

Hybridization Techniques and Hybrid Seed Production Methods in Cucumber

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Abstract

Cucumber (*Cucumis sativus* L.) is a very popular and remunerative vegetable crop among the farmers of Nepal and its area in cultivation is increasing year after year. Demand of hybrid variety of cucumber is increasing and 78% of hybrid seed of cucumber seeds used in the production system are imported from abroad. Realizing this fact National Horticulture Research Centre (NHRC), under the Nepal Agricultural Research Council (NARC), has taken an initiative in developing hybrid varieties of various vegetable crops including cucumber. This paper mostly covers theoretical concepts of cucumber hybridization. It also guides through practical approaches, experience and evidence of hybridization activities conducted at the NHRC, Khumaltar. It is partly a literature review and partly based on the experience of the NHRC. Among the various systems of hybridization the Gynoecious × Monoecious and Gynoecious × Gynoecious are most common practices and the Gynoecious × Monoecious system for hybrid seed production has been used in the NHRC, Khumaltar. In Cucumber, gynoecious lines are used as female parents for hybrid seed production, which does not require modification. However, in gynoecious lines, male flowers need to be developed to maintain these lines. In some cases, to increase seed yield or if used as female parents, may need hormones to induce more female flowers in monoecious line. Among the several growth regulators available for sex modification, application of Ethrel (200 ppm) at 2nd and 5th true leaf stage for the promotion of female flowers (pistillate) and for the promotion of male flower (staminate), Maleic Hydrazide (25-100ppm) at 2-4 true leaf stage are being used. The NHRC successfully has registered Madhu-F1 (HRDCUC004 × Bhaktapur local) and Krishna-F1 (HRDCUC009 × Dhankuta local) under the National Seed Board in 2078.

Key words: Gynoecious, Hybridization, Monoecious, Registered

Introduction

Hybridization has been considered the most effective practical approach for increasing productivity and developing desired traits in crop varieties. This approach is used to develop F1 hybrids, which are superior to their parental lines in terms of productivity, quality, and adaptability in diverse situations (Chakrabarty et al., 2023). As the hybrid is a product developed by crossing two genetically distinct parents, its production is determined by the various systems. It employs various methods, combining pollination control mechanisms, to govern the activities that determine the isolation distance, planting ratio, synchronization of flowering, rouging, and supplementary pollination. In Nepal, the National Horticulture Research Centre, under the Nepal Agricultural Research Council, has taken the initiative in developing hybrid varieties of various vegetable crops. The NHRC has already registered two cucumber hybrids that utilize local genotypes as one of their parents.

Hybrid seed production in Cucumber is a technical process that requires controlled pollination to maintain superior characteristics, such as increased yield, disease resistance, and uniformity in offspring. This process relies on strategically combining desirable traits from carefully selected inbred parental lines. The gynoecious and monoecious parents are used to develop the hybrids. We use this method to develop cucumber hybrid varieties at the NHRC. In Nepal, out of 38 registered and recommended varieties, seed production is possible for only two open-pollinated varieties: Kusle and Bhaktapur Local (OP). Cucumber growers used only 19% of open-pollinated seeds, and 78% of hybrid seeds used in the production system were imported from abroad (Kafle and Joshi, 2018). Therefore, seed production and marketing of the Nepalese cucumber hybrids through private sector is utmost important. Some studies suggested that the key components for successful cucumber production included quality seed production and distribution, introduction of improved varieties, disease and pest management, post-harvest management, and access to finance (Khanal et al., 2020).

Cucumber (*Cucumis sativus* L., $2n=2x=14$) is the member of the economically important family of cucurbitaceae. It is warm-season crops mainly grown in the tropical and sub-tropical regions of the world. Most farmers began growing hybrid cucumbers under plastic houses in accessible areas during the off-season to earn remunerative

returns due to their adaptability and high yields under these conditions (Gautam et al., 2021). Results revealed that the benefit-cost ratio was 3.22 in the study area (Khanal et al., 2020). The productivity of cucumber is very low in Nepal (15.21 mt/ha) (MoALD, 2079/80) compared to Asia (49.61 mt/ha) and world average productivity (39.34 mt/ha) (FAO Stat, 2021). This could be due to the use of local and open-pollinated varieties, which are grown in open fields. Most farmers used their local varieties for normal-season production in open fields (Gautam et al., 2021).

Methodology

This paper mostly covers theoretical concepts of cucumber hybridization. It also guides through practical approaches, experience and evidence of hybridization activities conducted at the NHRC, Khumaltar. Therefore, it is partly a literature review and partly based on the experience of the NHRC.

Conceptual Framework of Cucumber Hybridization

1. Floral biology and sex expression

Hybrid seed production of Cucumber is relatively easy because we need not to emasculate the perfect flower. It's a monoecious species having staminate (male) and pistillate (female) flowers borne on the same plant in different position and rarely bisexual. We can easily distinguish pistillate flowers by the presence of a visible inferior ovary behind the corolla, which requires pollen deposition onto their three-lobed stigma for fertilization. For hybrid seed production, we prefer the gynoeceous sex form which is commercially viable. These plants develop only female flowers, and we do not need to emasculate male flowers. The proportion of female and male lines in cucumber hybrids has been found to have been adopted from 3:1 to 5:1. In Northern India, the female and male rows are planted in a specific row ratio of 4:1 (Chakrabarty et al., 2023). At NHRC, we usually practice 5:1 ration because our male parents profusely develop male flowers.

In general, four systems of hybrid cucumber seed production has been proposed using a gynoeceous line (Robinson, 2000). They differ in the type of flower used as the pollen donor.

1. Gynoeceous × Monoecious
2. Gynoeceous × Gynoeceous
3. Gynoeceous × Hermaphroditic
4. Gynoeceous × Andromonoecious

Among these systems, the Gynoeceous × Monoecious and Gynoeceous × Gynoeceous hybrids are most commonly in practice and the NHRC use Gynoeceous × Monoecious system for hybrid seed production. This system became popular for the development of stable inbred lines for the gynoecey trait during the late 1950s. The hybrids produced by the cross of a gynoeceous and monoecious line resulted in hybrid vigor and a high degree of female sex expression, with uniform and concentrated fruit formation, which was especially advantageous for mechanical harvest (Robinson, 2000). Because it tends to produce mostly female flowers, seed from this type of hybrid is usually blended with seed from a monoecious cultivar, added in a proportion of about 10%. This practice improves pollination, which is required for fruit set in genotypes that are not parthenocarpic. However, it has the disadvantage of affecting uniformity, which is one of the principal advantages of hybrid cultivar production (Robinson, 2000). When the hybrid is parthenocarpic, blending is not required because fruits can develop without pollination. Parthenocarpic is the case for many cucumber hybrids used in greenhouse production.

2. Sex form modification

In general, the objective of sex form modification is to increase femaleness and subsequently increasing the seed yield. In Cucumber, gynoeceous lines are used as female parents for hybrid seed production, which does not require modification. However, in gynoeceous lines, we must develop male flowers to maintain these lines. In some cases, to increase seed yield or if used as female parents, we may use hormones to induce more female flowers in monoecious line. Several growth regulators available for sex modification can be classified into two groups

For promotion of male flowers (staminate)

- AgNO₃ (250 ppm) start from 2-3 leaf stage to 5-6 leaf stage for 3 times

For promotion of female flowers (pistillate)

- Application of Ethrel (200 ppm) at 2nd and 5th true leaf stage
- Maleic Hydrazide (25-100ppm) at 2-4 true leaf stage

3. Flower receptivity and effective pollination

Female cucumber flowers are receptive to pollen only on the day they open, and they begin to lose receptivity rapidly after that. If pollination does not occur within that window, the flower will wither and die, and fruit development will not take place. An earlier study in rainy season under naturally ventilated polyhouse showed that the pollination carried out at 9.00 AM increased the percentage (96.97%) of fruit setting in gynoeocious Cucumber (Nagar and Maurya 2015). In Khumaltar condition, we also prefer pollination around this time. Pollination (natural or manual) should ideally happen in the morning, when flowers are fully open and pollen is most viable.

4. Flower selection and cotton covering

Female flower from female line and male flower from male line that is supposed to be open on next day must be covered with cotton. The next day, the male flower from the male line should be picked up, and its petals should be removed. The cotton that is covering female flower in female line should also be removed and the anther of male flower should be rubbed in the stigma of female flower to transfer pollen. Pollination is conducted manually and should be done in the morning, from 7:00 a.m. to 11:00 a.m. The female flower should be immediately covered with cotton after completing pollination to prevent from crossing. In the female line, we should remove all female flowers appearing below the 8th node. Female flower in alternate node from 8th node onward should be selected for crossing. A total of nine fruits should be pollinated per plant i.e 3 flowers in each branch.

Crop Management Techniques

1. Climatic and soil requirement

Hybrid cucumber production, essential for high yields and disease resistance, is significantly influenced by climatic factors. It is a warm season crop; long period of warm, dry weather and abundant sunshine is needed. Optimum temperature for growth and development is 18-30°C. If growing temperature is less than 15°C at night there will be no growth and when temperature is above 30°C, there is adverse effect on female flower production and produce less number of female flower. Long day conditions and intense sun produce more male flower while short day conditions and mild sun produce more female flower. Consistent and adequate moisture is crucial. Relative humidity levels of 60-80% are generally preferred. Well-drained, fertile soil with a slightly acidic to neutral pH, ideally between 6.0 and 7.0 is ideal for cucumber cultivation. This pH range facilitates efficient nutrient uptake. Excellent drainage is paramount to prevent root rot. Sandy loam or loam soils amended with organic matter, such as compost or well-rotted manure, are preferred.

2. Planting Time

In the mid-hills, for seed production, Chaitra-Baisakh transplanting is preferred inside a plastic house. Generally, this transplant provides harvestable fruits in Asar-Shrawan. The seed requirement for the female line is 20g/ropani, and for the male line, it is 5g/ropani. Seed of male line must be sown in nursery 20 days before sowing of female line.

3. Crossing Block

Crossing block is the land/field where female and male line is planted. At the NHRC, we maintain a 5:1 male-to-female ratio. We recommend planting the male line 20 days before planting the female line to have sufficient pollen for pollination and crossing, as well as fertilization. Male and female lines are planted in separate rows in a crossing block. The crop geometry for female line is 1 m x 1 m and male line (generally monoecious) is 1.2 m x 1.2 m.

4. Manures and fertilizers.

Manures and fertilizers are applied in pits at final land preparation before transplanting. Well decomposed FYM or compost 5 kg, mustard cake 100 gm, bone meal 100gm, poultry manure 100, MoP 40gm, DAP 40 gm boizyme 3 gm, zinc 3 gm and borex 3 gm should be applied in the pits 2-3 days before transplanting. The first top dressing should be applied 10-15 days after transplanting, using 10 grams of urea, by creating a ring around the root zone. We should repeat this process three times at 15-20 day intervals. Since Cucumber is a heavy feeder, foliar application of multiplex @ 2 ml/litre or vegimax @ 1 ml/litre of water at 15 days intervals found effective.

5. Training and pruning

Cucumber is grown in stakes to improve fruit quality, yield and pest management. One main stem and two primary branches should allow to grow and others branches should be remove. After reaching to the height of 5-6 feet mesh is made from GI wire and branches are spread on the GI wire mesh. Pruning should be done frequently to disease and older leaf.

6. Irrigation

Cucumber has high water requirements and sensitive to water stress. The frequency of irrigation depends on soil type and weather conditions. First irrigation should be given immediately after transplanting. Flowering and fruit setting are the critical stages for irrigation. Irrigation should be done by making furrow or ring or drip system and avoid direct contact of leaves with water.

7. Rouging and field inspection

Off type plant from both male and female parents should be removed before flowering. If female flower does not appear upto 5th node, those plant should also be removed.

At least 3 field inspections should be done

1st: Before flowering- check plant and leaf characters (vegetative growth stage)

2nd: At the time of flowering-check flower, spine color

3rd: At fruit maturity- check the fruit characters, shape, size and color

8. Fruit Harvesting

In Khumaltar condition, the fruits become ready for harvesting 40 days after pollination and harvesting is done manually when seeds reach their maximum physiological maturity. Maturity indices indicate that the outer skin of the green variety turns yellow, while the white variety turns brown. We keep harvested fruits in a shed for 1-2 days to ensure they are well-matured. Then, the fruits should be cut longitudinally; the seed, along with the juice, is scraped out and allowed to ferment in a plastic bucket for 1-2 days to remove the gelatinous pulp from the seed. The pulp should be frequently stirred to prevent the growth of mold. Then the seeds should be washed repeatedly by rubbing with hands until the mucilage is completely removed from seed. After repeated washing the non-viable seed will float while viable seed remain in the bottom of container. The pure seeds are then dried in shade for 3-4 days. The seed should be dried until it has a moisture content of 10%.

The NHRC Product: Madhu and Krishna

The National Horticulture Research Center has been developing cucumber hybrids utilizing exotic and local germplasms. Its efforts have paid off, and the NHRC successfully registered Madhu-F1 (HRDCUC004 × Bhaktapur local) and Krishna-F1 (HRDCUC009 × Dhankuta local) under the National Seed Board in 2078 (HRD, 2022).

Table 1: Characteristics of the NHRC developed cucumber hybrids

Characters	Madhu - F1	Krishna-F1
Branching habit	Multiple	Multiple
Vine length (m)	4.6	4.43
Leaf blade size (cm)	31.2	32.88
Intensity of leaf color (green)	Dark	Dark
Sex type	Gynomonoceious	Gynomonoceious
Fruit shape at stem end	Obtuse	Obtuse but tapering
Fruit type	Slicer	Slicer, pickle
Fruit spine color	Black	Black
Spine size	Smooth	Smooth
Fruit shape	Elongated	Elongated
Predominant skin color	Light green with white stripe	Dark green
Secondary skin color	Dark green	White stripe
Skin texture	Netted	Clean
Flesh color	White	Cream with light color
Fruit length (cm)	25.83	27.77
Fruit girth (mm)	59.6	59.31
Fruit wt (gm)	522	519.64
Male: Female ratio	1:14	2:1
Pistillate in node no	6	7
Organoleptic taste	Very good	Very good

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