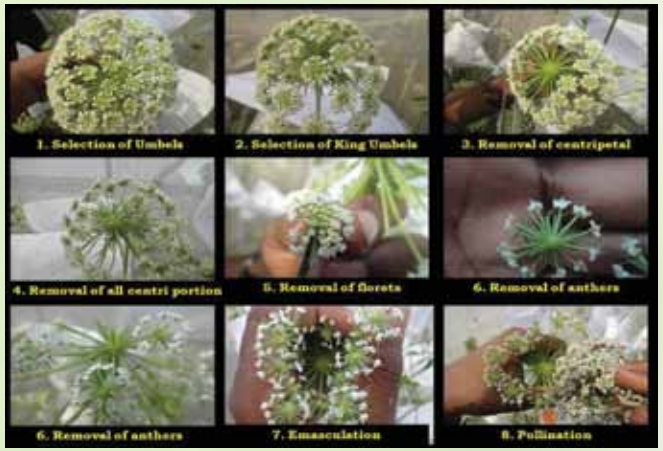

Fig 1. Stepwise crossing techniques in carrot crop

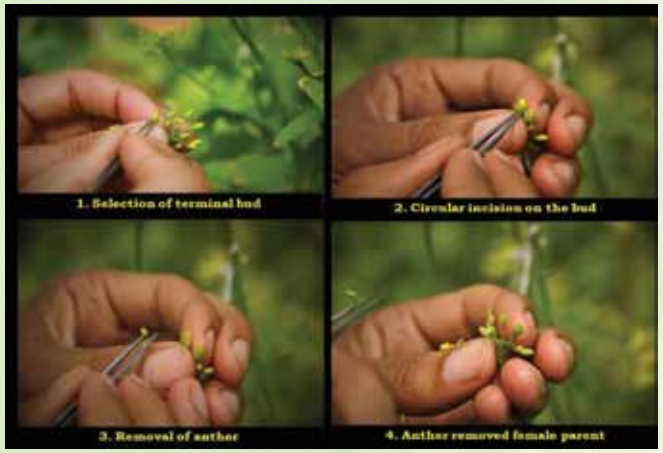

Fig 2 & 3. Stepwise crossing techniques in turnip crop

Fig 4 & 5. Stepwise crossing techniques in radish crop Selfing

Usually in radish and turnip, about 8 to 10 flower buds are pollinated in each inflorescence branch and the unopened young flower buds at the terminal end are removed whereas in of carrot, plants are caged by using muslin cloth that are placed over the umbels to be pollinated and tied tightly with a wire closure around seed stalks at the bottom, just below the umbels

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Floral Biology, Pollination Mechanism, Selfing and Crossing Techniques in Temperate Root Vegetables

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Introduction

Root vegetables are characterized by prominent, fleshy underground modified structure. Major root vegetables such as carrot, radish and turnip are grown under Jammu and Kashmir. These crops have variable nutritional food value and long storage life which contributed highest nutritional importance. Due to its nutritional value consumers and industry demand has been increased recently which gave scope to produce more. The hybrids in these crops are also gaining popularity all over the India. Though, its demand to produce varietal and hybrid seeds from the farmer themselves by understanding of selfing and crossing techniques of root vegetable crops.

Floral Biology

The most important aspects before proceeding of hybridization programme is the study of the science of flowers which consist of opening of flower, dehiscence of anthers, fertility of pollen grains and receptivity of stigmatic surfaces. Usually, anthesis of a flower occurring in the early morning in the root crops **(Table 1)**. Maturation of pollen grains as well as pollen dispersal takes place earlier than sigma receptivity in carrot whereas in radish and turnip its *vise-versa* in nature **(Table 2)**. Parameters of floral biology are influenced by environmental factors such as low and high temperature, light intensity, humidity and genetic factors. Thus, there is deviation in the flower opening, anther dehiscence, fertility of pollen grains and maturation of stigmatic surfaces. .

Hybridization techniques

For hybridization programme, raising of root crop, preparation of steckling, planting of steckling under controlled conditions, tools required, preparation of female flowers and pollination are the most essential steps. Raising of root crop is a primary step which is carried out during early September to December and the success of hybridization programme depends on the selection of quality root size, shape, colour of epidermal, xylem and phloem, coreless roots. Preparation of steckling is the second step which is crucial in case of carrot and radish because of it's biennial nature for flowering period. In order to get good success of hybridization in root crops, steckling should be planted during December to January under controlled green house or net houses for hybridization purpose.

Table 1: Floral biology of root vegetable under ICAR-CITH, Rangreth, Jammu and Kashmir conditions

Crop	Time Period		Fertility of pollen	Receptivity of stigma
	Anthesis	Dehiscence		
Carrot	7-10am	8-10 am	Immediately after anthesis	After pollen dehiscence on the day of anthesis
Radish	8-11am	9-10.30 am	Immediately after anthesis	Two to three days before to the day of anthesis
Turnip	7-10.30 am	8-10.30 am	Immediately after anthesis	Two to three days before to the day of anthesis

Tools required

A pair of fine tipped forceps, a spear pointed needle, a pair of scissors, a magnifying lens, a small vial of alcohol, tassel bags, crossing or pollinations bags, a hand stapler, label tags, crossing or pollination bags and pollen carrier are the common facilities required in hybridization programme.

Table 2: Breeding system of root crops which are used for hybrid seed production

Crop	Mode of pollination	Breeding system	Pollination vector
Carrot	Cross	Protandry & Male sterility	Honeybees
Radish	Cross	Protogyny & Sporophytic SI	Bumble & Honeybees
Turnip	Cross	Protogyny & Sporophytic SI	Bumble & Honeybees

Preparation of Female Flower

Before starting emasculation, we should be ensured that parenting material lines are true to the type. In root crops such as carrot, radish and turnip plants bearing hermaphrodite flowers, the female lines which are going to hybridize that are prepared by removing the pollen producing male part *i.e.* anthers. This operation is called emasculation. Emasculation should be done 2-3 days prior to opening of buds in radish while in carrot, it can be done any time in the day but mostly it is convenient and effective to perform in the mid morning to afternoon. Selection of flower buds for emasculation is the primary step.

Pollination

Usually pollination is done after emasculation of the next day morning prior to 11pm. Before pollination, stigmatic surface of the female flower should be checked for presence of self or foreign pollen. Flowers are bagged prior to opening in order to avoid contamination. Pollens are collected from the male parent flower or the flower is used as such for pollination. Pollen can be collected on a small scale by stripping the anther cone with a spear pointed needle or fine pointed forceps.