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Studying yield variations using precision farming in a date palm orchard

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Precision agriculture is a very cost effective for date palm orchards because a positioning system naturally exists as the tree positions are fixed and groves are always highly structured; the harvest and fertilizer are applied by hands, therefore there is no need for a GPS system. The aim of this research was to evaluate the effect of spatial treatment by precision farming in the productivity of a date palm orchard. An orchard of one ha and 186 Mozafati palms was selected for the experiment near the city of Bam in Iran. To study the performance, the number and location of male trees, trees age, yield, fruit length, bunch population and visual appearance were measured and recorded. A point at a corner of the orchard was selected as the center of an XY coordinate system then the tree location map was produced. Surfer software was used to analyze the data and to produce the tree characters maps. The maps show the management weaknesses including extra number of male trees which can be replaced by productive ones, combine plantation of young and old trees, the location of low production trees and the healthy condition of the trees. If this procedure is repeated for several years a comparison among characters will lead to new strategies for the grove. These simple insights to the orchard can increase the benefit and reduce the environmental damage. It is specially a useful tool for those farmers who do not visit the orchard so often and assistants run the business.

Key words: precision agriculture, yield map, date palm orchards

Introduction

Date is one of the most important fruits in more than 30 countries. It is a concentrated energy food which can be easily stored. Many products are obtained from date including sugar, honey, vinegar, juice and flour together with handicrafts such as baskets, ropes, hats and carpets derived from the leaves. Dates are spread around the desert regions of the world. The date total world production is approximately 5500 thousand tons. Iran date production is about 875 thousand tons. Over the period of 1999 to 2001, Egypt, Iran, Saudi Arabia and Pakistan has been producing 61 percent and Iraq, Algeria, United Arab Emirates, Oman and Sudan 29 percent of the total world production (Zaid, 2002). At these countries

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most of agricultural operations are being done manually which is very hard and time consuming (Shamsi, 1999). Any economical justified new method which can reduce these operations is welcomed by date growers (Al-Suhaibni *et al.*, 1992). Precision farming is a potential help which has not been introduced to growers and they use traditional management methods to run their groves. It is a system approach to manage crop and land selectively, according to their needs. Precision agriculture is the management of variability of yield in different points of a farm to increase the benefit and decrease the environmental damages. In most cases it needs the integration of high knowledge and technology tools (Timmermann, 2003) which farmers in developing countries cannot afford it. Some cases around the world show that the expensive elements of precision agriculture exist in the nature of some plantations and the high technology of precision agriculture is not essentially required for these farms. One example is tea which is planted in structured block in seven-year's cycles (Emmott, 1997) when each block surveyed and identified uniquely, positioning systems such as DGPS are not required. The measurement of variability of crop and soil is possible by producing manual yield maps for each block. Inputs are also applied by hand therefore the treatment map can easily applied by labors. In these conditions precision agriculture is not a complex technology; it is easily a key factor of successful management, by understanding the variability of yield in different points in the field through using manual yield maps. Another example is paddy rice in Japan (Shibusava, 1999). Date palm grove is a similar case where the positioning system naturally exists, because the tree position is fixed and groves are always structured. The harvest is by hand and fertilizers are applied by hand (Blackmore, 2005). The yield maps could be produced by recording the tree yield, fruit quality and other required data for each tree. These data can be used for better management of the grove to improve the benefit and environmental damages. It is important to know that a survey in Denmark shows that yield mapping clearly tops the list of employed precision agriculture techniques (Sorensen, 2002). It is probably the same in many other countries. Produced yield maps end to variable treatment of the crop and soil, which is the main aim of applying precision agriculture.

The date growers in the Middle East do not have a clear view of the trees condition such as tree yield and quality therefore they can not manage the orchard as they would by using new technologies. The main objective of this research was applicability of precision agriculture in date palm industry.

Materials and methods

To apply the yield mapping technique an orchard of one ha area near the city of Bam in Baravat was selected for the study. Few days before harvesting the location of trees were surveyed and plotted relative to a XY coordinate

system, fixed at south west corner of the orchard. A number was allocated to each tree. During the harvesting period for each tree important data including tree visual appearance, tree yield, fruit softness and length, tree number of bunches and tree age were recorded for a total of 186 trees. To measure the fruit softness and length, 10 random fruit samples from each tree were collected. Three levels of dry, semidry and juicy were allocated to fruit freshness. Largest dimension of fruits were measured and recorded as the fruit length. Depending on the variety and growing conditions, full production is usually reached after 10 to 15 years accompanied with the maximum number and size of leaves (Zaid, 2002). Therefore the tree visual appearance is an important factor and was determined for each tree by an expert base on the number, size and freshness of leaves and divided into three quality levels including: "Weak", "Medium" and "Good". The data were imported to work sheet of Surfer software version 7. In the field of plot document, the nearest neighbor grid system using separate maps were selected for producing maps. Seven group of maps including; male tree, tree visual appearance, yield map, fruit quality map, fruit length map, tree bunch population map, and tree age map were plotted.

Results

The male and young tree which were less than 10 years old and producing trees (Fig. 1). In all maps black points showed tree positions. For pollination purposes one male tree (does not yield) was enough in each ha (Rohani, 1998), but the maps showed that orchard had 10 male tree which was 5% of the grove population. Grower removed 9 trees and plant productive palm. In this figure young trees had 27 % of grove population and two rows of them exist in west part and one row in east part of the grove. These trees needed different cultural operations from others. Age map (Fig. 2) was helpful to find young trees location. The grower can apply more effective management on cultural operation program of this specific area. Age map also showed that 30% of the trees between 20 and 30 years old and in the center of orchard.

The grove yield map is illustrated in Fig. 3. The total yield of the grove was 10720 kg. By gathering the data of several years grower can predict the yield for coming years to assess required agricultural inputs and money and forward sale of the yield. Analysis of the yield data showed that more than %70 of the trees yield from 80 to130 kg, considering average yield of 20 kg per tree in the country (Ministry of Management an Planning, 2003). This grove is classified as very good. High yielding trees were mostly on central part of the grove. The fruit length map (Fig. 4) showed that most of the grove yields (87%) were big dates having 35 to 45 mm length which it is good for Mozafati variety and is suitable to export. The fruit quality map (Fig. 5)

showed that most of the trees (74%) produce semidry fruits which were although acceptable quality for Mozafati dates. The bunch population map (Fig. 6) indicated that most of the trees (74%) had 6 to 8 bunches. Comparison between tree age map (Fig. 2) and other maps showed that young trees aging up to 10 years have poor yield, quality, bunch population less than 4 numbers and fruit length less than 3 cm. These trees are located along the grove boundaries. Tree visual appearance showed 6% of trees in weak category which showed leaf of these trees that was not fresh and not good appearance. It showed 34% of the trees which indicated in medium class and acceptable appearance for date trees.

Comparison between Figs. 3 and 7 showed that trees with production between 20 and 120 kg had better visual appearance than others. Length of the fruit was one of the important parameters for the consumers and standard of date length which was different from one kind to another and mostly determined by consumer (Zaid, 2002). The length and quality of dates is reduced for tree yields more than 120 kg (figs. 4 and 5). Therefore, grower must reduce number of bunches to eliminate the tree production to the maximum of 120 kg. It showed that trees with bunch population between 6 to 9 are ideal. A regular practice was the removal of entire bunches when their number per palm was too high and depending on variety and growing conditions, full production accompanied with about 10 bunches per palm can be allowed (Zaid, 2002).

Discussion

The maps showed a clear view of the grove to the owner and introduced him a decision making tool to manage his grove more efficiently. It was 18 date growers and experts from 20 in a small survey. It is an effective tool to manage the grove from the office. Collecting more data from several years and analyzing them can give more useful and reliable information from the grove. For example a gross margin map can be produced (Blackmore, 2000) which helps the manager in decision making process. Although the gross margin map was the same shape as the yield map when uniform treatments are applied, it highlights the range of income for the field. A study (Mehrabi, 2004) showed that average gross margin for date production in kerman was 76760 Iranian Rial per tree. The average variable cost was equal to the price of 10 kg of date. In the other hand, the yield map can directly be used for cost benefit analysis; those tree which yield more than 10 kg bring benefit for the owner

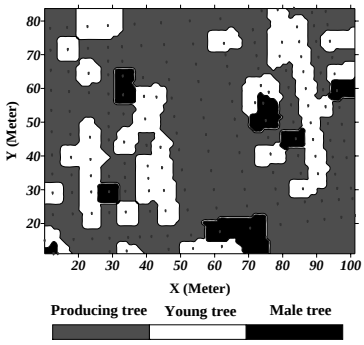

Fig. 1. Male tree map.

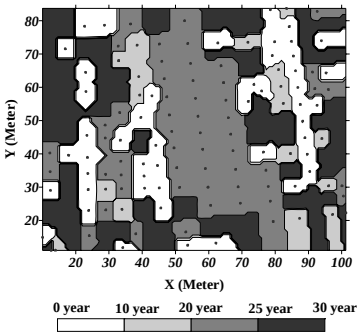

Fig. 2. Tree age map.

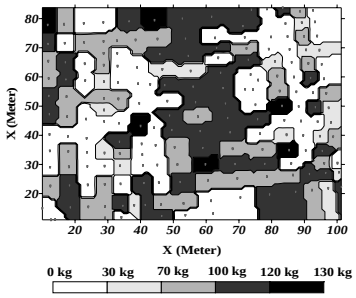

Fig. 3. Tree yield map.

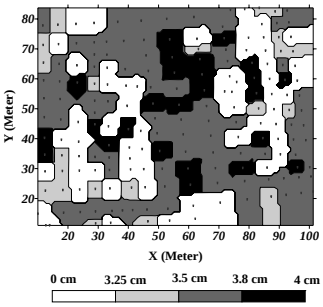

Fig. 4. Fruit length map.

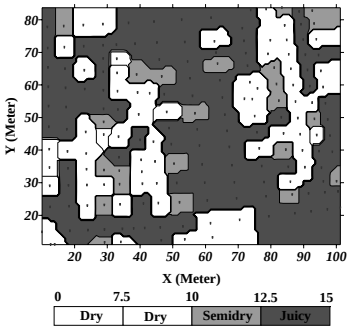

Fig. 5. Fruit quality map

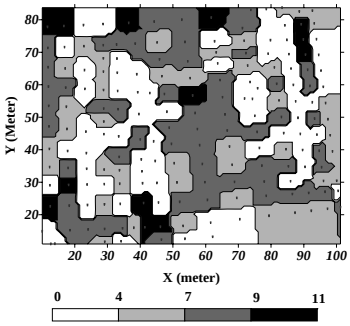

Fig. 6. Tree bunch population map

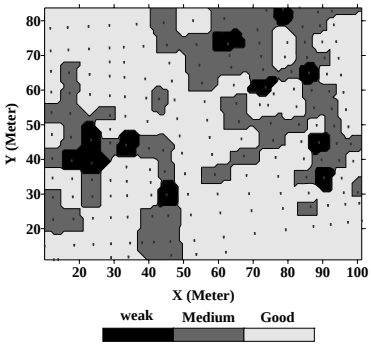

Fig. 7. Tree visual appearance map.

Each map gave some information about the grove. Comparisons among maps also demonstrated extra information. Some white strips are repeated among all these maps (figs 1-6). The age map showed the cause; this part has been occupied by young trees which not have a good yield (fig. 2). The fruit quality and quality is also low at these parts.

Comparison between age map (Fig. 2) and yield map (Fig. 3) expressed that at North West of the grove there was a region with a number of 25-30 year old trees which were classified in good yielding trees. The cause must be investigated by the owner.

Some agricultural inputs like fertilizer, pesticide and vacant fruit boxes are distributed among farmers by local government tool for local government agents to access correct value of low price inputs to each grower. Although yield mapping for dates does not need GPS systems but a study by Shannon *et al*. 2001 showed that compare to an expensive DGPS system a cheap $300 GPS has only a relative positioning differences or error of 1.78 meter. In a modern date grove the spacing between trees was 8 meters. It means that a cheep GPS has enough accuracy for yield mapping of date palm groves, therefore the yield maps can be produced by weighing each tree yield at harvest time and finding the relative position by the cheep GPS. If economically justified it is also possible to develop a more complicated system. To speed system measures the tree yield weighting process a machine vision yield calculator can be used. This system measures the tree yield by a camera instead of weighting fruits.

It can totally be concluded that: precision farming showed many applications in date palm groves management systems. Yield, quality, length, bunch population and age maps clearly showed significant spatial variability and were useful, simple and visual tools to evaluate the grove performance. The results showed a great spatial variability in tree yields from 20 to 10 kg. The local government which provided cheep agricultural inputs for growers be made profitional decision for distribution of aides by ranking groves base on the yield and quality, if they access to date maps of the region. The total benefit by optimizing agricultural operations increase and environmental damage caused by extra application farming techniques.

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