Robocrop Service Notes

Robocrop Service Training Program

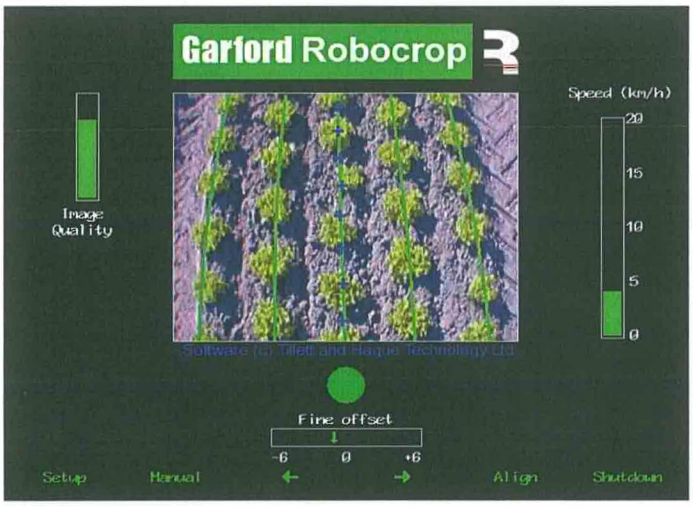
Overview

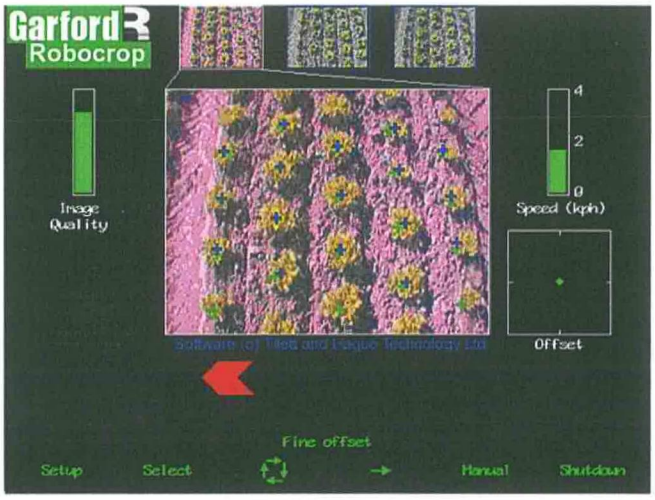
Robocrop Precision Guidance and Inrow Weeding systems utilise digital camera technology to view the crop ahead of the implement in order to locate the crop. Images are analysed by the on board computer and the control signal implemented by sideshifting the hoe and, on the InRow Weeder, adjusting the weeding rotor speed.


The Robocrop computer is looking for clusters of green pixels which generally relate to a pre determined grid which has been set up by creating a crop specific "configuration file" relating to ...

- crop row widths
- number of crop rows to be viewed by the camera
- nominal plant spacing along the row (InRow Weeder only)
- camera height and angle of inclination

Using the configuration file the Robocrop creates a "ghost grid" on the screen and then attempts to find the best match to this in the image.





Typical images for "Robocrop Guidance System" and "Robocrop InRow Weeder"

Once the grid has locked onto the image the system checks to see if the grid is located centrally in the image, if not then the hydraulic system is activated to correct the implement to the left or the right via a hydraulic sideshifting hitch or steered soil engaging discs.With the InRow Weeder Robocrop also uses the data to individually control the speed of rotation of the InRow Weeding rotors.

By analysing numerous rows of crop foliage within the image Robocrop will find a better average stem position than would be possible by analysing just one row.

The images are analysed at 25 frames per second to identify crop position.

Robocrop is automatically enabled each time it is lowered into work and also monitors forward speed in order to determine the required speed of reaction.

Robocrop monitors steering component movement and InRow Weeding Rotor position and speed, via a feedback loop, in order to determine precise control implementation requirements.

Camera view and performance.

Performance of the image analysis system is dependant on many factors...

Crop type, crop growth habit and foliage shape, crop foliage size, crop density, foliage colour, soil colour, weed colour, weed density, regularity of weed distribution, number of viewable rows, row widths, obstructions in the image, alternative crop colours, light conditions, implement speed and steering device reaction speed.

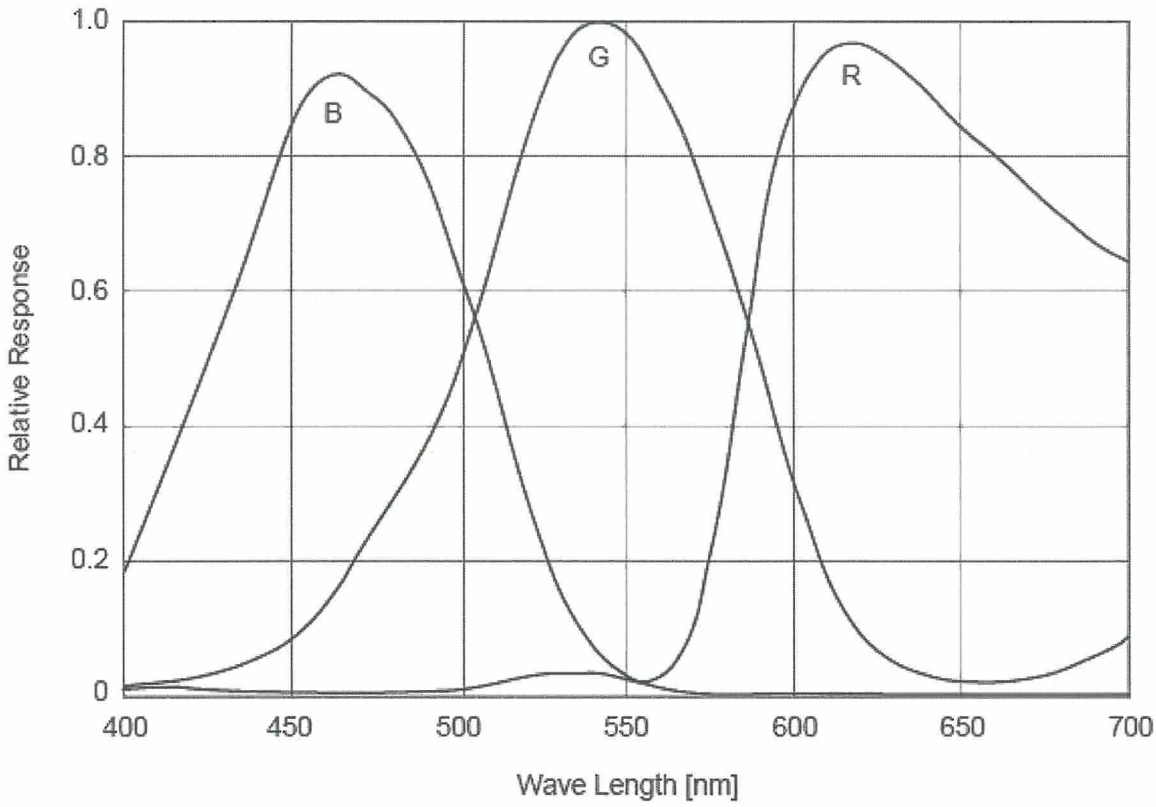
Crop type – generally broad leaf crops present a good image to the camera because the camera is looking at the crop from above, particularly toward the bottom of the cameras field of view which is most important as this is the point closest to the weeding tools and the last view the system has of the crop. Crops such as onions present a poor target at this point.

Crop growth habit and foliage shape – if the crop foliage is clustered in a tight rosette without any straggly leaf stems then the foliage will be a good indicator of the point at which the stems enter the soil.

Crop foliage size – generally the larger the foliage size then the more reliably Robocrop will lock into the crop, however as the foliage increases in size it can be more prone to irregular shape and can be effected by cross winds therefore accuracy can decrease.

Crop density – closely spaced plants present the best subject for good row following, good row following can be achieved with the camera viewing a smaller area of crop, widely spaced plants may require a higher camera position in order to get more plants in the image.

Foliage colour – in normal green colour mode the crop colour should be within the green spectrum within the wavelength 510 to 580nm (normal foliage colours). Greens toward the yellow end of the green spectrum are generally preferred to greens toward the blue end. If background weeds are nearer the centre of the bandwidth (540nm) then crop density must be many times greater than weed density.



The above chart shows the response of the 3 channels, Red green and blue of the camera image sensor.

Colour representation (colour reproduction is not true).

Soil colour – soils in the red sector, above 580nm, give the best contrast to the greens of the plant colour and therefore will enable the best results. Grey blue colours with high reflectivity give poorer results.

Weed colour – as previously stated, the further away from the green channel centre point of 540nm then the better performance.

Weed density – assuming that weed colour and crop colour are in a similar range within the colour spectrum, then the density of crop representing pixels within the image must be considerably greater than weed representing pixels.

Regularity of weed distribution – if weeds are gathered together in clusters then this may have a negative effect on crop location.

The weeds, above, are arranged in rows mimicking the crop rows. Row following would be difficult in the situation above even though the crop is quite large.

If weed distribution is regular then crop location can be successful even in quite small crops.

Number of viewable rows – generally the more rows that can be viewed then a better average crop position can be found (3 to 5 rows is optimal). However if the crop is small a lower camera position may be advantageous in order that more pixels in the image are fully accommodated be green and are not seeing partial foliage and soil mixed.
Row widths – narrower row widths will enable advantageous low camera positions (avoiding obstructions such as tractor wheel) and more rows in the image. However, very narrow row widths may encourage row skipping. Wider row widths will require higher camera positions in order to view numerous rows. If views are restricted due to small implements and wide row widths then often only one row can be viewed. This may result in less accurate row following if the foliage is irregular.
Obstructions in the image – if the above situation exists in the extreme it may be necessary to consider front mounting in order that the view is unobstructed.
Alternative crop colours – if the crop is not in the green colour range it may be possible to operate in the inverse colour mode (where the crop has more red spectrum and the background soil more green) or in the infra red spectrum where the density of organic material only is measured and not the colour.
Implement speed and steering device reaction speed – if good crop row references are not continuous along the row, performance can be improved if you reduce the reaction speed of the steering device and increase the forward speed of the implement. In this way the Robocrop will pick up good reference points intermittently but the implement does not have time to steer of the row in between time. However if soil is unlevel or if the rows are not very straight then high speed may throw the implement about and make row following difficult. Also on very narrow rows the risk of skipping from one row to another could be increased by the use of high speed.

Robocrop does not identify plant species. Robocrop looks for lines of green pixels (or clusters for the InRow) created by the crop row. If plant growth is poor (as in the picture below) then Robocrop cannot find the crop row because there is no line of green pixels.

Robocrop Precision Guided High Speed Hoe – layouts

Robocrop Guided Hoes (RGH) can be supplied in sizes from just a single row up to 12mtr frame size. The Robocrop Camera should be mounted in a position where it can have a clear unobstructed view of the crop.

Normally systems up to 3mtr should be front mounted in order that the camera can view the crop, larger machines would generally be rear mounted and the camera mounted to one side of the tractor. However if the crop forms a clear continuous line of green foliage then it is possible to lower the camera down to view a very small area of crop and still achieve good accurate line following.

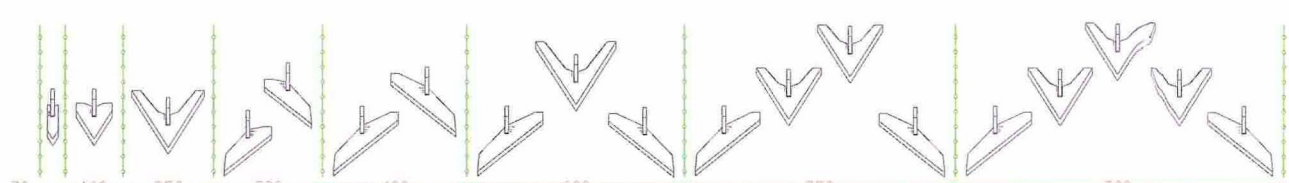
On the parsnip crop, below the crop foliage is quite irregular therefore it is important for the camera to be at standard height and view all 4 twin lines in order to get good row following.

On this cereals crop, below, the implement is quite narrow therefore the camera has to be positioned quite low in order to avoid viewing the tractor wheel. However due to the regular line of the crop successful row following will result.

Generally, closely spaced plants and closely spaced rows enable the Robocrop to work successfully even if the camera has to be mounted in a low position.

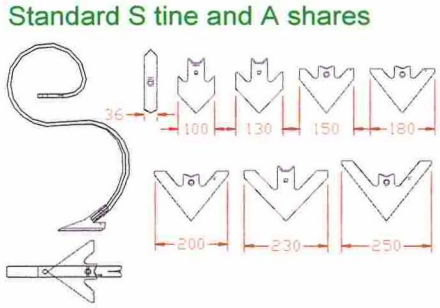
Less densely spaced plants such as Brassicas, lettuce, sugar beet, require a high camera position in order to view more plants and rows and therefore obtain a better average row position.

Cultivation tools – rows up to 30cm can use single flat A share, 28cm and above can use twin slash blades plus as many A shares as necessary. Below are a few examples of typical share arrangements.

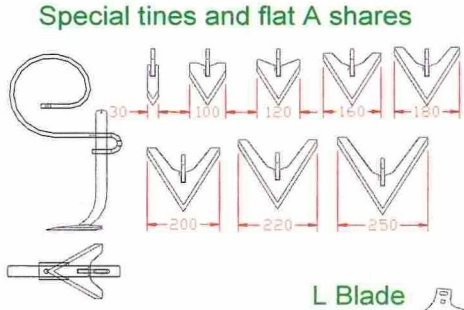


Tine and share types

Standard S tine and A shares

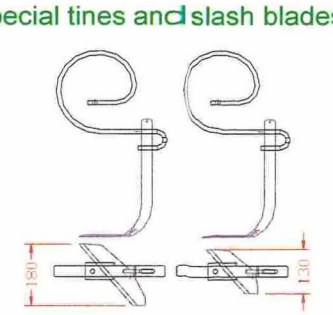


Special tines and flat A shares



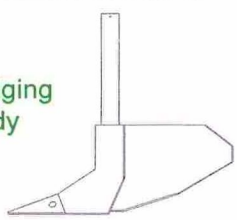
L Blade

Special tines and slash blades



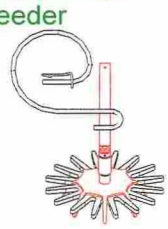
Other cultivation tools

Ridging body

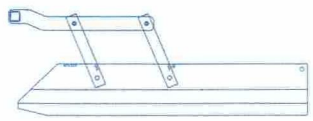


Side Disc

Rotary Finger Weeder



Crop Protection Shield



Spring Weeder Rake