I   Germinate broad bean seeds *in the dark*. (1)

Detail of how germination was achieved, eg, with seeds held between a roll of damp blotting paper and the side of a container. (1) For the mark, the description must include *adequate* details of the equipment used, not just "Plant seeds in soil".

Mix IAA with the paste and apply to the plumule hook of a bean seedling. (1) (Extra mark if the IAA/paste is applied to the *inside* edge of the hook. Do *not* penalise if tips of plumule cut off and paste applied to the stumps. Do *not* credit "Coat seeds / seedlings with paste".)

Leave *in the dark* (1) for not < 1 hour and not > 24 hours (1) and observe for straightening of the plumule / angle of straightening / record % straightening. (1)

If candidate makes the comment "All procedures must be performed in the dark.", this is worth 2 *marks*: the section I 'germination in the dark' point above **and** the section II mark below for applying auxin treatments without exposing the seedlings to light.

Deduct 1 mark if candidates deliberately expose *all* IAA-treated/control seedlings to the light; this will defeat the object of the investigation. (*No* penalty if some treated seedlings are placed in the light and some in the dark.)   **MAX 4**

II Select bean seeds from the same plant / pod / genetic stock / stage of development. (1) (But do *not* credit references to seeds / seedlings of the same size / age / species.)

Use a range of concentrations of IAA *solutions* mixed into the paste (or dilute IAA powder/ paste mixture into more paste). (1) (*Not* sufficient to discuss the use of different "concentrations of IAA / IAA powder".)

Apply the same amount of paste to the seedling / Add a standard amount of IAA to a known quantity of paste. (1)

Apply the paste always to the same position of the plumule. (1)

Apply the paste alone (as a control). (1) Allow this mark for a control, even if no reference is made to using paste, if the candidate makes it clear that something, eg, water is being *substituted* for the IAA. Do *not* credit " Apply no IAA".

An appreciation of the need to apply auxin treatments without exposing the seedlings to light which could trigger straightening: applying treatments in the dark / dim light / illuminated by a light to which plumule is not sensitive. Alternatively, an appreciation of the need to apply treatments *quickly* / in less than 2 minutes, so that light cannot have acted as a trigger. (1)

Repeat treatment on several other bean seedlings / to increase reliability. (1) (If the number of seedlings selected is specified in the description of the procedure, at least 5 must be used for this mark to be credit ed.)

Do *not* credit this time, references to maintaining a constant temperature or other environmental conditions.   **MAX 4**

(7)
(13)

5.

(a) Allow any sensible answer, for example:

To help bees to detect a food source and to become trained to the location of the unscented artificial flowers.

To encourage more rapid location of the food source before the observations of feeding behaviour can commence.

To increase the chances of the bees finding the food source.   *(1)*

(b) To eliminate the possibility that bees were visiting the same 'flower' because of its position rather than its colour. / To identify whether bees were visiting a flower in a particular place. *(1)*

(c) (i) The bees showed no colour preference. / The bees' colour preference is determined by chance. *(1)*

Allow "The initial colour chosen is not affected by sucrose molarity.".

(ii) Of the 20 bees tested, 11 went initially for yellow and 9 for blue 'flowers'.

$$\chi^2 = \frac{(11 - 10)^2}{10} + \frac{(9 - 10)^2}{10} = \frac{1^2}{10} + \frac{-1^2}{10} = \frac{2}{10} = 0.2 \ (1)$$

Allow tests to be performed on Tables 1 and 2 separately. $\chi^2 = 0.4$.

Allow calculations involving total numbers of visits, rather than bees.

Initial visits - yellow: 1100; blue: 1015; E = 1057.5; $\chi^2 = 3.42$.

Total visits - yellow: 1104; blue: 1022; E = 1063; $\chi^2 = 3.16$.

Probability range: 0.5 - 0.75 (1) (Allow also correct arguments based on an incorrect calculation of χ^2) *(2)*

(iii) Any **one** answer: eg,

There is no significant difference between the observed and expected results.

The null hypothesis (that the bees showed no colour preference / colour preferences are determined by chance) is accepted.

Results as different from expectation as seen in the observed figures could occur due to chance alone, in between 50 and 75% of similar observations with total numbers of this size.

(Allow alternative wordings of answers which follow the arguments above. Allow also correct arguments based on an incorrect calculation of χ^2 and/or reading from probability table. If no calculation attempted or probability given, do *not* credit answers here.) *(1)*

(d) (i) The original colour choice determines subsequent visits. (With few exceptions, bees revisited 'flowers' of the same colour as their original choice.) *(1)*

(ii) The energy value of the reward appears to have no influence, as there is no evidence of the bees that visited 'flowers' with 1M sucrose moving to 'flowers' with the richer energy source.

Also allow: "Numbers of initial visits to flowers with 1M sucrose were largely the same as for the 2M sucrose flowers." (or equivalent expression of idea). *(1)*

(e) Any sensible answer. For example:

By visiting flowers of the same colour, successful pollination/fertilisation is more likely.

Pollen is not wasted on visits to flowers of a different species. *(1)*

Do *not* credit a general discussion about cross pollination; the answer should be linked to flower colour.

(f) Any sensible answer. For example:

All food sources (energy rich and less rich) are fully exploited.

Competition for high-energy food sources / a particular food source is reduced.

To exploit fully a particular species in flower (through information transfer about position to other worker bees).

Bees collect nectar from different sources, increasing the amount of food for the colony.

Allow: "A variety of foods/pollen will be brought to the hive." but "Bees do not all go to the same flowers." is insufficient.

7

Answers must relate to the visits of bees to flowers, not the information about sharing of food in the colony. Therefore do *not* credit answers such as "Sugar from 1M and 2M flowers is shared, so weaker bees, which don't forage so well, benefit." *(1)*

(10)

6.

(a) There are large numbers of seeds in the 0-5 cm / 0-10 cm / surface layer (1). The number of seeds rapidly decreases with depth / below 5/10 cm. / Small numbers of seeds persist down to a depth of 30 cm (1). For 1 mark - general statement, such as: "Numbers decrease down from the surface.". *(2)*

(b) Seeds near the surface are eaten / die / killed off / deteriorate / decay / are blown away / are washed away (or other sensible response). Must say more than just "There was no maize crop.". *(1)*

(c) Ploughing would tend to push seeds deeper (and increase the chance of parasitising roots). / There will be more opportunity for seeds at the soil surface to be blown away or eaten. *(1)*

(Do *not* credit discussions of seeds from deeper layers being brought to the surface.)

(d) The deeper hole puts seedlings in an area of soil with fewer witchweed seeds (1).

With the gently-sloping sides of the hole, it is less likely that soil will fall into the bottom of the hole, carrying seeds from the surface layer. / Wider hole exposes more soil/seeds to the air, so more seeds can be blown away (1).

Do *not* credit references to improving the growth of maize so that they are stronger and more able to resist the effects of parasitism. *(2)*

(e) (The soil particles sink), leaving the seeds *floating* on the water surface (from where they can be removed and counted). *(1)*

Allow: "Seeds settle into a distinct layer" but *not* "Brings seeds to surface of sample." or "Separates seeds from soil.".

(f) (i) The combined results suggest that the differences in the number of witchweed seeds are not significant at each of the four compass points around the infected plot (or equivalent expression of idea). *(1)*

Allow: "Wind has the same effect in each direction.", but *not* "Seeds were transported in all four directions.".

(ii) Allow just "The number of seeds decreases with distance from the field.". *(1)*

(g) Strigol should be applied to the soil before planting maize (1). (Allow "Soil should be sprayed, ploughed and sprayed again." as indicating that no maize had been planted.)

Seeds present germinate and die with no maize roots to infect (1).

There is no point spraying adjacent fields, since seeds do not spread very far (though credit reference to "up to 1 metre from the infected crops"). / Resources can be concentrated on treating just the infected soil areas. / Apply Strigol by hand/tractor rather than by plane which sprays chemical over a wide area (1).

Allow the second mark above even if the spraying strategy is incoherent. *(3)*

(12)