

The Application of GPS for Weed Investigation in Winter Wheat Field

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Abstract

The application of GPS for weed investigation was introduced in this paper. The different scouting approaches for weeds in fields are presented. Two kinds of systems which are included in investigation are analyzed. There are four ways of making field investigation for weed relative information of density and position. The quick assessment is very fast and easy to implement. It works for perennial weeds. The regular grid sampling is a way that can be adopted by farmer for weed scouting, but it sometimes is time and labor consuming. The way of sampling at harvest is a map that is matched to the yield map, but it is an "after the fact". Adaptive sampling using aerial imagery can offer a potential way for weed investigation. There is an example of weed investigation in winter wheat field showed the weed distribution of position and varieties.

Key words: Weed investigation GPS Weed control

1. Introduction

The weeds have presented since farmers began to plant field. They will continue to grow with the grain production process in the future. The big influence of weed is that they decrease the crop yield greatly. The weeds can compete with the crop for the nutrition, sunlight and water etc. Weeds force the crop to decrease vigor and yield greatly. The out-of-control of weeds increases the difficulty of harvesting. And it also increases the input of weed control in the following crop growing seasons. The crop yield of wheat, corn, cotton and soybean decreased 23.9%, 28.8%, 36.3% and 35.3% respectively in the weed out-of-control field. But the loss will be 12.3%, 13.1%, 11.8% and 13% respectively if farmers use the chemical measures. The chemical weed control will still be the main measures for future crop production.

The over-dosage usage has got great environmental pollution in the advanced countries. There are a lot of new techniques used by the developed countries in order to decrease chemical pollution. Two ways of decreasing chemical pollution are widely used by most of countries at now. One way is that improves the chemical efficiency and the other changes the ways of chemical usage.

The broad acre blanket spraying was the way widely used in chemical spraying at most of places. Although the distribution and varieties of weeds are different in the whole field they are supposed to be all the same. In most of cases, weeds are highly aggregated in a field (Johnson et al., 1995). Drainage, topography, soil type, and microclimate play important roles in what weeds will be found and how successful and competitive they will be at a specific site. With the development of modern agricultural technique the genetic agriculture, precision agriculture and large scale production will be the trend in the future. The weed control will alternatively use these advanced techniques in order to reduce input of labor and energy.

The technologies of global positioning system (GPS) are widely used in present agricultural production. The combination of GPS with agricultural machinery greatly increased the production efficiency. GPS can help to input agricultural materials precisely based on the soil and crops. Spray equipment has been developed that will allow for different chemical treatments and rates to be targeted to different areas of the field. But the prescription maps are the keys to control variable input of agricultural products. Using information in the prescription map about weed variability to match the correct chemical with the weed present has been shown to result in better weed control, lower herbicide costs, and increased net return.

Developing effective site-specific weed management map is to obtain accurate and reliable data on the location of weed species and populations. This kind of site-specific weed management is very helpful

to monitor and weed growth and distribution. This will be successful in controlling weeds and improve profit. The weed distribution in the winter wheat field is scouted and the chemical spray map is developed in this research.

2. The components of weed field scouting

The weed field scouting is generally conducted under the help of GPS. The figure 1 is the basic components for the GPS. There are three parts in the whole system. The GPS component is used for positioning the weed patches in the field. The hand held computer is used for recording the data of field and weed infestation information. And the prescription software is for forming site specific weed management map. The weed populations and locations in the field can be recorded on the handheld computer. The weed density between sampling points can be estimated by using kriged interpolation.

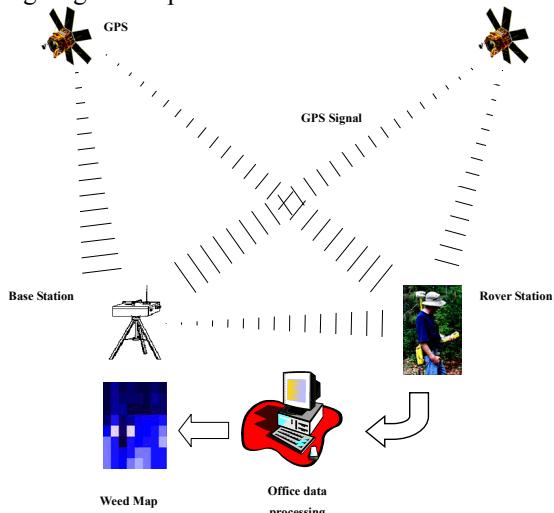


Fig 1. Basic Component of Weed Scouting

3. Recording system of weed field scouting

There are two systems used for weed field scouting. One is for notebook computer and the other is for handheld computer. The DGPS signal is connected with computer through common R232 serial port on the computer. The software can read the DGPS string and display the coordinates of scouting points on the screen. The weed distribution and varieties are also display on the screen which is related with the coordinates of sampling points. The picture of weed infestation can be taken at same time. The figure 2 is a recording menu for sampling. The weeds scope and related GIS attributes can also be recorded in the

database. All the recorded information can easily be downloaded from handheld computer in the office. And the software can interpolate the weed distribution map through Krige interpolation.



Fig 2. The software for weed scouting

4. Weed sampling scale and schemes in the field

Weed sampling scale and schemes in the field must consider the accuracy, sampling time and labor cost. Sampler can not record the weed infestation in every square meters. The sampling season and the anticipated prescription map should be considered. Supposed that the weed map is used for chemical spraying the sampling width would better fit the length of sprayer boom width. If the boom spraying width is 6 meters the sampling grid should be 6 meters too or several times of that width. But sprayer speed and the time it takes to change chemicals on-the-go can be included into the criteria for determining minimum grid size. At 7.2km/h, tractor travels 2 meters per second. If it takes 5 seconds to switch chemicals coming from the boom the 6×10 m² grid would be a more realistic grid size. If the tractor drives faster the grid could even be larger. But if the sampling grids are too big the heavy weed infestation sites may be neglected. Therefore there are four ways widely adopted in the weed field sampling in the actual production.

4.1 Field random sampling

There are two ways for the random sampling. For the small area the sampling people walk through the field , record the weed infestation position and weed varieties. But for the large areas, use a vehicle with DGPS to quickly identify the location of weed patches by driving in a grid pattern across the field, stopping only where weeds are present. This can be

accomplished by splitting a large field into areas with similar topography (drainage area, hilltop, side slope etc.) For each area the weed infestation is investigated. The advantages for this kind of sampling are that the GIS software will allow to determine percent field area occupied by the weed patches or individual weed patches. It is also very useful to determine the optimum time for chemical spraying. But its disadvantages are difficult to identify the weed patches when weeds are small. There will have a big difference for the real weed infestation and the investigation results.

4.2 Uniform field grid sampling

The grid sampling is collected data on a uniformly spaced grid coordinate system. The sampling software can show the grid node for sampling. The figure 3 is the software that used for grid weed sampling. The users can select the sampling style and determine the grid attributes. The grid sizes can be obtained through three ways. The first way is that users input the length and area of sampling. And the software can automatically calculate width of sampling. The second is the width and area of sampling. The length of sampling will show automatically. The third way is that the uses input sampling width and length. The software also can show the sampling grid points on the screen. The software will give a beep sound when the sampling person closes to the grid node. And the figure 4 shows the guiding screen for telling the optimum routine of completing the sampling. There are several ways for recording the weed infestation in the fields. The first is to record the actual weed density for different species. This method can be time consuming when weed density is high but does provide valuable information. The second method involves counting the weeds that will have a yield influence on the crops. This method is less time consuming than the other methods but does not provide detailed information on individual weed species. It can not evaluate the weed infestation in the whole field.

For the advantage of grid sampling the weed distribution map can easily be got through interpolation techniques. The map can show the weed coordinate and their species. But its one of disadvantage is to be difficulty for determining the grid size. The labor input and cost must be considered. Of course the weed grid sampling also has shown to be an effective method for soil sampling, where soil properties change gradually across a field and usually occur in larger blocks.

4.3 Weed sampling on the combine

The yield mapping system (yield monitor) has been widely used on the combine. There is a DGPS system on the yield mapping system which can provide the coordinate for combine. Therefore the weed sampling can be conducted with the yield monitor. Simple devices are connected to the DGPS signal on the yield monitor to record weeds as a field is harvested. The driver only needs push buttons on the device when he enters a weed patch. The driver also can push the button when he exits a weed patch. A weed map can be matched with a yield map. The weed map also can explain the crop yield change in the whole field. If the weeds are perennial the herbicides can be sprayed to the weed areas after harvest. This is an “after the fact” map and weeds have already caused harvest losses. Furthermore the driver will push the button continually when harvesting in a heavy weed infestation field.

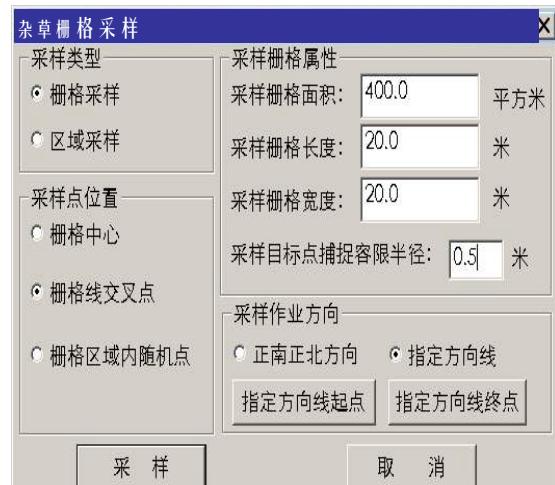


Fig 3. User interface for grid sampling

4.4 Remote weed sampling

The multispectral remote sensing techniques have been widely used in agriculture in recent years due to its low cost. It can be taken several times during a season or over years to give views of whole fields, farms and watersheds. The key points of remote sensing weed investigation are remote resolution and timing. Images taken just prior to post-emergence applications using a combination of visible and near-infrared bands can give information on the location of weeds. The remote sensing images also give a possibility of changing the sampling strategy by having access to weed information on a field scale in a timely fashion. But for its disadvantages the remote images must be analyzed by the trained professionals. Therefore, there may be considerable time between

when the data was collected and when it becomes available. For the post-emergence weed control the processing time for the images may be the main problem for missing the correct season for spraying chemicals.

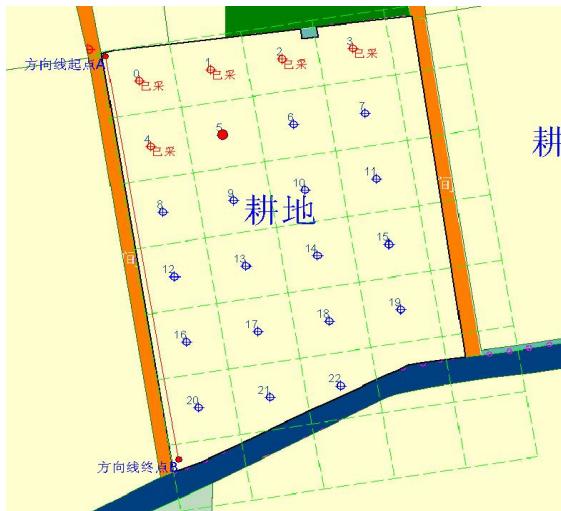


Fig. 4. Field guidance for weed scouting

5. A case study for weed sampling in winter wheat field

A field weed scouting was conducted in winter wheat field. The investigation started in early spring. The weed maps for different species are obtained. And a prescription map of chemical spraying was completed. The weed control result is perfect.

The investigation was conducted in Beijing Xiaotangshan National Precision Agriculture Experimental Station. The field investigation was grid sampling. And the grid size was $50 \times 50 \text{ m}^2$. The weed species, density and coordinate were recorded. The GPS was from Trimble company. The DGPS was got through the local differential treatment. And the position error was less than 1 meter. There were total 4 kinds of weed present in the field when sampling. The weed nominal name were *Humulus scandens*, *Convolvulus arvensis*, *Chenopodium album L.*, *Abutilon theophrasti Medic.* respectively. The investigation results are processed by ArcView3.2a software. And the inverse distance weights (IDW) was used for data interpolation. The density distributions for four weed species were interpolated and the results were showed in figure 5 respectively. The coordinate system in the process was Beijing-54 coordinate.

From the figure the weed distribution has the characters of patches. The four kinds of weeds didn't grow uniformly in the field. The *Humulus scandens*

grows on the corners except on the right lower corner. The *Convolvulus arvensis* is in the middle of field. The most of *Chenopodium album L.* distributed in the middle of field. And *Abutilon theophrasti Medic.* Is in the center and corners. If four weed maps are put together there are less weeds in the east of field. Therefore the less chemical herbicide can be used than the traditional ways.

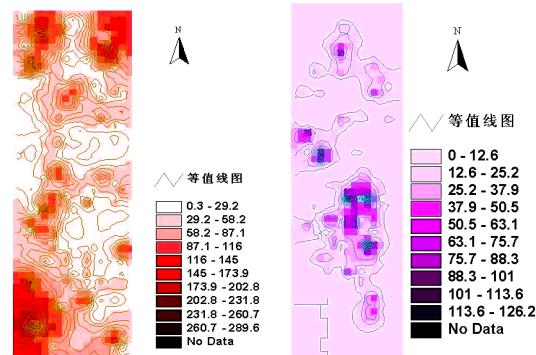


Fig. a *Humulus scandens* Merr.

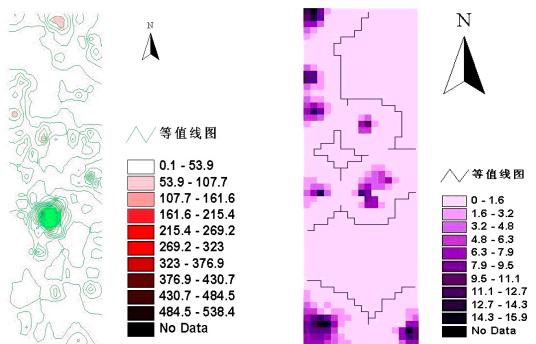


Fig. b *Calystegia hederacea* Wall.

Fig. c *Chenopodium album L.*

Fig. d *Chenopodium album L.*

Fig 5. Weed distributions in winter wheat field

6. Summary

Weed field scouting using GPS can get the field weed distribution map. It will be very helpful for improving chemical efficiency. The intelligent weed sampling and coordinate combination with the weed distribution is key point in the design of effective weed management strategies that help manage risk by providing information for weed control. This can increase the ability of weed control management. And it also can help to realize the target spraying of chemicals.

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REFERENCES

- [1] Oerke, E.-C., Dehne, H.-W., Schonbeck, F. and Weber, A. (1994): *Crop production and crop protection*. Elsevier, Amsterdam, 808 pp.
- [2] Cardina, J., D. Sparrow, and E. L. McCoy. 1996. "Spatial relationships between seedbank and seedling populations of common lambsquarters (*Chenopodium album*) and annual grasses". *Weed Sci.* 44:298-308.
- [3] Johnson, G. A., D. Mortensen, L. Young, and A. Martin. 1995. "The stability of weed seedlings populations and parameters in Eastern Nebraska corn(*Zea mays*) and soybean(*Glycine max*) fields". *Weed Sci.* 43:604-611.