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PRACTICAL SECTION FOR GROWERS

Background and Objectives

It is generally believed that commercial yields from well grown cauliflower crops are in the order of 60-70% of plants planted. Whereas in experimental trials yields can be as high as 90%, indicating that the producer may be able to achieve higher percentage cuts. Preliminary investigations have suggested that this reduction is not accounted for by loss of plants at establishment or during the growing season, and that it most probably occurs at harvest time. Commercial cutting of cauliflower crops has tended to become more dependent on market demands for the product than on the readiness of the crop to be cut. A reduced frequency of cutting may result in some losses as individual heads may reach maturity and become unmarketable between cuts.

Preliminary observations from experimental work at HRI-Kirton have highlighted three areas of interest:

- More regular cutting (3 times a week) produced more Class 1 heads

- The frequency distribution of numbers cut with time in a single plot tends to be normal and can span two to three weeks. Not cutting when, for example only 10% are ready, as may happen at the start or at the end of a crop would reduce the total cut by that 10%

- Individual heads do not remain in Class 1 condition for long, at least 50% of Class 1 heads were Class 2 or unmarketable in 2 days in an unreplicated study

These preliminary observations suggest that less frequent cutting would reduce the overall percentage cut. The study sought to establish definitively the period when loss of crop occurs and to quantify the field standing ability and investigate the major influences on this rate of deterioration.

The study consisted of three parts; a survey of commercial crops to establish levels of losses from planting to harvest, monitoring plants from commercially raised batches in fields and in plots at HRI Kirton, and studying effects of variety and spacing on field standing ability of cauliflowers.

Summary of results

- Crops grown in commercial fields yielded up to 94.5% marketable when recorded by HRI system, showing that commercial crops had high potential yields

- Commercial cutting was less effective than cutting regularly (3 times a week) which could reduce losses from over-mature plants (11.4%) and not recorded plants (6.6%). The pattern of commercial cutting was irregular

- Converting a weight of curd into number of heads on a fixed conversion can lead to errors in estimating total yield

- At planting, measuring actual plant density is more accurate than assuming planter is producing target population

- Measuring the area of cropped land is not straightforward in oddly shaped fields, inaccurate measurement can alter area by 16% which would affect yield estimates

- At planting missed plants accounted for up to 5% of target population

- At planting blind plants accounted for up to 0.4% of plants

- Up to 3.3% of plants were buried too deeply at planting, 50% of these failed to reach harvest

- Up to 1.7% of plants planted were weak spindly plants, 55% of these failed to reach harvest

- Double plants at planting tended to produce marketable heads

- Of plants with severe bird damage shortly after planting 10% died before harvest and 8% were late maturing
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- Losses from wheelings and crop edges were observed but not quantified, these could account for significant losses especially in smaller fields

- Field standing ability from Class 1 to Class 2 was longer for Forrest (3.1 days) than Fremont (1.9 days)

- Field standing ability from Class 1 to unmarketable was 6.4 days (Fremont) and 8.6 days (Forrest)

Action Points for Growers

- Plant only healthy plants, ensure planters discard weak and blind plants
- Ensure planting machine is well maintained to reduce the numbers of missing and deeply buried plants
- Consider using an extra person to gap up, replant deeply buried plants etc
- Reduce bird damage where possible
- Cut crop regularly in field
- Use a simple recording system at harvesting so gang/fieldsmen know which areas have been cut and when
- Check individual loads for curding to get accurate weight for conversion factor
- Allow adequate headlands so tractors can turn into crop without damaging plants, also minimise tractor damage to plants generally

SCIENCE SECTION FOR GROWERS

Introduction

Commercial yields from well grown cauliflower crops are generally somewhere in the order of 60-70% of plants planted. Whereas in experimental trials yields can be as high as 90%, indicating that the crop has the potential for a higher percentage cut. Preliminary investigations have suggested that this loss is not accounted for by loss of plants at establishment or during the growing season, and that it most probably occurs at harvest time. Commercial cutting of cauliflower crops has tended to become more dependent on market demands for the product than on the readiness of the crop to be cut. A reduced frequency of cutting may result in some losses as individual heads may reach maturity and become unmarketable between cuts, these heads will be lost.

Preliminary observations from experimental work at HRI-Kirton have highlighted three areas of interest:

- More regular cutting (3 times a week) produced more Class 1 heads

- The frequency distribution of numbers cut with time in a single plot tends to be normal and can span two to three weeks. Not cutting when, for example only 10% are ready, as may happen at the start or at the end of a crop would reduce the total cut by that 10%

- Individual heads do not remain in Class 1 condition for long, at least 50% of Class 1 heads were Class 2 or unmarketable in 2 days in an unreplicated study

These preliminary observations suggest that less frequent cutting would reduce the overall percentage cut. The study sought to establish definitively the period when loss of crop occurs and to quantify the field standing ability and investigate the major influences on this rate of deterioration.

The study consisted of three approaches; a survey of commercial crops to establish levels of losses from planting to harvest, monitoring plants from commercially raised batches in fields and in plots at HRI Kirton, and studying effects of variety and spacing on field standing ability of cauliflowers.

Methods

Commercial crops – survey

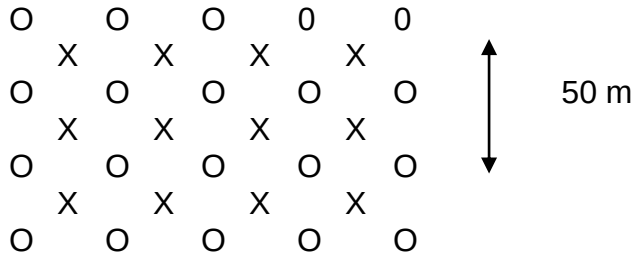
With the help of a local grower group twelve fields from their cropping schedule were identified for sampling. These covered the period of planting from May to July for cropping August to October. The fields identified covered a range of varieties and farms to give a spread of situations. The term “fields” in the report indicates an area of one variety planted at the same time, which might be the whole of a small field or part of a larger field.

Fields were visited within a few days of planting to record planting details and set up plots. In four areas of the field, four lots of 50 m of row were inspected for number of plants planted plus gaps to establish plant spacing and various failures at planting including gaps, double plants, very weak plants, deeply buried plants, blind plants and severe bird damage that might lead to the subsequent death of plants.

Twelve plots of 50 plants, (five rows by ten plants), were marked out using all five rows of the planter. These were laid out on a regular pattern to give four replicates of three plots in the main body of the field with replicates running up the tram lines. These were assessed after planting, two and four weeks later to check the state of the plants. At harvest these plots were allocated at random to three treatments.

1. Cut regularly by HRI staff (Mon, Wed, Fri)
2. Cut by HRI staff when crop cut commercially
3. Cut commercially but outcome recorded by HRI staff

To establish variability of the crop in the field post-initiation twenty, twelve plant samples were taken in a systematic five by four pattern across the field.



X harvest plots
O post initiation samples

Plots and sample areas were positioned away from field edges but spread out across the field, the distances between harvest plots was 50 m if the field was large enough. The replicates were evenly spaced across the available whole blocks in the field.

All the fields were planted on the same pattern with 16 rows at 61 cm spacing in a block, a missing row, two more rows, and one more missing row leaving tramlines for tractor access. They were planted with five row planter, using a range of machines depending on the farm, generally starting with a half block.

Post-initiation samples were dissected to measure leaf number and apex diameter. The fresh and dry weights of the total plant sample was determined.

At harvest on the plots cut by HRI staff, mature heads were classed as Class 1, Class 2 or unmarketable. Defects were recorded for Class 2 and unmarketable heads. Any undersized heads were recorded, as were missing plants. Recording continued on the appropriate days until commercial cutting was discontinued, then

the number of plants still remaining was counted as “not recorded”, these plants might or might not have gone on to produce marketable heads after this date. In category 3 plots, no obvious sign of the presence of a plot was given in order that the cutting gang would treat the plants in their normal manner, unlike category 1 and 2 plots which were marked with canes and warning tape, At recording, freshly cut stumps were inspected to determine if the head had been removed (marketable) or cut up (unmarketable). On completion “not recorded” plants were counted.

Owing to irregular cutting patterns in the field at the end it was felt that the four category 3 plots would not give an accurate estimate of what had been commercially removed from the field. Additional counts were made, taking 50 plants, in a single row at the front and back of the field for each block. Each of the 50 plants was recorded as cut and removed (marketable), cut and left (unmarketable) or uncut (not recorded). Records were collected from the group of how much marketable crop was removed from each field and what proportion was cut for face packing (leaf), curding or intervention.

The area of crop in each field or part field was measured. None of the fields was a simple rectangle so the field were subdivided, for measuring, into rectangles and triangles and appropriate measurements taken using a surveying wheel. The area was calculated from these. These measurements were checked against enlarged photocopies of ordnance survey large scale maps, where possible. Measurements of cropped field area were obtained from the group, which were compiled in a similar manner by an independent operator.

Monitoring

Plants from two batches of Fremont used in commercial fields were planted at HRI Kirton. Plots of 5 rows of 12 plants were planted at 61 cm x 46 cm spacing. Fifty plants per plot were cut either when the field was cut commercially or routinely three times a week. There were three replicates. The first monitoring plots were planted on 29 May and corresponded with Field 2 in the survey. The second monitoring plots were planted on 2 July and corresponded with Field 9.

Experimental study

The field standing ability was assessed in August and late September. Using two varieties, Fremont and Forrest, and two spacings, 61 x 46 cm and 61 x 51 cm, individual heads were tracked daily from first reaching maturity until they became Class 2 heads and then unmarketable. Plots contained four rows of 13 or 14 plants, depending on spacing, and 33 plants per plot were recorded. The trial was arranged as a two-by-two factorial design with three replicates.

Results

At Planting

At planting the group's target spacing was 61 cm x 43 cm (24" x 17") but the actual spacing measured ranged from 42.6 cm to 52.6 cm. For all but one field the planting rate was less than the target, this variation in field population was not included in the group's calculation of yield.

At planting, various faults were identified including missing plants (gaps), very weak plants, blind plants, double cells ie two plants in one cell, plants buried deeply (buried), the results are given in Table 1. These counts were done approximately 2 to 3 days after planting and on most sites there was some severe bird damage by this time. Severe bird damage was defined as at least one whole leaf removed by birds, this damage was also included in this table. If plants from all categories failed to make marketable heads this would amount to a total loss of between 2% and 30.5%, however excluding one field with 29% bird damage the mean figure was 5.6%. Not all plants would necessarily not make marketable plants, only gaps and blind plants would definitely be put in this category, combined these ranged from 0.2% to 5.1%. Gaps or missing plants were the most serious loss with four fields losing more than 2% of potential plants by this means. Deeply buried plants were a problem (>2% loss) on two fields. Of the faults with the transplants, doubles were the most common with four fields having over 2%, blind and weak plants were below the 2% level on all fields. Ideally all faulty plants should be discarded by the planters when selecting plants from the tray but in practice this is not completely achieved, up to 5% of the plants were poor. At planting from 1.5% to 10.5% of the adjusted target population were either missed, planted very deep or planted with poor plants. All of these faults could be reduced by more careful selection of plants by planting gang, good maintenance and adjustment of the planter or by the use of an extra member in the planting gang to gap up misses and correct deep planting.

From Planting to Harvest

As numbers of plants at planting that were weak, double, buried or severe bird damaged were low, the number found in the 50 plant plots was necessarily small. The fate of these plants were recorded to see if they survived to harvest to make a marketable head or not. Figures are presented as a percentage of affected plants at planting and are given for selected fields as a guide only (Table 2). Less than 50% of buried plants and less than 55% of weak plants went on to produce marketable heads. Bird damage and double plants were less serious conditions. From double plants there was no loss of plants or delayed maturity (not recorded). In this situation one of the two plants probably quickly became dominant and the other was suppressed, allowing the stronger plant to grow as normal. Of the plants suffering severe bird damage less than 10% died before harvest, however a further 6 to 8% were delayed maturity plants.

Post Initiation

Post initiation samples taken from each field and the second trial at HRI Kirton, showed that in general the variation (standard deviation) was greater on the fields than in the trial. This probably reflects the larger area of the fields and the changes in conditions experienced across the fields (Table 3).

Harvesting

Commercial harvesting of the twelve fields ran from 14 August until 7 October, this covered a period in September when there was oversupply on the fresh market and much of the crop locally was being cut for curd or into intervention. All of the 12 fields had some cutting for curd and only two fields were cut predominantly for leaf or face pack production (Table 4).

One main thrust of this investigation was to see how irregular patterns of cutting, expected from the commercial cropping, affected the proportion of class one heads cut. However where fields were cut for curd any marketable heads were taken and this did not allow us to record a loss of quality in heads from Class 1 to Class 2.

Following the pattern of harvesting by the cutting gangs was not straightforward. They did not always cut in the fields planned by the group at 3 pm the day before for a variety of reasons. These included last minute changes in plans or orders, completing orders from other fields, and lack of sufficient labour on the day. When they did cut in a specified field, gangs did not cut fields in a systematic way. In one field they initially cut from the left hand side for several blocks, returned three days later and cut from the right hand side for several blocks. They returned again and cut from the right hand edge again for several blocks with the next cut taken from the central area. Several blocks were left uncut. Finally the whole field was cut for curd but even after this some areas of the field had many plants left unrecorded. This apparently sporadic pattern of cutting reflected the size and type of curd the group was looking for to supply various orders. However, it meant that the 12 harvest plots were not representative of the total harvesting in that field and it was difficult to time the plots cut by HRI staff when crop cut commercially (Table 5).

On several of the 12 fields set up complete harvest records were not collected. On Field 2, one of the smaller fields, a large area of the field developed club root damage, the field was not cut commercially. On two adjacent fields we confused the field identification and were recording in Field 5 while the group were cutting commercially in Field 11. By the time the mistake was realised it was too late to correct it for either field, and records were lost. Field 3b was found to contain two varieties once cutting was underway and as the plots straddled the two varieties these were then treated as two "fields" but some of the harvest records were obviously derived from fewer plots. We were told two variety names for Field 3b prior to planting but understood it to be "either/or", rather than both to go in the same field.

HRI Cutting

Due to the uneven patterns of commercial cutting within the fields, plots cut according to commercial timing tended to be cut routinely three times a week as it was difficult to time plots individually. These results have been meaned together. These plots contained 50 plants when marked out a few days after planting thus percentages are on a basis of number of plants planted. Table 6, Fig 1 gives results from these plots. Up to 93% of plants produced Class I heads, the lowest was 70% and overall 79% to 94.5% of plants produced marketable heads. Recording on these plots continued until the group finished commercial cutting in that field, 0.5% to 15.3% of plants were "not recorded" at that time ie had not reached maturity. Levels of missing, small or unmarketable heads were low.

Commercial Cutting

On plots cut by the gang and then recorded, lower levels of marketable plants were recorded than on HRI cut plots, this ranged from 55.5% to 92% (Table 7, Fig 2). There were many more plants not recorded on these plots where the gang had not cut these plots recently when cutting was called off. There was also higher level of unmarketable heads due to irregular visits to individual plots. The four plots per field could not provide a reliable sample of the commercial cutting in the field and was highly influenced by the actual timing of cutting in the plot.

The additional 50 plant counts, two per block in the whole field, were calculated as a percent of plants present at harvest, thus any effect of losses from planting to harvest were omitted. Up to 92.6% of plants were marketable on this estimate falling to 75.1% on the lowest fields (Table 8, Fig 3). The remainder were divided between unmarketable heads and those not recorded, unmarketable heads were more common on most fields, up to 28.5%, but 15.1% were left unrecorded on field 3a. The % marketable from these 50 plants (50's) was in some cases close to that recorded on plots or even slightly higher, however it could be up to 25.1% lower.

Harvest records obtained from the group are given in Table 4. The yield is given as dozens of cauliflower per acre, a percentage cut, based on the number of plants per acre the group estimated from plant spacing – 10% to allow for tramlines, was calculated (Table 9). These figures drop below 50% on one field and generally reflect the levels of cut reported from cauliflower growers, but are well below the levels recorded in the plots or 50's.

As it was shown that the number of plants planted differed from the group's estimate the plant population was adjusted firstly to number of plants actually planted excluding gaps (pop^n 1). This figure was then adjusted to reflect the number of plants present at the start of harvesting (pop^n 2), the basis for calculating percentages from the 50's. The group yield based on population 2 brings all figures above 55% marketable but still leaves a large gap between group yield and yield from 50's, 30% less eg Field 8, see Fig 4.

Plotting the difference between % marketable from 50's and group adjusted % marketable shows a clear relationship between % of crop cut as curd and % difference except for Field 8. Excluding Field 8 there is a significant correlation (at 5% level) explaining 51% of the variation (Fig 5). Discussions with the group revealed that Field 8 might have had curd cut from it, wrongly attributed to another field, as several fields in the same area were being cut at the same time, and part filled bins could have moved from field to field. A possible explanation for a relationship between these two factors, % cut as curd and % difference, is that curd cut from fields is weighed in bulk bins and converted to heads using a seasonal conversion factor eg 8 kg per 12 heads. A small change in weight of heads would lead to a sizeable change in overall % cut, eg using 7 kg/doz results in a 14.3% increase in heads for a given weight. If 50% of the crop was cut as curd this would result in a 7.1% increase in crop harvested which would translate for example in Field 10 to an increase in adjusted % cut from 74.2% to 79.5%. No records were taken at harvest time of weight of curds but in 1997 records from another trial at HRI Kirton show that curds of Aviso (one of the varieties used here) averaged 7.13 kg/doz over September and October. This indicates that the figure used may have been too low.

Field Areas

Field areas are shown in Table 10 as measured by HRI staff and for the group by an independent operator. Both measuring teams used the same methods and measured only the area of planted crop. The difference between the two teams was as high as 16.1%. As group yields are worked out from total yield per field adjusted to a per acre basis, the accuracy of the acreage measurement plays a key role in the final yield figure. Correcting a 10% over-estimate of area, eg Field 1 would result in an increase of adjusted group yield from 79.6% to 88.8%. However, the difference between the two measurements of area were not consistent, HRI over-estimated the area in two fields which would decrease the % cut figures. HRI's estimates of yield are independent of the area of the field as they were made on areas of known size.

Inaccuracy in these measurements could easily occur in calculating areas as curved and irregular areas were broken down and measured as triangles or rectangles. Also in some fields where the measured field was a section of a large field, uncertainty could occur as to the exact division between plantings especially as HRI's measurements were taken well into the growing season. As the group were confident of their own measurements, no adjustments were made for area in trying to account for differences between measurements of yield, but its potential impact is noted.

Monitoring Plots

The first monitoring plots used plants from the batch planted in Field 2. Unfortunately no commercial cutting was carried out in the field, therefore no comparison could be made between cutting in the plots and cutting in the field.

The second monitoring plots corresponded to Field 9 which was cut commercially on 11, 14 and 21 September. Cutting commenced on all plots when it started in Field 9 and continued either three times a week or when cutting occurred in Field 9. The plots had matured more quickly than in Field 9 by a few days and on 11 September up to 80% of the plants were mature with many already going yellow and becoming Class 2. Little useful information was gained from these plots.

Experimental Study

Results from trial 2 are shown in Table 11. Class 1 curds remained as Class 1 for 2.5 days overall in mid to late September when trial 2 was cut. There was a significant effect of variety on this time showing that field standing ability in cauliflowers is variable. There was no effect of spacing on length of time. Similar effects were found in August when trial 1 was cut but heads remained as Class 1 for only 1.6 days. In trial 1 the time for Class 1 heads to become unmarketable was also recorded, this was 6.4 days for Fremont and 8.6 days for Forrest.

Discussion

Although large differences were found between the yields measured by the group and those measured by HRI, for which there is no definite explanation from this study certain contributing areas have been quantified and others highlighted.

One major finding is that, contrary to original expectations, yields in commercial fields when measured on small plots and recorded using HRI's routine system were very high, up to 94.5% marketable in one field. Thus there was no intrinsic loss of quality in the cauliflowers by being grown and treated on a large scale. However when it came to harvesting this crop commercially, yields were reduced by up to 15% compared with plot recording. There are several reasons for this firstly not all parts of the field are cut regularly resulting in some plants going over before cutting (11.4%) and some plants not reaching maturity before the last cut in that area (6.6%). These figures are much higher than on the cut plots. On the four gang cut plots in two fields, for example, the plots were cut one, two, three or four times. On another field the four plots were all cut four times but only once were all plots cut on the same day. A field plan which could be marked by cutting gangs to show where they had been could be used to prevent areas within the field being missed.

The yield figures from the 50's, which give a more representative sample of the field than the gang cut plots still show a wide discrepancy with the group's adjusted yields. Some of this can be explained by the conversion from weight of curd to cauliflower heads but other sources of error occur as well. For example some curds cut by the cutters are rejected for packing on the rig and may be discarded in the field. Such heads will show up as cut in field counts but not as marketable. The main reason for rejects will be knife damage to the curd or poor curd quality. However such losses are thought to be low by the group but have not been measured in this study.

A more major cause of discrepancies could be the edges and wheelings in the field. All the plots and 50's were taken from within the 16 row blocks and at least 20 m from field edges. During the harvesting it was observed that plants in the wheelings, especially the two centre rows, could mature earlier than those in the main block. They would thus be more likely to be overmature when cutting occurred. Also some damage from tractors was seen, either slight or severe damage was seen with plants even being run over. At the ends of the rows, where the tractor was turning in or out of the tramlines corner and end plants get damaged. Even without physical damage the plants at the edges of fields are more prone to pest attack both birds and rabbits as well as aphids and caterpillars, all these pests can delay harvest when damage to the plants is severe. Plants on the edges may also experience less good soil conditions if there is compaction from previous headlands in the field, these plants will grow less vigorously and either produce poor or late maturing heads.

In any sized field four of the eighteen cropped rows per block will be wheeling rows (side or centre) which is 22.2% of the crop. So any significant change in productivity from these rows will have an impact on the overall yield. In a small 6 ac (2.4 ha) field edges and headlands can also have a significant effect, taking a ten plant headland at the front and back, and eight plants at the sides represents 13.1% of the cropped area, on a 10 ac this would only drop to 11.8%. Thus edges and wheelings can

make up over 30% of the cropped area and even a 10% reduction in marketable yield in these areas would reduce overall yield by 3%. In some fields large numbers of damaged or unmarketable heads were seen but these were not recorded in detail.

The main areas of losses identified in this study are:

1) Losses at planting

2) Losses due to inaccuracies in plant population and area

3) Losses due to cutting regime

4) Losses due to wheelings and edges

5) Losses due to conversion from curd weight to number of heads

From this study there is good evidence that losses occur as a result of irregular cutting programmes even when much of the crop is being taken for curd. It would be expected that these losses would increase as the proportion of crop cut for leaf increased.

Technically losses occurred as actual planting density was not taken into account, this would be relatively simple to remedy. Also the cropped area was not easily identified, as two measurers gave different results. More attention should be paid to this to get accurate areas.

Losses at planting due to missed plants plus blind plants accounted for up to 5% of the losses. Planting double cells appeared to have no serious impact on harvest quality, however planting weak plants or burying healthy plants too deeply resulted in less than 50% of plants producing marketable heads, although both the problems only occurred at low levels at planting. Severe bird damage was less of a problem with only 10% damaged dying before harvest. These results are based on a small sample size and should be investigated further.

Losses due to wheelings and edges were not measured in this study although calculations show they occupy a significant proportion of the cropped area. Observations indicate that severe localised losses do occur on a regular basis and may account for some of the discrepancy between marketable yield from the group and this study.

Losses due to the conversion from curd weight to heads have been discussed and shown to be a potential source of error. Measurements of curd weights per count could be used to correct this situation.

This study has shown that commercial crops of cauliflower have the potential to produce 94.5% marketable heads, in line with trial plots at HRI Kirton and elsewhere. It has identified several sources of error and loss in the system, some of which have been quantified in one season, others which have only been identified here and would need to be quantified.

Areas requiring further work

- The fate of plants from faults at planting ie weak plants, double plants, planted too deeply and bird damage required further measurement. The occurrence in plot areas in fields was too low to provide reliable data. Individual plants could be marked at planting and observed up to harvest.

- The effects of wheelings, ends and sides of fields on crop quality and harvesting should be measured. Loss of quality in these areas could contribute substantially to reducing commercial yields.

- Monitor curd weights for variation between varieties, season and field to provide a reliable conversion factor from weight of curd to number of heads cut.

- Quantify the level of rejection of curds on the cutting rigs, to measure the number of heads cut but not marketed.

- Investigate varietal and seasonal variation in field standing ability across a range of varieties.

Acknowledgements

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Fig 1 HRI cuts % in each category

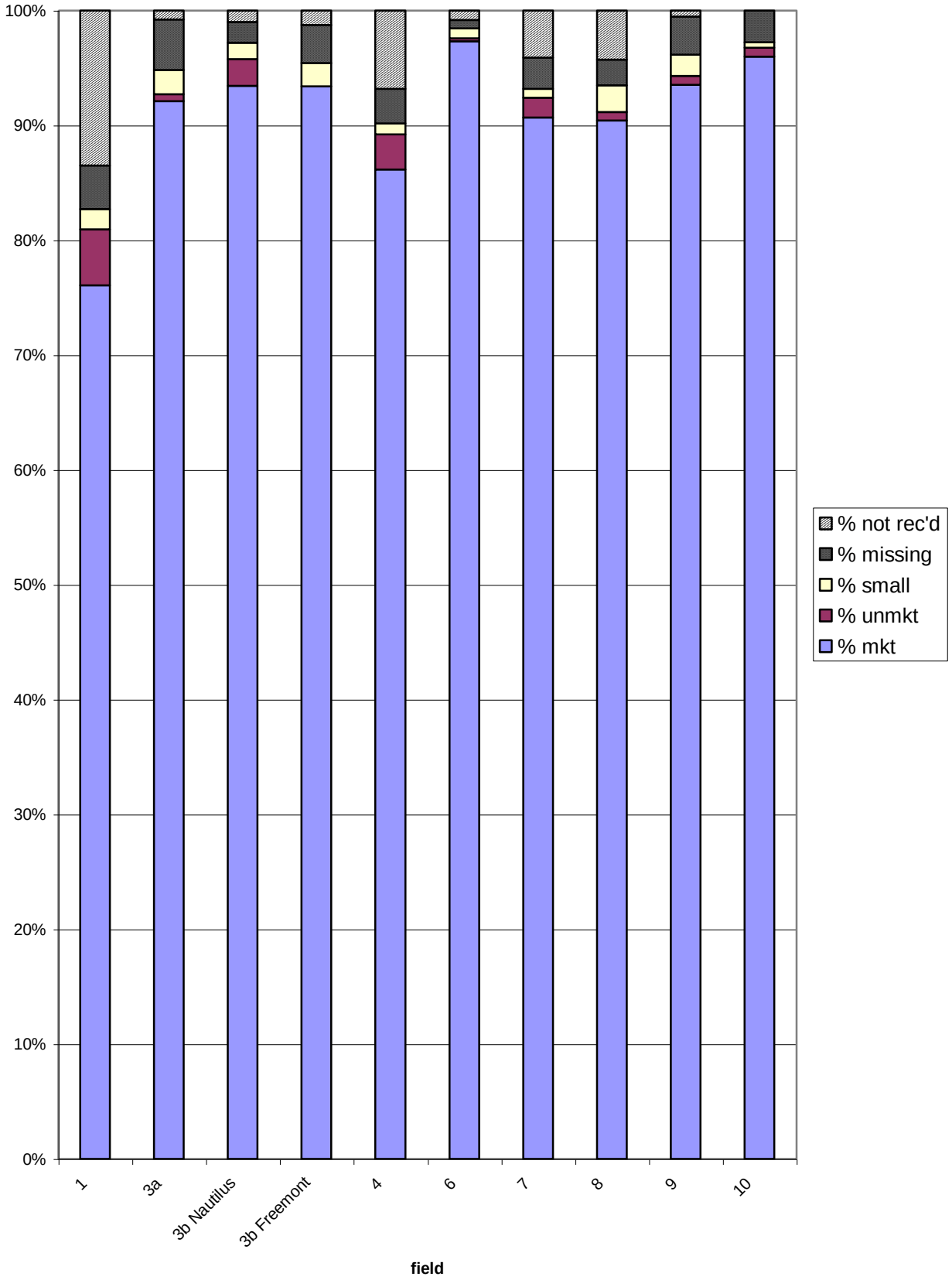

Fig 2 Gang cut plots % in each category

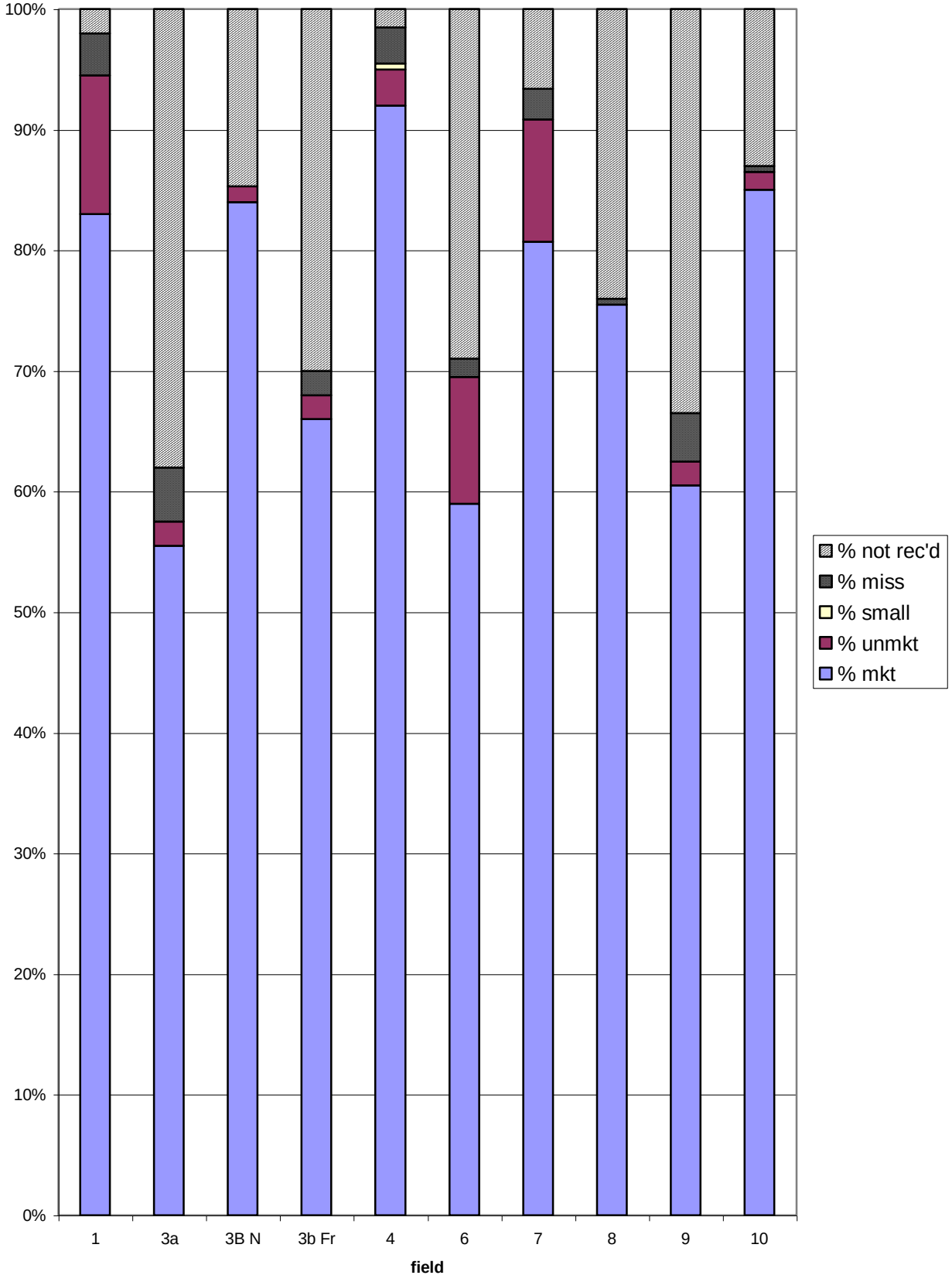

Fig 3 50's as % counted in field