PROPOSED POST ENTRY CONTROL PROCEDURES FOR MAIZE CROPS

This refers to the inadvertent planting of maize crops containing various GE events.

Introduction: *Zea mays* is a species that germinates once soil temperatures are above about 12C, germination is very slow below 12C. The seed is not dormant and therefore will not persist in the ground in an ungerminated and viable state for longer than the winter following the year of seed production. The crop is readily killed by ground frosts below 2.5C. It is an annual crop and no viable plant material or germplasm, other than seeds will persist over the winter. The seeds are large and are rapidly eaten by birds, insects and other animals including rodents, few residual seeds will therefore survive the winter.

Maize is a monotypic genus in NZ this means that it will not naturally cross with any other plant species in NZ. The seed is large and does not naturally shatter as the husk leaves retain it on the ear even after the crop reaches maturity. Dispersal is therefore by man or over short distances by birds and animals.

The pollen is wind dispersed and although it has been proven to be blown large distances, frequency of cross pollination by single rogue plants in a crop is typically less than .005% (CP_f) or less than 5 seeds per 100,000 at 30m and about 1/3rd this at 200m. Low but measurable quantities of pollen are detected 500m down-wind of maize crops. It is therefore clear that after the initial 30m or so of separation of the crops the rate of cross-pollination decreases only slowly but levels are very low. For example, for a separation of 200m between two crops, A and B where the frequency of a GE event in A (GE_A) is 0.5% the expected frequency of this event in seed produced by crop B will be less than;

$$GE_B = CP_f \times GE_A$$

$$GE_B = .00005 \times .002$$

$$GE_B = 0.0000010 \text{ or } < 0.0001\%$$

This is well be low the reliably detectable threshold accepted in all laboratories carrying out testing for GE events in maize. For New Zealand seed crops, it is accepted that the cross-pollination of maize or sweet-corn crops separated by at least 200m is negligible. These figures assume that the two crops are synchronous with respect to flowering and pollen shed. Where there is a 5% overlap in flowering and pollen shed in adjacent crops, the above levels fall to <0.000005%. Increasing the distance between crops, shelter belts, wind run and border rows in production fields will reduce these levels of cross pollination still further.

Spatial isolation can be modified by the addition of non harvested border rows, planting adjacent crops across the prevailing wind direction and by interspersing shelter belts between crops. It is difficult to quantify the effects of these precautions but the following figures can be used as a conservative guide.

Border rows, equivalent to 10m separation per row
Shelter belts, >10m high equivalent to 50 m additional separation
Across wind direction equivalent to 50m additional separation.

The maize varieties planted in NZ range in relative maturity ratings from about 75 days to 115 days. For crops planted on the same day, this translates to about 3 weeks difference in flowering and pollen shed date. In most crops flowering and pollen shed occur together. Pollen shed in a crop typically lasts for about 10 days with peak pollen shed (>60%) occurring for about a 5 day period, pollen production reduces rapidly outside this period. Therefore, crops can be isolated temporally by arranging crops to avoid flowering at similar times. This can be done by either planting crops of different maturities at similar times, or by separating planting times where crops have similar maturities.

In summary, it is very clear that the most effective method of isolating of crops to prevent cross pollination are spatial separation and temporal separation of flowering. The latter is the most effective method as once pollen shed has ceased cross pollination cannot occur. For crops separated by more than 30m and by more than 3 days between mid flowering, increasing the time between flowering dates is by far the dominant effect reducing cross pollination

In NZ, most maize crops are grown from hybrid seed and all hybrid seed is produced from inbred lines imported into NZ. All imported seed is tested for evidence of genetic modification and shipments in which evidence of GE events are detected is rejected or destroyed.   Therefore, GE events in hybrid seed in NZ can only occur at detectable levels if it is present in the inbred line parents. For this reason, certification of the inbred lines as being free of evidence of GE in accordance with accredited NZ standards should apply to all crops produced from the tested inbred lines.   For this reason, it is suggested that all batches of inbred seed and where appropriate hybrid seed imported to be sown in NZ are tested for evidence of GE.

In all cases, except a major failure of border control, the proportion of GE plants in a crop, if present at all, is likely to be very low and certainly below the level of reliable detection. The sampling and testing process is designed to detect with a high level of confidence (p>95%) the presence of 1% or more of GE seeds. Lower concentrations of GE seeds may be detected but the level of confidence will be less.

Control of an inadvertent GE release

Grain or Seed: Isolate and dispose by burning or burying to a depth of at least 1m of compacted soil to prevent consumption and distribution by rodents

Production fields:

Where the fields are fallow and maize stubble is intact:

- Stubble mulch or lightly rotary hoe as soon as possible after harvest to break up the stubble.
- Plough as soon as practically possible to incorporate stubble and to reduce the inadvertent dispersal of remnant grain.
- In the event that wet weather delays ploughing, and maize seeds remaining on the fields germinate, spray with a knockdown herbicide such as glyphosate or cultivate. Seed germinating at the end of the season will not shed pollen or produce seed till the following summer. Where frosts occur, volunteer maize plants will be killed.

Where fields are fallow with maize stubble incorporated into the soil:

- Cultivate the fields on at least two separate occasions when soil temperatures rise above 12C in spring to remove any emerged volunteer maize plants and to encourage viable seed remaining in the soil to germinate.
- There should be a period 10 days between cultivations to allow germination to occur.

Where it is not intended to fallow the fields:

- As soon as practically possible, plant the fields with a crop to protect against erosion and limit the financial impact on farmers involved.
- The crop following the GE maize crop could be any of the major crops grown in NZ although it must not be a hybrid maize or sweet-corn crop. It is highly recommended that crops such as Peas, squash or the small grain cereals (wheat, barley etc) be used, as the intensive weed management programs used in these crops will kill volunteer maize plants. Similarly, for a following pasture crop, animal grazing will effectively destroy emerging maize plants. Again, it is noted that volunteer maize plants are unlikely to survive the NZ winter.

Maize seed crops

- The option of planting an inbred seed maize crop by an experienced seed crop manager is possible. However, it is also the only option with any possibility of carry over of maize genes from one year to the next. Seed crops are intensely managed from planting through to harvest. Volunteers would be closely monitored and promptly removed. Volunteers also have a very high probability of being hybrids and therefore much larger and very distinct from the smaller inbred plants of the seed crop. All plants not "in row" must also be removed.

- The fields planned for maize seed should not be seeded prior to 7 November following cultivation to kill volunteer maize and encourage remaining seeds to germinate in the September and October period.

- Maize is normally grown on a 75 cm row spacing, inter-row and hand cultivation can be used to remove volunteer plants in the early stages of crop establishment and prior to canopy closure.

- Rogueing for removal of any plants not identical to the seed crop or not exactly in the planted rows is common practise in seed crops, this further reduces the potential of plant carry over from one season to the next.

Inspections:

- Crops, other than maize on all affected sites should be inspected on a monthly cycle from 1 September through 31 March. Inspections should include an area 10m outside the boundaries of the area in which the crop was grown and the route taken by harvesting and cultivating equipment to and from the cropped area.

- The inspecting agency shall maintain written records of each inspection and where a maize seed crop is not planted, shall include a count of the number of maize plants located at each site on each inspection.

- All maize surviving plants shall be removed/controlled within 10 days of that inspection.

- MAF shall provide an auditing procedure during the summer. If maize seed is to be grown at any site on which GE material was detected, MAF will inspect and sign off the site as acceptable for maize seed crop production before planting occurs, which in any case, shall not be earlier than 7 November following MAF inspection and 3 cultivations of each field in the period from 1 September to 31 October.

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- Provided no volunteer maize plants are observed in the last two inspections (February-March), monitoring shall cease at this time and landowners will have no further restrictions applied.

- If volunteer maize plants are observed in these last two inspections, a mutually agreeable strategy should be determined at such time, between, the seed producer, MAF and the landowner.

Specific examples:

Site 1: Gisborne
GE maize crop bordered by sweet corn north and south with a 20m spatial separation and a 12 day difference in mid silking and pollen shed between donor and receptor crops.

Reference values for crops with a spatial separation of 200m and no difference in mid silk time. The *distance factor* is the proportion of pollen from the donor crop likely to fertilise the receptor crop at a specified distance down wind of the donor crop.

Cross pollination (CP) = Frequency of donor plants (Qd) x distance factor

$$CP = Qd \times .002$$

For a 20m spatial separation

$$CP = Qd \times 0.008$$

For a 20m isolation with a 12 day separation of mid silk between donor and receptor crops it is estimated that <1% of the plants are shedding pollen

$$CP < Qd \times .008 \times .01$$

$$CP < Qd \times .0008$$

Therefore the effect of a 20m isolation plus a 12 day difference to mid silk is much greater than a 200m isolation with synchronous flowering. The sweet corn crops surrounding the GM crop are regarded as safe.

Site 2: Gisborne
GE maize crop with a 75m spatial separation and a 21 day difference in mid silking and pollen shed between the donor crop to an adjacent maize crop.

For a 75m spatial separation distance factor = 0.004

$$CP = Qd \times 0.004$$

For a 75m isolation with a 21 day separation to mid silk. It is estimated that 0% of the plants are shedding pollen

$$CP < Qd \times .004 \times 0$$

$$CP < Qd \times 0$$

Therefore the effect of a 75m isolation plus a 21 day difference to mid silk presents a negligible risk of cross pollination. The corn crop adjacent to the GM crop is safe.

Site 3: Pukekohe

GE maize crop with a 110m spatial separation and 1 tall shelter belt and a 9 day difference in mid silking and pollen shed between the donor crop and the nearest maize crop.

The shelter belt is equivalent to another 50m of spatial separation
Total separation is equivalent to 160m separation

For a 160 m spatial separation the separation distance factor = 0.003

$$CP = Qd \times 0.003$$

For a 110m isolation with a 9 day separation to mid silk. It is estimated that <10% of the plants are shedding pollen

$$CP < Qd \times .003 \times .1$$

$$CP < Qd \times .0003$$

Therefore the effect of a 110m isolation plus a shelter belt plus a 9 day difference to mid silk between donor and receptor crops is much greater than a 200m isolation with synchronous flowering. The corn crop adjacent to the GM crop is regarded as safe.