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Top working method and bloom density of pollinizers as productive determinant for spur type apple (*Malus x domestica* Borkh.) cultivars

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ABSTRACT

Apple (*Malus x domestica* Borkh.) shows gametophytic self incompatibility and requires cross pollination by suitable pollinizers. Gradual decline in natural pollinators and insufficient proportion of pollinizers have been observed in the apple orchards over the years across the North Western Himalayan region. This situation resulted in considerable pollination problem in the region. The present study was undertaken (during the years 2006–2010) to examine the effect of top working methods and time as well as type of pollinizers on different growth parameters for efficient pollination management. Chip budding performed in fall, late winter and summer gave significantly higher success rate (90.0, 89.8 and 80.9%, respectively). Other methods *viz*., side rind graft (85.6%) and cleft graft (71.2%) during February–March, and T-bud (71.7%) during July–August also gave better success. The highest shoot numbers (4.1) and length (92.8 cm) were recorded when chip budding was performed during September–October and February–March, respectively. In 4th year, chip budded scion branches of all the pollinizers recorded significantly higher number of spurs/m twig length with a range of 22.8 (December–January) to 24.7 (September–October). Significantly the highest bloom density (22.1) was recorded on chip budded (February–March) branches of pollinizers in 4th year. Fruit set on top worked trees of 'Oregon Spur' was only in the range of 18.0–20.1% in 1st year and reached to the range of 35.6–41.5% in 4th year. Seed numbers/fruit also increased to the range of 7.3–7.9 in 4th year from 2.9 to 4.6 in 1st year. All these factors resulted in better yield efficiency (2.6–3.8) of 'Oregon Spur' in 4th year. 'Manchurian' crab produced significantly higher shoot length of 86.5–87.2 cm and 146.1–149.2 cm in 1st and 4th years, respectively. However, 'Stark Spur' produced the highest number of spurs/m twig length of 28.9 when grafted/chip budded during December–January or February–March, and 27.1 when chip/T-budded during September–October or July–August. Top working with 'Manchurian' crab also resulted in significantly higher fruit set (44.2–45.4%) and yield efficiency (3.6–3.8) on 'Oregon Spur' in 4th year. This was followed by 'Stark Spur' as pollinizer (37.1–38.2% and 2.9–3.1, respectively). Highly significant positive correlation of shoot numbers, spur density and bloom density of pollinizers with fruit set and yield efficiency of 'Oregon Spur' were observed. 'Manchurian' crab was found to be very efficient as pollinizer, followed by 'Stark Spur' for spur type 'Oregon Spur' apple cultivar on the basis of higher bloom density and fruit set parameters.

1. Introduction

Pollination management in apple (*Malus x domestica* Borkh.) orchard has been considered as one of the important factors for higher fruit set and quality fruit production. All the cultivars under Delicious group like 'Red Delicious', 'Oregon Spur', 'Starkrimson' 'Red Chief' and 'Well Spur', *etc*. share common S-genotype. The multigene complex comprises a S-RNase gene in the pistil and S-haplotype specific F-box gene in the pollen tube (Hegedus, 2006), and constitute a gametophytic nature of self-incompatibility system. Optimum cross pollination of Delicious group of apple cultivars by any other suitable cultivar bearing different S-alleles becomes mandatory for fruit set. This is, in turn, responsible for higher fruit retention and yield efficiency. Two ovules in each carpel of apple flower have the capacity of setting two seeds or ten seeds per fruit, if at least; two viable pollen grains are transferred to each of the five receptive stigma of the flower from a compatible cultivar (Torchio, 1985). Better pollination ensures higher seed set per fruit resulting in good fruit size and shape (Way, 1995). The selection of apple pollinizers has become more complex over the years in view of adoption of spur type Delicious cultivars which have high bloom density. Moreover, bloom density of these spur type cultivars is higher under medium–high density plantation

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systems due to accommodation of higher number of trees per unit area. Selection of pollinizers which have proportionately higher bloom density as well as show annual regularity in blooming with bloom overlap is important for increasing the pollination efficiency of spur type cultivars. Under such situation, 'Golden Delicious', a commonly preferred non spur traditional pollinizer in the region fails to fulfill the pollination requirement for spur type cultivar like 'Oregon Spur', 'Well Spur' or 'Red Chief', because, 'Golden Delicious' shows bienniality in bearing and late in blooming. Another method of pollination management is placement of pollinizers in the orchard. The effective distance between the main apple cultivar and pollinizers should be approximately at 6–15 m depending upon the tree vigour to ensure better pollen transfer across the orchard (Warmund, 2002). Further, growers are least interested to sacrifice a major proportion of red fruit coloured cultivars for 'Golden Delicious'. Over the years, there is a drastic decline in apple productivity in many of the orchards across the mid-high hill temperate zone in the North Western Himalaya. Major reasons have been considered to be the decline in population of natural pollinators and the lack of sufficient number of pollinizer trees in the orchard. This situation has been further aggravated by climate change factors. Top working of pollinizers on the trees of main commercial apple cultivars has been considered to be a better option for orchards with inadequate proportion of pollinizers (Gautam et al., 2005). 'Red Gold' (red fruited), 'Stark Spur' (spur type) and *Malus manchurica* (Maxim.) Kom. (crab apple) may become efficient pollinizers under such situation. In general, cleft grafting has been practiced for top working to limited scale and time of this grafting is restricted only during late winter *i.e.* February–March (Phillips, 2005). However, chip budding has been found to be very good for propagation of quality planting material of woody plants (Gustafson and Morrissey, 2003) with higher success rate and better plant growth. This method of budding extends the regular budding/grafting season with active or dormant buds on active or dormant stocks. Though, this novel method has not been practiced for top working, but may give good result, and will provide a wider option to the grower in pollination management.

The aim of the present study was to work out suitable top working method and time as well as to examine the effect of bloom density of pollinizers on effective pollination of spur cultivar 'Oregon Spur' expressed in terms of certain vegetative and reproductive parameters.

2. Materials and methods

2.1. Site selection and experimental materials

The study was conducted in the apple orchard of Central Institute of Temperate Horticulture, Regional Station, Dist. Nainital, Uttarakhand, India, during the years 2006–2010. Geographically the orchard is located at 29′N latitude and 79′E longitude at an altitude of 2200 meters above mean sea level. Bearing trees (12–15 years old) of spur type apple cv. 'Oregon Spur' planted at spacing of 3–4 × 3–4 m on hill terrace system were selected for top working with pollinizers *viz*., 'Stark Spur' (spur type), *M. manchurica* (Maxim) Kom. (crab apple) and 'Red Gold' (non-spur type). The orchard was having scattered plantation of only 10% pollinizer trees comprising 'Golden Delicious', 'Red Gold', 'Tydeman's Early Worcester' and 'Manchurian' crab. Recommended management practices were followed during the experiment period.

2.2. Experimental methodology and observation recording

Chip budding and T-budding were performed in September–October (fall) and July–August (summer), while, side rind grafting, tongue grafting, cleft grafting and chip budding were performed during December–January (mid winter) and February–March (late winter). Three shoots (avg. dia. 15 mm) arising from the main primary branches at three different directions were selected at chest-shoulder height on the trees of cv. 'Oregon Spur' for top working. Scion woods (8–10 cm dia. with 3–4 buds) were collected from the healthy trees of selected pollinizers and grafted or budded as per procedures described by Hartmann et al. (2007). Different vegetative and reproductive parameters of grafted branches of pollinizers as well as top worked trees of cv. 'Oregon Spur' were recorded in the successive years starting from the 1st year of top working up to 4th year. However, grafted/budded branches were subjected to judicious dormant pruning in 2nd and 3rd years to facilitate vegetative growth and spur formation. Bee hives of *Apis cerana indica* Fabr. at 4 hive/ha were placed in the orchard. Number of shoots, shoot length (cm), number of spurs/m twig length, bloom density (nos. of flower cluster/cm^2 branch cross sectional area), per cent fruit set {(number of fruits set/number of flower clusters) × 100}, yield efficiency (yield/tree in kg/cm^2 trunk cross sectional area), and seed numbers per fruit (avg. of 20 fruits) were determined. Branch and trunk cross sectional areas were calculated using the formula: $\Pi(C/2\Pi)^2$, where, C is the circumference of the branch or tree trunk.

2.3. Experimental design and data analysis

Data were analyzed by factorial Randomized Block design with three replications. The whole study comprised two experiments. Experiment 1: factors – (i) pollinizer cultivars at three levels ('Stark Spur', *M. manchurica* and 'Red Gold'), (ii) budding methods at two levels (chip and T-bud), and (iii) budding time at two levels (September–October and July–August). Experiment 2: factors – (i) pollinizer cultivars at three levels ('Stark Spur', *M. manchurica* and 'Red Gold'); (ii) grafting/budding methods at four levels (side rind grafting, tongue grafting, cleft grafting and chip budding); and (iii) grafting/budding time at two levels (December–January and February–March). Ninety six and one hundred forty four trees of cv. 'Oregon Spur' were top worked (two trees in each replication) under experiment-1 and experiment-2, respectively. Every tree of cv. 'Oregon Spur' was top worked under the present study. Interaction effects of budding/grafting methods and time, and main effect of pollinizers on different parameters have been discussed for better understanding to standardize the technique of top working depending upon the methods, time and pollinizers. Correlation coefficients (r-values) were worked out for different vegetative and reproductive parameters by generating data of 3-way interaction of top working methods, time and pollinizers from both the experiments.

3. Results and discussion

3.1. Interaction effect of top working method and time

3.1.1. Top work success

Top working employed by budding/grafting methods at different seasons showed (Fig. 1) that chip budding in fall (September–October), late winter (February–March) and summer (July–August) gave significantly higher success rate (90.0, 89.8 and 80.9%, respectively). This was followed by grafting methods *viz*., side rind (85.6%), cleft (71.2%) and tongue (67.5%) performed during February–March. T-budding gave 71.7% and only 11.0% success during July–August and September–October, respectively. All the top working methods performed during December–January gave very poor success with a range of 16.2% (side rind) to 45.6% (cleft).