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An Evaluation of Impact of Precision Farming on the Production of Medicinal as Well as Aromatic Crops

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ABSTRACT

Precision site-specific crop methods of production have grown increasingly popular in countries with modern agriculture. It is not unexpected that adopting precise approaches is now necessary in the cultivation of therapeutic crops. Therapeutic herbs, also referred to as herbal drugs, have been discovered and used by humans in conventional medical treatments since ancient times. Many chemical compounds are produced by plants for a variety of purposes, including defence and protection against herbivorus animals, fungus, insects, and illnesses. While aromatic plants are utilized for their scent and flavor, medicinal plants are often those that are employed in modern and traditional medicine. Although smart farming as well as agriculture in aromatic and herbal plants have been studied, little has been published despite precision agriculture's long history and recent significant proliferation throughout the agriculture and scientific communities. The use of this novel approach and innovation can only be effective if it promotes ecological preservation and sustainable production. It's interesting to note that this later area is more advanced than modern (precision) plant production methods while examining both seasonal and permanent woodland plants, as well as when describing interplant interaction. It is possible to discover new techniques for using sensor networks in ecological studies from the study of therapeutic plants. The chapter discusses the potential applications of hand-harvesting and precision crop production technology devoted to the growing of therapeutic herbs.

Keywords Medicinal plants, Aromatic crops, Precision farming, GIS, GPS, Remote sensing.

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INTRODUCTION

The concept of precision crop cultivation from an engineering and IT perspective focuses less on defining the term "precise" and more on the gathering and administration of data using site-specific, or positioned, technologies (Auernhammer 2001). Therapeutic herbs, also referred to as herbal drugs, have been discovered and used by humans in conventional medical treatments since ancient times. Many chemical compounds are produced by plants for a variety of purposes, including defence and protection against herbivorus animals, fungus, insects, and illnesses. While aromatic plants are utilized for their scent and flavor, medicinal plants are often those that are employed in modern and traditional medicine (Petrovska 2012). Even though a particular technology may be extremely accurate, it cannot be considered a component of precision crop cultivation if the various conditions (soil characteristics, topological variations, prior treatment options) within spatially diverse treatment facilities (managerial zones) are not addressed in a customised manner. In contrast to conventional plant production, precision plant production requires precise gathering of information and treatment regarding technical aspects. This is because technological advancements in accuracy plant production must not only be spatially situated but also retain the accuracy of detection and remediation in line with site-specific strategies (Rao et al. 2004).

To achieve the aim of precision plant production, however, the needed accuracy must be carefully considered because the economic factors cannot be ignored. The results of the research shown that biological systems may not only tolerate certain errors but also correct them. Nearly anything is technologically possible in terms of precision, but greater accuracy also results in higher operating expenses (Finger *et al.* 2019). As the fundamental information is extremely exact, accurate plant production systems offer the opportunity to connect together the many production rates (from of the individual species through the field, land, region, and global level). New technology simultaneously enhances economic circumstances while reducing environmental effect (Barbaro *et al* 2011). The entire area was handled as a single homogenous unit in conventional plant production. The experiences demonstrated that indeed 1 ha of such a given area is sometimes too big to handle as a single, uniform management zone (Kovacs *et al.* 2014). Allocating area is responsible within the field where primary soil chemical, physical and topological structures may be viewed as a homogenous unit is one of the most challenging undertakings. Artificial intelligence techniques like neural networks and fuzzy logic are employed to complete these tasks (Mike Hegedus 2006). The trend is, however, to descend from the level of the organization zones to that of the specific plant. The issue is that those parcels only have roughly uniform properties, thus we must instead take into account the mean scores of several attributes. On-the-go detection technologies are the answer because they enable cost-efficient data collection and the creation of massive datasets, allowing for the definition of uniform treatment unit sizes based on data analysis (Reyns *et al.* 2002).

With the use of decision support models, the necessary treatments (such as the quantity of fertilizers, may be determined based on the features of the regions in a way that maximizes potential productivity while maintaining the need for sustainability. Although methodologies, IT (Information and technology) would be accessible for use in this sector of medicinal herbs cultivation as well, accurate crop production innovation has not yet gained widespread adoption (Singh 2010). The usage of pesticides for crop protection cannot be greatly decreased in practice using site-specific plant production technologies, as is widely recognized. But, if somehow the reagent could be sprayed as early as the infectious illness or pests show on the plant, it would be a significant advancement in the development of therapeutic plants. One may argue that true sustainable farming does not yet have the required top quality to safeguard medicinal herbs (Blackmore, 2002).

For example, the perseverance of the images produced using armed drones (UAV, unmanned air vehicle technique, e.g. Microcopter) is sufficient to identify relatively tiny objects at a height of 40 to 50 meters. As a result, we are quite near to becoming able to identify insects just by looking at them. Due to the rapid reaction, the amount of chemicals applied and any possible losses resulting from the quality of the plant being produced may both be considerably reduced. GIS (Geographical Information Systems), one of the fundamental components of precision technology, is frequently used in the tracking of wild animals, whether determining their range of dispersal or doing a TSA (Time Series Analysis) of their presence. Trend appears to be the exact reverse of the conventional vegetal observing: In one situation, the examination begins at the native (independent) side by side and progresses to the provincial level, whereas in the additional, the inquiry begins at the local level and progresses to the community scale, all the way to the level of each individual element or even minor constituents (Nemenyi *et al*. 2003).

Diversity and sustainability

This made the most impact on how people think about sustainability. The emotional restraint of ethics has been added to the ecological, social, economic, political and other elements. The expectation of utilizing the fertility potential of arable land to its fullest should be added to the concept above from an agrotechnological and social perspective, though. It's crucial to remember that hunger claims more lives each year than AIDS, malaria, and tuberculosis combined (FAO). The need for obviously biodegradable fresh resources for industrial and medicinal herbs has also been rising year over year at the same time (Patel *et al.* 2004, Naresh *et al.* 2012).

Because of intensive agricultural methods since the turn of the twentieth century, 75% of the genetic variability on arable areas has vanished. We must stop the loss of biodiversity worldwide if we want to maintain biodiversity in the ecosystem of arable land. On the other hand, it is impossible to ignore the most likely climatic change, which will drastically alter agricultural technology and practice. The signs driving a rise in variety as well as technological advancement must be considered by state decision-makers as well as farmers. Local communities must work to increase variety (Saunier and Meganck 1995). Thankfully, the condition is not as dire worldwide as it is in the so named industrialized nations, therefore extensive investigation is done to evaluate the present condition and track developments to ensure that the right interventions are effective. Particularly with regard to medicinal herbs, this is true. There are several excellent examples of this: A total of 187 distinct medicinal plants from 53 different families and 163 different species were examined in South Uganda. These plants' foliage, stems, bases, bark, branches, sap, bulbs, blooms, seeds, internodes, and fruits are among the components that are prepared for use in medicine. These species were either harvested from the wild or grown in gardens. According to the author, it must be made sure that these therapeutic vegetation are always present as uncooked resources (Ssegawa 2007).

At Malaysia's Tekai Tembeling Forest Reserve, which has 6,788 unique vegetation and other floras and contains 87 families, 179 genera and 331 species quantitative analysis was done. The researchers have determined that, given the forest's abundance and diversity of medicinal species, conservation evaluation must be launched instruction to upsurge the variety of curative species found there (Eswani *et al.* 2010). In order to classify the types, ideally the local or prevalent, and vulnerable healing plants, other examinations of plant variety were conducted in the Manali Wildlife Sanctuary of the North Western Himalayas. A total of 270 distinct species, divided into 84 families plus 197 genera, have been studied. The plant that is most therapeutic has been discovered between 2,000 and 2,800 meters above sea level. The diversity of plants reduced as altitude rose. There were 98 endemic species and 62 native species combined. The authors (Rana and Samant 2011) recommend systematic monitoring to look at modifications to the population in addition to changes to the environment of the threatened medicinal plants. The aforementioned instances unequivocally demonstrate that in order to successfully monitor, the problematic of protecting the variety of pharmaceutical plants must be addressed (Ali 2013).

GIS

The GIS (Geographic Information System) stays essentially a structure for managing geographical data, which aids in making well-informed decisions. It is crucial to stress that qualified personnel are needed for data analysis in order to reliably obtain information from vast databases. Yet, the GIS program includes a variety of mathematical methods for data processing and analysis. From the users' perspective, GIS is an inter digital mapping system that can alter data stored at multiple layers. As a result, necessary information can be gathered and relationships between the various layers may be examined using mathematical techniques (Fourie 2009). GIS libraries and information sources are necessary for models used in ecosystem and agro ecosystem applications. A geographic data analysis system's use might be crucial for model validation. We can monitor unique species, such as medicinal plants, thanks to a tool named Common Land Unit Program that ESRI (Wyland 2008) created in 1997. While processing data, one option is to periodically gather information (monitoring) on a certain plant. South Africa Fourie (2009), ESRI. The researched fields' contours were digitally captured from satellite photos, and at random, 45 by 45 m portions were chosen to gather data for validation (Nemenyi 2003).

Aerial photography was used to gather additional information from every field in to help identify the various species of plants. Statistical analysis follows this method. In the Eshkevarat area, which is situated in Iran's northern area, the growth rate features of viper's bugloss (*Echium amoenum*) were researched in hopes of examining the environmental effect on the growth and conservation of the species. Also, the impact of this plant on rural society's economic well-being was looked at. Data processing was done using GIS (Eslami and Kaviani 2011). GIS were used to assess the German chamomile medicinal plant's capacity for production as in province of Khuzestan's north (Iran). Relevant parameters were assessed at several geographical and temporal resolutions, including environmental elements, soil physical and chemical features (organic matter, EC and pH), climatic influences (precipitation and temperature), and topography (DEM). The ILWIS (academic 3.0) GIS program was used to evaluate the data, and 4 classifications were reached (Pirbalouti *et al.* 2012). The maps used in this study showed that, in the north of Khuzestan, 0%, 1.5% (15868.35 ha), 32.7% (345,930 ha), 65.8% (696091.6 ha), and N% of land, respectively, are presently desirable (S1), temperately suitable (S2), slightly suitable (S3), and not ideal (N) for chamomile plant production. You may learn more about this topic (GIS) by reading the publications by Nemenyi *et al.* (2003).

GPS (Global positioning system)

If GIS is used for crop cultivation, environmental data processing, or ecological data processing, more and more precise location of the acquired data is needed. Yet, increased positioning precision is needed for data gathering (detection and sensoring) for entry requirements (chemical fertilizer applications, planting). Nowadays, mobile technology is widely used. Due to this technique, the delay between identification and application is relatively small (2–3 s). At this period, the needed dose must be calculated, and application must begin with extreme precision (Unal 2020). The NAVSTAR GPS, or Gps for short, is the earliest and extreme sophisticated satellite-based location system. The system's most crucial component is founded on motions provided from several satellite broadcasting circling the earth. Depending on distance and time calculations, the GPS receiver determines its location. Users may always see between 5 and 11 satellites since the NAVSTAR organization's satellites move in six orbits, with a minimal of six satellites in each orbit. There are presently 31 operational satellites transmitting the location signals to the recipient as the oldest satellites must remained operational for a elongated period of time than anticipated Unal and Topakci (2015).

GNSS (Global Navigation Satellite Systems) offers additional facilities, including: Russia is in charge of the GLONASS, which has three orbits and eight satellites scheduled for each orbit. Although the military runs both systems, certain exposed signals are also made accessible to resident users. The most current GNSS, termed Galileo, is considerably different from the ones discussed previously in that it was intended to be run by civilian organizations. Also, this system is anticipated to have three orbits with ten satellites within every orbit and be accessible to customers in 2019 (Unal 2020). The users must be able to see at least 4 satellite broadcasting in order to get to the correct location. The positioning process is based on time and distance measurements. We are aware of our distance from different satellites during positioning. The distance between each satellite and us can only be on a sphere's surface, but if two spheres cross, our position can be reduced to a circle. We can determine which of two spots the three components intersect by comparing our location to a third satellite. The fourth domain in theory is the Earth's external, but since measuring the distance to the fourth satellite is more precise, the first of the remaining two locations will be chosen. The accuracy will increase with the number of satellites visible because the receiver's clock is significantly more incorrect (Lachapelle *et al.* 1994). Precision agriculture is evolving from being simply site-specific to being extremely exact. It is possible to achieve sub-inch (under 2.5 cm) precision by employing methods used to identify, such as RTK (Real Time Kinematic) approaches with one's own bases and mobile post or by means of the most precise locating service. This implies that a predetermined path can be tracked using auto navigation for planting, mechanical plant culture, or chemical plant protection. The capability of this equipment to vary the tracks for influence the equipment allows for the avoidance of soil compaction, which is one of its major benefits. It is crucial to stress the fact that improved precision technology has positive effects on the economy and the environment (Yousefi and Razdari 2015).

Remote sensing

As was already said, GIS offers helpful data when the input data is accurate sufficient to permit data processing. Other remotely sensed detecting technologies will replace the ESRI techniques stated previously, which include monitoring plant species from an aircraft. This would drastically minimize the number of checks. If one considers diversity conservation, the issue is clearly stated the Damayanti *et al.* (2011). Just 0.05% of Indonesia's medicinal herbs had already been discovered or had data on them accessible until 2001. There were the following fundamental issues: 1. Due to their lack of understanding of the fundamental distinctions in medicinal plants' variety, the amount of locals who could identify the plants is limited, 2. There aren't enough books and manuals available, and these institutions don't have enough taxonomists with the necessary training to do this task. The fact that this activity requires a lot of time and labor is another major issue. The writers exhort the future generation to pursue more education and specialization in this area. They contend that the research institutions would require additional expertise (Seelan *et al.* 2003).

The primary idea behind the approach for detecting the spectrum reflectance properties of leaves is that reflectance is dependent on how the greeneries appear in usual light. Green leaf area has low reflectivity in the visible region of the spectrum, however high reflectance is usual in the NIR (Near Infrared Reflectance) spectrum under stressful situations, such as those caused by a lack of nutritive ingredients. The fundamental idea behind using foliage indices is this. NDVI (Normalized Differential Vegetation Index), which is computed as (NDVI 14 NIR - RED and NIR+RED), or RVI (Ratio Vegetation Index), which is computed as (RVI 14 NIR / RED), are two of the most used vegetation indices (Pinter *et al.* 2003). For the analysis of crop canopy, both indices are used. On earth, all substances emit photons in the infrared spectrum of temperature (8–14). Evaporation has a significant impact on the surface temperature, making this phenomena capable of detecting physical changes in a variety of domains. Temperature disparities develop when damaged plants' leaves or stalks evaporate less quickly than healthy ones. The scenario is similar when separating weeds from soil or different crop cultivars (El Nahry *et al.* 2011. Mesterhazi 2004).

Contrarily, hyperspectral technology may offer ongoing spectrum in the visible, NIR, mid-infrared, and thermal infrared regions of the electromagnetic spectrum by dividing it into extremely tiny bands (of even only one nm band) (Shippert 2003). It is crucial to have exact knowledge of the cannabis plant in order to boost prevention, as drug use is rising sharply. Azaria *et al.* (2009) used aerial (AISA EAGLE 400-1,000 m) and oblique view (25-80 m) hyperspectral imaging techniques to identify cannabis in lab settings. Using the approach known as PCA (Principal Component Analysis), the collected data were assessed. Cannabis may be identified most effectively using the bands 530–550 as well as 670–680 nm (foli and canopy) (Govender *et al.* 2007).

Detection of weed as well as plant disease

Computer vision techniques must be used if more than one crop emerges in a field that has to be identified. The work of Andersen contains comprehensive details regarding computer vision methodology and real-world applications (2002). The description of shape and texture attributes was performed using the Content-Based Image Retrieval (CBIR) technology (Shapira *et al*. 2010). Fourier, unspecific The last descriptor, Fourier and Gabor-Zernike, has the best retrieval efficiency (92%) (Basavaraj *et al.* 2012). Hyperspectral imaging and computer vision-based methods for spotting variations in spot color or form can both be used to identify plant diseases. The image makes it very evident that different illnesses may be distinguished in the NIR spectrum (Sgouros 2008).

Ecophysiological models

The ecological and evolutionary models have two applications. One of these is the explanation of the rise of residents in nature, specifically the impact of climatic variables on growth. Using this approach, yield may be forecast. According to Popovic and Lindquist (2010), the framework is employed to explain the growth of various seasonal and perennials forest medicines as well as crop rotation competition (Gee *et al.* 2021). Plant production is another potential use for the morphological and physiological models. It is mostly utilized towards yield prediction, and models are created for this purpose. There are no production models for medicinal plants at this time. These models, like the ones previously described, take into account technological aspects like land preparation and technological characteristics of formerly crop species in the study area. These models have a distinctive feature in that they remain used in site-specific herbal manufacture, which implies that yield prediction is done locally (Nyeki *et al.* 2013).

Technological setting for production in precision plants

The size and placement of the zones are chosen using ai technology (fuzzy logic) in cases when soil physical, anatomical, and technical data are available. As was previously indicated, these zones are thought to have comparable characteristics. Research is ongoing because it's crucial that seed yield plus water content readings be accurate (Csiba *et al.* 2013). Because of the high dispersion and high expense of collecting soil samples in the past, averaging made the results untrustworthy. Data gathering on a variety of soil's physical and chemical characteristics is now feasible because to a recent technology advancement called on-the-go data collection (Mouazen *et al.* 2013, Nagy *et al.* 2013). Fertilization replenishment plans may be provided to a specific management zone rather easily utilizing these databases and the records from the climatic situations monitoring. It is important to note that result care models for fertilization are always being improved (Nyeki *et al.* 2013).

Modern variable rate peddlers apply fertilizer components in solid, liquid, or organic forms in accordance with the fertilization plan. There are various seeding equipment that can perform this function now, and precision agriculture has access to enough data to support variable rate planting. Variable rate watering is also the subject of study that is closely related to climate change in site-specific applications (Kovacs *et al.* 2014). In the past, different herbicides were diluted with water stored in a container. This isn't a particularly environmentally friendly practise since it is very difficult to determine how much chemical is needed for a field, and one area of the field may be overstressed by double-spraying the remainder. Landscape fuel injection spraying has become more popular during the past ten years. In this method, the first phase is weed classification and identification, the step two is weed modeling and selecting the right chemicals, and the third and last step is loading the chemicals into sprayer tanks. Only the necessary amount of chemical is applied by the landscape direct injection sprayer to the weed-covered patch (Mesterhazi 2004, Nemenyi *et al.* 2006). As a result, modern plant protection equipment can shield crops against diverse weeds using a variety of chemicals. The usage of chemicals may be significantly reduced thanks to this technique. The most advanced thermal micro-spray technology yet created by Davis University researchers (Zhang *et al*. 2012) has the potential to revolutionise environmentally friendly weed management.

CONCLUSION

The review is reassured that by combining their individual expertise and knowledge, biotechnologists, biosciences engineers, GIS researchers, chemists, physicists, plant breeders, biotechnologists, and last but certainly not slightest agricultural engineers can utilize the potential of a particular sector in an environmentally conscious and sustainable manner. The use of this novel approach and innovation can only be effective if it promotes ecological preservation and sustainable production. It's interesting to note that this later area is more advanced than modern (precision) plant production methods in the study of annual and perennial woodland medicinal herbs as well as aromatic in the account of interplant opposition. It is possible to discover new techniques for using sensor networks in ecological studies from the study of therapeutic plants. The chapter discusses the potential applications of hand-harvesting and precision crop production technology to the farming of medicinal and aromatic vegetation.

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