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Use of an Automatized System to Avoid the Deterioration of Soil in the Cultivation of Asparagus in the Mexicali Valley of the Baja California, Mexico

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Abstract - An investigation was made to analyze an automatized system (AS) as electronic device to supports that soil utilized to the asparagus cultivation process, in an agricultural industry located in the Mexicali Valley, where is located in the northwest of the Mexican Republic. This automatized system avoids the occurrence of the deterioration of the soil for the presence of pH water low (acidic action), and the constantly se of the pesticides to avoid presence of pests. This automatic device as electronic component, have a specialized sensor, to detect when not exits moisture in the soil, and with this activate a relay as electro valve and connected to a water pump, to supply water to soil, and with this maintain the adequate moisture, and avoid the deterioration. A microanalysis using the Scanning Electron Microscopy (SEM), of the soil deterioration process was made to detect when was begin this phenomena process, and invert this process to avoid the deterioration action in soil. This was relevant because with the use of the AS, was increased the productivity and quality of the asparagus in this agricultural industry evaluated. Also, was applied a mathematical algorithm to determine the optimal steps in the agricultural process from harvest action, inspection of asparagus, package activity and distribution of this important vegetable. This scientific study was made in 2022.

Keywords: Agricultural industry, automatized systema, productivity-quality indices.

1. INTRODUCTION

Asparagus is a highly coveted vegetable for its nutritional properties, which is why it is widely used in homes, restaurants and food stalls (Palermo et al, 2014; Boari et al, 2013). In the asparagus cultivation process, a very relevant factor can be considered such as having fertile soils, which have a great capacity to be well drained, with an optimal infiltration rate, efficient water retention for cultivation, without having compacted soils and an optimal soil pH of 6.2 to 7.0 and the adequate moisture in the soil (Jaramillo et al, 2016; Renna et al, 2013). Figure 1 illustrate the three principal characteristics mentioned above and considered in the cultivation processes of the asparagus (Slatnar et al, 2018; Acosta-Naranjo et al, 2020).

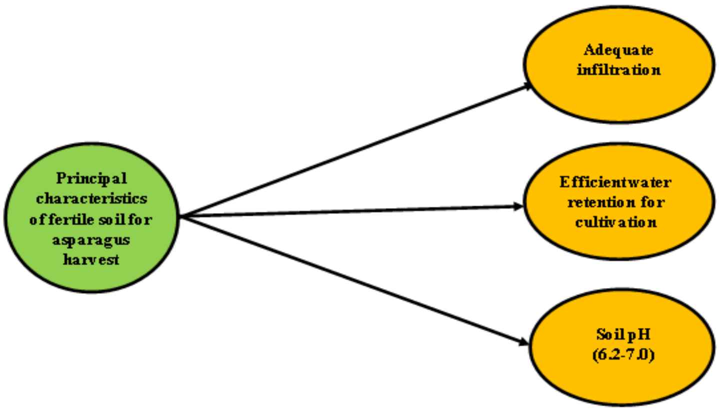

Fig -1: Main characteristics in the cultivation of asparagus
Source Analysis of research literature

1.1 Asparagus nutrients

The asparagus cultivation process involves several aspects, one of them being relevant, the nutrients it requires for its growth, where various nutrients are contemplated that are mentioned below in table 1.

Table -1: Nutrients of the asparagus

Properties Nutrients	Characteristics
Nitrogen	It is the main nutrient that is required by asparagus throughout its growth period, and especially in the first years of the plant's life, for the formation of its tissues and physiological functions. For efficient growth, 75% N-NO3 and 25% N-NH4 are considered
Phosphorous	This nutrient is required in small amounts, but it is very necessary to reduce fibrosity and have a stronger plant in its growth process and better-quality asparagus.
Potassium	It is of great interest in the growth of the plant, because it supports the transport processes of carbohydrates within the plant, to reduce the presence of fungicidal agents that harm the development of the plant.
Calcium	It is required to have optimal growth, being part of the phloem of the asparagus plant, which supports the distribution of water and nutrients necessary for its efficient growth.
Magnesium	Supports the photosynthesis process for optimal plant development and efficient growth of asparagus.
Boron	It is important because it helps the asparagus crop to develop efficiently, with 1.5 ppm being the optimal amount required. With this nutrient, asparagus is considered to be rich in pectin, which develops in the cell wall of plants that grow above the ground, and is widely used in the food, cosmetic and pharmaceutical industries. In the eating process, it helps the stomach to generate an adequate metabolism and digestion and prevents the accumulation of glucose in the blood

In this table is showed the principal nutrients and its characteristics of participation in the grown of plant and the asparagus, where this vegetable need of this nutrients to grown efficiently (Solana et al, 2015; Guarrera et al, 2013).

1.2 Cultivation in the Mexicali Valley

Is a productive zone of the northwest of the Mexican Republic, where is cultivated some agricultural products as vegetables, pasts and grains (principally corn). Also, is considered as same region as other zone of Baja California State as San Quintin, where can replicate this investigation and can observe the difference between regions (Ortiz, 2012). In the Mexicali Valley are some agricultural industries, which cultivate to send to sale the agricultural products to the Baja California population and California State of United States of America (USA) population, where consume a lot of these agricultural products cultivated in the Mexicali Valley (Avendaño et al, 2005; Grijalva, 2014).

1.3 Application of mathematical algorithms

At present there is a great diversity of activities in which mathematical algorithms can be applied, the most relevant being those elaborated and used in industrial processes of any type of industry, the agricultural industry being one of the most interesting, for to be a source of food supply worldwide (Akpinar et al, 2014). These mathematical algorithms are used to perform functions in an orderly manner and without generating any type of error or defective product that leads to the generation of rework actions, which may indicate loss of material and decrease in productivity and quality levels, thereby economic losses originate for all types of industry (Cheng, 2017). The process for developing mathematical algorithms is based on the use of simple algebraic operations (including addition, erst, multiplication and division), which are combined with complex algebraic operations, and which help to define the behavior of certain factors of interest for each case of study (Roshani et al, 2017). This process can be elaborated by computer specialists and by people specialized in programming specialized computer systems. Mathematical algorithms are considered as guide models to be able to understand the behavior of some type of activity or system that involves some relevant parameters, as is the case of this scientific study that were used by specialists in the field of productivity and agricultural quality and experts. in computing device programming functions ((Akpinar et al, 2013). All this is done, based on a series of stages, where the initial stages, the required process stages and the final stages are determined; to keep track of what is being evaluated. To develop mathematical algorithms, it is not necessary to be an expert in the area of computing, but in the processes of a specific subject (Kellegöz et al, 2017). By understanding the objectives of each activity and together, the stages to evaluate and generate the mathematical algorithms are determined, building the flow of a diagram with geometric figures such as square, circle, rhombus, rectangle, arrow, line, and some other type. figure that represents an action in an industrial process, such as the one evaluated in the agricultural industry where the research was made (Roshani et al, 2013). One of the applications that is widely used in the industry is the prediction or estimation of the activities of interest that are evaluated, with the aim of being able to know the possible events or occurrences that may occur and thus determine the possible actions to be considered for prevent industrial operations, whether simple or complex, from having any complicated situation. Said complicated situations can be, that delays in the production process, loss of material, or on occasions some type of accident or generation of some health symptom, even mild or serious, or disease that is reflected in the body of a person from the manufacturing area in particular, forever in his life (Janardhanan et al, 2019).

1.4 Automatized systems to agricultural activities

Are utilized to control any type of activity with basic or specialized electronic components, which have specific functions, and can activate electrical, electromechanical, pneumatic or hydraulic systems (Aghajani et al, 2014). This is utilized in a lot industrial processes, where is necessary the control in simple or complex operations, where acts with a low and high electrical current and voltage, controlling some kind of parameters of interest, as for example, heigh, weight, speed, distance and other characteristics considered in the manufacturing aeras of diverse industrial companies. In this investigation was utilized to control the moisture of soil where was cropped the asparagus, to avoid that soil was dry and begin its deterioration action, and not can use to the cultivation process of this important vegetable or other kind of agricultural products.

1.5 Microanalysis of soil

This part of the scientific study was made to evaluate at microscopy level, to determine the moment to need inspect the AS operation to control the moisture, and observe a detail the compounds added to the soil, where was presented acidic organic and inorganic compounds that accelerate the deterioration of soil and need spend economical financial to repair this part of soil deteriorated (Gustavo Lopez B. et al, 2017). This was relevant, because can know the acidic organic and inorganic compounds and made some improvements to ensure with the AS, the good conditions of the soil where were made the cultivation process of the asparagus.

2. METHODOLOGY

This investigation was elaborated to determine the periods of time that was necessary inspect about the deterioration phenomena of soil utilized in the cultivation of asparagus, being realized in five steps, which are explained next:

a) An evaluation of the agricultural operations with mathematical algorithms.

b) A design and development of a new automatized system to control the moisture of soil and avoid the deterioration.

c) A microanalysis of deterioration process of the soil, using the SEM technique.

d) An evaluation of the cultivation process with the ANOVA test.

e) An analysis of the productivity and quality indices.

3. RESULTS

The scientific study was relevant, and was obtained important information to improve the cultivation process and the productivity and quality indices, where were increased, with the AS that avoid the deterioration of soil. The five types of analysis are presented in the next sections.

3.1 Mathematical algorithm to simulate agricultural operations

In all industrial operations, can be applied the simulation analysis to estimate the operative yielding of workers of manufacturing areas, industrial machinery and equipment, and especially in the agricultural industry, the crop yielding of the agricultural products, considered without pollution, the specific weight, physicochemical characteristics, and nutritive properties (Şahin et al, 2019). In this scientific study, this mathematical simulation was made with the MATLAB software of the MathWorks Co., obtaining relevant results and observing as a real situation of any type of activities. In this investigation, was considered other parameters as atmospheric climatic factors as temperature and relative humidity in addition to the factors mentioned above, obtaining a correlation analysis of the pH and the atmospheric climate (of the air) was also considered, with the parameters of temperature (°C) and relative humidity, where in this region of the northwest of the Mexican Republic, in certain months of the year, considered the month of May and June; There are temperature and relative humidity levels considered as a warm climate (greater than 35°C and 60%), which on occasions, these levels have harmed the growth of asparagus in this area of the country. The purple lines enclosing other lines, where the first purple line contains a blue and a green line (at the top), while the second purple line contains the yellow, brown, and blue lines (back section below the first). purple line of the graph), the third violet line encloses strong green, light green, strong blue and strong blue (back under the second violet line of the graph), the fourth violet line which is the last line encloses the yellow lines, orange, blue, brown and green). Each section is an analysis of the types of soil found in the Valley of Mexicali, such as dry-sandy soil (first purple line), semi-humid silt soil (second purple line), saturated-clay soil (third purple line). and loamy-humid soil (third purple line). This correlation analysis means that in high pH (higher than 7), and high levels of climatic parameters (higher than 35 °C of temperature and 60% of relative humidity), the grown level (productivity and quality) of asparagus was low, but in low pH (around 5 to 7) and low indices of climatic parameters (lower than 35 °C of temperature and 60% of relative humidity), the grown level of asparagus (productivity and quality) was high, as is showed in figure 2.

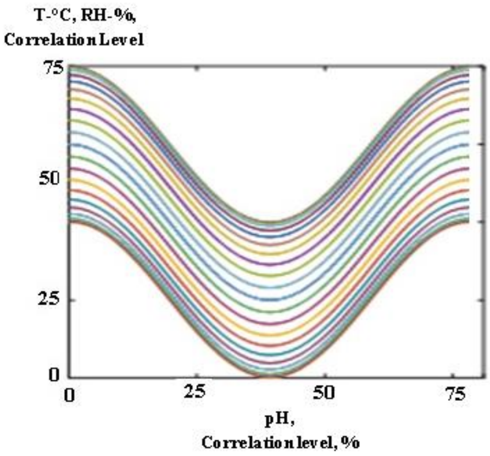

Fig -2: Mathematical simulation with mathematical algorithm of the correlation of pH and atmospheric climatic parameters in the agricultural industry evaluated

Source Analysis of research literature

3.2 Automatized system used to control moisture in soil

When not was made adequately the irrigation process and being improved when a new automated system was designed and developed, which is illustrated in figure 1 and its operation is explained in steps. The new device as a prototype proposed as an automated action to detect any situation of critical function represented as a block diagram in figure 3, to control times, increasing the production time and reducing the stop time.

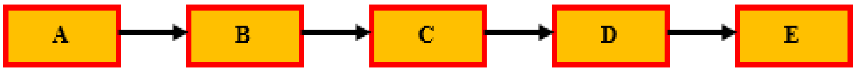

Fig -3: Steps of the automatized system used to improve the irrigation process in the agricultural industry.

The robust device contemplated in figure 1, considers the next steps explained now of with each step:
A) Power supply. Generates the electrical energy necessary for the automated system to operate in optimal conditions.
B) Detection of humidity. Has the function of detect the humidity any zones of the crop aera cultivation, with specialized electronic sensors and send an electrical signal to next step, in two actions, when (1) the soil has humidity and (2) soil does not have humidity.

C) Indicators of detection of humidity in soil. This step originates two types of signals with an electrical bulb of red color when not exists humidity in the zone of soil analyzed, and with other electrical bulb of green color, when exists humidity in the soil evaluated zone. This part is an automated operation, indicating only one function (red or green colors).

D) Water supply action. When the soil required water to moisten the soil for the asparagus cultivation process, was activated a water pump, to supply water and maintained the adequate moisture in soil.

E) Data information storage process. The automatized device was connected to a computer system that stored the data captured of this automatic component to control the moisture of soil to obtain the major crop yielding of asparagus in this investigation.

3.3 SEM analysis in soil

This part of the scientific study was made to detect by periods of time, when was begin the deterioration of soil and take the detection to inspect and use the AS adequately to avoid this physicochemical phenomenon. This microevaluation action was made with the SEM technique, where was observed in the figure 4 the deterioration process of the soil in this agricultural industry evaluated.

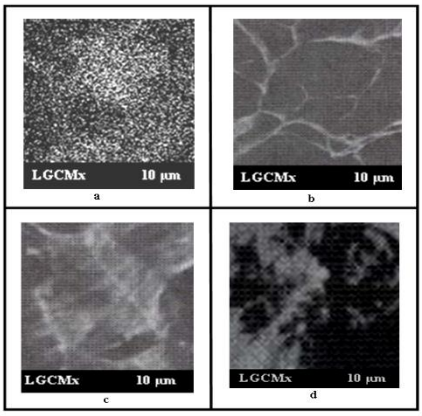

Fig -4: Microanalysis at 10X of the steps of deterioration soil at: (a) 1 day, (b) 3 days, (c) 5 days and (d) 7 days without moisture in the agricultural industry evaluated

Figure 4 shows the deterioration process, where was observed the process from 1 to 7 days, being illustrated by the presence of white zones in each microphotography of the four sections at 10 micra, and was appeared as a white point in the first section, then white lines. Also, white bit zones and finally white big zones, considered the deterioration process of soil of some areas of the cultivation process of the agricultural industry evaluated. This occurred before made this investigation and apply the automatized system.

3.4 ANOVA Analysis

The Anova analysis represents the numerical data of the average values of any type of evaluation, about the periods of cultivation and crop processes, where were evaluated all parameters mentioned, being the pH in soil and water and use of nutrients the most important. This is representative correlation analysis to determine the relation between the parameters mentioned, where are the average is the principal factor and the numerical data that is compared of each value obtained of the experimental process of this investigation. Next is presented the Anova analysis in tables 2 as cultivation process and table 3 the crop process and its explication after the table. The representative level indicates the relation of each value and the average with the difference between it as less than 0.05 (being the 0.05, the 5% of tolerance of defective products or the reach of goals at 95%, which is the difference of 100% of the 5% using as representative level). Table 2 shows the maximum representative level with the cultivation process, which was compared with other factors as atmospheric temperature and relative humidity, type of material used in pipelines to transport water to the cultivation process, and the use of G flow as new method in this type of agricultural industry. These meanings that the cultivation process was very important in this scientific study and indicates that all plants of asparagus grown adequately. In this investigation, was considered this factor as relevant and was applying optimal methods to improve its industrial processes and was elaborated courses of this relevant topic to specialized people and operative workers to take care of any type of residue and dispose to the specialized department of each industrial company to avoid any type of environmental and health symptoms to people of the manufacturing aeras. Others factors were evaluated too, and was observed fewer representative levels with the same type of analysis, calculating the difference of the average and each numerical data, and was obtained the difference with major quantity of values higher than 0.05.

Table -2: Anova analysis of the cultivation process (2022)

Factors Month	Cultivation Process Value	A=Abs (Average Value-Numerical Data)	Representative Level	Observations
January	0.740	0.016	1	Indicates that is significative level
February				
March	0.799	0.043	1	Indicates that is significative level
April	0.768	0.012	1	Indicates that is significative level
May	0.739	0.018	1	Indicates that is significative level
June	0.717	0.039	1	Indicates that is significative level

July	0.675	0.081	2	Indicates that is not significative level
August	0.779	0.023	1	Indicates that is significative level
September	0.857	0.101	2	Indicates that is not significative level
October	0.764	0.008	1	Indicates that is significative level
November	0.761	0.005	1	Indicates that is significative level
December	0.833	0.077	2	Indicates that is not significative level
Average	0.756			
Standard Deviation	0.057			

Representative Level. (1) Have relation and influence this factor in the correlation analysis of Anova
Representative Level. (2) No have relation and influence this factor in the correlation analysis of Anova

Table -3: Anova analysis of the crop process (2022)

Factors Month	Crop Process Value	A=Abs (Average Value-Numerical Data)	Representative Level	Observations
January	0.747	0.025	1	Indicates that is significative level
February	0.873	0.101	2	Indicates that is not significative level
March	0.727	0.045	1	Indicates that is significative level
April	0.727	0.045	1	Indicates that is significative level
May	0.851	0.079	2	Indicates that is not significative level
June	0.676	0.096	2	Indicates that is not significative level
July	0.760	0.023	1	Indicates that is significative level
August	0.856	0.101	2	Indicates that not is significative level
September	0.776	0.004	1	Indicates that is significative level
October	0.770	0.002	1	Indicates that is significative level
November	0.775	0.003	1	Indicates that is significative level
December	0.741	0.031	1	Indicates that is significative level
Average	0.813	0.772	1	
Standard Deviation	0.712	0.056	2	

Representative Level. (1) Have relation and influence this factor in the correlation analysis of Anova
Representative Level. (2) No have relation and influence this factor in the correlation analysis of Anova

Productivity and quality indices in the agricultural industry of the Mexicali Valley

These important parameters were evaluated to determine the effect about the knot use of automatized system (before tis scientific study) and use the AS in the cultivation process and observed in table 4.

Table -4: Evaluation of productivity and analysis of the cultivation process (2022)

Factors	Productivity, %		Quality, %	
Month	WTAS	WAS	WTAS	WAS
January	57	78	53	80
February	61	79	50	82
March	60	80	49	79
April	58	83	50	77
May	59	79	53	82
June	63	80	55	80
July	60	81	52	84
August	64	80	50	82
September	65	84	56	84
October	63	85	54	83
November	62	82	55	81

WTAS. Analysis without use automatized system
WAS. Analysis with use automatized system

Table 4 illustrated the difference of the productivity and quality levels, where was used the automatized system and not use it, showing an increase with the use of the AS, and with this the economic gains.

4. CONCLUSIONS

This investigation got relevant results about the cultivation and crop processes of asparagus in the Mexicali city, which is a region located in the northwest of the Mexican Republic and were participate specialists of this interesting thematic. One of the important aspects to be able to grow a coveted vegetable, which is asparagus; is the preparation of the soil, in addition to controlling the moisture when was utilized the automatized system and avoid the soil deterioration. It is necessary to make trench furrows with a width of 30 centimeters, to place a layer called humus, in addition to compost, manure and nutrients, such as those mentioned above in this scientific study process. The use of mathematical algorithms in this investigation was considered as a new tool in this type of activities and also, the use of the G process flow, as new process flow, was increased the productivity and quality of the asparagus in the agricultural industry where was made this scientific study. This generated a reduction in the costs by errors in the manufacturing processes and a low percentage of bad asparagus (with less size, weight, dirty and contaminated), as was obtained before this scientific study; to increase the economic gains. In this investigation, was evaluated the distribution flow in the warehouse putted the carton boxes of asparagus, to detect quickly any type of bad asparagus, and not originate any problematic situation in the cultivation and crop processes.

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