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Thermal intro Row Weed control Optimized Machine With Image Processing

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ABSTRACT

Farming organic vegetable and crops have grown as a market desiring commodity. Weed control in farms has been costly and laborous and it has always been hard to achieve a proper weeding. A few chemicals are commonly applied in organic farming. Thermal weeding with flame burners seems a good solution; however, it has its own drawbacks, such as; damaging the main crops, low performance, being influenced by enviromental changes, high fuel consumption, etc. A two-burner flamer, protected with steal shield was mounted on a self-propelled frame supported with a DC motor to control the speed. Heat was trapped by shield that allowed greater speed. A digital camera was utilized for turning of the flames and saving gas. Field experiments were conducted during May, 10 days after first crop buds were emerged. Various tractor speeds of, 8, 12 and 15 km h-1 were employed. Grasses are harder to control than broad leafed weeds, due to their protected buds, however, system design maximized flames exposure time which resulted in more efficient weed control, especially in grasses. Damage percentages were greater in the slower speed treatments. Compared with proper weeding and highest speed it was found that speeds of 8 to 12 km h-1 would yield an approval result.

Keywords: Flaming, Burner, Weeds, Gray value, Threshold

INTRODUCTION

Farmer's most vicious nemeses are weeds. Their every year struggle to overcome this issue indicates that. There are two common reasons for that. Firstly, they grow again one or two weeks after getting dealt with. Secondly, high costs of weeding. Moreover, people desire to purchase organic ingredients, rules against usage of chemicals in a wide range and eliminate farmer's choices for weeds annihilation. Mechanical weeding has some flaws and is not always possible. On the other hand, thermal weeding with heat produced by flames can be troubleshooter. The idea of utilization of fire returns back to early farmers. They used to burn stubble of the harvest in order to destroy weeds, insects and their seeds, however it has been proven it harms the micro-organism and reduces soil fertility, too. Agricultural applications of flaming were developed for field crops, fruits and vegetables in the 1940s (Lague et al., 1997). Then, with the advent of reasonably priced herbicides, interest in flaming subsided. Recent developments, including an increasing number of herbicide resistant weeds, higher costs of herbicides, and more concern about

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pesticides in the environment, have resulted in a renewed interest in flaming for weed control (Wszelaki et al., 2007). Rahkonen et al. (1999) implies that the threat of flaming poses to micro-organisms is small because of low raise in soil temperature. Effectiveness of flaming has been proved for field corn (Ellwanger et al., 1973), strawberry (Lampkin, 1990), cotton (Seifert and Snipes, 1996), cabbage (Holmoy and Storeheier, 1993), carrots, sweet corn, and onions (Rifai, 1994), cabbage and tomato (Wszelaki et al., 2007). Ascard 1995& 1997 have studied on fuel pressure and sequence of flaming. Raising the fuel pressure allowed the ground speed to be increased but using tandem instead of single burners did not. Exposure times in the range of 65–130 ms are sufficient to kill many annuals (Ascard, 1997). Time of exposition to flame is very sensitive for a proper flaming and it is brief and only the exposed tissues may be disrupted initially or defoliation. A second flaming that reaches the underlying tissues and buds would be more effective than a single treatment. Ascard (1995) also compared the dose response of different weed species to flaming at various growth stages. Results have shown that different species have different responses and regrow powers. The monocots like corn which have their apical bud situated at the center of their leaf bases, often just below ground are hard to kill as the bud is well protected. In comparison dicots, such as beans, mostly have their apical meristem at the top of the plant and their lateral buds at the base of the leaves in the open air, so it is much easier to get heat into their buds (Merfield). In contrast to cultivation, flaming does not disrupt the soil surface, thus reducing the risk of soil erosion, and it does not bring buried weed seeds to the surface, where germination is likely to occur. Also, flaming can be used when fields are too wet or stony for cultivation (Rifai, 1994). Flaming may provide added benefits, like insect or disease control, in addition to weed control (Lague et al., 1997).This method also has some disadvantages. One of them is low speed due to need for lengthening exposure time. Installment of lots of burners as a solution is not economic, and also then the machine would need more fuel and tanks to contain such amount of fuel which means more traction power and this contradicts one of the main reasons of developing flaming that is low traction power requirement in soil with small friction degree like sand. Our all the purpose in conduction this research is to design, develop and test a flaming mechanism to control intra-row weeds with heightened traction speed and less fuel consumption to result in more efficient weed control.

MATERIALS AND METHODS

On 23 May 2013 at 8 AM and n lines of wheat farm tests were conducted. A self-propelled frame with 150 cm width equipped with DC motor was used. This dc motor made the system have a variable forward speed. The speeds of 4, 8, 12, 16 kmh-1 were applied for pulling the device. Liquefied Petroleum Gas (LPG) is the most common fuel supply in flame weeding. A 3 kg fuel bottle provided the Propane. An electrical 2/2 valve k283 manufactured in Iran operated the fuel flow's cutoff. Valve also had a taper of infant amount of flow to hold the flame. A steel frame of 20*20*50 (height, width and length) were formed for three main reasons. First on is to act as a shield, this is necessary to reserve the crops from heat stroke and possible damages. Secondly, to trap the heat inside the frame, when the heat reaches a plant's surface, it can only move through the plant's tissues by conduction. This is a tortuously slow process with the heat moving only a fraction of an inch over tens of seconds. This heat tunnel gives more time for raising the plants temperature. The third on is that it keeps the flame toward despise the wind blow. Wind could cause misdirection of flame, interruption of flaming and in high speeds blowing the flame out. For highest exposure time period the burners were set along the rows with 30 degree to the ground. Average height of the weeds was the most important factor in characterization of the burners distance from the ground. Experiments with wooden frames and with random tosses showed that the average height were between 8-9 cm. A 15 cm above ground burner installment furnished optimum temperature and best opportunity to destroy the plants. Two thermocouple type temperature sensors were attached to development interface board to inspect temperature diversion inside the shield frame that they were placed in the position of 5 and 30 cm from the outset.

5 and 15 days after flaming verdict were beheld and data were collected from farm. Detection of plants injury were both assessed visually and with machine vision technics. Some given areas were selected and marked. Visualized inspection was adjudged by three referees. Numbers of weeds were counted and pictures were taken. Green area was measured before treating and after treating. The difference between two areas was considered as an indicator for system efficiencies evaluation. Weeds were counted in a 1m2 quadrat placed over the center of each treatment row 1 day before flaming, and 4 and 15 DAF. Pre-flaming counts were used to calculate field uniformity, density, and a modified relative abundance, as in Thomas (1985). Field uniformity was the number of sampling locations in which a species occurred, expressed as a percentage of the total number of samples. Density was the number of individuals of a species per square meter. Relative abundance was the sum of the relative field uniformity and the relative mean field density (Wszelaki et al., 2007).

RESULTS

This systems was evaluated by three main criteria including spent time for image conversion and processing, system ability for plant and background (soil, residues , stones and etc), discrimination and effectiveness ratio.

Table1.

Distance from outcome (cm)	Average Temperature (ºC)	Maximum Temperaure (ºC)	variations of Temperature (ºC)
5	180	216	49
30	482	521	67

Color space selection

In the practical implementation of research system in the farm, it was clearly observed that the core of the system was plant (as ROI) and background discrimination section. As a matter of fact, contrary to human visual processing, image processing in computer are performed in gray scale, so just one color part of a color space can be selected and used in the image processing, there were a lot of color spaces, but their conversion calculation needs some extra time. This would make some problem in real time control. The camera could just acquire in one gray space and two color space including RGB and YCbCr. Figure 1 shows three part of the YCbCr color space separately. As it mentioned in the methods section Cb and Cr were blue color differences for reference blue color and red color differences from reference red color, respectively. Since these color parts did not include color information about green color, so it did not good result in discrimination between soil and plant. But wet soil section disappearing in the images was resulted in these images, and it was an advantage for this color space, and it did not show any information about soil cracks. Since in histograms (sections b, d and f in figure 1) of the color parts, no clear bi-peaks could has been observed, so this color space was not a reliable space for automatic threshold process.

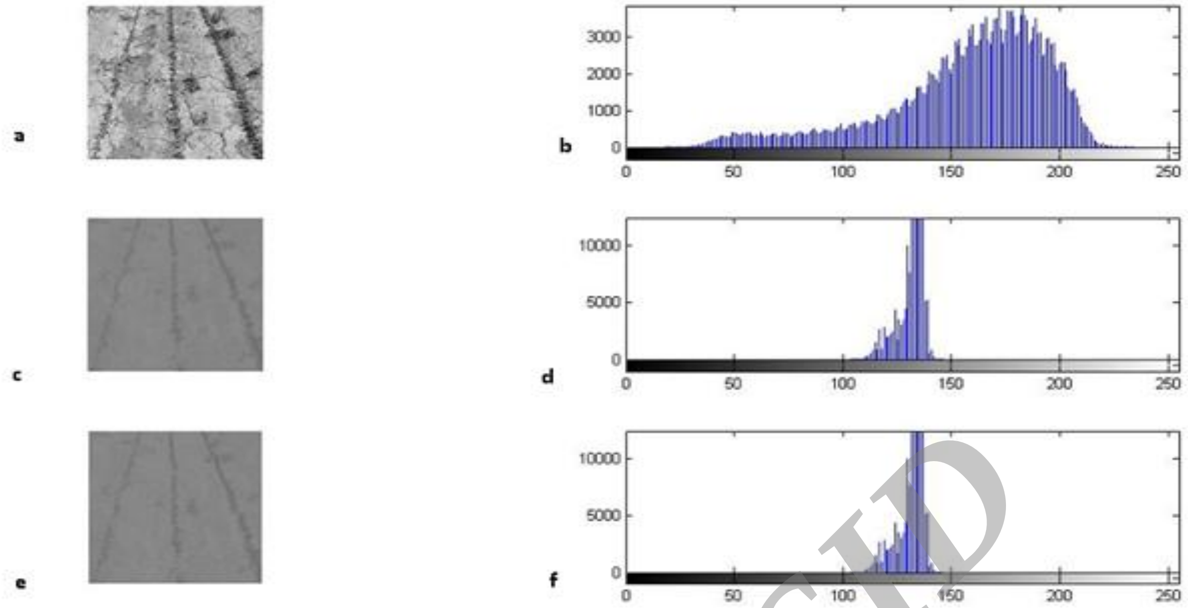

Figure 1. a. intensity part c. blue intesity e. red intesity information in YCbCr color space andb, d, and f were their histograms

Gray scale images

Conventional gray scale in most image programing algorithms is calculated by summing equal portion of red, green and blue colors ($0.33\times R+0.33\times G+0.33\times B$). As it could been seen in the figure 2.

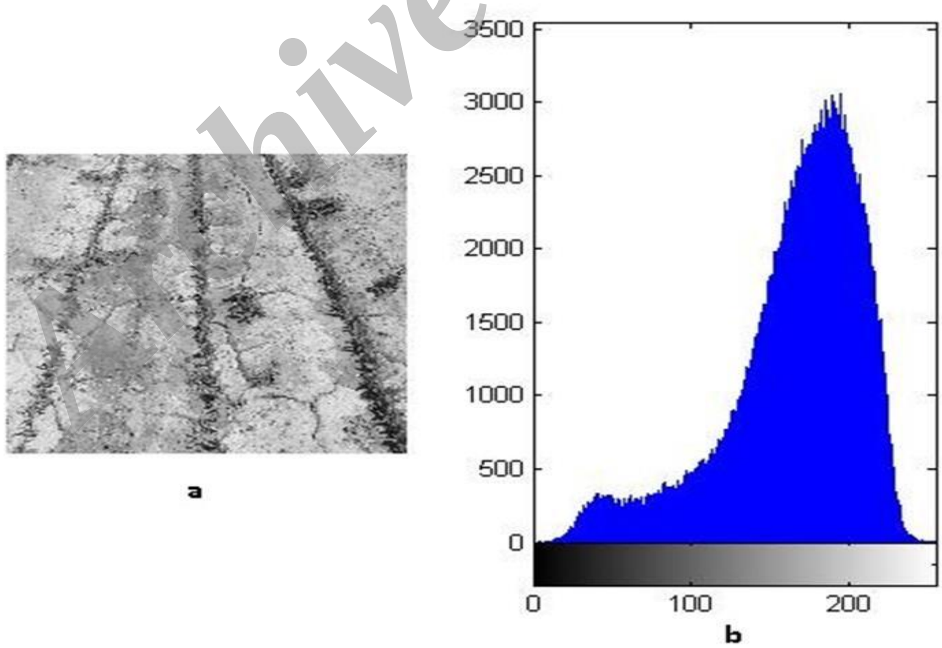

Figure 2 .a. Gray scale image b. Gray image histogram

As it could be clearly observed in the figure 1.a dry soil can be easily distinguished from plant objects. But wet soil had a gray value very close to plant and so could not be distinguished from plant, as it could be seen from figure3. Plants' shad and soil track had a gray value to plant and certainly would be mixed with plant section of the images. Figure 1.b shows histogram of the figure 1.a., there are not clear and separate peaks in the histogram. As it was mentioned in methods, Otsu automatic thresholding method was used for thresholding. For the best thresholding process, clear peaks were necessary, so this gray scale images were not a suitable choice. it does not need any time for the color space conversion and it was this type's advantage.

RGB color space intensities

Then each RGB color space parts, means R, G and B were considered for the remainder of the image processing. Time cost for these color part separation was so little (0.0005-0.001 s) (figures 2.a, 2.c, 2. e). The G part related to green color (figure 2.c) was expected to show better results in comparison with other parts.

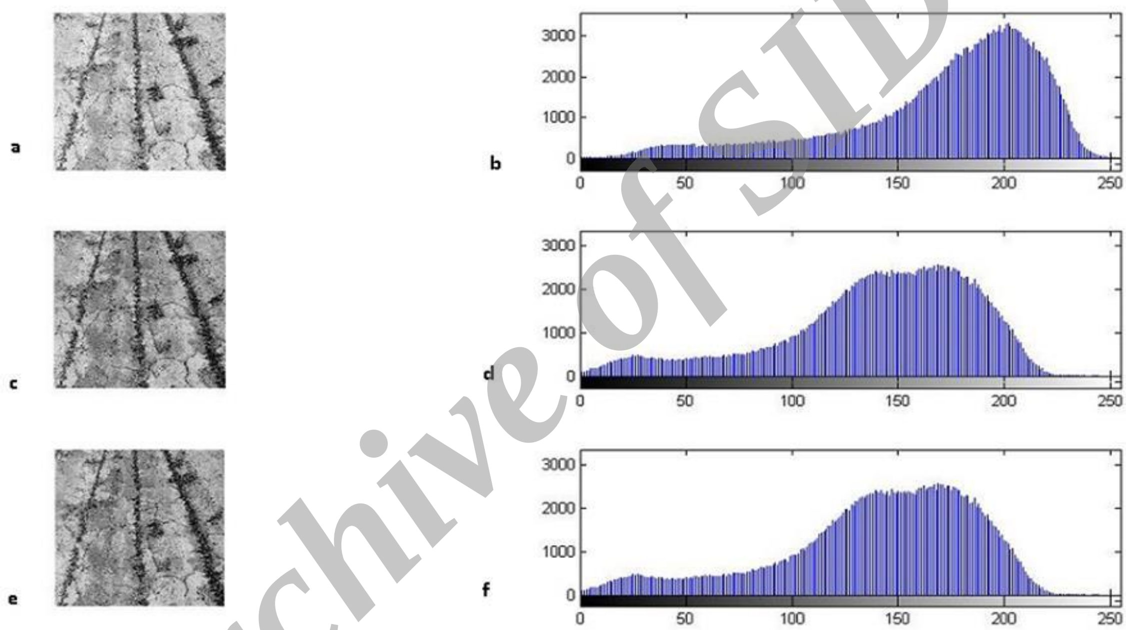

Figure 3. a. Red part of space image c. Greeb part of soace image e. Blue part of space image b, d, f Histogram of R, G and B parts

This color part showed better results in comparision with gray scale space, because plant sections were seen in better discrimination from soil and other background objects. But as it could be seen in the figure 2.c wet soil sections had a intensity value close to plant sections and was not vanished in soil.

RGB converted to greenness intensity

Figure 3.a shows the image converted by the equation 1. Since the green intensity was highlighted by the factor 2 so as it was expected, more discrimination was observed between soil and plant.

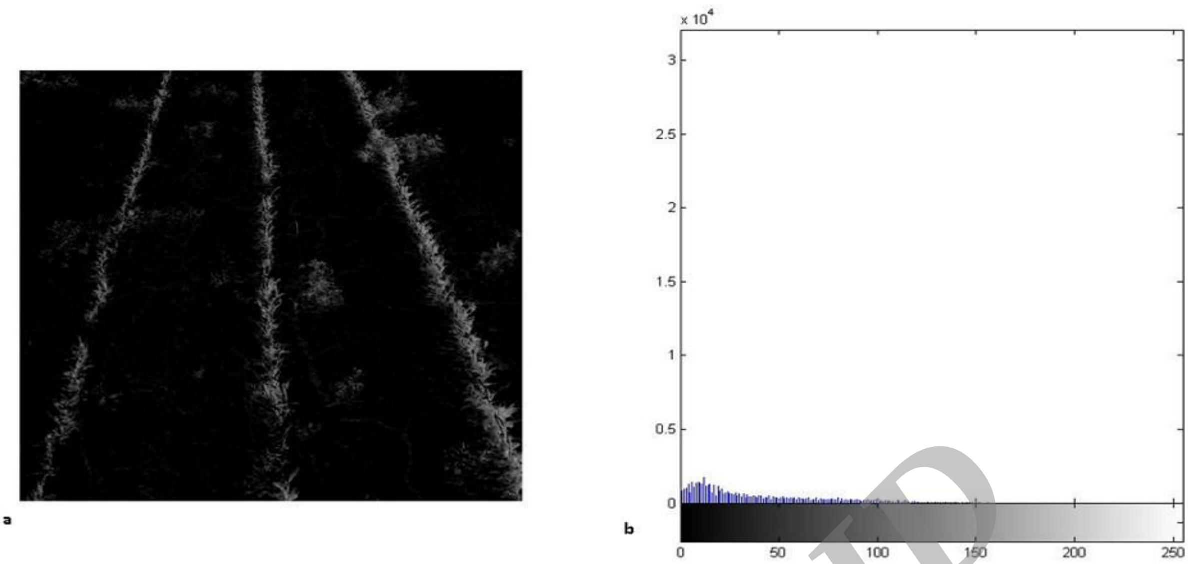

Figure 4. a. Converted image by greeness conversion b. Greeness image histogram

This better discrimination could be seen in figure 3.a. Figure 3.b showed that all gray value of pixels related to soil was converted to zero, so we had two separated peak that one of them had value of 0 and all remainder in the histogram was related to plant. So thresholding process could be performed so easily, because threshold value could be considered with values of a number close to 1 or so a little greater than 1. Figure 4 shows segmented image by this space.

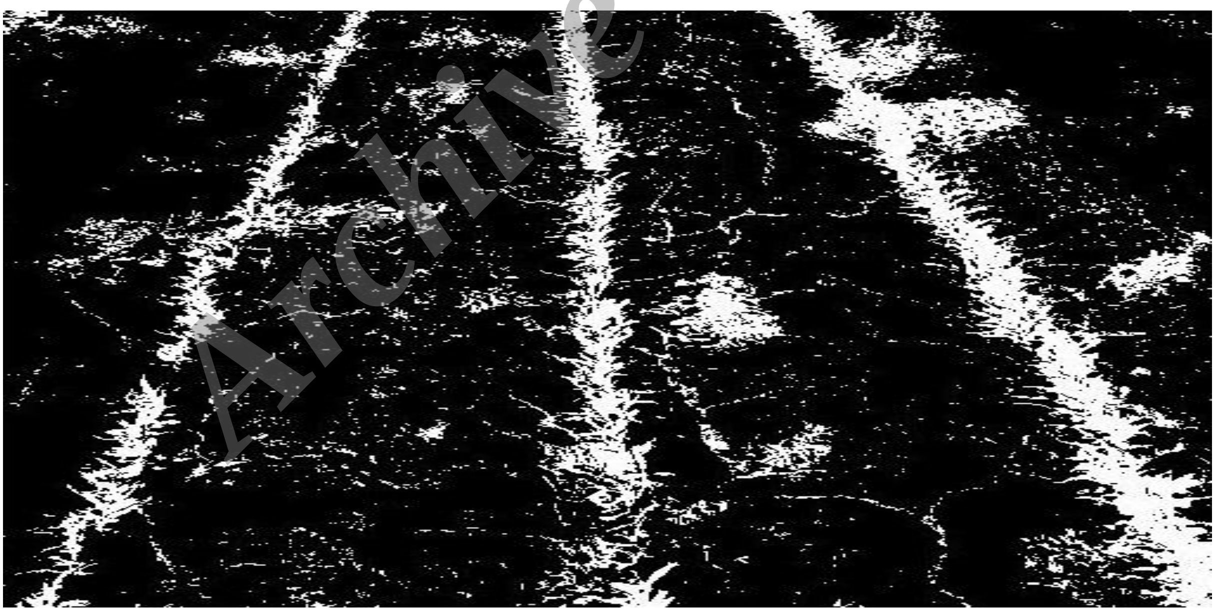

Figure 5. Thresholded image

This conversion type helps to automatic Otsu thresolding segmentation. Figure 5 shows the result. As it could be observed in figure 4 wet oil section was omitted. Just some small point related to small stones and thin lines related to soil cracks were remained that it was easily improved by the filtering (Figure 6).

Figure 6. Filtered images and improved image

After filtering and deleting noise from images, Hough transform was used to find the row (Figure 7).

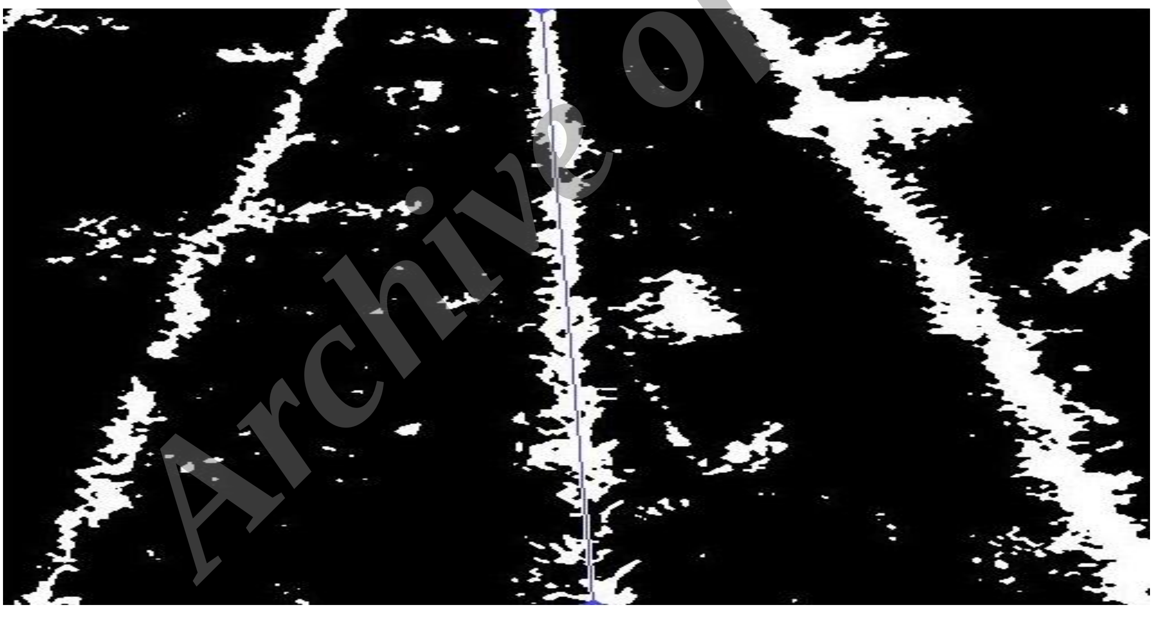

Figure 7 . Detected row by hough transform

After detecting row in the picture, plant row section were deleted by consider a width based on plant growth level (Figure 7).

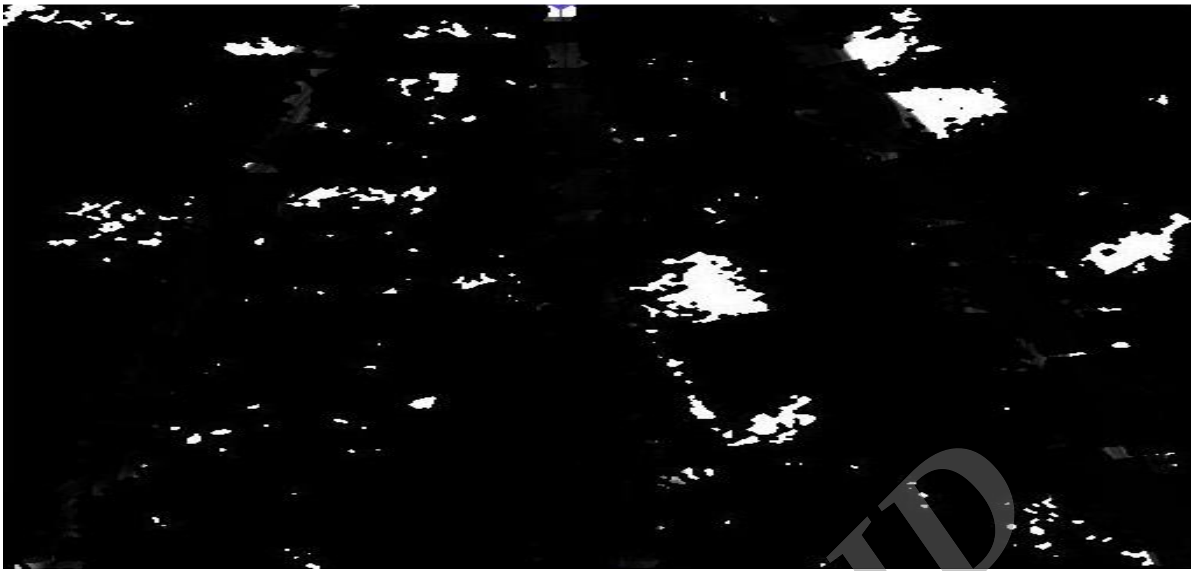

Figure8 . Image after deleting plant section

Then every spot of the image was numbered, and each spots' area were calculated, and small spots were omitted and center of the remainder were obtained (Figure 8).

Figure 9. image after omitting small spots

Center points coordinates then sent to developing board that it transferred information to determine what time the control system relay should be opened.

DISCUSSION

For distinguishing main crops and weeds, all crops between rows were considered as weeds. Sensors outcomes are shown in table 1. The variations of temperature were caused by flames on/off time period, weather temperature and wind speed. The highest temperature was reported in an area with high weed density that resulted in fuel valve being open for long time. The thermocouple closer to burner was more influenced by flames and temperature raise was more insignificant. The thermocouple near the outcome was under new air and wind impression and less in touch with flames. Counting of weeds in marked areas demonstrated that machine was available of destroying almost every small weed. The bigger weeds defoliation was considered as the factor of controlling unwanted plants. For broad leafed weeds number of leaves disappeared after 5 and 15 days were measured. After 5 days 78, 64, 56 and 37 percentages were disappeared or injured at 4, 8, 12, 16 kmh-1 respectively. The weeds injury after 15 days was 96, 87, 81 and 64 percentages at 4, 8, 12 and 16 kmh-1, respectively. Having fuel consumption under consideration and compromising with an approved weeding, an 8 to 12 km h-1 would give an acceptable result.

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