therefore farmers have to use upgraded technology for cultivation activity (digging, seed sowing, fertilizing, spraying etc.). So it's a time to automate the sector to overcome this problem. In India there are 70% people dependent on agriculture. So we need to study on improving agricultural equipment. Innovative idea of our project is to automate the process of digging and seed sowing crops such as sunflower, baby corn, groundnut and vegetables like beans, lady's finger, pumpkin and pulses like black gram, green gram etc. and to reduce the human effort. Since we have lack of man power in our

country, it is very difficult to do digging and sowing operation on time, Automation saves a lot of manual work and speed up the cultivation activity. The energy required for this robotic machine is less as compared with other machines like tractors or any agriculture instrument, also this energy is generated from the solar energy which is found abundantly in nature. Pollution is also a big problem which is eliminated by using solar plate.

2. Machine Operation Methodology

In this machine a solar panel is used to capture solar energy and then it is converted into electrical energy which in turn is used to charge 12V battery, which then gives the necessary power to a shunt wound DC motor. This power is then transmitted to the rear wheel through chain drives. Consequently, in this project an attempt is made to make the electric and mechanical systems share their powers in an efficient way.

The basic objective of sowing operation is to put the seed and fertilizer in rows at desired depth and seed to seed spacing, cover the seeds with soil and provide proper compaction over the seed [1]. The recommended row to row spacing, seed rate, seed to seed spacing and depth of seed placement can vary from crop to crop and for different agro-climatic conditions to achieve optimum yields. Typical application of seed sowing of Cereal's including ground nut, all types of dal's, oil seed crop's etc. [2].

A solar panel is a device that collects and converts solar energy into electricity or heat or mechanical work. Solar energy is first used to charge a storage battery. An electric battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. The solar energy stored in the battery is utilized to operate DC motor. A DC motor is a device that converts direct current (electrical energy) into mechanical energy. By using the bevel gear and Chain drive with sprockets power is transferred to the wheels for their movement. AT89S52 Microcontroller is used to automatically control the machine. IR Sensors are fitted to the machine for automatic turning operation and to sense the obstacle in the moving path. An infrared sensor is an electronic instrument.

2.1. Experimental Setup

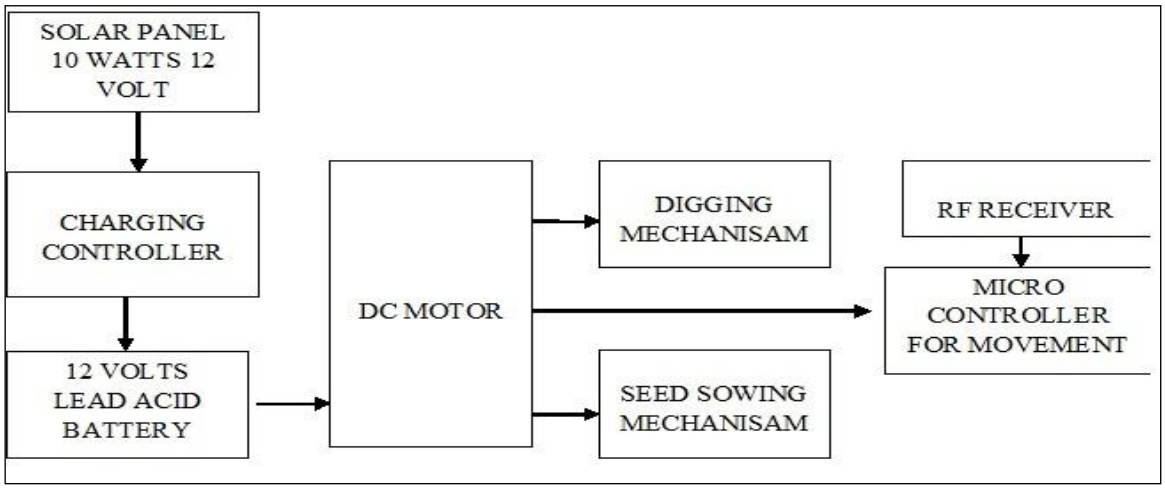

Figure 2.1.1: *Experimental Setup*

2.2. Line Diagram of the Machine with Dimension

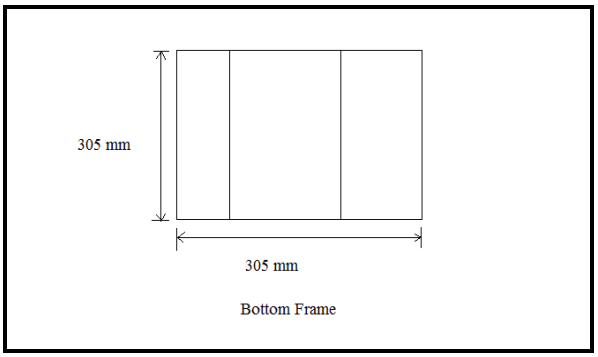

Figure 2.2.1: *Bottom Frame*

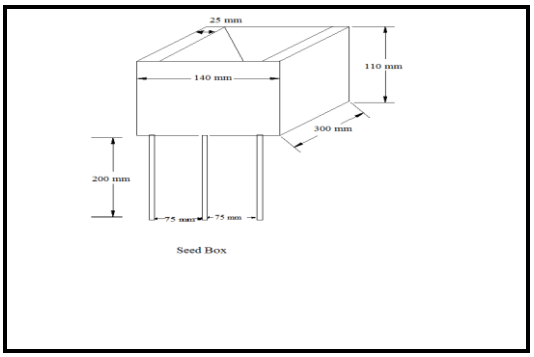

Figure 2.2.2: *Seed Box*

2.3. 3D Model Pictures of Digging Tool Mechanism with Frame

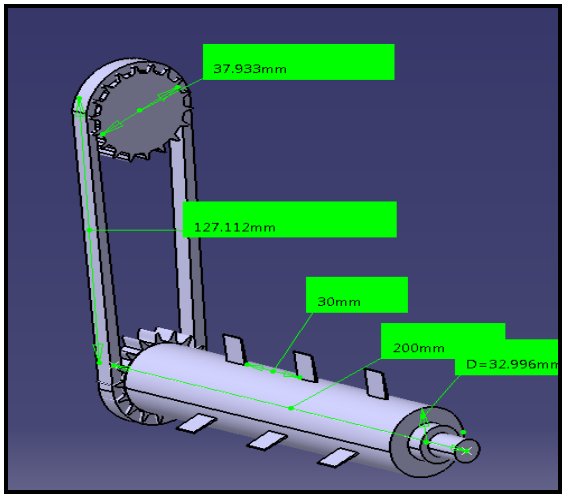

Figure 2.3.1*: Chain-Sprocket and Digging Tool Arrangement*

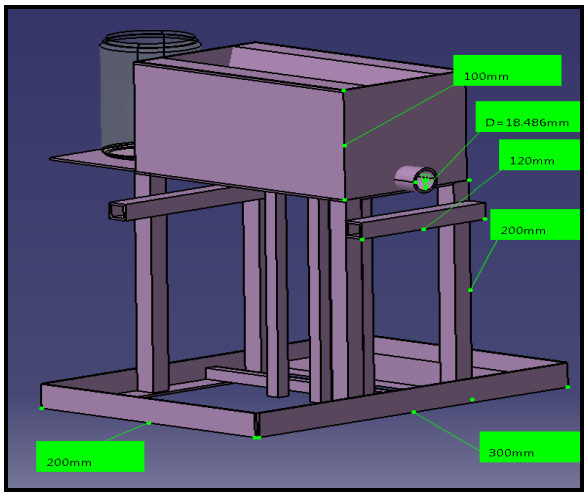

Figure 2.3.2*: Base Frame Structure*

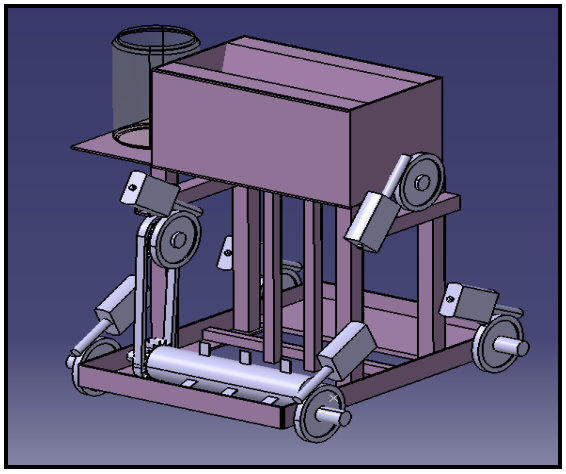

Figure 2.3.3: *Assembly of Drive Mechanism*

2.4. Photographs of Model

Figure 2.4.1: *Solar Panel and Experimental Setup*

Figure 2.4.2: *Digging Tool Arrangement*

Figure 2.4.3*: Seed Container and Dropper*

3. Performance Characteristics

Prototype of the solar operated automatic seed sowing machine developed has the following Performance characteristics.

- Working speed of the machine depends upon the DC motor and energy stored in the battery.
- Prototype Machine can dig the soil in three rows up to 5 inch by rotating the digging tool by the help of DC motor.
- Digging speed depends on the moisture content in the soil and tool tip.
- At the same instant from the seed dropper seed is placed in all the three rows at a distance of 4 inch.
- No. of seed placing at an instant can be varied by altering the size of holes in the dropper.
- By the help of 4 post sensors, machine will sense the track length of the field and takes an automatic turning at the end of the boundary.
- In the future work this machine can also be further designed to detect obstacle present in the path by using IR sensor.

Conclusion

As we know that in our country about 70% of population lives in villages & their mainly income depend on the agricultural source. Hence my prominent aim of this project Solar operated automatic seed sowing machine is to fulfill the tasks like digging, seed sowing, water pouring and fertilizing by using non-conventional energy sources. Thus solar operated automatic seed sowing machine will help the farmers of those remote areas of country where fuel is not available easily. And also they can perform their regular cultivation activity as well as saves fuel up to larger extent. At the same time by using solar energy environment pollution can also be reduced. Thus aiming to save the revenue of government & also most demanded fossil fuel.

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Research Article | Open Access

Developing an Informative Agricultural Crop Related Software

Subhadip Dey[1] and Sayan Jana[2]

[1]Faculty of Agricultural Engineering, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India
[2]Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India

Correspondence should be addressed to Subhadip Dey, subhadipdey23071994@gmail.com

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Abstract The paper propose the development of an interactive, flexible and user-friendly software for getting information about the amount of fertilizer, insecticide and medicines for some agricultural crops in Visual Studio 2008 environment and evaluation. From the software user will get the detail amount fertilizer needed for his particular cultivated area along with the information about the insecticide and medicine need for resisting the insect or disease that harm the crop. The software is made in regional language (Bengali) so that every common people of this region can understand the language. The information regarding to the software are valid only in the soil condition of West Bengal, India.
Keywords *Fertilizer; Software; Agricultural Crops; Pest; Crop Disease; Visual Studio*

1. Introduction

Fertilizer is a material that originate naturally or synthetically and which is applied to the soil or plant tissue for the essential growth of the plants [1]. According to conservative estimates report 30-50% of the crop yields are attributed to natural or synthetic commercial fertilizer [2]. There are three macronutrients of fertilizer. They are nitrogen (N), potassium (K) and phosphorus (P) [1]. The classification of nutrients essential for the healthy plants is based on the elements but the elements are not used as fertilizer. The macronutrients are consumed in larger quantities and are present in plant tissue in quantities from 0.15% to 6.0%in a dry matter basis [2].

Particular Insects and pests attack the particular crops depending on the seasons. They harm the crop and sometimes this becomes the most effective cause of the loss of desired yield of that particular crop. So, to protect the crop from these insects, insecticides are used in fields. These are mainly chemicals that are available in market in different forms, like powdery, liquid, soluble powder, insoluble powder etc. [2]. These fertilizers should be applied to crop in proper time.

Same as Insects some diseases cause harm to crops and take part in reduction of yield of that crop. So, some safety precautions are taken to reduce the chance of occurring the disease to the particular

crop. Chemicals are available in the market in various forms. Proper application and application in time in the field of the particular crop enhance the yield.

2. Method for Calculating the Amount of Fertilizer Needed

Let the amount of nitrogen, phosphorus and potassium needed to any particular crop is N, P, K

Assume the fertilizer that will be given contains x% Nitrogen, y% Phosphorus

Let N>P>K so requirement of nitrogen to that fertilizer is high

100 gm of that fertilizer contains y gm of phosphorus

To give the total amount of phosphorus the amount of fertilizer needed = {(100*P)/y} = A

Now as the fertilizer contains nitrogen compound also, so, the amount of nitrogen that we will get from the complex fertilizer = {(A*x)/100} = N'

Now the amount of Nitrogen needed = (N-N')

This amount of Nitrogen should be given to the field by using a single fertilizer that contains Nitrogen compound

Let the single fertilizer be Urea that contains 46% Nitrogen

So the amount of Urea needed to overcome the Nitrogen deficiency is = [{100*(N-N')}/46] and to overcome the Potassium deficiency let use MOP that contains 16% of Potassium

So the amount of MOP needed = {(100*K)/16}

3. Software Development

In this software all the information and data are in-built. The users only have to input the amount of area on the time of calculating the amount of fertilizer needed for the particular crop for the particular area. It is very user-friendly and updated.

4. Layout

The user will first face a form that contains the categories of field i.e. i. Fertilizer; ii. Insect; iii. Disease. User can select any of the categories and it will redirect the user to next form according to the selected category. The language that user will face is Bengali.

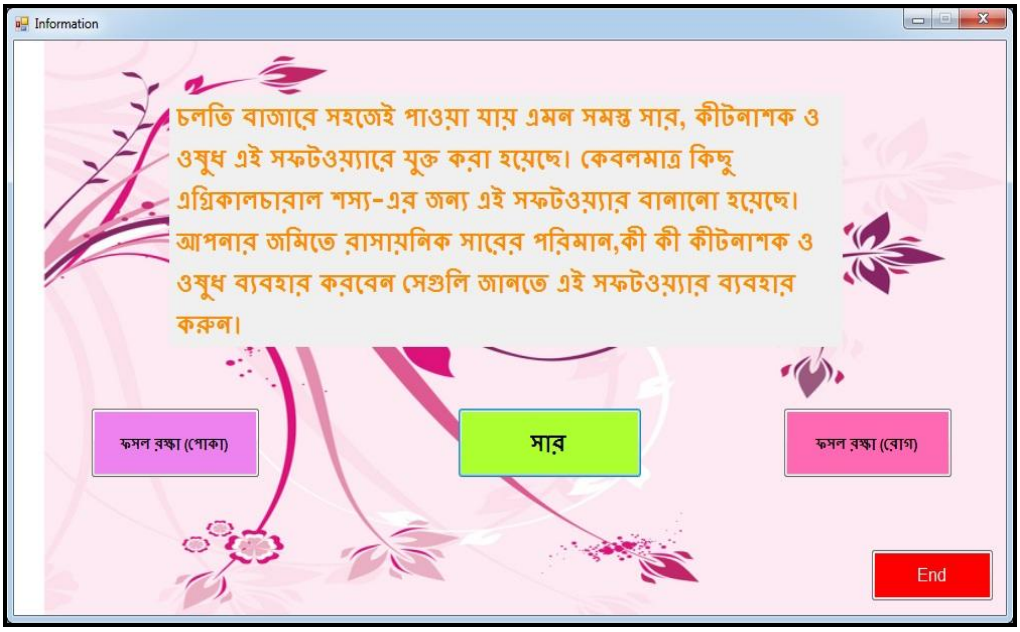


Figure 1: *Selection of Category*

Then if the user select fertilizer it will redirect to the categories of soil form and after selecting the soil category it will directly redirect the user to the crop form. Here user will get many types of crops and accordingly user can select one at a time.

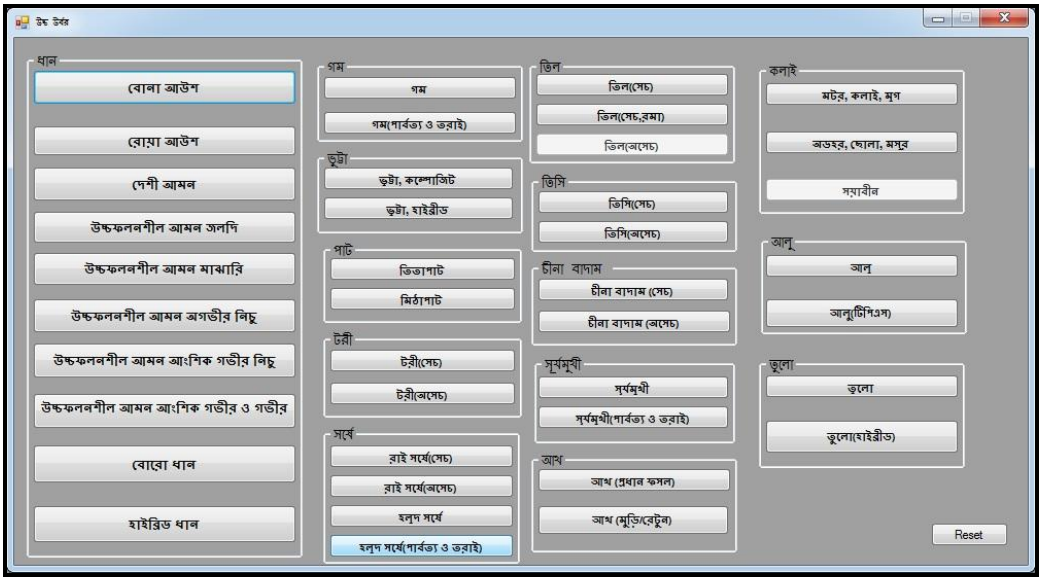


Figure 2: *Selection of Crop*

Then it will ask the user to enter the amount of area in which crop will be practiced.

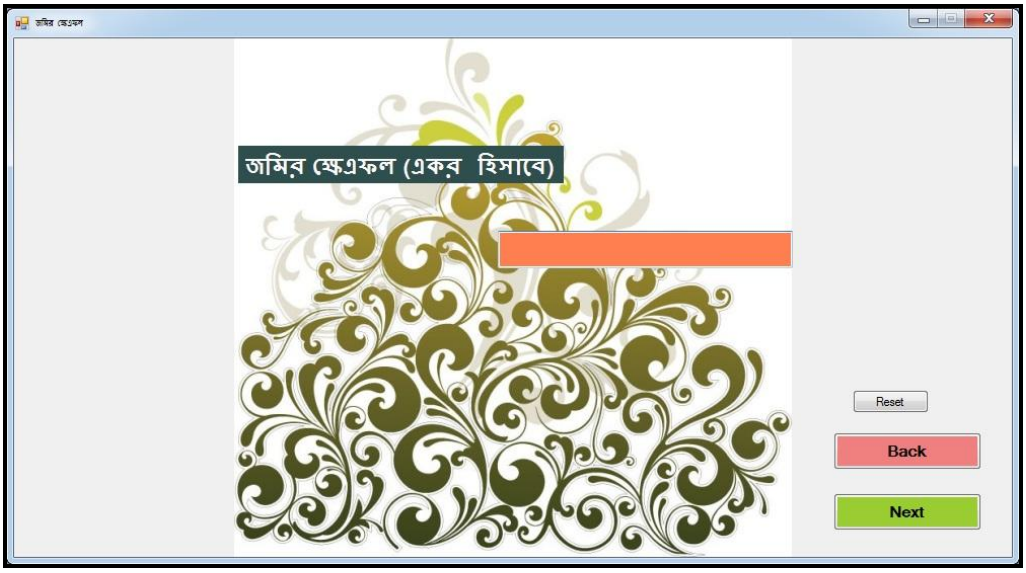


Figure 3: *Input of Area of Cultivation by User*

Then the user will redirect to the fertilizer form where available fertilizers are given as set format. User can choose any one set at a time. The available fertilizers are highlighted in green color.

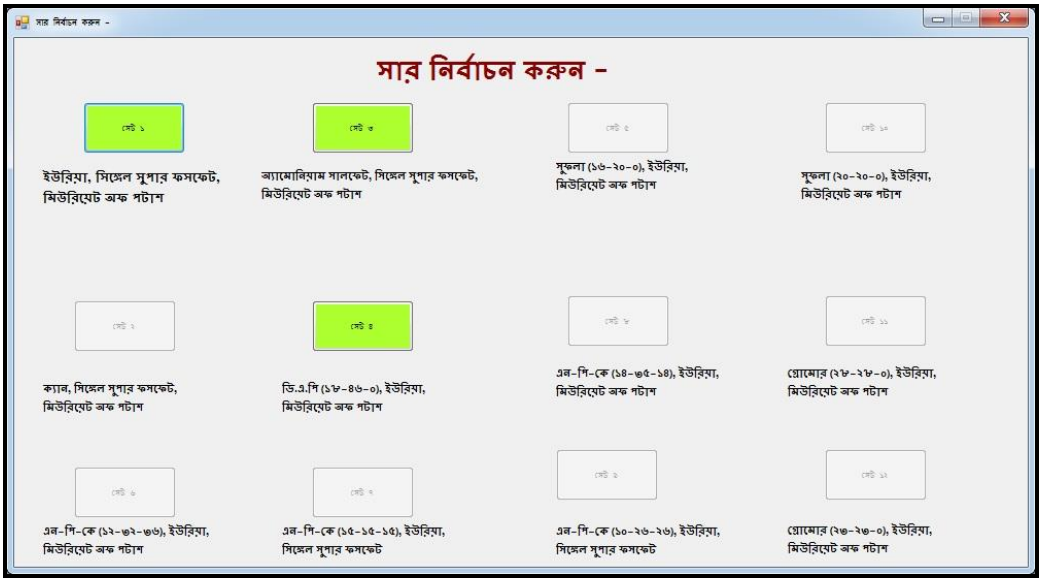


Figure 4: *Selection of Fertilizer*

Thereafter it will redirect the user to the final result form, where user will get the result after clicking the button. Here, user can close the software or can go the insect or disease form according to desire.

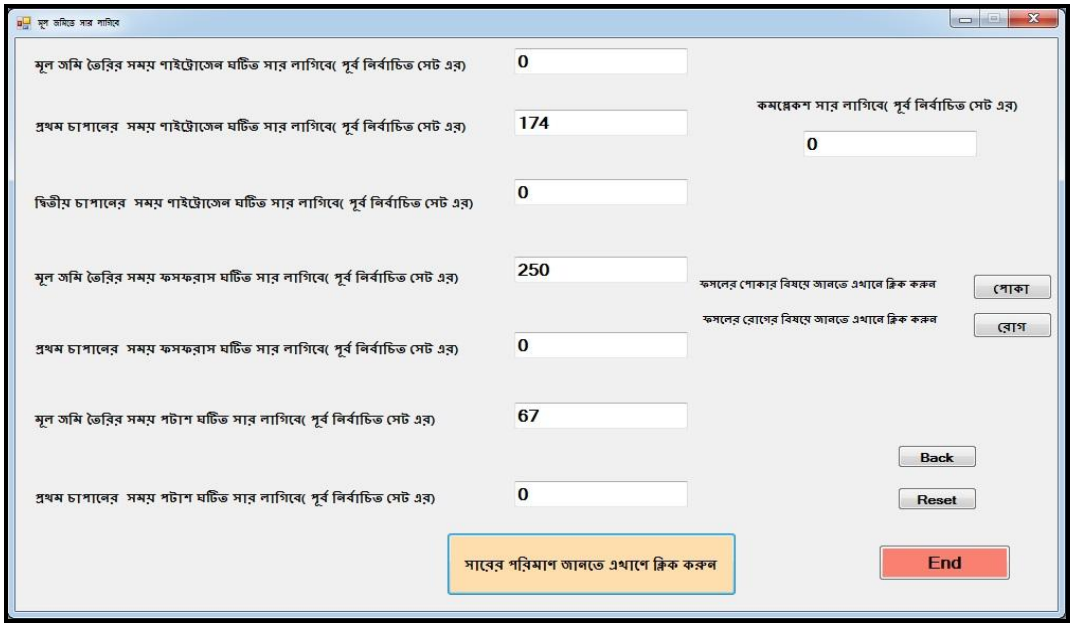


Figure 5: *Result*

If the user select insect or disease at the beginning of this process or after getting result of the amount of fertilizer it will redirect to another form that contains crops and the common insects that generally attack the particular crops. Here, at first users have to select the crop and then users have to select the particular insect.

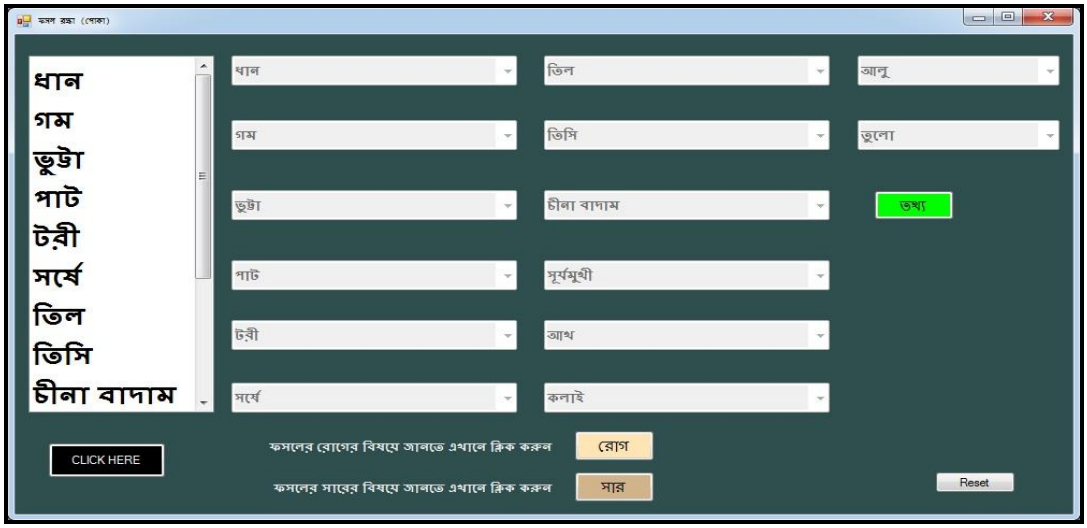


Figure 6: *Selection of Crop and Insect*

Then it will redirect user to final information form.

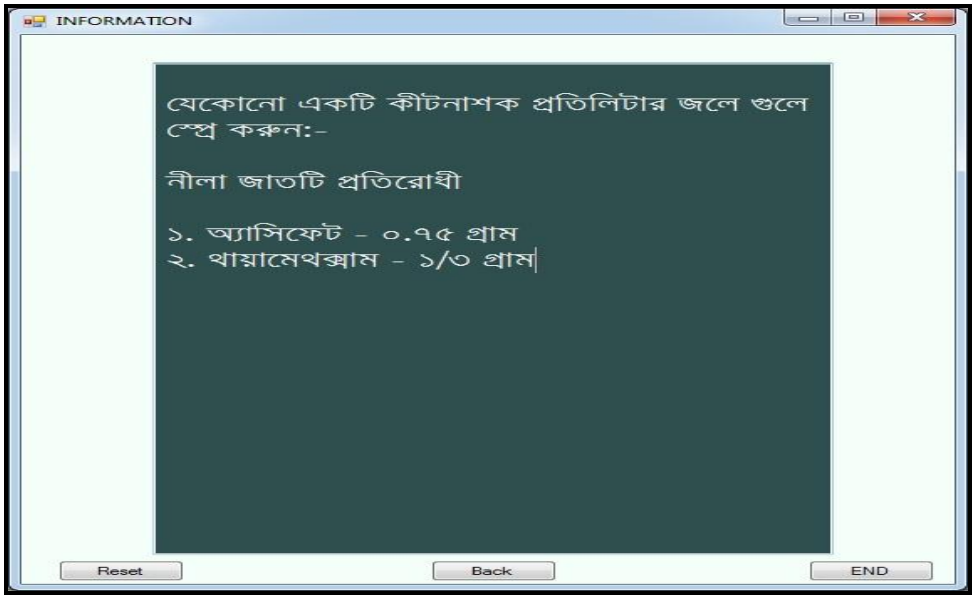
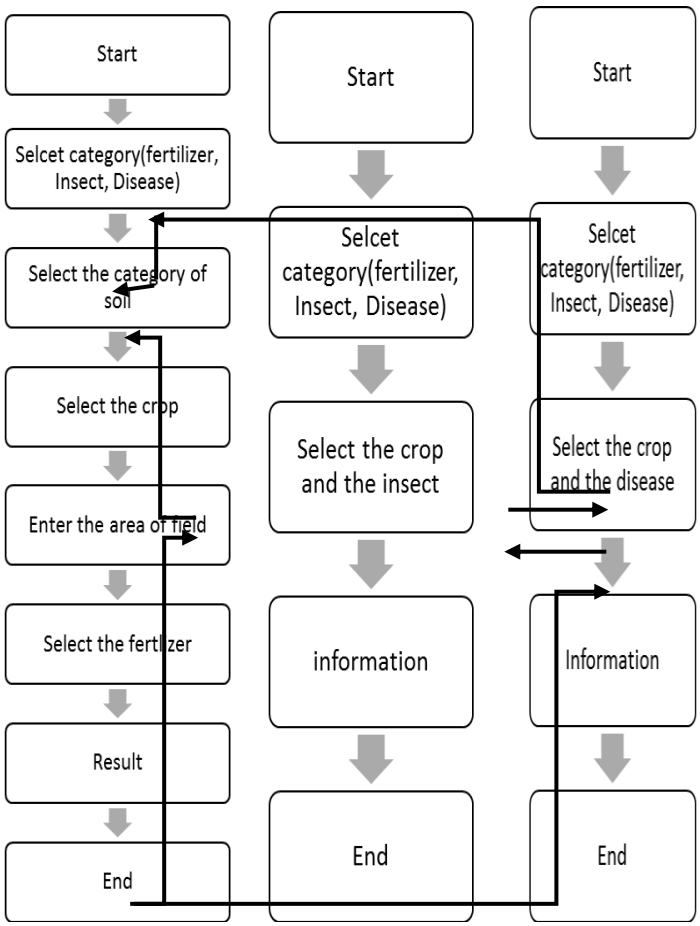


Figure 7: *Information*

In case of disease it is same as the insect. Only thing is that user will get diseases instead of insects in this particular form.

5. Algorithm for the Software



a) Fertilizer *b) Insects* *c) Disease*

6. Conclusion

At earlier time people did those calculations manually and it took much time to evaluate the result. But by using this software anyone can evaluate the result within a short time. To use this software the user need not to know much thing. User will only input the amount of field area and other things will be selected at selection procedure. The main thing is that this software is developed is regional language which will help all types of people of this region to understand. The information is also in regional language (Bengali), so any person who does not know other languages will understand the information easily. All the information regarding to this software are valid only to soil condition of West Bengal, India.

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Research Article **Open Access**

Diversity of Culture Dependent Mycoflora of the Rhizosphere and Non Rhizosphere Soil of Maize (*Zea Mays* L.)

Deehunkimin Khonglah, Haobam Romola Devi and M.S. Dkhar

Microbial Ecology Lab, Department of Botany, North Eastern Hill University, Shillong, Meghalaya, India

Correspondence should be addressed to Haobam Romola Devi, romola.h@gmail.com

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Abstract The present investigation was carried out in pot experiment. Collection of rhizospheric and non-rhizospheric soil was done at fifteen days time intervals. For the isolation of the of culture dependent soil fungi, serial dilution plate method was followed using Rose Bengal Agar medium. Soil samples were collected aseptically from the rhizospheric and non-rhizospheric regions of maize from each experimental pot for a period of 105 days. Results revealed that fungal CFU (Colony Forming Unit) was higher in the rhizospheric soil than the non-rhizospheric soil throughout the sampling period. Altogether 41 fungal species were isolated from the rhizospheric and non-rhizospheric soil. Of which, 2 species belongs to Oomycota, 3 species to Zygomycota and 36 species to Ascomycota. A total number of 39 and 32 fungal species were isolated from rhizospheric and non rhizospheric soil respectively. Twenty eight fungal species were found to be common from both the soil samples. *Acremonium, Cladosporium* and *Penicillium* species were the dominant fungal species among the isolates. Shannon diversity index was high in rhizospheric soil community and Simpson dominance index was high in non rhizospheric soil community. Similarity Sorenson's Co-efficient index of the rhizospheric and non rhizospheric soil community was found to be highest during the 90th day of the sampling period.

Keywords *Colony Forming Unit; Fungi; Diversity Index; Dominance Index*

1. Introduction

Living plants create a unique habitat around the roots which is favourable for the proliferation and metabolism of numerous microorganisms. The microorganisms living in this complex region influences the health of a plant and also the surrounding soil ecosystems. Rhizosphere is directly influenced by root secretions and associated soil microorganisms. Much of the nutrient cycling and disease suppression needed by the plant occurs immediately adjacent to the roots.

Fungi are known to colonize diverse habitats and substrates and plays substantial role in plant health and productivity besides producing diseases. Studies on soil fungi have received much attention since the problems of soil mycological investigation was probed in by Adametz (1886). According to

Waksman (1952) the abundance of microorganisms in soil is influenced by various factors such as organic matter, soil reaction, moisture, temperature, aeration and nature of crop grown. The role of fungi in the soil is an extremely complex one and is fundamental to the soil ecosystem (Bridge and Spooner, 2001).

Fungi play a crucial role in the transport, storage, release and recycling of nutrients and also in the development and health of a plant (Thorn, 1997; Bridge and Spooner, 2001; Martin, 2001). Despite their extraordinary impacts on ecosystems, relatively little is known about them. Therefore, an improved knowledge of the structure and diversity of fungi can lead to a better understanding of their roles in soil ecosystems.

Both the generic compositions as well as size of the flora vary with the type of soil and with its physico-chemical characteristics. Among various physico-chemical characteristics of a soil, temperature, pH, moisture content, and organic carbon play important roles in regulating the population and activity of soil microbes.

The aim of the present investigation was to provide data on fungal population in the rhizospheric soil of maize and also to compare the rhizospheric fungal population with that of the non rhizospheric soil.

2. Materials and Methods

2.1. Collection of Soil Samples

Soil samples were collected from the rhizospheric and non-rhizospheric regions from each experimental pot at fifteen days intervals for a period of 105 days. For rhizospheric soil sampling, three maize plants were uprooted and complete root system with soil adhering to it was removed with the help of a sterilized digger and collected in sterilized polythene bags. For the non rhizospheric soil, samples were collected randomly from three experimental pots and mixed thoroughly to get a composite sample. The rhizospheric and non rhizospheric soil samples collected were stored at 4°C for further analysis.

2.2. Isolation and Enumeration of Fungi

Serial dilution plate method (Johnson and Curl, 1972) was followed for the isolation of rhizospheric and non rhizospheric fungi using Rose Bengal Agar medium (Martin, 1950). The soil particles closely adhering to the root system was collected aseptically by gently shaking the root system and was used for the isolation of rhizospheric fungi. For the non rhizospheric soil, samples were collected randomly from the three experimental pots and mixed thoroughly to get a composite sample.

Colony forming unit (CFU) of fungi was estimated by counting the number of fungal colonies. The CFU per gram soil was calculated on the dry weight basis.

2.3. Identification of Fungi

The fungal species were identified on the basis of their morphology and reproductive structures by consulting monographs by Subramaniam (1971), Barnett and Hunter (1972), Ellis (1972) and Domsch et al. (1980).

2.4. Diversity Analysis

The diversity indices of the culturable fungi were estimated following the methods of Shannon (1948), and Simpson (1949), and community similarity was determined using the methods of Sorenson (1948).

Shannon Diversity Index

Shannon Index (H) = $-\Sigma p_i \ln p_i$

Simpson Dominance Index

Simpson Index (D) = Σp_i^2
pi = n/N
Where n= number of individual species
N=Total number of individuals
Ln= Natural Log

Sorenson's Coefficient (CC) = 2C/ (S1+S2)

Where, C= number of species the two communities have in common,
S1= Total number of species found in community 1
S2= Total number of species found in community 2

2.5. Soil Physico Chemical Properties

Soil pH was read by using electronic digital pH meter. The moisture content of the soil sample was determined by oven dried basis by drying 10 gram of soil in a hot air oven at 105°C for 24 hours and the dry weight was taken. Soil organic carbon was estimated by colorimetric method of Anderson and Ingram (1993).

2.6. Statistical Analysis

The relationship between the physico-chemical characteristics of the soil and the fungal count was determined by calculating the correlation coefficient (r) and each sample was analyzed in triplicates and averaged value was taken.

3. Results and Discussion

Fungal CFU exhibited variations throughout the sampling periods in both the rhizospheric as well as non-rhizospheric soils (Figure 1). Fungal CFU ranged from 9.2 to 36.9 x $10^3 g^{-1}$ dry soils for the rhizospheric soil and 2.8 to 24.8 x $10^3 g^{-1}$ dry soils for non- rhizosphere soil. Highest fungal CFU was observed on the 7th sampling period in rhizospheric soil and on the 6th sampling period in the non-rhizospheric soil (Table 1).

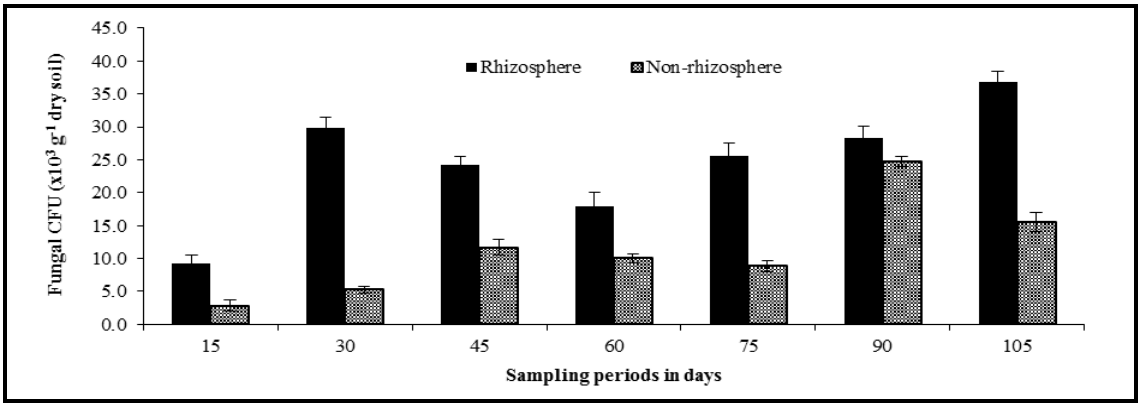

Figure 1: *Fungal CFU (x10^3 g^{-1} dry soil) of Rhizosphere and Non-rhizosphere soil of Maize (Zea mays L.)*

Table 1: *Fungal CFU (x10^3 g^{-1} dry soil) of Rhizosphere and Non- Rhizosphere soil of Maize (Zea mays L.)*

Sampling Periods (days)	Rhizosphere Soil	Non- Rhizosphere Soil
15	9.19±1.40	2.81±0.84
30	29.83±1.68	5.28±0.51
45	24.18±1.33	11.69±1.19
60	17.98±2.00	10.04±0.70
75	25.59±1.87	8.82±0.89
90	28.37±1.71	24.79±0.79
105	36.86±1.56	15.48±1.42

Higher fungal CFU in the rhizospheric soil than that of the non- rhizospheric soil may be due to the different types of substances released from the roots such as carbohydrate (sugars and oligosaccharides), organic acids, vitamins, nucleotides, flavonoids, enzymes, hormones, and volatile compounds (Prescott, et al., 1999) that may have stimulated the microbial activities in the root region as compared to the non rhizospheric soil. The exudate from the roots acts as a signal which stimulates the biological and physical interactions between roots and soil microorganisms (Nannipieri, et al., 2003). The exudate modifies the biochemical and physical properties of the rhizospheric soil and contributes to root growth and plant survival resulting in a dense and active microbial population in the root region.

Plants secrete many compounds through their roots to serve symbiotic functions in the rhizosphere. The release of organic compounds by the roots results in dramatic changes in the physical, biological and chemical nature of the soil and also sustains the continuum of microbial populations colonizing niches from the plant's interior and into the bulk soil which has an impact upon their environment. Plant roots exert strong effects on the rhizosphere by providing suitable ecological niches for microbial growth (Bais, et al*.,* 2006). The rhizosphere contains many bacteria that feed on sloughed-off plant cells, termed *rhizodeposition*, and the proteins and sugars released by roots and it is also known that maize seeds exude a large variety of compounds that affect and modify the surrounding soil (Vilchez, et al*.,* 2000). Furthermore, it is known that the total number of microbes is higher in the rhizosphere soil as compared to the bulk soil due to the continuous supply of nutrients via the root exudates (Kowalchuk et al., 2002 and Nunes da Rocha et al*.,* 2009).

Table 2 depicts the list of fungal species isolated from rhizospheric and non-rhizospheric soil of maize plant. Altogether 41 fungal species were isolated from the rhizosphere and non-rhizosphere soil. Of which, 2 species belonged to Oomycota, 3 species to Zygomycota and 36 species to Ascomycota. A total number of 39 and 32 fungal species were isolated from rhizosphere and non-rhizosphere soil respectively. Species of *Acremonium, Cladosporium* and *Penicillium* were the dominant fungal species among the isolates.

Table 2: *List of Fungal Species Isolated from Rhizosphere & Non-Rhizosphere Soil of Maize (Zea Mays L.)*

Sl. No.	Fungal species	Rhizosphere	Non-rhizosphere
	OOMYCOTA (2 genera, 2 species)		
1	*Phytophthora cactorum*	+	-
2	*Pythium irregulare*	+	+
	ZYGOMYCOTA (3 genera, 3 species)		
1	*Mortierella ramanniana*	+	-
2	*Mucor racemosus*	+	+
3	*Rhizopus oryzae*	+	-
	ASCOMYCOTA (19 genera, 36 species)		
1	*Acremonium cerealis*	-	+
2	*A. kiliense*	+	+
3	*A. strictum*	+	-

4	*Alternaria alternata*	+	+
5	*A. tenuissima*	+	+
6	*Arthroderma tuberculatum*	+	+
7	*Aspergillus fumigatus*	+	+
8	*Cladosporium cladosporioides*	+	+
9	*C. macrocarpum*	+	+
10	*C. sphaerospermum*	+	+
11	*Exophiala jeanselmei*	-	+
12	*Fusarium solani*	+	+
13	*Geotrichum candidum*	+	+
14	*Gliocladium catenulatum*	+	+
15	*Humicola fuscoatra*	+	+
16	*H. grisea*	+	+
17	*Mammaria echinobotryoides*	+	-
18	*Nannizzia grubyia*	+	+
19	*Nectria ventricosa*	+	-
20	*Paecilomyces carneus*	+	+
21	*Penicillium brevicompactum*	+	+
22	*P. canescens*	+	+
23	*P. daleae*	+	+
24	*P. fellutanum*	+	+
25	*P. janthinellum*	+	+
26	*P. jensenii*	+	+
27	*P. lanosum*	+	+
28	*P. restrictum*	+	-
29	*P. sacculum*	+	-
30	*P. simplicissimum*	+	-
31	*P. spinulosum*	+	+
32	*Phoma eupyrena*	+	+
33	*Scytalidium lignicola*	+	+
34	*Trichoderma harzianum*	+	-
35	*T. koningii*	+	+
36	*Verticillium dahliae*	+	-

Species such as *Phytophthora cactorum, Mortierella ramanniana, Rhizopus oryzae, Acremonium strictum, Mammaria echinobotryoides, Nectria ventricosa, Penicillium restrictum, P. sacculum, P. simplicissimum, Trichoderma harzianum* and *Verticillium dahlia* were restricted only to the rhizospheric soil. Whereas *Acremonium cerealis* and *Exophiala jeanselmei* were isolated only from the non-rhizospheric soil. Twenty eight fungal species were found to be common in both the soil samples.

Rhizospheric and non-rhizospheric soil exhibited similar fungal species as fungi residing in the rhizosphere most likely have originated from the surrounding bulk soil and might have thrived under conditions prevailing in the neighbourhood of plant roots. It must therefore, be assumed that fungal communities in the rhizosphere form a subset of the total fungal community present in bulk soils (Curl and Truelove, 1986).

In most of the sampling periods Shannon diversity index was higher in rhizospheric soil than that of the non rhizospheric soil (Figure 3), whereas, Simpson dominance index was higher in non-rhizosphere soil (Figure 4). Sorenson's coefficient value was lowest in 15th day of sampling period, whereas, it was highest during the 90th day of sampling period (Figure 6).

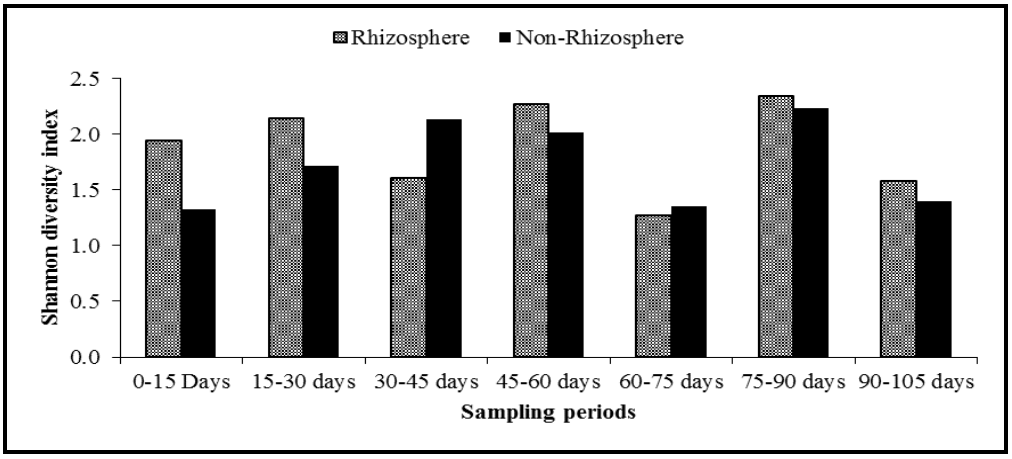

Figure 2: *Shannon Diversity Index of Rhizosphere and Non-Rhizosphere Soil of Maize (Zea mays L.)*

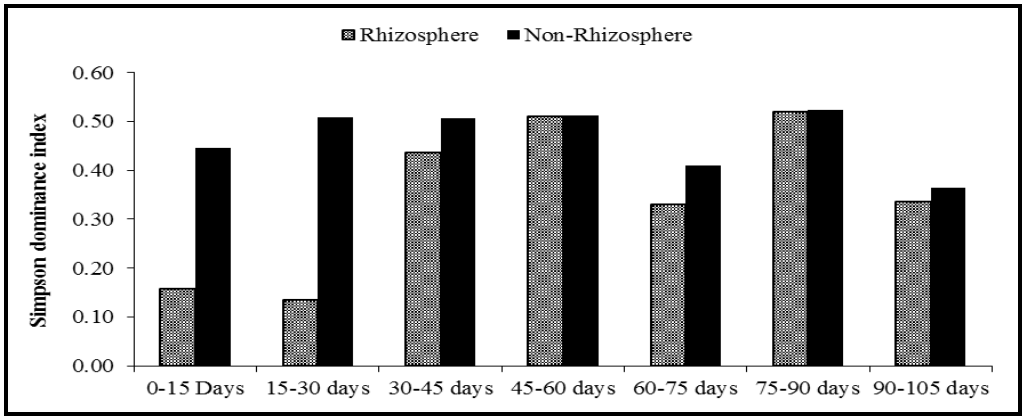

Figure 3: *Simpson Dominance Index of Rhizosphere and Non-Rhizosphere Soil of Maize (Zea mays L.)*

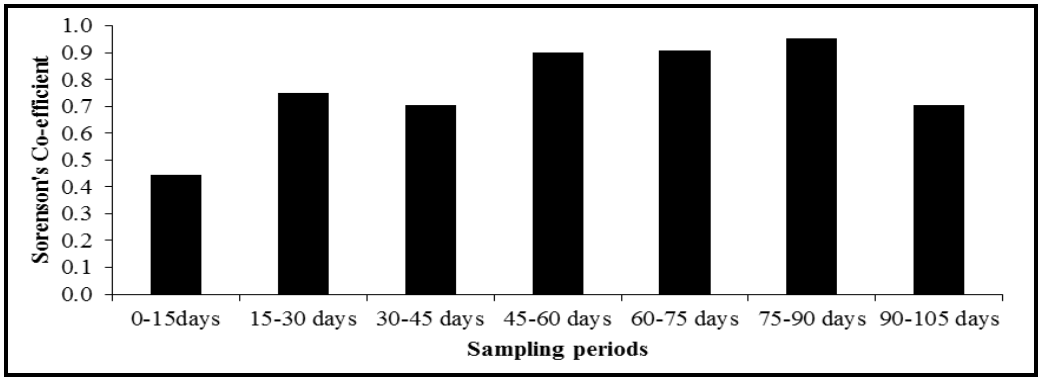

Figure 4: *Sorenson's Co-Efficient Index of Rhizosphere and Non-Rhizosphere Soil of Maize (Zea mays L.)*

3.1. Physico-Chemical Properties of Rhizosphere and Non-Rhizosphere Soil

Table 3 depicts the mean values of the physico-chemical properties of rhizospheric and non-rhizospheric soil of maize plant with standard errors (SE). pH of soil was acidic in both rhizospheric and non- rhizospheric soil (Figure 5). pH of soil ranged between 5.3 and 6.5 in rhizosphere soil and 5.6 and 6.2 in the non- rhizosphere soil. pH of rhizospheric soil was slightly more acidic as compared to the non- rhizospheric soil which can be attributed to the fact that respiration by plant roots and soil microorganisms released H^+ ions (Sinha, et al., 2009). Also respiration leads to carbon dioxide (and

eventually to bicarbonate/carbonic acid) generation. In addition to respiration of the roots themselves, the rhizosphere is very rich in carbon due to the prokaryotes to fungi to small animals living and respiring in the rhizosphere more than in the bulk soil.

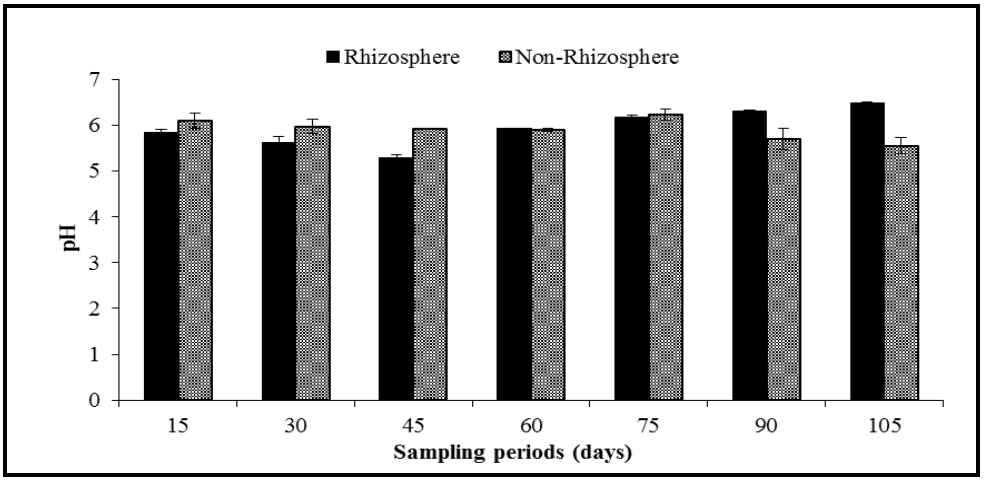

Figure 5: *pH of Rhizosphere and Non-Rhizosphere Soils of Maize (Zea mays L.)*

Table 3*: Mean values of physico-chemical properties of Rhizosphere and Non–Rhizosphere soil of Maize (Zea mays L.) with standard errors (SE)*

Soil properties		Sampling Period (days)						
		15	30	45	60	75	90	105
pH	R	5.84±0.06	5.62±0.13	5.28±0.09	5.93±0.01	6.17±0.05	6.32±0.00	6.49±0.02
	NR	6.10±0.17	5.97±0.15	5.92±0.01	5.89±0.03	6.23±0.13	5.70±0.23	5.55±0.18
MC	R	30.84±0.87	30.41±0.51	25.58±0.06	22.10±0.51	30.92±0.61	29.48±0.72	31.24±0.66
	NR	28.51±0.69	29.74±1.13	25.87±0.08	20.36±0.22	31.93±0.41	27.38±0.01	30.99±1.28
OC	R	0.81±0.01	0.88±0.02	1.45±0.10	1.08±0.05	0.41±0.05	0.37±0.05	0.50±0.04
	NR	0.74±0.02	0.91±0.02	1.11±0.03	0.11±0.01	0.24±0.03	0.51±0.04	0.34±0.01

Note: R*=Rhizosphere soil;* ***NR*** *=Non- Rhizosphere soil;* ***MC*** *= Moisture content (%);* ***OC*** *= Organic carbon (%)*

Throughout the sampling periods, the moisture content was found to be almost similar in rhizospheric as well as non- rhizospheric soil (Figure 6). This may be due to regular watering of the plant. Moisture threshold affects the availability of oxygen in some soils, if it's too high, microbial growth is restricted. Soil moisture is one of the key factors influencing soil microbial activity and soil organic matter decomposition (Brady and Weil, 2002). When soils become dry, it causes a decrease in enzyme activity (Sardans and Penuelas, 2005) and it reduces the thickness of water films on soil surfaces and therefore, the rate of diffusion of substrates to microbes (Stark and Firestone, 1995).

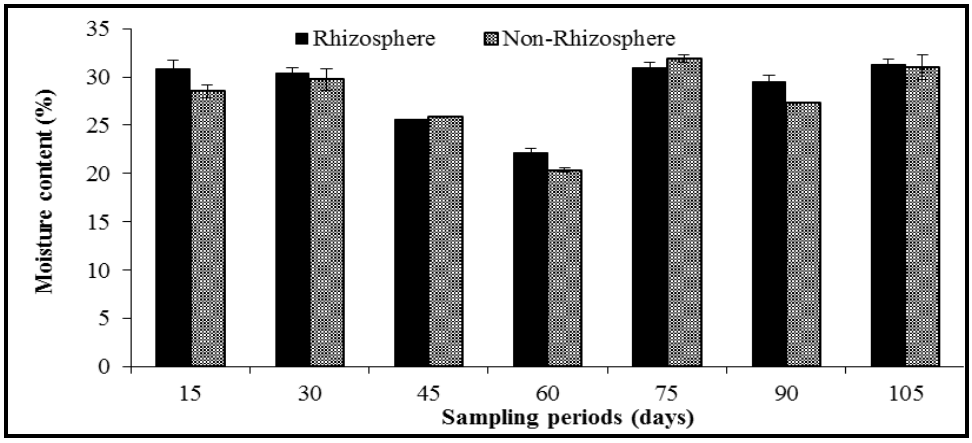

Figure 6: *Moisture content of Rhizosphere and Non- Rhizosphere soil of Maize (Zea mays L.)*

The organic carbon content in the rhizospheric soil was higher as compared to the non- rhizospheric soil (Figure 7). The soil organic carbon ranged from 0.37 to 1.49% in the rhizospheric soil and 0.11 to 1.11% in the non- rhizospheric soil. Increase in soil organic carbon in the rhizosphere is affected by rhizodeposition, which involves wide range of processes by which carbon enters the soil including root cap and border cell loss, death and lysis of root cells (cortex, root hairs etc), flow of carbon to root associated symbionts living in the soil, gaseous losses, and leakage of solutes from living cells. Apart from this, most plant in natural and semi natural vegetation systems forms symbiotic associations with fungi which facilitates the flow of carbon to and through this symbiotic interface resulting in increased carbon content in the root region compared to the bulk soil (Leake, et al., 2004).

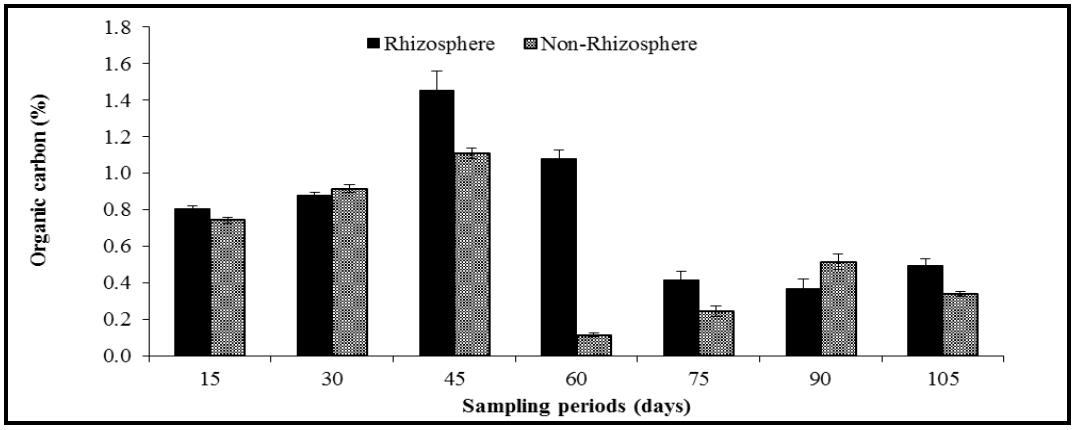

Figure 7: *Organic carbon of Rhizosphere and Non-Rhizosphere soil of Maize (Zea mays L.)*

3.2. Statistical Analysis

Table 4 depicts the correlation coefficient values between fungal CFU and the physico-chemical properties of rhizospheric and non- rhizospheric soil of maize plant.

In rhizospheric soil, organic carbon was found to have significantly negative correlation with moisture content ($r = -0.69$; $p \leq 0.05$) and pH ($r = -0.89$; $p \leq 0.05$ and $p \leq 0.01$). In non- rhizospheric soil, CFU of fungi was negatively correlated with pH ($r = -0.71$; $p \leq 0.05$).

Table 4: *Correlation coefficient (r) values of fungal CFU with physico-chemical properties of Rhizosphere and Non-Rhizosphere soil of Maize (Zea mays L.)*

Soil properties	MC	pH	OC
Fungal CFU	NS	NS	NS
MC		NS	-0.69
pH			-0.89
	Non-Rhizosphere Soil		
Fungal CFU	NS	-0.71	NS
MC		NS	NS
pH			NS

Note: MC= Moisture content; **OC**= Organic carbon; **NS** = Not significant
Insignificant values are marked with 'NS'

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T.chebula and Its Medicinal Value

Prasanta Kr. Biswas and Subhadip Dey

Department of Food Engineering, Faculty of Agricultural Engineering, BCKV, Nadia, West Bengal, India

Correspondence should be addressed to Subhadip Dey, subhadipdey23071994@gmail.com

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Abstract This paper contains some of the information about the *Terminalia chebula* a well-known medicinal plant grows in India. The main discussion is on some of the chemical compounds that are mainly found in *T.chebula*. Here the structures of the compounds along with their uses are mentioned.
Keywords *T.chebula; Chemical Compounds of T.chebula; Haritaki; Medicinal Value of Compounds Found in T.chebula*

1. Introduction

Terminalia chebula, the most common medicinal plant grows mainly in the sub Himalayan tracks from Ravi eastwards to west Bengal and Assam. The tree is mainly of 15.24m in height and 1.5-2.4m in girth with a cylindrical bole of 4-9m. It is also called the 'king of medicines' in Tibet. This plant is considered as medicinal plant from thousands of year in Ayurveda. The bark of Terminalia has been used in India for more than 3000 years. It is used primarily as heart remedy. An Indian physician named Vagbhata has been credited as the first to use this product in the seventh century A.D. Research on terminalia has been going on since the 1930s. In Ayurveda it is thought that *T.chebula* destroys all the germs in the body and cleans the body. The main useful parts are bark, leaves, fruits and flowers. Modern science found that the tree is capable of resisting many diseases in case of animals. This is mainly considered as the resistor of heart diseases, nausea and other abnormalities. According to Ayurveda there are many sub-divisions in *T.chebula* like Vijaya, Rohini, Putana, Amruta, Abhaya etc. of which Vijaya variety is considered as best.

2. Constituents Associated with *Terminalia Chebula*

So many phytochemical constituents are found in *T.chebula* extract which are very much useful in medicinal purpose. The phytochemical extracts consist of Tanin (15-20%) which after hydrolysis gave chebulic acid and D-galloyl glucose. Beside these the carbohydrate like glucose and sorbitol are present in the extract. *T.chebula* possesses glycoside compound like Chebuloside I and II. It also contains phenolic compounds like Ellagic acid, 2,4-chebulyl-β-D-glucopyronase, Chebulinic acid (3-

5%), Gallic acid, Ethygallate, Punicalagin, Terflavin-A, Terchebin, Luteolin, Tannic acid (30%), Luteic acid and other components like Acoumarin and Chebulin. It also contains some other compounds.

3. Descriptions of Functional Compounds

The extract of *T.chebula* has antioxidant effect, hepatoprotective effect, cryptoprotective effect, antidiabatic effect and so on. The functional compounds are specially the major cause of these effects. Some of the constituents are explained below:

3.1. Tannin

The polyphenolic compound present in *T.chebula* is tannin (15-20%). It is mainly found in leaf, bud, seed, root, and stem tissues of a plant. Sometimes it is found in secondary phloem, xylem i.e. the growth areas of trees.

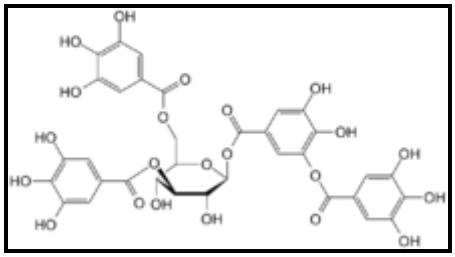

Figure 1: *Tannic Acid (One Type of Tanin)*

Tannin has a poor contribution in antioxidant activity and cardiovascular activity. Other sources from where we can get Tannin are fruits like pomegranates, berries, nuts; smoked food like cherry, oak; and also in herbs, spices, legumes and chocolates.

3.2. Chebulic Acid

One of the phenolic compounds mainly extracted from the ripe food of *T.chebula* is Chebulic acid. The compound also possesses an isomer Neochebulic acid.

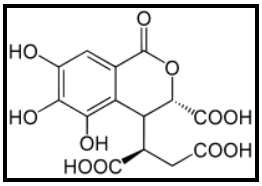

Figure 2: *Chebulic acid according to Lee, 2010 [1]*

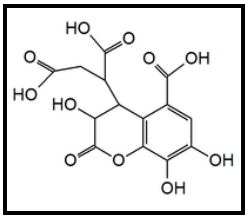

Figure 3: *Chebulic acid according to Klika, 2004 [2]*

This compound acts as a hepatoprotective compound [3]. Chebulic acid was used to prevent advanced glycation end products-induced endothelial cell dysfunction; however the antidiabetic effect of chebulic acid is questionable [4].

3.3. Chebuloside II

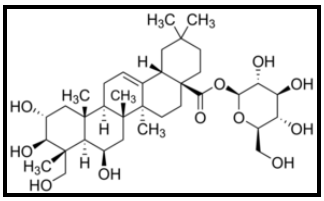

Figure 4: *Chebuloside II*

The molecular formula of chebuloside II is **C36H58O11** and the molecular weight is 666.84 g/mol. It has hepatoprotective activity against anti-tuberculosis (anti-TB) drug-induced toxicity. TC extract was found to prevent the hepatotoxicity caused by the administration of rifampicin (RIF), isoniazid (INH) and pyrazinamide (PZA) (in combination) in a sub-chronic mode (12 weeks). The hepatoprotective effect of TC (*T.chebula)* extract could be attributed to its prominent anti-oxidative and membrane stabilizing activities [5].

3.4. Ellagic Acid

One of the most useful compound present in *T.chebula* is Ellagic acid. It is marketed because of having the ability to prevent and treat a number of human maladies, including cancer. But these claims have no such strong proofs. Actually plants produce Ellagic acid from hydrolysis of Tanins.

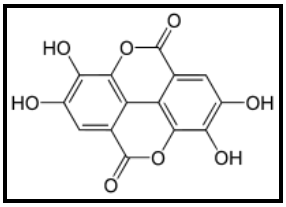

Figure 5: *Ellagic Acid*

The molecular formula of Ellagic acid is C14H6O8 and the molecular weight is 302.19 g/mol. Ellagic acid has some anti-cancer properties. It also acts as an antioxidant and cause apoptosis in cancer cells. It reduces the effect of estrogen in promoting growth of breast cancer cells in tissue cultures. There are also reports that it may help the liver to break down or remove some cancer-causing substances from the blood. It is also claimed that Ellagic acid also reduces heart disease, birth defects, and liver problems [6]. The present available research does not support these claim at this time. This ellagic acid can be extracted from many other sources like oaks, macrophytes (*Myriophyllum spicatum)* and medicinal mushroom (*Phellinuslinteus)* [7]. It is available also in some fruits like wild strawberries, raspberries, blackberries, cloudberries, pomegranate, walnuts, pecans, beefsteak fungus, and cranberries [8].

3.5. Chebulinic Acid

One of the important phenolic compound present in *T.chebula* is Chebulinic acid. It is mainly found in the fruit of the tree [9].

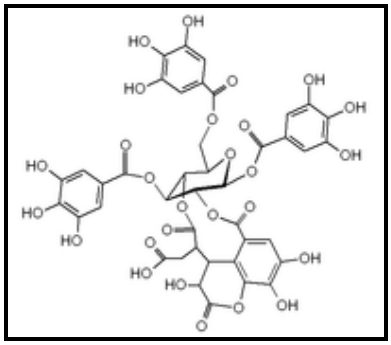

Figure 6: *Chebulinic Acid*

The molecular formula of Chebulinic acid is C41H32O27 and the molecular weight is 956.67 g/mol. Some researchers claim that it has antihypertensive activity. It has some inhibitory effect on erythroid differentiation likely through changing transcriptional activation of differentiation relative genes, which suggests that Chebulinic acid or other tannins might influence the efficiency of some anti-tumor drug induced differentiation or the hematopoiesis processes. It is also found in the seed of *Euphoria longana* [10].

3.6. Gallic Acid

Gallic acid is a trihydroxybenzoic acid, a type of phenolic acid.

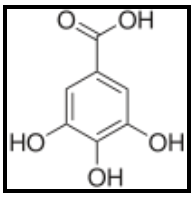

Figure 7: *Gallic Acid*

The molecular formula is C6H2 (OH) 3COOH. Gallic acid seems to have anti-fungal and anti-viral properties. Gallic acid acts as an antioxidant and helps to protect our cells against oxidative damage. Gallic acid was found to show cytotoxicity against cancer cells, without harming healthy cells. Gallic acid is used a remote astringent in cases of internal haemorrhage. Gallic acid is also used to treat albuminuria and diabetes. Some ointment to treat psoriasis and external haemorrhoids contains gallic acid. It is also found in oak species; stem bark of *Boswelliadalzielii*, *Drosera, Rhodiolarosea, Toona sinensis,* etc. [11].

3.7. Punicalagin

Punicalagin is an ellagitannin.

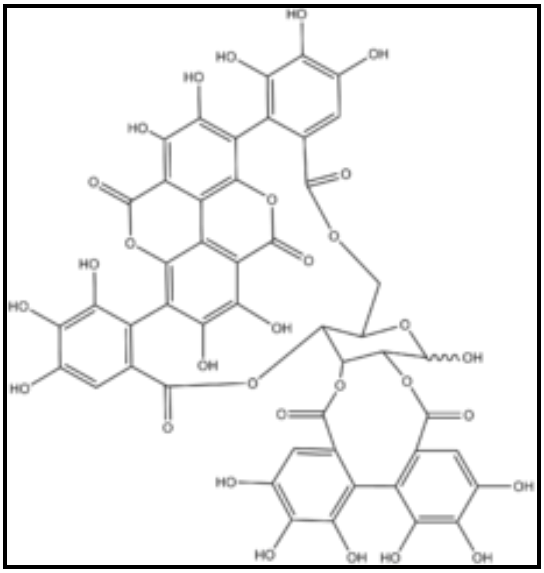

Figure 8: *Punicalagin*

The molecular formula of Punicalagin is C48H28O30 and the molecular weight of this compound is 1084.71 g/mol [12]. Medicinal purpose is not well-known.

3.8. Luteolin

It is a flavone, a type of flavonoid. It has a yellow crystalline appearance. It is most often found in leaves, but it is also seen in rinds, barks, clover blossom, and ragweed pollen [13].

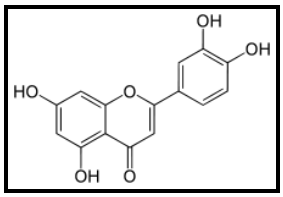

Figure 9: *Luteolin*

The molecular formula of C15H10O6 and the molecular weight is 286.24 g/mol. It was used in China as a traditional medicine for treating various diseases such as hypertension, inflammatory disorders, and cancer. It functions as either antioxidant or pro-oxidant biochemically. Luteolin's anticancer property is associated with the induction of apoptosis, and inhibition of cell proliferation, metastasis and angiogenesis [14]. Furthermore, luteolin sensitizes cancer cells to therapeutic-induced cytotoxicity through suppressing cell survival pathways such as phosphatidylinositol 3'-kinase (PI3K)/Akt, nuclear factor kappa B (NF-kappaB), and X-linked inhibitor of apoptosis protein (XIAP), and stimulating apoptosis pathways including those that induce the tumor suppressor p53 [15]. There are many adverse effect caused by Luteolin in human being. Nausea, vomiting, and gastric hypersecretion, may occur. It was seen in one animal study. It has adverse effects in laboratory studies with endometrial cancer cells by blocking endocrine effects of the hormone progesterone [16]. It is found in celery, broccoli, green pepper, parsley, thyme, dandelion, perilla, chamomile tea, carrots, olive oil,

peppermint, rosemary, navel oranges, and oregano. It is also found in the seeds of the palm *Aiphanes aculeata.*

3.9. Luteic Acid

It is a natural phenol present in the myrobalanitannin, tannin found in the fruit of *Terminalia chebula.* This was showed by Maximilian Nierenstein in the year of 1945. It is also an intermediate product in the synthesis of ellagic acid.

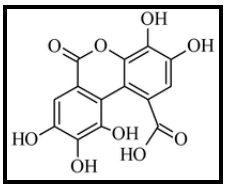

Figure 10: *Luteic Acid*

The molecular formula of luteic acid is C14H8O9 and the molecular weight is 320.21 g/mol. Medicinal purpose of this component is also not well-known [17].

4. Conclusion

T.chebula, a well-known medicinal plant contains various chemical compounds. Some of the chemical compounds are briefly discussed here, although some of the chemical compounds along with their medicinal use are not well known.

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